LETIZIA DIPASQUALE

Understanding Chefchaouen

Traditional knowledge for a sustainable habitat

FIRENZE UNIVERSITY PRESS

La collection littéraire
ricerche | architettura, pianificazione, paesaggio, design
est articulée dans la série
Études Euro-Méditerranéenne

La série de publications scientifiques *Études Euro-Méditerranéennes* a le but de diffuser à l'échelle internationale les études et les recherches résultant de la coopération entre l'Ecole d'Architecture, de Design et Urbanisme de l'Université Euro-Méditerranéenne de Fès et le Département d'Architecture de l'Université de Florence.
Chaque volume est soumis à une procédure d'acceptation et d'évaluation qualitative fondée sur l'examen par les pairs, et confiée au Comité scientifique de rédaction du Département d'Architecture.
Toutes les publications sont également en libre accès sur le Web, pour promouvoir non seulement leur diffusion mais aussi une évaluation ouverte à l'ensemble de la communauté scientifique internationale.
Le Département d'Architecture de l'Université de Florence promeut et soutient cette collection pour apporter une contribution à la recherche internationale sur ce projet, à la fois sur le plan théorico-critique et opérationnel.

ricerche | architettura, pianificazione, paesaggio, design

LETIZIA DIPASQUALE

Understanding Chefchaouen

Traditional knowledge for a sustainable habitat

Firenze University Press
2020

UNIVERSITÀ DEGLI STUDI FIRENZE | DIDA DIPARTIMENTO DI ARCHITETTURA

Understanding Chefchaouen : traditional knowledge for a sustainable habitat / Letizia Dipasquale. — Firenze : Firenze University Press, 2020.
(Ricerche. Architettura, Pianificazione, Paesaggio, Design ; 2)

https://www.fupress.com/isbn/9788855181785

ISBN 978-88-5518-177-8 (Print)
ISBN 978-88-5518-178-5 (PDF)
ISBN 978-88-5518-179-2 (XML)
DOI 10.36253/978-88-5518-178-5

Photographic credits
Where not otherwise indicated, the images and photographs are by the author. The drawings of the section *The building culture* are made in cooperation with Vittoria Volpi.

Acknowledgements
INN-LINK-S Local and Indigenous Knowledge Systems and Innovation research unit, *Association Rif Al Andalous pour la protection du patrimoine*, Regione Toscana, all the inhabitants of Chefchaouen.

progetto grafico
didacommunicationlab
Dipartimento di Architettura
Università degli Studi di Firenze

Susanna Cerri
Federica Giulivo

Published by Firenze University Press

Firenze University Press
Università degli Studi di Firenze
via Cittadella, 7, 50144 Firenze, Italy
www.fupress.com

This book is printed on acid-free paper
Printed in Italy

Imprimé sur papier de cellulose pure Fedrigoni Arcoset

ELEMENTAL CHLORINE FREE GUARANTEED
ACID FREE
LONG-LIFE ISO 9706
HEAVY METAL ABSENCE CE 94/62

CONTENTS

FUP Best Practice in Scholarly Publishing (DOI 10.36253/fup_best_practice)

THE PRINCIPLES THAT
TRADITIONAL SOLUTIO
RESPECTED. THIS IS
ARCHITECTURE CAN SU
ECOLOGICAL QUALITY,
OF VERNACULAR ARCHI
ARID REGIONS OF THE

PRODUCED THE
NS MUST BE
THE ONLY WAY MODERN
RPASS IN HUMAN AND
THE ACHIEVEMENT
TECTURE IN THE HOT
WORLD.

Hassan Fathy, 1986

PREFACE

Bent entrance passageway of a courtyard house (© L.Lupi, 2007)

The premise for this work has its roots in the well-established idea that the safeguarding of cultural (natural, tangible and intangible) heritage must be guaranteed for the future generations, not only because it is a source of the cultural identity of a local community, but also because it is a driving force behind the local economy and the sustainable development of territories. A sustainable development that is broadly interpreted, in other words integrating the environmental, cultural, economic and social spheres, and putting communities and human wellbeing at the center of the development process.

The medina of Chefchaouen represents an architectural heritage of great value: it is a living fabric of places, experiences, memory and identity. The architecture of the medina combines the local building traditions of the Jbalas region and the influences of the Andalusian civilization imported from the Moorish refugees coming from Spain after the fall of the Emirate of Granada. The medina is characterised by a network of roads with courtyard dwellings organized according to the patterns and rules of the Islamic city. The morphological conformation of the territory, very rugged, determines the shape of the city, which develops in steps, all exposed to the south, protected by the mountain peaks that have given the city its name. The most evident characteristic of the medina is the colour of the lime render of the walls, which lost their angles due to the many layers of whitewash that have been applied by the women of the city over the years. The art of limestone is combined with the art of colour: originally white, in the last century Nila or indigo, in a wide range of shades that have spread throughout the walls to cover almost the whole city, giving it a fabulous atmosphere and highlighting the wise will of the people to protect the stone walls, otherwise very vulnerable.

Nowadays such built heritage is threatened by an ongoing process of transformation, demolition, replacement of parts of buildings or renovations using modern materials, as well as non-compatible interventions. In particular, the use of modern and standardised materials such as reinforced concrete seems to meet the need for modernity and to provide greater durability and water resistance to the buildings, while in fact, the climatic and environmental conditions make the indiscriminate use of reinforced concrete technology completely inadequate

FUP Best Practice in Scholarly Publishing (DOI 10.36253/fup_best_practice)

Letizia Dipasquale, *Understanding Chefchaouen. Traditional knowledge for a sustainable habitat*, © 2020 Author(s), content CC BY-NC-SA 4.0 International, metadata CC0 1.0 Universal, published by Firenze University Press (www.fupress.com), ISBN 978-88-5518-178-5 (PDF), DOI 10.36253/978-88-5518-178-5

Public fountain in the medina of Chefchaouen (© L.Lupi, 2007)

and not sustainable, in addition to being a major threat for the safety and stability of the building when rehabilitation and consolidation interventions are not appropriate.

The present research is based on several years of study and on visits to Morocco and Chefchaouen. It began in 2005, as a participation in an international cooperation project funded by the Tuscan region, which had as partners in Italy the SPEF Scuola Professionale Edile of Florence and the TaeD Department of Architecture and Design Technologies "Pierluigi Spadolini" of Florence and as partners in Morocco the Rif Al Andalous association based in Chefchaouen and the ENA École Nationale d'Architecture in Rabat. The idea of the project originated from the proposal to develop and implement a project for the construction of a vocational training center aimed at the qualification, improvement and innovation of traditional construction techniques, in support of the reconstruction and redevelopment processes undertaken after the seismic event of February 24, 2004, in the Al Hoceima area north of Chefchaouen. The research presented here began as part of the degree thesis discussed by the author in collaboration with the architect Vittoria Volpi, stands as a preliminary and preparatory phase for the creation of the documentation and professional training center on traditional construction cultures, which could constitute an element for promoting socio-economic development and the preservation of architectural heritage.

This volume collects, updates and extends the results of the investigation launched fifteen years ago and aims to systematise the intangible knowledge necessary to formulate sustainable strategies for the rehabilitation and conservation of Chefchaouen's heritage aimed to improve the quality of life within the medina. The concept of intangible knowledge related to the architectural heritage includes not only the techniques, materials, and building components, but the local building knowledge, transmitted from generation to generation, concerning the constructive process, the maintenance of the artifacts, a sustainable management of resources, and the choice of architectural and technical solutions, more appropriate and sustainable, which reflect the response of the community to the need for spaces, following a large process of adaptation to the environment and the socio-cultural and economic requirements.
The work is the result of a thorough investigation of the medina, several observations of buildings in a different state of conservation, as well as a number of surveys of courtyard houses and building elements, in order to understand how these structures were formed and transformed on both a technical and cultural level. The missions and direct visits undertaken throughout the entire medina, and in particular in some buildings and building complexes identified as case studies, documented with manual survey tools and analyzed from a morphological, distribution and functional point of view with regard to the modifications introduced in the ways of using the spaces. Visits were paid to residential and public buildings, construction sites where rehabilitation or restoration work was under way, to kilns for the production of lime and bricks, and to deposits of materials. During these visits material samples were taken and interviews were conducted to record information and data, particularly with regard to the production processes, which were clarified thanks to the interviews with the *maalem*, the two old master builders interviewed. The fieldwork produced a large set of data and qualitative and quantitative information, which was then used as the basis for an interdisciplinary interpretation. The results of the investigations and interviews confirmed that the technical skills of the artisans of the past are partially available today, but in the process of disappearing as there is no continuity in the provision of such highly specialized work. The investigation was supported by the study of the available documentation, largely made available by the cultural association Rif Al Andalous in Chefchaouen.
The book addresses the theme of the architectural heritage of the medina with an interdisciplinary approach, that includes the architecture as part of a system that has to be studied along with, and not detached from, its environment, a deep knowledge of the natural, social and cultural context and all the factors that brought about the architecture. It is structured in such a way that each part addresses a scale of analysis. The first part focuses on

the environmental and socio-economic context, and carries out an in depth analysis of the characteristics of the urban and architectural morphology. Through the analysis of the settlement development of the city of Chefchaouen from its origins to the present times, the rules that give structure to the urban fabric and the basic module of the city – the courtyard house – are made more understandable. The analysis of the building types, through the comparison between the different variants of the courtyard model, is aimed at understanding the rules that give life to the shape and distribution of spaces. An analysis of construction techniques cannot be separated from a study of the urban types through which these techniques have developed and evolved over time. Therefore the analysis of the architectural types allows us to design with awareness models for the homes of tomorrow, which may be able to absorb the identity and sustainable characteristics of the traditional house.

The central part of the work, which illustrates the building culture of the medina, takes up the Italian tradition of the "Manuali di recupero[1]", born as tools linked to specific contexts and aimed at identifying an approach operational for the recovery of the built heritage of the historic center. The study of the building techniques allows us to understand their potentials and weaknesses, so that they can be respected, improved, or innovated in intervention phases. It is not always possible or appropriate to use traditional techniques for conservation actions, but it is important that the materials and techniques that are used are compatible on a material and structural level with the building, and are sustainable on an environmental and social level, without compromising the authenticity of the built heritage.

Thanks to the involvement of the CNR-ICVBC laboratory in Sesto Fiorentino, the chemical-physical characteristics of the traditional materials taken on site and those used in the current construction practices aimed at the consolidation or restoration of ancient artefacts have been compared. The support of the colleagues from the "Materials and structures" section and the Official Material and Structural Testing Laboratory of DIDA, University of Florence, made it possible to evaluate the structural behavior of some constructive elements: the mechanical resistance of the masonry in their various variants, and the structural behaviour of the main types of roofing. The structural behaviour of the components of a building is a piece of information of fundamental importance for

[1] Among others: Giovannetti F. , Marconi P. (eds.) 1997, *Manuale del recupero del centro storico di Palermo*, Flaccovio, Palermo; Giovannetti F. (ed.) 1998, *Manuale del recupero del Comune di Città di Castello*, DEI, Roma; Giuffre A. (ed.) 1993, *Sicurezza e conservazione dei centri storici: il caso Ortigia: codice di pratica per gli interventi antisismici nel centro storico*, Laterza, Roma; Ranellucci, S. (ed.) 2011, *Manuale del recupero della regione Abruzzo*, DEI, Roma

designing improvement interventions, especially in those cases where there are changes in the extent of the loads applied in traditional structures.
The last part of the book deals with the main challenges for the future of the medina: the sustainability principles embedded in Chefchaouen's traditional architecture, that can provide support for the innovation, rehabilitation and design of new housing models; an analysis of the risks faced by the medina, including natural, social and anthropic threats caused by the dynamics of transformation to which the architectural heritage, both tangible and intangible, is subjected today. The objective is to be able to establish conservation, intervention and rehabilitation strategies that allow the prevention and mitigation of possible damages through sustainable and compatible actions aimed at increasing the resilience of the medina.
The book is not just a collection of information concerning the architectural heritage of Chefchaouen, but is also a means of transmitting important skills and knowledge from the past to the present. It can be a useful and handy reference manual for architects and other experts, but it can also be a stimulating book for students, and all those interested in Moroccan culture, architecture and society. It is hoped that this contribution will also highlight the richness and variety of heritage resources, their value to society, the importance of community participation in heritage management, and the shared responsibility in the preservation of cultural heritage and its mobilisation in development. It should be noted that the value of Chefchaouen does not depend on the ability to keep everything changed over time, since man and his needs, the landscape and the environment that surround him, as well as the economy and society, are constantly evolving: change cannot be stopped, nor should the medina take on the appearance of an amusement park for nostalgic tourists.
The value of Chefchaouen is given by its cultural landscape, made up of the interaction of man and the surrounding environment, of the human ability to harmonise with it through the different expressions of a tangible and intangible culture which, for millennia, has been able to shape the territory without ever compromising the delicate balance and its ability to regenerate. A different path towards modernity can be traced starting from local resources and the tangible and intangible culture of these places; a road that does not give up its own identity and history, that does not invest in a future in which all territories are equal to each other. The effort is therefore to define a path linked to tradition, which builds a future in which to innovate processes and forms of adaptation to the territory without distorting its behavior.

CHEFCHAOUEN: CULTURAL LANDSCAPE, ARCHITECTURAL KNOWLEDGE AND INTANGIBLE HERITAGE

Saverio Mecca
Università degli Studi di Firenze

Door knocker (© L.Lupi, 2007)

Cultural and urban landscapes represent the traditions of the different places, the cultural characters, the organization and the social and religious rituals of the populations.
UNESCO defines a "living" or "evolutionary" cultural landscape as a landscape that maintains an active role in contemporary society, closely associated with a traditional way of life, and in which the evolutionary process continues.
Also, the monuments, as isolated or emergency episodes, are now recognized as a part of the environmental context of reference, the "cultural landscape", which identifies a specific and unique character or identity of places, the result of the interaction between an individual asset and its context, architecture and environment, art and society. It is defined as a "cultural landscape", since as man has organized and shaped the space creating a specific fusion between nature and culture.
Also in the Mediterranean Landscape Charter (1993), prior to the European Landscape Convention (2000), the plurality of the values attributable to the landscape is affirmed, understood as the result of the combination of affective, identifying, aesthetic, symbolic, spiritual or economic factors and of natural, cultural, historical, functional and visual aspects.
Chefchaouen, the city with its mountain, its architecture and its population are an excellent example of the concept of "cultural landscape".
The relativity and plurality of the values of cultural heritage, their variability in relation to different historical periods and socio-cultural contexts emerge as further aspects connoting the landscapes: the identification of a place as heritage is the result of a process of assignment of values that cannot be defined in absolute form, but only in a relative way to the specificity of each epoch and context. Each community, through its collective memory and awareness of its past, is responsible for identifying and managing its assets.
If the main goal of actions on the landscape is to guide change, it is necessary to work in a dynamic process, observing the continuous transformation of the physical environment and the evolution of collective conceptions and beliefs.

FUP Best Practice in Scholarly Publishing (DOI 10.36253/fup_best_practice)
Letizia Dipasquale, *Understanding Chefchaouen. Traditional knowledge for a sustainable habitat*, © 2020 Author(s), content CC BY-NC-SA 4.0 International, metadata CC0 1.0 Universal, published by Firenze University Press (www.fupress.com), ISBN 978-88-5518-178-5 (PDF), DOI 10.36253/978-88-5518-178-5

A knowledge-oriented systemic action is therefore fundamental to identify the physical-material and cultural-immaterial characteristics of the landscape on which to intervene, and above all the process of its evolution, the peculiarities of the elements that constitute it and guarantee its integrity and authenticity: this is to guide choices about what is worth keeping, and which actions and tools are best suited to the purpose.
Thus in the management of cultural landscapes and urban ecosystems protection is founded on the problem of environmental, socio-cultural and socio-economic sustainability.
The relationship between the enhancement of cultural resources and territorial development processes is one of the most debated issues in national and international organizations and in the scientific literature of the sector, increasingly attentive to enhancing multi-disciplinary approaches. In 1994 the Declaration of Nara (preamble, point 4) placed at the center of the scientific debate the delicate process of the rediscovery of the identity of cultures in their authentic essence. The recognition of local identity characteristics requires in fact to enlarge the formal and informal partnerships that participate in the definition of globally sustainable development processes. Furthermore, it requires that the actions be specific, coherent with respect to the characteristics of the places, thus favoring the provision of sustainable actions, such as to increase the local territorial capital without reducing that of other territories.
The definition of intangible cultural heritage, and the consideration that it is a source of identity, creativity, and diversity, has largely contributed to delineating a global approach to heritage, which closely links tangible and intangible assets, the object or the event in its environmental (the place) and historical (the diachronic cultural dynamics) contexts.
The multidisciplinary approach of the protection and the anthropological character of the knowledge of the territory comes from the global dimension of culture, where material and immaterial aspects cannot be distinguished (Istanbul Document of 2001); respect for diversity and the involvement of heritage “owners” are the basis for an “ethical” approach to cultural identity.
The safeguarding of identity is linked to the use of measures that can ensure effective research, identification, and documentation.
Article. 13 (d) of the WH Convention encourages the countries of the world to adopt appropriate legal, technical, administrative and financial measures to establish departments for the documentation of their intangible cultural heritage and to make it more accessible.

The WH Convention also invites the countries of the world to create an inventory of institutions, archives, and other documentation systems, museums or ethnographic departments that operate with the elements of the identified intangible cultural heritage.
The WH Convention also encourages the participation of traditional artists and local creators in the identification and revitalization of the intangible heritage, while encouraging public bodies, non-governmental associations and local communities to identify, safeguard and promote this heritage.
Even the new definition of authenticity, which emerges from the Nara document, a condition for sites to be registered in the WH List, is borrowed from a meaning mostly linked to attributes such as customs and traditions, spirit and "feeling": this suggests that some sites registered in the WH List as tangible cultural and natural heritage are important above all for their intangible attributes.
Tangible and intangible are therefore indissoluble, and must therefore be treated as a whole, without separation, although it may seem easier to deal with the tangible than to manage the intangible. Not caring about the "physically tangible" would weaken the support necessary for the development and maintenance of the relative intangible practices; in the same way, not to worry about the continuity of the unfolding of traditions and rituals would mean undermining the survival of the associated tangible heritage.
On the basis of these assumptions, once again it is necessary to "listen to places", in the way that this exemplary book by Letizia Dipasquale does, and not simply to carry out a detached interpretation of them: it is necessary, in other words, to focus attention on the sustainable management of the architectural heritage through its careful knowledge, the control of the functions and the meanings attributed to the places and their compatibility, integrating traditional and contemporary ways of living.

Ugo Tonietti
Università degli Studi di Firenze

Stairs in a courtyard house (© L.Lupi, 2007)

The *medina* of Chefchaouen is the emblematic representation of the extraordinary and fascinating complexity that can be enclosed in the articulation of a historical built system.

If we ask it, with the patience and curiosity necessary for asking the right questions, it can speak to us of all that is hidden in those walls, in the bizarre succession of houses and shops which creates a small city, but is also a fertile cross-section of history and human wisdom.

The first impact is through the senses and carries us through an unknown other where the colours of the facades, the rhythm of the doors and windows, the freedom of the architectural forms, in their however naive and unprogrammed simplicity, produce a harmonious, surprising, and I daresay even moving effect.

Spontaneous and vernacular architectures can also be works of art, can tell us about a process of settlement, carried out by a community and stratified throughout time, in which the many different voices are part of a coherent expression, capable of producing a strong sense of fascination.

To wander through the narrow alleys of Chefchaouen is an exciting experience because it makes us relive, even to those who are not experts in architecture, and not necessarily at the conscious level, part of the path of man on this planet: the section that concerns the forms of dwelling that began with sedentarism and developed, speaking very different languages, yet all strangely familiar, for almost 10,000 years until the threshold of contemporaneity.

It is a language articulated by the composition of stones and bricks, timber and earth, mortars, metals and fabric. For millennia every settlement was built in this way, obeying to the laws of physics, to the constraints of the environment, yet also following the individual paths of imagination and ingenuity. This is why the Anatolian houses of Çatal Hoyük and the courtyards of the Maghreb, the powerful Inca walls and the fragile Syrian cupolas are all part of the same extraordinary narrative.

It is the story of *human diversity*, if we wish to use an expression from the geneticist Luigi Luca Cavalli Sforza, only that this diversity speaks a language that is supported by a shared grammar even when expressing phrases, concepts and forms that are absolutely original. I believe

FUP Best Practice in Scholarly Publishing (DOI 10.36253/fup_best_practice)
Letizia Dipasquale, *Understanding Chefchaouen. Traditional knowledge for a sustainable habitat*, published by Firenze University Press (www.fupress.com), ISBN 978-88-5518-178-5 (PDF), DOI 10.36253/978-88-5518-178-5

opposite page
Lime painted wall
(© L.Lupi, 2007)

that the greatness and importance of the study of human settlements lies precisely in this: they tell us, through what could be deemed a "building culture", how human societies evolved, how they related to the environment, with what strategies, what concerns, what solutions. It is a bumpy ride which can vary depending on the time and the place, on the degree of cohesion of a society, on its imaginary, on the periods of shortage and development, on peace and war, on its capacity for interaction, exchange and hybridisation. We will discover how refined and arduous the relationship with nature is, how great the effort to maintain sustainability, since it is necessary to know defend ourselves from an unkind nature without, however, exerting undue violence upon it. I believe that if we are capable of reading the book of building cultures (we are referring to the wonderful contribution by Antonino Giuffrè[1], matchless investigator of the behaviour of wall systems) may help us to understand, or rather may contribute to support the multidisciplinary effort to understand human society, obviously in addition to constituting the necessary starting point for any intervention aimed at the safeguarding of this precious heritage.

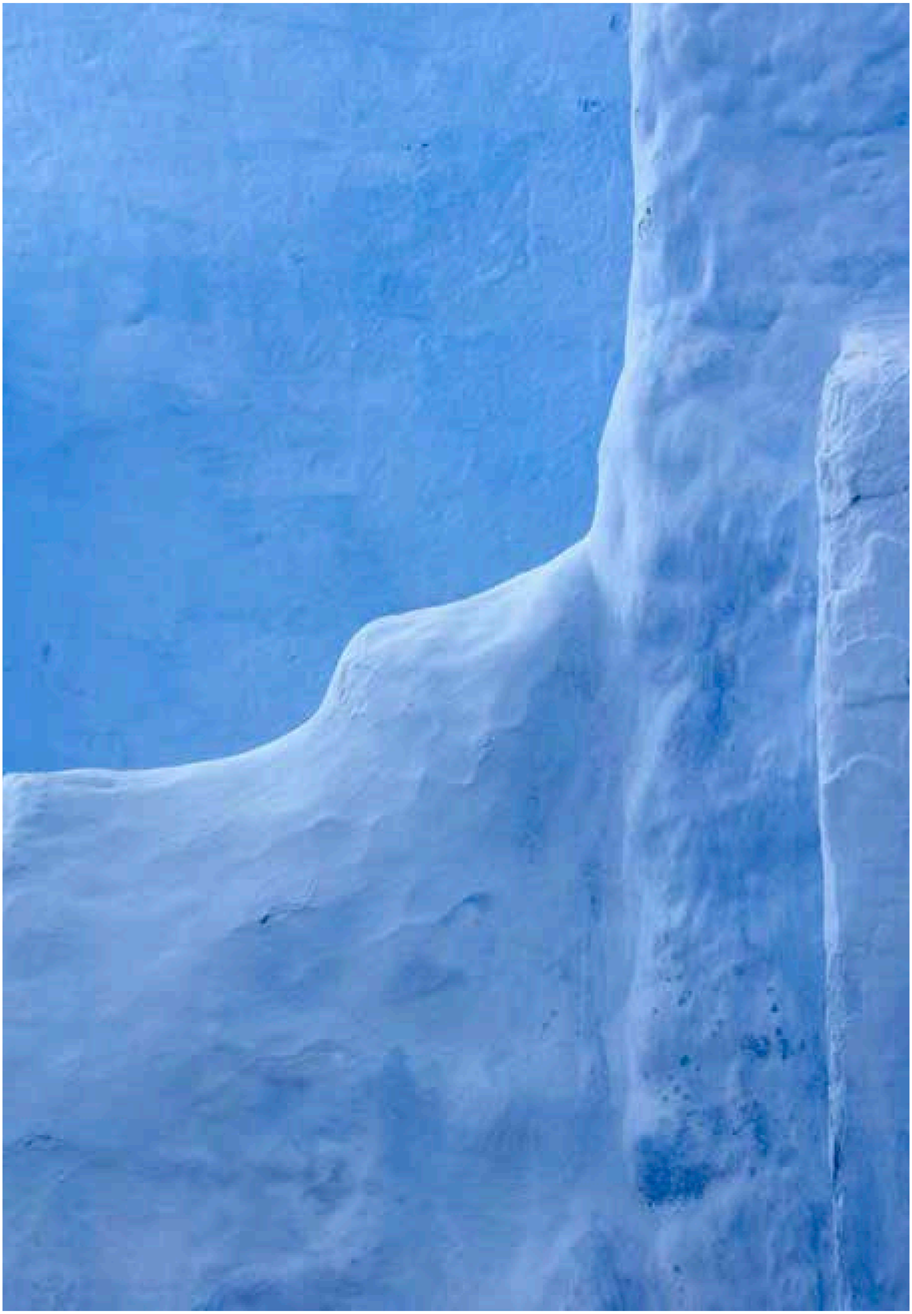
The case of Chefchaouen is paradigmatic.

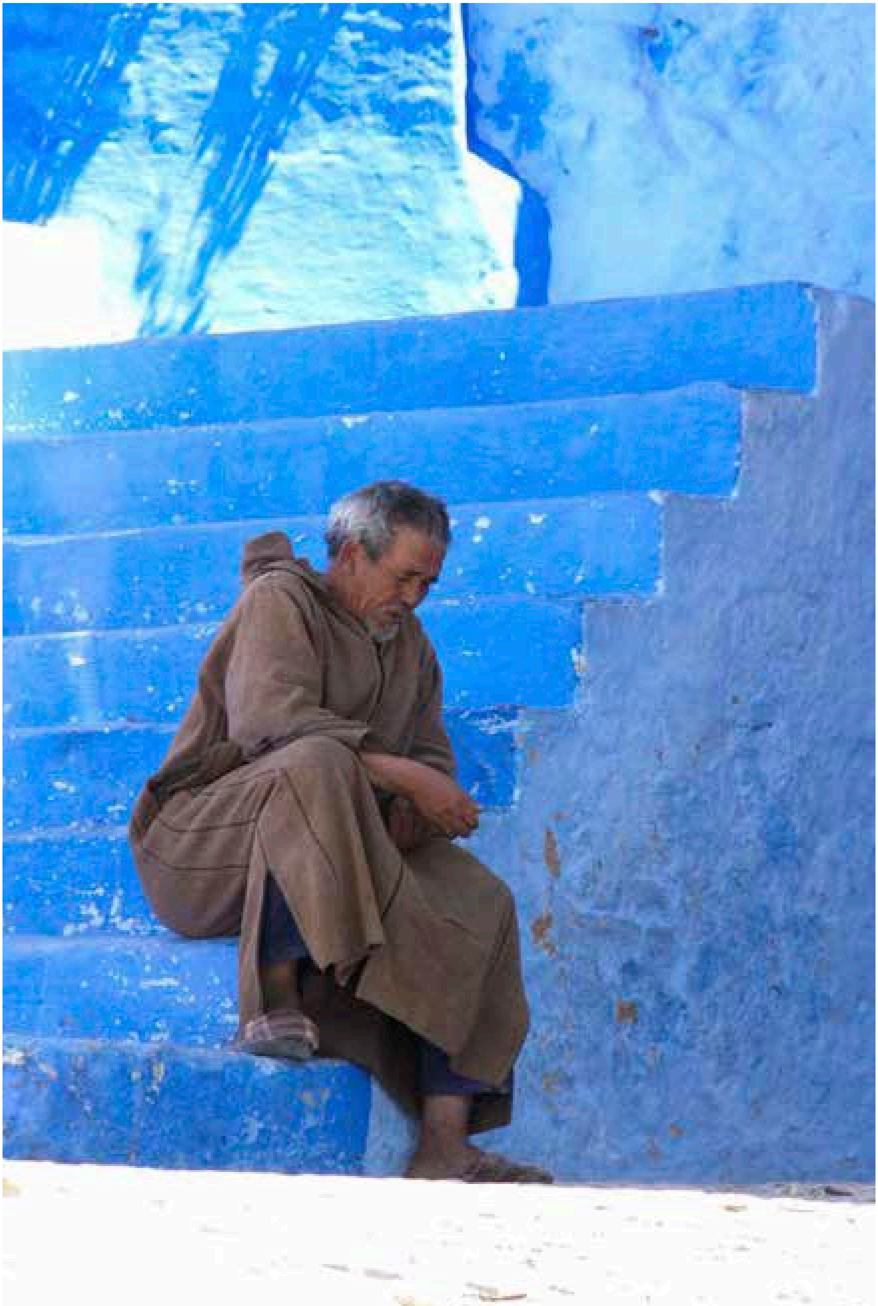
A population that was escaping, during the late 15th century, from the territories in the Iberian peninsula where Islamic Caliphates had shone for centuries, crossed the strait of Gibraltar and settled for the most part in the mountains of the Rif. Two cultures blended together in the building of a society and of a city: the rougher, autochthonous "Berber" component (which had already built a defensive system in that place, the *kasbah*) and the refined expression of the kingdom of Granada known as *al-Andalus*. It is from this fertile mix that the "pearl" of the Rif originated, yet it would be the result of a complex challenge.

Three elements appear as difficult to deal with in that context when attempting to establish a town that is both lasting and coherent with the beauty of the splendid neighbouring cities: the almost exclusive availability as building material of a stone which is relatively hard and therefore difficult to work with; the demands of life in a mountainous environment which is rainy and presents strong temperature variations; the frequent occurrence of earthquakes.

With scarce economic and technological resources available, the inhabitants of the Rif al-Andalus have invented for themselves a strategy for building the load-bearing walls of their houses which, despite the non-workability of the stone, creates walls and partitions with a mechanical behaviour that is compact and unitary even under heavy dynam-

[1] A. Giuffrè, A. (2010), Leggendo il libro delle antiche architetture. Saggi (C. Carocci and C. Tocci, eds.). Gangemi Editore.





Old inhabitant of the medina
(© L.Lupi, 2007)

ic action. The solution that they found consists in the construction of a sort of agglomerate in which a knowledgeable setting of the stones – careful to combine the various sizes and forms so as to form a well engaged framework, even with some "diatonic" elements – is associated to a plastic mixture that allows the irregular ashlars to be placed in an accommodating matrix in which the roughness can be smoothed out. This mixture is made of earth and lime; yet its reliability as cohesive element of the system, necessary for permitting a homogeneous transfer of the loads to the ground, is entirely entrusted to the capacity of the matrix to remain malleable; it must not be altered or weakened by rain or snow, nor by the strong Summer sun. This is why it is necessary to protect this device with a sort of "protective mantle" made with a thick layer of lime which ensures a constant level of humidity for the underlying wall. Yet the system, which is fragile overall, does not tolerate significant alterations or damages, or any decay which would immediately generate a crisis: this is why it is essential to regularly provide maintenance to the mantle, and to periodically restore it. And as in many places throughout the planet, this need becomes an occasion for social cohesion and cultural expression.

Every year the whole town will take part in the maintenance works, turning them into an occasion for celebration, a search for identity, an opportunity to compete in the placement of those incredible brush-strokes of indigo on the walls of houses; it is in this way that Chefchaouen dresses in that amazing symphony of variations of blue that we have come to know.

How can one forget the assault of hundreds of young men who in Spring climb the walls of the Friday Mosque in Djennè (Mali), the largest raw-earth Mosque in Africa, in order to compete in the replacement of the plaster and the restoration of its damaged parts?

When the relationship with the environment is guided by choices that result from the ingenuity of a collective, the social dimension – human history shows us – becomes dominant and charges with meaning also the technical and architectural solutions, transforming them into symbols or images. The involvement of entire populations is also at the basis of the invention of the *foggara*, which is the name given in the Algerian Sahara to the long tunnels excavated for ensuring the supply of water in arid places (they are known as *khettara* in Morocco, *qanat* in Persia, where they were invented, and are present everywhere from Central Asia to China). In conclusion, the slow process that results in the definition of *tacit knowledge* in societies is always a collective and shared process.

Building cultures are an essential part of this formidable deposit of knowledge. We are used to recognise them in evolved cultural systems, where written treatises prevail, yet these are only the last stage in a knowledge path that began to develop in rural and marginal contexts (those typical of our origins). Since the construction of a settlement using only traditional materials depends entirely of the places and is conditioned by them, the knowledge of the thousands of languages spoken "spontaneously" by peoples for building their own dwellings is especially valuable. These cultures safeguard a precious archive of competencies, they tell us about solutions for facing the heat and the cold, for addressing issues concerning water and aridity, for constructing shells that are stable, yet pleasing. Building cultures are a "book" that is full of teachings on how to do what the Latins called *struere*, which in its first acceptation refers to "arranging by layers, placing an element above another", in other words to how a wall is built. It may seem strange, but also the world of structures owes a lot to these pre-modern precursors.

Just think of the devices (and Chefchaouen does not lack in examples) that the various cultures have produced all over the world for opposing seismic actions: methods for laying ashlars in the wall (even using a timber cage, as in the case of the *Kalà* of Elbasan in Albania), joining elements between walls, static schemes, both massive and light, the *Gaiola* or the *baraccata* houses, the Peruvian *quincha*, or the very "modern" idea of seismic isolation (the use of gravel or sand under the palace of Knossos in Crete, the cylindrical wooden trunks above the capitals in the Palace of the Dey in Ottoman Algiers).

The process of construction of a building culture is slow and careful, it looks back at failures and selects the good results, accepts innovation and is a sort of still where the "key" concepts of each building methodology are distilled. It is in this context, which cannot be separated from the environment, that what Giuffré has called the "*regola dell'arte*", or good workmanship practices, was developed. It is a characteristic of every territory and represents a fundamental reference for any intervention strategy for safeguarding the historical and vernacular heritage, which must be efficient, mechanically and physically compatible and sustainable. Yet, since it is a tacit and widespread knowledge, it is intimately connected to the societies that safekeep it; for this reason, now that these societies are in danger of disappearing under the irresistible seduction of modernity (to which we undoubtedly owe great advances), it becomes arduous to maintain its precious precepts. Globalised technological culture represents the first serious menace to their existence; after all it is not simple to accept inevitable and radical changes in the lifestyle while preserving knowledge and ideas which were generated in remote times.

This is a task that we must take on.

We cannot give up so many valuable teachings. In the same way that we attempt to defend the languages and dialects spoken throughout the planet, the wide variety of these cultures represents an incredible wealth for the present times, a depository of knowledge and science. We must not forget that we can build with blocks of salt or only with gypsum, with raw earth, that cupolas can be made without supporting beams, that an architecture by subtraction can exist…

Clearly we often come to realise that there are weaknesses and errors, that the performance of the construction can be enhanced with a few simple devices; we understand, however, that this is where it all started, from the crucible of local diversity in which the many languages that make us human were generated.

And finally it is significant to discover how these languages have some constants; some are evidently the result of mechanical requirements (the laws of physics cannot be broken), but others are simply the result of the human intelligence that generated them.

The scenario toward which we must tend is that which understands the lessons of history. An alluring indication of this lies before our eyes as we wander through the medina and Chefchaouen, and it includes a splendid metaphor: it is contained in the apparently random repetition of arcades that connect the buildings on opposite sides of the streets. It is now a new image; our Mediaeval hamlets offer plenty of examples: we now discover it to be a feature of the Rif Al-Andalus and it expresses once more a search for structural solidarity and collaboration between all the buildings of the old city.

It is undoubtedly a fundamental device for providing protection from earthquakes, but it also carries an important suggestion of social ethics.

CONTINUITY, CHANGE AND CONTEMPORANEITY IN THE EVOLUTION OF THE ISLAMIC CITY

Raffaele Paloscia
Università degli Studi di Firenze

Cittadella, Sousse, Tunisia, 2018

Continuity[1]

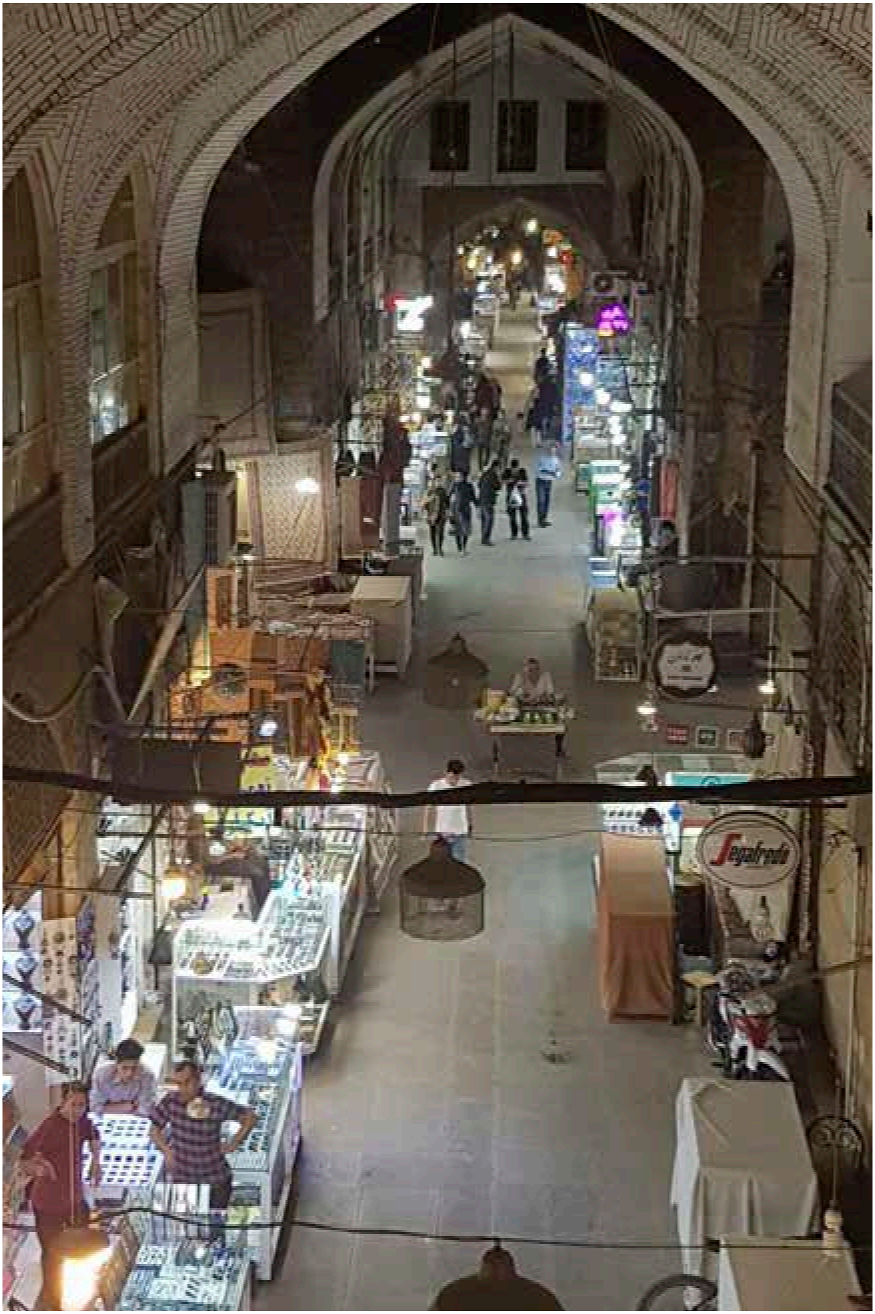
Heat and a pungent smell, intense and very close. A fearful and sudden movement in order to understand where they come from: the nearby mouth of a donkey, with a load of minute leather goods, waving its way with ease among the passersby on one of the narrow cobbled alleys of the *suq*. In front of him and behind him other animals pulling carts and wagons, bicycles and tricycles with surprising modifications, women, both veiled and not, more or less silent, tireless merchants shouting and inviting among old brass scales, fierce bargaining buyers, children of all ages, often with marked faces but always smiling and slipping away, minute tables for a more or less quick cup of tea, stalls and stands with fruit, vegetables, fabrics, sheep's meat and heads, bright-coloured locally manufactured leather objects, the same colours that can be seen in the round basins full of pigments, pride of the local manufacture, that can be glimpsed from nearby terraces; an out-of-season tourist, perplexed, unsure of his movements yet visibly satisfied.

A few years ago I was immersed in the captivating city of Fez, great centre for the diffusion of Islamic culture, imperial city *par excellence*, the most ancient of those in Morocco, whose multiplication was the result of the decision and superstition of rulers, fearful and determined to not reside in the realms and capitals that were those of their fathers (Cuneo, 1986). They have thus given us a polycentric urban system with a great cultural wealth, dense with architectural suggestions that are multifaceted in terms of place and period, as well as of building materials and techniques. This is a feature that is common not only to the Morocco of the ancient dynasties, but also to those settlements that were either founded or incorporated in those lands that were conquered and converted to Islam. The result is a morphological and symbolic thickening with widespread contamination and cultural syncretism, toward which the Muslim conquerors, especially in the most enlightened historical phases, showed a great aperture.

[1] The texts is an update and extension of a previous text by the author: *La città islamica. Tradizione, colonialismo e globalizzazione* (Mecca et al. , 2012).

FUP Best Practice in Scholarly Publishing (DOI 10.36253/fup_best_practice)

Bazar,
Isfahan, Iran,
2019



In most of the cities scattered throughout the immense Muslim territory – the world for Muhammad was a system of faraway cities connected by the caravan roads (Fusaro, 1982) – the availability of water in loco was the *conditio sine qua non* for an originary settlement. This is an availability that is linked to the presence of underground aquifers in the area in which the settlement was founded or, very often, to the great capacity, derived from daring and tested techniques handed down by Islamic tradition and locally interpreted in the most diverse ways yet coherent with the contexts of reference, to collect and convey water, often from great distances, through articulated systems such as *foggaras* or *khettaras*. These are terms which are used in Morocco and North Africa to indicate works of hydraulic engineering that consist in complex underground channels that originated in the very ancient Persian *qanats*, which conveyed water obtained in areas at higher elevations toward lower places and which can be recognised from the outside by the long rows of mounds of earth that result from the excavation of ventilation and maintenance shafts (De Cesaris et al., 2017). These are systems that were widespread throughout the centuries in the entire Islamic world, including Spain and Sicily, both for the irrigation of agricultural plains which otherwise would remain arid, and for supplying water to small and large settlements, from minute oases to great urban centres.

Within the compact fabric of cities the market, *suq* or *bazaar*, lies always as the founding and ordering element of the urban space. In its apparently chaotic pulsation, it underlies the strict and articulated rules of behaviour for the relationships between merchants, between merchants and clients, as well as the times and manners of usage of private and public spaces, which present variations in accordance with local traditions and serve as starting point for the evolution of the various types of architectures and urban fabrics: whether a market concentrated in an original central nucleus, extended and compact in its mostly covered streets, or else winding along narrow arteries, dense with small shops commonly distributed approximately in concentric circles and specialised in all sorts of products.

The structure of the buildings and the covering of the alleys, which are of all sorts of types, but also frequently made only with wooden panels and rush mats, more or less worn-out, is such that in addition to the habitual users of the place, only the most attentive observers are capable of identifying, along the commercial pathways in the midst of the flow of goods, moneys, sellers and buyers, the entrances of buildings with often monumental features of great architectural value and with varying functions, both religious and civil. The sacred and the profane interweave in an alternation, on the one hand, of mosques with their minarets and other places linked to them, such as the *hammam*, devoted to personal hygiene and social interaction, as well as *madrase* where Quranic education can reach the university level, and on the other of hospitals, military and government buildings and other service-related

Caravanserraglio,
Kashan, Iran, 2019

opposite page
Wind Catcher Tower
Yadz, Iran, 2019

structures. Among them stand out in terms of size the *fonduk* and urban caravanserais for lodging merchants, buyers and tourists, or recently adapted for commercial activities and craftsman workshops.

The central section of the urban space – with the exceptions, however numerous and widespread, of the presence of a fortified citadel or of the great Friday mosque with its many minarets – is not structured therefore on the basis of a localised hierarchy but rather incorporates everything in the tight sequence of often minute and modular "shops, which are as burrows carved into the wall", as described by an enthralled Edmondo de Amicis during his voyage to Morocco at the end of the 19th century (de Amicis, 1882).

A curvilinear sequence, dense with interior connections, that only occasionally refers to the labyrinthine morphology of ancient residential areas. More distant areas where urban space progresses toward a conformation that little by little modulates its uses passing from the public or collective dimension, through a series of intermediate passages, to the narrowest blind alleys which traditionally belong to an almost exclusively private usage.

Nothing can be seen from the street of the interior structure of the residences, which are enclosed by continuous walls without openings other than the more or less finely deco-

rated front doors, and develop on the inside around a large interior courtyard, through which light penetrates the various family spaces and enters into that delicate micro-climatic balance that mitigates the strong heat during the day-time.

This complex settlement organism, with its various components, is enclosed by solid defensive walls with towers and turrets, gates of different sizes, often almost intact even today and rich with the traces of successive expansions and modifications undergone through time, frequently with interior subdivisions that delimit the various neighbourhoods along ethnic and religious lines.

These fortifications continue until the Citadel, which is also fortified and is the only place that is truly detached and isolated from the rest of the urban context.

Immediately outside the walls lie the other spaces that complete the cycle of life of the inhabitants. These include the cemeteries with their small tombs pointing toward Mecca which create modular shapes in an often shining white that in coastal cities – for example in Rabat – fill the gaps between the ancient bastions and the sea, thus generating suggestive and timeless landscapes.

Mosque
Old Delhi,
India, 2015

Mosque
Moschea,
Agia Sofia,
Istanbul,
Turkey, 2019

opposite page
Mosque
Touba, Senegal,
2012

Transformation

What has been outlined here, however briefly and approximately, refers to a morphological and functional structure and to an urban fabric which constitute the part – often already lesser in terms of built surface in the contemporary Islamic city – which is dense of memory, of religious symbolism and with a strong sense of belonging. It is the result of a process that unraveled throughout the centuries, without traumatic breaks to the urban image, at least immediately perceptible as a consequence of the passage of time, which mends with ease the various passages and transformations the more we go far back in time to distant ages. A process that is also the direct expression, through the built forms, of specific types of government, of dwelling and of collective life as conveyed by the communities in question.

Many urban centres underwent the first clear break with the arrival of the colonial era and with the transposition, in construction, as well as in urban expansion and transformation, of the European models that were predominant in the various colonising countries. Models that were completely alien to Islamic culture and tradition even though, in those more enlightened cases, applied with a certain respect, mixed with fear, derived from the strong and proud cultural identity of the colonised population. This is one of the reasons why juxtaposition and separation were preferred to demolition and superimposition when developing the new sections of cities built with the use of predetermined urban development plans, not damaging, or at least only partially, most of the ancient settlements of great historical and architectural value.

Between the late 19th century and the early 20th century, and especially in the areas of French domination, orthogonal urban grids based on predefined spatial hierarchies became widespread. These included large blocks of buildings, long streets, some of which *boulevards*, with rows of administrative, commercial and service buildings that established linear elements which connected potential functional poles. In other cases, especially in areas under British influence and in immediately subsequent periods, new expansions or the remodeling of low-density areas became widespread. These included urban areas that were increasingly planned according to a rationalist zoning model or, more rarely, to less dense and curved patterns, derived from the Howardian model of the garden city.

The social categories to which these new settlement areas were destined, which were planned and had building standards with a quality similar to those existing in Europe, were the European residents and those few local westernised upper-classes that had abandoned the old historic centres leaving them to decay and to the lower classes.

Contemporaneity

During the progressive affirmation over the past few decades of globalised models at various scales, the gap widened, also in the Islamic world, between a wealth that is concentrated in small élites and an increasing urban poverty. Witness to this is the imposition of the symbolic representation of luxury which lacks awareness and care for the environment and for the local culture and is a far cry from the rich and majestic residences of Islamic rulers, compounds of traditional yet innovative culture. Its undisputed icons, patronised by social classes of rich *parvenus* wandering in places invented by global finance and tourism, are the macro-protuberances stolen from the sea in the Persian Gulf, especially in Dubai, mythical realm of a globalisation without time or place, whose fictional link to Islamic tradition is entrusted to the aerial image of its *arabesque* and palm-shaped layout.

In parallel to this, the urban poor increase progressively, escaping from a de-structured and impoverished agricultural sector and from a pervasive desertification, in search of a better life in the large metropolises where they crowd themselves in those areas adjacent to the formal built system which are not desireable, due to their location or to the features of the terrain, for other uses. In these areas a minute, yet very dense and swift building process takes place, with all sorts of makeshift building types made of poor materials and débris. The *bidonvilles* or *slums* – which at a global level reach a billion inhabitants, that is one eighth of the planet's population2 - lead their progressive path toward an increasingly unrestrained land occupation which produces phenomena of urban dilation that reach levels that had previously been absolutely unimaginable. As for example with Cairo, the largest of Islamic capitals, which with its over 20 million residents for years now has constantly occupied the second place in the world in terms of the number of inhabitants, although international demographic statistics in this respect are somewhat uncertain.

Yet surprisingly, it is precisely in these settlements, whose image at a distance seems out of focus, chaotic and lacking in any identity, that the Islamic city seems to restitch some of the links that had been considered irreparably broken with the ancient culture and tradition that preceded it.

The historical and architectural heritage of the great historic centres, in fact, although capable of opposing resistance thanks to the force of the cultural and social traditions that produced them, were however affected by decay, extremely high dwelling density and exogenous, inappropriate and homogenising intervention technologies. At the same time, in the more distant areas of the informal city, of spontaneous and uncontrolled building, certain forms of use of the urban space, as well as architectural traits and symbolic features appear which are derived in a more or less direct way from the sediments of the centuries-old Islamic settlements (La Greca, 1996; Paloscia et al. 2010; Bertagnini & Morbidoni, 2012).

In these contexts of consolidated informality, the urban street remains the main stage in which the residents carry out the cultural and behavioural patterns that characterise the local community and where the conflict between the forms and functions of contemporaneity and the uses, symbols and meanings derived from tradition are more strongly manifested (Mennat-Allah, 2019).

These are dynamics of conflict which are also potentially fertile with positive outcomes for satisfying the needs of the inhabitants. However, unlike in the historical eras to which we relate the slow sedimentation of the idea of the Islamic city in a plurality of original settlement structures, the appearance of two disruptive elements is to be considered decisive today (Morbidoni, 2014): the unprecedented and dramatic temporal acceleration of the processes of generation and transformation of the new urban fabrics and the unbridgeable disparity at all levels between the capacity of intervention of the various actors involved, the most powerful of which, in their opposition to fragile and impoverished urban areas, appear increasing-

[2] UN-Habitat, Slum Almanac 2015-2016, UNON, Nairobi, 2017.

ly alien to the contexts and to their dwelling cultures, more globalised and technologically predominant.
It is in the unforeseen manner that the resolution of this relationship will assume that we may perhaps define and recognise in the future as the "Islamic city". An open issue that is to be analysed and debated in order to monitor its processes, modes and evolutionary potential.

References

Cuneo P. 1986, *Storia dell'Urbanistica. Il mondo islamico, Laterza, Bari.*

Fusaro F. *1982, La città islamica, Laterza, Bari.*

De Cesaris A., Di Giorgio G., Ferretti L. V. 2017, *Attraverso l'Iran. Città, architetture, paesaggi*, Manfredi, Roma.

De Amicis E. 1882, *Marocco*, Fratelli Treves editori, Milano.

La Greca P. 1996, *Il Cairo. Una metropoli in transizione*, Officina Edizioni, Roma.

Paloscia R., Bertagnini E., Morbidoni M. 2010, *Genesi della città informale nei contesti arabo-islamici. Il caso del Cairo in Archivio per l'Antropologia e la Etnologia vol. CXL.*

Bertagnini E., Morbidoni M. 2012, *Informality and tradition in the Islamic metropolis: the Cairo case* in M. Alaa Mandour, Y. Eka Putrie (eds.) 2012, *Contemporary Architecture of Islamic Societies: Between Globalization and Traditions*, UIN-MALIKI Press, Malang.

Mennat-Allah E. H. 2019, *Cairo's Livable Streets*, Conference proceeding *ArchCairo* 8: *Building the Future Now: Rights to Better Living*, Architecture & Contexts, Il Cairo. .

Morbidoni M. 2014, *Informalità e tradizioni insediative mediterranee. Percorsi evolutivi della 'città senza progetto'*, in Frediani, F. (ed.), *The Mediterranean Cities between myth and reality*, Nerbini Helvetia, Firenze.

opposite page
Walls – Cemetery
Fez, Morocco, 2011

Stairs in a courtyard house (© L.Lupi, 2007)

Local and traditional knowledge systems

In a given society, the existence of a local culture implies the successful elaboration of a process of awareness and sedimentation of diffused knowledge. The word "knowledge" implies the dynamic act of learning, building something that does not exist a priori but that can be grasped in its making. It is a shared opinion that knowledge can be classified into two major systems: scientific, academic and generalizable knowledge, on the one hand, and non-academic, practical and contextualised knowledge, the so-called local knowledge, on the other. In the introduction to the paper "Indigenous knowledge and implications for the sustainable development agenda" published by UNESCO, traditional knowledge is described in the following manner:

> Indigenous, traditional or local knowledge refers to the knowledge and know-how unique to a given society or culture, which encompasses the cultural traditions, values, beliefs, and worldviews of local people, including specific beliefs, rules and taboos that are part of the customary law of a specific group. Indigenous knowledge is therefore vital for the survival of the historical and cultural heritage of a particular group as it forms its backbone of social, economic, scientific and technological identity (Magni, 2016, p. 5).

In other words local or Indigenous knowledge represents the accumulated experience, wisdom and know-how unique to cultures, societies, and for communities of people, which have evolved over many generations within their particular ecosystem, and define the social and natural relationships with their environments. These sets of understandings and meanings are part of a cultural complex that encompasses language, naming and classification systems, practices for using resources, ritual, spirituality and worldview. It provides the basis for local-level decision-making about many fundamental aspects of day-to-day life (Emery, 2000; Boven and Morohashi, 2002). Today the concept of traditional and local knowledge is applied in various fields of study and research, assuming specific terms based on the reference area: Indigenous Knowledge (IK), Indigenous knowledge systems (IKS), Traditional Ecological Knowledge (TEK), traditional knowledge, ethnobiology, ethnobotany, ethnoscience,

FUP Best Practice in Scholarly Publishing (DOI 10.36253/fup_best_practice)

Entrance to a textile workshop
(© L.Lupi, 2007)

vernacular architecture, material knowledge, local knowledge, etc. Human knowledge in fact covers all aspects of human life such as: the notions on the origin of the cosmos, characteristics of territories, ancestral relations, food and health systems, its institutions, skills and resources, its experiences and history, how to react to disaster and changing conditions, in all their dimensions, social, natural and spiritual, and at all levels: individual, family, community, society, world and cosmos.

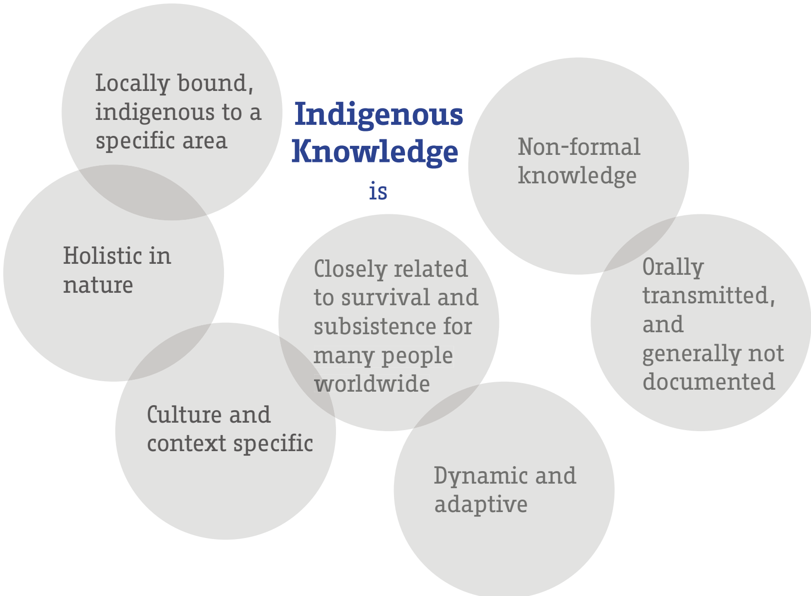
Academic studies on local and indigenous technical knowledge dates back to the 60s, but in recent decades the possibility of using such knowledge as basis for development is more and more shared and discussed (Emery, 2000; Tharakan, 2015; Boven & Morojashi, 2002). The recent spread of interest in this field may be attributed to a number of factors: surely the energy crisis, climate change and the incidence of largely man-made ecological disasters have brought an increase of interest towards strategies seeking to promote low technology and local resources.

The management of ecosystems for survival and well-being has been pursued actively by traditional communities over generations. Management includes production activities such as agriculture, food (from agricultural activities and prey), services for health and maintenance, regulation and adaptation activities such as water management and of course, habitat models. Throughout history, traditional communities have also devised ways and measures to adapt to environmental and socio-economic changes; hence, such knowledge systems have been constantly evolving, adapting to changing circumstances and realities, and contributing at the same time to ecological resilience.

Over the last hundred years, while the global economy has increased, in terms of industrial output and services, it has also resulted in a decline in the diversity of cultures and use of traditional ways of managing natural resources (Subramanian & Pisupati, 2010). While it is true that today there are many initiatives that address the conservation of cultural diversity, there is certainly a need to develop appropriate methodologies to understand and assess indigenous knowledge, as we move to better integration between the two streams of knowledge, modern and traditional.

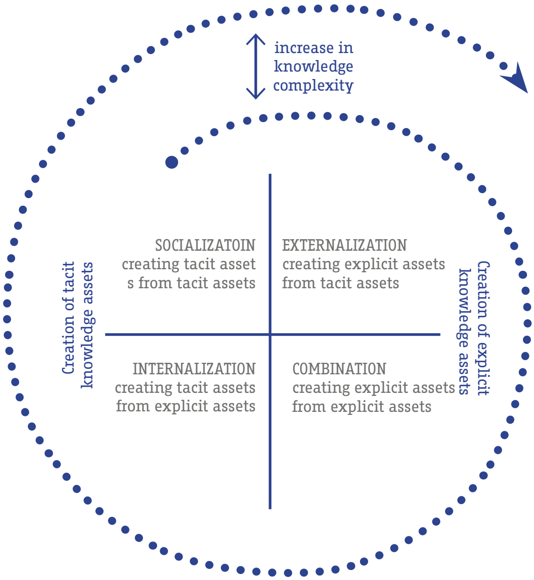
Knowledge, in its Western-scientific meaning, is distinguished from indigenous-local knowledge by its aim of universality and objectivity. The first is in fact systematised in written records and reproducible experiments, and this allows it to reach a much wider diffusion than local knowledge. Whereas scientific knowledge is conceived as an abstract entity independent from practice, indigenous knowledge also includes know-how, the empirical, the sacred and intuitive. Indigenous or local knowledge is generally tested over a long period of time and reinforced by trial and error. Local knowledge dynamically uses communication chan-

Indigenous knowledge characteristics adapted from: Boven K., Morohashi J. (eds.) 2002, p.13



opposite page **SECI Model of Dynamic Knowledge Creation.** Adapted from: (Nonaka, 1994)

nels that are not necessarily structured, such as oral communication or direct observation, from generation to generation, and is therefore seldom documented. This type of knowledge includes the entire cultural context in an interdisciplinary way, in fact the population of a place thinks and manages its natural context as a complete system where the various components interact with each other (Warren 1992; Tharakan, 2015).
In any case, scientific and local knowledge are not mutually exclusive. Indeed, it can be said that indigenous knowledge is almost always accompanied by scientific-experimental activities and it is distinguished only by a practical orientation, a close link with experience and a full insertion into the cultural context.
With the advent of modernity and the industrial revolution, communities characterised by a system of relationships based on local knowledge have undergone an inevitable evolution. The change in the systems of relationship has produced a change in the habits and customs that governed them. In the generational succession, many of the principles of traditional communities have been lost or have been deliberately abandoned. These include the living model and traditional building systems. With the introduction of new materials and technologies, the construction habits handed down from father to son for generations, linked to the now decayed community, have been lost. In the many cases in which new technologies have not been received with the technical rigour they require,



the advent of modernity and the need for change in society have left these communities vulnerable to those disastrous events of nature, which for centuries they had been able to face.

Knowledge construction processes: from general to local, from tacit knowledge to codified knowledge.

Ikujiro Nonaka (1994) distinguishes tacit knowledge, which is difficult to formalise and communicate, from explicit knowledge, in other words knowledge which is transmissible through a formal and codified language.

Tacit knowledge presents a content that is deeply rooted in an individual's actions and thoughts in a specific context; it will therefore be made up partly of technical skills and partly of mental models, beliefs and perspectives which have become so settled that they are taken for granted and cannot be easily expressed. Explicit knowledge, on the other hand, is connoted in order to be easily expressed, captured, stored and reused, to be transmitted by databases, books, manuals and messages.

However, tacit and explicit knowledge are not separate entities, but rather interact in a mutually complementary manner in the cognitive activities of human beings. Nonaka and Takeuchi, in the essay entitled "The Knowledge Creating Company" (1995), define the interaction between these two types of knowledge as a complex process that is divided into four phases:

General versus local dimension and the codified versus tacit dimension (Stiglitz, 1999, p. 13)

	Codified Knowledge	Tacit Knowledge
General Knowledge	Global public goods. Generally applicable and "downloadable," i. e., can be transferred by conventional vertical teaching methods--but "rediscovery" improves ownership.	General tacit knowledge (e. g., implicit grammatical rules of English) could be learned by horizontal methods (e. g., natural language learning) or might be (partly) codified and taught.
Local Knowledge	Localized explicit knowledge. Even if hypothetically available from center, should be locally "reinvented" to have ownership.	"The hard stuff. " Combines horizontal learning and local reinvention.

1. *socialisation*: transfer of tacit knowledge between individuals through observation, imitation and experience (from tacit to tacit);
2. *externalisation*: conducted through dialogue or collective reflections, it is based on analogies or metaphors to translate tacit knowledge into documents or procedures (tacit knowledge become explicit);
3. *combination*: it is the consequent reconfiguration of the bodies of explicit knowledge through the classification, addition and organisation of processes, and their dissemination within the reference group;
4. *internalisation*: explicit knowledge translates into tacit knowledge in individuals (from explicit to tacit).

This process can be explained graphically through "Nonaka's spiral", which shows how this circular process leads to an effective growth of knowledge within an organisation or a social group. The methods through which the transfer of tacit local knowledge can take place are traditionally the so-called "horizontal" methods. They are strongly oriented to learning by doing, through twinning, apprenticeship, travel, imitation, and mutual training between different experts. "Vertical" tools are used instead when the knowledge is encoded, in other words when it can be deposited in physical or digital archives, as well as in libraries (paper or electronic) and made accessible. Vertical methods are those commonly used in teaching lessons where the process of learning takes place following a hierarchical relationship, with well-defined roles.

The critical nodes of development based on local knowledge are found in the transition from one dimension of knowledge to another, dimensions that are well outlined in the scheme developed by Stiglitz (1999):

Summarising, the main phases that can make an important contribution to social learning processes through the codification and enhancement of knowledge, are:

- a first phase of knowledge acquisition that develops simultaneously on two levels: on the one hand the critical acquisition of knowledge coming from the outside but adapted to the context, and on the other the local creation of knowledge through knowledge-based research and development programs which are indigenous;
- a second phase of knowledge absorption, through the development of good continuing education programs;
- a last phase of communication that presents itself as intrinsically critical since it is based on the need to know how to exploit new communication technologies to one's advantage.

Vernacular heritage and its value for cultural biodiversity

For decades now, following the awareness of the effects of cultural homogenisation caused by the processes of globalisation, the interest in enhancing the "local" has led to the development of studies and research on architecture internationally recognised as "vernacular" or traditional but also in many contexts of "spontaneous", "widespread", or "popular" architecture. The acceleration of industrialisation phenomena has in fact determined a progressive introduction of standardised urban, architectural and technological solutions, which have replaced traditional models, gradually causing a loss of the link between territory, environment, and the socio-cultural context. Paul Oliver, who published the Encyclopedia of Vernacular Architecture, the first to show the remarkable diversity of the buildings constructed and lived in by the people of over a thousand cultures, thus defines vernacular architecture:

> Vernacular architecture comprises the dwellings and other buildings of the people. Related to their environmental contexts and available resources, they are customarily owner- or community-built, utilising traditional technologies. All forms of vernacular architecture are built to meet specific needs, accommodating the values, economies and ways of living of the cultures that produce them (Oliver, 1997, p. xxiii).

The different forms and types of local construction are therefore determined by socio-cultural factors, as well as by the climatic and environmental conditions and by material and technical limitations.

Local materials and building techniques, acquired both from endogenous evolutionary processes or borrowed from other cultural influence, are used to meet the physical and socio-economic needs of a group, generating remarkable architectural models (building techniques, urban morphologies, building types, patterns, etc.) that have been adapted to the his-

Ksar, Draa Valley, Morocco

opposite page **Trulli,** Apulia, Italy

torical-cultural background and the specific environmental constraints of each territory. The variety of architectural models reflects the diversity of ecosystems and the economic and social structures of the groups. Within this architecture there is room for both the humblest models of workers' homes and the large houses of the ruling bourgeoisie, as they reflect the entire social and economic structure. It is therefore evident that speaking of vernacular architecture and local knowledge means considering an incredibly vast variety of structures and systems, so much so as to recall the biodiversity of living beings. In fact vernacular architecture shows us the various, distinctive and often beautiful and ingenious ways in which people, throughout the world and over time, have imagined, designed, used and maintained their built environments (Vellinga, 2015). Understanding, respecting and accepting the local values of heritage implies understanding, respect and acceptance of a diversity of identities. Cultural heritage and its diversity plays a fundamental role in fostering strong communities, supporting the physical and spiritual well-being of its individuals and promoting social cohesion. Respect for diversity is important in cultural and political terms, but it also has economic and social value. The policies for valorising the local culture can ensure important beneifts for human development, since both the conditions for investment and resources already exist in place and do not need to be imported. In UNESCO and UNDP documents the term "cultural biodiversity" is often used when it comes to indigenous or traditional knowledge, and the

motivations for protecting the m are not dissimilar from those in the ecological and ecosystemic field. “Indigenous knowledge and biodiversity are complementary phenomena essential to human development. [...]. Very little of this knowledge has been recorded, yet it represents an immensely valuable data base that provides humankind with insights on how numerous communities have interacted with their changing environment” (Warren, 1992). This statement by Michael Warren refers to technical knowledge in the world of agriculture, but the discourse can be extended to other domains as well.

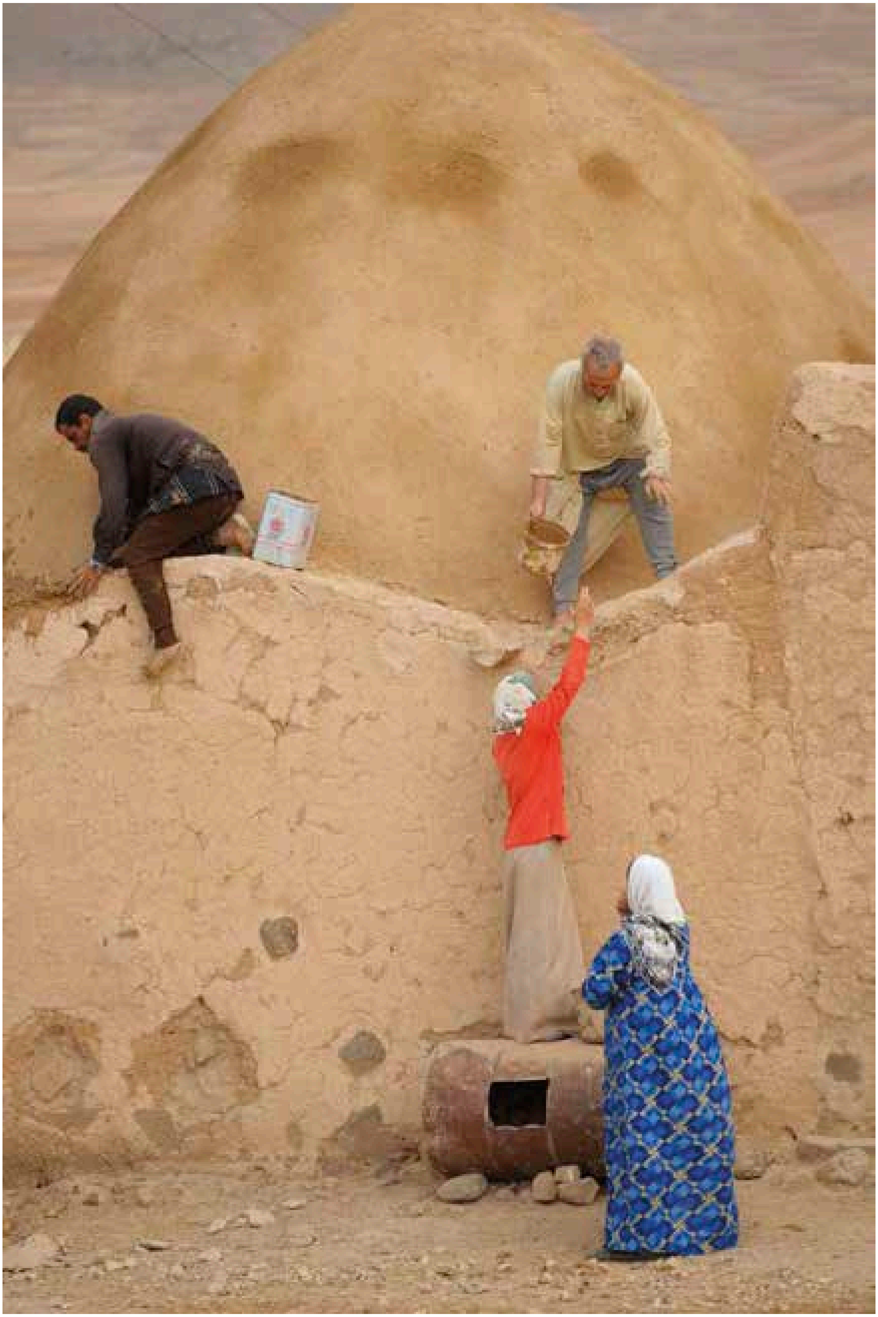
Point 14 of the Action Plan of the Universal Declaration on Cultural Diversity (2001), which was adopted by UNESCO’s 31st General Conference, encourages cooperation between Member States for “respecting and protecting traditional knowledge, in particular that of indigenous peoples; recognizing the contribution of traditional knowledge, particularly with regard to environmental protection and the management of natural resources, and fostering synergies between modern science and local knowledge”.

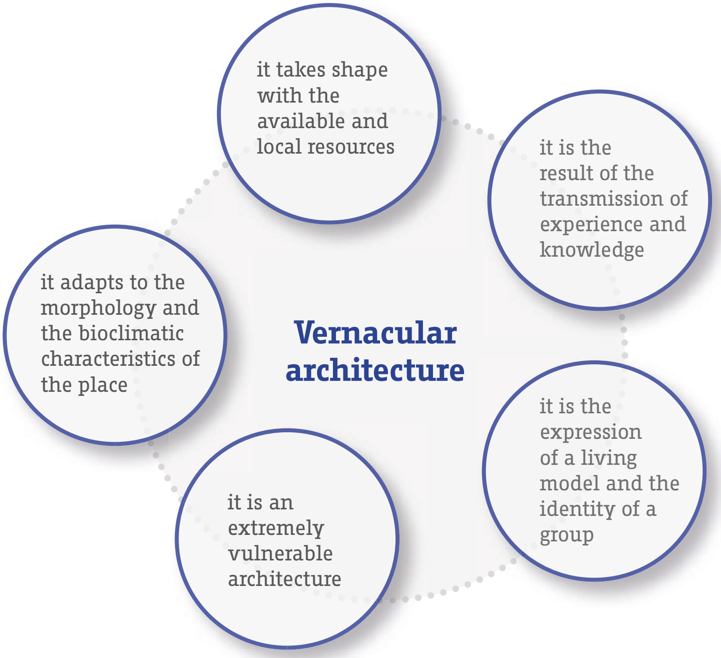
While maintaining specific characteristics linked to the place and culture of reference, traditional or vernacular architecture shares universal elements, common to all territories and all societies. In particular:

- it takes shape with the available and local resources, combining them in different ways based on the socio-economic and cultural background and the needs to protect the territory from the climate and environmental risks.

Syrian corbelled domes
Aleppo region, Syria
(©L.Lupi,2009)

opposite page
Some of the vernacular architecture characteristics





- it adapts strongly to the morphology and the bioclimatic characteristics of the place. It stands out for its respect for the environment and the nature of the place, which it knows how to exploit to its advantage: sun, winds, soil, water are elements that are an integral part of the architecture.
- it is the result of the transmission of experience and knowledge, which has evolved according to a process of experimentation, through trial and error.
- it is the expression of a living model and the identity of a group; the way of life takes shape through typological models, the use of symbols and decorative elements that constitute the cultural identity of the society that inhabits them.
- it is at the same time an extremely vulnerable architecture as any changes or transformation (natural, climatic, social or cultural), can easily trigger serious problems of deterioration, speed up its functional obsolescence, social discredit and poor valorisation.

Therefore, given the universal nature of vernacular architecture, various international organisations have requested the protection and recognition of this heritage as a cultural asset and international "value". The recognition of its value is linked to the process of evolution of the concept of cultural heritage, which at first focused on monuments yet over the decades has extended to various forms of both tangible and intangible representations of cultural identity. In 1965 the *Venice Charter*, adopted by ICOMOS, requested international recognition for

the first time of the value of traditional architecture as opposed to monumental architecture, and urged that this heritage be made comparable, in its cultural meanings, to historical monuments.

In 1972 the General Conference of UNESCO adopted the Convention concerning the Protection of the World Cultural and Natural Heritage. This Convention recognised as heritage not only a few monumental assets of exceptional value, but also a wider range of both natural and cultural sites. UNESCO defines cultural heritage as "the legacy of physical artifacts and intangible attributes of a group or society that are inherited from past generations, maintained in the present and bestowed for the benefit of future generations" ("Tangible Cultural Heritage," n. d., para. 1).

The *European Charter of the Architectural Heritage*, adopted by the Council of Europe in 1975, includes the need to preserve a constituted heritage "not only of our most important monuments: it also includes the groups of lesser buildings in our old towns and characteristic villages in their natural or manmade settings". Its value is justified as an "expression of history and helps us to understand the relevance of the past to contemporary life".

In 1992 the *World Heritage Convention* adopted the first international instrument to recognise and protect cultural landscapes. The Committee acknowledged that cultural landscapes represent the "combined works of nature and humankind, they express a long and intimate relationship between peoples and their natural environment", thus including a large part of the vernacular and rural heritage.

Furthermore, the *Nara Document on Authenticity* (1994) acknowledges that "judgements about values attributed to cultural heritage, as well as the credibility of related information sources, may differ from culture to culture, and even within the same culture. [The] respect due to all cultures requires that heritage properties must be considered and judged primarily within the cultural contexts to which they belong".

In 1999, during the 12th General Assembly of ICOMOS in Mexico, the *Charter on the Built Vernacular Heritage* was ratified. In this chart the Vernacular heritage is described as "the traditional and natural way by which communities house themselves", and as "a continuing process including necessary changes and continuous adaptation as a response to social and environmental constraints".

The interest of this charter, in addition to the definition it gives of vernacular architecture and the recommendations it provides for its conservation, lies in considering this heritage as a key element for sustainable development and expression of the cultural identity of a community: "the built vernacular heritage is important; it is the fundamental expression of the culture of a community, of its relationship with its territory and, at the same time, the expression of the world's cultural diversity". Moreover it declares: "The built vernacular heritage occupies a central place in the affection and pride of all peoples. It has been accepted as a characteristic and attractive product of society. It appears informal, but nevertheless orderly. It is utilitarian and at the same time possesses interest and beauty. It is a focus of contemporary life and at the same time a record of the history of society. Although it is the work of man it is also the creation of time. It would be unworthy of the heritage of man if care were not taken to conserve these traditional harmonies which constitute the core of man's own existence" (ICOMOS, 1999, p.1).

Another fundamental step for the codification of the concept of heritage was the UNESCO Convention for the Safeguarding of Intangible Cultural Heritage, which is defined as the ensemble of all "the practices, representations, expressions, knowledge, skills – as well as the instruments, objects, artefacts and cultural spaces associated therewith – that communities, groups and, in some cases, individuals recognize as part of their cultural heritage. This intangible cultural heritage, transmitted from generation to generation, is constantly recreated by communities and groups in response to their environment, their interaction with nature and their history, and provides them with a sense of identity and continuity, thus promoting respect for cultural diversity and human creativity"(UNESCO, 2003).

opposite page
Medina of Fez,
Morocco

Medinas: the core of Moroccan Cultural heritage

Morocco, a country of about 30 million inhabitants, with a rich and centuries-old history, is endowed with a cultural heritage characterised by great diversity and originality. A rich and diversified tangible heritage, consisting of 31 *medinas*, *Ksours*, *Kasbahs*, archaeological remains, colonial cities, monuments and historic buildings, as well as hundreds of scattered historic minor rural settlements, is accompanied by an equally rich intangible heritage, which includes traditions, know-how, cultural events, crafts and building knowledge. Among these elements of the heritage, the medinas occupy a special place since they still constitute inhabited spaces dense with tangible and intangible heritage.

> Medinas are the physical representation of social and cultural identities that are at the origin of the Arab world. As such, their significance for local, national, and international identities in the context of a globalizing world would seem very high, and their survival, which is threatened by the current trends of decay, would seem equally important (Bigio & Licciardi, 2010, p.2).

They are the result of the adaptability of Arab and Berber culture to the climate and local resources, to the social and productive organisation, to the coexistence of customs and traditions. As such, their significance in the context of a globalising world would seem very high, and their conservation and enhancement, which is threatened by the current trends of deeply transformation or decay, would seem equally important. Medinas are a source of pride and of collective belonging for the population at large, and exert great attraction for foreign visitors, providing sources of foreign revenues, opportunities for employment and job creation, tourism, and exports of handicrafts. The cultural value of the medinas is internationally undisputed, and seven of this unique set of historic cities in Morocco (Rabat, Tetouan, Fez, Essaouira, El-Jadida, Meknes and Marrakech) have found their international recognition with their inclusion in the UNESCO list of World Heritage Sites.
Until Maroccan independence in 1956, medinas, ksours and villages, often dating back to medieval times, constituted the place of residence for the majority of the population (which was 11. 6 million in 1960), given that the "new" urban settlements (*villes nouvelles*), created as of the beginning of the twentieth century by the French or Spanish

Protectorates, were reserved for European residents (Bigio and Licciardi, 2010). In the past 70 years, the urban landscape of Morocco has changed enormously, responding to the combined pressures of demographic growth (in 2020 the national population had reached almost 37 million), urbanisation, and the gradual modernisation of the national economy. The colonial urban settlements have become the cores of expanding modern towns, which have adopted European standards of land-use, urban planning, design of residential typologies, and service infrastructure. In parallel to this urban expansion, which has provided better modern-day surroundings and accommodations, Morocco has also experienced the growth of informal settlements, slums, and substandard housing in the peri-urban areas of its towns. Historic medinas, which have been founded as self-contained urban universes, generally encircled by defensive walls, complete with institutional, economic also social activities, have transformed from self- suf fi cient cities to central urban cores of much larger urban agglomerations. This has transformed their role, socio-economic organization and the pro fi le of medina users.

During the 1970s, following the awareness of international organisations (UNESCO, Icomos, World Bank) regarding the deplorable situation of most of the historical fabrics of the medinas, these institutions, in collaboration with the Moroccan ministerial departments (Culture, Interior, Housing and Urban Planning, Tourism, etc.) initiated a series of material, social and institutional actions aimed at curbing the deterioration processes of the medinas.

Restoration of walls and historical monuments, restoration of basic equipment and infrastructures, urban and landscape redevelopment, development plans and preservation of historical fabrics, recovery of buildings in a state of ruin, development of tourist circuits, promotion of craftsmanship, are among the many actions that have been taken to promote the image and attractiveness of these historic places (REMAM, 2018).

To date, however, the processes of deterioration and decay have not stopped, indeed, in addition to the phenomena of abandonment and decay, there are also improper transformations that jeopardize both the identity and integrity of the medinas. The knowledge necessary to maintain and preserve this amazing heritage is disappearing at an increasing pace. Raising awareness and sharing knowledge and the value and of the medinas can contribute to increase its significance, therefore contributing to its safeguarding.

Cultural heritage and sustainable development: an intertwined path

Cultural heritage tells the stories of the world's peoples and performs an irreplaceable role as a source of meaning and identity for communities and individuals. The material part of the cultural heritage, objects and sites, are evidence of human activities, perceptions, skills and ideas. At the same time intangibles such as knowledge, beliefs and value systems are fundamental aspects of heritage that have a powerful influence on people's daily choices and behaviours. Certainly, the architectural heritage and of the ensemble of intangible cultural expressions, knowledge and skills that define a community, are not a relic of the past, but are increasingly instrumental in steering sustainable development and the well-being of communities.

It is evident how the fast and recent changes in the global environment and within human society carry the potential risk of irreversibility and endangering the integrity of the human-environment system. In this context of changes, the potential of local knowledge, culture and heritage as elements for development has in recent decades gained the attention of scholars and policy makers. At the basis of this growing interest is the concept of development, no longer understood as the infinite pursuit of material and economic objectives, but as a process of change towards a continuous improvement of the human condition. The centrality of the human condition in development is already highlighted in the Brundtland Commission Report "Our Common Future" (1987), where the commonly accepted definition which is given to the concept of "sustainable development" is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs ". With this definition, the report underlines the need to go beyond the focus on physical sustainability to involve, instead, the great question of human equity, giving due importance to topics such as the human population, food security, species extinctions, energy, industry, and urban development.

Since 1987, the concept of sustainable development has had a long journey, characterised by extensive debates, congresses and conventions. Along this path, heritage has played a more or less important role in the mainstream sustainable development debate despite its crucial importance to societies and the wide acknowledgement of its great potential to contribute to social, economic and environmental goals.

The Political Declaration adopted by the 3rd UCLG (United Cities and Local Governments) World Congress in 2010 recognises culture as the fourth pillar of sustainable development and calls on cities and local governments around the world to develop strong cultural policies and to include a cultural dimension within all public policies.

From a political and institutional point of view, one of the most important events relating to environmental issues is certainly the United Nations Conference on Sustainable Development, held in Rio de Janeiro in 1992, also known as the Earth Summit. Within this Conference, the international community acknowledged the seriousness of the issues concerning the limits of growth and consequently outlined a comprehensive global action, signing two conventions (one on climate change, the other on the protection of biological diversity) and three declarations. These include the Rio Declaration, which points to the importance of heritage in steering sustainable development, and Agenda 21, a broad and articulated action programme in which operational criteria, objectives and reference strategies for sustainable development are established, a sort of manual that has guided the sustainable development of the planet for over 20 years.

On 25 September 2015, the United Nations General Assembly, following the Sustainable Development Summit held in New York, adopted the 2030 Agenda for Sustainable Development (Agenda 2030), included in a document entitled “Transforming our world: the 2030 Agenda for Sustainable Development“. It constitutes the new global development framework based on 17 Sustainable Development Goals (SDGs) divided into 169 objectives in the sectors of economy, social development and environmental protection.

Cultural aspects play a crucial role in the 2030 Agenda: it claims that cultural rights, heritage, diversity and creativity are central components of human and sustainable development. Policies responsive to cultural contexts can generate better, sustainable, inclusive and equitable development outcomes, and both the economic and social dimensions of poverty can be addressed through cultural heritage and cultural and creative industries (UNESCO, 2019).

The breadth of the heritage sector allows for meaningful connections with almost 17 SDGs. For instance, Goal 11, which advocates inclusive, safe, resilient and sustainable cities and

Thematic indicators for culture in the 2030 agenda (Unesco, 2019)

human settlements, SDG7 (Affordable and Clean Energy), SDG12 (Sustainable Consumption and Production Patterns) in reference to sustainable tourism, and SDG15 (Life on Land) have straightforward intersections with heritage.

Today it is a shared opinion that cultural heritage, through a variety of goods and services and as a storehouse of knowledge, can make a direct and significant contribution to sustainable development, intended as a development where each of the three pillars, environmental, economic and social – including intra and intergenerational equity - is given adequate consideration. At the same time, achieving sustainable development is a condition to guarantee the conservation of the heritage. Indeed, unsustainable development is perhaps the most significant threat to heritage conservation, both in developing and developed countries. The protection of heritage, as an attribute of natural and cultural diversity, plays a fundamental role in fostering strong communities, supporting the well-being of its individuals and promoting respectful development towards the environment, optimizing resources and reducing negative impacts on the territory.

Cultural heritage is also a powerful asset for inclusive economic development, by attracting investments and promoting locally based jobs related to a wide range of activities in areas such as tourism, conservation, construction, food production, traditional healing and the production of crafts of all kinds and the arts in general.

Finally, cultural heritage appears also to be closely connected to the fundamental components of an inclusive social development. As a vehicle to express values and identity, and organise communities and their relationships through its powerful symbolic and aesthetic dimensions, cultural heritage is essential to the spiritual well-being of people. The acknowledgement and conservation of the diversity of cultural heritage, fair access to it and equitable sharing of the benefits derived from its use enhance the feeling of place and belonging, mutual respect and sense of collective purpose, and ability to maintain a common good, which has the potential to contribute to the social cohesion of a community and reduce inequalities (UNISDR et al., 2013).

Vernacular architecture and sustainability

In recent years a specific interest in the sustainability of vernacular architecture has emerged. Vernacular architecture is a tangible and intangible cultural heritage with a highly sustainable value as it represents the history of settlement and adaptation to a given place, social and productive organisation, development of customs and traditions, etc. Many studies and publications have appeared that highlight the sustainable character of vernacular architecture, emphasising its ecological friendliness and appropriateness, as well as its environmental performance (e. g. Fathy, 1986, Frey and Bouchain, 2010; Weber and Yannas, 2013; Correia, Carlos and Rocha, 2014). Much of this recent work is aimed to assess the extent to which specific vernacular traditions are environmentally sustainable, evaluating the thermal properties of a building type or investigating the ways in which its layout, form and materials relate to local climatic and geographic conditions (Vellinga, 2015). Nonetheless, in order to be able to truly understand the relationship between vernacular architecture and sustainability, the social, economic, and cultural aspects of sustainability will need to be looked at as well.

Vernacular architecture is intricately related to its context and thus influenced by any changes that take place in or as a result of it. Changing weather patterns, the depletion of natural resources, changing energy demands, and so on, will have clear impacts on the sustainability of vernacular traditions. In the same way, cultural and economic changes, caused by processes of population growth or depopulation, conflict, changing ways of life, personal aspirations, migration, globalisation or rapid technological transformation may have a big impact on the sustainability of vernacular architecture (Vellinga, 2015).

The cultural sustainability of the vernacular habitats is frequently neglected and sometimes the practicality, cost and maintenance of these architectures outweigh their environmental qualities and performance. The decline of vernacular traditions is often ascribed to the strong influence of Western culture and modernity, which has influenced the replacement of traditional technologies with their modern equivalents, since it is seen to represent a more contemporary and progressive model of life (Foruzanmehr et al, 2011). Although this is to a great extent true, much more research from a cultural perspective needs to be carried out

opposite page
15 principles of sustainability of vernacular architecture according to the Versus wheel
(from: Correia et al. 2014b)

in order to fully comprehend the views and needs of the ultimate users. It is evident that there are two fundamental aspects in the current dialogue of the sustainability of vernacular traditions: cultural (which entails other issues such as economic factors) and environmental. It is the understanding of current environmental, social, cultural and economic conditions which will allow us to adapt the vernacular to suit modern needs and therefore use the principles for a more sustainable future.

The project The VerSus project. Lessons from Vernacular Heritage to Sustainable Architecture ", funded under the European Culture 2007-2013 programme, attempted to codify the principles and lessons of sustainability expressed by the vernacular heritage, and to define innovative strategies and models to integrate these principles both in the field of recovery and the new design of sustainable architectures.

The VerSus project was conducted from 2012 to 2014 by five university research groups[1], with extensive experience in the rehabilitation and enhancement of architectural and cultural heritage. The demand for sustainability to which the cultural heritage responds has been translated into 15 sustainability principles, 5 for each area (environmental, socio-economic, socio-cultural), summarized in the wheel shown on the previous page.

Environmental sustainability refers to the capacity of settlements to integrate with the environmental features of a place, limiting the negative impacts, including those related to climate change, and the recognition of the overall necessity to nurture territorial regeneration.

Socio- cultural sustainability is understood as the capacity to guarantee and reinforce the sense of belonging, the cultural diversity, the local knowledge and know-how, the personal and communal welfare, the recognition of cultural values (both tangible and intangible) and social cohesion. It tries to gather all the Social and Cultural positive impacts observable in vernacular solutions.

Socio- economic sustainability refers to the capacity of producing and maintaining within the region the maximum possible of added value, in order to guarantee social welfare.

The lessons we can learn from vernacular architecture in these three broads spheres are manifold, and can help us not only to further the conservation and retrieval of this architecture already in existence but to rethink new architectures in the light of the lessons of the past. In this creative learning process, acknowledging the appropriateness of vernac-

[1] ESG Escola Superior Gallaecia of Villa Nova de Cerveira (PT) as coordinator, INN-LINK-S Research Unit, University of Florence (IT), CRAterre-Ecole d'Architecture of Grenoble (FR), Università degli Studi di Cagliari (IT), Universitat Politècnica di València (ES), with the support of the Unesco Chair Architecture de terre, culture sconstructives et développement durable, ICOMOS-CIAV -International Committee of Vernacular Architecture, ICOMOS-ISCEAH - International Scientific Committee on Earthen Architectural Heritage.

ular technologies, resources and forms is important, however it is essential to take into consideration the features that were unsuccessful and failed and those that have been unsuccessful and no longer sufficiently functioning due to changes in cultural and economic circumstances. Such knowledge and information could be gained through scientific research, but also by investigating the views and perceptions of the users of vernacular buildings.

"Vernacular traditions are dynamic and generated through a continuous and dialectic interplay of stasis and change, precedent and creativity, stability and innovation" (Asquith, Vellinga, 2006, p. 19). Overcoming the challenges of the present and future by accepting and responding to this dynamism, will allow for an environmentally and culturally sustainable future built environment. This integrated approach will create new perspectives and methodologies in order to address the issues of housing and urban design in the future. The challenge is to find the balance and create architecture that is sympathetic to its place and context while considering environmental, social and cultural values.

Vernacular Heritage contributes to resilience

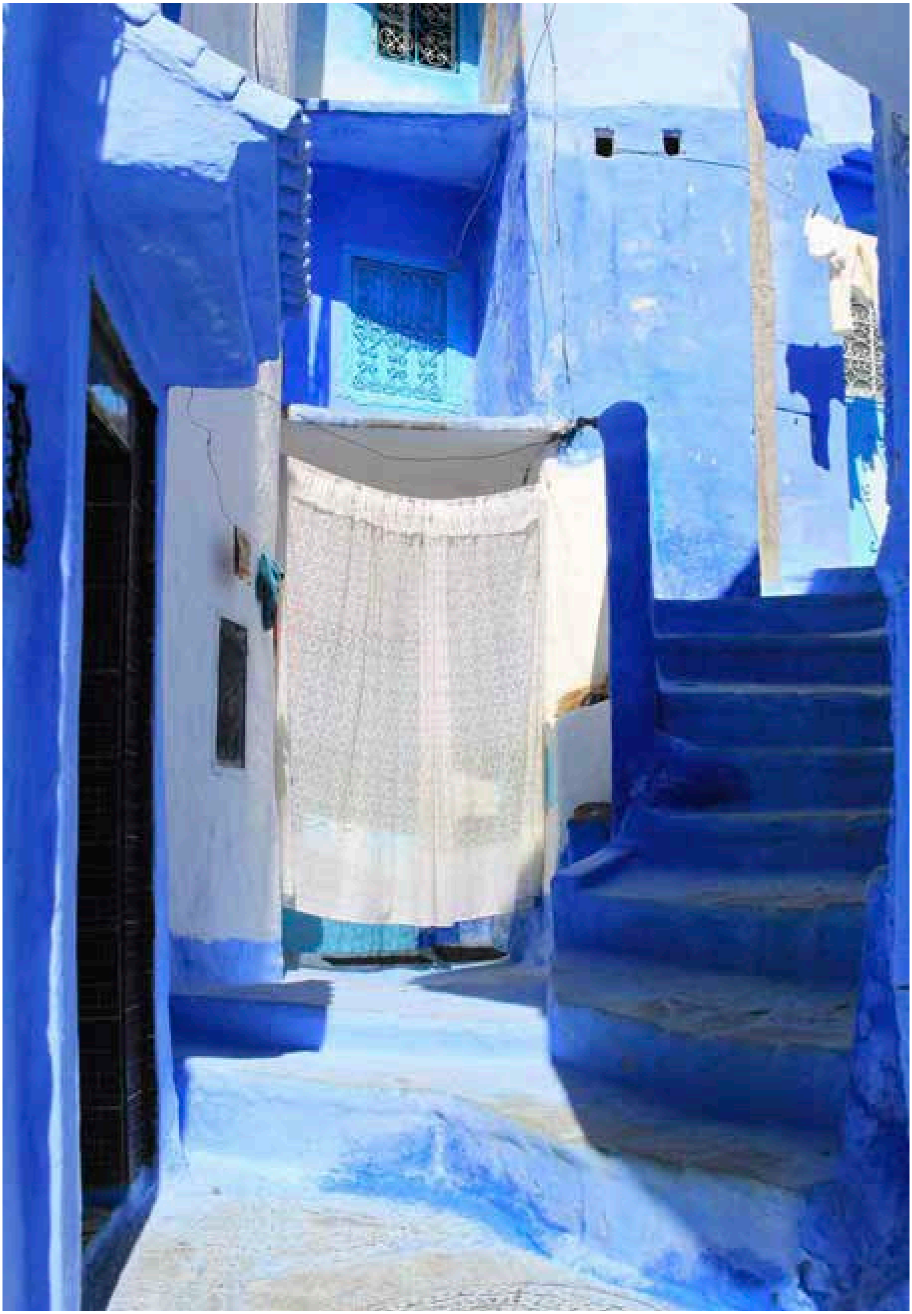
A building culture results from the adaptation of a community to the environmental conditions of the territory in which it is established. Communities have generally integrated local resources, climate and risks into their daily practices, developing their own strategies to cope with natural hazards and to enhance their habitat sustainability, durability and resilience. Traditional or vernacular architecture heritage is characterised by three specific factors that are relevant for resilience:

- interaction with climate change and changing socio-cultural conditions;
- interaction with a certain environment and its risks;
- evolution through centuries through a process of trial and error.

Traditional knowledge and practices, when kept alive and dynamic, enable communities to better face natural hazards and changes. In fact the use of local knowledge and resources can help local masons and craftspeople to rebuild their habitats after a disaster, or help the community to reduce its dependency on external support, providing the livelihood sources required for a sustainable recovery. Therefore, the protection of knowledge, beliefs, values and behaviours embedded in the cultural heritage, should be promoted also because of the fundamental spiritual and social support and the sense of belonging it provides to communities during the disaster recovery phase, as well as the contribution it makes towards building resilience. As part of the Versus project, the relationship between vernacular architecture and resilience on an environmental, social and economic level was investigated (Correia et al., 2014b).

Environmental resilience reflects the effectiveness of a habitat to deal with changing environmental conditions by reducing its physical vulnerabilities. In traditional societies, climatic variability and the uncertain presence of water and other resources lead local communities to develop adaptive practices in order to respond to variability and change, making up in this way for the lack of modern technology, transports, and global market economy.

The socio-cultural dimensions of resilience in vernacular communities include intangible traditional knowledge regarding change adaptation: beliefs, social behaviours, knowledge, building cultures and social cohesion can help to understand the dynamics of the place and disseminating local knowledge regarding practices and actions to cope with disruptions. The transmission of intangible traditional knowledge regarding change adaptation occurs mainly orally: tales, songs and proverbs were used to store the collective memory of communities. The transmission of know-how from generation to generation makes it possible for communities capable to recover their living systems in case of perturbations.



opposite page
Strategies from vernacular architecture to improve the resiliency of a site
Adapted from (Correia et al., 2014b, p.73)

The Socio-economic dimensions of resilience in vernacular settlements regards the capacity to avoid and reduce economic crisis and scarcity threats. It is linked to the capacity of traditional communities of producing food, energy, building materials and services, using local and human resources. The 'proximity' of productive areas to the dwellings, as well as shared cultivation and construction cultures, promotes the 'self-sufficiency' of vernacular settlements. Being based on natural conditions, traditional productivity requires a deep knowledge of seasonal cycles, natural disasters and social crisis management. Some strategies present in vernacular architecture have been identified, which are capable of improving the resilience of a site, and may involve the phases of prevention, resistance, and / or adaptation to a crisis. They can be summarised in the diagram on the opposite page.

To conclude, both modern science and traditional knowledge play vital roles in the way communities deal with crises, disasters and profound change. Scientific and technological advances should take advantage of the capacities and resources already available locally. Indigenous knowledge for disaster reduction lies in the accumulated experience that comes with the close relationship of communities to their environment, in their capacity to read the signs in the environment to predict hazards. Likewise, local technologies and construction practices often reflect adaptations to the environmental conditions. Blending the traditional and the modern creates a fertile ground for innovation and enhances local ownership and acceptance of new risk reduction initiatives.

References

Asquith L., Vellinga M. 2006, *Vernacular Architecture in the Twenty-First century*, Taylor & Francis, London.

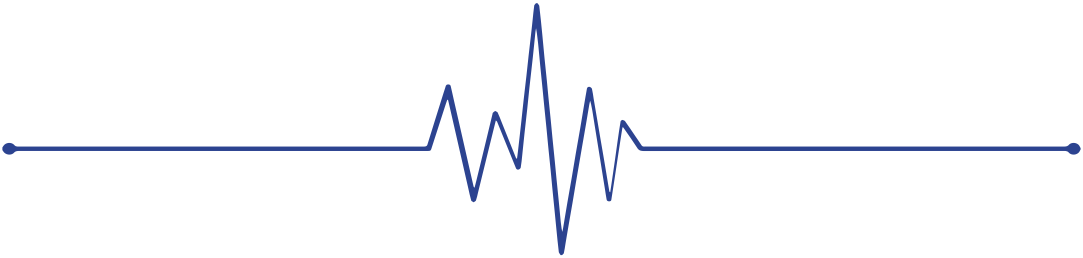
Asquith L. 2006, *Lessons from the vernacular: Integrated approaches and new methods for housing research*. In: Asquith L., Vellinga M., *Vernacular Architecture in the Twenty-First Century: Theory, education and practice*, Taylor & Francis, London, pp. 128-144.

Bigio A. G., Licciardi G. 2010, *The urban rehabilitation of medinas, The World Bank Experience in the Middle East and North Africa*, The World Bank, Washington, < https://openknowledge.worldbank.org/handle/10986/17382> (04/2020).

Bigio A. G. 2010, *The Sustainability of Urban Heritage Preservation. The Case of Marrakesh*, The World Bank, Inter - American Development Bank, Washington, USA

Bonner S. 2006, *Building Tradition: Control and authority in vernacular architecture*, in Asquith L. and Vellinga M., *Vernacular Architecture in the Twenty-First Century: Theory, education and practice*, Taylor & Francis, London, pp. 23-45.

Boven K., Morohashi J. (eds.) 2002, *Best Practices using Indigenous Knowledge*, Nuffic, The



	PRE-CRISIS PHASE PREVENTION + MITIGATION APPROACHES	CRISIS PHASE RESPONSE + RESISTANCE APPROACHES	POST-CRISIS PHASE RECOVERY + ADAPTATION APPROACHES
ENVIRONMENTAL	• Land use management • Assuring appropriate choice of site • Considering the hydrography of the place • Use of locally available materials • Considering the specific characteristics of local risks	• Use of climate-adapted and durable materials • Appropriate architectural and structural conformation • Natural hazard management	• Flexible design • Sharing of building cultures • Development of self-construction systems in order to facilitate fast recovery
SOCIO-CULTURAL	• Recognising local living cultures and traditions • Understanding the value of the place and its dynamics • Disseminating local knowledge regarding practices and actions to cope with disruptions	• Knowledge of alerting systems • Strengthening the network of relationships and trust • Transmitting cultural values and history • Ascribing value to the development of collective welfare • Building common infrastructures and shared spaces	• Swapping know-how on change management • Activating mutual reciprocal actions and sharing of food, labour and knowledge • Incorporating strategies for fast post-disaster recovery including temporary structures
SOCIO-ECONOMIC	• Using local and accessible resources • Optimising the use of materials and promoting indigenous workmanship • Selecting productions adapted to the local conditions • Reinforcing local production of food • including spaces for productive activities at domestic scale	• Sharing goods • Integrated production • Recognising the value of local products • Enhancing local economy empowerment • Promoting collective use of spaces	• Storing and pooling of resources • Sharing infrastructures and facilities • Planning mobility according to human and physical resources availability • Enhancing technical simplicity and self-building activities in building process • Optimizing construction efforts

Hague, The Netherlands, and UNESCO/MOST, Paris, France <http://www. ecdip. org/docs/pdf/bestpractices. pdf> (04/2020).

Correia M., Carlos G., Rocha S. (eds) 2014a, *Vernacular Heritage and Earthen Architecture: Contributions for Sustainable Development*, CRC Press, London.

Correia M., Dipasquale L., Mecca S. (eds.) 2014b, *VerSus: heritage for the future. Vernacular knowledge for sustainable architecture*, FUP, Firenze.

Dipasquale L., Mecca I. 2016, *Vernacular architecture as codified model for the contemporary sustainable project*, «TECHNE - Journal of Technology for Architecture and Environment», Nov. 2016, pp. 190-198.

Dipasquale L., Mecca S., Özel B., Kısa Ovalı P. 2014, *Resilience and Intangible Heritage of Vernacular Architecture*, in Correia M., Dipasquale L., Mecca S. (eds.), *VerSus: heritage for the future. Vernacular knowledge for sustainable architecture*, FUP, Florence.

Emery, A. R. 2000, *Guidelines: Integrating indigenous knowledge in project planning and implementation*, KIVU Nature Inc.

Fathy H. 1986, *Natural Energy and Vernacular Architecture: Principles and Examples with reference to Hot Arid Climates*, The University of Chicago Press, Chicago.

Foruzanmehr A., Vellinga M. 2011, *Vernacular Architecture: question of comfort and practicability*, «Building Research & Information», 39 (3), pp. 274-285.

Frey P., Bouchain M. 2010, *Learning from vernacular: towards a new vernacular architecture*, ActesSud, Arles.

ICOMOS 1999, *Charter on the built Vernacular Heritage*,< https://www.icomos.org/charters/vernacular_e.pdf> (04/2020).

ICOMOS, UNESCO, & ICCROM 1994, *The Nara Document on Authenticity*, < https://www. icomos. org/charters/nara-e. pdf> (04/2020).

ICOMOS Working Group 2019, *The Future of Our Past. Engaging Cultural Heritage in Climate Action*, <https://indd. adobe. com/view/a9a551e3-3b23-4127-99fd-a7a80d91a29e> (04/2020)

IPCC 2012, Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation'. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK, and New York, NY, USA.

Magni G. 2016, *Indigenous knowledge and implications for the sustainable development agenda*, UNESCO, <https://unesdoc. unesco. org/ark:/48223/pf0000245623> (04/2020).

Mete T. 1990, *Vernacular architecture: paradigms of environmental response*, Brookfield, Avebury.

Mitchell N., Rössler M. and Tricaud P-M. 2009, *World Heritage Cultural Landscapes: A handbook for conservation and management*, UNESCO World Heritage Centre, Parigi.

Nonaka I. 1994, A *Dynamic Theory of Organizational Knowledge Creation*, «Organization Science», 5 (1), pp. 14-37.

Nonaka I., Takeuchi H. 1995, *The Knowledge Creating Company*, University Press, Oxford.

Oliver P. 2006, *Built to Meet Needs: Cultural Issues in Vernacular Architecture*, Elsevier, Oxford.

Nguyen A. T., Truong N. S. H., Rockwood D., Tran Le A. D. 2019, *Studies on sustainable features of vernacular architecture in different regions across the world: A comprehensive synthesis and evaluation*, «Frontiers of Architectural Research», 8 (4), pp. 535-548.

Oliver P. (ed.) 1997, *Encyclopedia of Vernacular Architecture of the World*, Vol. 1, Cambridge University Press, Cambridge.

Rapoport A. 1969, *House form and culture*, Prentice Hall, Englewood Cliffs, NJ.

REMAM Réseau Marocain des Anciennes Médinas 2018, *État des lieux des médinas des villes membres*, GiZ / Moroccan Ministry of Interior.

Subramanian S. M., Pisupati B 2010, *Traditional Knowledge in Policy and Practice Approaches to Development and Human Well-being*, United Nations University Press.

Stiglitz, J. 2000, *Scan Globally, Reinvent Locally: Knowledge Infrastructure and the Localization of Knowledge*, in *Banking on Knowledge: The Genesis of the Global Development Network*, Ed. Diane Stone, Routledge, London, pp. 24-43.

Stovel H. (ed.) 2004, *Monitoring World Heritage*, UNESCO World Heritage Centre, Parigi.

Tharakan J. 2015, *Indigenous knowledge systems-a rich appropriate technology resource*, «African Journal of Science, Technology, Innovation and Development», 7(1), pp. 52-57.

UNESCO 2003, *Text of the Convention for the Safeguarding of the Intangible Cultural Heritage*, <https://ich.unesco.org/en/convention> (04/2020).

UNESCO 2010, *World Heritage Convention and Sustainable Development*, Parigi, UNESCO World Heritage Centre.

UNESCO 2018, *Culture for the 2030 Agenda*, United Nations Educational, Scientific and Cultural Organization, 7 Paris, France, <https://www. uclg. org/sites/default/files/culture_in_the_sdgs. pdf> (04/2020).

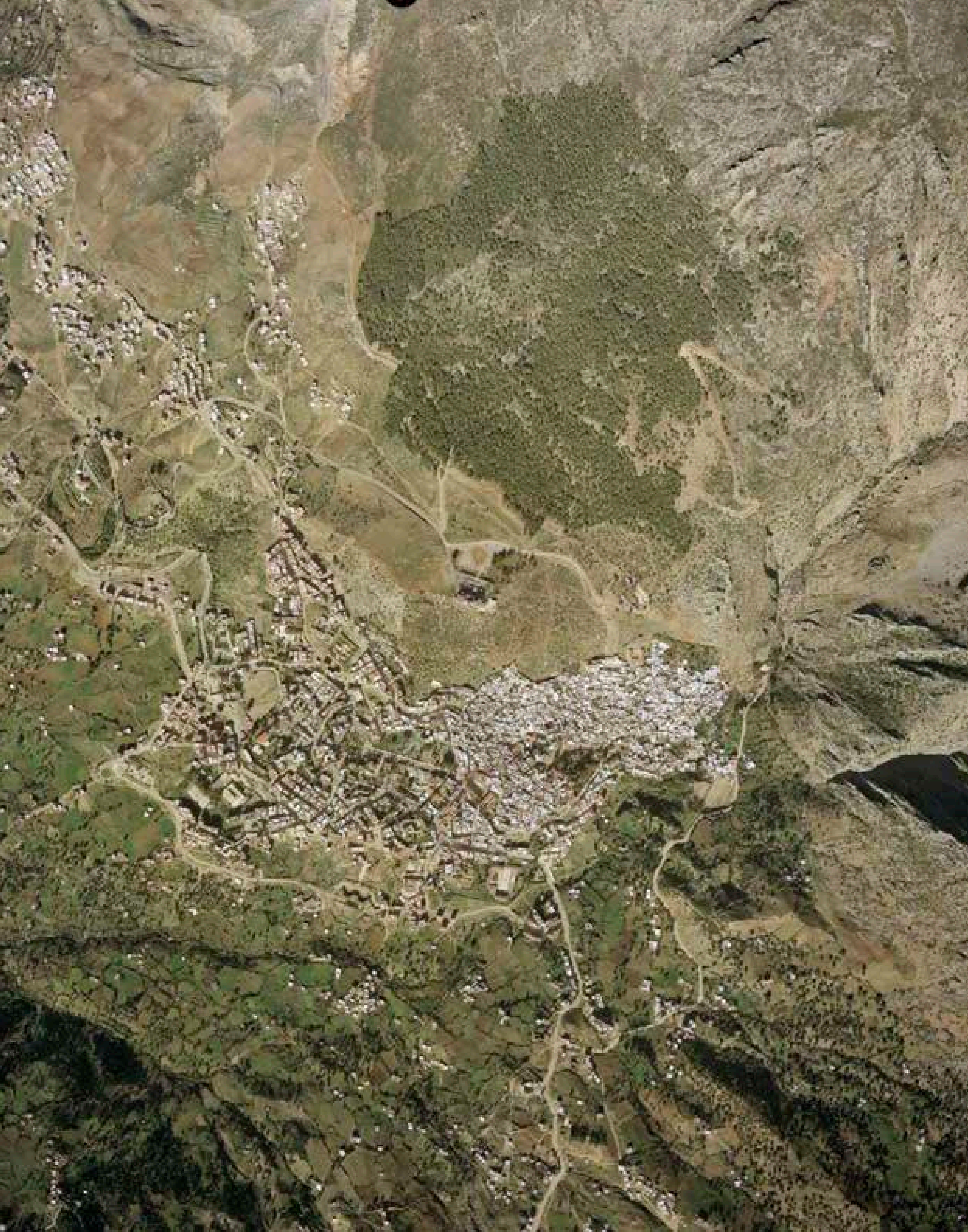
United Cities and Local Governments (UCLG) 2018, *Culture in the Sustainable Development Goals: A Guide For Local Action*, < https://www. uclg. org/sites/default/files/culture_in_the_sdgs. pdf> (04/2020).

UNISDR, UNESCO, Marsh United Kingdom, ICOMOS, ICORP & ICCROM 2013, *Heritage and Resilience: Issues and Opportunities for Reducing Disaster Risks*, UNISDR, *<https://www. undrr. org/publication/heritage-and-resilience-issues-and-opportunities-reducing-disaster-risks>* (04/2020)

Unesco 2019, *Culture | 2030 indicators*, < https://unesdoc. unesco. org/ark:/48223/ *pf0000371562> (06/2020)*

Weber W., Yannas S. 2014, *Lessons from Vernacular Architecture*, Earthscan, London.

Territorial, urban and architectural morphology



Aereal view of Chefchaouen

The city crouches in a fold in the mountain; it is discovered at the last minute.
Charles Focauld, 1883

Geomorphological context

The city of Chefchaouen is located in the north-west of Morocco, approximately 50 kms as the crow flies from the Mediterranean sea, on the slopes of the Rif mountains, which run parallel to the coast. The Rif range has an extension of approximately 32,000 km^2 and constitutes a barrier, in both geographic and landscape terms, between the Mediterranean and the rest of Morocco. Its geological structure is relatively recent and very rugged, formed by silicious and calcareous layers, and with peaks that are not higher than 2500 ms. Chefchaouen stands at 600 ms above sea-level and in proximity of the spring of Ras el-Maa, on a slope protected by the peaks of mountains Djebel Meggou and Djebel Kala. The two peaks that rise above the medina influenced the choice of the name of the town, which in fact derives from the Berber terms *Chouf*, meaning "look" and *Echaouen*, which in Amazigh means "horns", and is a term used to indicate the peaks of mountains. Therefore, the meaning of Chefchaouen is "look at the horns", and more specifically, "look at the peaks of the mountains".

The territory of the province of Chefchaouen is part of the "Intercontinental Biosphere Reserve of the Mediterranean", which includes part of Andalusia (eastern area of the province of Cadiz and western section of the province of Malaga) and the north of Morocco (provinces of Tangiers, Tetouan, Larache and Chefchaouen), declared as such by UNESCO in 2006 with the purpose of protecting biodiversity in the area and favouring cooperation between the two shores of the Mediterranean. The wealth and diversity of the flora, fauna and habitats between the two shores derives in great measure from its position as intersection of various bioclimatic regions and influences, and as migrating route between the European and African continents, which determines the presence of seasonal nesting.

The province of Chefchaouen is mainly rural, with 90% of its 434,924 inhabitants living in the countryside (Direction Regionale de Tanger-Tetouan-al Hoceima, 2018). The city of Chefchaouen is the only municipality of the province, created in 1975. The rural territory is organised in 12 *caïdats* (small rural settlements) and 27 rural communes. There is a great contrast of living standards and infrastructures between the urban area (the municipality of Chef-

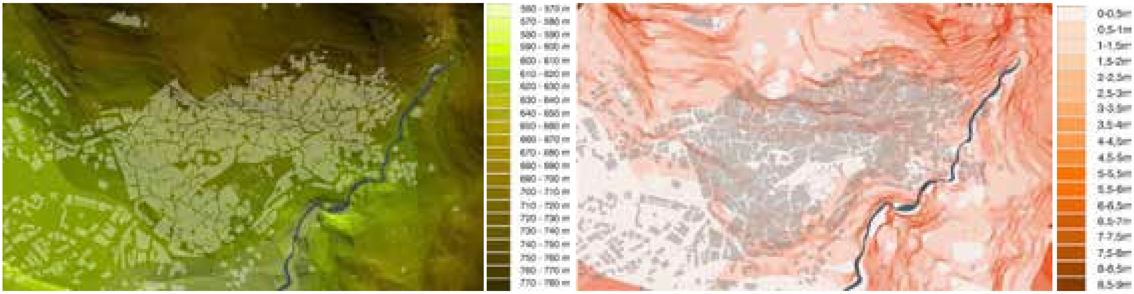
FUP Best Practice in Scholarly Publishing (DOI 10.36253/fup_best_practice)

Panoramic view of the medina from the Kasbah

chaouen) and the 27 rural communes, which are characterised by the people living in the mountains and their culture, the Jbala and the Ghormara.

The territory as a whole presents a great diveristy of tree species, which has resulted from long plant domestication processes in the western Mediterranean, undertaken by the Berber population of the Jbala and Ghomara. Berber communities are the safekeepers of this natural heritage, of knowledge and know-how passed on from generation to generation, which represents the coming together of the Berber, Arab and Spanish cultures (Ater et al., 2012). The arboreal heritage is characterised prevailingly by deciduous forests and evergreen sclerophyllous scrub within the Mediterranean bioclimatic zone. The territory comprises a variety of habitats with land cover which features diverse uses including pasture, agricultural, livestock, and human settlements. The area is also home to rare flora species, such as *Acer granatense*, *Alnus glutinousa* (Common alder), and *Betula celtiberica*.

The topographic features of the site had a decisive influence on its urban and architectural structure: the city, in fact, is located on a slope protected by the valley, exposed to the south, with a more or less regular decline until the riverbed of *oued Lao*.
The terrain where the medina stands goes from 520 to 760 ms above sea-level, and has an average slope of 12%. The difference in level, which is approximately 250 ms allows for a favourable exposure of the buildings towards the valley to the south, with a great landscape view.
The geological context of the area, characterised by the presence of barriers of sandstone and marly limestone creates favourable conditions for the collecting of water in the rocks.
The choice of the site for the foundation of the city is not only due to its position, naturally protected from enemy attacks, but especially to the abundance of water from the spring of Ras El Maa spring , wich flows from a crevice on the calcareous ridge and provides potable water to the medina.



Elevation and clivometric map

opposite page **Weather averages of Chefchaouen** In blue: min. temperature (°C). In grey: avg. temperature (°C). In red: max. temperature (°C). Own elaboration based on: climate-data. org

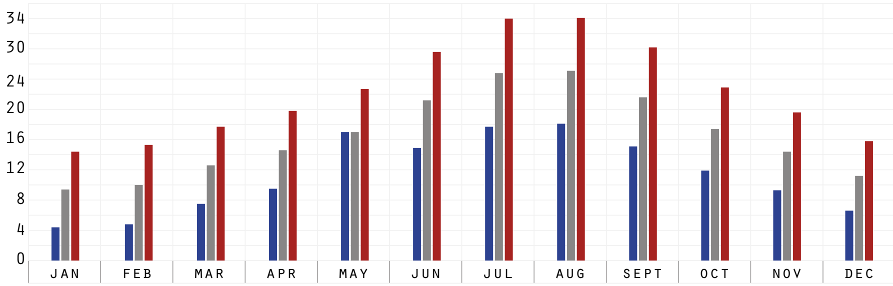
Climate

The climate of Chefchaouen, which derives from a double marine influence coming from both the Atlantic and the Mediterranean, is of the Mediterranean type, mild and humid in comparison to the rest of the country, and has the highest precipitation rate at the national level. It is characterised by a hot and dry Summer season, with temperatures that rise above 40° C, and a cool and rainy season which goes from October to April. Precipitations vary between 800 and 1400 mm/annum, on occasion reaching 2000 mm/annum with some snowfall, although rarely (Hillali et al., 2002). The amount of the precipitations and their intensity, together with the Summer heat, influenced the morphology of the architecture: the pitched roofs of the houses in the medina are in fact an adequate answer to the abundant rainfall and the the consequent need for its discharge. The thickness of the walls and the materials traditionally used offer appropriate protection against the Summer heat.

The demographic context

With a density of 100 inhabitants/km^2, the Moroccan Rif is one of the most densely populated mountain ranges in the Mediterranean. The population is of Arab and Berber or Amazighs origin[1], with two indigenous tribes dominating the mountains areas: the Jbala[2] and the Ghomara. Due to its particular history, the medina of Chefchaouen was originally populated predominantly by Andalusian Arabs and Spanish Jews, and later by Berbers from the surrounding rural areas. The presence of the Berber community which inhabits the mountains around Chefchaouen is visible in places where commercial exchange takes place in the medina of Chefchaouen. Every day, in fact, the Jbala offer their agri-

[1] The word "Amazigh" refers to the descendants of the pre-Arab inhabitants of north Africa, known to the world as Berbers, and is today the preferred term for this cultural group.
[2] The word "Jbala" comes from Arabic جبل, *Jbel*, which means "mountain". Thus Jbala means "mountain people". They speak an Arabic Hassani-dialect influenced by the Berber and Spanish languages due to the proximity to Spain, which also controlled the region during the protectorate era (1912-1956).



cultural goods or artisan products along the main streets and in the souk. Jbala women are easily recognizable by their traditional dress, consisting of shawls called *mendils* made from cotton or wool. These rectangular shawls are often woven in stripes of white and red and they are wrapped around the waist to form skirts. They are also used as shawls and for securing babies or goods on the back or front of the body. The traditional outer garment of the men is the *djellaba*, a one-piece cotton or woolen cloak with a pointed hood. The Jbala wear pointed toed leather slippers (*babouches*). Natural light brown, yellow and white are the most common colours. Reed hats are another traditional feature of the Jebala dress for both men and women. Women's hats are often adorned with woven woolen tassels and roping in black, white and red variations.

In the early 20th century the territory of the Rif was often visited by Jewish merchants. For a long time the Jewish community, which had always been present in the medina, lived in the same neighbourhoods as the Arabs, until it was given (around 1557) a space outside of it where to build their own district, subsequently known as the *Mellah*. Around 1760, the Jewish families, as a result of the attacks suffered from the mountain tribe of the Khmas, asked to be relocated inside the walls. Mohamed El Arabi Raissouni, upon orders from the Sultan, granted a plot of land near the kasbah, where they built the new *Mellah*, which included a large souk and workshops for the processing of textiles and metals. The *Mellah* was protected by walls and two gates: one to the medina and the other to the countryside (Bouchmal, 2010).

Regarding the demographic evolution of the medina, the first source on the numbers of the population is due to Charles de Foucauld, who visited the city on July 3rd, 1883. De Foucauld estimated the population at the time to be somewhere between 3,000 and 4,000 inhabitants. As described in Focauld's visit, there was harmonious cohabitation between Jews and Muslims. In 1920, on the eve of Spanish colonisation, the city had a population of approximately 10,000 people living in more or less 750 dwellings. Between 1942 and 1947 there was a 3.14%



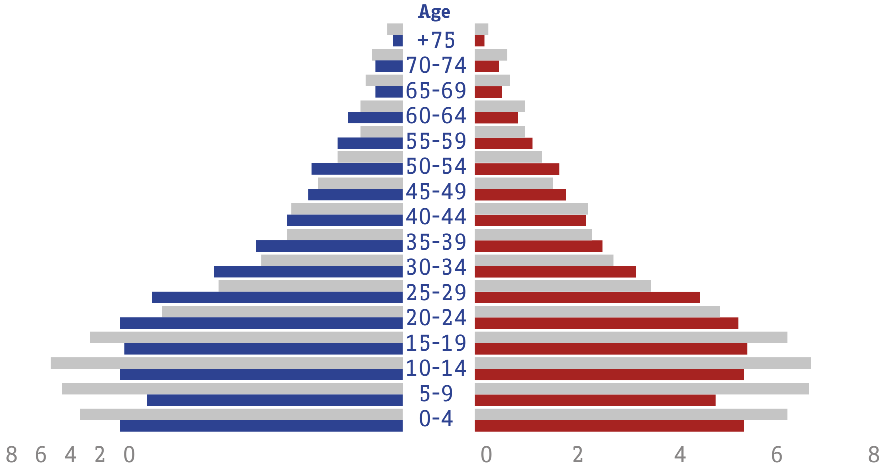
Traditional dress of Jbala women

opposite page
Age pyramid
In blue: male persons in 2014.
In red: female persons in 2014.
In gray: data from 2004
Adapted from (Direction Régionale de Tanger-Tétouan-al Hoceima, 2018)

increase in population. This growth can be probably to the immigration into the city of people from rural and mountainous areas, especially from the regions of the central Rif which periodically suffered from drought and famine. The urban population diminished around the time of the end of the Spanish protectorate (1956): between 1954 and 1960 more than 2000 people left the city, mostly Portuguese and Spanish citizens. After 1960, the population starts growing again, reaching a total of 23,563 inhabitants in 1982, also as a result of the continuous flow of immigrants from the surrounding mountains. The considerable increase in population which began in 1975 brought about important effects on the urban and social structure of the city. Due to the increasing housing density the traditional fabric is transformed through processes of accumulation and accretion for the purpose of obtaining new dwellings. The population within the walls of the medina almost doubled between 1971 and 1994 (from 11,531 to 19,567 inhabitants), and represented 70% of the total population.

In 2004 the urban population reached 54,762 inhabitants, of which approximately 20,576 people distributed in 3,500 dwellings of the medina, with a density of 910 inhabitants per hectare. The average size of a family is of 5.1 people.

In 2006 the medina had approximately 18,000 inhabitants, with a density of 600 people per hectare. The colonial city outside the walls had an extension of 120 hectares, while the suburbs extended over 318 hectares, with a density of 35 people per hectare.



No official data on demographic growth in recent years have been found, but the trend observed is that of growth with an average annual growth of 1.24% (in line with the Moroccan average) (Direction Regionale de Tanger-Tetouan-al Hoceima, 2018), with a decrease in the number of residents living inside the medina. The constant increase of population in this period is due to the arrival of people from the surrounding rural areas which settled in the suburbs of the city. Despite the existence of a development plan, urban development is not completely controlled and in suburban areas new constructions often precede the building of infrastructures (roads, water supply, hygienic services, public lighting, etc.).

The age pyramid is somewhat inverted in comparison to the rest of Morocco; there are relatively few young people, who leave Chefchaouen to study in the larger cities and mostly do not return. At the provincial level, the rate of employment was 51.5% in 2016, in comparison to 45.2% at the national level. The rate of unemployment for that same year is 4.8% in the province, against 9.6% in the region and 9.4% for the whole of Morocco. The province of Chefchaouen has made considerable efforts in the fight against poverty, which was reduced by 60.8% between 2007 and 2014. In the city of Chefchaouen the poverty rate diminished from 6.4% in 2007 to 0.8% in 2014, with a vulnerability rate of 5.3% (Direction Regionale de Tanger-Tetouan-al Hoceima, 2018).

Traditional berber carpet

Traditional *djellabas* (©L. Lupi, 2007)

Economic and productive context

Chefchaouen had an important economic role in the past due to its geographic position, at the crossroads of the commercial routes between Fez and Ceuta, and in the middle of the western Rif. The density of commercial flows between these two cities had a strong impact on the development of the city until the late 20th century.

Today, tourism is the main sector of economic activity, with an annual flow of approximately 120,000 tourists (Direction Régionale de Tanger-Tétouan-al Hoceima, 2018). The medina of Chefchaouen is among the destinations which are alternative to the more renowned cultural (imperial cities: Fez, Marrakech, Rabat and Meknes) or coastal (Rabat or Essaouira) touristic circuits. Over the past years it has received a progressively increasing amount of tourists especially from Morocco or Spain, but also from other European countries and other continents. Data published on the *Monographie Provinciale De Chefchaouen* (Direction Régionale de Tanger-Tétouan-al Hoceima, 2018) show how, from 2013 to 2016, occupancy rates in the province's classified hotels (many of which are in the medina of Chefchaouen) increased in 30% (from 39,028 to 50,993). 49% of the tourists for 2016 are Moroccan, followed by Russians, Japanese, French and Spaniards. Foreign tourism in the past was partly linked to the consumption of hashish, and in fact young and not so young travellers arriving mostly from Europe came to Chefchaouen attracted by the possibility of finding cheap, good quality hashish, and of visiting a farm where marihuana is cultivated and transformed. During the past few years tourism has greatly increased due to a series of factors. The picturesque appearance of the medina became increasingly known by a wider public, thanks in part to the diffusion of images through the web and social networks, to the point of earning for Chefchaouen international fame as the "blue pearl of Morocco". The world of the medina with the soft curves and infinite hues of indigo and blue were soon used as set for the advertisements of famous fashion brands, thus increasing its visibility and notoriety. Certainly also the policies for the promotion of tourism in the territory, undertaken by an efficient municipal administration and aimed at valorising not only the city, but also the territory and its natural heritage, contributed to this effect. Some examples of this heritage are the forest of the regional park of Bouhachem, which has an extension of 80,000 hectares, or the waterfalls of Akchour and God's Bridge, a natural arch in red stone that stands 25 meters above the river Farda, which over thousands of years has excavated the rocks. The new "demands" of tourism and emerging segments (sustainable and responsible tourism), although minoritary, present interesting features under the profile of environmental and social impact, but also due to the quality of the economic spin-offs they can generate.

Set for photo shoot in the medina.
In recent yeats nicknamed "Blue pearl of Morocco", Chefchaouen has become a destination for many tourists, including local ones, for its spectacular views

Sales (in value and quantity) of handicrafts in the market indoor, 2016
own elaboration based on: Monographie provinciale de Chefchaouen, 2016

In 2016 the province of Chefchaouen had 68 hotels, for a total of 1,796 available beds. 88% of the hotels are of a lower category (from 1 to 3 stars) and there are no high-end category hotels (5 stars) (Direction Régionale de Tanger-Tetouan-al Hoceima, 2018). This shows the lack of attention to the quality of the accommodation offer. In general, the accommodation offer is in expansion and many of the new structures were developed during the past few years, mostly by converting courtyard houses. Hand in hand with the hotels, a network of commercial and catering activities has recently developed in the medina. These commercial activities are mostly involved with the sale of local and Moroccan handicrafts.

The tourism-oriented vocation, which extends to the entire province, favours the production of crafts as well, which is one of the main sectors of the local economy. The artisan sector plays a key role in the province of Chefchaouen, from both the social and econom-

products	products value (in 1000 DHS)	quantity in (Q)
wrought iron	16	100
clothing	100	12
woodwork	600	250
leather goods	300	10
Coverage	160	30
Footwear	40	7
fashion jewellery	100	4
miscellaneous	1,000	20

ic points of view. Artisan-related activities, which derive from the Berber and Andalusian roots of the city, constitute an important part of the cultural heritage of the city. A 2016 survey identified 38 cooperatives and 688 associated artisans working with fabric, wood and, to a lesser extent, iron and leather.

Chefchaouen is recognised as one of the most important fabric production centres in Morocco, together with Ouazzane, Tetouan, Rabat and Marrakech. Fabric workshops use wool, linen and cotton in the production of carpets, *djellabas*[3] and hoods. The wool used to be processed in the medina, while now it is imported. It is usually undyed, so dark brown and off-white are the common colours for *djellabas*. White *djellabas* are worn for religious festivals. The typical fabric with red and white stripes is worn by Jbala women around the shoulders and the waist.

Prior to the Spanish dominion, the production of silk, a tradition which had been brought from Andalusia, was also widespread. In the gardens of the houses and outside the city walls there were many mulberry trees for breeding and feeding silkworms. During the period of the Spanish occupation the mulberry trees outside the city were felled and the practice was gradually abandoned (Bouchmal, 2010).

Leather is used for the production of bags, sandals and *babouches*, yellow for men and black or red with rounded points for women.

Crafts involving wood concern especially the painting and sculpting of wood for the frames of doors and windows, as well as for floors and roofs. Polychromic geometric or floral motifs,

[3] The *djellaba* or *jillaba* is a long, loose-fitting unisex outer robe with full sleeves, and a baggy hood called a *qob*. It is made in different colours that traditionally indicate the marital status (single or married) of the bearer: a dark brown *djellaba* indicating bachelorhood. *Djellabas* are generally made of cotton for summer wear and coarse wool for the winter.

Little shop with typical fabric with red, white and blue stripes (©L. Lupi, 2007) of Andalusian origin, are reproduced on cedar or Moroccan spruce (*Abies marocan*a, in Arabic *al-chuh*).

The city houses a Centre for Traditional Crafts aimed to preserve the quality of products and artisan know-how, where it is possible to follow on site the traditional manufacture of local artisan products. It also serves as a training, meeting and exhibition centre and includes 17 workshops.

The industrial sector is rather weak, also due to the geographic isolation and the lack of a nearby railway network or an airport. The closest airport is the one in Tangiers, situated at 120 kms from Chefchaouen and which, due to the road conditions, is approximately 3 hours away. In 2013, the province of Chefchaouen had only 18 industrial plants, devoted mostly to the transformation of products from the primary sector (olive pressing, fig drying, wool).

The development of agriculture at the provincial level is made difficult by the rugged topography and has a low level of mechanisation, irrigation and usage of selected seeds. This favours traditional agriculture which, however, is strictly dependent on climatic factors. In 2016, the useful agricultural surface totaled 106,676 hectares, of which only 8,7% was mechanically irrigated. Cereal crops are the most important (approximately 21% of the total), reaching a production of 21,080 tonnes in 2016. 3% of agricultural land is cultivated with vegetables, which are fundamental ingredients of the Mediterranean diet. In 2010, the Mediterranean diet of the city of Chefchaouen was included in Unesco's World list of intangible heritage[4]. Together with Chefchaouen, the list of intangible heritage sites related to the Mediterranean diet included other communities that are considered as emblematic: Pollica in Cilento (Italy), Koroni (Greece) and Soria (Spain).

As for arboriculture, most of the production involves olives (83% of the agricultural surface is devoted to arboriculture), followed by figs and almonds. Regarding agrobiodiversity two important characteristics can be highlighted (Bouchmal et al. 2010; Ater at al. 2012):

- the persistence of marginal and/or rare crops: examples among cereals include the cultivation of einkorn wheat (*Triticum monococum*, locally known as *chqalia*), rye (*Secale cereale*, called *chentil*) and sorghum (*Sorghum bicolor*, called *dra*); the cultivation of legumes such as vetches (*Vicia ervifilia*, locally known as *kersanna* and *Vicia sativa*, or *kerfala*), grass pea

[4] "The Mediterranean diet constitutes a set of skills, knowledge, practices and traditions ranging from the landscape to the table, including the crops, harvesting, fishing, conservation, processing, preparation and, particularly, consumption of food […]. The system is rooted in respect for the territory and biodiversity, and ensures the conservation and development of traditional activities and crafts linked to fishing and farming in the Mediterranean communities which Soria in Spain, Koroni in Greece, Cilento in Italy and Chefchaouen in Morocco are examples" (Convention for the safeguarding of the intangible cultural heritage, Unesco Doc. ITH/10/5. COM/CONF. 202/INF. 4. 2 Paris, 12 November 2010, p. 45).

of the genus Lathyrus (*Lathyrus sativus*, *Lathyrus cicera*, *Lathyrus ochrus*) and cowpea (*Vigna unguiculata*, or *loubia hamra*).

- the importance of fruit trees: in addition to the importance of Mediterranean species such as olive, fig and vine, there are rosaceous plants such as plum or pear and sub spontaneous species such as walnut and cherry. There is a great variety of species for fruit trees, especially in the case of figs, which are a characteristic element in Rifan agroecosystems.

The agricultural know-how of the Jbala is rich and varied, and covers a wide range of aspects, such as knowledge of the calendars for the care and maintenance of plants (grafting, pruning, etc.), the existence of codes for ownership management, the processing and conservation of products, etc. The conservation of the diversity in these agro-ecosystems is linked to the maintenance of some of these practices. For example, the marginal cultivation of rye and hulled wheat still exists, especially in the production of straw used for several purposes, such as roofing for rural dwellings or the construction of small shelters for animals. Breeding is devoted 70% to bovines, and the remainder, at higher altitudes, to sheep and goats.

Official data concerning the production of marihuana are not available, yet there are numerous studies that demonstrate the great extent of the production and of its economic effects. The introduction of cannabis to Morocco dates back to the period between the 7th and 15th century. In the 18th century the Rif Mountains became the main growing area. Traditionally, chopped cannabis herb mixed with chopped tobacco – a mixture known as *kif* – was smoked in a pipe with a small clay or copper bowl. At the end of the 19th century, 90 % of France's need for pharmaceutical cannabis products – which were not prohibited at the time – was met by imports from Morocco. With the arrival of the European colonial powers, a control regime developed that would vary over time between regulation, prohibition and, ultimately, turning a blind eye to cultivation in the Rif. Today, well-kept cannabis fields in the area are openly maintained on terraced slopes. Before the 1980s, cannabis cultivation in the Rif extended over probably less than 10,000 hectares. In 2003 a crop monitoring survey by the United Nations Office on Drugs and Crime (UNODC) and the Moroccan government revealed that 134,000 hectares were under cultivation, producing 3,080 tonnes of hashish. Moroccan authorities claim that the area under cannabis cultivation in the Rif mountains decreased by 65 per cent from 2003 to 2013 (Chouvy and Afsahi, 2014).

References

Ater M., Hmimsa Y. 2012, *Agrosystèmes traditionnels et savoirs agronomiques des paysans du pays Jbala-Ghmara*, in *Le patrimoine séculaire des Jbala-Ghmara Construire la connaissance, valorisiser le patrimoine, fêter la Culture et céer la richesse*, Rapport d'activité, <https://jbala. hypotheses. org/101> (11/2019).

AA. VV. 2000, *Chefchaouen entre l'ordre urbain et le chaos*, Actes des journes d'etude, Chefchaouen.

AA. VV. 2001, *Il Marocco andaluso. Alla scoperta di un'arte del vivere*, Electa, Milano.

AA. VV. 2004, *Marruecos y Andalucia*, Actas de las jornadas: Rehabilitacíon y intervencíon en las ciudades historicas de Andalucia y el norte de Marruecos, Tetouan.

Blickman T. 2017, *Morocco and Cannabis – Reduction, Containment or Acceptance*. TNI Drug Policy Brief-ing 49, Amsterdam, <https://www. tni. org/files/publication-downloads/dpb_49_eng_web. pdf> (11/2019)

Bouchmal F., Calvo G., Jabiot I., Vignet-Zunz J. (eds.) 2010, *Regards sur les patrimoines Jbala*, in Ac*ts of Forum International Planète terroirs, Chefchaouen 2010*, Ministre de La Culture, Royaume du Maroc, <https://issuu. com/terroirsetcultures/docs/livret_patrimopine/45> (11/2019).

Bouchmal F. 2010, *Chefchaouen: médine d'inspiration andalouse et à empreinte juive*, in *Regards sur les patrimoines Jbala*, in A*cts of Forum International Planète terroirs, Chefchaouen 2010*, Ministre de La Culture, Royaume du Maroc, <https://issuu. com/terroirsetcultures/docs/livret_patrimopine/45> (11/2019).

Chouvy P., Afsahi K. 2014, *Hashish Revival in Morocco*, in «International Journal of Drug Policy», Elsevier, 2014, 25 (3), pp. 416-423.

Direction Regionale de Tanger-Tetouan-al Hoceima 2018, *Monographie Provinciale De Chefchaouen*, Royaume Du Maroc, Haut Commissariat Au Plan.

Hillali M. M., Tansamani M. 2002, *Inventaire des Ressources et Potentialités touristiques de la Province de Chefchaouen*, Association de Développement Local (ADL) Chefchaouen, Fundacion Instituto de Promocion y Apoyo al Desarrollo (IPADE), Madrid

IHEM, Conseil Recherce Formation 2004, *Etude de faisabilite relative a la rehabilitation du tissu ancien de la medina de Chefchaouen*, Royaume du Maroc, Ministere delegue charge de l'Habitat et de l'Urbanisme, Tetouan.

Ministere Charge de la Population 1994, *Etude Monographique de la province de Chefchaouen*, Programme de Nations Unies pour le developpement, Tetouan.

Karkouri M. 2004, *Etude du Plan Local d'Habitat et du Developpement Urbain de la Ville de Chefchaouen*, Royame du Maroc, ministere de l'Amenagement du territoire, Tanger.

Rovero L., Fratini F. 2013, *The Medina of Chefchaouen (Morocco): A survey on morphological and mechanical features of the masonries*, «Construction and Building Materials», 47 (2013), pp. 465-479.

Volpi V. 2009, *Chefchaouen e il suo territorio: elementi di geografia e geomorfologia*, in *Chefchaouen. Architettura e cultura costruttiva*, Mecca, S., Dipasquale, L., Rovero, L., Tonietti, U., Volpi, V., ETS, Pisa, Italia, pp. 43-49.

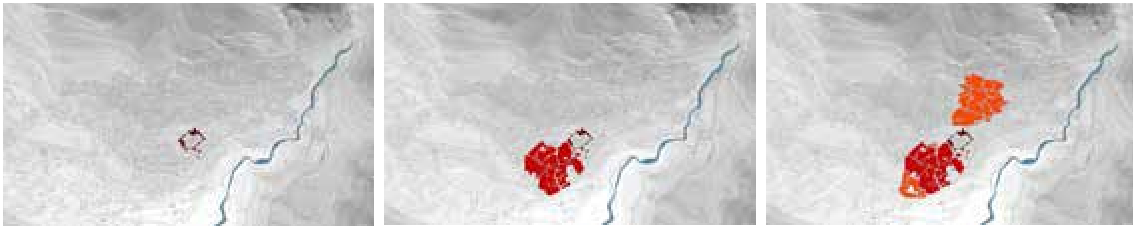
View of the city (© L.Lupi, 2007)

The foundation of Chefchaouen is linked to its strategic position, protected as it is by the ridge of the Rif range and wedged between to mountain peaks at a place that is ideal for controlling the routes that lead to the coast. The city has always been shrouded in a sacred and religious atmosphere. It has considered a holy place and virtous city due to the fact that it was founded by a family of Idrisid *shurafa*, descendants of the Prophet Muhammad, and is located in the proximity of the tomb of Abd al-Salam ibn Mchich, who introduced Sufism to the Maghreb. The tomb of Abd al-Salam ibn Mchich is a place of pilgrimage for Muslims, so Chefchouen has been for centuries a must destination for pilgrims visiting the tomb of the saint. Before 1925 non-Muslim foreigners were rarely allowed into the city. It is for this reason that it was known to Europeans only thanks to brief descriptions from 19th century travellers.

The foundation of the kasbah (1471)

The presence of the Portuguese, who settled on the Atlantic coast of the Maghreb since the 15th century, was fundamental in the decision to establish the city of Chefchaouen. The city of Chefchaouen was founded in 1471 (year 876 of the Hegira) as a defensive fortress by the monk-warrior Mulây Alî Ibn Rashîd, who belonged to the tribe of the Akhmes. He was a descendant of the Idrisides, the first Muslim dynasty to autonomously rule Maghreb al-Aqsa (Morocco), who claimed to be descendants of the Prophet Muhammad.
Mulây Alî Ibn Rashî left his native region in the early 15th century to go and fight in Granada, which at the time was occupied by the Arabs, yet constantly under threat from the Spanish. After several years of battle, during which he gained fame as a great warrior, he returned to Morocco to defend his land from the threat of Portuguese expansion on the northern coast. After taking Asilah and Tangiers, in 1471 he decided to create a large army and to build a military base: the Kasbah of Chefchaouen, situated in geographically suitable place where a small Berber settlement already existed. Soldiers from his region and other religious fighters, or *mujâhidîn*, settled in the *kasbah* with their families.

FUP Best Practice in Scholarly Publishing (DOI 10.36253/fup_best_practice)



Phases of development of the medina of Chefchaouen (1471-1900)

The Souika quarter (1471-1491)

The settlement soon extended outside of the *kasbah* and turned into a small city spread over an area of four hectares which included a mosque (known today as *Al Aadam* mosque), a surrounding wall with towers and solid gates. The inhabitants of the region and some Andalusian refugees were attracted by the fertility of the land and the strategic location and soon gave origin to the first quarter of the medina of Chefchaouen, known as *Souika* (or *Al Suwiqa*), which developed around *Utah Hammam* square, and housed the first hammam, as well as a *funduq*.

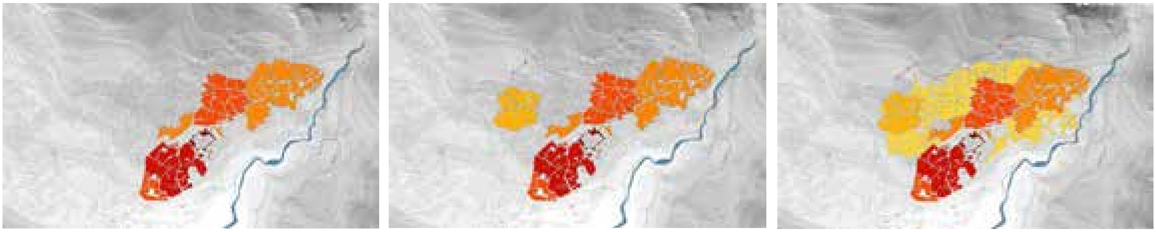
The origins of Rif al Andalous quarter (1492-1540)

Between 1492 and 1540, following the fall of the Kingdom of Granada (1492), the city accommodated a second wave of Andalusian refugees, who settled to the north-east of the city, outside the first circle of walls, forming what would become the Rif Al Andalus quarter. In these years the settlement of Chefchaouen is already strong, both militarily and politically, to the extent that it became the capital of the princedom, which would be independent between 1471 and 1560. Its political and cultural influence reached not only the nearby cities of Tetouan and Targa, bur as far as the northern Atlantic coast.

A powerful characters of this period was Sayyida alHurra (meaning Free Lady), who ruled the region along with the cities of Tetouan and Chaouen between 1518 and 1542, and continued the struggle (*Jihad*) that his father had started against the Portuguese and Spanish. She has been known for her aggressive temper and her intelligence, a combination which proved to be a strategic weapon against the enemy.

The Al Onsar and Sebanin quarters (1540-1564)

Other migrations from Andalusia formed the quarters of Al Onsar and Sebanin, which are situated to the east of Souika and Rif al Andalus. The development of these two new quarters is closely linked to the spring of Ras el Maâ: the new quarters soon included



mills for grinding grain and spaces for washing and working wool. The Sebanin quarter in particular houses many textile workers, and its name derives from the washing activity (*Sben*) which took place along the river.

The arrival of large numbers of Andalusian Arabs between 1540 and 1560 determined an additional development of the city. The Al Aadam mosque was expanded and completed with the addition of new bays. Around this building, which stands next to the *kasbah*, lies the central space of the city, Outa Hammam square, which takes its name from the first Turkish baths (*hammam*) located precisely on the square; at this time were built also a *zawiya* (or *zaouia)* and four *fonduk*.

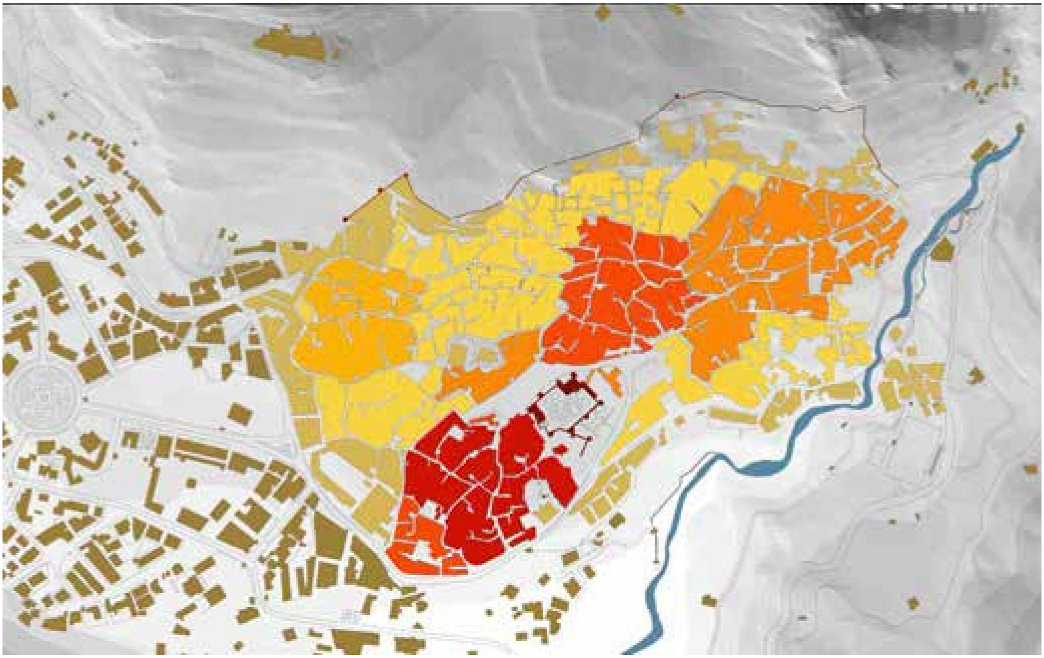
This was a period of great splendour for Chefchaouen: the Andalusian not only sought refuge but actually settled in the city, bringing with them resources, competencies and skills, particularly in the building and productive sectors, which led to the construction of public and private buildings in the Andalusian style, as well as to the establishment of the new water distribution network, of silk, linen and carpentry workshops.

The architectural and building systems put in practice in this period represent a balanced synthesis between a careful use of local resources (stone, earth, lime, wood), and a combination between the building culture of the Berber population and the more sophisticated Andalusian architecture.

In 1560 the Saadi Sultan Mulây Abdallah al-Ghalib Billah settled in Morocco and strengthened the centralised power, fighting off the pretenses of independence of several cities and regions. Chefchaouen eventually lost its political independence, yet it continued to exert its religious and cultural influence on the region.

The last historic section of the city: Souk (1609-1700)

In the early 17th century, the city welcomes the last wave of Andalusian refugees, both Muslim and Jewish, who will settle to the north-west of the city, forming in 1609 the Souk quarter. This area took its name from the market which took place every Monday next to the gate



The medina and the new city (in green color)

to the quarter, known as *Bab Souk*. The walls that surround the city were adapted to its new dimensions with nine entrance gates. Every quarter has the necessary services to be self-sufficient: mosques, schools, fountains, *hammam*, ovens and textile workshops. Outside the walls laid the cemeteries, fruit and vegetable gardens, as well as a small Jewish community.

The expansion of the city and the origin of the El Kharrazine quarter (1700- 1800)

During the 18th century, the demographic growth and the arrival of the *Jbala*, inhabitants of the Rif mountains, determines the development of the Sebanine and Al Onsar quarters, and the birth of the new quarter of El Kharrazine, which occupied the urban gap between Souk and Souika.

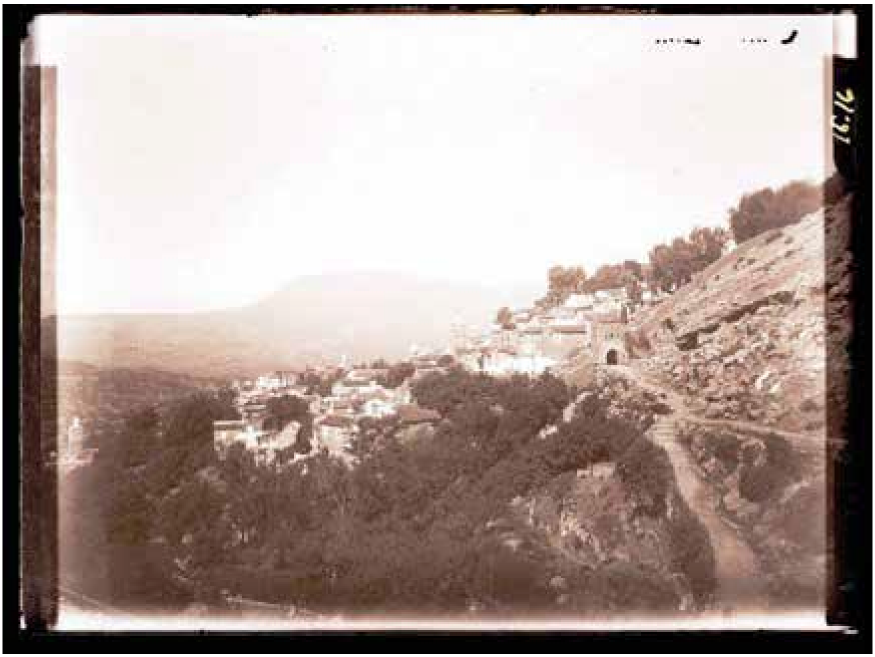
Around 1760 the Jewish families that lived outside the city expressed their discontent to the Sultan Mohamed Ben Abdellah regarding the attacks suffered from the mountain tribe of the *Khmas*. Mohamed El Arabi Raissouni, upon orders from the Sultan, established a piece of land inside the walls, and in the proximity of his own home, for the construction of a *Mellah* (Jewish quarter), thus integrating the Jewish community into the life of the medina. The Jews, who were well known for their skills as goldsmiths and merchants, would give a new thrust to the economy of the city. During the second half of the

18th century and the whole of the 19th, a period of decadence settles in as a result of the many political conflicts that plague the country.

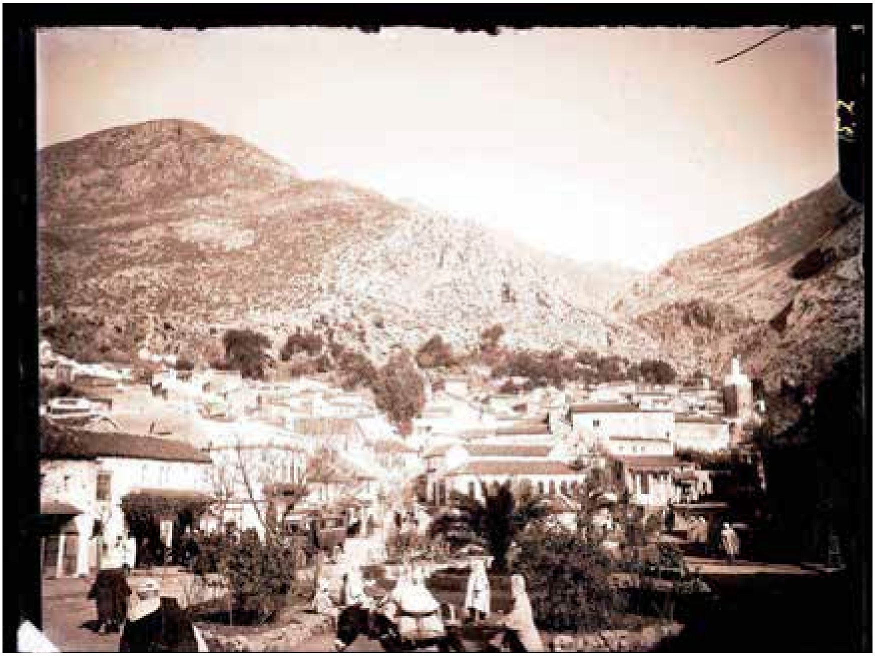
Origin and expansion of the new city and degradation of the medina (1900-2000)

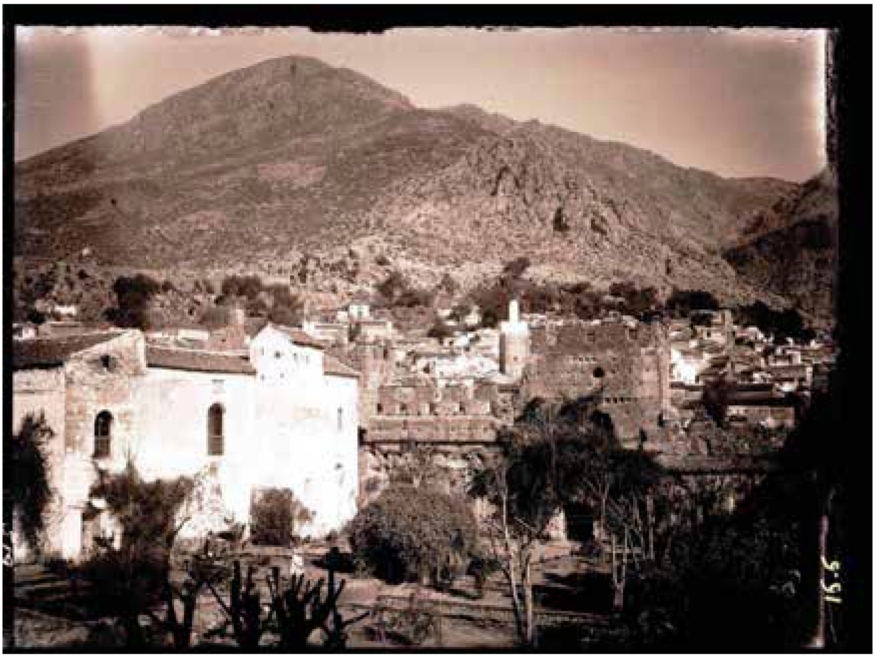
From the writings of Charles de Focauld, who in 1883 managed to spend a night in the city disguised as Jew, we learn that the total population at the time was somewhere between 3000 and 4000 souls, including some Jewish families.
In 1920 the Spaniards took over the city, marking the beginning of the Spanish protectorate. The city thus became once again a focal point of resistance to all foreign intervention until 1956, year in which the Kingdom of Morocco obtained its independence.
During the first period of Spanish administration (1920-1924), the road was built that connects Tetouan to Chefchaouen and the works were undertaken for supplying water to the camp and hospital which stood outside the medina. During the second period of Spanish administration toilet facilities and schools were built inside the walls and a new access to the medina was opened behind the kasbah. This was done by tearing down part of the old walls and the Al-Harmun gate. A project was undertaken as well to refurbish Outa Hammam square, which was renamed Plaza de España, with the inclusion of flowerbeds and a fountain at its centre.
The structure of the new city is characterised by wide avenues and great elongated rectangular blocks of buildings. This was the first urban development plan for the city of Chefchaouen, which was never entirely carried out, yet was the basis for the second, drafted in 1928. This second and definitive project for the expansion of the city still includes the idea of creating a new circular Plaza de España, this time outside of the medina, thus giving back its old name to Outa Hammam square.
The expansion of the city will therefore take place along the axis that links the medina to the new Plaza de España, currently known as Avenue Hassan II. Both development plans were based on the idea of a garden-city. During this period a series of service buildings were constructed, such as the hospital, the post office and the Catholic church, all under the direction of architect Manuel Latorre Pastor.
During the early Thirties Spanish engineers designed a new water distribution network, while at the same time the medina was paved.
The first local strategic development plan for the city (*Plano de Ordenación de Xouen*) was drafted in 1944 by architect Pedro Maguruza. In it the urban fabric is reorganised around the current Mohammad V square (ex Plaza de España). The plan does not give the attention it

and opposite page
General view of the city
ca. 1910-1930
photographer: Paul Servant (1878-1958)
© Tangier American Legation Institute for Moroccan Studies (TALIM)
http://archnet.org/sites/18200



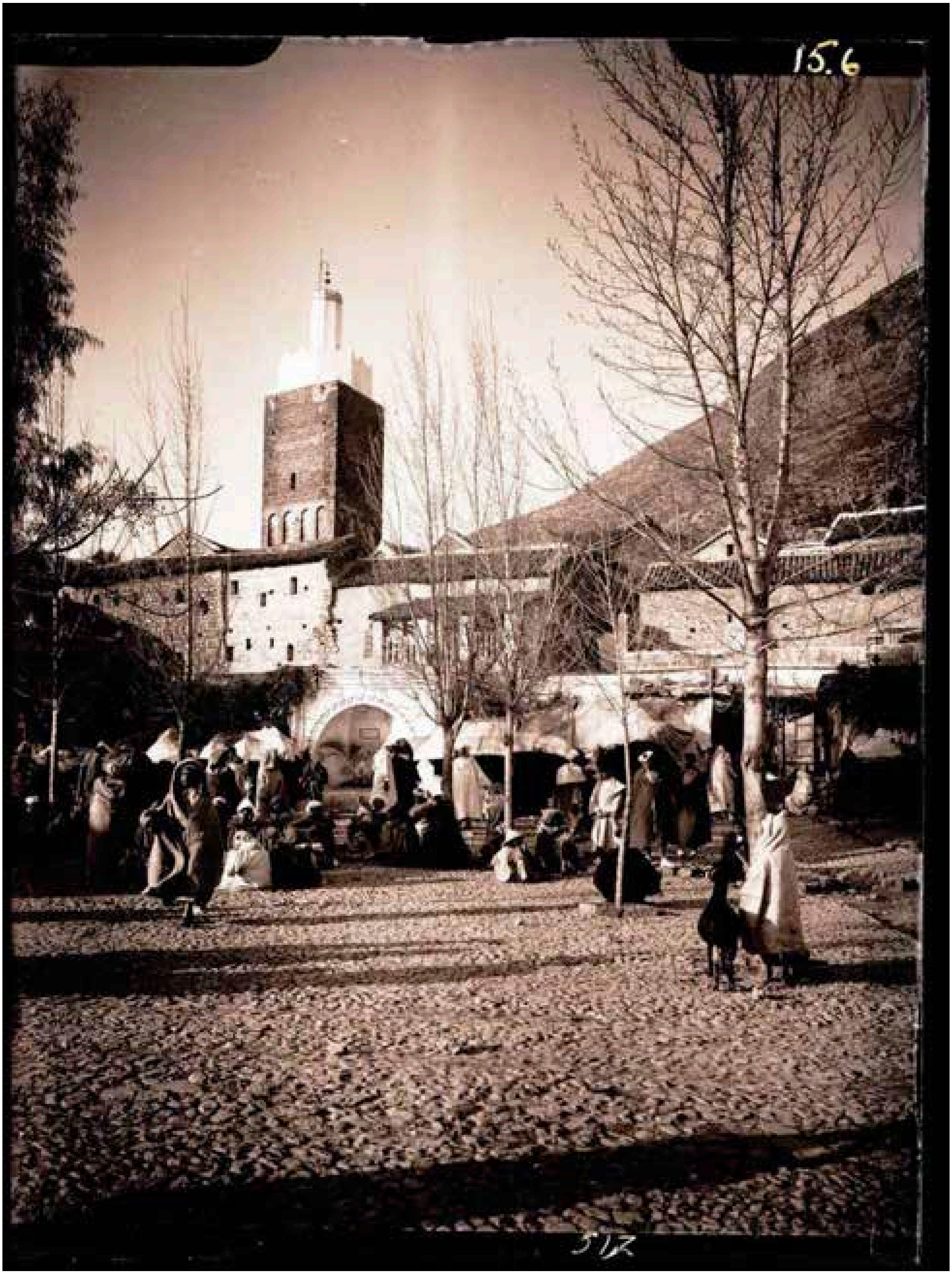
Views of the city, the walls, and Bab Onsar
ca. 1910-1930
photographer: Paul Servant (1878-1958)
© Tangier American Legation Institute for Moroccan Studies (TALIM)
http://archnet.org/sites/18200





Views of Outa Hammam square before the restoration of the Kasbah
ca. 1910-1930
photographer: Paul Servant (1878-1958)
© Tangier American Legation Institute for Moroccan Studies (TALIM)
http://archnet.org/sites/18200

opposite page
Jamaa Sebanin, Exterior view of a public square and minaret of the mosque
ca. 1910-1930
© Tangier American Legation Institute for Moroccan Studies (TALIM)
http://archnet.org/sites/18200


15.6

opposite page
Exterior view residences on the road to town
ca. 1910-1930
© Tangier American Legation Institute for Moroccan Studies (TALIM)
http://archnet.org/sites/18200

deserves to the relationship between the medina and the new city, and establishes only a few main communication routes and some land to be allocated for future expansion. From the Seventies onwards there has been an increase in population that has resulted in a non-regulated expansion of the city. After the Eighties the medina underwent a process of decay due mostly to the progressive abandonment of dwellings, faulty and insufficient infrastructures, especially sewers and garbage disposal systems. The increase in population density in the medina resulted in the uncontrolled addition of storeys and sections to the existing buildings, often upsetting their original morphology, with courtyards and pitched roofs, ultimately damaging the architectural heritage and the structural safety of the buildings. The city outside the walls increasingly accommodates those inhabitants of the medina who no longer find adequate dwellings in the historic centre. This is due either to the lack of space, or else to the inadequacy of the old buildings in terms of the needs of modern city life.

References

AA. VV. 2001, *Il Marocco andaluso. Alla scoperta di un'arte del vivere*, Electa, Milano.

Boujibar N. El-Khatib 2002, *Chefchaouen. The holy city of the Rif Mountains*, in Touri A. et al., *Andalusian Morocco: A Discovery in Living Art*, Museum With No Frontiers, Vienna. Kindle edition.

Dipasquale L. 2009, *Formazione ed evoluzione della città*, in *Chefchaouen. Architettura e cultura costruttiva*, in Mecca S., Dipasquale L., Rovero L., Tonietti U., Volpi V., ETS, Pisa, Italia, pp. 49-56.

Dipasquale L., Mecca S., Rovero L, Tonietti U. 2008, *Technical knowledge and traditional architecture in medina of Chefchaouen (Morocco)*, Proc.2nd Int. Conf. on Mediterranean Heritage RIPAM, Universitè Cadi-Ayyad, Marrakech.

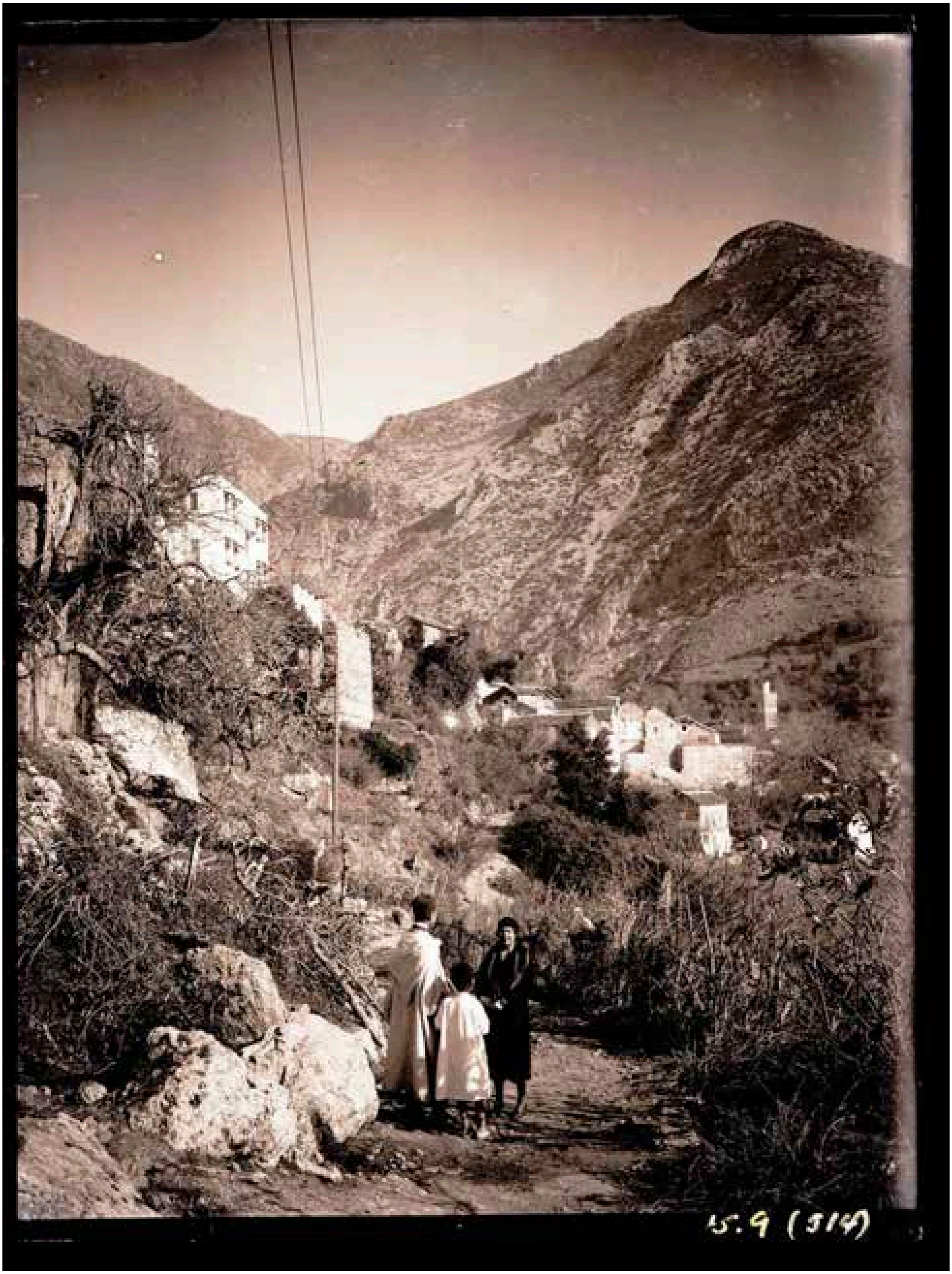
Direccion general de arquitectura 1944, *Plan General de ordinacion de Xauen*, Ministerio de la Gobernacion, Madrid.

Ingeneiros Consultores (A. E. C. I.) 1997, *Schema Directeur d'Amenagement Urbain S. D. A. U. Chefchaouen*, Royame du Maroc, Ministere de l'interieur, Reino de Espana, Ministerio de Asuntos Exteriores.

Naciri M., El Hassani A. 1985, *Etude architecturale de la medina de Chefchaouen*, Royame du Maroc, Centre National de documentation, Sevice de Reprographie et Imprimerie, Rabat.

Roca J. R. 2011, *Tangier and Its Surroundings, Assilah and Chefchaouen an Illustrated Guide*, J. R. Roca, Alicante.

Nieto A. B. 2000, *Arquitectura Y Urbanismo Español En El Norte De Marruecos*, Junta De Andalucía, Consejería De Obras Públicas y Transportes, Sevilla.



Urban fabric

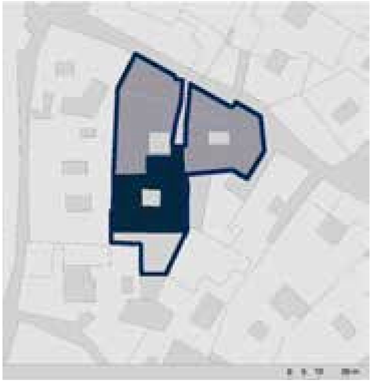
The morphology of the medina developed in strict relation to the environmental and topographic features of the site, while at the same time responding to social and cultural needs in its distribution of dwellings and public spaces. The source of Ras el Maâ river, located outside the walls to the north-east of the medina, was fundamental both in the choice of the foundation site and in the later development of the shape of the city. Still today it supplies water to the whole city, feeding its fountains, providing energy for mills and irrigation for gardens and orchards.

The medina has a dense fabric, with narrow and winding alleys. The urban structure is not determined by a grid of streets, as in the Hyppodamean model used in cities under Greek and Roman influence, but rather the result of the aggregation of buildings that form sections of the city, apparently without any strategic urban plan. The way in which buildings are grouped together, in strict conformity to the site, which is characterised by a complex and uneven geography, has produced the existing urban fabric and the distribution of the city's spaces. Its complex structure is the result of the sum of a finite number of elements that constitute the grammar of the urban fabric. From an understanding of its elements we can reveal its structure. Quoting Roberto Berardi's study of the medina of Tunis:

> *L'espace de la ville nous est apparu comme la définition, à partir d'un nombre défini d'éléments discrets, d'une série d'opérations d'articulation toujours plus complexes. Toute combinaison d'organisme est fonction de toutes les opérations qui ont mené à lui. Inversement, toute modification induite dans l'ensemble agit sur le sens des unités élémentaires composantes, les déforme en vue de nouvelles relations et de différentes finalités. Nous avons essayé de proposer le thème de cette ville comme l'étude du système de signes que les hommes ont tracé au sein de l'espace, avec les moyens donnés par l'espace, pour transformer le milieu naturel en leur propre milieu culturel* (Berardi, 2016, p. 146),

In order to understand the urban structure of Chefchaouen we can begin with an analysis of the basic elements that constitute the urban fabric:

FUP Best Practice in Scholarly Publishing (DOI 10.36253/fup_best_practice)



basic elements of the urban fabric
Dar, Derb, Hawma

- *dar*, the house, expression of family life;
- *derb*, the alley, expression of conviviality;
- *hawma*, the neighbourhood, expression of social interaction.

Dar, the house

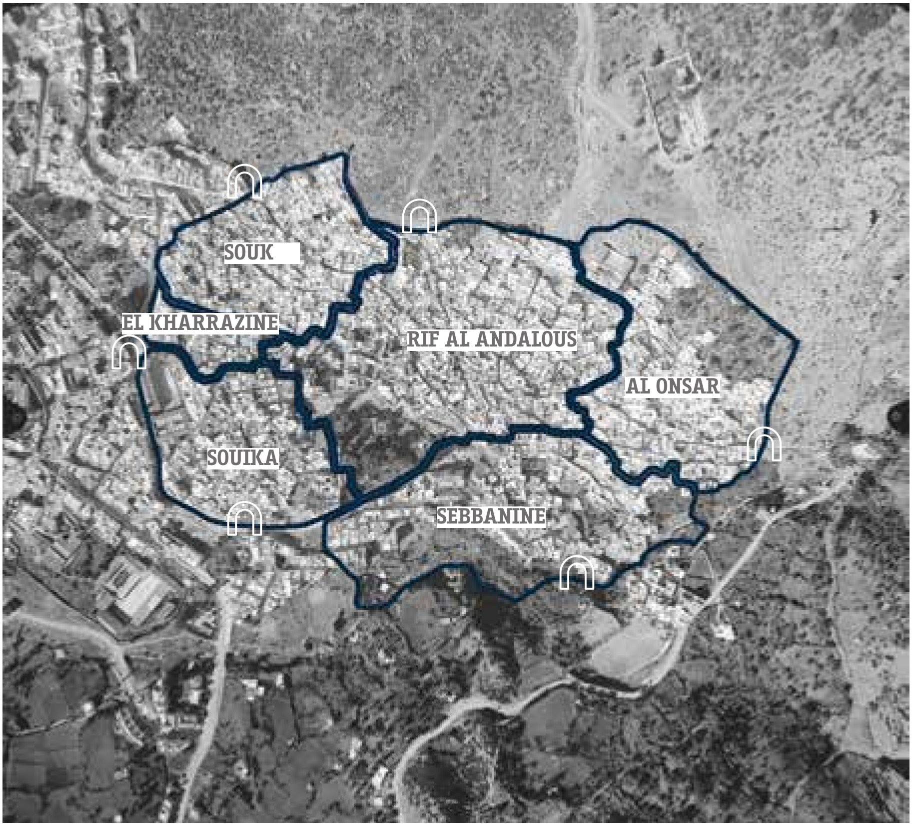
In the spatial organisation of the medina, the basic unit is the *dar*, the courtyard house, space of intimate family life which houses one or more families, often related and economically interdependent.

opposite page
Quarters in Chefchaouen
and access doors to the medina

The courtyard house is organised around the central courtyard, space of distribution and sharing of everyday activities. It opens to the public spaces almost exclusively through the main door, while the main windows face the interior courtyards. Before the Spanish occupation, whenever windows overlooking the street were necessary, they were small and protected by curtains and metal grills, in accordance with the precepts of the Quran and rules of social behaviour. This results in the houses being built leaning against each other, thus generating a compact urban fabric.
The dense and compact rhythm of the medina of Chefchaouen is therefore derived from the juxtaposition of cells, as in a beehive. The courtyard houses fit together, support each other, unite and intertwine; and thus what may appear to be the ground floor and first floor of a single dwelling could actually be part of an adjacent building.

Derb, the alley

The *derb* is a blind alley, and can be defined as a semi-public transit space onto which open the entrances to the dwellings. It is the common space for a certain number of houses which more or less revolve around a central nucleus, constituted by one or more



houses belonging to a well-to-do family which often gave its name to the alley and was in some way related, either economically, by blood ties, or simply as neighbours, to the rest of the inhabitants of the *derb*.

In addition to serving a distributive function at the urban level, the *derb* represents an extension of the house, an actual filter between the city and the interior of the dwelling. The inhabitants of a *derb* form a small supportive community. The relationship between the neighbours of the *derb* is traditionally intense and characterised by everyday visits, the sharing of meals, reciprocal assistance, participation in a variety of ceremonies and rituals, exchanging gifts and loans (Metalsi, 2016). Administrative matters, as well as the care and maintenance for common spaces are also regulated by shared rules that are based on the respect for the neighbourhood. This is also the place where many everyday activities take place, from children playing to the social interaction of women: the boundary between pub-

Derb, the alley

lic and private spaces is uncertain. The *derb* communicates with the exterior through a wider street (*sáncat*), which belongs to the higher level: *hawma*, the neighbourhood.

Hawma, the quarter

The life of the medina is organised around quarters, or neighbourhoods, known in Morocco as *hawma*. The *hawma* is a space that is intensely lived and clearly perceived by its inhabitants: all everyday needs are fulfilled by the services present in the neighbourhood: bakeries, public baths, fountains, mosques, *záouia* and shops for victuals and provisions. Within the *hawma* there is a reciprocal social control; behaviour rules are highly respected values, which regulate any rivalries between the inhabitants. Until the end of the 19th century the quarters of the medina were very closed organisms, they had their own walls

and its inhabitants shared social and geographic origins. Today the sense of belonging to one's *hawma* is still very strong, yet the various quarters communicate through economic and social interactions.

Quarters in Chefchaouen

The medina of Chefchaouen is currently divided into six administrative quarters: Souika, Rif Al Andalus, Al Onsar, Sebanine, Souk, and El Jarrazine. Each of them has peculiar social and morphological features related to the terrain, the presence of certain services, its position vis-à-vis the main square or the gates to the medina.

The *Souika* quarter lies at the core of the city's nucleus. It was initially surrounded by walls, some sections of which still remain. The name of the quarter, which literally means "small

Rif Al-Andaous quarter

opposite page **Al Onsar district (© L.Lupi, 2007)**

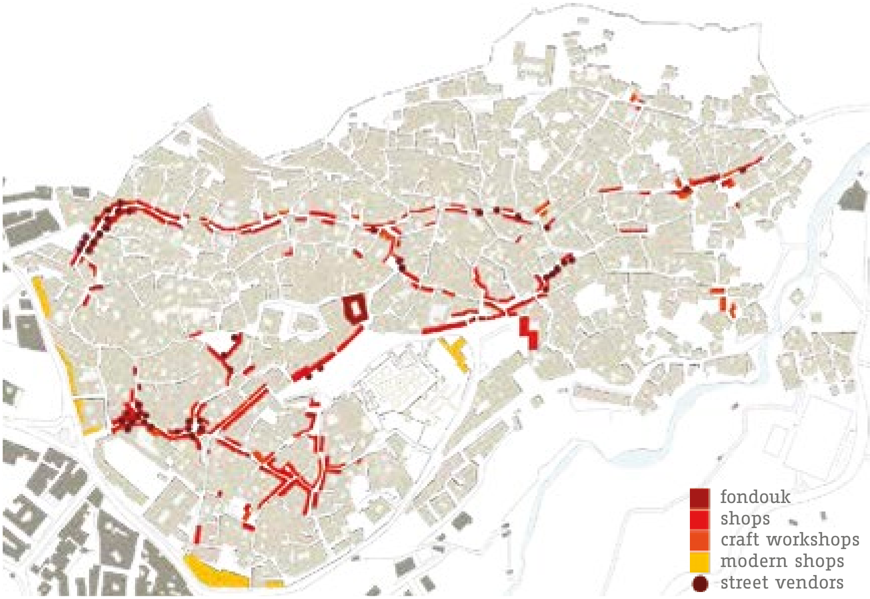
market", is due to the enclosed market, the *kissariya*[1], which was built at the end of the 15th century. The market has expanded to include the narrow alleys of the quarter, which houses a dense series of shops which provide products of all types. The oldest, and also most beautiful houses of the medina are located within this maze of alleys. Many buildings have been renovated thanks to foreign funding, and a considerable number have been turned into hotels. The gates of traditional houses are carefully designed: their height and ornamentation are a distinctive sign of the economic status of the family.
The *Rif Al-Andalus* quarter, created for housing the second wave of Andalusians that arrived after 1492, was built outside the first city walls. The organisation of the space is

[1] *Kissariya* is the old name for the covered market, an enclosed are with very solid doors and a great hall where goods and handicrafts were stored and sold, thus serving as a sort of primitive shopping mall (Metalsi, 2016)

characterised by the great slope of the terrain, The buildings are usually two or three-storeys high and in some cases have opposite entrances on different levels, taking advantage of the slope in the terrain. The narrow residential alleys often have steps for overcoming the said slopes, and rock walls as buttresses.

The *Al Onsar* quarter originated halfway through the 16th century as a result of the new wave of Andalusian refugees, and its development is closely linked to the source of Ras el Maâ river, outside *Al Onsar* gate (literally "the woman"). Carpentry and textile workshops are situated in this are. It is the quarter that has undergone the most transformations over the past years: some buildings have been abandoned while other have been restored, often deeply transforming the original structures.

The *Sebanine* quarter also originated in the mid-16th century and is closely related to the presence of the river. Many mills which provide flour to the ovens of the medina are located



Commercial and productive activities

opposite page **Traditional services in the medina**

in this quarter. The social life of the neighbourhood takes place around *Sebanine* square, which has a mosque, a bakery and shops. To the south, which has developed over the past few decades, the urban fabric is very different: the new streets are wide and the buildings are high and with windows.

The *Souk* quarter, the last within the historical centre, originated in the early 17th century with the last wave of Andalusian immigrants, the *moriscos*. It begins at *Bab Souk*, which is currently one of the most important points of entry into the city, to the north and south of one of the main thoroughfares of the medina, Avenue Hassan I. The alleys in the residential section, located in the upper part of the neighbourhood, are very steep and narrow, with the houses often placed directly against the rock.

The *El Jarrazine* quarter was chronologically the last, and its development began during the 17th century. It is located between the quarters of *Souk* and *Souika*. Its morphological features are very similar to those of *Souika*, although it includes several buildings which have a more modern structure. At its core lies *Hauta* square, characterised by a central four-sided fountain and paving with Andalusian motifs.

Services, commercial and productive buildings

The elements that characterise the collective and productive dimension of the medina are: the *souk*, the *foundouk*, the *hammam*, the religious buildings, the artisans' work-

shops, the ovens and the mills. While the residual space is located around the *derbs* – in turn made of the aggregation of courtyard houses –, the commercial and productive space is the result of the aggregation of a linear series of cells: the shops and workshops. All public buildings in the medina are located around *Outa Hammam* square, along the main roads that lead to the gates to the medina, and along some secondary roads adjacent to them.

The souk

The main commercial space is the *souk* (or *sùq):* this is where deals and commercial exchanges take place. It is a noisy and animated place which contrasts with the peace that pervades in the residential neighbourhoods. This space of flux, which provides all the products necessary for the life of the medina, is also a place of social interaction between merchants, people from the rural areas and from other cities, tourists and the inhabitants of the medina.
The *souk* is constituted by small shops placed alongside the street. The cells of the *souk* house small artisans' shops and workshops, who work and deal in leather, textiles and carpets; many small shops sell victuals and goods for everyday use; small herbal stores offer natural cosmetics to both locals and tourists.
Berber women from rural communities sell vegetables, fruit, bread and eggs in the streets of the *souk,* in addition to other street vendors who sell all types of goods throughout the market (candy, cheese, tobacco, etc.).

Souk streets (© L. Lupi, 2007)

The cells of the *souk* are small, and either square of rectangular. The average cells is approximately 3 m high, 1,50-2 m wide and 2-3 m long. The doors, which open outwards during the day, as well as the walls and exterior section of the shop, are used to put the available goods on display. These goods can be handled directly and are not placed behind shop windows. The interior of the shop is often separated from the street by a wooden plank that the seller must step over in order to enter.

Production and commerce is regulated by corporations, known as *hanta*. The corporation plays both an economic and social role, and also serves the purposes of a workers' union. Production is organised into small autonomous production units. The *amin*, or head of the corporation, has the assignment of controlling the quality of the produced goods, of defending the activities carried out outside of the corporation, as well as of assisting the members of the corporation whenever they find themselves in trouble.

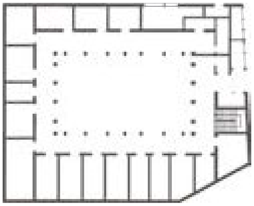
Souks are located along main thoroughfares. In particular the streets of the quarter of Souika are the core of the commercial area of the medina.

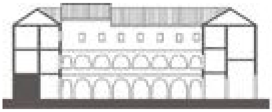
The fonduk

The *fonduk* (or *fundouq* or *fondak)* is one of the most ancient institutions in the medina. Originally created for organising the commercial relations between the city and the mountain communities, it is a large structure that provides accommodation to travelers, merchants and rural inhabitants who come to the medina to sell their agricultural products and buy mostly crafted goods. It was originally devised as well as shelter for animals and as storehouse for goods. The building is organised around a central courtyard which is accessed through a single monumental entrance that opens onto the street and which houses a doorman or the administrator of the *funduk*, who welcomes visitors. The courtyard is surrounded by porticoes; the rooms on the first floor were reserved for providing accommodation to travellers, whereas those on the ground floor were used as storehouses and occasionally as stables.
Of the four *funduk* in Chefchaouen, only one is still used for its original purposes, the rest are no longer in use and waiting for rehabilitation. It is located at the north-west corner of Outa Hammam square and is also the largest, with a total surface of approximately 596 m^2. It has approximately fifty rooms between the ground and first floors, as well as pantries, storerooms and latrines. The central courtyard is paved with rounded pebbles and is surrounded by a portico which has a series of small rooms currently used as storerooms. On the first floor the covered balcony serves as distribution for the rooms, currently used as storerooms but originally for accommodating travellers and merchants.
Some restoration interventions can be observed to the colonnade of the lower portico and in the upper balcony: the columns that were situated to the right were substituted by pillars in reinforced concrete and some spaces in the upper left balcony were walled in to enlarge the rooms. The building has a sober and simple style; the only decoration is on the exterior facade of the entrance. Very carefully designed and maintained, like all doors to public buildings in Chefchaouen, it has a roof supported by built-in columns and a series of stalactite-like decorations. The opening in which the door is situated has the shape of a broken horseshoe, above which is an arcade with smerlons.

The hammam

The *hammam* has always played a fundamental role in Muslim society. Its function is linked to ritual ablution; the faithful visits the *hammam* for acquiring the state of purity that is necessary for prayer; purification is in fact one of the essential aspects of Muslim practice. Bathing





Fondouk of Outa Hamma place
Schematic plan, cross-section, and views of the courtyard
(photos © L. Lupi, 2007)

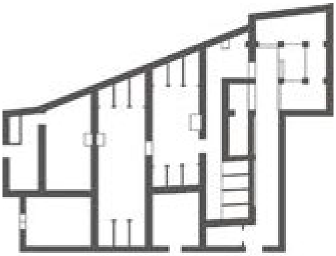
in Islamic culture is not only a religious practice, but also a distraction and a pleasure, and baths are places for social interaction; adults, the elderly and children go to the *hammam* to bathe, have a massage, to chat and relax. *Hammam* were built next to mosques so they could be used for ablutions before prayers, and also occasionally inside the homes of well-to-do families.

The architecture of the Islamic *hammam*, especially those of the Middle East, was influenced by that of the baths belonging to earlier civilizations as Romans and Byzantines (Raftani & Radoine, 2008). The influence of the existing Roman public bath or *thermae* is noticeable at the following levels: the *hammam's* layout as a linear spatial organization; the same progression of three rooms with different micro-climatic ambiances with the cold room (*frigidarium*), the warm room (*tepidarium*) and the hot room (*calidarium*); the central heating system (hypocaust); and the canalization system (Raftani & Radoine, 2008). The presence of three bathing spaces with varying temperatures can be considered as a typical characteristic of the Moroccan *hammam*, in contrast with the *hammam* of the Middle East where the cold room has almost disappeared. The architecture of the *hammam* of Chefchaouen is far from being monumental. The *hammam* buildings are well integrated within its urban fabric, they embrace the scale of its neighbouring buildings and are not seen immediately from outside. The physical volume and size of the hammam reveals itself only if one gets to the top of one of the neighbouring terraces because of the vaulted roof.

The *hammam* of Chefchaouen follows a simple linear layout: immediately after the entrance, always after a turn, there is the undressing room. This is the most important space in the *hammam* in terms of proportions and decorations. The hammam reception area is also located within the undressing space. Along the walls there are small niches for keeping clothes. After the undressing room there is a transit space that is not heated, yet kept warm by its proximity the heated room. The cold room is often equipped with a cold-water basin and a subsidiary space accommodating the toilets.

After this there is a first heated room, or warm room, which allows the body to gradually adapt to the high temperature of the following space, the steam room, *el-wasti* in the local dialect. This is the bathing spaces, that follow a typical transition from the cold room to the hot room where the basin of hot water is located. The bathing areas is composed of a long and narrow rectangular rooms roofed by barrel vaults.

The hot room is locally known as *ed-dakhli*. This space is generally composed by a long rectangular plan adjacent to the furnace and covered by a barrel vault. Both the warm and the hot room usually have a series of private washing niches with stone or brick benches (called *mtahra)*. The hot room is also equipped with a wall basin for hot water (called *barma)*, where



Hammam
Schematic plan, *cross-section*, external and internal views (photo ©L. Lupi, 2007)

opposite page
Traditional mill

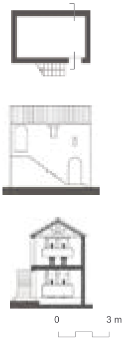
the hot water arriving directly from the furnace. The Quran prescribes the use of running water for ablution purposes, which in fact are carried out by sprinkling rather than by immersion.

Interior lighting is limited, yet ensured by small skylights inserted in the vaults of the roof, whereas aeration is obtained through vents located on the walls. There is no furniture other than wooden benches with cushions along the walls in the undressing room. The furnace (locally named *farnachi*), has an independent entrance from the street, which is used for supplying firewood. This room is separated from the hot room by a thin wall with small perforations which allow the passage of hot air and ventilate the space. The hot water, cold water and drainage circuits all use terracotta tubing.

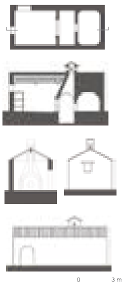
The textile workshops

Textile production is one of the main productive activities in the medina. Products include woollen textiles – used for making *djellabas*, the traditional garment that is a sort of hooded tunic –, woollen carpets, linen fabric and traditional cotton fabric with red and white stripes that Berber women wear on their shoulders and around the waist.

The workshops that produce textiles are mostly located in the quarters of Souika and Rif Al-Andalus. They are generally rectangular, approximately 8 m long and 2.5 m wide, and covered by a double pitched roof clad with red tiles. They are divided into two rooms, one



Textile workshop
Schematic plan, cross-section, facade, external view



Public oven *(farran)*
Schematic plan, cross-section, facade, external view

above the other, each with an independent door that opens on the same facade: access to the upper room is through a stone staircase on the outside of the building. There are two looms in every room. Lighting is limited since it comes in only through the door and small openings or embrasures. The walls are usually in rough stone; clay bricks are used in order to strengthen the corners and abutments of the doors and of the small skylights.

The mills

Located along Ras el Maâ river, their construction is attributed to Andalusian Spaniards who, since the foundation of the city, organised an ingenious water system. Their architecture is simple and consists in a small rectangular structure divided into two levels: the ground floor which houses the millstone, and below it the space that contains the water wheel.
The water from the river is channeled from the main course of the river to the mill; the strong pressure of the water activates an iron wheel with paddles that, through a vertical wooden gudgeon, transmits the movement to the millstone placed horizontally on top of another grindstone that is fixed. The grain is inserted through a large wooden funnel placed above the millstones, whereas the flour is collected in a crate placed below them.

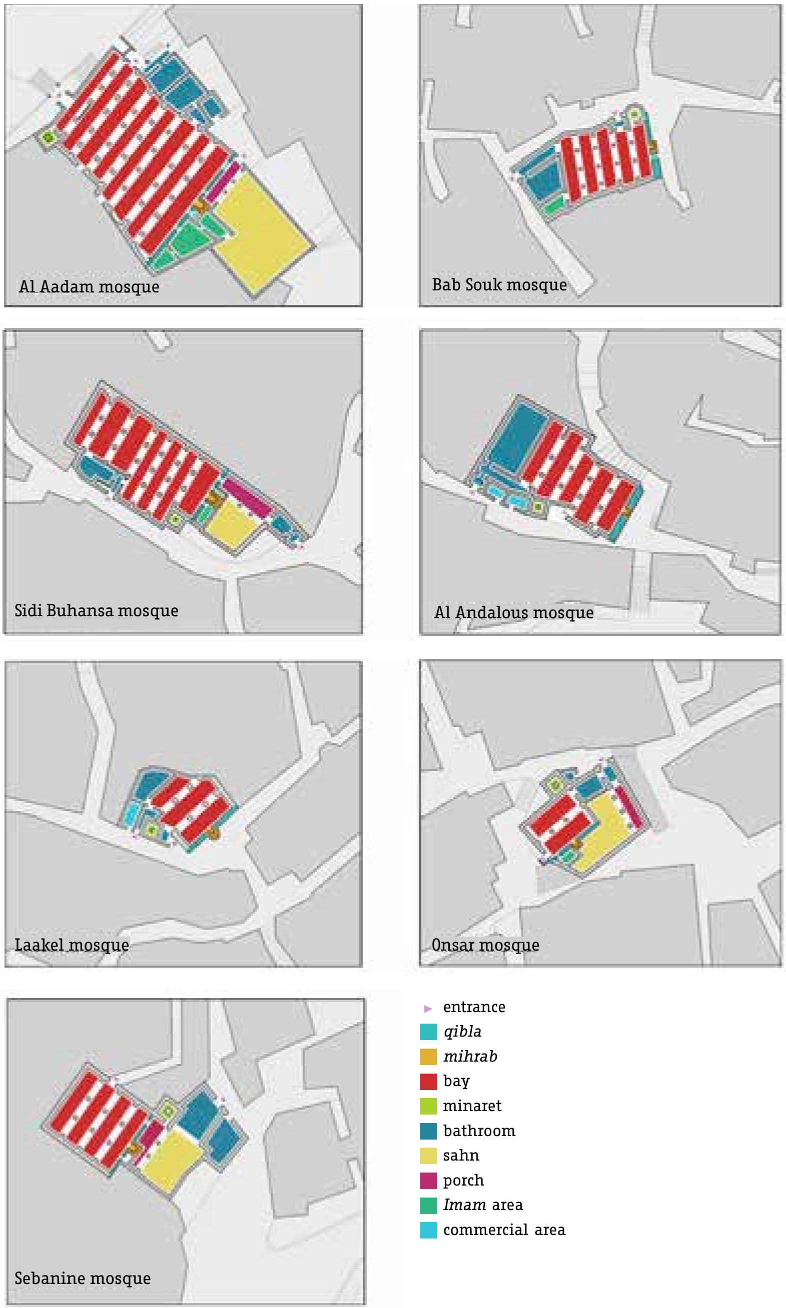
The public oven (farran)

Fifteen *farran* are still active in Chefchaouen. They are usually located at the crossing of main neighbourhood thoroughfares and serve families who make their own bread-dough at home and need an oven to bake it.
The structure of the oven is a brick vault; the mouth of the oven is placed at ground level, and those who bake stand inside a hole 3-4 m^2 and 1 m deep that is located next to the mouth of the oven. The walls of the oven are in rough stone and have perforations for ventilation.

Religious buildings: mosques

The word mosque derives from the Arab *masjid*, meaning “place of prostration before God”. It is a spiritual and also a place of social interaction for the faithful who meet there on Friday, the holy day, and five times a day, at the time of the *djamaa*, the call of the *muezzin* from atop the minaret.
The architecture of the mosque finds its origins in the home of the Prophet in Medina, a private space used as a place for prayer and social interaction characterised by a large square courtyard approximately fifty metres per side, with two shaded areas. Muslims pray toward the *Kaaba* in Mecca, the sacred direction or *qibla*. Before prayer they must carry out ritual ablution as a symbolic act of purification of the individual before God. Once a week, Friday at noon, the community gathers in the collective worship led by the successor of the Prophet (*imam*). This is not only a moment of worship, but also an opportunity for transmitting news and decision. The place where the community meets on the holy day is known in Arab as *masjid al-jama'ah*, in other words the community mosque.
The centre of the medina in an Islamic city is usually where the main mosque, or Friday mosque, is located. It represents the spiritual and cultural life of the medina, and besides

Floor plans of the mosques in the medina of Chefchaouen (adapted from Nicosia V., 2008)



being a place of worship, the Friday mosque is also a political, cultural, administrative, legal and assistance centre.

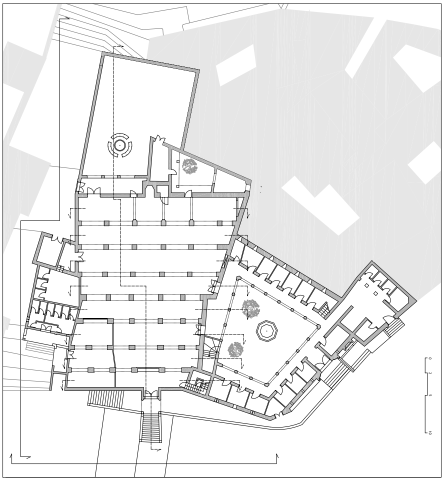
The space for common prayer is partly covered and partly exterior. At the centre of the courtyard or near it is located a basin, which may be accompanied by a fountain for the ritual ablutions. The size of the covered space (*haram*) varies in relation to the area of the courtyard (*sanh*) and the latter can be partly surrounded by a portico (*riwaqs*). The roofing of these spaces is double-pitched in all Chefchaouen mosques. The prayer hall, usually rectangular or square, in Chefchaouen is always hypostyle, with columns distributed regularly that support the structure of the pitched roof. The bays of the prayer hall, basic unit that is repeated as though it were a module, are always parallel to the wall of the *qibla*. Prayer halls in Chefchaouen are characterised by a certain degree of sobriety, the exterior walls are usually whitewashed with lime and the only decorative elements are the entrance doors and minarets.

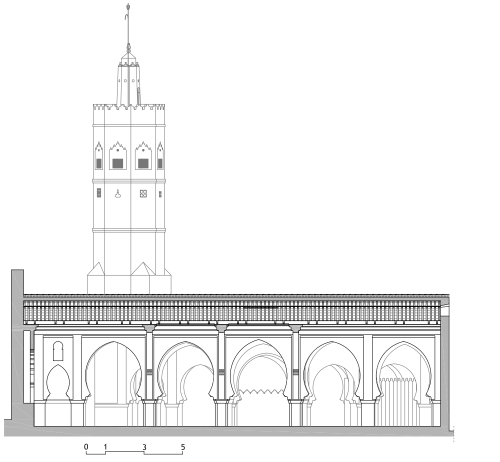
Mosques are always built with the *qibla* pointing in the direction of Mecca. Therefore a correlation exists between the *qibla* and the surrounding urban fabric. If the Mosque was built first, as it often is the case in many Islamic cities, then the street pattern would evolve around and from the Mosque. In the middle section of this wall is the *mihrab*, a niche or recess, richly decorated, that indicates in which direction the faithful should pray. The *minbar*, or pulpit is always placed to the right of the *mihrab*. It consists in a staircase of varying heights, atop of which stands a small platform with a small cupola or pyramidal roof. The *imam* who guides the Friday prayers also delivers the *khutbah*, or sermon, from this platform.

The function of the minaret is to call the faithful to prayer and from it the voice of the *muezzin* is broadcast. It has the shape of a tower, with a square or rectangular base, although some exist with an octagonal base, such as in the case of the mosques of Al Aadam and Bab Souk.

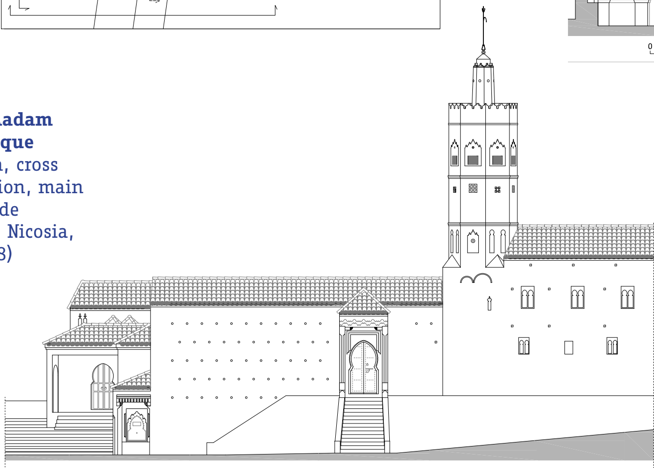
The main mosque in Chefchaouen, Al Aadam, is located next to the Kasbah, in Outa El Hamam square, which is also the heart of the medina of Chefchaouen. It is the *masjid al-jama'ah*, the community or Friday mosque, and constitutes the largest religious space of the city. It is also the oldest mosque: founded between the 15th and 16th centuries, it was restored in the 19th century and it has undergone further modifications during the 20th century, including the addition of the portico of the main entrance.

The prayer hall is 452 m^2 and occupies the central body of the complex. It is formed by eight naves which run parallel to the wall of the *qibla*. Every nave includes five or six horseshoe arches supported by pillars. The pillars are distributed on an irregular grid, aligned only along the direction of the bays, each of which is of a different size. The women's prayer hall is situated at the rear nave, with an independent entrance separated by wooden panels approximately 2 m in height.





Al Aadam mosque plan, cross section, main facade (©V. Nicosia, 2008)



opposite page **Al Aadam mosque view** (©L.Lupi, 2007)

The minaret is octagonal: the eight faces, divided into three parts, are decorated with arches sculpted in brick, either simple or polylobate, with square majolica panels above them. The corners, built entirely in brick, stand out due to their red colour, whereas the remaining parts have been tinted with an ochre colour that contrasts with the white of the lime that covers the upper part of the minaret and its lantern, and originally all of the walls of the mosque.

The prayer hall has three accesses. The main entrance is on Outa Al Hamam square and is connected to the level of the square through two wide flights of steps, one at the front and another lateral to the entrance gate. The second entrance is to the eastern side of the oratorium, under the public service portico, and leads to the back of the prayer hall, which is reserved for women. The last is from the side of the mosque adjacent to the *kasbah*, at the same level of the oratorium, and consists of two successive gates.

opposite page
Minarets in the medina

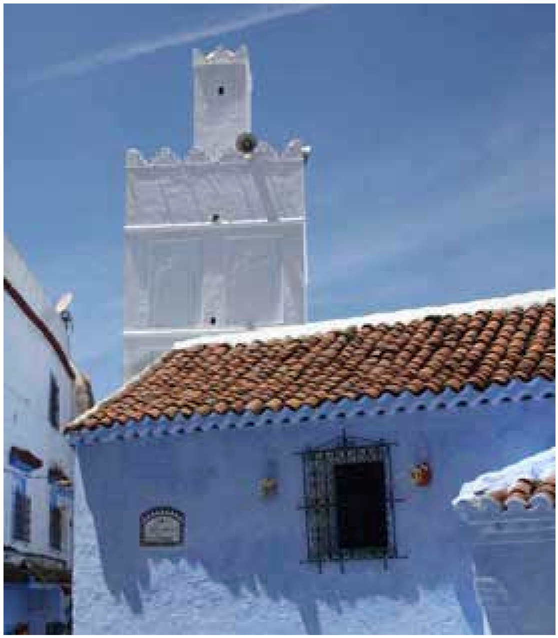
The mosque expanded together with the demographic growth of the city and underwent several restoration and maintenance interventions. The last restoration intervention is from 2006, the first after 1932. The walls, which used to be white with a light blue tint applied together with the lime, currently have ochre tones, similar to those of the nearby kasbah. White lime was used only for the base, the stairs and the toilets. The more important interventions involved the interior of the building and especially the roof. The eight bays of the mosque had a traditional Andalusian roofing system. The decay of the parts in wood, due to decades of neglect and lack of maintenance, resulted in the tearing down of the original roof, and in its exceptionable replacement with double-pitched roof in reinforced concrete with the intrados clad in painted wooden panels which simulate the original roof.

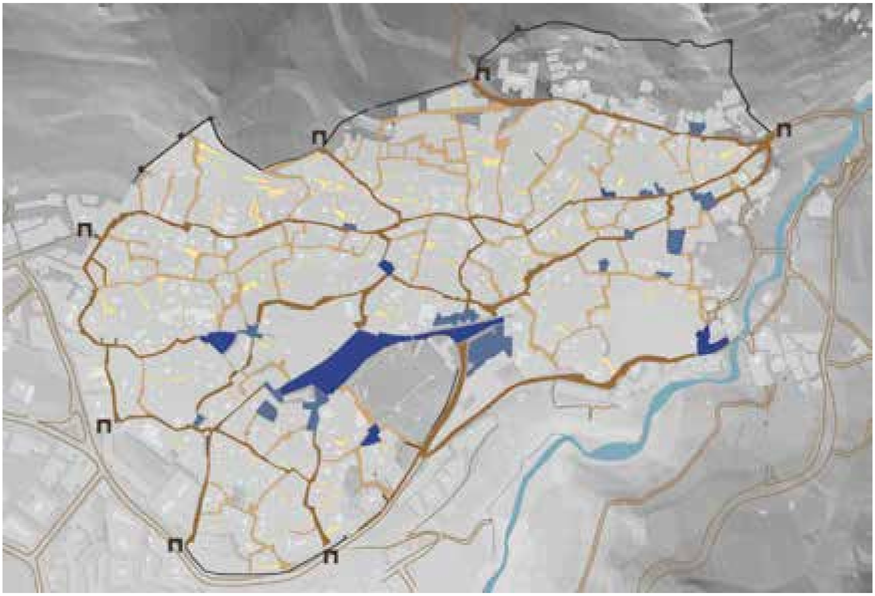
All the quarters have a mosque, and next to them stand other religious structures, the Quranic schools known as *madrasas* or *medreses*, whose structures are similar to those of mosques (a covered prayer hall and an open courtyard), and the *zaouias*, mausoleums where the faithful gather at the tomb of a saint or at a cenotaph erected in honour of a saint, to meditate and recite Quranic verses.

The main mosque and Sebanine mosque are the only that stand on a square. The rest are located within the dense network of alleys of the medina and their presence is only perceived at the last moment, when the minaret appears among the surrounding buildings.

Streets and public spaces

The streets are characterised by a constant flow of activity. Place for transport, connection, commercial exchanges and social interaction, the streets sharply contrast with the





Street hierarchy
- squares
- widening
- main roads
- secondary roads
- alleys
- city gates

courtyards of houses, which are places of tranquility and silence. The width of the pathways is narrow, designed for allowing the passage of a loaded beast of burden. The course is generally uneven, given the morphology of the terrain, and interrupted, especially at crossroads, by widenings in the road which are used as meeting places.

The main thoroughfares follow the natural terracing of the contour lines. The orientation of the main roads was strongly influenced by the direction of the flow of the water which was channeled from the source following the course of the terrain so as to supply the whole medina.

It is rather hard to find one's way within the dense network of alleys, due to the irregularities of the pathways and the sparse landmarks. The sound of the water from many fountains, the various smells, the appearance of the large wooden gates and the voices of children and merchants are important signs for orientation. Despite the rather tortuous paths, it is possible to identify a main system for traversing the medina. A first axis begins at *Bab Souk,* crosses the medina passing through the heart of the city and the souks and reaches the gate that leads to the river, *Bab Onsar*. A second thoroughfare begins at *Bab Al Mukaf* and reaches the main square, *Outa Hammam*, which is the centre of the social life of the city. Secondary roads branch off from the main streets, occasionally intersecting with the into the residential sections of the medina, quieter and free of shops and services.

Place Outa Hammam (©L.Lupi, 2007)

opposite page **Place El Haouta**

Another urban feature of Chefchaouen is the covered passages (*sabbat* or *qantra*). These are small parts of buildings that jut out, thus connecting buildings standing on two sides of the street. Their role is first of all functional, since they enlarge the area of first floor levels of courtyard houses, but it is also structural, since they provide support for the walls of both buildings. This is usually where the *Mesria* (the master bedroom) is located. They create a shaded area in the street which then becomes a place for social interaction and a reference point for passers-by.

Squares and widenings

Outa Hammam square, which has an area of 3,000 m^2, is the largest and most ancient square in the medina. It is located at its centre and all main arteries start from it. Originally, and until the Nineties, a market took place on the square two times per week

which served the inhabitants of the city and the peasants and shepherds from the surrounding areas.

The most important public buildings of the city are located around this square: the main mosque, the *Kasbah*, the *funduq* and the *hammam*. Its current appearance is the result of a recent intervention; the mosaic and pebbles pavement, the leafy trees and the cafe-restaurants with open-air tables.

Inside the medina squares are rare and are located at the crossroads of main thoroughfares. They are important places of social interaction and commercial exchange. *Kenitra* square, which is one of the main commercial areas, is located in *Rif Al Andalus* quarter. The visual space focuses on the wall fountain placed at the lowest level of the square, where the radial pavement converges. *Sebanine* square is the fulcrum of the quarter of the same name: dominated by the presence of the mosque, it opens towards the views of the river, with its distinctive stone bridge, and of the surrounding mountains.

Secondary roads of the medina (©L.Lupi, 2007)

Zaituna square, located in the *Al Onsar* quarter, is very scenic due to its rugged topography: a centuries-old olive tree at its centre is the most remarkable feature and gives its name to the square (*zaitun* means olive in Arabic). *Haouta* square, which has been restored 10 years ago, has a pavement (*sarbíia*) decorated according to the Andalusian technique of decomposing the plane for creating geometric motifs (the art of the geometric decomposing of the plane is called *tser*, which literally means intertwining). The rich decorative motif is made in stone and the geometric figures that form it are the typical Arabic six-pointed star (*qbachouna*) and four-hammer decorations; the two figures intertwine in a play of solids and voids. At the centre of the square stands a four-faced fountain, which is also decorated in the Andalusian style.

There are other widinings in the medine, sometimes at a crossroads and others at a void created by the demolition of a building. There is often a fountain nearby with a group of men or elderly people in conversation or children playing.

The water supply network

Water is an element in the organisation of the medina's fabric: the water supply network is one of the main factors to condition the formation of the urban structure. The importance of water in an Islamic city is also influenced by the Quran, which prescribes giving water to the thirsty (Metalsi, 2016). The source of *Ras el Maâ*, whose position determined the location for the foundation of the city itself, is located to the east of the medina, outside the walls, and

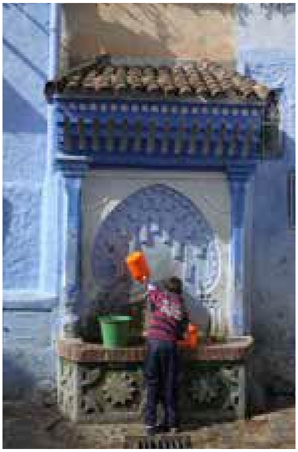

Covered passages *(sabbat* or *qantra)*

opposite page **Public fountains** *(seqqâya)*

is reached from *Bab Onsar* gate. The river supplies water to the entire city, feeds its fountains, provides energy for mills and irrigation for gardens and orchards.

Already after the first wave of Andalusian immigrants, the water distribution network had been organised by way of a system of channels which traversed the medina longitudinally: the underground channel, which is 80 cm wide, begins at the source and crosses the centre from east to west, adapting to the contours of the terrain. The water supply network hidden underground continuously reveals itself. Along its path there are in fact numerous fountains, and in the past also openings from which users could easily take with buckets the water they needed for their everyday activities. From this main channel, the quarters situated below and to the south, were supplied through secondary canals. Inhabitants from those neighbourhoods located to the north, and therefore at a higher altitude, needed to get their water from the main channel.

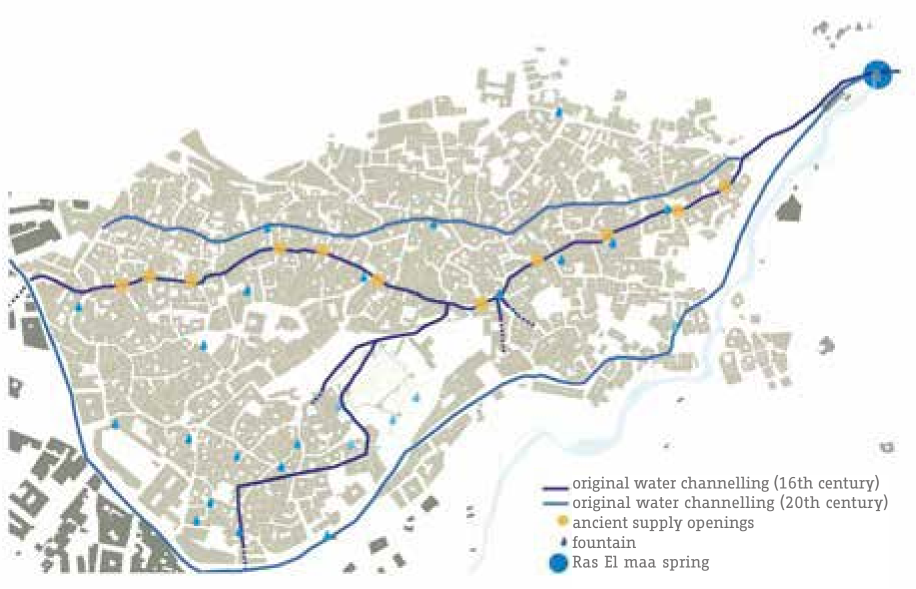
In the early 20th century the Spaniards introduced a modern system of water supply distribution which brought water to all of the medina's quarters. They built two new water distribution channels as well as electricity for pumping water to areas situated at a higher altitude than the main channel. They also built an aqueduct to the north of the city, which gathers rainwater and water from the source of Ras el Maâ, in order to distribute it in times of drought. From this moment onward many dwellings were equipped with private fountains (*maâda*).



Public fountains (*seqqâya*) are a typical feature of the medina of Chefchaouen: they are found on the street, either in widenings or at crossroads, and supply water to dwellings which are not connected to the water supply network. Fountains are never higher than 2 m, and when they are placed against a wall they never protrude more than 50 cm. They are divided into three parts: the basin, the arch and the roof. They are decorated with Andalusian-style arches and richly painted; some are four-faced and are covered by a four-pitched roof.

The fortification system: the walls and the Kasbah

The walls of Chefchaouen reflect the various phases in the history of the city. During the development of the medina, as new inhabitants arrived from the surrounding regions and from Spain, the walls were expanded in response to security needs. Today some sections remain of the last circle of walls which enclosed the city during the last expansion phase, whereas there are no traces left of the previous circles of walls, demolished for collecting building materials, or simply absorbed within the newer buildings. The section of the wall that is still visible and better preserved today is the one that encloses Al Onsar quarter to the east and to the north.
The *kasbah* – which in Arabic means fortified citadel – is located at the south-west corner of Outa Hammam square. It was the first building built by the founder of the city, Mulay Alì Ibn Rachid, between 1471-1472, as a military barracks and fortified residence. Its plan is rectangular: inside the walls there is a large garden and the old residence of the founder of the city, transformed today into a museum and a Centre for Andalusian Studies. The current residence dates back to the late 17th century, when Mulay Ismail was in power, and was certainly built by his governor, Ali Errefi; it has the classical shape of traditional Moroccan

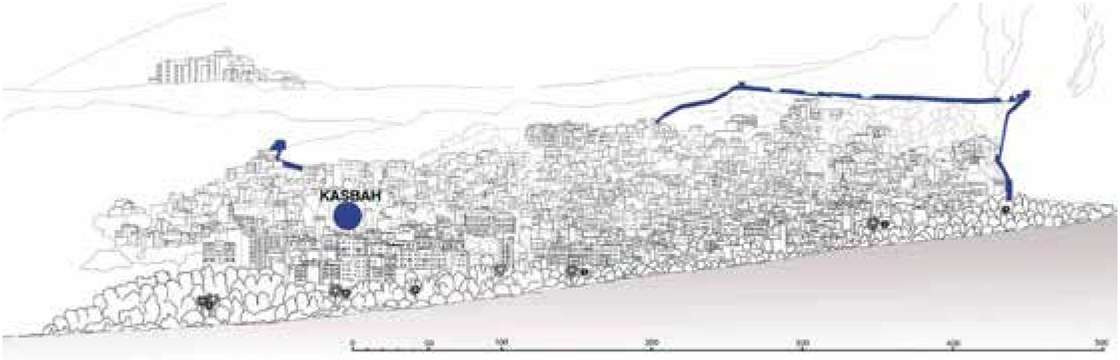


Water supply network

opposite page
Fortification system

houses, with a ground floor with a courtyard and a first floor with a balcony, now used as an exhibition space.

The *kasbah* is surrounded by a large wall in raw earth built using the rammed earth technique, crowned with merlons and with a walkway on the inner side. Ten towers, three of which were modified during the last restoration intervention, stand along the wall at varying distances between them. The whole structure is dominated by a large tower, 20 m high, which used to house the prison on its ground floor. The last restoration included an exceptionable intervention that attempts to conceal the work carried out by imitating in painting the texture of the wall. The *kasbah* is currently accessed by an entrance made on the north-west side of the central in 1930. It was originally accessed through a gate located to the east, in the direction of the *souk*, and another to the west, in the direction of the mosque. The one on the side of the *souk* is low and narrow, with an L-shaped entrance, which impedes seeing the inside of the structure from the street. *Yama' al-Kebir* gate, which is located on the side that leads to the mosque, is currently used as a space for temporary exhibitions.



References

AA. VV. 2001, *Il Marocco andaluso. Alla scoperta di un'arte del vivere*, Electa, Milano.

AA. VV. 2002, *La medina di Tetouan,Guia de arquitectura*, Junta de Andalusia, Sevilla,

Bianca S. 2000, *Urban Form in the Arab World - Past and Present*, Thames & Hudson, Zurich.

De Blasio B., Eslami A. (eds) 2003, *Luoghi di scambio e città del Mediterraneo*, *storie,culture, progetti*, Iriti, Reggio Calabria.

Eslami A. (eds) 2002, *Architetture e città del mediterraneo tra oriente e occidente*, De Ferrari, Genova.

Guez, J. P. 2003, *L'architettura del Mediterraneo*, Gangemi, Roma.

Jayyusi S. K., Holod R., Petruccioli A., Raymond A. (eds.) 2009, *The City in the Islamic World*, Brill, Leiden, Netherlands

Mecca S., Biondi B. 2005, *Architectural Heritage and Sustainable Development of Small and Medium Cities in South Mediterranean Regions*. ETS, Pisa.

Naciri M., El Hassani A. 1985, *Etude architecturale de la medina de Chefchaouen*, Royame du Maroc, Centre National de documentation, Sevice de Reprographie et Imprimerie, Rabat.

Nicosia V. 2008, *La medina di Chefchaouen: la moschea Al Aadam. Analisi delle tecniche costruttive e individuazione di strategie per il recupero,* Degree thesis, University of Florence, Florence.

Petruccioli A. 2007, *After amnesia: learning from the Islamic Mediterranean urban fabric*, ICAR, Bari, 2007.

Privitera F., Metalsi M. 2016, *Le signe de la Médina. La morphologie urbaine selon Roberto Berardi*, DIDAPress, Firenze

Raftani K., Radoine H. 2008, *The architecture of the hammams of Fez, Morocco,* Archnet-IJAR, « International Journal of Architectural Research»- Volume 2 - Issue 3 - November 2008, pp. 56-68.

City walls
(©L.Lupi, 2007)

Bab Souk
(©L.Lupi, 2007)

opposite page
View of the Kasbah
(2017)

View of a courtyard (©L.Lupi, 2007)

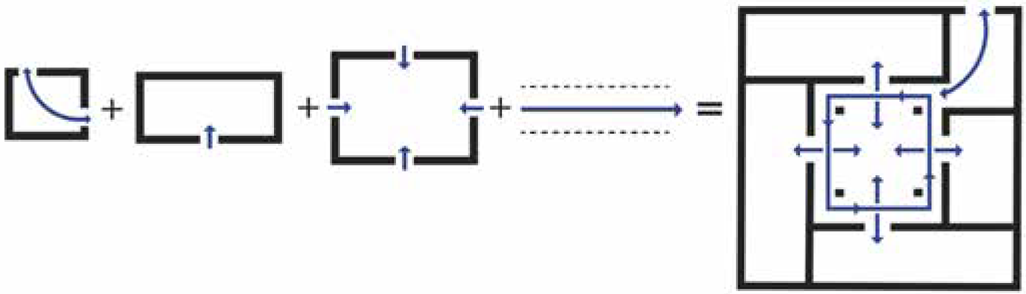
The courtyard house, typological model and basic unit of the medina

The *dar*, or courtyard house, is the basic element of the structure of the medina. It is from this element that the volumes and voids that give shape to the city are designed. The word *dar*, which means "house" in Arabic, derives from the verb *dara* which means, among other things, to circulate, to take place, to go on, to be held, and to centre on or around (Spahic, 2014). The circular form recalls the traditional organisation of the nomadic encampment, but the term also refers to the primary function of the dwelling space. The house is in fact the physical locus around which numerous human activities take place: promoting and upholding the family unit as well as educating and carrying out all the activities necessary to meet the daily needs of the family.

In the *dar* the rooms are distributed around the interior courtyard, known as *Wast ed-dar*, which means "centre of the house". The courtyard held a special role within a residence. Its benefits are environmental (natural lighting and ventilation) social (collective space), cultural (privacy, introversion) as well as functional (accessibility, circulation). The model of the courtyard house, in which all spaces are distributed around the central courtyard and are closed to the exterior, reflects the Islamic social system. The walls that surround the house divides the world into two clearly distinct and opposed spaces: the interior spaces, sacred and private, and the exterior space, public and profane. The Quran establishes the inviolable sacredness of the home, space of the intimate life of the family, that is closed to the streets outside in order to protect the wives and children, and open to the inside. Traditionally the tasks carried out by males were done outside, in the public sphere, whereas women carried out their activities in the interior, private space; the division of spaces according to gender, in an Islamic society, ensures social equilibrium.

Besides the visual privacy provided by the courtyard form, it also provides acoustical privacy. The courtyard house absorbs the noise of the house within itself. Also the surrounding rooms provide a noise barrier between the inner heart of the house and the street outside. This helps in providing a quieter and private outdoor space to enjoy.

FUP Best Practice in Scholarly Publishing (DOI 10.36253/fup_best_practice)



Main elements of the courtyard house
the entrance, the courtyard, the room, the gallery

There are four elements which are always present in a house: the entrance, the courtyard, the room, the gallery. Arranged surrounding the central courtyard, these elements correspond to an ordered sequence determined by the use of space and the need for confidentiality gathering together to form an open parallelepiped. The various configurations of the basic elements, often given by the adaptations to the morphology of the terrain and to pre-existing structures, give life to a great number of variations to the basic typology.

- The entrance: it protects the house from the exterior; this passage is never direct but includes one or two right angles that generate a break in the visual and pathway axis and impede the direct view from the street into the house.
- The room: the basic cell, it is rectangular, narrow and long, with a central door on the longer side and three closed sides; it does not communicate with the other rooms but always opens onto the courtyard.
- The courtyard: the open space, rectangular, unroofed, and of varying sizes, where all spaces of the house converge.
- The gallery: space of distribution, circulation and filter between the rooms and the courtyard, generally protected by a loggia. It is located between the courtyard and the rooms.

The openings toward the exterior are uncommon, small in size and with curtains and iron grilles to protect domestic intimacy, impeding the view of the interior of the house from outside.

The entrance to the house is preceded by the *derb*, the blind alley which leads to two or more courtyard houses; this space is a filter between public and private space. In this space the members of families belonging to the same *derb* can interact and communicate without having to reach the main street. It is remarkable for the narrowness of its curves, which block perspective, its silence and the darkness under the *sabbat* (the parts of the

houses which jut out onto the *derb*). This configuration amplifies the sense of intimacy and impenetrability and highlights the opposition between public and private.

> Our house gate was definitively a hudud, or frontier, because you needed permission to step in or out. Every move had to be justified and even getting to the gate was a procedure. If you were coming from the courtyard, you had to first walk down an endless corridor, and then you came face to face with Ahmed, the doorkeeper, who was usually sitting on his throne –like a sofa –, always with his tea tray by his side, ready to entertain. […] Our house gate was a gigantic stone arch with impressive carved wooden doors. It separated the women's harem from the male strangers walking in the streets (uncle's and Father's honor and prestige depended on that separation, we were told). Children could step out of the gate, if their parents permitted it, but not grownup women. "I would wake up at dawn" mother would say now and then. "If I only could go for a walk in the early morning when the streets are deserted. The light must be blue then, or may be pink, like at sunset. What is the color of the morning in the deserted, silent streets?". (Mernissi, 1994, pp. 21-22)

Wast ed-dar: the courtyard, core of the dwelling

The courtyard, called *wast ed dar* in Arabic, meaning "core of the house", serves as a circulation space connecting the different areas of the house and as common meeting ground. Being closed to the outside, it bears an introverted character, representative of the Muslim family life; in Islamic culture, private courtyards often provide the only outdoor space for women to relax unobserved (Aguilar et al., 2014). The patio is often surrounded by an arcade that acquires the additional function of acting as a transitional space between private rooms and the open air.

The courtyard is the space that connects all the dwelling cells, which in turn open to it. It not only provides lighting and ventilation of the dwelling, but also plays a fundamental role in the everyday life of the family, since it is the work space for the women, a playground for the children, and a space for conviviality for the whole family. The presence of this open external space complies with functional needs, making the house flexible, transformable, and possibly expandable, according to the needs of its inhabitants.

The courtyard also has a spiritual value and represents a place for the relationship between Man and God. In fact its centre, obtained from the intersection of two symmetric axes pointing to the four cardinal directions, represents earthly materiality; the four corners represent the columns which support the heavenly vault. The vertical axis which rises from the centre represents the relation between man and the heavens; God, represented by the heavenly vault, blesses the house through the courtyard (Guez, 2003; AA. VV., 2002).

The courtyard, as privileged space of the house, is also the place in which architectural and decorative care is focused, while the exterior walls are simple and bare. The outside walls of the house of a richer family are no different from those of a humble family, the differences will lie in the treatment of the surfaces of the courtyard, the decoration of the arches, interior walls and ceilings, the ceramics which clad the interior walls, the presence of a fountain or interior garden (*riad*) and the abundance of water.

Spaces and functions of the dwelling

The principle of the *Mouqabala*[1], regulates the organisation of the rooms: the distribution of the spaces follows a symmetrical scheme along the two axes; the rooms face each other on three or four sides.

> …there was the square and rigid courtyard, where symmetry ruled everything […]. The courtyard was surrounded by an arched colonnade, supported by four columns on each side. […]. Then, facing one another in pairs, across the courtyard, were four huge salons. Each salon had a gigantic gate in the middle, flanked by enormous windows, opening into the courtyard. In the early morning, and in the winter, the salon gates would be shut tight with cedar wood doors carved with flowers. In the summer, the doors would be opened and drapes of heavy brocade, velvet, and lace let down, so breeze could flow in while light and noise were kept away
> (Mernissi, 1994, p. 4)

The courtyard house in Chefchaouen is generally built on two levels, the ground floor, the first floor and the terrace, and has a double-pitched roof. The upper level receives sunlight in the winter, while the ground floor remains cool during the summer. The rooms are multi-functional spaces where various activities are carried out: living-room during the daytime, bedroom during the nights, work place for the women, who cook, sew or work wool. The typology of the courtyard house is adequate for the extended Arab family. According to tradition, in addition to the guestroom, every room houses a family nucleus, which can consist of 5 to 7 people. When a family has two rooms, one is for the parents and the other for the children. When the families that share a house are not related by blood ties, it is common to find fabric or plastic screens that divide sections of the courtyard and protect the intimacy of each family.

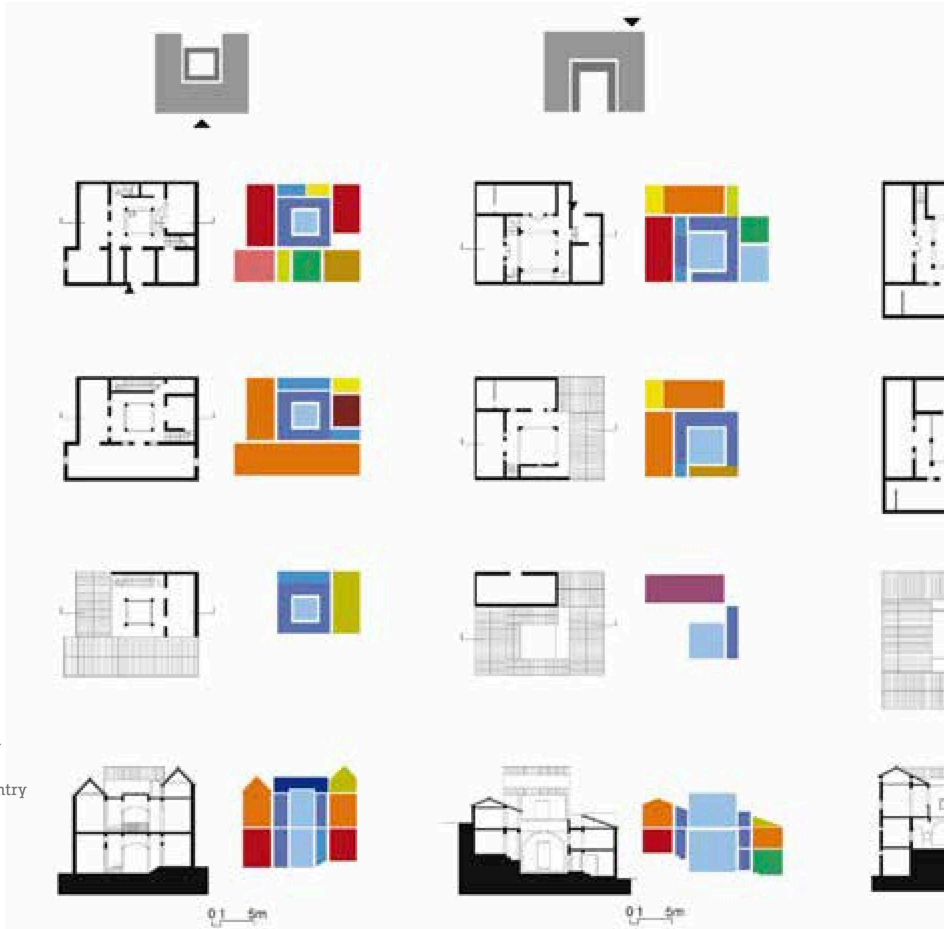
[1] Mouqabala, is a mathematical term linked to the figure of Muhamed Ibn Al-Khwarizmi, an Arabic mathematician from Baghdad who lived in the 7th century. The mouqabala corresponds to one of the two fundamental operations used for the resulutions of first and second degree equations with numerical coefficients and consists in the cancellation of like terms on opposite sides of the equation. Mouqabala, translated in Latin as oppositio, means precisely “to put in opposition”, to balance, in opposition to the other of the two fundamental operations, al jabr, to fill, or complete.

> Facing me across the courtyard was the salon of Uncle and his wife and their seven children, which was the exact reproduction of our own. […] On the right side of the courtyard was the largest and most elegant salon of all – the men's dining room, where they ate, listened to the news, settled business deals, and played cards. […] on the courtyard level, […] life was proper and strict. Only upstairs were things less rigid. There, divorced and widowed aunts, relatives, and their children, occupied a maze of small rooms. […] Upstairs was also the place to go for storytelling. You would climb the hundreds of glazed steps that led all the way up to the third and top floor of the house, and the terrace which lay before it, all whitewashed, spacious and inviting (Mernissi, 1994, p. 15-17).

From an interview with Ali Raïssouni, certain features of the Chefchaouen house can be deduced, more simple and sober than those of richer cities such as nearby Tetouan or the imperial cities: "The *Chefcheunie* home is known for its almost ascetic simplicity and modesty. The *Chefcheunie* home is built in image of its inhabitants, far away from luxury and opulence. In its sobriety it is closer to a dwelling for an anchorite and his followers. Contrary to Tetouan, Fes and Marrakech, where there are palaces for kings, princes, governors and rich merchants, the houses in Chefchaouen are destined to modest farmers or poor artisans who possess just enough to live, as well as for the imam, nomadic merchants and livestock breeders. Most of the inhabitants lived religiously and concerned about the afterlife. […] Most of the houses accommodate more than one family. It is very rare to find a house occupied by a single family […] When a family has two or three rooms, these are used by the sons and their wives. In other cases, the sons leave their parental home after marriage and move with their wives to another house. The daughters always leave home after marriage. If one of the daughters divorces she will return to her parents' home and take an available room. The inhabitants are well known for their solidarity and reciprocal support. When a family loses their home they always find refuge in another family's house. In the same way, when a family emigrates to Chefchaouen, it is easy for them to find a room in a house, often without pay or for a small rent".

The organisation of the Chefchaouen house presents some peculiar elements which differentiate it from the general typology in the north of Morocco. One of these elements is the *Maq'ad*, a room which opens to the courtyard and is an expansion used as common space and for receiving guests. Another is the *berchla*, an attic which is accessed from the terrace (*stah*).

The courtyard house often includes an open space on the rear or a garden (*riad*); it is sometimes used for keeping chickens, goats, mules or donkeys. The water is supplied to the various rooms through the *sāqiya* (which carries spring water). Occasionally there are wells, and more rarely fountains, although only in richer dwellings.

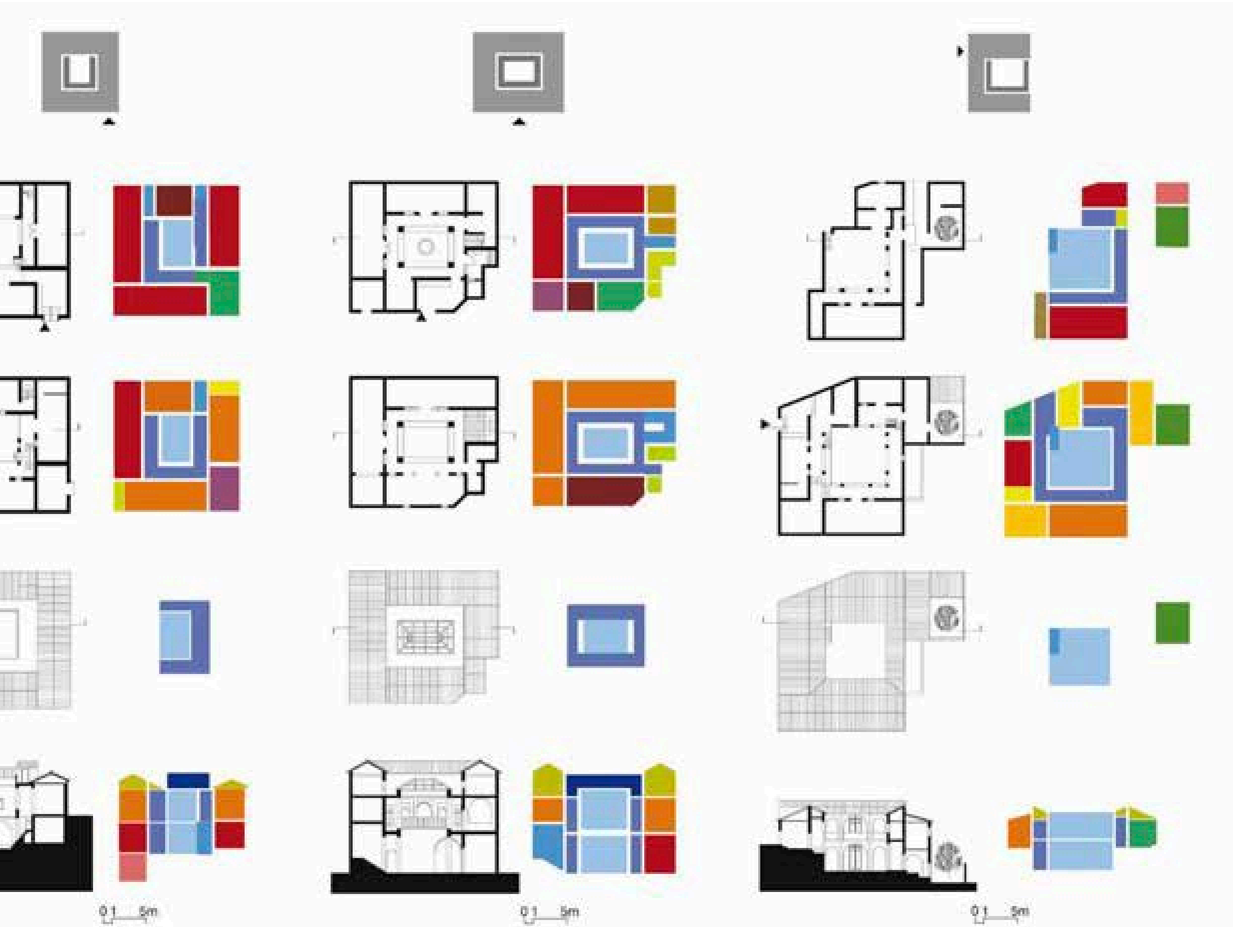


Dwelling spaces

- *Wast ed-dar* | courtyard
- *N'bah* (or *burtal*) | gallery
- Stairs
- *Stah* | terrace
- Workshop
- *Maq'ad* | living-room
- Porch
- Annex
- *Quobba* | hall
- *Ghorfa* (or *bayt*) | room
- *Kosina* (or *matbakh*) | kitchen
- *Mesria* | master bedroom
- *Tarma* (or *bayt el-muna*)| pantry
- *Berchla* | attic
- *Bit el Maâ* | bathroom
- *Ryad* | garden
- *Madkhel ed-dar* (or *skifa*)| entrance

Dwelling spaces

- *Madkhel ed-dar (or skifa)*| entrance: it represents the filter between the street and the interior of the house: it is generally L or S-shaped in order to avoid external gazes and to preserve family intimacy: the threshold of the house is traditionally interpreted as a boundary between feminine (interior) and male (exterior) space.
- *Wast ed-dar* | courtyard: it is the core of the house, a central open-air space, common and multi-functional, which hosts most of the daily activities.
- *N'bah (or burtal)*| gallery: it is the circulation and filter space between the rooms and the courtyard, generally covered by an arcaded porch.



- *Maq'ad* | living-room: common room which opens onto the courtyard, it constitutes its natural extension. It can be located either on the ground floor or on the first floor and has seats on three of its sides. It is a common space where much of everyday domestic life takes place.
- *Ghorfa* (or *bayt*) | room: common and multi-functional space used for living, eating and sleeping. It is a simple rectangular volume 2,30 to 2,50 m long and 5 to 8 m wide. The pavement is the work surface for domestic activities, the low sofa-beds are usually placed on the four sides of the room.

Typological variants of *berchla* (attic)

opposite page **Entrance door of a room** *(ghorfa)* (©L.Lupi, 2007)

- *Quobba* | hall: it is the most important room in the house, used for receiving guests. It is more richly decorated than spaces devoted exclusively to the family. On one side of this hall it is common to find access to the *tarma*, a sort of pantry.
- *Mesria* | master bedroom: this is the room of the head of the family. It is accessed by way of a secondary staircase connected to the *kaada*. It is often in correspondence to the *sabbat*, that is the volume located on the second floor which juts out over the street in order to expand the space of the house, generating covered passages in the street.
- *Kosína (or Matbakh)*| kitchen: the activities related to food are not usually carried out in the same place. In fact food is prepared over a fixed stove in the kitchen, whereas it is also cooked over a movable stove (*kanoun*) in the courtyard.
- *Bit el Maâ* | bathroom: this is the room for ablutions. Built in Turkish style for bowel movements in a squatting position, it allows for the comfortable ablutions. This place is often located next to the kitchen.
- *Hammam* | Bathroom: it is usually a small room with a vaulted roof and low seats along the walls, heated by way of a firewood furnace placed underground. Only the houses of richer families have private hammams.
- *Tarma* (or *bayt el-muna*)| pantry: this is a small room usually located halfway between the ground and first floors. It is relatively low (2-3 m) compared to other rooms in the house. It can be used as a pantry or as a bedroom when necessary.
- *Berchla* | attic: in Chefchaouen this space is usually used for drying fruit and pulses, thanks to its natural ventilation. It is exactly the same size of the room below it, and its height is usually between 1 and 1,5 metres.
- *Stah* | terrace: this is the house's terrace, located above the gallery. It was traditionally the place for female social interaction, where women could meet with their neighbours, as well as carry out domestic chores. The *berchla* is accessed from the terrace when it is situated above the upper floor.

Evolution of the courtyard house in the medina

opposite page
Addition of two floors on a traditional courtyard house
(©L.Lupi, 2007)

The Andalusian Arab families which came from Spain from the mid-15th century and settled in Chefchaouen, used to get together in groups of two to five families, often related by blood, in order to build the courtyard house where they would then live together. The remaining spaces between the various courtyard houses were gradually filled in with new residences, while the courtyard houses themselves were often with the passing of time divided into various parts or joined to adjacent buildings. This generated a myriad different types of residence which cannot be easily classified according to recurring typologies. There are houses with two opposite boundary walls and buildings with series of storeys connected by a single or double-ramp staircase, and frequently L-shaped or C-shaped buildings which result from the division of what originally was a courtyard house. The Islamic socio-economic system, based on the conservation of family links, has influenced urban development enormously. According to the Islamic inheritance system, male sons remain under the authority of their father even after they marry, and bring their wife and their new family to live in their parental home. The practice of dividing the inheritance and therefore materially subdividing the house for ensuring accessibility to every single unit generates deep transformations to the building. The processes of subdivision and expansion are both horizontal and vertical, consequently saturating the urban fabric. The horizontal expansion brings about the disappearance of many gardens (*riad*), and/or the partial reduction of the central courtyard. Vertical expansion, on the other hand, implies the disappearance of pitched roofs and the transformation of the built volumes.

Other types of transformation derive from processes of evolution of the socio-cultural context, which has slowly distanced itself from the strict rules of Islamic tradition, and from the introduction of modern building types and models. Thus, for example, windows on the facade are more frequent, as well as wider, whereas they tend to lose their traditional outline and decoration. The shutters of traditional doorways, which allowed the visitor to either give warning of his arrival or to enter directly, were substituted by locks, for safety reasons. The great variety of traditional arches in courtyards is also being progressively lost, since architraves in reinforced concrete are easier and faster to build.

The modifications suffered by the buildings in Chefchaouen, especially during the past twenty years, have partially compromised the authenticity of traditional features. The buildings that preserve the typological and constructive features are those few which were the subject of accurate restoration interventions, and the many found in a state of decay but have not yet undergone alterations to their form or structure.

Plan, section and use of spaces of 3 courtyard houses. From top to bottom: Dar Hadri, Dar Karchouch and Dar Aissoui. (© L.Dipasquale, V. Volpi, 2006)

Uses and evolution of the courtyard house: some case studies

Dar Hadri, Souika quarter, 15th century

Situated in the quarter of Souika, Dar Hadri goes back to the foundation of the city. It is one of the few houses in the medina which has kept the traditional structure: the house stands on two a storeys above ground and a terrace on the third level and is inhabited by a single patriarchal family. The original architectural elements are in good state of conservation. The arches of the courtyard also preserve their original structure and the floors and ceilings, decorated in the Andalusian style, are still visible. The tiled pitched has also been preserved, as well as the garden on the rear.

In 2006 the house was inhabited by twenty three people belonging to seven family nuclei. Nucleus A consists of an unmarried man who occupies the room next to the entrance. The largest room on the ground floor is occupied by young high-school students (nucleus B). Two well-to-do women in their fifties occupy two rooms on the first floor (C, D).

Nuclei E and F, also on the first floor, consist of two couples, one of which has a girl. Despite there being many people in the house, a peaceful coexistence is possible thanks to the reciprocal respect and support of the inhabitants and to a good management of common spaces.

Dar Karchouch, al Onsar quarter, circa 1920

Dar Karchouch is a house which was built much more recently, during the first years of the 20th century, by the Caïd of the city, in accordance with traditional architectural and building rules. The openings that separate the patio from the gallery are simple, made with acute arches and timber architraves on the upper levels. The house originally did not have a kitchen and each family cooked in their own room. Later, an uninhabited room on the first floor was transformed into a kitchen. The private *hammam* on the ground floor is currently not in use. The house maintained its original volumes, consisting in two levels above ground and the terrace. It was originally inhabited by a patriarchal family, whereas in 2006 it was inhabited by four people divided into three family nuclei. On the ground floor lives a man in his forties who occupies one room (nucleus A); on the first floor an elderly lady with a 6-year old girl and an unmarried woman (nuclei B and C).

Dar Aissoui, Rif Al Andalus quarter, 15th-16th century

Dar Aissoui goes back to the period in which Rif Al Andalus quarter was founded, that is the 15th and 16th centuries. Its original configuration was completely modified: the house was initially inhabited by a single patriarchal family and stood on a single level with the terrace above the gallery and a pitched roof. A second and third storey were added recently, built with more modern techniques and lacking in the formal and decorative elements of the traditional house. The galleries (*n'bah)* of the first and second floors are completely devoid of decoration: instead of the arches there are simple rectangular openings with large corner pillars.

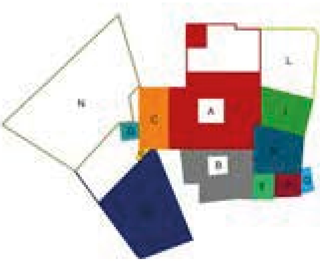
The house is entered directly from the street, without the filter offered by the *derb*. On the ground floor three rooms are occupied by artisans workshops and grocery stores.

The kitchen is on the ground floor, open to the courtyard, and is used by all the families and serves as a place for family reunions.

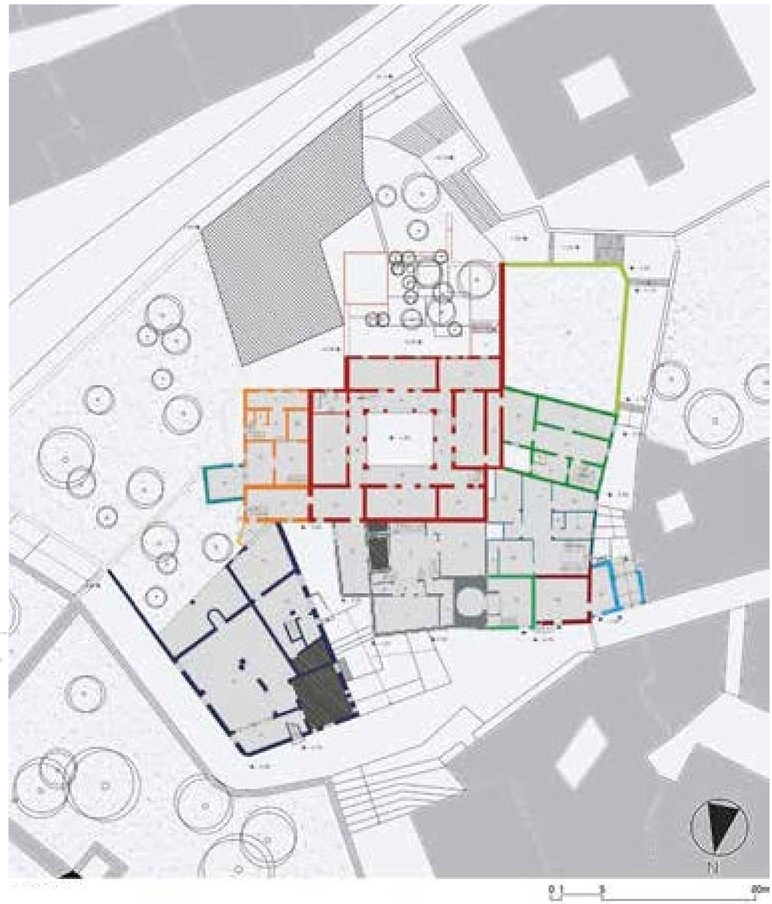
In 2006 it was inhabited by an expanded patriarchal family, made of two brothers with their families of seven people each.

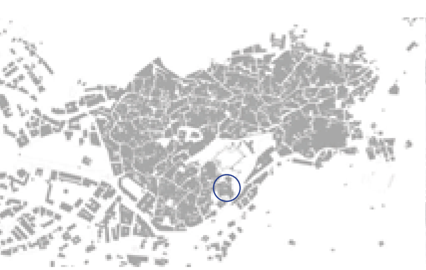
Evolution and transformation of a complex of buildings

A complex of buildings has been surveyed as case study to better identify the morphological and constructive features, trying to undestand its evolutionary dynamics and transformations



Facades and first floor plan of a complex of buildings
(© L.Dipasquale, V. Volpi, 2006)



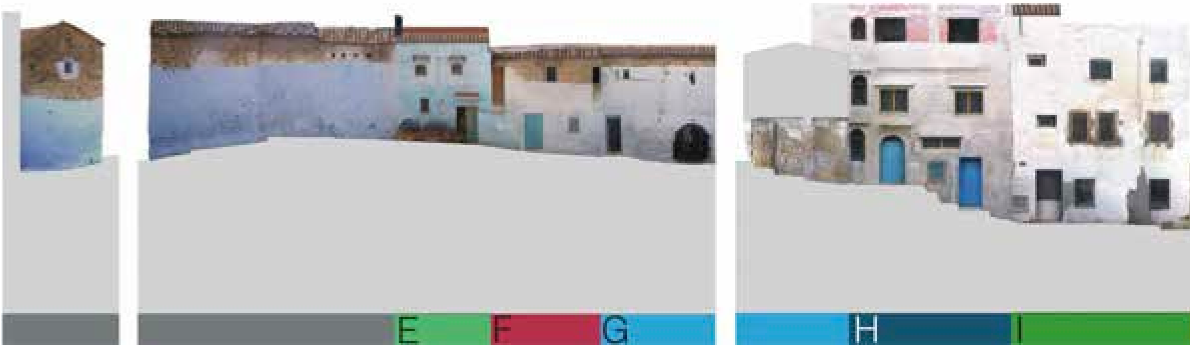


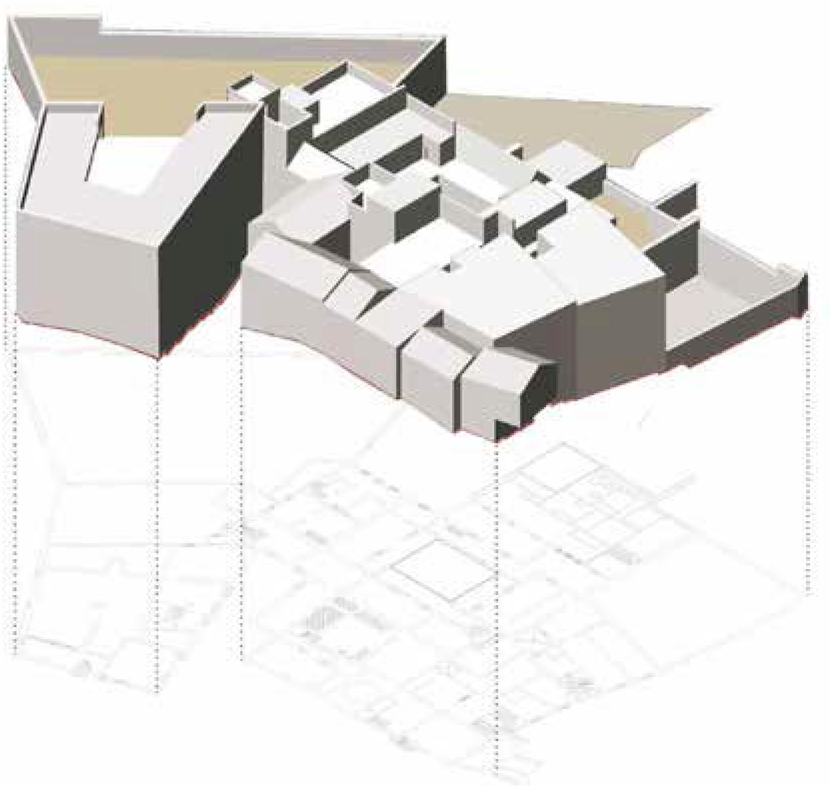
over time. It externally appears as a single very compact and intricate body in which the individual buildings that are a part of it are difficult to identify, is constituted by various adjacent bodies, different in terms of structure, origin and historical development. The resulting shape, however presents a relatively regular building pattern which is developed from dar Raïssouni, the most ancient courtyard house in the medina. The knowledge of the evolutionary process that led to the current distributive configuration is fundamental for the subsequent phases of analysis. In fact through the investigation of the various methods and the sequence in which the various different elements were put together allows us to determine the existing relationships and heterogeneities between the bodies, and to formulate hypotheses and opinions regarding the behaviour of the structures.

The complex is situated to the south of the medina in a sloping terrain between the *kasbah* and the ancient walls, and near *Belhacen* square, not far from the main square, *Uta Hammam*. The complex presents building types, techniques and materials that are typical of the medina of Chefchaouen, but also recent transformations that have completely altered its architectural features and morphology.

The hypothesis concerning the evolution of the complex through time was based on a stratigraphic analysis and on historical photographs, maps, as well as on oral documentation provided by the inhabitants of the area.

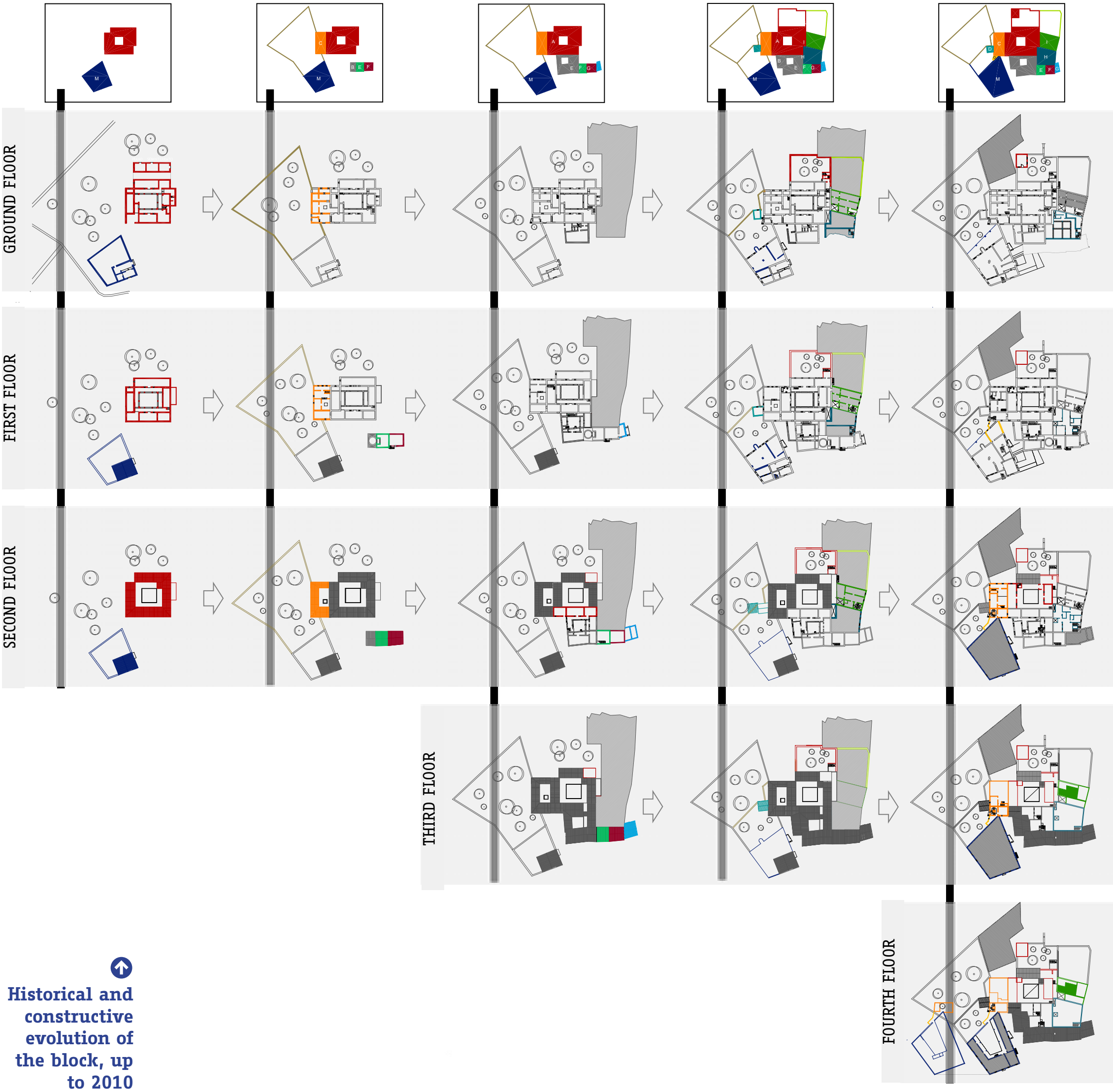
Five main development phases were identified, which correspond to the most relevant transformations of the complex.





Facades, courtyards of the buildings A and B and axonometric view of a complex of buildings
(© L.Dipasquale, V. Volpi, 2006)


L
A
C



Historical and constructive evolution of the block, up to 2010

opposite page **View of the block in 2018**

Phase 1: 1471 to the 16th century

The Raïssouni house (building A), which originally belonged to the founder of the city, Moulay Ali Ben Rachid, was the first residential building built outside the kasbah. The building originally included all the typical features of the traditional dwelling: rooms distributed around a central courtyard, two storeys, terrace, and pitched roofs, under which

was located the *berchla*. Due to the noble origin of the family, the house also included a private *hammam*, which today is no longer in use. Adjacent to the house was the *Zaouia Raysuniya* (building M), which according to oral tradition was founded by the famous princess Saida El-Horra, daughter of Moulay Ali Ben Rachid, who is buried there. It is was small shrine, with a garden attached to it which contains the family cemetery.

Phase 2: 16th-17th century

The Raissouni extended and began building a new residence (building C), a C-shaped courtyard house adjacent to the original nucleus, also two-storeyed, with pitched roofs and a private *hammam*. At that same time two small public buildings were constructed to provide services to the new quarter: the public oven (building E) and a workshop (building F). The latter was used as a tannery during the past two decades, and after a period of decay and disuse it was recently restored. It is not possible to determine what its original function was. Also the walls (M) that enclose the garden and family cemetery were built at that time.

Phase 3: 17th-20th century

The Raïssouni family continued expanding to the north and built a third courtyard house on three sides and with three storeys (building B), to accommodate other family members. This third house used the nearby public oven for a private *hammam*. Another storey was added to the buildings of the oven and the workshop and a third workshop was built (building

Height of buildings, demolitions, superelevations and cloggings, up until 2010

opposite page **View of the block (buildings B, E, F, and H) in 2018**

G). In the year 1760 some Jewish families from Spain requested asylum from the sultan Mohamed El Arabi Raïssouni, which he granted, offering the refugees some land near his home for the construction of a *Mellah*. The *Mellah* included 22 houses which accommodated approximately 200 Jews, as well as two synagogues. These dwellings, abandoned at the beginning of the 20th century and then ruined, have disappeared. There are traces of the ancient gate of the *Mellah* (building G) and of the synagogue, which can be identified from the mosaics that are still visible on the outside of the wall that encloses the Rassouni garden. Due to the uncertainty in both oral accounts and documents it was not possible to determine with precision the limits to this area.

Phase 4: until 1970

An additional volume was added to the third Raïssouni house (building B), which completes the building as it is today. The definitive dimensions of the Raïssouni riad are determined by the enclosure walls. The buildings of the *Mellah* were abandoned and partially reused by new builders (buildings I and H). The *zaouia Raissouniya* is extended: a large prayer hall is added and a *mihrab* is built. Within the garden on the rear of the *zaouia* a small two-level volume with a double-pitched roof is added (building D), used as a store-

room on the ground floor and connected on the first floor with the second Raïssouni residence (building C9) and used as a bedroom. At the same time, and based on that volume, a high wall is built for separating the Raïssouni garden from the cemetery. A section of the ancient Mellah is annexed to the Raïssouni house (building A) and enclosed with a wall (L), in preparation for future additions.

Phase 5: from 1970 to the present

During the past 30 years additional storeys have been added to the structures, thus altering the original features of the buildings.

In the Raïssouni house (building A) two of the three pitched roofs were demolished for the purpose of building two large spaces used as storerooms. The second Raïssouni house (building C) had a storey added to it with a flat roof. The *zaouia* was radically modified: its surface was doubled and four storeys were built above it. Nothing remains of the ancient buildings except the gate with its ogival arch.

A connecting structure (building O) between the Raïssouni house (building A) and the *zaouia* was recently built: this building, which is four-storey high, allows the Raïssouni family to traverse building C and access the upper storeys of the *zaouia*.

from left to right
View of the building B before 1990 and in 2006

opposite page
View of the building B in 2018

The western side of building B was demolished and new two-storeyed structure was built in its place. To the south, instead, it was raised one storey, while the roof was partially demolished in order to build a terrace and a kitchen.

On the western side of the block, buildings H and I were raised one storey. Building H is the one that suffered the most interventions, both from a formal and structural point of view, which totally altered its traditional features and introduced alien decorative elements. To the south of the block, between building A and the street, a four-storeyed residence was built, with modern features.

Based upon the hypothesis of evolution of the complex it is possible to develop an analysis of the building lexicon. The prevailing building technique is mixed brick and stone masonry, and in bricks and reinforced concrete for interventions undertaken during the past 50 years. Interior partition walls are mostly made of full bricks in buildings which have not undergone modifications, and of hollow bricks in new constructions. Timber floors and roofs, originally present in all buildings, have been partially substituted by brick floors and steel beams. In the expansion interventions carried out during the past years, the floors for terraced roofs are mostly built using steel beams and hollow bricks.

The complex and articulated panorama of superfetations, transformations, demolitions, reconstructions without any respect for forms, proportions, architectural style, construction characteristics and structural balances, constitutes an exemplary demonstration of the danger in the uncontrolled evolution of the medina, where the interventions of restoration, do not follow rules aimed at sustaining the authenticity and dimensional, functional and structural compatibility, as well as environmental, with the existing.

References

Abdelmalek A. 2007, *Courtyard housing. Past, present and future*, Taylor & Francis, London.

Aguilar B., Dipasquale L., Mecca S. 2014, *The patio house in Morocco: A sustainable design strategy*, in Correia M., Carlos G., Rocha S. (eds), *Vernacular Heritage and Earthen Architecture Contributions for Sustainable Development*, CRC Press-Taylor & Francis Group, London, pp. 489-494.

Dipasquale L., Mecca S., Picone, A., *Courtyard houses*, in Correia M., Dipasquale L., Mecca S. (eds.) 2014, *VerSus: heritage for the future. Vernacular knowledge fo sustainable architecture*, FUP, Firenze, pp. 150-160.

Hakim Besim S. 2013, *Arabic-Islamic Cities: Building and Planning Principles*, Routledge, London.

Edwards B. (ed.)2006, *Courtyard housing: Past, present, future*, Taylor & Francis, New York.

Edwards B., Hakmi M., Petruccioli A. & Sibley M. 2005. *The Courtyard House. Typological Variations Over Space and Time*, Taylor & Francis, London.

Jayyusi S. K., Holod R., Petruccioli A., Raymond A. (eds.) 2009, *The City in the Islamic World*, Brill, Leiden, Netherlands.

The building culture

If we analyze the construction process of a house, we see that the builder possesses in thought the form of the house; he knows what the fact of being a house is. In a certain sense the house has its beginnings in house: in something immaterial (its concept) that generates something that includes the material. Aristotle, Metaphysics

A local culture reflects the ability of a human group to adapt to a space, time and context, it manifests itself through the knowledge and implementation of local resources in order to meet specific needs (for example in the field of construction, agriculture, medicine, etc.). In terms of habitat, a local building culture translates an adaptation of the constructive idea to material and immaterial conditions in order to organise a collective and individual living space. The construction of the habitat means associating a physical construction with a set of needs, ideas, values, practices and beliefs, which are expressed through a harmony between forms and materials. The knowledge related to building and construction is present in various spheres: decision-making on settlement locations, management of resources, land and urban areas, architectural composition, construction materials and worksite planning and organization.

The influences of near and far cultures often contribute to the definition and improvement of material responses. The phenomena of migration, trade or invasions imply an enrichment of knowledge, the loss of part of it or the emergence of innovations. Thus, thanks to external influences and transformations in the balance of resources and internal needs of a community, in a local culture (as in a process of corporate evolution), phenomena of "incremental innovation" can occur when it comes to subsequent additions and small changes to the ways of building, or of "radical innovation" whenever innovative and unprecedented technologies are introduced.

Reading the constructive fabric of the medina of Chefchaouen shows a fascinating programme where languages and solutions belonging to different periods and knowledge overlap, but basically dating back to the two lineages, the native Berber, and the Andalusian. The different cultures have found here a wise modality of integration and hybridisation until the moment in which they had to confront modernity which, here as elsewhere, has produced a real crisis in the system of knowledge and in the construction practice.

Deciphering the language expressed by a building, a settlement or a territory implies a critical analysis that aims to separate the complexity of the built system into more readable parts, ac-

FUP Best Practice in Scholarly Publishing (DOI 10.36253/fup_best_practice)
Letizia Dipasquale, *Understanding Chefchaouen. Traditional knowledge for a sustainable habitat*, published by Firenze University Press (www.fupress.com), ISBN 978-88-5518-178-5 (PDF), DOI 10.36253/978-88-5518-178-5

Systemic breakdown of a built system (adapted from Maretto, 1973).

HIERARCHY OF LEVEL OF COMPLEXITY	SCALE HIERARCHY: building	settlement	territory
element	materials	building type	urban type
structure of elements	building technique	urban tissue	pattern of property division
system of structures	building systems	street layout	territorial layout
organism	building	settlement	territory

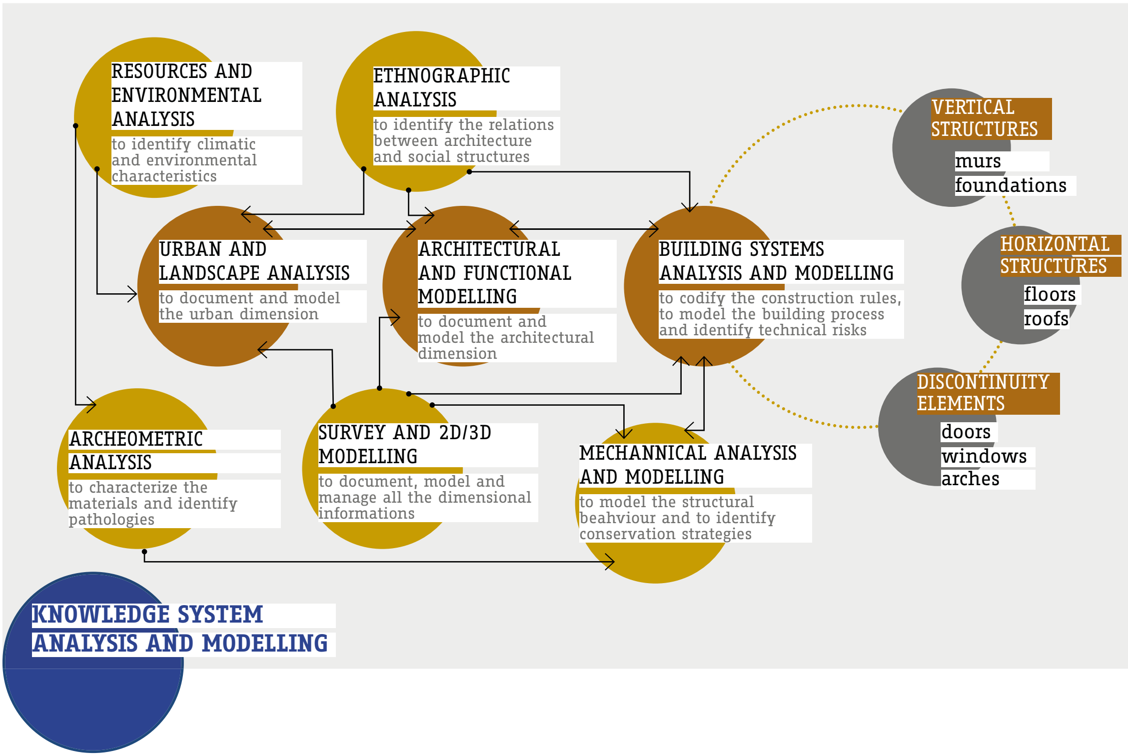
opposite page **Conceptual scheme of the interdisciplinary approach to the analysis of the architectural knowledge system of Chefchaouen**

cording to a systemic approach: the building is seen as a system, or a set of parts (components) interacting with each other to achieve one or more common purposes. The parts are the letters that make up the words in our dictionary, which through complex grammatical and syntactic rules take on different layouts to give life to the constructive lexicon. This type of approach allows us not only to verify the common characteristics for the classification of techniques and types, but to codify their implicit rules and founding principles. It is therefore a question of making tacit knowledge explicit and shareable: externalising and combining knowledge, according to Nonaka's spiral approach, to encourage sharing and internalisation in a reference group.

In the process of analysing the construction techniques of the medina of Chefchaouen, the building is considered as a set of finished components, which are the construction elements, each of which has its own constructive reason (Giuffre, 1993). The most recurrent and significant elements have been identified and classified, in order to make explicit the techniques that represent models of structural, technological and executive quality.

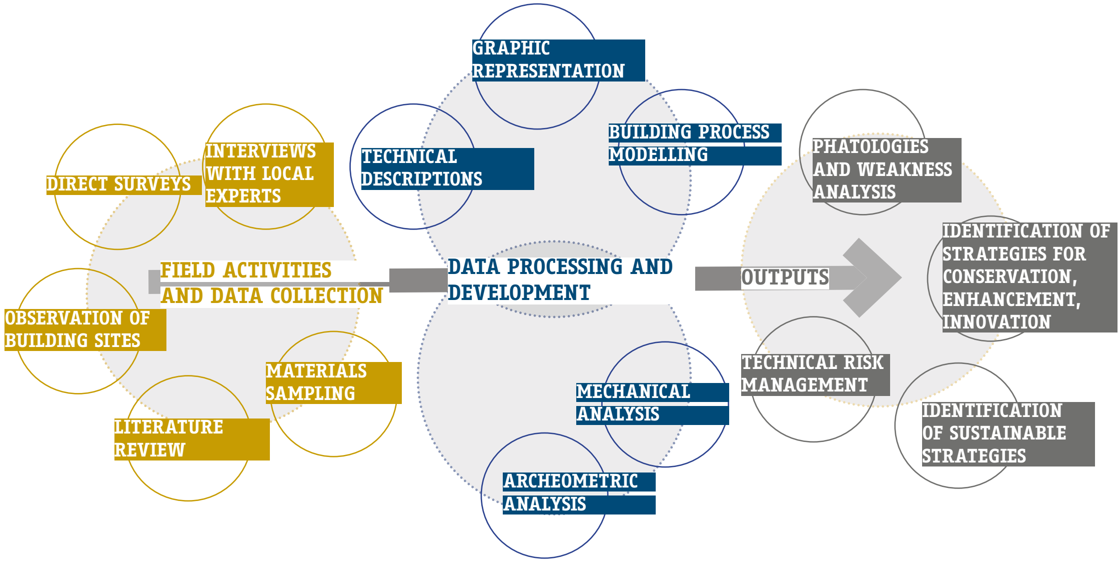
The simplest components of the building structure are the building materials: stone, bricks, earth, wood, lime. The construction elements are composed of the basic elements, the materials, linked by a relationship of dependence and recognisable by a coherent geometric shape. The construction elements in turn connect with each other according to relationships of mutual necessity and dependence to form the building organism. It is possible to recognise the function of each constructive element, but each role is adequately fulfilled only if properly connected to the other elements.

The survey of the masonry construction techniques and openings was carried out mainly from the outside of the building, through the observation of the masonry laying and the



coating. In the cases of buildings in a state of neglect or ruin, it was possible to document the section and better observe the wall texture. Samples of materials were taken to be documented by the CNR Institute for the Conservation and Valorization of Cultural Heritage (ICVBC), located in Florence, and to undergo mechanical analysis, which was carried out with the support of the Official Material and Structural Testing Laboratory at the Department of Architecture (DIDA), University of Florence. Horizontal structures, floors and roofs were observed and measured during visits to the interiors of houses, which were made accessible thanks to the deep sense of hospitality that characterises the community of Chefchaouen, which opened its doors without prejudice to allow the direct observation of the rules that have allowed the development and conservation of their heritage.

The interviews with the *maâlem* (the ancient master builders) Mohamed Tounsi and Ahmed Rahmuni and the direct observations of the restoration site of a historic building located in the Rif Al Andalous district were of fundamental importance for understanding and identi-



Methodological approach adopted to codify the architectural traditional knowledge of Chefchaouen

opposite page **Interview with maâlem Tounsi and observation of a restoration site**

fying the individual actors, the operations, the construction procedures and tacit rules of traditional building. The structure of the traditional yard follows a hierarchical scheme with the *maâlem* at the head. He personally chooses his work group, made up of the *maâlemin*, masons who are entrusted with the main construction operations, and the unskilled workers. The simple masons and the unskilled workers meet every day at the first light of dawn in Outa El Hamam square, equipped with their work tools, waiting to be hired. These work groups are traditionally coordinated by a corporation, a sort of union made up of technicians and craftsmen who share the same interests. The management of the corporation is entrusted to a master craftsman, the *amine*, who performs trade union and technical functions.

The *maâlem* are the custodians and transmitters of the local building culture. In the past they guided all construction activity, from the choice of materials, to the carpentry and the finely decorated details. More than one *maâlem* may be present in the same city, often with different skills, even if their knowledge still embraces the entire constructive knowledge. In the absence of manuals and reference texts, the constructive knowledge that the *maâlem* inherited from Andalusian engineers is in turn transmitted orally and through apprenticeship on site, from father to son, from teacher to apprentice. The value of this knowledge is so high that it cannot be granted to anyone. It is the *maâlem* himself who chooses who to pass on his art to, often to some of his sons or to an apprentice with outstanding skills.


If in recent decades we have been witnessing the loss of local construction knowledge and the consequent degradation of the traditional architectural heritage, the reasons are also linked to the loss of the figure of the *maâlem* that is no longer scrupulously handed down from father to son as it once was, and is being slowly yet increasingly replaced by small private construction companies, often not adequately trained in traditional construction systems and restoration techniques.

References

Caimi A., Crété E., Joffroy T., Moles O., Serlet M. 2017, *Detailed country profile Fiji: local building cultures for sustainable and resilient habitats*, CRAterre, Grenoble.

Dipasquale L., Jorquera N., Mecca S. 2011, *An interdisciplinary approach to a cultural and architectural heritage: earthen dome architecture in Syria* in Fioravanti M, Mecca S. (eds.), *The safeguard of Cultural Heritage. A challenge from the past for the Europe of tomorrow*, FUP, Firenze, pp. 233-236.

Dipasquale L., Mecca S. 2015, *Local Seismic culture in the Mediterranean region*, in Correia M., Lourenco P., Varum H. (eds.), Seismic Retrofitting: Learning from Vernacular Architecture, CRC Press Taylor & Francis Group, London, pp.67-76.

Giovannetti F. (ed.) 1998, *Manuale del recupero del Comune di Città di Castello*, DEI, Roma.

Giuffre A. (ed.) 1993, *Sicurezza e conservazione dei centri storici: il caso Ortigia: codice di pratica per gli interventi antisismici nel centro storico*, Laterza, Roma.

Maretto P. 1973, *Nell'architettura: metodologia di lettura critico-operativa della realta architettonica, edilizia urbana e territoriale*, Teorema, Firenze.

Mecca S., Jorquera N. 2009, *An interdisciplinary approach to a cultural and architectural heritage*, in Dipasquale L., Mecca S. (eds.), *Earthen Domes and habitats. Villages of Northern Syria. An architectural tradition shared by east and west*, ETS, Pisa. pp.153-156.

Nonaka I., Takeuchi H.1995, *The Knowledge Creating Company*, University Press, Oxford.

Sanna A., Ortu G. G. (eds.) 2009, *Atlante delle culture costruttive della Sardegna*, DEI, Roma.

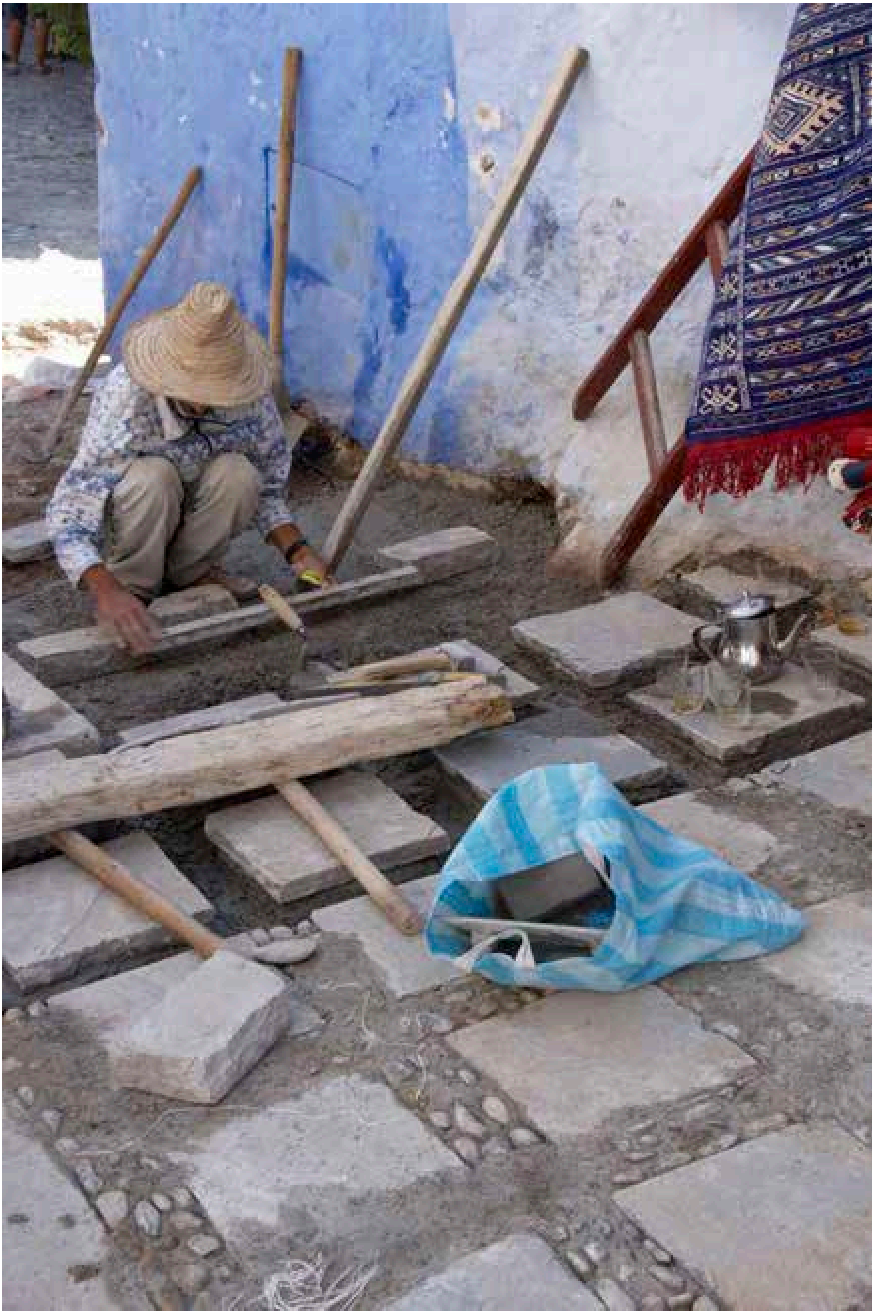
From extraction to the worksite

The vast repertoire of building techniques of the architectural lexicon of the medina is the result of a knowledgeable combination of the raw materials available in the area: stone, wood, earth and water.
In premodern construction the location of productive installations was thus often linked to the location of the raw material itself, so as to reduce the cost of transport from the place of extraction to that of production. This was also influenced by the lack of adequate transport means and infrastructures.
In the vicinity of Chefchaouen there are several traditional kilns for the production of bricks are still active, as well as others for cooking lime and quarries for the extraction of stone used in construction. Today, materials are transported with trucks and left close to the main entrances to the medina, usually in the open. Cement and bricks are stored in warehouses near the gates to the city before being carried to the worksites. Site managers arrange the place of delivery with the transport personnel, based upon the location of the site within the medina. From these delivery spots the materials are carried to the site with mules or wheelbarrows. Inside the medina the traffic of motor vehicles is not possible due to the dimension of the streets and to the presence of steps and the unevenness of the terrain. Transport takes place from seven in the morning to five in the afternoon, although during the Summer transport can begin as early as five in the morning, when it is cooler, the streets are less crowded and there is less probability of controls, in case the site is not operating legally. Mule transporters in the medina, according to the interviews carried out, are paid by the day, whereas those in the new city are paid in accordance to the number of loads carried during a day's work.

Stone

The stones used for building in the medina is extracted in the immediate vicinity of the city. Extraction takes place in open-air quarries located on the slopes of mount Jbel Kelaa and others along the road to Tetouan, in the areas of Souk Larbaa and Beni Messane. The separation

FUP Best Practice in Scholarly Publishing (DOI 10.36253/fup_best_practice)



of blocks in the quarry depends on the structural attitude of the rock. When the process is easy the natural joints of the rock are used (cracks due to magmatic rock, stratification of sedimentary rocks, schistosity from metamorphic rocks), opened with the use of wedges and mauls; when the process is more complex grooves are excavated around the block with the use of a pick-axe or else with maul and bit until it is separated from the rock with wedges inserted in the last surface to be separated. The pieces obtained by division are subsequently hewn and shaped. Sizing is classified into large stones (*ikbir*), flat, medium-sized stones (*twate*), used for regulating the base level, and small stones (*áachchou*), used for filling in. The most widespread stones used for building in Chefchaouen are calcareous (hard and soft) and siliceous.

Siliceous stone (Al jar-butartak)
Siliceous rock is formed by the accumulation of organogenic debris or the breaking down of older rocks. Siliceous stone contains mostly silicates and silicon dioxide (SiO_2). Its colour is dark grey and its surface is compact and not very porous. It is shaped into rustic or rough ashlars. It is hard and has good features in terms of resistance to compression and is therefore used as pebbles for exterior mosaic cladding.

Hard calcareous stone (Al jar-sam)
Sedimentary rock almost entirely made of calcite ($CaCO_3$). The colour is clear and can vary from tones of grey to hazelnut. The granularity is fine and compact. It is a hard and resistant stone used in masonry. The blocks in the masonry are small-medium sized and roughly shaped.

Soft calcareous stone (Keddane)
The mineral composition of this stone does not vary much from the previous one. Variations concern the granularity of the material, which in this case is more porous. It is soft and easy to work. Clear in colour, its porosity varies approximately from 0.2 cm to 1.5 cm in diameter. It is the most widespread material in masonry, easy to reduce into ashlars, more or less shaped according to need. Given its good resistance and workability, the blocks made of this stone, and above all the cantons, are well-squared. Fragments and scraps are often mixed into the mortar.

Timber

Timber is used for ceilings and roofs, but also for doors and windows. In the past timber was taken from the woods in the mountains around the city, whereas today it is often imported *opposite page* **Terracotta kiln near Chefchaouen for the production of brick and roof tiles.** (© L. Lupi, 2007)

from countries such as Brazil and South Africa. The types of wood that are most used in Chefchaouen are cedar (*ærz*), which comes form the Atlas, it is quite soft and is therefore used for cladding and for handicrafts; spruce (*soha*) and red fir (*sanawbar*), both quite resistant and adequate for roofs and ceilings.

The wooden beams used for ceilings and floors were painted using polychromatic geometric designs based on interlacing star-shaped polygons or plant motifs. In the medina, especially in the Sebanine quarter, there are still some carpentry workshops which make or repair doors and windows.

Traditional ceilings and floors today are being increasingly substituted by structures in reinforced concrete and hollow bricks. Often, with the aim to reproduce the traditional aesthetics, a floor in bricks and cement will be covered by a wooden planked floor and by richly decorated wooden rafters that do not have a structural function.

Terracotta

Bricks and tiles, produced from clay baked in traditional kilns, are widely used in Chefchaouen for roofs, parts of walls, columns, arches, masonry support elements, and sewage systems.

Bricks are usually 21 x 10 x 2,5 cm or 22 x 10 x 3 cm. Bricks and tiles are produced with clay mixed with other components such as sand, sawdust, or manure.

Brick masonry is commonly used for interior walls, and rarely for exterior surfaces, especially in traditional building. It is usually plastered with lime mortar. Additional storeys and other accretions are usually made with bricks. Walls are quite standard. The width of the wall varies from 5 cm (in the case of shiner brick partition walls) to 35 cm (in the case of three-headed load baring walls).

Production of bricks and roof tiles

The production of bricks and tiles in the region of Chefchaouen is still carried out according to traditional processes.

The main raw material for the production of bricks and tiles is clay. The first phase of the production process consists in the obtention of clay, which is excavated manually in the vicinity of the kiln. The mineral composition of clay and its purity are elements that have a strong impact on the final quality of the brick, thus the location of the kiln was chosen based upon the quality of the terrain. Kilns were always located outside the city so as to prevent pollution and fires. When clay is extracted it is in the form of irregular clumps and thus before being worked it is placed in a pit full of water of varying sizes

and covered by a cloth, where it remains for 2-3 days. In this period the mixture is stirred once in a while so as to dissolve the clumps and eliminate impurities. It is then left to rest so that water can rise to the surface and the clay remain on the bottom. At this point the clay can be taken out of the water and left to rest in a basin for an additional 2-3 days before being used.

The mixture is pressed by hand on wooden or metal moulds. These moulds are previously sprinkled with sand so as to allow the brick to slide out easily. Bricks are made on the ground: the worker takes the necessary amount of clay to fill the mould, which has a parellelepiped shape (single or double), presses it by hand, lifts the mould and leaves the brick on the ground. Tiles are made on a shelf with a brick base and a clay surface. The mixture, less humid than the one that is used for bricks, is first pressed in a trapezoidal mould and then placed on a truncated cone shape that gives it its typical curve. In the past tiles were shaped directly on the thighs of the kiln worker.

The kiln is spacious on the outside, so as to permit the storing of the pieces that are ready, and to set those that are about to be baked. In fact, before the baking process the pieces are left on the ground in parallel rows for a couple of days, to permit a first natural drying process. During this sun-drying phase the pieces lose water and their volume contracts approximately 10%. If the pieces were baked without undergoing this phase, the evaporation of the water through heat would be too fast and would cause the breaking of the bricks. The kiln is usually square, with a truncated-pyramid exterior shape. The lower part is built with stone walls and is partially buried in order to keep heat better and to ease the phases of loading and unloading of materials. The upper section has an cylindrical interior cavity and the structure is made of brick walls covered with clayey mortar. The lower section includes a combustion chamber which is supplied through an opening that is partially walled during baking in order to prevent the dispersion of heat and to limit ventilation. Another smaller opening is present on the opposite side of the kiln and is left open so as to maintain a good draught and allow smoke to exit.

Fuel consist in small and very dry branches which generate high flames. The combustion chamber, approximately 2 m high, has a brick vault which forms the support of the kiln with many holes for the passage of heat. On this vault the bricks and tiles are staggered in layers, forming a pyramid, so as to allow the circulation of air and a homogeneous diffusion of heat. This space has a lateral entrance for easily placing the pieces that are to be baked. During the baking process this opening is completely blocked.

Tiles, being thinner, break easily and are therefore placed last, on top of the bricks, so as not to be too close to the source of heat.

The average kiln has a capacity of 20000 bricks and 10000 tiles. A kiln is never used only for tiles, which are made upon request.
The pieces are baked for 24 hours, keeping the vents open. After this, the two openings are completely blocked and a first slow cooling process begins, which will take an additional 24 hours. For the clayey earth to become robust and hard the kiln must reach temperatures of at least 700°C. The higher the heat the more compact, strong and vitrified the baked clay will be. The colour of the brick depends on the content of oxides in the clay, and of the baking temperature. The irregular colour and resistance of traditional bricks depends mostly on the difficulty in controlling the exact temperature, as well as the distribution of heat within the kiln.
Once the bricks have been baked and cooled, the layer of earth that covered the structure is eliminated and the bricks can be taken out and stored in the open-air, while waiting to be carried to a warehouse or site.
The empirical system for verifying the quality of a completed brick is based on an assessment of resonance to percussion: a clear crystalline sound indicates a good brick, a sharp metallic sound indicates an over-cooked brick, whereas a dull sound indicates a dented or badly baked brick. The quality of the mixture is controlled instead on the fractured face: a good mixture presents a fine grain, porous and homogeneous, and when it is immersed in water it absorbs it slowly without effervescence.
The analyses carried out on some samples taken from the medina have revealed irregularities and imperfections. Both in bricks taken from traditional houses and in bricks that have been more recently produced.
From the formal point of view, the imperfect shape proves that bricks are manually compressed. The composition of the mixture of the analysed bricks is irregular, with evident particles of lime and large grains of aggregate. Also the baking process is irregular, as can be seen from the various tones of colour present on exterior surfaces.

Lime

Lime is a fundamental material which characterises the traditional architecture of the medina. It is used for stabilising the earth used for obtaining mortar, for plastering interior and exterior walls, as finishing for pavings without tiles and on roofs to prevent water infiltration.
The raw material for its production is limestone, a sedimentary rock rich in calcium carbonate ($CaCO3$) which is extracted in certain quarries in the vicinity of Chefchaouen.
Along the road to Tetouan, approximately 15 km from Chefchaouen, a kiln that uses traditional methods for the production of lime is still in use.

opposite page
Lime kiln near Chefchaouen

It is a circular construction in the shape of a truncated cone, built at the foot of a steep terrain which ensures isothermy and guarantees two easy accesses: one from below for supplying fuel to the combustion chamber and another one from above for loading and unloading. The lateral and exterior walls can be made with any type of stone, while the interior chamber must be made with very resistant calcareous stones, held together by a heavy-duty lime mortar. On the lower part, next to the ground, the kiln has an opening which is wide enough to allow the introduction of materials for combustion.

The production process begins with the excavation of the calcareous material, which is abundant in the area around Chefchaouen. The extracted rock is broken into medium-sized ashlars and baked in the calcination oven.

A very delicate phase of the process is the loading of the oven. In the central part of the kiln an expert kiln worker places a first circle of stones, known as central ring, touching the walls of the structure and on which other ashlars will be piled, leaving an ovoid-shaped space that creates a vault and becomes the combustion chamber. On the walls of the central ring empty spaces are left between the stones. These voids are kept until the top of the kiln and serve as an enforced draught, which is necessary for a proper combustion. Once the cone is completed, stones are inserted that fill the gap between the central cone and the walls, until reaching the upper level of the terrain. The larger blocks are used for building the combustion chamber, while stones of decreasing sizes, which require less baking time, are piled on the outside of the vault. The load is completed on the top with a layer of stones to form a small cupola which is covered by a lime mortar that is kept humid and has the function of preventing the dispersion of heat during the baking process, while allowing the emission of air.

The kiln visited during the mission of November 2007 was of a traditional type, and was active discontinuously depending on demand. An open interview was carried out with the kiln workers in order to understand its operation. The first information obtained from the conversation is that the best season for the production of lime is Summer, although the kiln, again depending on demand, could be in operation all year round.

The first operation of the process is to gather the necessary branches and logs for the combustion process, which must be continuous and uninterrupted for 15 days. Two teams of workers, one during the daytime and another at night, ensure supply of fuel to the kiln, which must remain at a temperature between 800°-1200°C. The baking of the limestone is the longest phase of the entire production process. The fuel used must generate an elevated heat with high flames, and this is why very dry and small pieces of wood and branches are recommended. The fuel is inserted in the combustion chamber with the

opposite page
A woman lime painting the space in front of the house entrance
(© L. Lupi, 2007)

use of a shovel or a pitchfork through a small opening at the centre of the door, which once the fire has been lighted is blocked with stones and lime mortar.

Once the baking process is completed the opening is blocked and the stones are left to cool inside the kiln for another 24 hours.

At the end of this process the weight of the stones is reduced by approximately a third and their consistency is porous. Burnt lime, also known as quicklime, can be acquired in blocks or in powder. In any case it must be kept in hermetic containers because it is highly hygroscopic.

In order to obtain the final product, or slaked lime, the baked blocks are immersed in basins full of water where a hydration process takes place, together with a violent release of heat that breaks the stones. This procedure is known as lime slaking. The hydrated lime is obtained when it is put out with an amount of water approximately equal to the amount of lime. The resulting hydrate is a soft and fine powder, which is sold in paper sacks like cement and must be kept in a completely dry place. It is less sensitive to frost than lime putty. Lime putty is obtained when quicklime is put out with an amount that is superior to that of the lime (a ratio of approximately 3:1). In this way a maleable and greasy mass is obtained which is then seasoned.

The water that separates from the mix is called limewater or milk of lime, and is obtained when quicklime is put out with an amount of water that is approximately equal to that of the lime.

As long as it is humid the lime is easy to work and mould, whereas once it is dry it becomes a material that is relatively resistant to water, and has good mechanic properties and an excellent stability through time.

During the process of drying the mixture, there is a loss of water through evaporation and, thanks to the reaction with the carbon dioxide in the air, calcium carbonate is formed. This phenomenon is known as carbonation: the lime returns to its initial form as calcareous rock, yet with crystals that are much smaller than they were originally.

The carbonation reaction is very slow due to the low concentration of carbon dioxide in the air, so the complete transformation of the calcium hydrate into a carbonate requires several years. This lime is called aerial lime because it requires contact with air for it to set, unlike hydraulic lime which can become hard even when immersed in water.

The loss of water through evaporation causes a contraction. For this reason slaked lime is never used on its own, but always together with an inert material, such as sand, in order to avoid breakage.

Lime-based plaster (*lebs*)

The typical blue plaster of the buildings in Chefchaouen is made by adding a pigment to milk of lime which is unalterable upon the action of the chemical agents contained in lime, as well as of those from the atmosphere. The original blue pigment was probably derived from a Murex shell, which is usually a shade of royal purple once prized by the Romans and Byzantine empires. Shades of indigo were apparently made for the use of dying the blue thread used in the Jewish shawls. Other sources (Naciri and Hassani, 1985) state that blue dye can be made from the woad plant (*nila*), which gave a slight blue tint to the white of the lime and remained for about ten days, providing coolness to the tinted surfaces. Blue is also used to trick mosquitos, who perceive it as clear flowing water, which they are not attracted to.

The Sephardi Jewish community that settled in Chefchaouen brought along their tradition of painting buildings blue. According to Jewish belief, the colour blue represents the sky, which in turn reminds people of heaven, peace and safety. There is, therefore, a strong tra-

opposite page
Facades painted with traditional lime plasters

dition among Jewish communities of painting things blue and using blue dye to colour fabrics, especially prayer mats. Older residents say that the blue-coloured walls of Chefchaouen were only found in the Jewish part of the city, the *mellah*, until fairly recently, while most of Chefchaouen's buildings within the medina used to be white.

The vibrant pigments used today for painting in Chefchaouen are probably synthetic. The colored powders are sometimes mixed with water, not with clay.

Whitewashing was usually carried out only in the space accessible to the person doing the painting. The task was traditionally done by women, who not being able to climb ladders for cultural reasons, whitewashed only the ground floor (to a height of approximately 2 m) and the part of the facade easily accessible from the window.

Lime is an important element for hygiene in both homes and streets; it is in fact a well-known antiseptic and for this reason it is used for whitewashing the pavement of houses without tiles, but also the pavement of the *derbs*.

Whitewashing has a limited duration, however, due to the low resistance to rain and humidity. After a few days the tint loses luminosity, after which it decays easily and peels off. Streets and facades are therefore white approximately three times per year, whereas pavements in dwellings were traditionally whitewashed as often as once or twice a week, depending on how many people live in them.

Earth

The mortar used in traditional worksites is a mixture of clayey earth (*thrab*), lime putty (*gir*), water, and a varying amount of hay and brick fragments. The ratio between earth and clay is 5:2.

It is thus a specific type of mortar made of a part of binder (lime) and a part of clayey earth that collaborates in the cohesive action of the binder. Lime acquires binding properties when mixed with earth and inert matter. The mixture of lime and earth is traditionally left to settle at the worksite for three months before being used; this practice allows a good carbonation of the lime, yet results in an irregular mixture with clumps of solidified lime. The earth used in the mortar is a clayey earth that usually comes from an excavation at the worksite itself. The water/binder ratio is essential for obtaining a good mortar. Masons tend to dilute the mixture to obtain a material that is easier to work with, although the mechanical features after setting are better if the content of water is low, unless the low maleability does not generate irregularities in the material.

The mixture of earth and clay was also used in the past for building rammed earth walls.

opposite page **Geometric patterns for zellige decorations,** exhibited at the Kasbah Museum, Chefchaouen

The use of the rammed earth technique is evident in the walls of the kasbah. It is probable that this method was also used in the construction of some walls in the older quarters of the medina. In this case the earth is used by compressing a damp mixture of earth clay gravel, clay and small and medium-sized stones as reinforcement, into an externally supported wooden frame.

Today, for the building of walls, cement is used in the mortar mixture instead of lime. The cement is mixed with fragments of porous calcareous rock (*porbo*) with a variable granularity that goes between 0.2 cm and 1 cm in diameter. The ratio between cement and *porbo* is 1:3. The other materials used in the production of cement-based mortar are sand, and gross gravel (*grava*), derived from fragments of hard calcareous rock with a variable granularity that goes between 0.5 cm and 3 cm in diameter.

Sand is usually taken from the beaches around Tangiers; it is not sieved before being used in the worksite, in fact there are traces of shells and sea pebbles. However, the use of marine sand in the mortar mixture is generally advised against since the salts present in it cause efflorescence on the walls.

Zellige tilework cladding

Zellige (also *zelige* or *zellij*) is an enamelled terracota made in a variety of colours and cut by hand, used for the decoration of walls, columns and sometimes floors. The mosaic tilework is made from individually chiseled geometric tiles set into a plaster base. Each shape of the *zellige*, called *furmah*, has a specific name. The *furmah* can fit into each other to compose geometrical polychrome motifs that draw figures which repeat themselves all over the decorated surface. The different combination of basic shapes gives rise to an almost infinite quantity of combinations that differ in patterns and colours. The main patterns are star-based and can be identified by their number of points. Within a single star pattern, variations abound—by the mix of colours, the size of the *furmah*, and the complexity and size of interspacing elements such as strapping, braids, or "lanterns." There are also non-star patterns— honeycombs, webs, steps and shoulders, and checkerboards. This framework of expression meets the need to create spatial decorations that avoided depictions of living things, consistent with the teachings of Islamic law.

The art of zellige was brought to Chefchaouen by the Andalusian Arabs. In fact it flourished in the Spanish area known as Al-Andalus between 711 and 1492, and it is a typical feature of Moorish architecture. Fez, Meknes and Tetouan are still production centers for zellige tiles.

The zellige starts from the production of square, monochrome, hard tiles from which smaller pieces are cut with a special hammer according to traditional forms. The colours used traditionally for colouring the tiles are derived from natural products. The white base colour of the enamel is obtained by covering the clay pieces first with lime mortar (*khfîf*) and with siliceous sand in an aqueous solution. Blue is made by melting natural cobalt arsenide, previously burned to form cobalt oxide, with quartz and potassium. Brown is obtained by local minerals such as oligisto rock or manganese (moghnâsîya kahla). Yellow comes from local ferrous minerals that appear in mixtures such as limonite or stibnite (natural antimony sulfide). Green is the result of adding copper oxide to the white enamel and is also derived from calcosine (natural copper sulfide).

For pavements also 5 × 15 cm tiles (called *bejmat*) are used, with a thickness of 2 cm.

Since their production requires many hours of work and is therefore quite expensive, in restoration interventions they are often substituted with square industrial ceramic tiles that measure between 12 and 14.5 cm and are decorated on the entire surface.

The word *zellige* is currently used in a general way to identify enamelled ceramic tiles.

Physical and mechanical features of traditional materials

In order to deepen the knowledge on recurring materials in traditional building a specific research was carried out for obtaining their chemical, physical and mechanical characteristics (Rovero, Fratini, 2013). A series of specific campaigns were undertaken in situ for identifying and obtaining representative samples of the materials present in local constructions.

Stone masonries similar to sample B4 (on the left) and B6 (on the right)

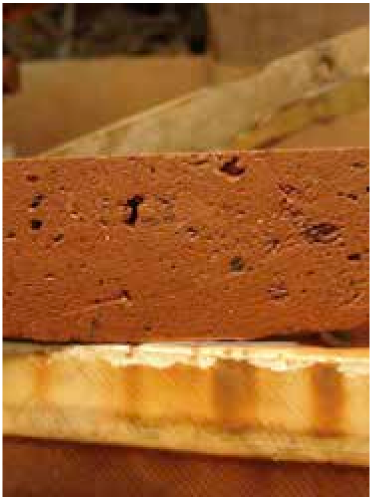
Samples were taken of stones, bricks and bedding and cladding mortars that are typical of traditional masonry, as well as samples of bricks, stones, mortars, binders and aggregates used in current building practices. A description follows:

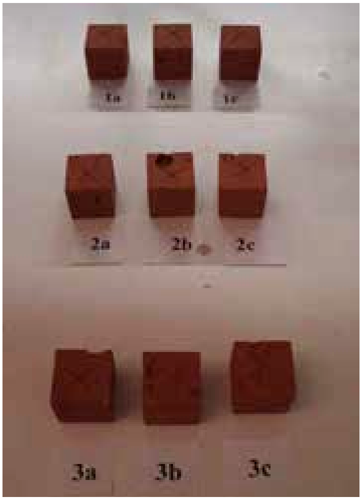
- B1, traditional brick (*massiso*): it has be taken from the wall of a house under renovation in the medina. It has an irregular shape, the structure is heterogeneous with lime lumps, vitrified zones and large granules of the framework.
- B2, fragment of a traditional brick (*massiso*): it was part of the inner wall of the Al Aadam Mosque, before its last restoration (in 2007).
- B3 recent brick: it comes from the brick kiln which is located along the road to Tetouan, in the village of Dar Akoubae. The element does not have smooth and flat surfaces. Several imperfections due to the craftsmanship are visible.
- B4, light-colored gray-brown block of stone (*jar-sam*). The material is fine grained and compact. It was taken from an open air deposit of materials next to the the city walls. It is similar to the blocks used in many traditional walls of the medina.
- B5, block of stone, dark gray-brown in color (*jar-butretak*). It has be taken, as B4, from an open air deposit of materials next to the city walls. The material is fine grained and slightly foliated. The blocks in the masonry are small-medium sized and roughly shaped.
- B6, block of stone, gray-brown in color (*keddane*). It was also be taken from an open air deposit of materials next to the the city walls. It is soft and easy to work.

- M1, masonry joint mortar. Taken taken from the wall of a building under restoration within the medina. The mixture, light brown in colour, is not homogeneous, with evident white lime lumps apparently not mixed with an earth binder.
- M2, mortar from the render of a building under restoration within the medina. It is light brown in colour, with an earthy aspect, similar to the renders of many traditional walls of the medina.
- M3, mortar from the render of a building under restoration within the medina. It is gray brown in colour, seemingly with strong cohesion, and it is similar to the renders of many traditional recently renovated walls recently in the medina.
- M4, mortar for internal plastering, coming from the restoration yard of the Al Aadam Mosque. Local masons said that it is a mixture of sand and lime in equal proportion and it is always kept fluid through the constant addition of water. The mixture is prepared on the floor inside the mosque in order to decrease evaporation and setting. This mixture, with fine aggregate, is used for the finishing layer of interior walls.
- M5, mortar of the original finishing, taken from an inner wall of the Al Aadam Mosque, before restoration. On the samples different whitewashings are easily distinguishable.
- C1, white paint for outdoor use, from a courtyard house restoration site in Rif al Andalous quarter.
- C2, powdered slaked lime (*jir*), from a restoration site in Rif al Andalous quarter.
- C3, artificial gravel (*grava*), taken from a restoration site in Rif al Andalous quarter. The particles size is between 0.5 and 3 cm, and it is used for making concrete.
- C4, fine gravel (*porbo*), taken from a restoration site in Rif al Andalous quarter. The particles size is between 0.2 and 1 cm. It is used for the realization of mortars for masonries, slabs and concrete.
- C5, sand (*ramla*), with particles size below 0.2, used in the reinforced concrete mixture. The sample is taken from a restoration site in Rif al Andalous quarter. The material comes from the beaches of Tangier. It is not sieved, as can be seen by the presence of shells.
- C6, clinker powder, from a restoration site in Rif al Andalous quarter.
- C7, earth for ceiling floor, from a restoration site in Rif al Andalous quarter.
- C8, lime for ceiling floor (*jir*), from a restoration site in Rif al Andalous quarter.

On the above mentioned samples the following analyses have been performed:

- study of mortars in thin sections (optical microscope in transmitted light) in order to define the structure of the carbonatic binder (lime) and its distribution with respect to the earthy matrix and sandy framework;
- principal mineralogical composition determined through powder X-ray diffraction





from left to right
Section of brick (massiso) of new production (sample B3).
Cubic specimens, obtained by cutting of samples B3, for uniaxial compression test
Uniaxial compression test

opposite page
Mineralogic composition

(XRD). Semiquantitative data were obtained through comparison of the peaks elongation with that of standard samples;

- clay minerals composition determined on fraction <4 lm, through powder X-ray diffraction (XRD);
- uniaxial compression test on the brick samples (B1 and B3) and on stone samples (B4, B5 and B6) to determine compressive strength. Given the small amount of available brick and stone blocks and trying to undertake the highest number of tests in order to have statistically significant data, cubic samples of side 40 mm were realized. Monotone uniaxial compression tests were carried out using an hydraulic press with 50,000 N loading cell, four displacement transductors placed on the upper surface of the loading plate and a data recorder (TDS). The tests have been performed by controlled displacements in order to record the load–displacement diagram also in the post peak phase.

Mineralogical and petrographic analysis were performed by Fabio Fratini from the CNR Institute for the Conservation and Valorization of Cultural Heritage (ICVBC), located in Florence. Mechanical analysis were carried out by Prof. Luisa Rovero with the support of the Official Material and Structural Testing Laboratory from Department of Architecture (DIDA), University of Florence (Rovero, Fratini, 2013).

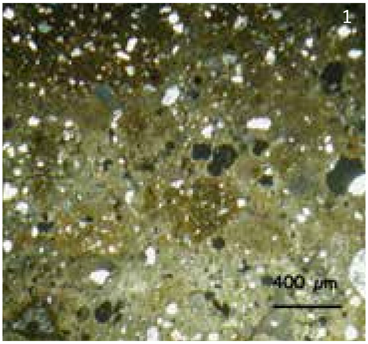
The mineralogical and petrographic analysis of rock samples shows that sample B5 (*jar-butretak*) is a silica rock (flint or chert) with a compact structure and very low porosity. Samples B4 (*jar-sam*) and B6 (*keddane*) are limestones with very different struc-

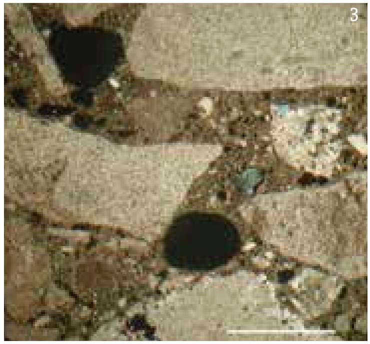
		Quartz	Feldspars	Calcite	Dolomite	Gehlenite (Fired bricks)	Clay	Notes
C1	Whitewashing	tr		100				
C2	Powder slaked lime							Ca(OH)2
C3	Grinded gravel				94		6	
C4	Fine gravel	tr		94	tr		6	
C5	Sand	60		39			tr	
C6	Clinker			11				Alite
C7	Earth for ceiling	12	5				83	
C8	Lime for ceiling			83	tr		17	
M1	Joint mortar	4		42			54	
M2	Plaster mortar	10		60			30	
M3	Plaster mortar			72	14		14	CSH
M4	Finishing mortar			~90	8			
M5	Finishing mortar	6		>90				
B2	Old brick	30					~70	
B3	New brick	30	3			tr	~55	
B4	Stone			95			5	
B5	Stone	95					5	
B6	Stone	5		90			5	

tures: B4 has a very compact micritic structure originating from a carbonate mud and B6 is a fine grained bioclastic limestone originating from the accumulation of small fossil remains bound by a scanty microsparitic calcite cement.

The white coating paint (C1) is made of lime. Sample C2 is made up of powdered hydrated lime [Ca(OH)2]. Sample C3 (gravel) is made up of granulated dolomite (artificial gravel). Sample C4 (fine gravel) is made of calcite and comes from the crushing of a hard limestone similar to B4. Sample C5 (sand) is made of 60% quartz and 39% calcite. Sample C6 (clinker powder) displays the typical composition of a Portland clinker as indicated by the presence of C3S (alite). Sample C7 (earth for ceiling floor) is made mostly of clay minerals (more than 80%). It is therefore a very fat earth, probably purified, to gain higher waterproofing. The clay minerals analysis does not show the presence of swelling clay minerals, therefore this earth reacts little to moisture.

The sample of masonry joint mortar (M1), used in the traditional masonries, contains 42% calcite, 40% of clay minerals and 4% of quartz. This particular composition points out that this mortar is made by mixing a part of lime binder and a part of earth (made mainly of clay). The clay is made up of illite, chlorite and kaolinite with a small percentage of quartz. The absence of swelling clay minerals assure a low reactivity with respect to water. Sample M2 (plaster mortar) shows a composition quite similar to M1 but richer in lime (60% of calcite, 30% of clay minerals, 10% of quartz). The microscopical aspect evidences the poor mixing





1. Thin section under optical microscope in transmitted light (XPL) of plaster mortar (sample M2).

2-3. Thin section under optical microscope in transmitted light (XPL) of plaster mortar (sample M3)

opposite page from left to right

Load–displacement diagrams

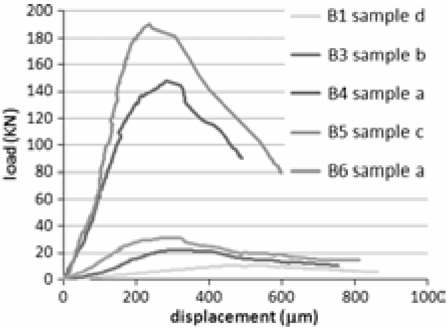
Compressive strength of the blocks.

of lime and earth. Sample M3 (plaster mortar) is a strong cohesion mortar made of a gray brown-binder and a gray-whitish aggregate with rare ground fired brick fragments 0.5–1 cm in size and with a relative abundance of macropores. The analysis shows that mortar is made with a modern hydraulic binder (Portland cement) and a relatively well-selected carbonatic aggregate obtained by grinding. The mortar is lean and it was carefully blended with a relatively high amount of water. Above this mortar render, three layers of whitewashing can be observed: lime, cement slurry and again lime. The analytical data of sample M3 show that in many restorations the traditional plasters are replaced with cement-based plasters.

Sample M4, premixed mortar for internal plastering, is a mixture of lime and a carbonatic aggregate (mainly calcite with a small percentage of dolomite, thus slightly different from porbo) in equal proportion.

Sample M5, mortar of the original finishing, is made up of a mixture of aggregate (calcite with a small percentage of quartz) and lime in equal proportion.

Compression tests on brick samples (B1 and B3) showed rather poor mechanical properties for original bricks (B1), degraded by time and characterized by heterogeneity and porosity, and medium–low mechanical properties for bricks of new production (B3). In both cases, the crack patterns showed vertical fractures and expulsion of parts of the block. Compression tests on cubic samples of stone (B4, B5 and B6) showed very different mechanical behaviors. The comparison between the load–displacement diagrams shows that the blocks B4 and B5 have high strength and stiffness and a brittle type behavior, while the block B6 has a lower strength and stiffness and a pseudo ductile behavior both in pre-peak and in post-peak phases. The mode of failure was also different: samples B5 and B4 exhibited a sudden break and vertical fractures, while the B6 samples exhibited crack patterns that were less regular and a post peak characterized by subsequent



	B1	B3	B4	B5	B6
Compressive strength (MPa)	6,96	13,4	92,3	124,2	20,1
	Stand. dev. 0,459	Stand. dev. 1,276	Stand. dev. 11,16	Stand. dev. 12,17	Stand. dev. 2,37
	Coeff. of var. 0,066	Coeff. of var. 0,095	Coeff. of var. 0,121	Coeff. of var. 0,098	Coeff. of var. 0,118
	samples 7	samples 5	samples 5	samples 6	samples 5

settling of the material, probably due to the filling of the pores due to material crushing. In order to understand the mechanical characteristics of the mortars, they has been compared using the Italian standards (DM 14/01/2008) that classify mortars according to their composition. The composition of mortar M1 could be compared to that of class M4, which is an hydraulic mortar made of one part of hydraulic lime and three parts of sand. This class is referred to an average compressive strength of 2.5 MPa. The binding action in the medina masonry mortars is performed both by the lime and by the clay component, therefore it is possible to assume that the strength of this mortar is close to that of M4 class (Rovero, Fratini, 2013).

References

AA.VV. 2000, *L'arte mudejar: l'estetica islamica nell'arte cristiana*, Electa, Milano.

AA.VV. 2001, *Il Marocco andaluso. Alla scoperta di un'arte del vivere*, Electa, Milano.

AA.VV. 2004, *Techniques et pratique de la chaoux*, Eyrolles, Paris.

Dipasquale L., Nicosia V. 2009, *I materiali del cantiere tradizionale*, in Mecca S., Dipasquale

L., Rovero L., Tonietti U. & Volpi V. (eds.), *Chefchaouen, Architettura e cultura costruttiva*, ETS, Pisa, pp.111-117.

DM 14/01/2008, *Approvazione delle nuove norme tecniche per le costruzioni*, G.U. n.29 del 04/02/2008, suppl. ord. N.30.

Naciri M., El Hassani A. 1985, *Etude architecturale de la medina de Chefchaouen*, Royame du Maroc, Centre National de documentation, Sevice de Reprographie et Imprimerie, Rabat.

Naji S. 2001, *Art et architectures berbères du Maroc*, Edisud, Aix-en-Provence.

Rovero L., Fratini F. 2013, *The Medina of Chefchaouen (Morocco): A survey on morphological and mechanical features of the masonries*, «Construction and Building Materials », vol 47 (2013), pp. 465–479.

MORPHOLOGICAL AND STRUCTURAL FEATURES OF THE OF MAIN MASONRY TYPES

The walls observed and surveyed in the medina of Chefchaouen were classified with the purpose of charting the traditional historical walls (from the 15th to the 19th centuries), based on the identification of the main typologies, each of which is subdivided into three or more variants. Various in situ investigations have been conducted in order to provide an accurate description of the most common types of masonry, using manual measurements through direct inspection. Accurate surveys were taken on masonry without plaster of abandoned buildings with collapsed parts. In these cases it was possible to measure the size of the wall components, surveying photographically and drawing external faces and sections of the wall. The survey allowed the representation of stones, bricks, mortar and voids.

The main typologies identified, in order of recurrence, are: mixed stone and brick masonry (M1), stone masonry (M2), brick masonry (M3) and rammed earth with stone masonry. The criteria for selecting the main typologies are the recurring presence and the best building practice (in comparison with the variants), assessed on the basis of the size of the elements that compose the masonry, the setting of the masonry, and the ratio between blocks and mortar. The variants differ from the main typologies in terms of the different size and distribution of the elements.

The masonry type which uses only bricks can be found only sporadically in exterior load-bearing walls, yet it is quite common in interior partition walls.

The first phase of the construction process of a stone, or mixed stone and bricks wall consisted in the preparation of the materials. The stones were subdivided according to their sizes in order to have them at hand during the construction of the wall. The stones often needed to be reduced in size or moulded at the worksite with a bush hammer. The construction of the wall began with the two extremities, in brick or in squared calcareous stone. The tools used for controlling the vertical and the horizontal of the wall were the plumb line, bubble level, and strips of wood. The bricklayer placed a line between the two corners of the wall for determining the horizontal and began to place the stones. The two bricklayers, one on each side of the wall, placed a stone each, side by side on the same row. Ashlars were also

FUP Best Practice in Scholarly Publishing (DOI 10.36253/fup_best_practice)
Letizia Dipasquale, *Understanding Chefchaouen. Traditional knowledge for a sustainable habitat*, © 2020 Author(s), content CC BY-NC-SA 4.0 International, metadata CC0 1.0 Universal, published by Firenze University Press (www.fupress.com), ISBN 978-88-5518-178-5 (PDF), DOI 10.36253/978-88-5518-178-5

Walls resting on a rocky outcropping

opposite page **Mixed stone and brick masonry (M1)**

divided among the bricklayers who, upon completion of the thickness of the wall with smaller stones, prepare the surface for placing the next ashlar on the row above. The link between the sides of the wall took place by placing half-sized stones which took up ⅔ or the entire thickness of the wall. After having placed the stones a layer of mortar was spread with the trowel so as to fill in all the gaps between stones and prepare the surface for the subsequent row. The larger and more regular the stones, the less mortar was needed.

The foundations

Choosing a good terrain is the preliminary phase for the builder of walls. When rocks appear on the surface the wall is supported directly on them, otherwise a ditch is excavated approximately 50 cm wide and with a depth that varies between 30 and 120 cm, when the topography is uneven. The average depth, however, is generally between 50 and 70 cm.

The foundations are laid directly on a terrain made of homogeneous rock: when it is impossible to demolish a rock it becomes part of the wall of a courtyard or a room.

Foundations are usually composed of large stones joined with lime and earth mortar.

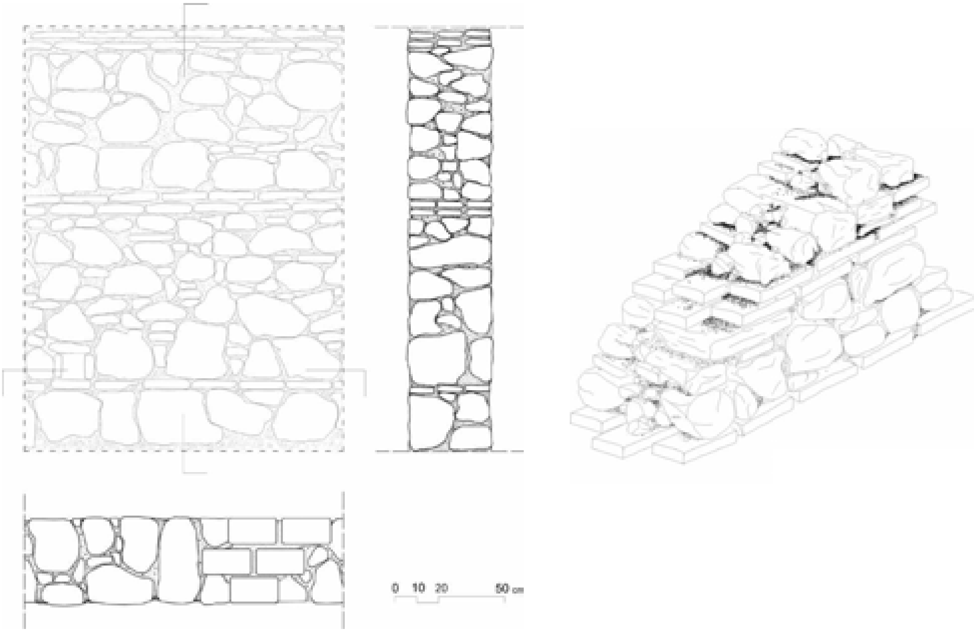
The construction begins with a layer of a mixture of earth and lime on the bottom of the excavation, on which a layer of large stone blocks is placed with the use of a specific tool (*bedjana*) that has a wooden handle and a steel head. This is followed by another layer of earth and lime mortar and small stones for filling in the gaps, also packed down with the *bedjana*. This compaction is carried out until the sound of the packing down produces a sort of echo. An additional layer of blocks is then placed and the process is continued by alternating layers of mortar and stones until the ground level is reached.

Mixed stone and brick masonry (M1)

Blocks can be made of hard limestone rock (al *jar-sam*), or soft limestones (*keddane*). Mixed masonry walls are made of two connected sides, one interior and one exterior, built with rough stones of the necessary size to cover most of the section of the wall, in combination with bricks.

The blocks have a length ranging from 10 to 30 cm, a height ranging from 10 to 25 cm, and a width ranging from 10 to 30 cm, with irregular shapes. Soft limestone is used mainly to build corners, openings lintels, or jambs. A core of fine filling material and mortar is present in the wall section, filling all the voids between the blocks.

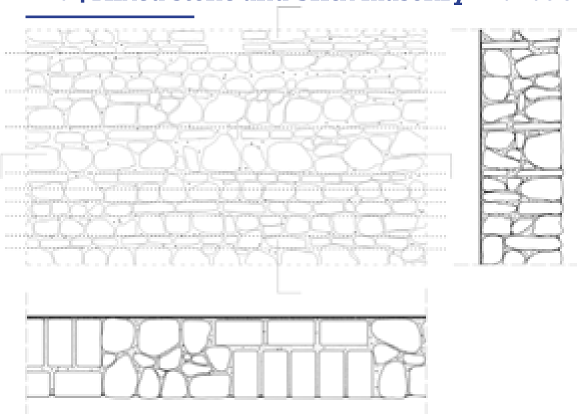
M1 | Mixed stone and brick masonry • main type



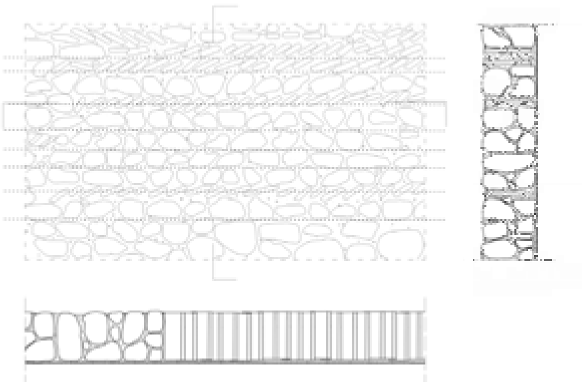
Rows of bricks are placed every 60–80 cm. They consist in two to three rows of juxtaposed bricks with the aim of regularizing the wall structure and to create connection between the internal and external wall. The shorter ends (header faces) of the bricks face the outside of the wall. A thick plaster of earth and lime, which is coated with a second lime-based layer, covers the walls. In relation to how regular the shape of the stones is, the percentage of mortar can vary from 4 to 25% of the volume of masonry, until a maximum of 50%. The mortar is made of 2 parts of lime for 5 parts of earth.

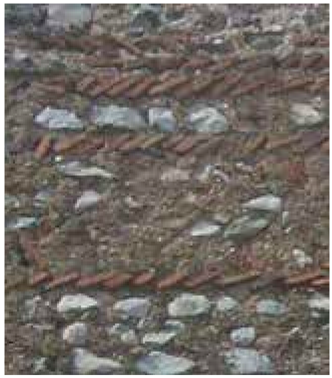
The thickness of the wall is never less than 40 cm on the ground floor. In the upper levels it is progressively reduced until reaching 25 to 30 cm. The mixed masonry walls are protected by an earth and lime plaster with an additional finishing layer in lime which is 2 to 5 cm thick. The lime finishing is applied to the base of the wall and up to approximately 2 m, and around the windows. These sections of walls, besides being more exposed to the action of rainfall, are protected with plaster because they can easily be reached without the use of ladders by the women, which traditionally took care of the maintenance of all parts of the house. Surfaces are constantly whitewashed, and therefore consist of countless layers of white and indigo blue applied over time.

M1a | Mixed stone and brick masonry • variation a

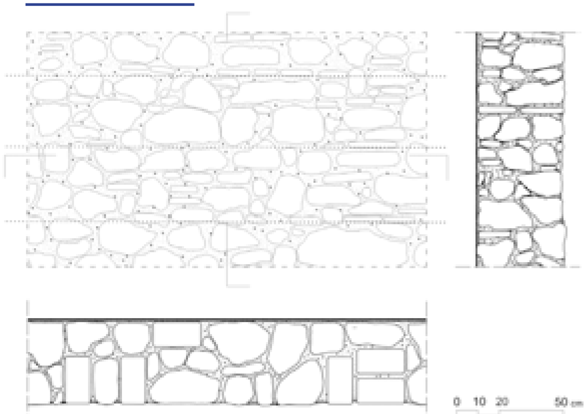


M1b | Mixed stone and brick masonry • variation b





M1c | Mixed stone and brick masonry • variation c



M1 Variants

M1 | Mixed stone and brick masonry – main type

The form and dimension of the stones varies from 7 to 30 cm wide and 5 to 25 cm high, placed so as to establish a good amalgamation between the parts. In the wall there is a nucleus of minute filling material with some binding elements (binding stone or *diatoni*) between the two facades. Courses of bricks are placed every 60–80 cm and consist in two or three rows of juxtaposed heading elements.

M1a | Mixed stone and brick masonry – variation a

The form of the stones is mostly homogeneous with medium-small sizes, 6-12 cm wide and 5-10 cm high. The rows are mostly horizontal and the composition homogeneous and compact. The courses of bricks are placed at an inter-axis of approximately 20 cm, not continuously but only in certain sections.

M1b | Mixed stone and brick masonry – variation b

The size of the stones is mostly homogeneous, 6-20 cm wide and 6-15 cm high, and are placed horizontally in a regular and continuous manner throughout the masonry. Courses of bricks are laid with only their stretchers showing and with an inclination of 45°. One or two courses of 45° bricks can be overlaid, with an inter-axis that varies between 15 and 40 cm.

M1c | Mixed stone and brick masonry – variation c

Stones are medium-sized and irregular, between 8-35 cm wide and 4-20 cm high. The setting is irregular and disorderly. The use of bricks is scarce and sporadic: bricks can be stretchers or headers, and do not create a continuous plane. Their function is to create horizontal surfaces for placing the following layer of stones.

Stone masonry (M2)

Stone masonry is made of hard limestone blocks (al *jar-sam*), with a compact structure or soft limestones (*keddane*). The stone blocks are roughly hewn or even not hewn, irregular in shape, basically a square, bound with lime-earth mortar. Stones are usually arranged in horizontal rows of different heights. The stones are laid down with the most regular face on the outside of the wall. The courses are regularized by mortar and stone fragments placed in order to press the stones into the wall thickness. Each stone is usually placed on at least two elements of the row below in order to avoid the alignment of vertical joints.

Based on their shape, the large stones occupy a greater or lesser portion of the wall thickness. The placement of the external stones of the two facing walls allows an irregular indentation enabling a transverse connection (*scarf*). Moreover, some stone blocks running through a wall from one face to another (or for at least 2/3 of the wall thickness), to bind it together (binding stone or *diatoni*) are occasionally present. The amount of mortar used for this type of masonry depends on the regularity of the stone blocks (from 4% to 25% of the masonry), filling all the voids between the blocks. Mortar is generally made using 2 parts of lime for 5 parts of earth. According to their size, blocks are classified into three main groups:

- big size stones (*ikbir*): blocks made with siliceous rock have a length ranging from 30 to 45 cm, a height ranging from 5 to 20 cm, and a width ranging from 20 to 35 cm, and a very irregular shape, almost never hewed. The limestone blocks have a length ranging from 30 to 45 cm, a height ranging from 15 to 25 cm, and a width ranging from 15 to 30 cm, and are hewed, therefore reasonably well shaped.
- medium-sized stones (*twate*): flat medium-sized stones used for regularizing the laying surfaces. In the case of schist the sizes can vary from 2 to 6 cm wide to 10 to 15 cm long, whereas calcareous rocks can vary from 15 to 20 cm wide to 15 to 20 cm long.
- small-sized stones (*áachchou*): small stones used to fill in the gaps, whose sizes are very variable depending on the nature of the material.

The wall thickness is generally between 35 and 50 cm and decreases on the upper storeys. The wall height varies from 4 to 8 m (which generally corresponds to two floors).

All the walls are protected by plaster, usually made of earth and lime, coated with a second lime-based layer.

M2 Variants

M2 | Stone masonry – main type

Stone masonry made of hard limestones blocks of various sizes. The blocks are roughly hewn, irregular in shape, bound with lime-earth mortar. The wall is composed of rough and irregular elements laid as headers and rarely as stretchers. Stones are placed in horizontal rows at different heights with the laying surfaces regularized with the use of smaller elements and gross mortar.

M2a | Stone masonry – variation a

The composition is irregular, lacking in horizontal courses; large stones are irregular and chaotically placed, sometimes as headers and others as stretchers. No elements are present that cover the whole thickness (diatoni). Small and medium-sized stones are used for filling

Stone masonry (M2)

in the gaps created by the irregular shape of the blocks, but do not generate horizontal planes. This type of masonry is generally used for retaining walls.

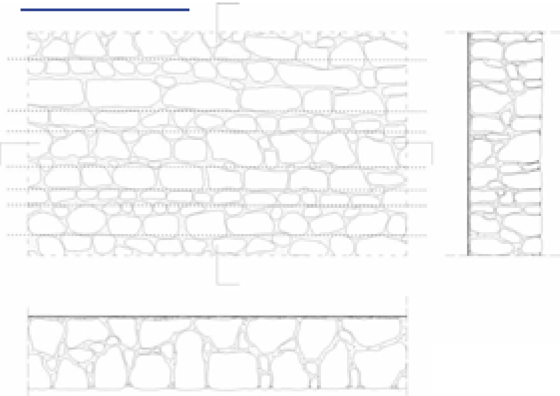
M2b | Stone masonry – variation b

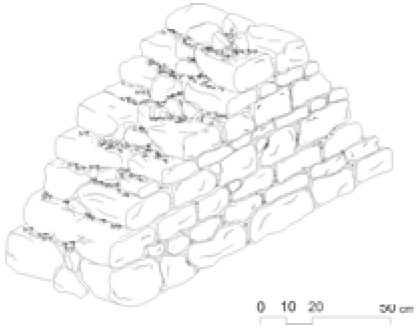
The wall is composed of irregular elements, placed generally as headers. There are few large yet many small and medium-sized blocks. Horizontal courses are not continuous. No stones were observed that cover the whole section of the wall.

Brick masonry (M3)

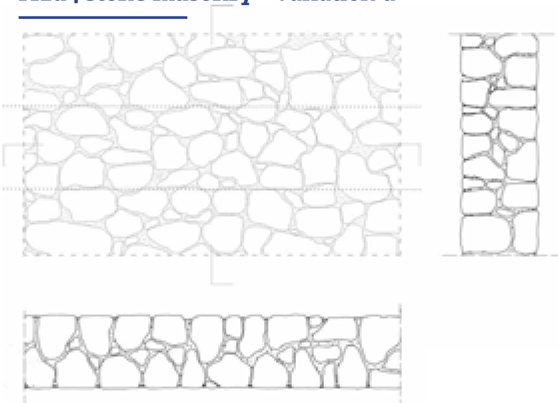
M3 masonry is composed of fired-clay bricks (*massiso*), which are bound with a lime and earth mortar. Bricks are made still today by hand in wooden moulds and baked in traditional kilns in the proximity of Chefchaouen. The sizes of the solid blocks are usually 21 cm long x 10 cm wide x 2.5 cm high, or 22 cm x 10 cm x 3 cm. Courses are almost regular and mortar joints are from 2 cm to 4 cm thick, depending on the bonding pattern. No vertical joint continues through more than one layer. Mortar binds the individual units together and provides a degree of weatherproofing to the structure being built. Perpends are never contiguous across courses.

M2 | Stone masonry • main type

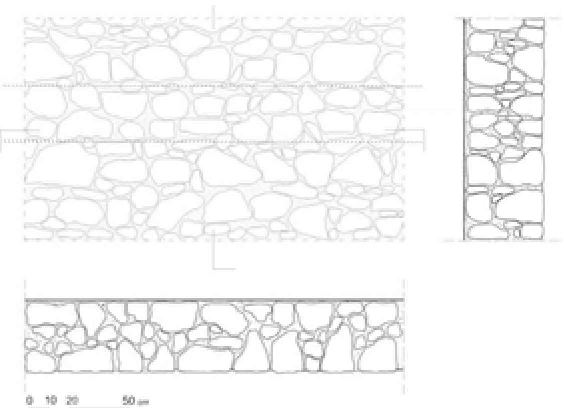


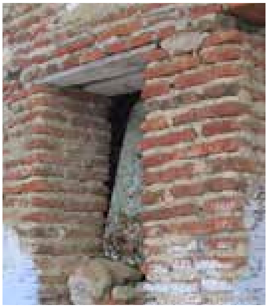


M2a | Stone masonry • variation a



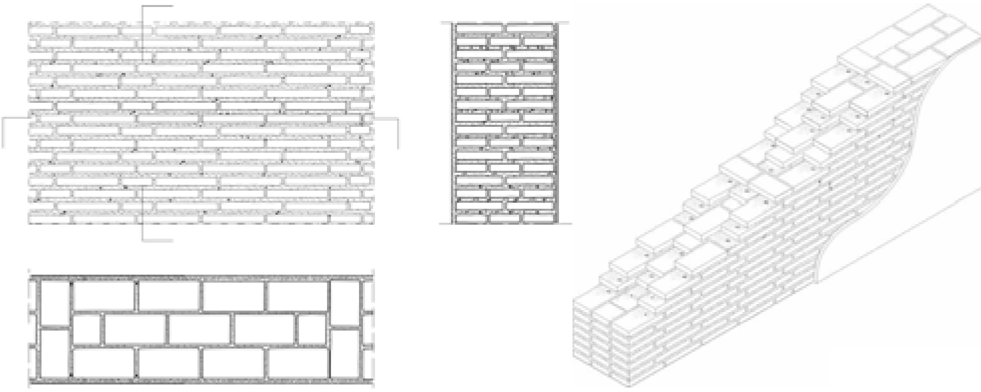
M2b | Stone masonry • variation b



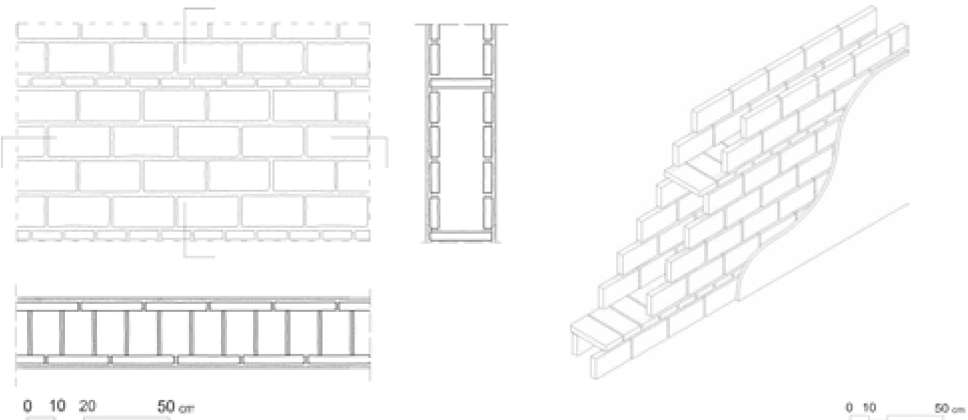


Brick masonry (M3)

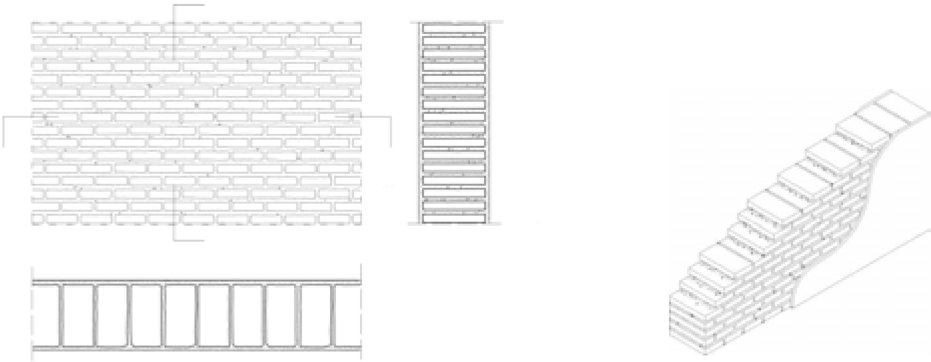
M3a | Brick masonry • Three-headed load bearing



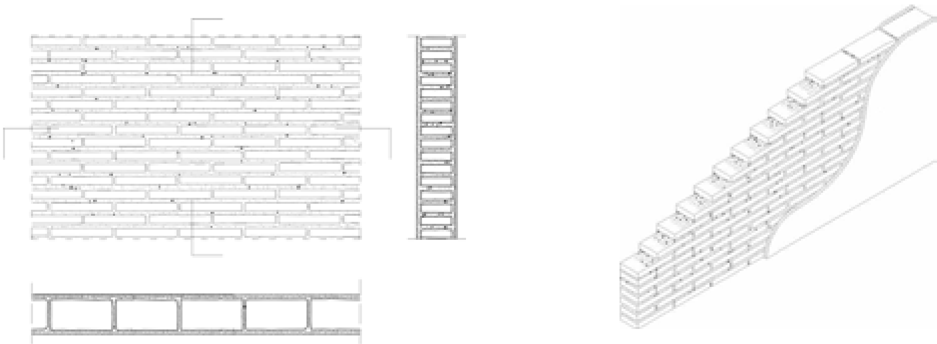
M3b | Brick masonry • Two-headed non-load-bearing partition (*tabique a la capuchina*)



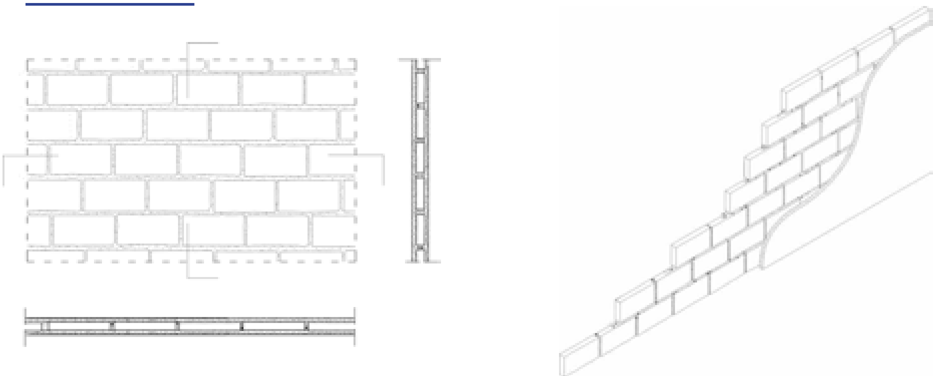
M3c | Brick masonry • Two-headed load bearing | Header bond



M3d | Brick masonry • One-headed non-load-bearing partition (*jabha*) | Stretcher bond



M3e | Brick masonry • Non-load-bearing partition (*tabique*) | Shiner bond



Rammed earth wall in the kasbah of Chefchaouen | *tâbya* (M4)

Brick masonry is found only sporadically in exterior load-bearing walls, while it is used frequently for interior partition walls. It is usually whitewashed with lime mortar. Fired-clay bricks are one the main building materials of the Moorish architecture. In fact bricks are used for building arches in courtyards and for windows and doors, where the decorative motif is based on the length of the brick as module for the geometric construction of the figure.
This masonry technique is much used also in more recent interventions regarding the addition of upper storeys or partition walls.

M3 Variants

M3a | Three-headed load bearing
The wall is composed by three leaves of stretcher bricks, which are laid with the longest end parallel to the face of the wall. Every four stretchers a header is laid, with the center of the face above the midpoint of four stretchers in the course below. Headers connect the three leaves together.

M3b | Two-headed non-load-bearing partition (*tabique a la capuchina*)
Cavity wall, with two leafs made of bricks laid on the long narrow side with the broad face of the brick exposed. The two leafs are connected by header bricks, laid every 45-50 cm.

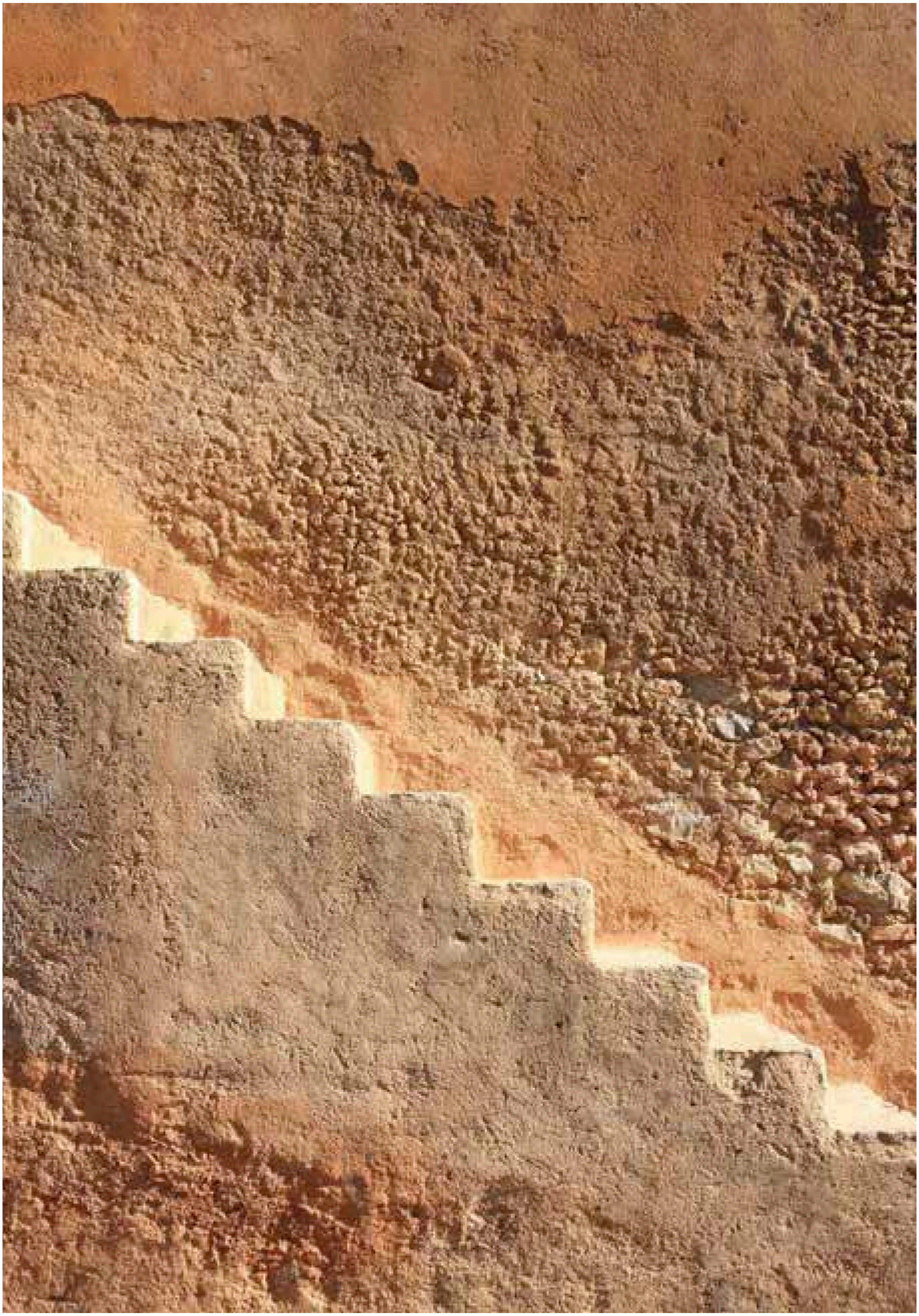
M3c | Two-headed load bearing – Header bond
All bricks are headers, so they are laid on their widest edge so that their shorter ends face the outside of the wall.

M3d | One-headed non-load-bearing partition (*jabha*) **– Stretcher bond**
All bricks in this bond are stretchers, with the joints on each course centred above and below by half a brick. The longest end of the brick is parallel to the face of the wall

M3e | Non-load-bearing partition (tabique) – Shiner bond
Bricks are laid on the long narrow side with the broad face of the brick exposed.

Rammed earth wall | tâbya (M4)

Walls are built as a series of layers by compacting a humid mixture of earth and lime within a temporary wooden formwork, used as a mould for the desired form and dimensions of each section of the wall. The material is compressed in courses, so as to gradually erect



Rammed earth and stones wall with courses of bricks

the wall up to the top of the formwork. After the course is complete the formwork can be removed. Tamping was manual with a long ramming pole locally known as *bedjana*. The lime in the mixture works as a stabiliser, which counteracts the maleable behaviour of the clay. Rammed earth technique is very frequent in Andalusian military architecture and was used in Chefchaouen for building the walls of the Kasbah.

Moreover, in the older sections of the medina there are some buildings which use the mixture of earth and lime in combination with local stones for the construction of load-bearing walls. Calcareous stones are placed in the formwork together with a humid mixture of earth and lime compacted with a ramming pole (*bedjana*). Hard calcareous stones (*jar-sam*) were commonly used in combination with earth in the construction of public buildings, whereas porous calcareous stones (*keddane*) were more commonly used for building the walls of dwellings. The high porosity of the stones in fact ensures a better thermal insulation of the walls.

In the execution of the wall a layer of a mixture of earth and lime is placed first, and over it a layer of large stones which is then compressed. The procedure continues by placing an additional layer of the humid mixture of earth and lime, then small stones are used for filling in the gaps after which compaction is carried out with the use of the *bedjana*. When the sound of the ramming produces a sort of echo this means that the layer has been sufficiently compressed. After this the wall continues to be erected by laying the next course of mortar and large stones.

In walls made of rammed earth and stones it is common to find courses of bricks, used for regularising with a horizontal plane the structure of the wall and to provide reinforcement and joints between the two sides of the wall. One or two courses of overlapping bricks are placed at a distance of 60-100 cm. Units are laid on their widest edge so that their shorter ends face the outside of the wall.

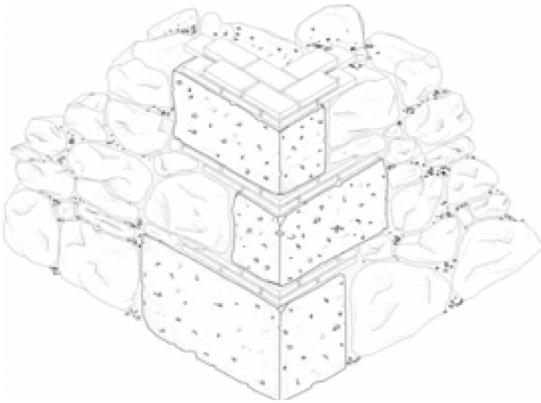
Masonry corners

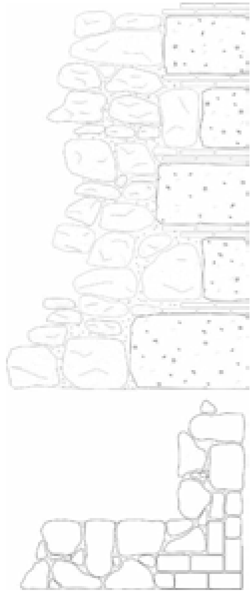
The exterior corners of the masonry walls of the buildings are always carefully executed. The function of the corners is that of linking two converging walls. Builders were aware that the formal quality of the corner resulted in corresponding mechanical efficiency, thus they have always paid special attention to the construction of this part of the building, using good quality quoins, which provide permanence and strength.

Quoins are made of stones or bricks, placed regularly so as to form a sharp corner at a right angle. The bases of corners (up to the first ceiling) are often made with stones that are larger than at the top. In some cases the sharp edge of the corner is rounded after the base un-

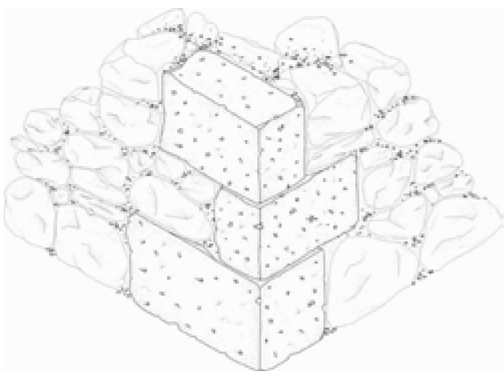
Mixed quoin with limestone blocks and bricks (Q1)

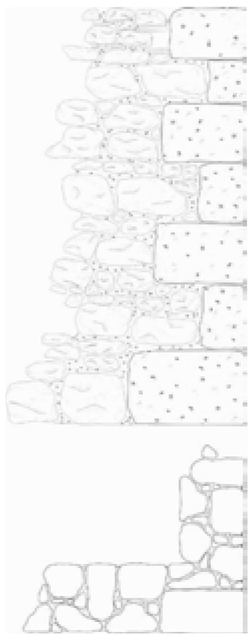
Q1 | Mixed quoin with limestone blocks and bricks



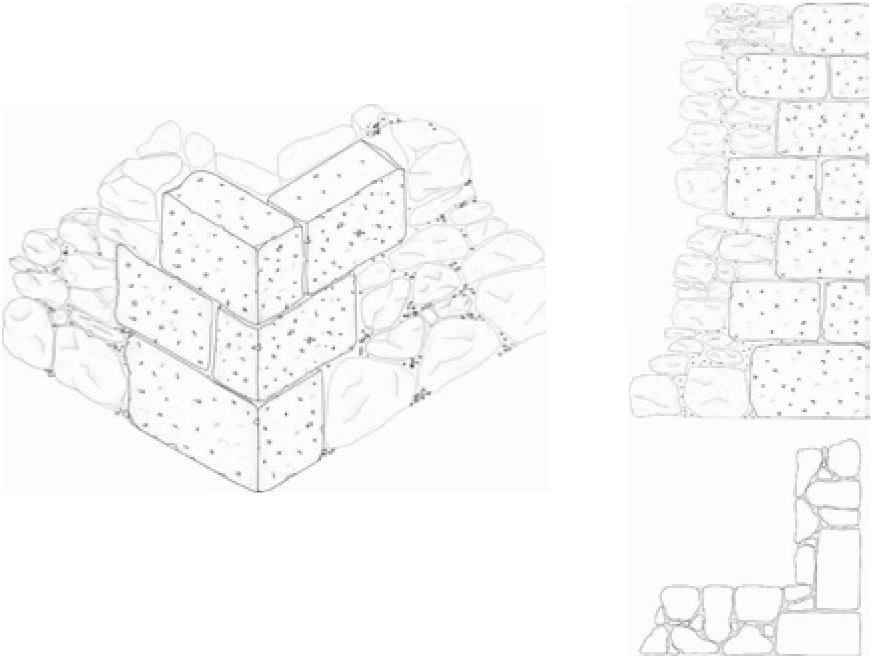


Q2a | Stone quoin with ashlar soft limestone blocks • variation a

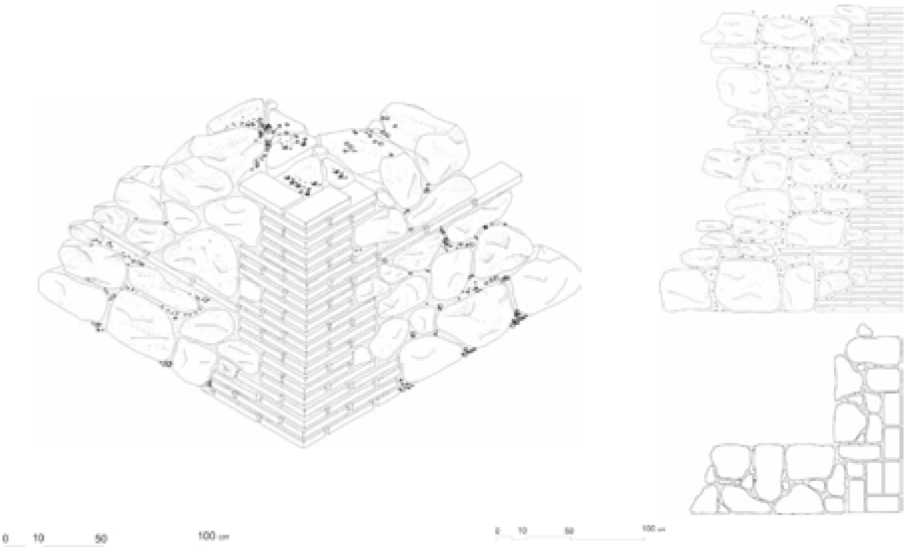




Q2b | Stone quoins with ashlar soft limestone blocks • variation b



Q3 | Brick quoins



til a height of 2 m for creating a rounded corner on the wall, whose depth varies from 7 to 20 cm, with the purpose of not obstructing the view and allowing the circulation of animals through the main arteries of the medina. Rounded quoins are generally made of bricks and can be decorated on their upper section with a blind arch or with moulding made with plaster. There are three main types of quoins.

Q1 | Mixed quoins with limestone blocks and bricks

It is composed of alternating courses of stones and bricks. The number of alternating courses may be regular or could change throughout the entire height of the wall. This type of quoin is present in all types of masonry.

Q2a & Q2b | Stone quoins with ashlar soft limestone blocks

This type of quoin is present only in stone walls. The blocks of stone used for the quoin are larger than those used in the masonry (approximately 30 x 40 x 60 cm) and take up most of the thickness of the wall (approximately two thirds). Every course of the quoin can include one or more blocks of stone; in both cases the superimposition is carried out in such a way that the upper block staggered by half of its length with respect to the one below, so as to allow a better binding with the masonry. Quoins with double blocks ensure a better bonding with the adjacent masonry.

Q23 | Brick quoins

This type of quoin is present mostly in mixed stone and brick masonry with the presence of brick edging. The width of the quoin on the facade goes from a minimum of two headers to a maximum of six headers, while the depth of the wall is generally of one to two headers. The type of bricklaying can be repeated regularly or can also vary throughout the entire length of the quoin while respecting, however, the staggering of joints between adjacent courses.

Quality of masonry types

The structural quality of masonries depends on a series of factors and construction devices which form the “rule of art” (*regola d’arte*): the compressive strength of its components (mortar and blocks), the shape of the blocks, the volumetric ratio between the components and the wall texture, etc. The masonry construction techniques observed in Chechaouen are aimed to obtain structures that are as monolithic as possible, consistently with available resources (i.e., hard and scarcely hewing stones and poor mortar with low amount of lime). In a masonry with a monolithic behavior there should not be any possibility of a vertical divi-

Masonry types	Connection between the exterior faces of the wall	Masonry laying	Size and shape of the elements of the wall	Mortar
M1 | Mixed stone and brick masonry main type	⊕⊕⊕	⊕⊕⊕	⊕⊕⊕	⊕⊕
M1a | Mixed stone and brick masonry variation a	⊕⊕	⊕⊕⊕	⊕⊕	⊕
M1b | Mixed stone and brick masonry variation b	⊕⊕	⊕⊕	⊕	⊕
M1c | Mixed stone and brick masonry variation c	⊕	⊕⊕	⊕	⊕
M2 | Stone masonry main type	⊕⊕	⊕⊕	⊕⊕⊕	⊕⊕
M2a | Stone masonry variation a	⊕⊕	⊕	⊕⊕	⊕
M2b | Stone masonry variation b	⊕	⊕	⊕⊕	⊕

Qualitative evaluation of the quality of the masonry types of the medina of Chefchaouen according to the main criteria that guarantee their monolithicity

sion of the section into two exterior and autonomous wall surfaces. After seismic actions, a wall built *a regola d'arte* should not disintegrate, but exhibit collapse mechanisms for turning over as if it were monolithic, even if built with different elements.
The criteria that ensure a monolithic behaviour of the wall, and therefore a good mechanical resistance, are described below.

Connection between the exterior faces of the wall

This criterion can be fulfilled by ensuring the bonding of the superimposed stones, or else by using binding stones (*diatoni*), passing stones that unite the two opposite sides of the wall. Good connections between the walls and between structural horizontal elements both in plan and elevation should be present so that the structure can assume a transverse monolithic behavior when oscillations are induced by seismic actions.

Masonry laying

A correct placing of the stones ensures the adequate friction of the contact surfaces which then can transmit the loads uniformly to the underlying elements. The search for horizontality through the use of small stones or brick flakes is useful for enhancing the mechanical behaviour of the wall. The horizontal position of the stones, in fact, permits the formation of linear joints during the oscillations of the wall, which trigger a cinematic

overturning action which is reversible, within the limits of the stability field of the wall, the moment the external action comes to an end, therefore without inducing the collapsing of the wall. When stones are not regularly placed, instead, the rotation in case of an earthquake would generate stress on irregular and wider sections of the wall.
In the case of type M1 (mixed stone and brick masonry), the insertion of horizontal brick rows inside the stone masonry reveals an attention to ensure horizontal layers of block which are able to distribute uniformly the stresses and to enhance monolithic behavior.

Size and shape of the elements of the wall

A wall has good quality if the large elements prevail over the small ones, so as to take up most of the section, or if the size of the elements is homogeneous. The main type of mixed stone masonry (M1), for example, presents a good distribution in terms of the size and shape of the elements. It is composed of medium-large stones with smaller stones used for filling the gaps that result from the irregular features of the stones, and of rows of bricks that regularise the course of stones. Also in the main type of rough stone masonry medium-large elements are placed in alternation with smaller ones which are used to fill the empty spaces between larger blocks and in horizontal rows so as to ensure a better horizontal laying.
The constructive process of type M2 (stone masonry) is based on the assembly of roughly hewn stones, irregular and thus difficult to overlay. In particular, the builders tried to get the binding stone (diatones) with stones occupying at least 2/3 of the thickness of the wall and to minimize the voids inside the masonry structure by utilizing a large amount of mortar, which, filling the gaps between the blocks of stone, can offer a suitable means to transfer the loads to the ground. The rule to be followed in placing the stones consists in the coexistence of large and small sized blocks in order to guarantee the presence of cross connections. In the main type of M2, the attempt to obtain monolithicity is more successful, since the blocks which are more squared allow a greater horizontality of block courses, cross interlocking, and the arrangement in staggered manner of vertical joints.

Mortar

The main function of mortar in masonry is that of regulating the contact and friction between the elements and to avoid load concentrations when surfaces are not regular. In the case of masonry built with small elements, in which the engaging of the stones is not enough to ensure the monolithicity of the wall, mortar should compensate for this defect in the binding. The slow grade of resistance to traction of the binding substance, however, prevents it from fulfilling this task. When the placing of the stones is well organised the cohesion of the

Scores assigned on the parameters of the "rule of the art" (construction devises)
NC = Not Complying. PC = Partial Complying C = Complying (adapted from: Rovero& Fratini, 2013)

	Vertical actions			Out-of plain actions			In-plain actions		
	NC	**PC**	**C**	**NC**	**PC**	**C**	**NC**	**PC**	**C**
Mortar quality/effective contact between elements/wedges	0	0,5	2	0	0,5	1	0	1	2
Presence of diatones/cross interlocking	0	1	1	0	1,5	3	0	1	2
Shape of resistant elements	0	1,5	3	0	1	2	0	1	2
Dimensions of resistant elements	0	0,5	1	0	0,5	1	0	0,5	1
Strength of elements	0,3	0,7	1	0,5	0,7	1	0,3	0,7	1
Arrangement in staggered manner of vertical joints/plan interlocking	0	0.5	1	0	0.5	1	0	1	2
Horizontality of bocks courses	0	1	2	0	1	2	0	0,5	1

Masonry categories as a function of the Masonry Quality Index (MQI) changing the external actions
A = good behavior of masonry, B = behavior of average quality of the masonry; C = inadequate behavior of masonry. (adapted from: Borri et al., 2011; Rovero& Fratini, 2013)

	Masonry categories		
	C	**B**	**A**
Vertical actions	**0 ≤ MQI < 2.5**	**2,5 ≤ MQI < 5**	**5 ≤ MQI ≤ 10**
Out-of plain actions	**0 ≤ MQI ≤ 4**	**4 < MQI < 7**	**7 ≤ MQI ≤ 10**
In-plain actions	**0 ≤ MQI ≤ 3**	**3 < MQI < 5**	**5 ≤ MQI ≤ 10**

opposite page
Results of the MQI for M1, M2 and M3 type
C = Complying, PC = Parcial Complying NC = Not complying (with the ''rule of art''). (adapted from: Borri et al., 2011; Rovero& Fratini, 2013)

mortar is less important: even a non-cohesive mortar carries out the function of regularising contact. Since the mortar used in the masonry examples presented does not have a good degree of cohesion, larger elements and a correct laying is necessary for obtaining a resistant wall.

The mortar used in Chefchaouen is the same in all masonry types. It is obtained by mixing lime binder and earth. The compressive strength of this mortar was evaluated to be about 2.5 MPa by taking into account the chemical composition and the comparison with the traditional mortars considered by the Italian standards DM 14/01/2008 (Rovero &Fratini, 2013).

Numerical estimate of the compressive strength using the Masonry Quality Index (MQI)

A numerical estimate of the mechanical parameters of the walls can be made on the basis of the qualitative criteria evaluation, using the method known as *Masonry Quality Index* (MQI) (Rovero& Fratini, 2013; Borri et al., 2011). This method consists in evaluating the presence, the partial presence, or the absence of certain parameters that define the "rule of the art", namely a set of construction devices that, if executed during the construction of a wall, provides a good behaviour and ensures compactness and the monolithicity.

	M1 Mixed stone and brick masonry	M2 Stone masonry			M3 Brick masonry	
		B4 blocks	B5 blocks	B6 blocks	B1 blocks	B3 blocks
Mortar quality/effective contact between elements/wedges	NC	NC	NC	NC	NC	NC
Presence of diatones/cross interlocking	PC	PC	NC	PC	PC	PC
Shape of resistant elements	PC	PC	NC	PC	C	C
Dimensions of resistant elements	NC	PC	PC	PC	PC	PC
Strength of elements	C	C	C	C	PC	C
Arrangement in staggered manner of vertical joints/plan interlocking	PC	PC	NC	PC	C	C
Horizontality of blocks courses	PC	PC	PC	PC	C	C
Vertical actions: IQM and masonry category	4 B	4,5 B	1,5 C	4,5 B	5,2 A	7,5 A
Out-of-plain actions: IQM and masonry category	4 C	4,5 B	1,5 C	4,5 B	4,5 B	6,5 A
In-plain actions IQM and masonry category	3,5 B	4,5 B	1 C	4,5 B	4,5 B	4,5 B
Compressive strength min and max (MPa)	2,1–3,8	2,3–4,2	1.2–2.1	2,3–4,2	2.6–4.7	4.2–7.5
Young modulus min and max (MPa)	1099–1579	1197–1713	652–967	1197–1713	1354–1921	2019–2797
Shear stress min and max (MPa)	0,04–0,06	0,05–0,07	0.02–0.03	0,05–0,07	0,05–0,07	0,07–0,11

The following construction devices were considered in the qualitative criteria evaluation:

- mortar quality/effective contact between elements/wedges;
- presence of diatones /cross interlocking;
- shape of resistant elements;
- dimensions of resistant elements;
- strength of elements;
- staggered arrangement of vertical joints/plan interlocking;
- horizontality of block courses.

Three evaluations regarding compliance with the parameters of the "rule of the art", Complying (C), Partial Complying (PC), and Not Complying (NR), were then considered in relation to three types of actions, vertical actions, out of plain actions, and in plain actions.

In this way, it is possible to reach a synthetic evaluation of the quality of the wall for each type of masonry and for each type of action which the wall is subjected to. For each parameter a scores is assigned. The scores obtained from each parameter are then summed to obtain an overall score, the Masonry Quality Index (MQI), determined for each type of action. According to the MQI, the masonry can be catalogued in three categories:

- category A, good masonry behaviour;
- category B, average quality masonry behaviour;
- category C, inadequate masonry behaviour.

Regarding the results obtained by the Quality Index Method we can observe that despite the strength of the stone (e.g. sample B5), the overall strength of the masonry cannot be high because a structure capable of stress uniformity and monolithic behaviour is not guaranteed. Regarding the results obtained for the M3 type of masonry (brick masonry), we can observe that the greater strength of the block influences the overall strength of the masonry; the only difference between the M3 masonry with blocks B1 or B3 is precisely the strength of the blocks, evaluated as Partially Complying (PC) for blocks B1 (6.96 MPa) and Complying (C) for blocks B3 (13.4 MPa).
Regarding the results obtained for the M2 type of masonry (stone blocks walls) we can note that the most influential factor is the shape of the blocks and how this deviates from the ideal block that is large and parallelepiped-shaped. An appropriate masonry texture should present regular blocks, diatones, cross interlocking, arrangement in staggered manner of vertical joints and horizontality of blocks course. For this reason the masonry with B5 blocks has a strength that is lower than that of the other masonry types, because B5 blocks are hard and difficult to work and therefore are placed with very irregular shapes.
The M1 masonry type (mixed stone and brick masonry), which is widespread everywhere in the medina and based on recurring horizontal brick rows inside the stone masonries,

must be considered as a solution to this problem: this ensures horizontal layers of blocks that are able to distribute the stresses uniformly, thus enhancing the monolithic behaviour needed by the masonry, as evidenced by the results obtained with the method of the quality index.

References

Blasi C., Guerrieri F. 1999, *Manuale per la riabilitazione e ricostruzione postsismica degli edifici: Regione dell'Umbria*, DEI, Roma.

Borri A., Cangi G. 2011, *Metodi qualitativi per la valutazione della qualità muraria*, in Donà C., De Maria A. (eds.), *Manuale delle murature storiche. Analisi e valutazione del comportamento strutturale*, Dei, Roma, pp. 237–294.

Dipasquale L., Mecca S., Rovero L, Tonietti U. 2008, *Technical knowledge and traditional architecture in medina of Chefchaouen (Morocco)*, in *Proceedings of II International conference on Mediterranean heritage RIPAM*, Universitè Cadi-Ayyad, Marrakech, 24-26 ottobre 2007.

Dipasquale L., Volpi V. 2009, *Le murature*, in Mecca S., Dipasquale L., Rovero L., Tonietti U. & Volpi V. (eds.), *Chefchaouen, Architettura e cultura costruttiva*, ETS, Pisa, pp.127-138.

Dipasquale L. 2012, *La valorizzazione della risorsa lapidea per lo sviluppo locale negli Iblei. Innovazione, sostenibilità e competitività*, PhD thesis, Università degli studi di Firenze.

Dipasquale L., Mecca S., Omar Sidik D. 2014, *Earthquake resistant structures*, in Correia M., Dipasquale L., Mecca S. (eds.), *VerSus: heritage for the future. Vernacular knowledge for sustainable architecture*, FUP, Firenze, pp. 232-240.

Dipasquale L., Rovero L., Fratini F. 2016, *Ancient stone masonry constructions*, in Harries K.A & Sharma B. (eds.), *Nonconventional and Vernacular Construction Materials. Characterisation, Properties and Applications*, Elsevier, Kidlington, UK, pp.301-332.

Giovanetti F. (ed.) 1998, *Manuale del recupero del Comune di Città di Castello*, DEI, Roma.

Giuffrè A. 1991, *Letture sulla meccanica delle murature storiche*, Kappa, Roma.

Giuffrè A. (ed.)1993, *Sicurezza e conservazione dei centri storici. Il caso Ortigia*, Laterza, Bari.

Giuffrè A. 1999, *Codice di pratica per la sicurezza e la conservazione del centro storico di Palermo*, Laterza, Bari.

Mecca S., Dipasquale L., Nicosia V., Rovero L. Tonietti U., Volpi V. 2008, *Local Architectural and Building Knowledge Survey for Conservation of Medina of Chefchaouen (Morocco)*, in Proceedings of I international Conference "XXI Century And Historical Islamic City, Baku, Azerbaijan.

Rovero L., Fratini F. 2013, *The Medina of Chefchaouen (Marocco): A survey on morphological and mechanical features of the masonries*, «Construction and Building Materials», 47 (2013), pp. 465-479.

Vegas F., Mileto C. 2013, *Lazos de Alarife. Manual sobre tecnicas y materiales tradicionales en Malaga y en el Norte de marrueccos para la recuperacion de su patrimonio comùn*, Servicio de Programas/OMAU, Malaga.


زنقة الحاج المختار

Entrance door of a courtyard house (© L. Lupi, 2007)

Doors

In Chefchaouen's architectural culture (and of Islamic cities in general), doors are an element of primary importance which represent the connection between the private family area and public spaces. Size, form, decoration, the type of frame used as well as the ornateness of the surrounding walls are symbols that express information about the family that lives in the house and the function of the building,

The various types of decorations combined between them, in addition to the presence or absence of a roof, create a great number of variants, not easily classified into recurring types.

Doors are therefore classified in accordance with the constructive principles of openings, which can present various types of associated decorations. Based upon the construction schemes found within the medina, four different types of doors can be identified: architraved doors; semi-circular arched doors; segmental arched doors; and pointed arched doors.

Within the thickness of the wall the opening always presents two parallel elements: an external arch and an internal wooden architrave. The wooden architrave can be composed of a combination of beams (7 x 10 cm) or of wooden planks (approximately 5 x 20 cm), the number of which varies depending on the thickness of the wall. These wooden elements are placed after having mounted the external arch, so that the extremities fit into the wall at least 15 cm and approximately 10 to 30 cm higher than the intrados of the arch. The door is then fitted into them.

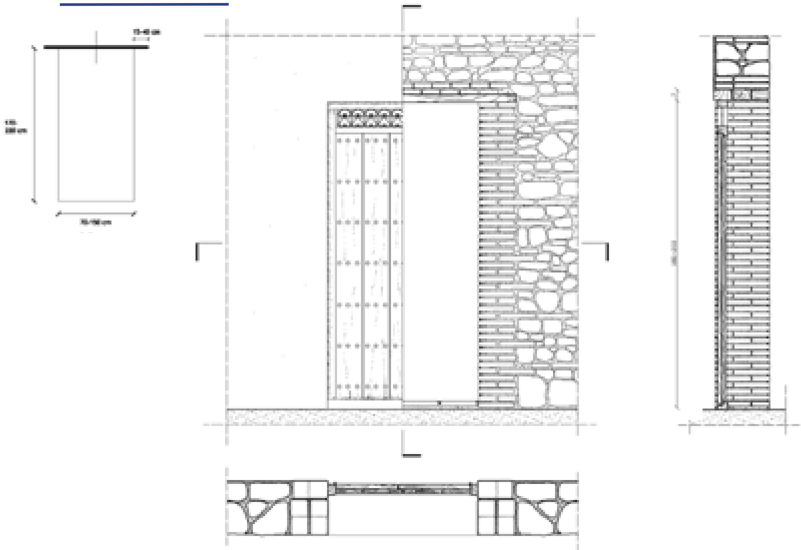
D1 | Architraved door.

It consists of two vertical supports (piers) and a beam (architrave - lintel). The wooden architrave supports its own weight, as well as that of part of planks the wall above, and transfers it in an almost vertical manner to the piers and therefore to the foundations. The architrave consists on one or two adjacent planks (section approximately 15-30 cm x 5-10 cm) or else of three or four beams (section approximately 7-10 cm x 7-10 cm), depending on the thickness of the wall.

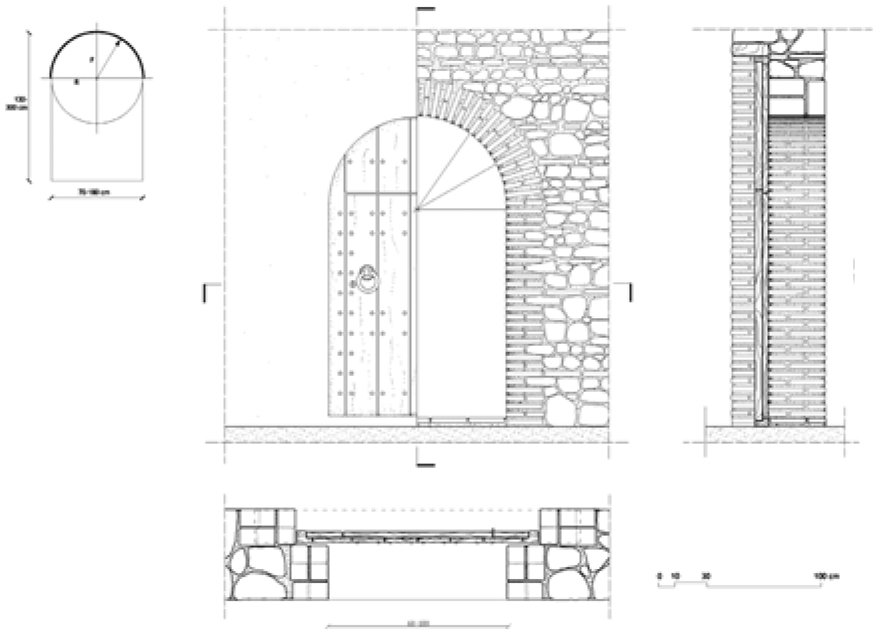
FUP Best Practice in Scholarly Publishing (DOI 10.36253/fup_best_practice)

Letizia Dipasquale, *Understanding Chefchaouen. Traditional knowledge for a sustainable habitat*, © 2020 Author(s), content CC BY-NC-SA 4.0 International, metadata CC0 1.0 Universal, published by Firenze University Press (www.fupress.com), ISBN 978-88-5518-178-5 (PDF), DOI 10.36253/978-88-5518-178-5

D1 | Architraved door



D1 | Semicircular arched door



The piers are generally built with bricks, or else with a mixture of bricks and stone. Architraved doors are used especially for souk shops, where the door is placed on the external edge of the opening, so as to permit a full opening toward the outer end of the shutters. In the entrances to residences the door is place instead on the interior edge. Within homes, on the other hand, architraved doors are used in all cases in which pointed arches are not used. The size of the opening depends on the usage of the room: in the case of shops they are usually quite wide, as much as 180 cm in width (to favour the exhibition of the merchandise), whereas in residential dwellings the width is inferior, generally between 70 and 90 cm. The height is usually between 180 and 220 cm. They are often protected with shingled roofs, and rarely decorated. It is common in Chefchaouen to find examples of the mistaken practice of removing the wooden architrave and leaving the bricks exposed in one or more layers. This practice puts in danger the stability of the opening.

D2 | Semicircular arched door

It consists of two vertical supports (piers) with an arched structure above. The rise of the arch (the distance from the springing line to the highest point of the intrados or bottom of the arch) is fixed as half of the span. The semicircular arched door is used especially for the entrances to rooms, also smaller in size, for reducing the possibility of outside looks. Used especially in more humble abodes, it is always whitewashed and generally lacks a roof or any special moulding.

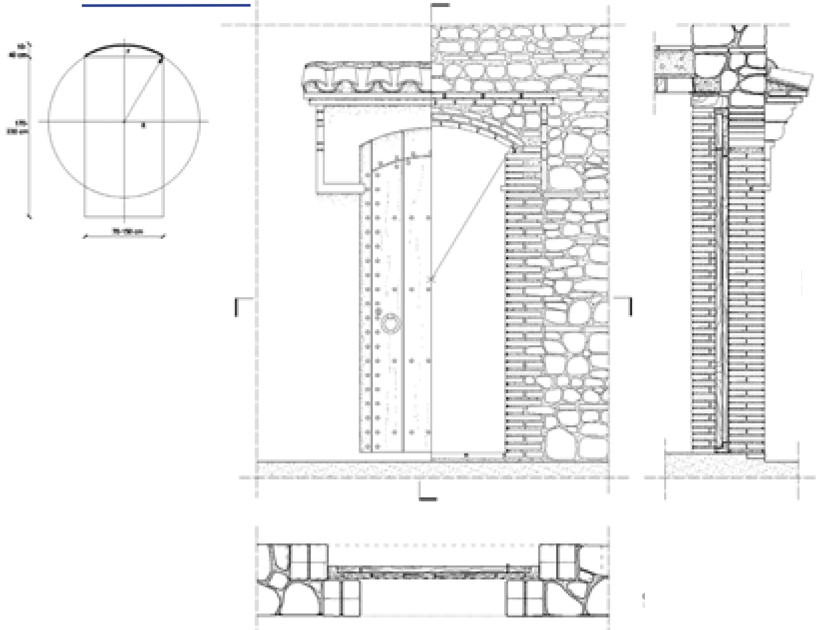
A supporting beam is usually used in the construction of the arch which is made of a wooden plank placed horizontally and supported on the piers, as well as by juxtaposed bricks that give form to the arch, and bonded with a weak lime and earth mortar which is easy to remove.

D3 | Door with segmental arch

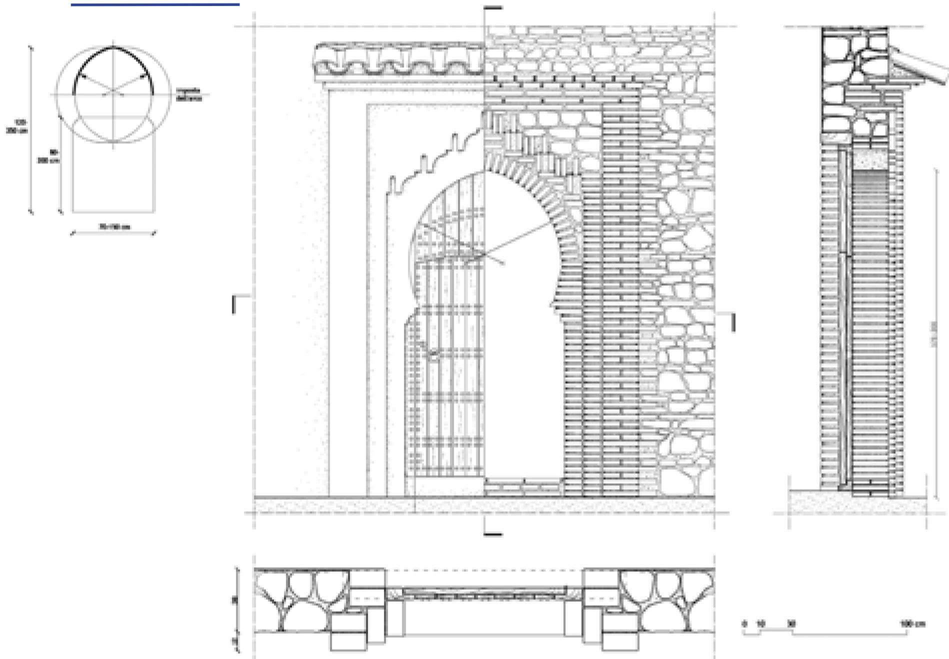
The building method always uses two vertical supports with an arched structure above them. The rise is less than half of the span and the center of the arch is below the springing line. It is known in Arabic as *hilaliyeh*, meaning "crescent moon".

The structure is built using the traditional supporting beam in wood and bricks. The bricks that make the arch are placed headwise (an not radially from the centre) in one or more overlapping layers. The arch is usually whitewashed together with the rest of the opening. This type of door is used throughout the medina, especially as entrance to residential dwellings, approximately in equal numbers to the semicircular arched door. These doors with segmental arch are often finished with rich decorations, probably to mark the entrance to wealthier homes.

D3 | Door with segmental arch



D4 | Door with pointed arch



D4 | Door with pointed arch

It consists of two piers on which stands a pointed arch built over two centers located above the springing line. The arch is locally known as *mchouk*. Bricks are placed in the shape of the arch immediately above the piers until the height of the springing line, after which with the use of the supporting beam the bricks are placed radially with respect to the two centers. This type of door is used especially in residential dwellings, for rooms that face onto the courtyard, but also as main entrance to houses, mosques and other public buildings.

Windows

The position and size of the windows are determined by social and cultural factors. Windows, in fact, are essential in regulating the relationship between interior and exterior spaces. In the same way, internal windows separate the spaces accessible to the various members of the family from the private space.

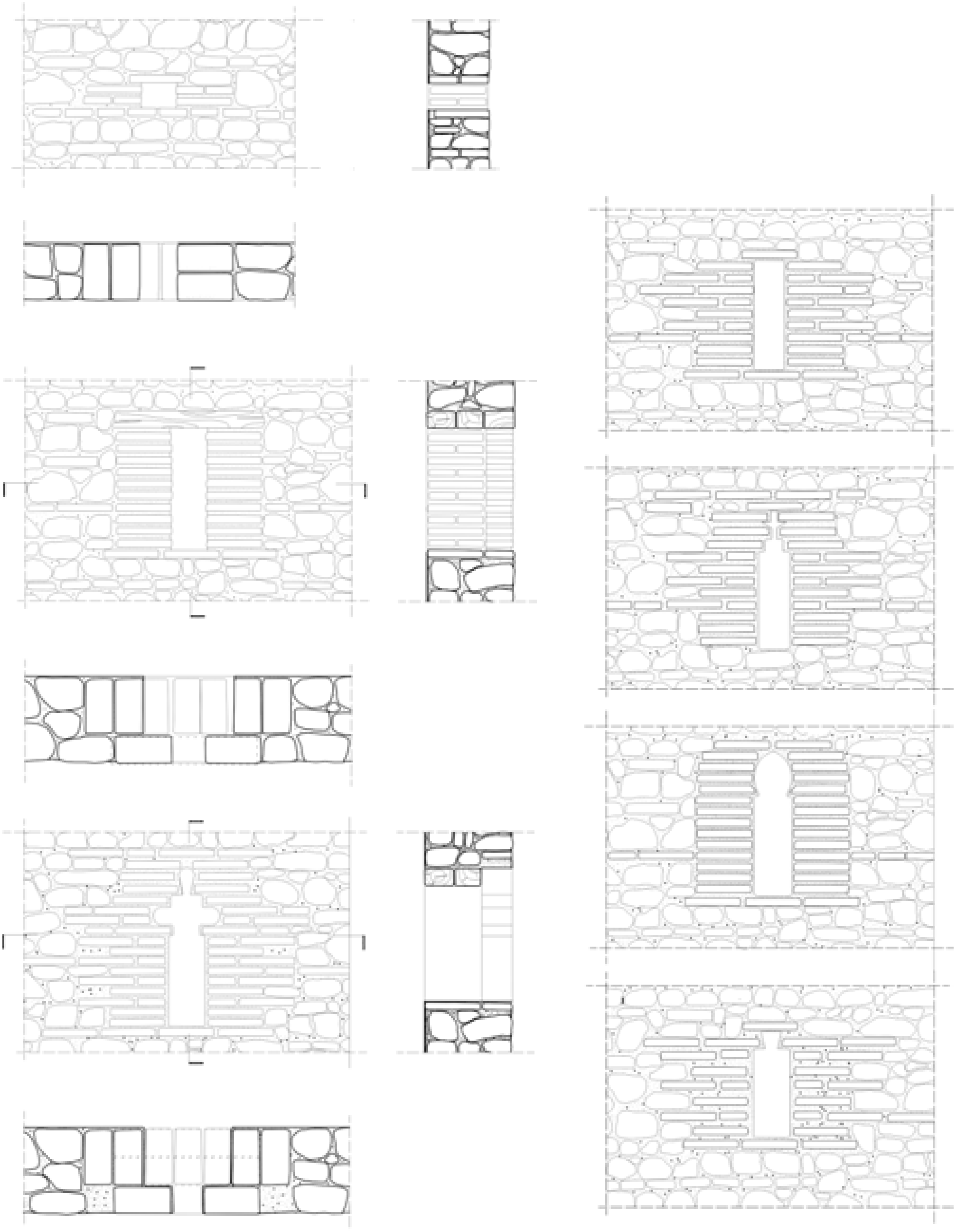
Before the Spanish colony (1926), large windows facing the exterior were rare. Openings onto public spaces were narrow vertical rectangles, used for a limited view of the outside, or as simple ventilation apertures which also allowed to see outside without being seen. Unlike these small openings, isolated on blind exterior facades, the interior openings of the courtyard are large, providing natural lighting and ventilation to the various spaces of the dwelling. After the Spanish occupation the use of rectangular or double windows became widespread also on the exterior walls of buildings. These windows were framed and richly decorated, thus contributing to the formal character of the medina.

Embrasures *(Chaq el khyara)*

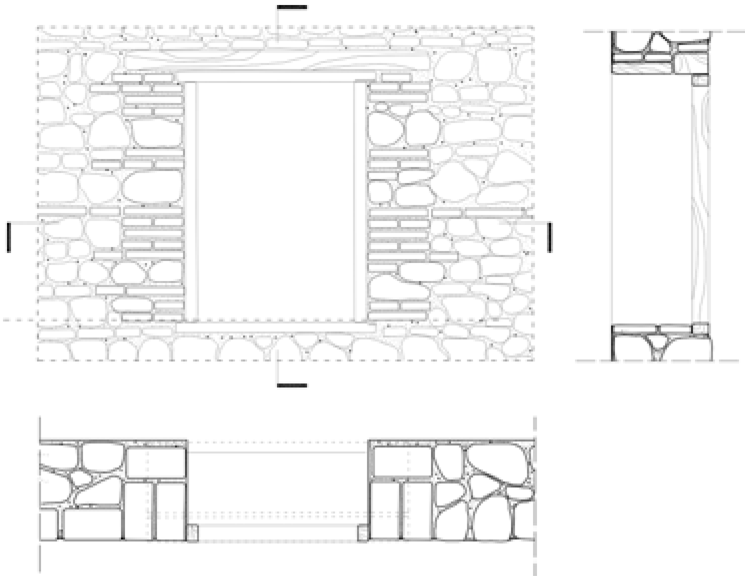
The narrow openings on the exterior facades of buildings are usually between 10 and 15 cm wide and between 30 and 45 cm high. They are also used in the arch of the courtyards, often only as decoration. The opening can be a simple vent, only a few centimetres wide, which therefore does not need the use of an architrave. When the opening is shaped as an elongated rectangle it requires a single wooden architrave and a series of beams (2 to 4) of various sizes (generally 5-10 cm x 4-8 cm), inserted approximately 15 cm into the wall.

In those cases when the opening takes on different decorative forms, an interior wooden architrave is used, made of adjacent planks, as well as an exterior one made of bricks. The area of the embrasure is approximately 30-50 cm wide, whereas the opening visible on the facade is no greater than 15 cm wide: this favours looking out and permits a greater diffusion of natural light. Jambs are almost always made of bricks (rarely of stones) and cover the entire thickness of the wall.

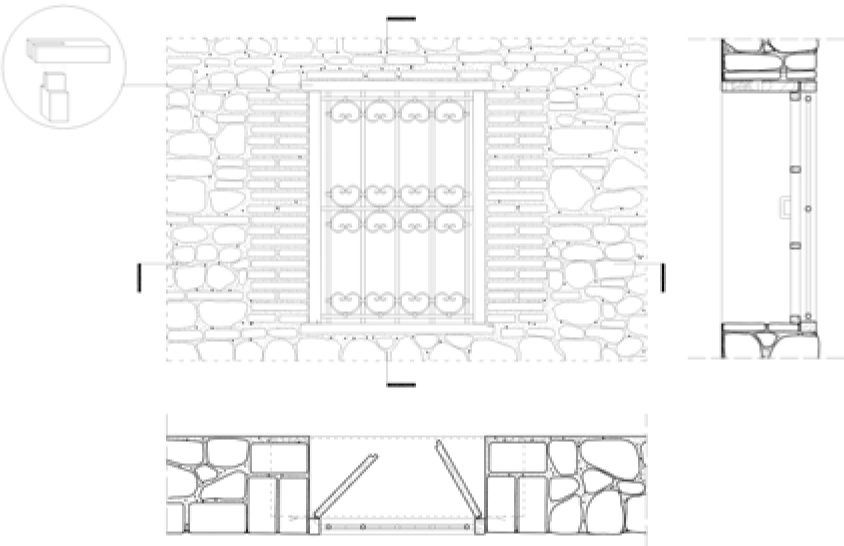
Embrasures (*Chaq el khyara*)



FR 1 | Window with wooden lintel • exposed-



FR 2 | Window with wooden lintel • non-exposed



FR | Window with wooden lintel

This type of window is used traditionally on the walls of structures facing the courtyard. The wooden lintel consists on one or more planks placed on the piers and inserted 10 - 30 cm into the wall. The lintel may remain exposed or be whitewashed. The size of the opening can vary between 20 x 30 cm and 60 x 100 cm.

The piers are generally made entirely of bricks or else alternating bricks with stones; in both cases the elements are placed so as to build a right-angled corner on the exterior and ensure a proper anchoring to the surrounding walls. In some cases the pier can be splayed on the interior to ensure better lighting on the inside. The pier on the facade is between two and four headers wide, whereas the thickness is that of the entire wall. Windowsills are usually made with bricks and generally do not jut out.

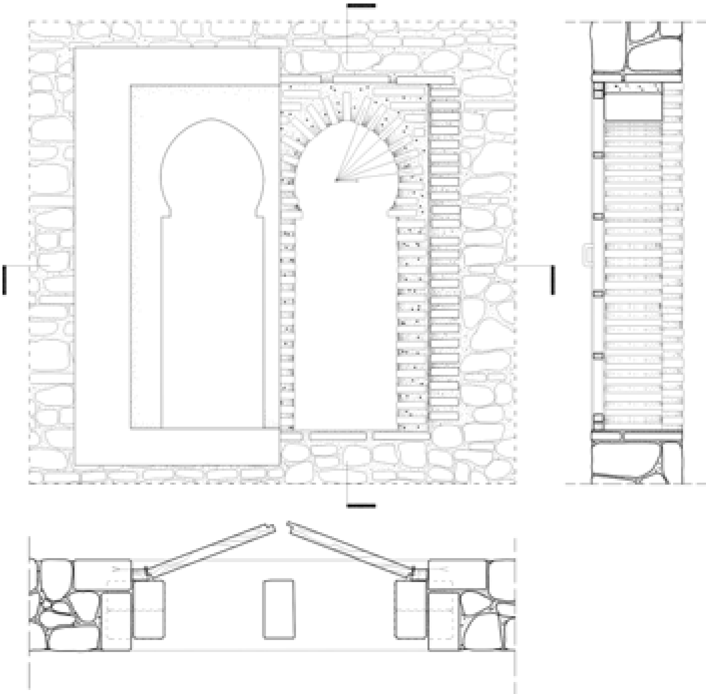
This type of window generally has a fixed timber frame, mounted on the wall with the use of metal clamps. The protective metal grill and the rear structure are fixed to this frame. The fixed frame is composed of horizontal and vertical elements consisting in 3-7 cm wooden beams linked through a system of tenon and mortise joints, and fastened with two nails. The moving frame, which is hinged onto the fixed frame, consists of a series of horizontal and vertical wooden elements that distribute the shutters into various parts.

The two recurring variant can be identified as having the lintel exposed (type 1) or non-exposed (type 2). In the first case the lintel is placed flush with the frame and consists in one or more timber boards, 3-5 cm thick, placed along the entire thickness of the wall. The second type is generally composed of two parts: on the outside by a wooden slat of approximately 7x7 cm, and on the inside by one or more boards with a 3-5 cm thickness and the intrados flush with the one on the exterior.

FB | Double Window

Double windows, which are found on the exterior walls of important or public buildings, became widespread only after the Spanish colony (1926). They are made of brick with two pointed arches (*mchouk* arches) which rest on two lateral piers and a central pillar made of bricks. These arches can be placed in line with the exterior wall or else a few centimetres into the wall so as to create a frame. The height of the windows varies from 60 to 100 cm approximately, whereas the width of the individual openings is between 10 to 40 cm (the small size serves to prevent outside looks), for a total of approximately 100 cm. The central pillar, which is about 12 cm wide, consists of superimposed header bricks. Double windows are generally whitewashed to smoothen the edges and curves

FB | Double Window

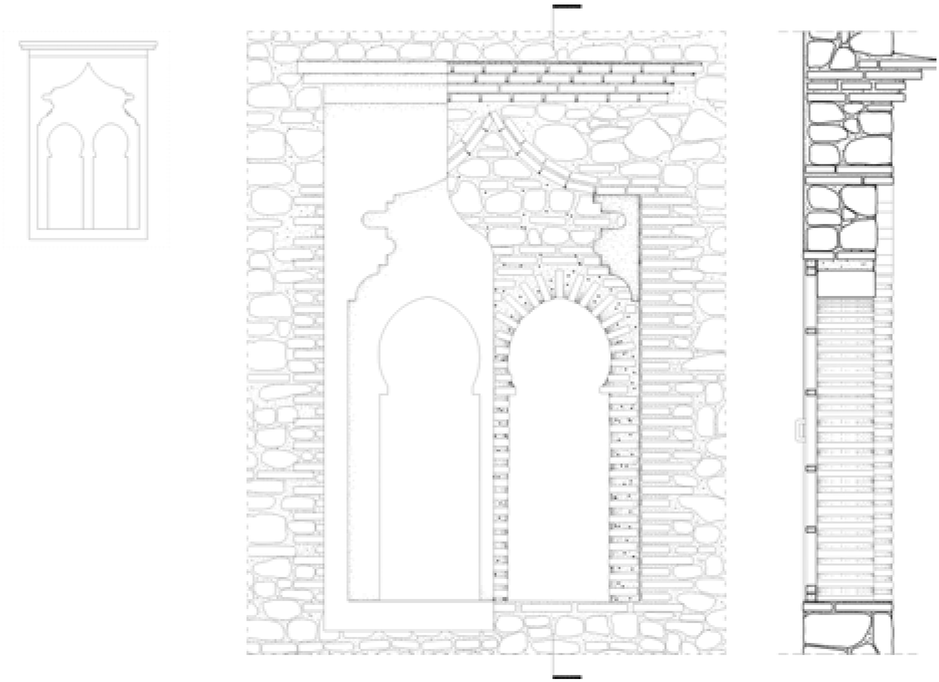


of the arches. This type of window does not envisage the use of a protecting grille. Two rows of bricks are placed flat above the two arches (in one or more layers) with the use of a horizontal timber template that is removed afterward. The architrave, together with the lateral piers, forms a rectangular frame around the arches. The space between the arches and the architrave is filled with mixed stone and brick masonry.

Decoration of doors and windows

Doors and windows are often decorated with arches, introduced during the Spanish colony and today assimilated into the image of the medina. There are several variations, all of which, however, can be considered as an application of the traditional decorative systems used in Chefchaouen for courtyards or public fountains. This type of decoration is usually combined with double windows, and more rarely to those with architrave.

FB | Double Window • decoration with inflexed arch

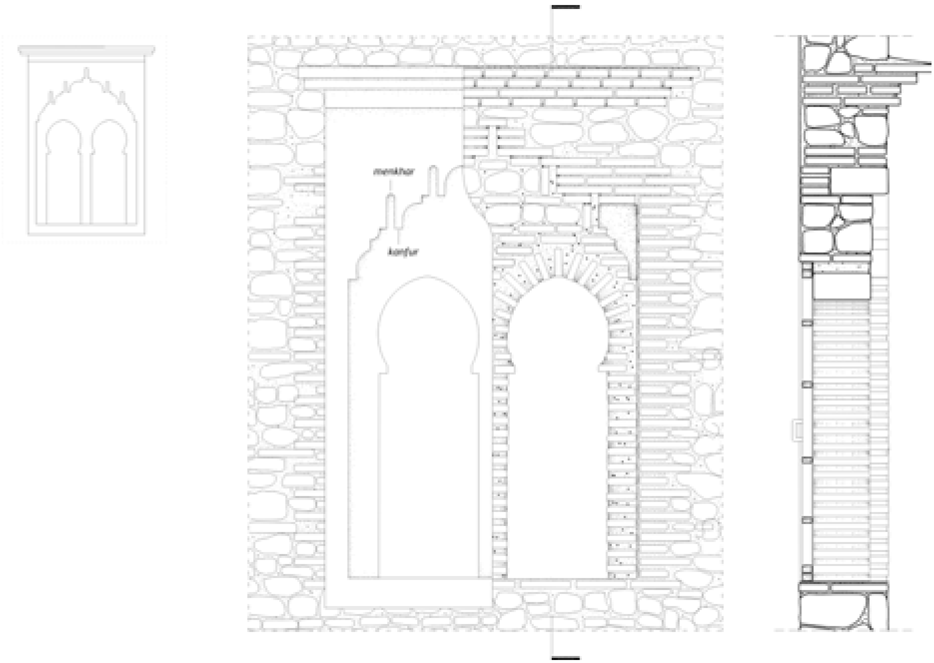


Among the variations the following are documented: the decoration with inflexed arch, and the so-called *Rakhwi* moorish arch, composed of foils and stalactites patterns. Both of these false arches are built by setting the bricks according to the shape of the desired arch. A shelf made in plaster (*lugben*) completes the decoration, which protrudes several centimetres from the level of the opening, thus creating shading which highlights it. The bricks are placed either end or side first and either whole or in pieces, so as to form the various decorations, which are then finished with plaster.

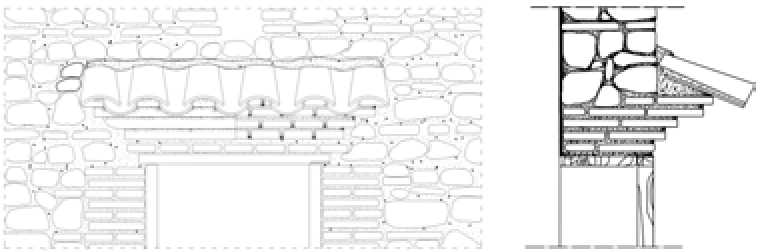
Awnings

The function of the awnings is that of blocking sunlight in summer and protecting from rain in the winter. They are made with superimposed rows of bricks (two to four rows) which jut out from the level of the facade, so as to create a protrusion approximately 10 to 30 cm long that is then finished with lime plaster.

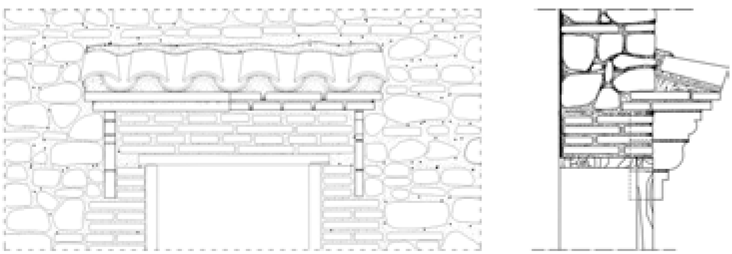
FB | Double Window • decoration with Rakhwi moorish arch



Awning • type 2



Awning • type 3



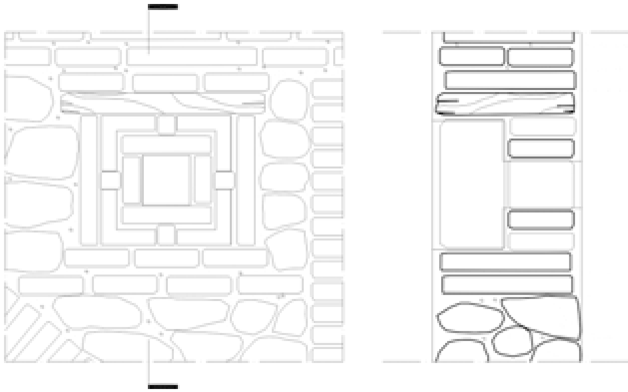
Three examples of awnings for rectangular architraved windows have been documented:

- an awning made of simple layers of superimposed bricks that progressively jut out toward the top of the structure (type1),
- an awning similar to the one above, yet with added roof tiles (type 2);
- a very common type of awning, especially in more recent buildings, which consists of protruding bricks supported by two lateral shelves made with special moulded bricks (type 3).

Decorative openings

The walls above the arches in the courtyard are generally characterised by the presence of small and roughly square openings. These openings are decorative elements of the façade, probably with the purpose of enhancing the ventilation of the upper part of the cor-

Decorative openings.



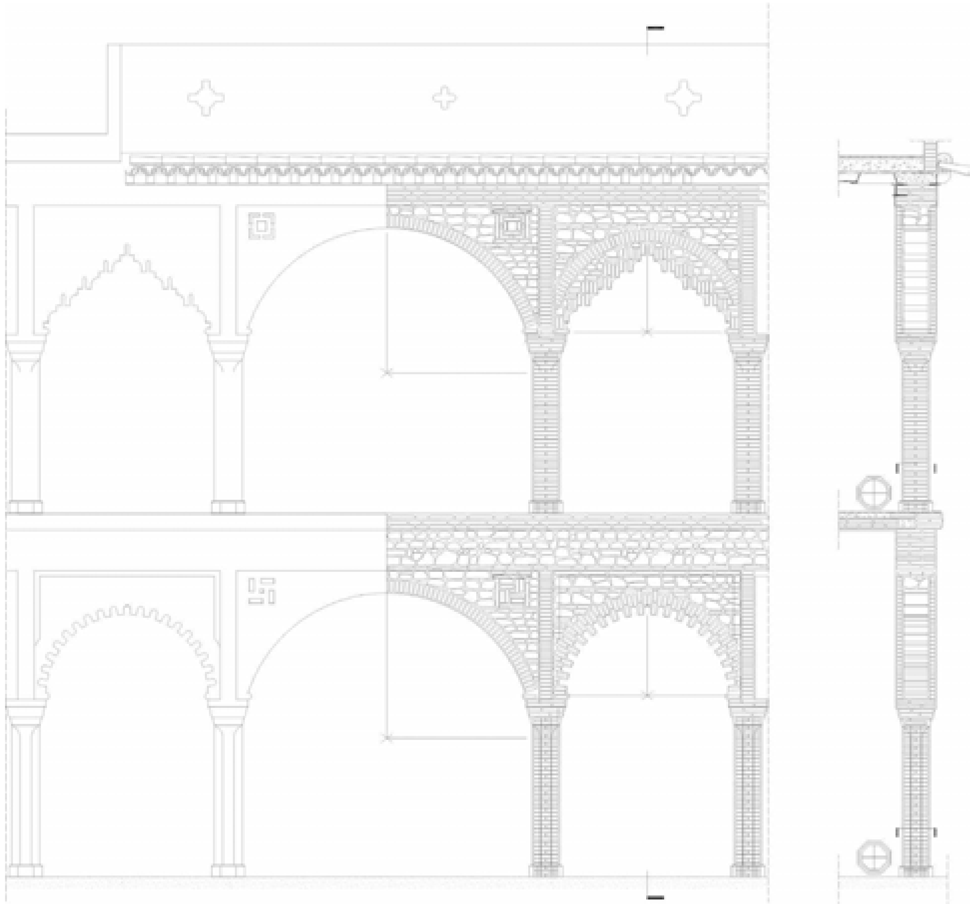
ridor that surrounds the patio, above the arches, thus allowing air to circulate and ensuring a constant replacement. These openings are made with whole and fractioned bricks, assembled in such a way as to form a variety of designs, and a small timber architrave.

Arches

Arches are used in the construction of doors and windows, as counter-arches between the exterior walls of houses, in the facades of courtyards and even in fountains, not only as a structural element, but also and especially as decoration.

The shape of the various types of arch is greatly influenced by Moorish architectural tradition. Inheriting earlier arch forms from the Greeks and the Romans, the Moors developed a variety of new shapes including the horseshoe, multi-foil, pointed and ogee arches. The dedication they had for arches is due to the mystical/symbolic meanings associated with them, as well as to their functional advantages.

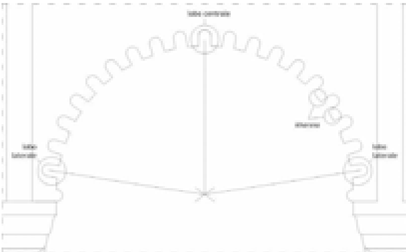
Whereas in the Roman building tradition the most widespread type of arch is the semicircular type, in the regions influenced by Islamic culture the pointed arch is more common. The Moorish arch is often made with the use of protruding bricks and the centreline of the circle or circles composing the arch is higher than the springing line, making the body of the arch wider than the narrowest part of the opening. This kind of arch is called “horseshoe” because of its shape, or also “Moorish arch” (*mugrhrabi* in Arabic, from “Maghreb”). Horseshoe arches can take rounded, pointed or lobed forms.

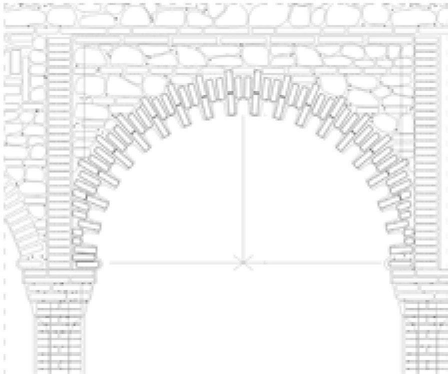


The arch profile can also be accompanied by rich decorations made with bricks that protrude from the natural vaulting line, even if they do not act as arches but only as decorative elements.

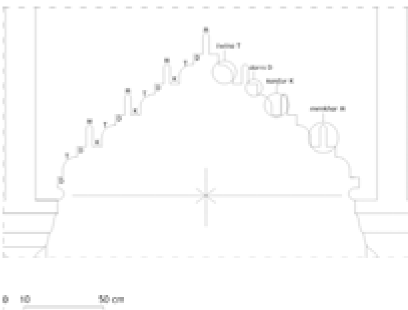
A temporary formwork is needed to support the bricks during construction. When the topmost brick is set, the arch is complete and the formwork can be removed. The formwork is often made by a horizontal wooden element supported by the piers and by bricks placed over it reproducing the shape of the arch; the bricks are set with a mortar made of lime and weak earth, which facilitates its subsequent removal.

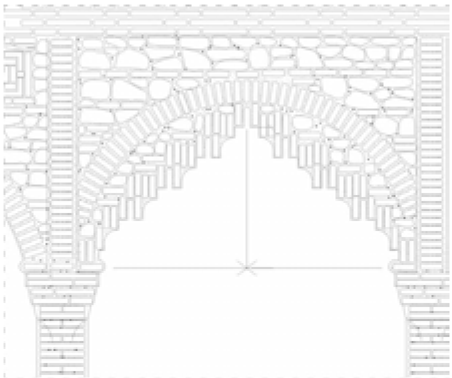
Rakhwi Arch





Arch with Kharsna





The two most frequent types of decorative arches found in the medina, which are used either as arches in the courtyard or as decoration for entrances and fountains, are described below.

Rakhwi Arch

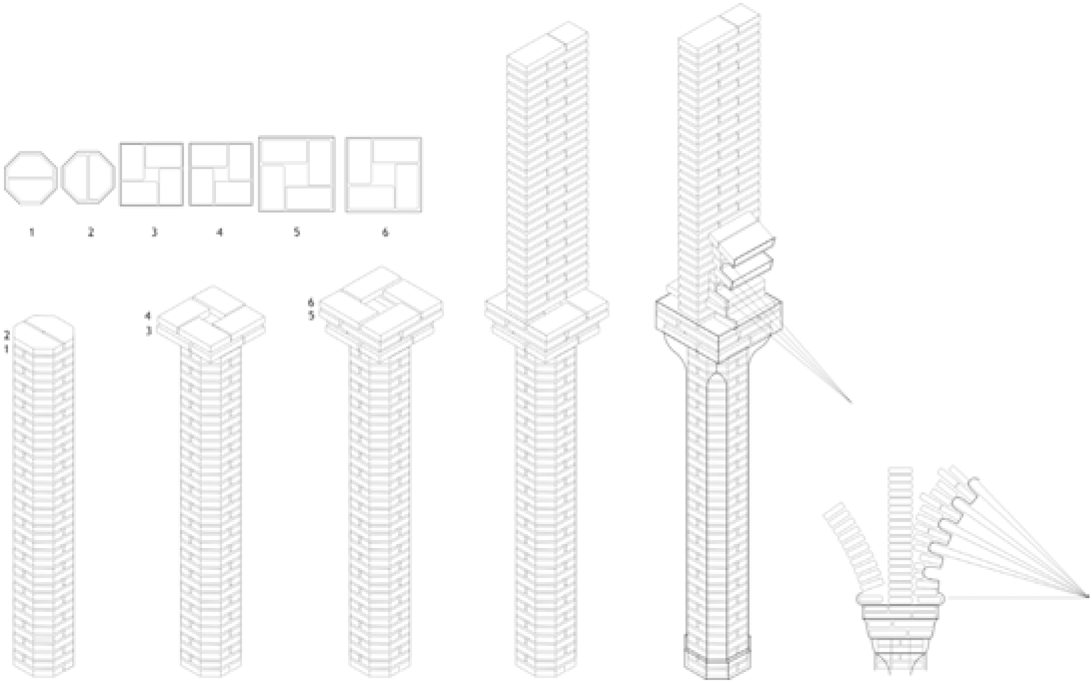
This type of arch is obtained by laying the bricks on the long narrow side with the short end exposed (approximately 11 cm), staggered so as to obtain protrusions and cavities. This distribution generates a type of decoration composed alternatively of two elements: the *menkhar* (the sunken part, meaning "nostril") and the *kanfur* (stalactite-like element). The number of *menkhar* is always odd, since this is the topmost element of the arch. Given the size and lay-

out of the bricks, the resulting *menkhar* and *kanfur* are approximately 10 cm high, while their width is between 3 and 5 cm, depending on the thickness of the mortar that covers it. The passage from a *menkhar* to the next takes place through a junction obtained by modelling the finishing mortar, constituted by a curved section, known as *twina*, and another at a right angle known as *darss* (or *dahl*). Since the width and height of the *menkar* and *kanfur* remains constant, the variable element of the arch is represented precisely by this curved connecting element, whose width and height can vary by adding or removing bricks and placing them at the desired height, thus making it possible to cover various spans while maintaining this type of decoration.
Once the columns on which the arch is placed have been built, and after having calculated the exact number of the *menkhar* and the width of the *twina* and *darss* connecting elements in accordance with the width of the span, a wooden board is placed horizontally on which the first bricks are laid with their long narrow side exposed. The mortar will keep the bricks in a fixed position. The subsequent level is then built by laying the bricks with the help of a wooden supporting beam and bricks, and so on until completion of the arch with a *menkhar* element. Once all the bricks have been laid, mortar is used for the corners and curves.
The structural system consists in an upper arch that supports the masonry: the bricks that are used for the decoration of the arch in fact are not enough for supporting the vertical loads.

opposite page
Building process of columns and capitals in courtyard arches

Arch with Kharsna

This type of arch is a variation of the semicircular arch, yet its appearance features a series of foils. A foil is an architectural device based on a symmetrical rendering of leaf shapes, defined by overlapping circles of the same diameter that produce a series of cusps to make a lobe. Bricks are laid with their long narrow side exposed, and cusps (called *kharsna*, meaning "teeth") are built by alternating bricks that jut out from the line of the arch with two or more bricks that remain behind the said line. The width of the lobes varies depending on the number of bricks used.
When building an arch it is necessary to calculate, from the width of the area that is to be covered, the number and width of the lobes to be made. According to the *maâlem* the result was obtained by making several attempts until a central lobe was set with two other lobes marking the arch and the intermediate lobes at equal distances between them. Once the columns on which the arch stands has been set, the bricks are laid radially from the center with the help of a supporting beam and a string fixed to the wooden plank.

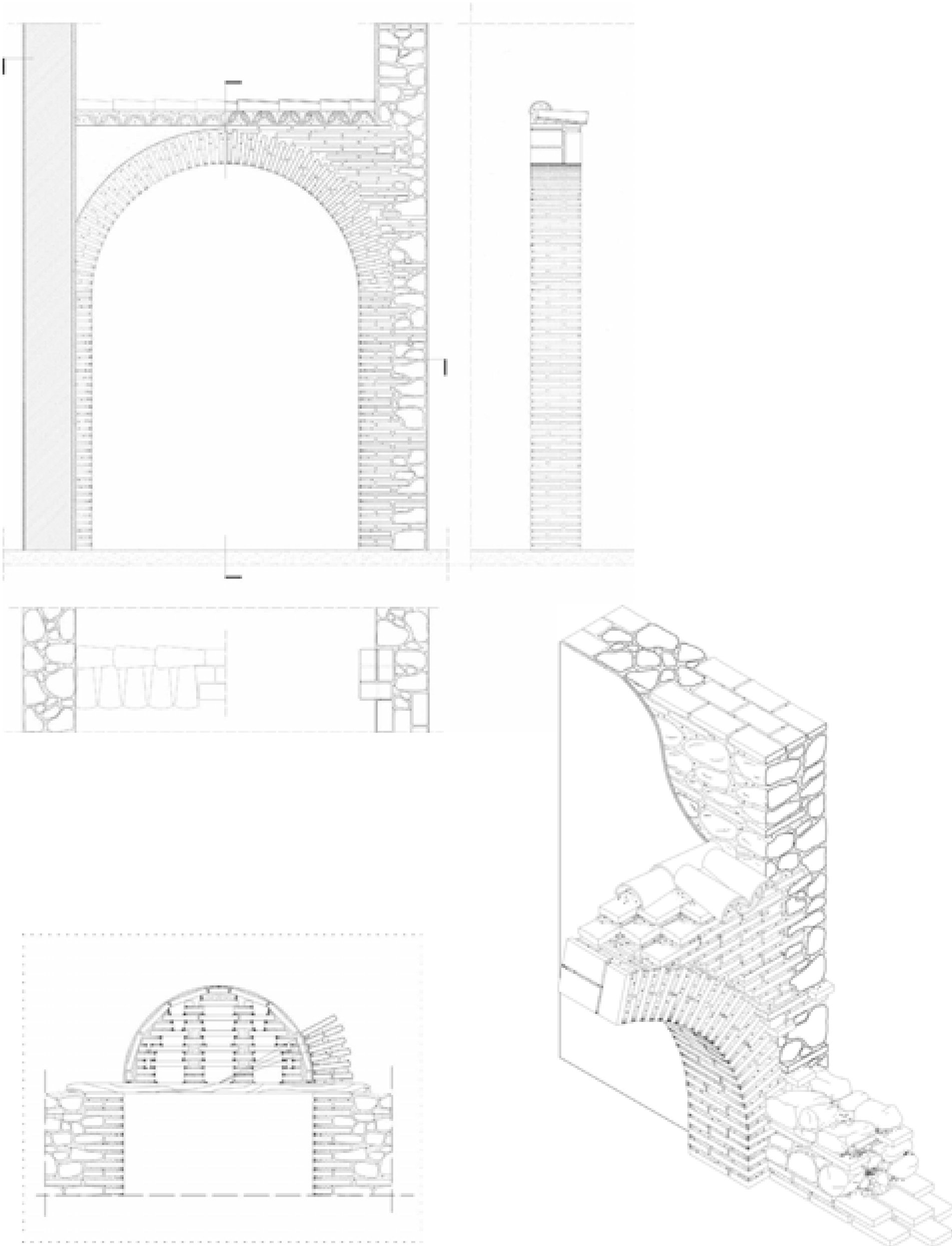


The lobes that result from the empty space that is left once the supporting beam is removed is filled during the building process by low resistance materials such as earth with a bit of lime, or else by bricks laid with very weak mortar, so that once the mortar between the bricks is dry and the arch is stable they can be easily removed, thus leaving empty spaces between one brick and another. After this process is finished the edges are rounded with mortar.

Building of columns and capitals in courtyard arches.

The columns for laying out arches in courtyards are built entirely with bricks. The horizontal section of the column consists of two symmetrical bricks, moulded as to create an octagonal column, or else rounded until obtaining a circular section. The various layers of bricks are placed orthogonally to each other. The capital, instead, is built by placing the bricks flat to form a square shape with four or more superimposed levels and with the joints appropriately staggered. The lower layers are made using smaller portions of bricks, so as to create a section that is smaller than that of the upper layers: in this way, by modelling the finishing mortar the form of the capital is obtained, which is then extended upwards. The shoulders of the

Counter-arches



arch are built above the capital by laying superimposed layers of one or more bricks, depending on the thickness of the wall.

Counter-arches

Counter-arches placed between opposite buildings are present throughout the medina and constitute a traditional anti-seismic measure: they are set on brick piers incorporated into the masonry they are supporting and are usually also made with bricks. Counter-arches can be simple or be an element in a more complex structure, such as the *qantra*, which is the name for traditional covered passages.

Vaulting and domes

Domes and barrel or tunnel vaults made with bricks are not very frequent in the medina of Chefchaouen. They are used almost exclusively for the ceilings of public and private baths (*hammam*), in other words in spaces in which the level of humidity does not allow the use of timber. Cupolas are always small in size, and bricks are laid in concentric circles, with joints radiating from the center.

MORPHOLOGICAL AND STRUCTURAL FEATURES OF FLOORS AND TIMBER ROOFS

Al Aadam mosque roof (©L. Lupi, 2007)

Floors

The horizontal or floor systems identified in the medina of Chefchaouen can be divided into two main categories: floors with timber structure and floors with small vaults.

Timber floors are more widespread since they belong to the building tradition of the medina, and can be further divided into 4 variants:

- F1a: Andalusian single framed timber floor;
- F1b: Berber single framed timber floor;
- F1c: Berber double framed timber floor;

The type of floors with small vaults which have been identified in the medina can be classed into 2 variants:

- F2a: Floor with log structure and small gypsum vaults
- F2b: Floor with steel structure and tile vaults (*bóvedas*).

Timber floors

The most widespread variant is the single framed timber floor with wooden planking. In most of the buildings in Chefchaouen, in fact, the rooms develop lengthwise, spans are short or moderate with a maximum width of 3.5 m. Therefore the floor consists of wooden joists (also called bridging joists), supported on end walls. In the case of spaces with a greater span, such as certain public buildings or L-shaped entrances (*ustuan*), the floor consists of a main structure made with squared logs and a secondary structure consisting of joists.

The wood used is generally local: spruce (*soha*), red spruce (*sanawbar*), which is very resistant, and cedar (*ærz*). The latter comes from the region of the Atlas and is quite soft, due to which it is generally used for cladding and decorating.

The timber elements used in a floor are:

- beams for double framed floors (locally called *outra*), of sizes that vary between 8x15cm and 15x20 cm. They are used for spans between 5.50 to 7 m. They are spaced 60 to 150 cm apart.

FUP Best Practice in Scholarly Publishing (DOI 10.36253/fup_best_practice)

Letizia Dipasquale, *Understanding Chefchaouen. Traditional knowledge for a sustainable habitat*, © 2020 Author(s), content CC BY-NC-SA 4.0 International, metadata CC0 1.0 Universal, published by Firenze University Press (www.fupress.com), ISBN 978-88-5518-178-5 (PDF), DOI 10.36253/978-88-5518-178-5

- joists (locally called *oukkaf*), generally 7x7 cm; however, depending of the spans (1 to 5 m), the dimensions of joists can be 5 to 8 cm wide, and 7 to 15 cm high. They are generally spaced 10 to 35 cm apart.
- wooden boards (locally called *ouerka* or *rchak*), generally 2 to 5 cm thick, 15 to 20 cm wide and 180 to 200 cm long.

Load-bearing structure, that is made of beams and joists, rests on the bearing wall, occupying ½ to 2/3 of the wall thickness. The support on the wall is made of flat stones and bricks.

opposite page **Berber double framed timber floor (F1c)**

In the Andalusian floor, joists are supported on a little wooden board which is 7 cm wide and approximately 1 cm thick and has the function of distributing the load of the joists on the masonry.

Beams and joists are generally rustic, worked with a hatchet and with irregular edges in Berber-style floors (F1b). Beams in double framed floors can also be built with uneven logs. In Andalusian-type floors the joists are squared off with sharp edges, trimmed with a saw and often decorated with images that reproduce geometric and floral motifs.

Planking consists of wooden boards, which are placed at 90 degrees to the joists and fixed to them with nails. They provide a support and weight distribution layer for the slab.

The filling layer that forms the slab consists of a mortar made of earth, lime, small stones and brick fragments. Earth slab thickness is between 10 to 20 cm, depending on the distance between joists.

The screed, on which the finishing layer is laid, generally consists on a lime and sand mortar with a thickness that varies between 2 and 5 cm.

The finishing layer varies according to the nature and function of the building. Depending on the requirements the screed the layer can be finished either with a lime milk (in modest dwellings, attics and terraces) or with a tile floor finish (*sellig*).

As for terraces, the final layer consists on a screed made with a mortar composed of lime, sand, brick fragments, oil and ashes with a thickness between 3 and 4 cm. The finishing layer is generally made using a layer of lime milk.

The floors with a timber structure that were identified lack any particular devices for joining the floor to the masonry. Horizontal seismic actions can therefore cause the slipping out of the beams from their supporting points.

In wealthier homes, the intrados of the floors is often decorated in its central section with a *bsat*. This decorative element, square in shape and in sizes which vary depending on the width of the room between 50 cm and 1 m, consists of boards painted with floral or Arabesque motifs. The boards are fitted and nailed to the intrados of the joists and framed

by wooden strips that are nailed to them. Small, decorated pieces of wood are placed between the boards of the *bsat* and those of the intrados, fastened by way of indents in the joists.

Implementation

The floor is generally built by two to five people depending on the difficulty of execution. When the load-bearing wall reaches the desired height (between 3.5 and 4 m), the level for setting the beams is prepared with the use of bricks and flat stones, and in the case of Andalusian-type floors by placing thin boards around the internal perimeter of the masonry. The beams are then placed on the wall. The spaces between the masonry and the beams are filled in with a mortar made of earth, lime and small aggregates. In this type of floors a small wooden plank is set into a recess between one joist and another on the inside edge of the wall. The board provides support between joists, hides the support of the joist to the wall and also has a decorative function and is often painted with floral motifs. After the placement of the joists the boards are set side by side and nailed, being careful to place the ends at the center line of the joist. The implementation of the base requires a swift execution for better results, and therefore often also a larger number of workers. The mortar for the slab is poured slowly and then set with the use of a *bedjana*, a tool that consists on a wooden handle with an iron disc at-

opposite page
Andalusian single framed timber floor (F1a)
Detail of *bsat*

tached to it. After this a layer of screed made of lime and sand mortar is applied, which is then covered by a lime milk finishing or else by a pavement.

Timber floors variants

F1a | Andalusian single framed timber floor

The timber elements, well squared off, are richly decorated by geometric or floral motifs in vivid colours. The joist are always placed on a small wooden board set along the perimeter of the load-bearing wall, with the purpose of better distributing the loads of the individual joists. Toward the centre of the floor there is often a decorative element in wood, known as *bsat*.

F1b | Berber single framed timber floor

The wooden joists are rough-cut. On the wall it is common to have a board for supporting the wooden element, but the joists are often placed directly on the bricks that are part of the wall at the level of the floor. The joists are not always squared-off and the surface can either remain rough or be whitewashed blue or white.

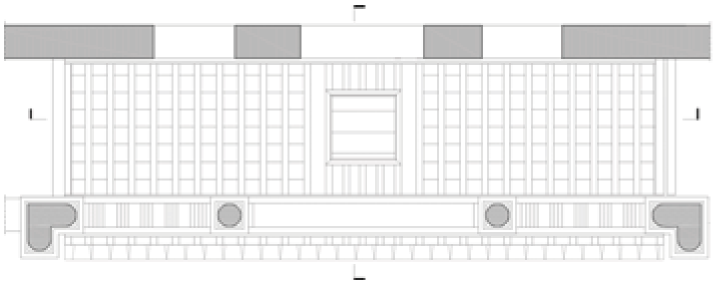
F1c | Berber double framed timber floor

The main structure consists of beams (8x15 to 15x20 cm) widely spaced (60 to 150 cm). The secondary structure is made of joists which are smaller (7x7 cm), with the ends placed on the beams and a variable spacing (15 to 25 cm). This type of floor is used to cover the large spans of covered passages in streets (*maqaad*), of some house entrances, or public buildings.

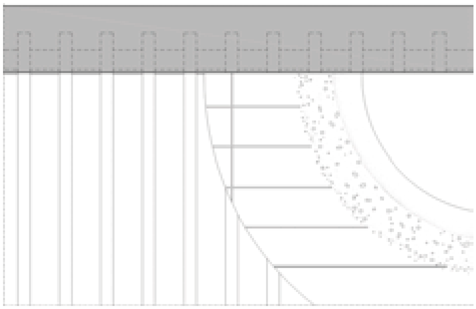
Floors with small vaults (F2)

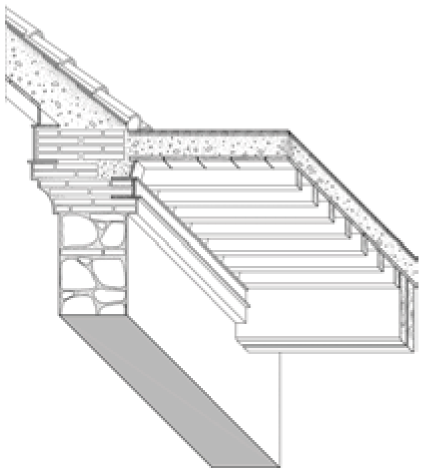
This type of floor originated in Spain and are rarely used in the medina of Chefchaouen. They are probably a recent introduction, dating from the period of the Spanish protectorate. Among floors with small vaults in residential buildings two types can be identified: one which uses gypsum and another which uses bricks. Tile vaults and domes are always used to cover the buildings which house the hammam: vaulted brick roofs, in addition to helping retain heat, are porous and contribute to prevent humidity related decay.

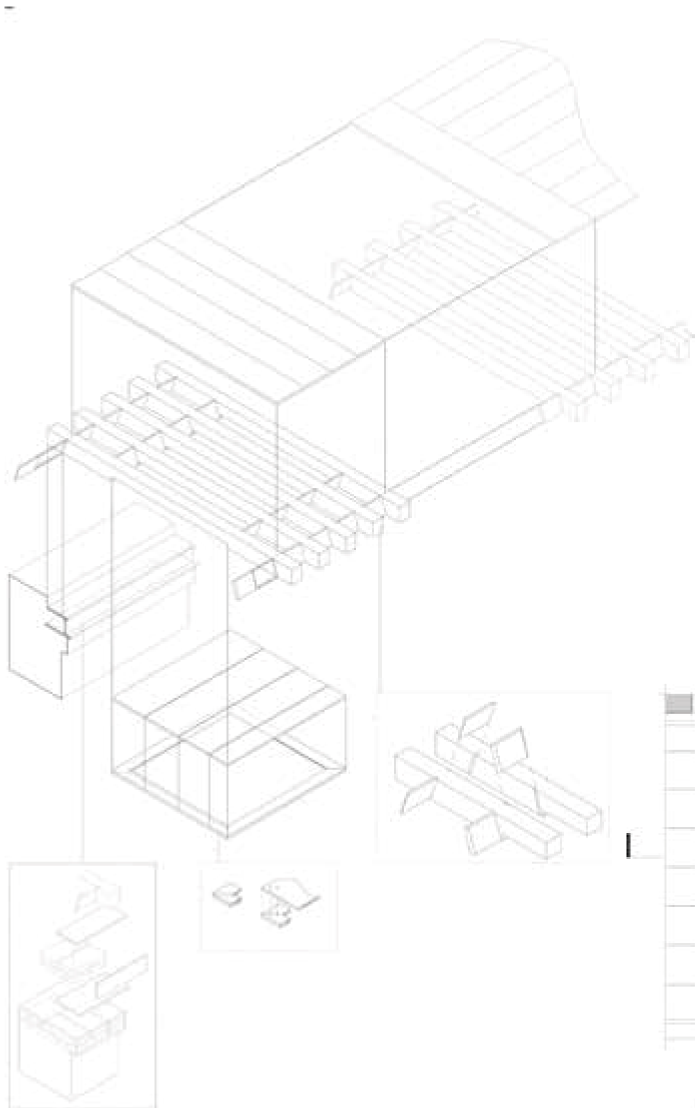
F1a | Andalusian single framed timber floor

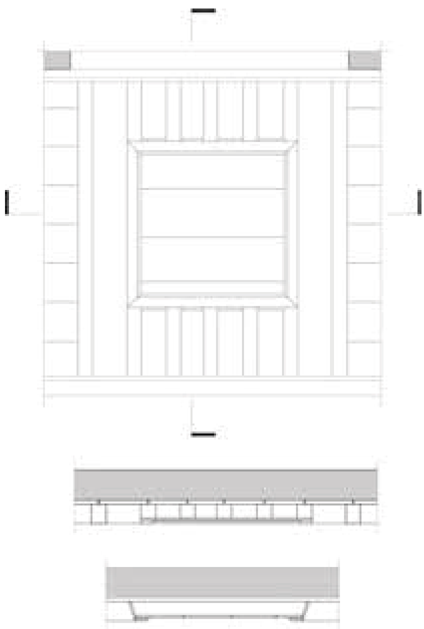


opposite page
Andalusian single framed timber floor
Detail of *bsat*

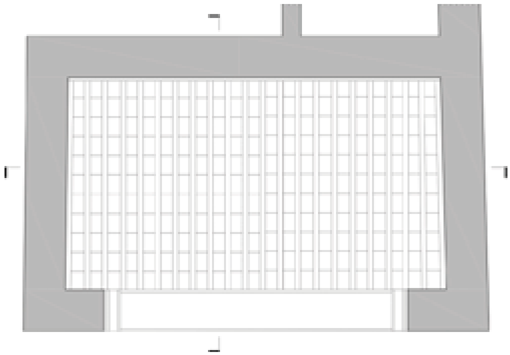


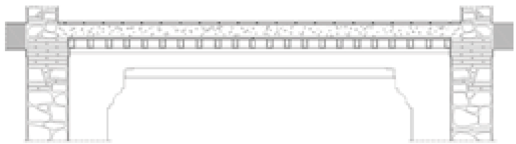


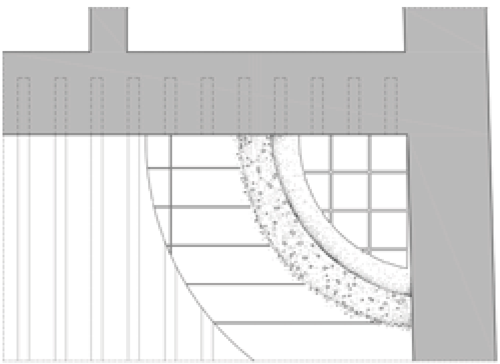


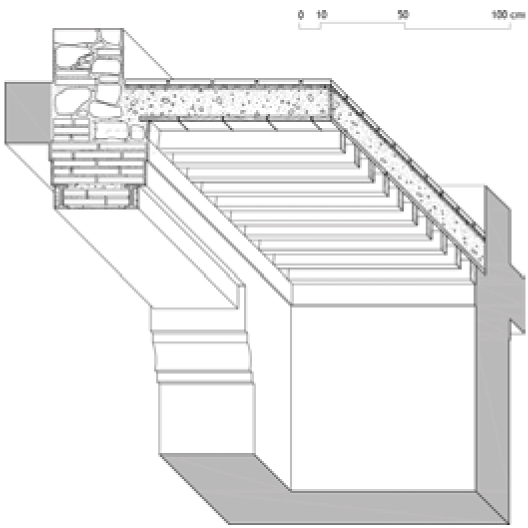


F1b | Berber single framed timber floor

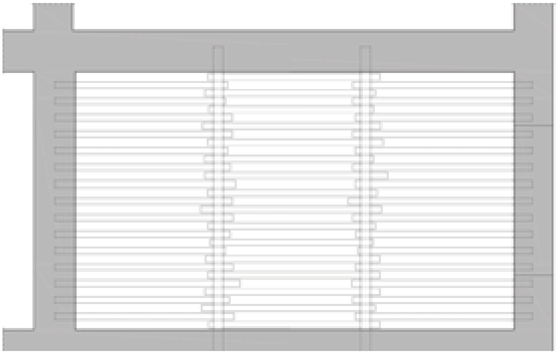


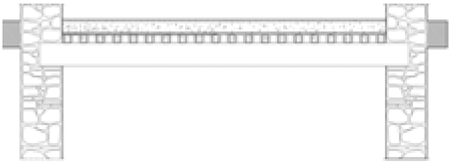


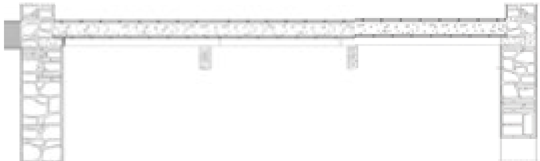


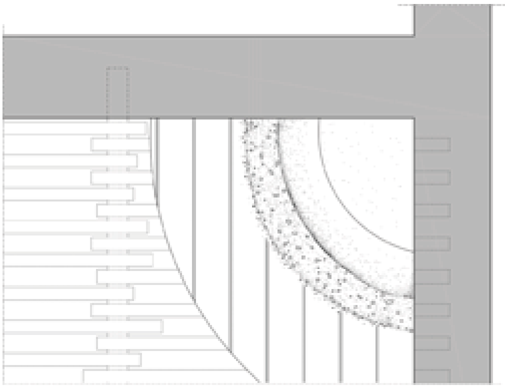


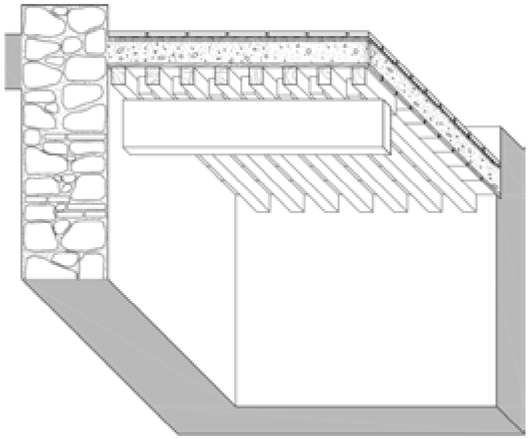
F1c | Berber double framed timber floor











Floors with small vaults variants

F2a | Floor with timber structure and gypsum vaults *(bóvedas)*

The load-bearing structure is made of timber beams with varying sizes (8x15 cm to 18x22 cm). The span of the spaces covered with this type of floor can vary between 1.80 and 5,50 m. The spacing is generally between 50 and 90 cm. The beams are only partially or roughly squared-off and the exterior surface is rough. The small vaults are made using a gypsum mixture laid during the construction process. In this case the marks from the timber formwork which is removed after the drying process is complete can be observed on the interior intrados. The extrados of the small vaults have a lime plaster finish.

F2b | Floor with steel structure and tile vaults *(bóvedas tabicadas)*

The main structure consists of a series of double T steel section bars placed at a distance that varies between 50 and 80 cm. The small vaults are usually constructed by laying two layers of light bricks lengthwise, without ribs or formwork. The tiles are laid across and over each other with a quick setting gypsum-based mortar, on which a 10-15 cm screed is applied. This technique, known as *bóveda tabicada*, is widespread in Spain and in all areas under Andalusian, Catalan or Valencian influence, yet sparsely used in Chefchaouen. In some cases this type of floor shows deformities because originally made with section bars of inappropriate dimensions, or has lost some of its resistance due to corrosion.

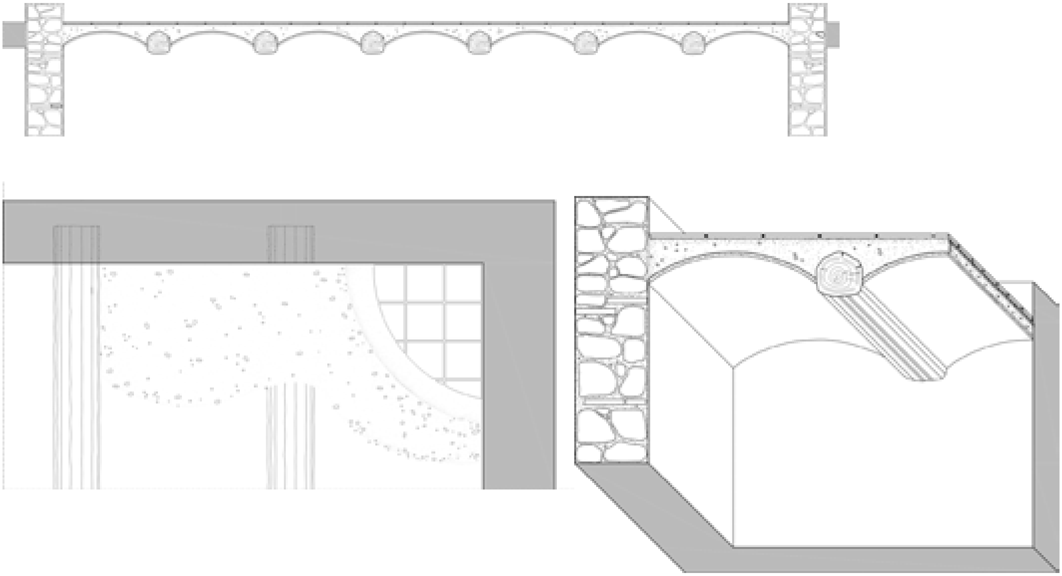
Timber roofs

The traditional roofs in the medina of Chefchaouen are of the double pitched type. As a result of observation, in-field surveys, and interviews with local master builders (*maâlem*), two structural categories have been identified: the Berber structure and the Andalusian structure.

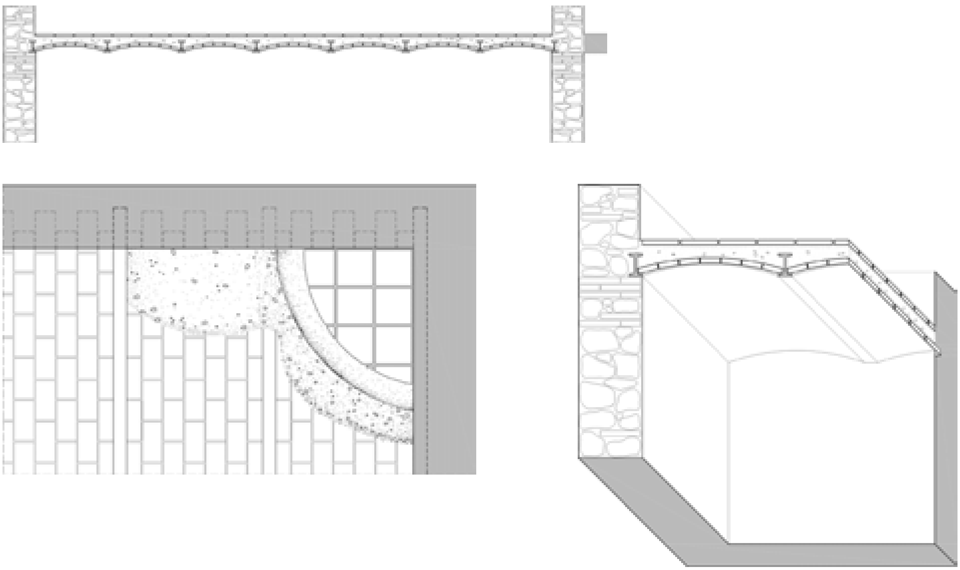
Traditional roof are always clad with locally produced brick tiles. The two different structures can be distinguished by the slope of the pitch: between 30% and 40% in the case of the Berber roof, whereas the slope of Andalusian roofs have a greater degree of inclination, between 70% and 90%.

The Berbef roof is the simplest and also the oldest of the two types. The ridge beam is supported by very close sloping rafters, and sometimes it is aided by two principal rafters joined to a horizontal beam. Timber elements are roughly hewn with a hatchet (*sciakkor*). The Andalusian structure is more complex and interesting from the constructive point of view and uses well squared and often finely decorated wooden elements. The varieties of wood used are cedar (*Ærz*), fir (*soha*) and red fir (*sanawbar*). While cedar is of-

F2a | Floor with timber structure and gypsum vaults *(bóvedas)*



F2b | Floor with steel structure and tile vaults *(bóvedas tabicadas)*



ten used for decorations, fir and red fir are mainly used to build roof structures. The timber used is traditionally obtained from forests located in the province of Chefchaouen.

Andalusian type timber roof (R1)

This remarkable type of timber roof is a recurrent building system derived from Moorish architecture. In Spain this roof structure is called *armadura de par y nudillo*, i.e. rafters ("pares") and collar beams ("nudillos"). This type of roof is rich in decorations with carvings and paintings on the wood. Many examples are widespread in central and southern Spain, especially in religious buildings and noble palaces (Nuere 2000; Candelas Gutiérrez, 2003). Central and southern Spain correspond to the region which was known as Al-Andalus during the period of Arab domination (711 to 1492). This area, characterized by a Classical Roman tradition, received architectural and artistic influence from Islamic culture as well as from that of the Berbers.

The art of Mudéjar carpentry in Spain is also known as *carpintería de lo blanco*, in reference to the colour of wood which has been stripped and squared-off, in opposition to *lo pietro*, carpentry which uses rough-cut wooden elements.

Roofs with *par y nudillo* structures were widespread in Spain through the Middle Ages and well into the 16th and 17th centuries, and became diffused in other areas of Spanish influence. Indeed somewhat similar structures are to be found in in many church roofs Sicily, dating from the Saracenic invasion, as well as in similar structures built in Latin America during the 16th and 17th centuries[1]. In Chefchaouen the Andalusian-type wooden structure was imported by Andalusian master builders, and it was widely used – with some modifications vis-à-vis the Moorish constructive technique – for the roofs of the rooms of the courtyard house and the bays of Mosques. The span is 3 to 4 m in courtyard houses and up to 7 m, in the case of Mosques.

opposite page **Andalusian timber roof**

Main features of the structure

The roof timber structure consists of a single frame double-pitched roof, with coupled rafters placed parallel to the shorter side of the room that is to be covered. The coupled

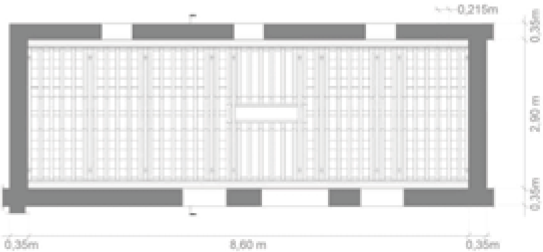
[1] A great scholar of Moorish historic carpentry in Spain is the architect Enrique Nuere. In 1980 he translated the manuscript *La carpintería de lo blanco* by Diego López de Arenas (1727), recovering the knowledge on this building technique, which had been lost since the 18th century. In order to spread his findings and to avoid this knowledge to be once more forgotten he has very actively worked in teaching this craft and writing a large number of books and articles. Among his published works we can highlight: *La carpintería de lo blanco. Lectura dibujada del primer manuscrito de López de Arenas* (1985), *La carpintería de armar española* (1989, and a second revised and extended edition in 2000), *La carpintería de lazo. Lectura dibujada del manuscrito de Fray Andrés de San Miguel* (1990) and *Nuevo tratado de la carpintería de lo blanco, con la verdadera historia de Enrique Garavato, carpintero de lo blanco y maestro del oficio* (2001).

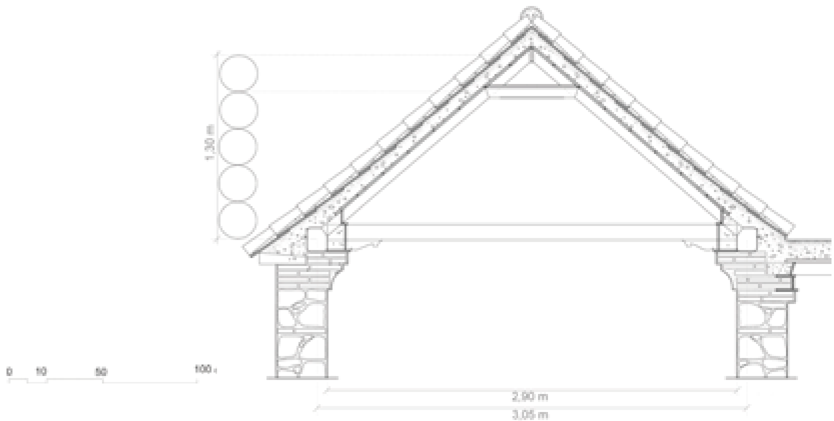
rafters are counterposed and connected at the ridge to a plank with nails. The plank does not have the structural function of a ridge beam, but it is particularly useful during the phase of setting the structure, because it allows to keep the spacing between rafters. Every coupled rafter is connected by a transversal timber element (collar beam), that is placed in the upper part of the structure, at a distance from the ridge of about one-fifth of the length of the rafter. Collar beams have a 5 to 7 by 10 to 15 cm section and a length of approximately 60 to 65 cm. The far ends of collar beams are shaped and carved so as to provide a suitable support for the connecting joints of the rafters. The collar beams, due to their joints with the rafter, provide a unilateral connection, capable of transferring compression forces, but are inefficient if subjected to tensile forces.

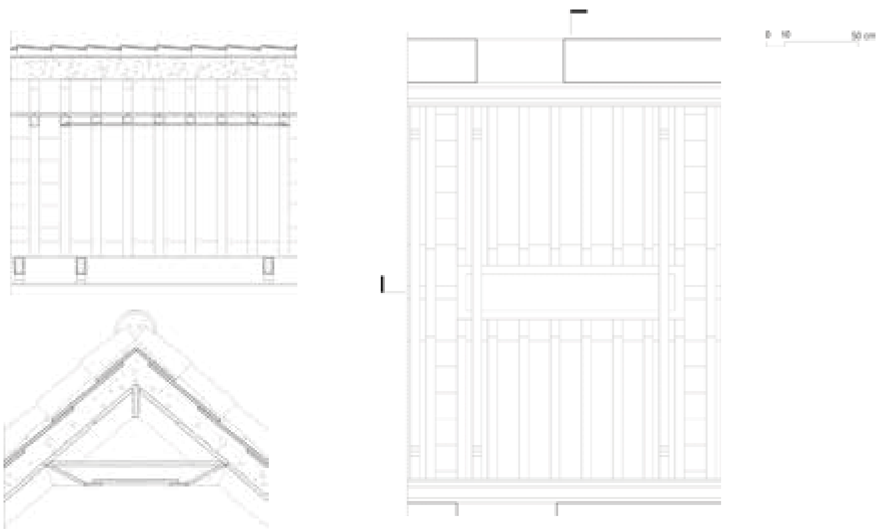
Horizontal wooden planks rest on the collar beams; they are wedged into the grooves carved in the rafters. Between the collar beams additional oblique planks are wedged into their corresponding grooves, thus completing the connecting system. The succession of the horizontal beams with the boards in between results in a flat surface, which in Spain is called *almizate* or *harneruelo*.

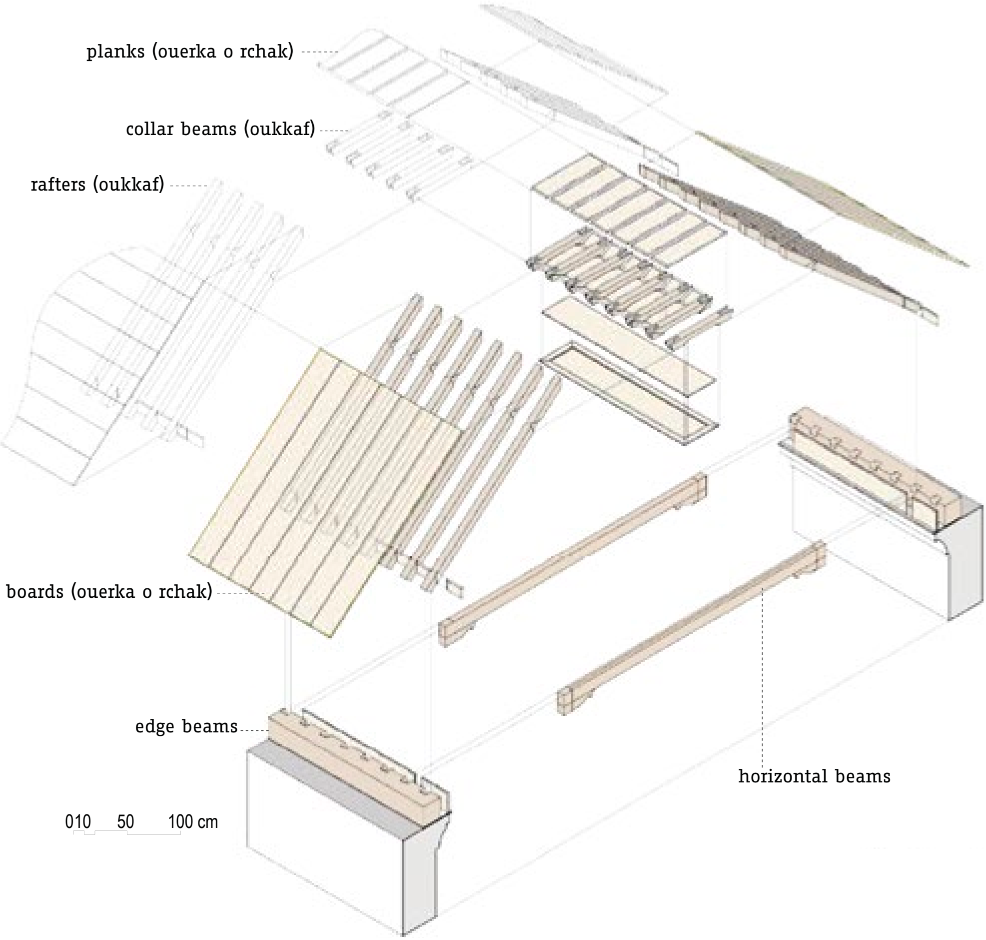
An additional set of boards is placed in the central part of the ceiling, at the lower edge of the collar beams, wedged to the collar beams and nailed to the boards. The ensemble of these elements constitutes the *bsat*.

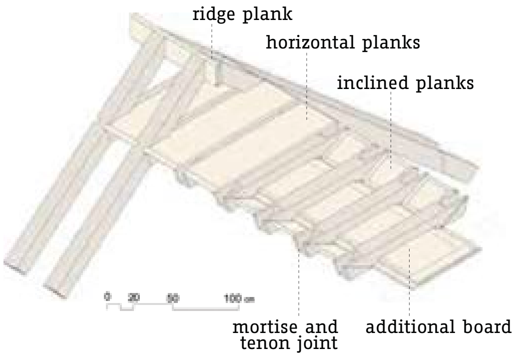
R1 | Andalusian type timber roof

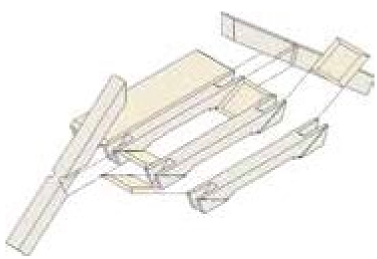







planks (ouerka o rchak)
collar beams (oukkaf)
rafters (oukkaf)
boards (ouerka o rchak)
edge beams
horizontal beams
010 50 100 cm


ridge plank
horizontal planks
inclined planks
0 20 50 100 cm
mortise and tenon joint
additional board



Andalusian timber roof
External view

The bases of each couple of rafters are connected to two edge beams with rectangular cross section, placed at the top of the longitudinal walls, which provide support for the roof structure and allow a good distribution of the actions transmitted on the masonry walls. The connection between the rafters and the edge beams is obtained through a cavity hollowed out on the upper corner of the edge beams.

opposite page
Andalusian timber roof
Internal view and detail of bsat

Additional horizontal beams are often placed at the same level of the edge beams, transversally to the room. They have a rectangular cross section of approximately 7x15 cm. In order to reduce the span and to provide a suitable end support, the beams rest on a wooden corbel. The transversal beams can behave as tie beams, given their U-shaped grooves where the longitudinal edge beams are placed forming a cross-lap joint.

In the Spanish *par y nudillo* timber roof these transversal beams works as tie beams, because they are positioned under the edge beams and connected to them through a cross lap joint. In Chefchaouen, the connection with the edge beams is not sufficient to ensure the function as tie beams, since the connection is often made of simple metal brackets or nails with a wooden corbel. Considering this node geometry, although a pair of nails is usually present, the connection cannot transfer the tensile force from the transversal beams to the edge beams. As explained by the *mallems* and the inhabitants who were interviewed, these beams, usually placed in couples, only serve the purpose of providing support for a possible attic usually used as a storeroom or garret. The transversal beams have a variable spacing of approximately 1.30 m and when placed in couples and 0.45 m.




The inner surface of the Andalusian style roof is often painted with geometric, floral and Arabesque patterns, and framed by additional wooden planks.

Roof deck and covering

The wooden boards that form the roof deck are nailed to the upper edge of the couple of rafters, arranged transversally to the room at the central part and longitudinally at the ends. They provide the roof deck for both pitches, ensure a good overall stiffness and, at the same time, preserve the spacing between the rafters unchanged. The deck provides support for the screed and for the roofing tiles. The screed, with a thickness between 5 and 12 cm, is constituted by a mix of earth, lime, pebbles and fragments of bricks. The curved tiles are placed in two superposed inverted layers directly on it.

The gutter system is made by curved tiles and bricks, arranged so as direct the rainwater away from the masonry walls and preserving the earth mortar and plaster. Depending on the arrangment of the tiles, we can identify two typical gutter systems: the simple (G1) and the protruding gutter (G2 and G2b).

Implementation

After finishing the execution of the perimeter walls 2 or 3 courses of bricks that protrude approximately 15 cm are often placed on the top in order to create a wide and solid base for supporting the roof beams. The edge beams are placed on the side walls, then each pair of rafters is erected and placed together with the transversal connecting element. The base of the rafters is stuck on the notch carved into the edge beams, without nails. The next pair of rafters is placed after the insertion of both the inclined and horizontal planks, which connect them to the previous pair. The spacing between the rafters is very reduced (between 10 and 20 cm) and corresponds approximately to double their width. The building process is characterised by a great simplicity of execution, similar to a modern prefabrication system.

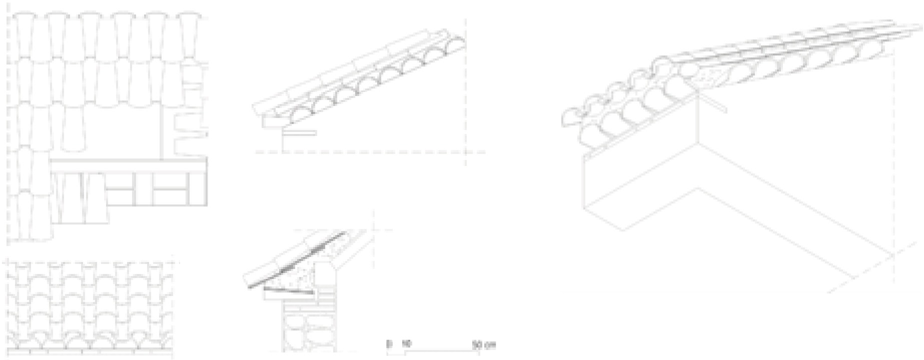
The site was always headed by a *maâlem*, or the master builder, who had an excellent knowledge of geometry and was capable of drawing and representing, with the use of in-scale models, the structure of the roof to be built. The *maâlem* established the dimension and spacing of the elements, based upon the size of the room and the slope of the roof.

Structural behavior

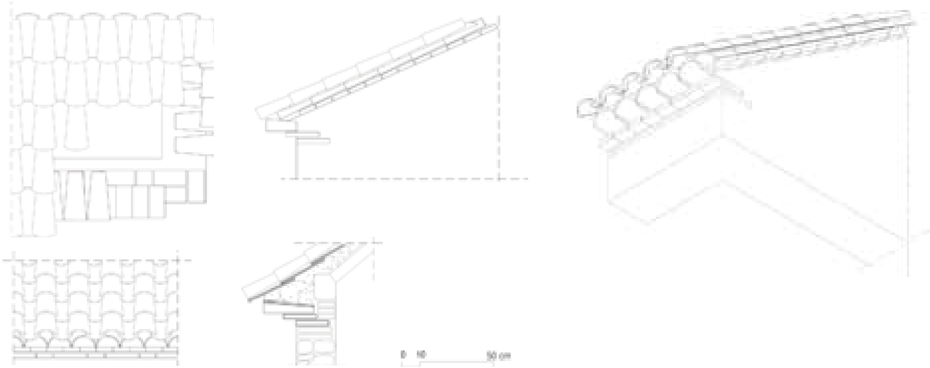
An in-depth analysis of the structural system of the Andalusian type roof was undertaken in 2017/18 (Galassi et. al., 2018a), in cooperation with prof. Stefano Galassi and Giacomo tempesta from the Section of Materials and Structures of the Department of Architecture of the University of Florence. A series of numerical simulations were carried out with both 2D and 3D-models using the Finite Element Method (FEM) software Straus7, in order to assess the safety of the structural system and to highlight its vulnerabilities both inherent and deriving from possible seismic events.

The timber roof structure of a room in Dar Raissouni was examined as case study. The role that each structural element plays in order to assure the equilibrium of the roof system was highlighted using 2D-models. The numerical analyses revealed the structural behavior of the timber structure in which a significant role is played by the collar beam that connects, in proximity of the ridge of the roof, the two counterposed rafters. Due to the tenon and mortise joint, the collar beam cannot behave like a tie beam, but as a strut, so that it contributes to contain the flexural deformation of the roof while at the same time conferring a higher degree of safety to the hinge-joint between the two rafters near the cusp. Numerical simulations have proven that the Andalusian-type roof system has a gener-

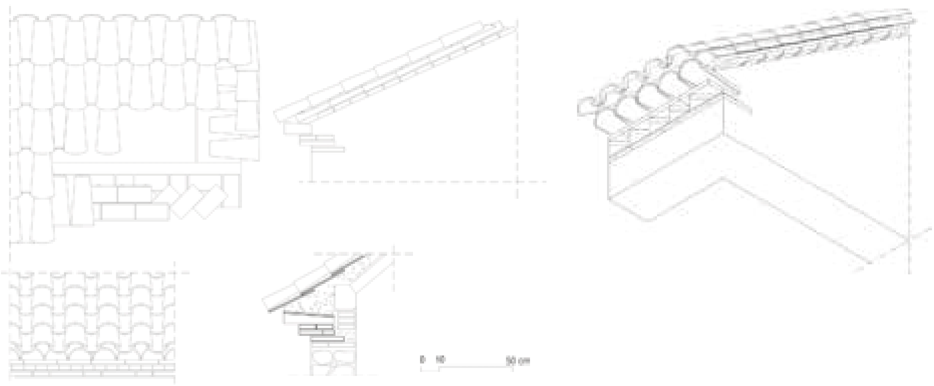
G1 | Simple gutter system

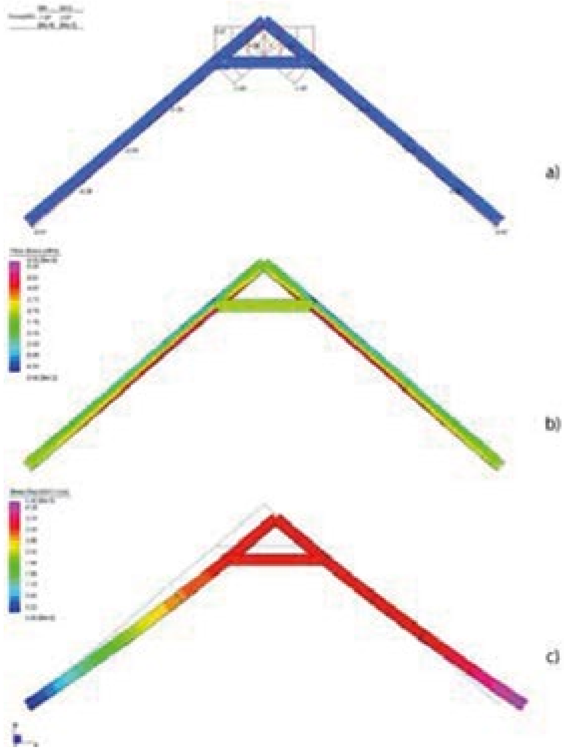


G2a | Protruding gutter system



G2b | Protruding gutter system





Model–statically determined structure joined to the walls by a pinned and a roller support
(a) axial load; (b) stress state; (c) horizontal and vertical node displacements. (Galassi et al. 2018a)

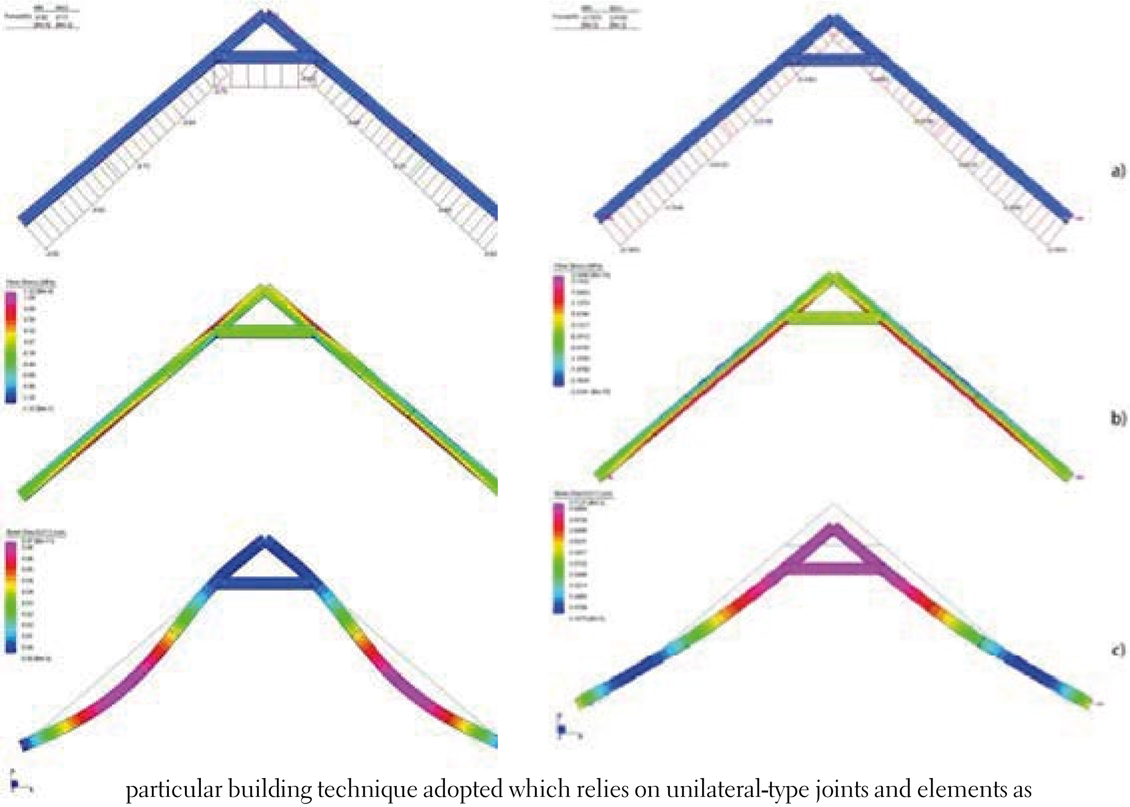
opposite page
Model–statically indeterminate structure joined to the walls with pinned supports
(a) axial load; (b) stress state; (c) horizontal and vertical node displacements (Galassi et al. 2018a)

Model–statically indeterminate structure joined to the walls by pinned supports subjected to inelastic displacements of approximately 0.6 cm
(a) axial load; (b) stress state; (c) horizontal and vertical node displacements (Galassi et al. 2018a)

al structural consistency and a sufficient level of safety in the case of gravitational loads, even if the structure is in a state of unstable equilibrium assured only by the friction between the edge beam and the masonry.

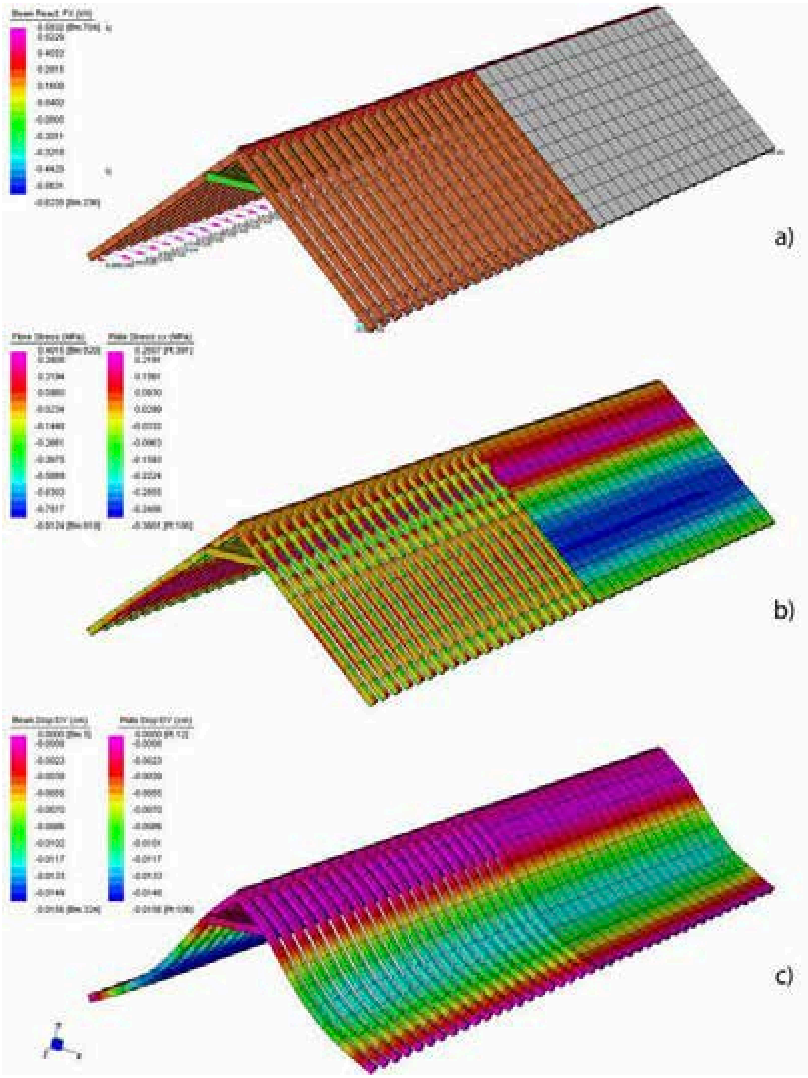
In order to assess the seismic vulnerability level of the Andalusian roof, an additional analysis was carried out, performing a three-dimensional model (FEM_4 model) (Galassi et al., 2018a). The seismic action has been computed by reference to the Moroccan "Règlement de Construction Parasismique RPS 2000-Version 2011" (RPS, 2000). The analysis of the model highlights that the seismic action does not significantly increase the thrust transmitted to the wall, nor does the axial load on the collar beam. Therefore, considering an earthquake of medium intensity but with a high probability of occurrence, the Andalusian-type roof shows a good level of safety.

The main reasons for the good structural behavior of the roof can be attributed to the moderate spacing between the rafters (21.5 cm) and the high slope of the roof pitch, which determine a very low horizontal thrust on the wall. At the same time, the analysis can ascertain that the building system presents some inherent vulnerabilities due to the



particular building technique adopted which relies on unilateral-type joints and elements as well as on frictional supports. Some critical elements and weakness that affect the safety for gravitational loads of the building system have been identified:

- the thickness of the screed (8 to 10 cm) over the planks induces an extremely heavy load, even if its distribution on each element does not reach very high values thanks to the reduced spacing of the rafters;
- the tenon and mortise joint between the collar beam and the rafters acts as a unilateral connection, avoiding a behavior as tie beam;
- the horizontal beams, when not connected to the longitudinal edge beams, can not behave as tie beams and absorb thrust on the perimeter walls;
- the node between the rafters and the edge beams obtained through a simple cavity hollowed out on the upper corner of the edge beams;
- the edge beams supported on the top of the walls without fasteners;
- the connection between the roof structure and the walls at the level of the longitudinal beams that are simply placed (as sleeper beams) on the top of the walls without fasteners.



3D model of the Andalusian-type roof for seismic analysis. Results regarding the gravitational load combination with the seismic action in the transverse direction: (a) thrust transmitted to the walls; (b) stress state; (c) vertical displacements. (Galassi et al. 2018a)

The fact that the edge beams are simply supported on the masonry walls without fasteners causes an inevitable small horizontal displacement of the edge beam toward the outside. In fact, the thrust on the perimeter masonry walls cannot be entirely balanced by the support reaction exerted in correspondence to the interface between the edge beam and the masonry wall, which is only based on the friction force. Therefore, a slight horizontal sliding toward the outside inevitably occurs. This weak stability is confirmed by the horizontal crack that is visible on the outside wall of the room, at the height of the edge beam. This type of damage has been acknowledged by the Moroccan regulations "Reglement parasismique des constructions en terre RPCTerre 2011" (RPCTerre 2011), which proposes devices for the anchorage of the roof to the walls in order to reinforce and improve the joint. Following the structural analysis conducted and considering the vulnerability of the masonry, which is composed by hard and scarcely hewed stones and a poor mortar with a low amount of lime, it is considered more appropriate to strengthen the connection between the transversal and the edge beams and alter as little as possible the masonry section (Galassi et al., 2018a).

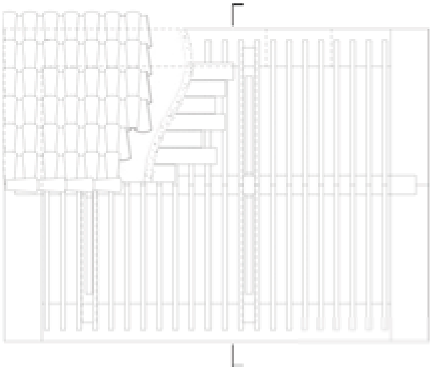
Berber timber roof (R2a, R2b, R2c)

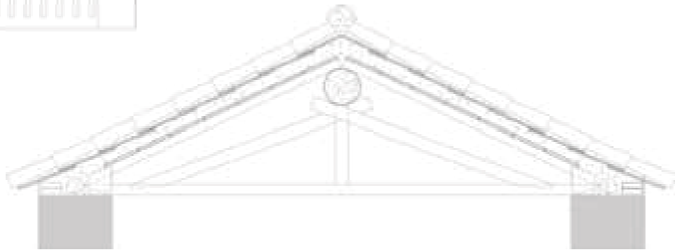
The Berber timber roof – unlike the Andalusian variety – uses rough-cut wooden elements. It always supports a double pitched roof and occurs in three different versions depending on the dimensions of the room to be covered. It is used for covering residential buildings or craft shops.
The two simplest cases consist of common rafters supported on the longitudinal walls and on 1 or 3 beams. The end of the beams are supported on the transverse walls. When the longitudinal dimension of the room is more than 4-5 m, the structure system is aided by a king post truss composed of two principal rafters, the tie beam and the king post. The king post is directly linked to the tie beam to which it transfers roof loads, causing a noticeable deflection.

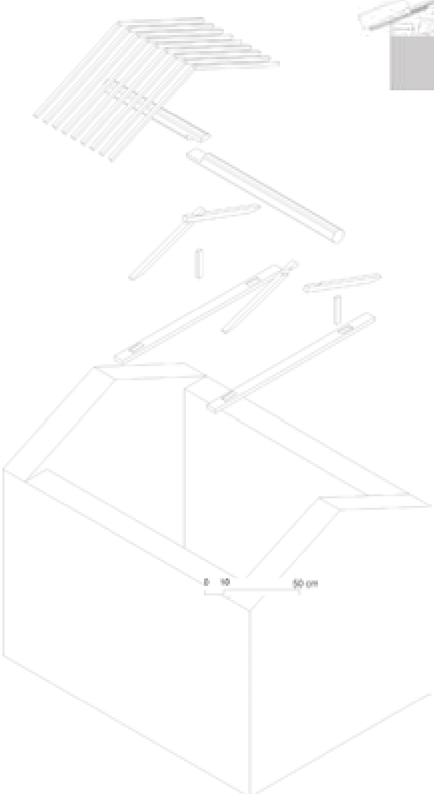
Main constructive features

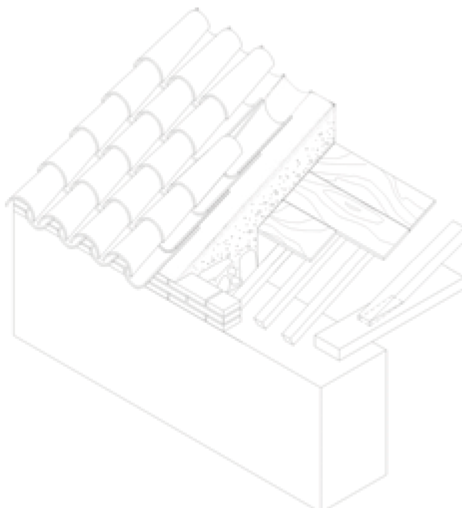
The simplest arrangement of the Berber roof structural system is made of a ridge beam that provides support to sloping common rafters, transversely oriented (R2c).
The ridge beam (locally called "*saham*") has an approximately circular cross with a diameter that ranges from 15 to 25 cm. Often two other main beams are arranged parallel to the ridge beam, at about half the distance between the centerline of the roof and the longitudinal walls (R2b). The main beams are leaning on the transversal walls, placed on a brick tile and inserted in the masonry, in order to level the bearing surface.
The secondary warping consists of common rafters (*oukkaf*) with a section of approximately 5-7 cm by 5-7 cm. The rafters are placed with a reduced spacing of approximately 15 cm. The common rafters transfer their self-weight and the dead load of the roof to the peripheral walls directly or, in a few cases, by means of an edge beam, placed at the top of the walls, to which they are connected through half-lap joints with grooves carved on both members. In the case in which the length of the room exceeds 5 m, the ridge beam is composed of dif-

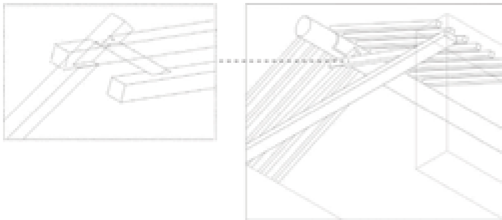
R2a | Berber timber roof • type 1



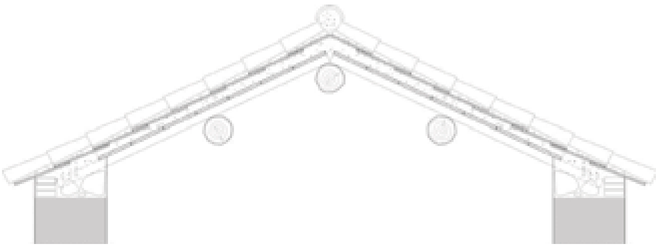








R2b | Berber timber roof • type 2



R2c | Berber timber roof • type 3

Berber timber roof (R2a)
Interbal view

ferent parts assembled using half lap joints. At the junction point the beams are supported by three trusses, consisting of two principal rafters, a tie beam and a king post (R2a). The two principal rafters, which present a rectangular cross section, are connected at the top through a half lap joint, with grooves carved on both members. The king post consists of a vertical wooden element, also with a rectangular cross section, which is nailed to the side of one of the two principal rafters. This vertical element rests directly on the tie beam and transfers a significant portion of the roof load coming from the ridge beam directly to the mid-span of the tie beam. In some cases the king post is inserted into a groove carved in the mid-span of the tie beam, in such a way as to form a dado joint, that is a joint made by cutting a groove with a dado blade or router bit across the width of the tie beam the same size as the end of the king post that fits in it.

This type of joint is aimed at maintaining the compressed king post in its vertical position. The connection between the king post and the tie beam implies a stiffness in the vertical plane of the truss higher than that of a traditional king post truss (where the king post is not connected to the tie beam), but, in so doing, involves a very different structural behaviour, because of the shear force transferred by the king post at the mid-span of the tie beam, that cannot work as a perfect tie. The connection between the principal rafter and the tie beam is done by a notch approximately 3 cm high carved In proximity to the the masonry support. This causes dangerous vertical shearing forces orthogonal to the grains of the tie beams.

The trusses are supported directly on the masonry, without edge or sleeping beam wall plates. The absence of load distribution elements causes significant stress concentration on the masonry wall and, consequently, the occurrence of cracks or deformations due to the crushing of masonry.

Roof deck and covering

The planks that form the roof deck (*ouerka* or *rchak*) are supported and nailed on the rafters. Their dimensions are about 3 cm thick, 15 to 20 cm wide and 70 to 120 cm long.

The roof boards support an approximately 10 cm-thick screed made of a mix of earth, lime, pebbles and fragments of bricks.

The roofing is made of curved tiles, laid in two superposed inverted layers directly on the deck, so as to obtain sloping pitches of approximately 20%.

Implementation

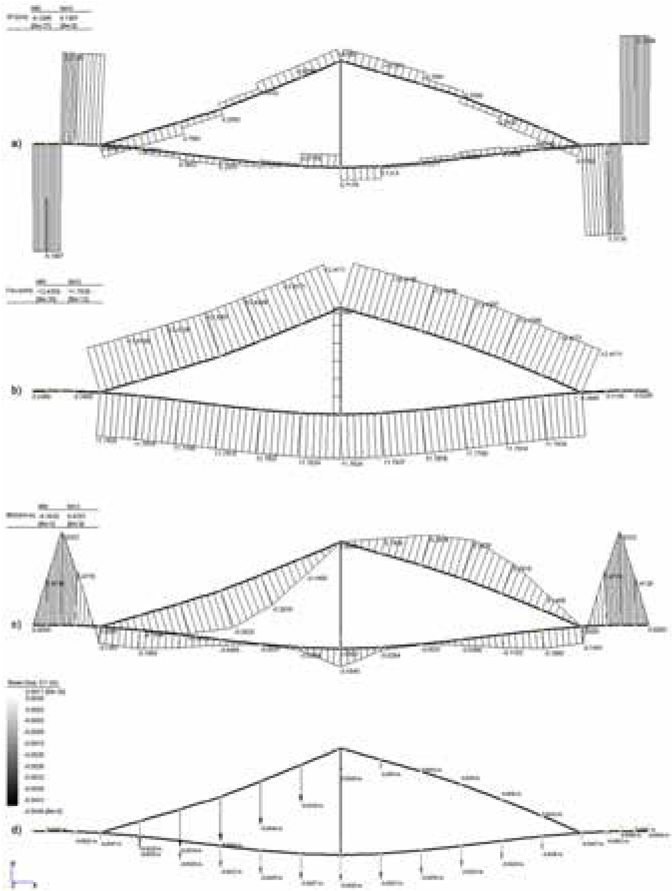
The wood species employed are fir (*soha*) and red fir (*sanawbar*), local timber with good mechanical properties. The preparation of the timber members is carried out by using a saw, or an adze for the oldest members. However many timber defects weaken the strength of the material: wide knots, moisture spots and, occasionally, insect bores are detectable, mainly in the principal rafters.

Structural behavior[2]

The case study taken under analysis is the intermediate truss of the roof covering a room, measuring 2.50x3.70 m in a courtyard house located in the Rif al Andalous district. In this case the tie beam of the intermediate truss shows the typical deflection of the Berber truss, with a maximum deflection of up to 11 cm. However, it is worth noting that the geometric survey has not highlighted a considerable deflection of the ridge beam, limited to approximately 4 cm and, therefore, much lower than that of the tie beam.

Considering the excessive deformation of the timber members which compose the truss of the roof, a clear sign of a strongly compromised structure, numerical simulations have been carried out with the Finite Element Method (FEM) software Straus aimed at analyzing the safety level of the structure in detail. The numerical analyses have highlighted that, despite its similarity to an ordinary king post truss, for the particular positioning of the members to form the structural geometry and the type of connections between members, the Berber truss is a structure with a peculiar mechanical behaviour in which the very pronounced deformation of members is mainly due to the lack of stiffness of the tie. Its current condition cannot

[2] The structural behavior of the Berber timber roof has been analyzed with the cooperation of Stefano Galassi and Giacomo Tempesta from the Section of Materials and Structures of the Department of Architecture of the University of Florence.

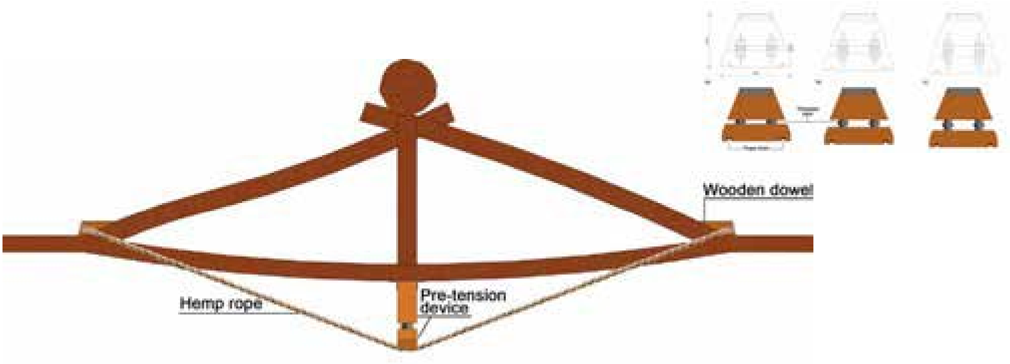


Results of the FEM model (unfavourable fundamental combination): (a) shear force; (b) axial load; (c) bending moment (Galassi et al. 2018b)

opposite page **System proposed to reinforce the existing Berber roof structures**

be considered safe not only due to the increase of deformations continuously caused by the creep, but also because of the very reduced dimensions of the members.

With the purpose of providing a solution to improve the behaviour of the structure through the reduction of the increments of the deflection and consequently prevent the risk of a possible collapse, a targeted strengthening intervention has been proposed (Galassi at al., 2018b). The proposed system employs local materials and it is inspired by the mechanical model of the "reinforced beam" called "inverted king post truss" and based on the single-strut-double cable system, whose reinforcement, in this specific case, is made of hemp fibres intertwined in such a way as to form a chord. The device conceived to put the chord in tension does not need skilled workers and can be installed in a very short time.



References

Candelas Gutiérrez A. L., Ariza López I. 2005, *Funcionamiento estructural de las armaduras de par y nudillo. Metodología de análisis*, in *Proc. Cuarto Congreso Nacional de Historia de la Construcción*, *Cádiz*, ed. S. Huerta, Madrid.

Dipasquale L., Volpi V. 2009, *Le coperture*, in Mecca S., Dipasquale L., Rovero L., Tonietti U., Volpi V. (eds.), *Chefchaouen. Architettura e cultura costruttiva*, ETS, Pisa, pp.167-181.

Dipasquale L., Galassi S.,Tempesta G., Ruggieri N. 2020, *Analysis and conservation strategies of traditional timber roof structures in Northern Morocco*, in *Proc. REHABEND 2020: Construction Pathology, Rehabilitation Technology and Heritage Management*, pp.1391-1398.

Galassi S., Dipasquale L., Ruggieri N., Tempesta G. 2018a, *Andalusian timber roof structure in Chefchaouen, Northern Morocco: construction technique and structural behavior*, «J. Archit. Eng.» 24 (3).

Galassi S., Ruggieri N., Dipasquale L.,Tempesta G. 2018b, *Assessment of the Moroccan vernacular timber roof: a proposal for an eco-friendly strengthening system*, «Journal of Architectural Conservation», vol. 24, pp.224-248.

Nuere E. 1998, *Geometría y lazo en la carpintería hispano-musulmana*, in *La arquitectura como diversidad*, Institución Fernando el Católico, Zaragosa (ES), pp. 47-76

Nuere E. 2000, *La carpintería de armar española*, Munillalería, Madrid.

Ruggieri N. 2017, *Historical Overview on Criteria and Techniques for Reducing Timber Structures Deformability*, «Journal of Architectural Conservation», 3 (2017), pp. 211-227.

Royaume du Maroc, Ministère de l'Interieur, Ministère de l'Equipement et du Transport, Ministère de l'Habitat, de l'Urbanisme et de la Politique de la Ville, *RPCTerre 2011: Règlement parasismique des constructions en tierre RPCTerre 2011*.

RPS (Royaume du Maroc, Ministère de l'Habitat et de la Politique de la Ville) 2000, *Règlement de Construction Parasismique*, RPS 2000-Version 2011, Décrét n. 2-02-177 du 9 hija 1422 (22/02/2002), RPS, Djibouti, Africa.

Learning from local building culture to improve a sustainable & resilient habitat

LESSONS OF SUSTAINABILITY FROM THE TRADITIONAL BUILDING CULTURES

The local and traditional knowledge that has shaped Chefchaouen's medina for hundreds of years was key to fulfilling the community's housing needs, integrating local resources, climate and risks to enhance their habitat sustainability, durability and resilience.

This knowledge represents a resourceful database of technological measures ranging from construction techniques and details, technical devices, particular beliefs and specific behaviours at the territorial, settlement and household levels, with a significant potential to define sustainable design guidelines for the future, through respectful maintenance and a balanced and lasting development, capable of keeping alive the cultural identity of the place.

Elements of sustainable design are integral to vernacular architecture which has evolved over time, using local materials and technology emerging from natural and cultural environments, creating optimum relationships between people and the places they inhabit.

In this chapter the principles of sustainability that are hidden behind the forms and techniques adopted in the traditional building systems of the Chefchaouen medina are identified and analysed. These principles are closely related to the context in which they developed, and from them lessons can be derived that still today may positively influence innovation in the project of rehabilitation processes, as well as in new constructions, enhancing community and habitat sustainability and resilience.

Indeed, many of the lessons provided by traditional architecture may be timeless, that is, they remain applicable also with current global pressures of social, economic, environmental and political change. One of the first, certainly among the most famous scholars who supported a notion of a-temporality of the traditional architecture and its sustainability, was Christopher Alexander, who in his book *Timeless Way of Building* (1979) proposes a design method based on traditional patterns. For Alexander, timelessness is a distinctive element that characterises the environmental aspects of indigenous vernacular dwellings and settlements, where traditional builders followed a creative process that not only avoided damage, but instead improved the cultural and natural landscape. Among these, he describes some features that characterise the Islamic city. For example, he highlights the importance of the proximity be-

FUP Best Practice in Scholarly Publishing (DOI 10.36253/fup_best_practice)
Letizia Dipasquale, *Understanding Chefchaouen. Traditional knowledge for a sustainable habitat*, published by Firenze University Press (www.fupress.com), ISBN 978-88-5518-178-5 (PDF), DOI 10.36253/978-88-5518-178-5

tween the working and the living quarters, the in-between spaces, or the courtyard house, the basic pattern model of the medinas, which is well suited to contexts with changing needs and environmental and sociocultural needs.

Knowing the principles of sustainability inherent in vernacular architecture is essential to guide a conservation process that starts from these principles and enhances them, instead of cancelling them, as often happens in modernisation interventions. In fact, there are more and more cases in which, for example, non-breathable plasters are applied, preventing the walls from transpiring; in many cases, the building's thermal insulation has been worsened by replacing the pitched roofs with non-insulated terraces; the courtyard was eliminated to increase the living space; toxic, incompatible or high environmental impact materials have taken the place of natural ones in the rehabilitation and restoration processes of recent years.

Looking for sustainable design paths for future architecture and human settlements, we can rely on past findings for developing resilient planning strategies, analysing, selecting, testing and verifying the intangible heritage of traditional architecture.

The approach followed here in order to identify the principles of sustainability has been tested in the VerSus project: Lessons from Vernacular Heritage to Sustainable Architecture, a EU Creative Europe project coordinated by Escola Superior Gallaecia with the cooperation of four European partners: Università degli Studi di Firenze (IT), CRAterre-Ecole d'Architecture de Grenoble (FR), Università degli Studi di Cagliari (IT), Universitat Politècnica de València (ES) (Correia et al., 2014b). Starting from the observation of case studies of vernacular architectures, the aim of the project was to codify traditional building knowledge to provide a catalogue of conceptual solutions and strategies for sustainable projects. The project, following an inductive method, identifies 15 principles embodied in vernacular knowledge, 5 for each area of sustainability (environmental, socio-cultural, socio-economic), and for each of them recurrent design strategies, which can be integrated both in the rehabilitation and in the design of new sustainable architectures.

In this chapter, the 15 VerSus principles of sustainability have been observed in the vernacular architecture of the medina of Chefchaouen, and for each of them recurrent design strategies and solutions, capable of responding to each principle, have been identified on the urban, architectural and constructive scale.

This analysis of sustainability in vernacular architecture adds to general knowledge of traditional buildings, and can contribute to future architectural conservation. Sustainable principles should be surveyed and assessed as any other preservation value (such as

e.g. architectural and historical value) for conservation and development projects, and at the same time can be a good leading point and a recipe for complex design requirements in new construction.

Physical, cultural and economics determinants of the medina

In the development of a traditional settlement, such as the medina of Chefchaouen, the urban form, the spatial organization, the distribution of functions and public spaces, the shape of the dwellings and their functional organization, as well as the choice of materials and building techniques represent a morphological response to both environmental and climatic constraints, as well as to the socio-economic and cultural characteristics of societies.
The city of Chefchaouen, as seen in the previous chapters, developed in an environmental context characterized by a Mediterranean climate, with hot summers, few winter months with rainfall and rare snow episodes. To the north the city is protected by the Rif mountain range, while to the south it opens up towards the valley. Chefchaouen was founded on the current site not only due to its sheltered position that naturally defended it against the attacks,

opposite page
Buildings adaptation to the topography of the territory.

but also because of the abundance of water rising from a crack in the limestone ridge, which played a key role in the development of the medina.

From a socio-cultural point of view, intimacy, discretion, and the need for protecting family privacy are elements of the Arab Muslim culture that have undoubtedly influenced the form of the settlement. There is a clear hierarchy between public, semi-public and private spaces, marked by systems of filtering, protection and passage from one level to another. The strong sense of solidarity and mutual help between families and neighbourhood communities, which is also an important element of Islamic culture, translates into the presence of special semi-public spaces, used for children's play, for relationships between adults, especially women, which traditionally were not allowed social relations in open public spaces.

The traditional economy of the medina is based on a self-sufficient production system: the residential fabric integrates the productive activities, and the raw materials are allocated in the immediate surroundings. The transformation processes and the production of services are integrated with the built-up area, or when incompatible with the medina, they take place at close distances.

The combination of physical, cultural and economical determinants influences the requirements of the inhabitants who over the years have given shape to a habitat capable of responding to their needs starting from the resources available and the existing environmental constraints. The change of these determinants logically implies a change in the requirements of the inhabitants and in the definition of the settlement models.

Understanding environmental sustainability

The principles of environmental sustainability refer to the capacity of human intervention to be integrated with the environmental characteristics of a place, in decreasing or avoiding the building's adverse environmental impacts. Observing the medina of Chefchaouen we can recognize some strategies that gave shape to the traditional settlement, referring to the following principles of environmental sustainability.

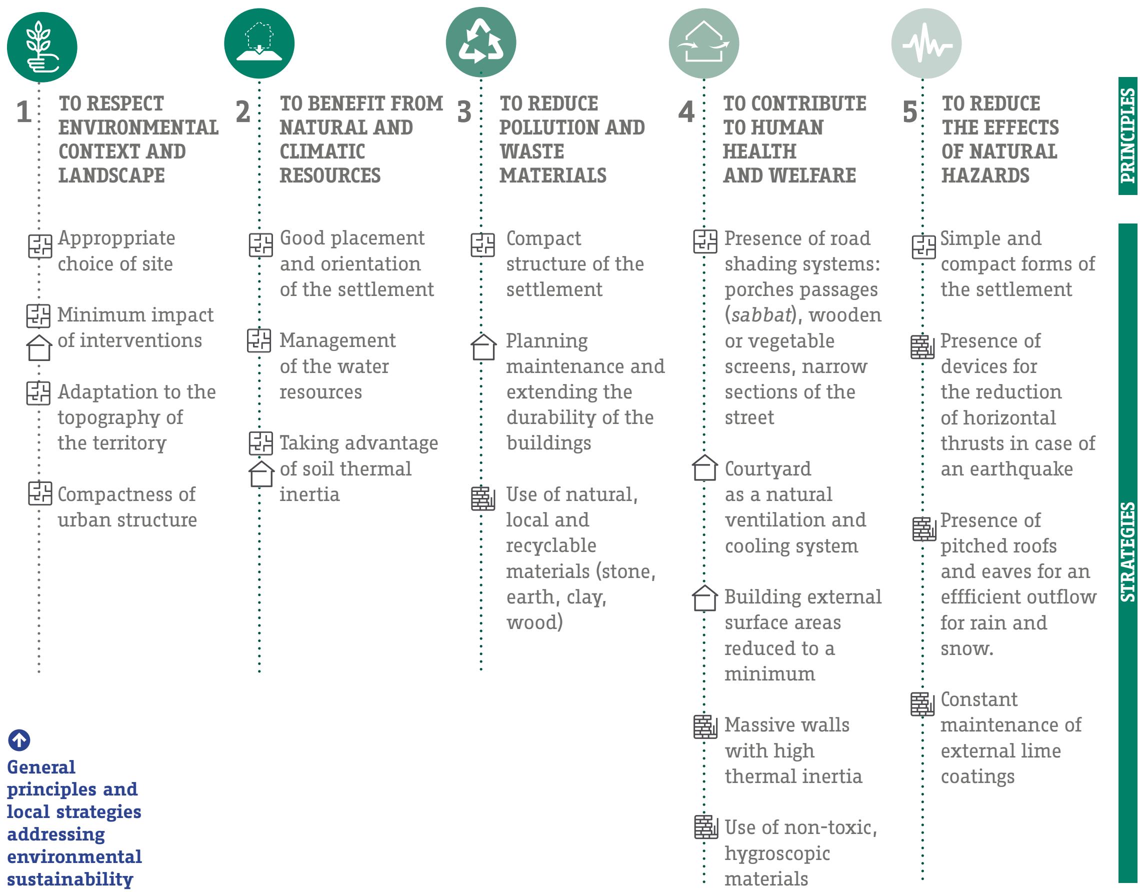
1.Respecting environmental context and landscape.

The medina of Chefchaouen takes shape in close relation with its landscape, to which it owes its physical and historical identity. The materials and buildings come from the territory and adapt to it. The main axes follow the land contours and the settlement form adapts to the topography of the territory, trying to derive benefits, while respecting the environmental characteristics of the place.

The displacement efforts and the land movements are reduced, using as little floor area as possible and controlling the inclination of the paths. The urban structure is condensed and compressed, with an efficient utilization of the land, which has many environmental, economical, and social advantages when compared to the dispersed form of modern settlements.

2. To benefit from natural and climatic resources

The development of the historic core takes into account the natural resources and the aspects that influence the microclimate of the site. The medina is protected from prevailing winds thanks to the peaks of mountains Djebel Meggou and Djebel Kala. The town is south facing, on a land with an average slope of 12% which favours the exploitation of natural sunshine during the winter season. Main streets are mainly oriented on the east-west axis, allowing complete shade against the sun during the hotter hours. This can also allow for desirable prevailing winds to channel through the alleyways and provide ventilation while offering shelter from harsher winds. The sloping layout of the built-up area allows taking advantage of soil thermal inertia.



General principles and local strategies addressing environmental sustainability

urban and territorial scale
building scale
construction systems scale

The hydrography of the place is part of the urban plan of the city. The channeling of the waters from the source of the Ras El Maa river, which are used for vital and productive activities, takes advantage of the course of the land to ensure distribution that traditionally took place without the aid of mechanical means. All terrain slightly lower than the irrigation intake was served by gravity distribution of the water

opposite page
Use of natural and local building materials

3. To reduce pollution and waste materials

Traditional building materials are natural and local: limestone, earth, clay, wood. They are not harmful or wasteful, they are renewable, recyclable or naturally decompose, re-

turning to nature at the end of the useful life of a structure. Therefore, the use of natural materials reduces pollution and environmental degradation and takes place in the context of a cyclical ecological process.

The materials are easily available in the immediate proximity of the construction site, thus decreasing the carbon foot-print derived from transportation: the stone is surfacing or at low depth, the excavated earth is used for the production of mortars, the clay, extracted near the medina, is transformed into bricks in special furnaces.

On the contrary, today, issues of resource depletion, concerning for example the timber elements, as well as the ease of finding modern materials, makes access to natural materials increasingly rare.

4. To contribute to human health and welfare

The urban structure and the courtyard house, the widely used housing model in the medina, integrate bioclimatic principles that improve the internal comfort of the building.

In the winding and narrow streets of the medina shady areas are generated, and refreshing breezes are channelled, while the effects of the strongest winds are reduced. At the urban level, other cooling systems are obtained thanks to wooden shading systems, sometimes integrated with vegetation, or thanks to covered passages (*sabbat*).

Road shading systems: wooden and vegetable screens; porches passages (*sabbat*),

opposite page **Compactness of urban structure** (© L. Lupi)

The building surface areas, exposed to the sun in summer and cold in winter, are reduced to a minimum, thanks to the aggregation system, where buildings are built against each other.

Courtyards are a key element in terms of lighting and ventilation. They present a series of passive design principles and thus allow optimising the building's thermal performance, thus enhancing human comfort conditions. The natural elements of the courtyard, i.e. earth beneath and sky above, ensure its direct contact with nature. The courtyards represent the main channel of natural lighting to the indoor spaces of the building. They are generally sufficiently narrow to provide a shaded area in the summertime, and yet sufficiently wide to gain solar radiation in the wintertime.

The thermal performance of courtyards has been studied by many researchers (Abdulkareem, 2016; Aldawoud, 2008; Almhafdy et al., 2015; El Harrouni et al., 2018; Soflai et al., 2017; etc.). Studies show that the level of thermal comfort in a courtyard is determined

by microclimatic factors, especially solar radiation and wind. The effect of these parameters may be evaluated with respect to the courtyard's geometry, dimensions, proportions and its orientation, as the key design variants to provide appropriate thermal comfort in the courtyards.

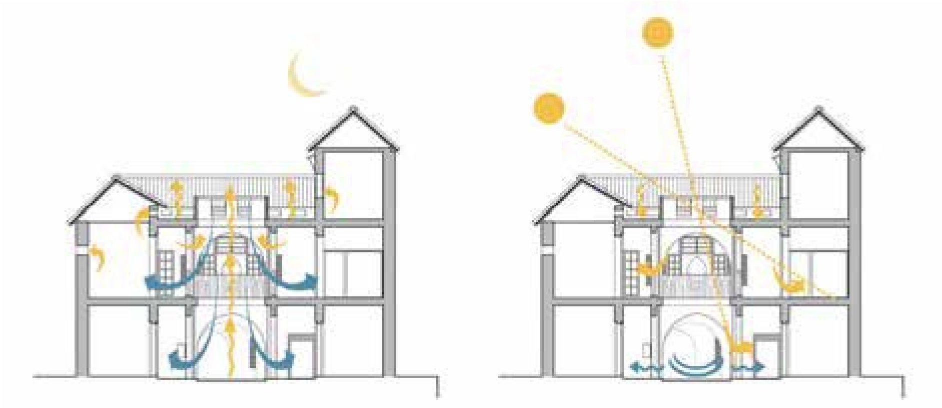
The central courtyard acts as a natural cooling and ventilation system thanks to the air convection property that is based on the principle of the rising of warm air which is replaced by cool air. The air in the courtyard becomes warmer as the day progresses toward night-time, while cool air is stored in the courtyard in laminar layers and flows into the indoor spaces around the courtyard. The temperature in the courtyard slowly rises in the morning, allowing the courtyard to stay cool till solar radiation falls directly onto it.

At night time, the air of the patio, which has been heated directly by the sun and indirectly by the walls, rises up while nocturnal cool air gradually replaces it. As the cool air dissipates from the floor and adjacent rooms, convection current is created and therefore adds to the comfort within the house. During the summer period, night ventilation enables cool air to enter the indoor spaces through open windows and arches and thus removes the heat stored in the thermal mass of the building envelope during the day. The combination of shading and night cooling ventilation enables the reduction of temperatures of the indoor spaces and the courtyard, keeping them within acceptable limits, close to thermal comfort levels. When there are fountains, the presence of water provides evaporation cooling which

The courtyard as passive design device works as a modifier of the microclimate and acts as a heat sink and cold air storage

opposite page
Day time and night-time air circulation in the courtyard house

increases air humidity and enhances thermal comfort conditions during hot-dry days. The arrangement of a large number of openings in the building's walls around the courtyard helps towards the ventilation and the cooling of individual rooms.
Smaller openings are located at a higher position in the exterior facades facing the street. Their high level position provides visual privacy from passers-by and ensures the cross ventilation of indoor spaces. Moreover, due to the difference in temperature and density of the air, they ensure the extraction of hot air towards the external environment (stack effect), thus contributing to the cooling of spaces during the summer period.
The walls of the courtyard houses are constructed using stones, earthen mortar and lime plaster with a thickness between 300-500mm. The thick wall acts as a thermal mass which regulates the temperature of the internal areas and enhances thermo-hygrometric well-being.



The building materials (earth, stone, wood) are non-toxic and hygroscopic (therefore capable of regulating the humidity of the rooms) helping to ensure healthy and comfortable environments.

5.To reduce the effects of natural hazards
The medina is designed to provide a safe and protective environment for all its inhabitants. The simple and compact forms of the settlement guarantee mutual contrast mechanisms between the buildings, favouring resistance over time and protection in the case of earthquakes. The traditional building systems integrate small devices capable of guaranteeing a good response of the buildings to horizontal thrusts in the case of an earthquake: for example the presence of counter-arches in the narrow streets of the medina or the buttresses, located above all in the most vulnerable points of buildings or when these are located on steep slopes. Andalusian-type floors and roofs are designed to distribute loads evenly and to minimize horizontal thrusts. Unlike most of the medinas in Morocco, the roofs of Chefchaouen have a double sloping pitch and particular attention is paid to the eaves system, to allow adequate outflow of rainwater.

Understanding socio-cultural sustainability

Urban spaces and houses reflect the convictions, beliefs, lifestyles, practical know-how and knowledge of the communities who live them. Islamic culture, as well as the local identity and values, are manifested in the forms of the settlement and have a strong influence on people's choices, behaviours and well-being.
In the medina of Chefchaouen, socio-cultural sustainability is expressed through the following principles:

PRINCIPLES

6 TO PROTECT THE CULTURAL LANDSCAPE

- Strong visual and physical interrelation between settlement and landscape
- Wise management of spring water
- Organic shape that adapts to the topography of the terrain.

7 TO TRANSFER CONSTRUCTION CULTURES

- Transmission of empirical know-how through building experiences
- Presence of figures capable of guaranteeing the conservation and transmission of knowledge (*maalem*, *amine*)
- Constant maintenance managed by the inhabitants

8 TO ENHANCE INNOVATIVE AND CREATIVE SOLUTIONS

- Evolving building techniques from experience, through processes of trial and error
- Integration of influences from Andalusian and Berber building cultures
- Use of lime plasters as answer to cultural and environmental requirements

9 TO RECOGNISE INTANGIBLE VALUES

- Hierarchy of spaces from public to private
- Presence of filter and in-between spaces: derb, galleryes, entrance...
- Simplicity and austerity in the facades of buildings to promote social fairness
- Court as a space for privacy and family intimacy
- Proper distribution of windows and screening to ensure protection from the sight of neighbors and passers-by

10 TO ENCOURAGE SOCIAL COHESION

- Presence of common infrastructures for sharing services and to promote social meetings
- Streets accessible only to pedestrians (no cars or scooters)
- Presence of semi-private spaces, as a space for social and intimate activities
- Courtyard as a space for sharing, socialization and household labor

STRATEGIES

General principles and local strategies addressing socio-cultural sustainability

urban and territorial scale

building scale

construction systems scale

6. To protect the cultural landscape

The cultural landscape is the result of a process of mutual adaptation between man and the natural elements of the place. The cultural landscape lives through the visual aspect of materials, constructive details, through the relationship between buildings and their surroundings: roads and houses adapt to the sloping shape, the outcropping rock is a visible part of the streets and the houses.

The town grew in an organic fashion by agglutination, that is adding one unit to another without a preconceived plan. Like a system of blood vessels, streets branch out from a central square to become lanes and narrow alleys and finally come to a dead end.
Water is also an element of cultural value that has been wisely and efficiently domesticated through open and underground channels to feed the community's productive and vital activities. All these elements demonstrate not only man's ability to adapt to the landscape to meet his needs, but above all determine a sense of belonging, a bond of the inhabitants with the context.

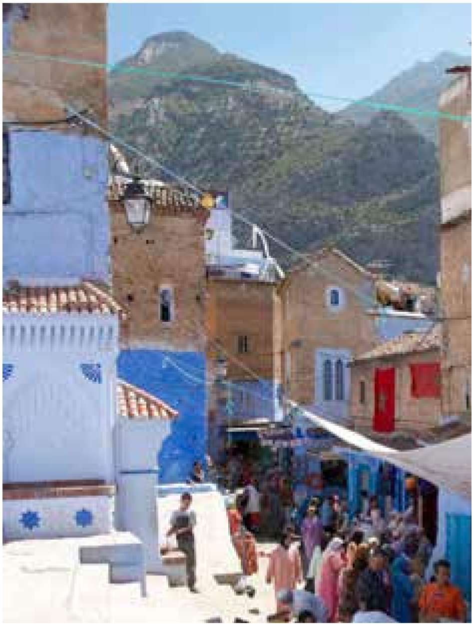
7 To transfer construction cultures

The architecture of the medina testifies to the knowledge and know-how of the craftsmen and builders who built it. The traces of constructive cultures live through the elements that make up the structure of the city.
The sharing of knowledge traditionally took place directly on the construction site and on the workshops. The knowledge was handed down from father to son or from teacher to apprentice. The presence of corporations, with key figures, capable of managing the various stages of the construction process (e.g. the *maalem* or the *amine*) ensured the transmission of knowledge.
The maintenance of the buildings and the space in front of the house was a task entrusted to the inhabitants, linked to seasonal cleaning and refurbishment rituals.
In particular, women were entrusted with the task of whitewashing the surfaces of the external facades accessible to them: the basements and the areas around the windows.
The current dispersion of knowledge on local building cultures should make us reflect on the identification of innovative strategies for the enhancement and transmission of knowledge in contemporary society.

8. To enhance innovative and creative solutions

The architecture of the medina expresses a surprising creativity that reflects a high degree of collective intelligence and a process of building experimentation that has gradually turned into experience. Ingenuity is expressed in terms of adapting to available resources and using them wisely. The creative solutions are the result of the integration of building knowledge, derived from experience, through processes of trial and error, with cultural influences: Andalusian, Jewish, Berber.
Thus the characteristic lime coatings, first white then blue, spread in Chefchaouen thanks to the influences of the Andalusian and Jewish cultures, and at the same time constitute a re-

Interrelation between settlement and landscape



Water supply canal used for used for irrigation, washing laundry, and feeding mills

Traditional building techniques as Integration of influences from Andalusian and Berber cultures

opposite page
Bent entrance passageway and galleries as filter space

sponse to the need for cooler and healthier environments, to the need to ward off insects, as well as to protect the walls from water infiltration.

Other remarkable expression of creativity are the applications of the Andalusian decorative and geometric art rules for the creation of decorative brick motifs for arches, windows or paving; the sophisticated and efficient systems of joints for Andalusian roofs and floors; the geometric and floral decorations and painting for wooden elements (floors, ceilings, doors, window frames).

9. To recognise intangible values

Spatial elements of the medina are dimensioned and arranged in order to respect the cultural values of Islamic society. Privacy (visual, acoustic and olfactory) and spatial hierarchy are the characteristics that are most often found in the generation of the urban fabric and in the morphology and functional organization of the house. This is done through private spatial elements such as courtyards; the bent entrance passageway from the street; the arrangement of transitional spaces and internal circulation; a proper distribution of openings to ensure protection from the sight of neighbours and passers-by; a hierarchy of spaces from public to private.

In particular, a key filter space of the medina is the blind alley (*derb*), a semi-public space to which only families that share it have access. In this semi-public zone people know each other, outsiders are asked about their intentions. The blind alley is a space to meet, visit, a space for exchange and conviviality. Women and children move freely here; men too, provided they are considered as relatives. Daily visits, mutual assistance, participation in various ritual ceremonies, exchanges of donations, make this space a small community governed by the ethics of neighbourly relations and linked by a network of solidarity and mutual help.

opposite page **Streets accessible only to pedestrians encourage encounters between adults and the safe play of children** (© L. Lupi)

Secondary through-streets form the boundaries and a buffer between quarters, leading to public spaces serving the whole community.

Within the house, the spaces are arranged to ensure family privacy. The house is almost closed to the outside, the rare windows are never found on the ground floor to ensure privacy and confidentiality. The windows are shielded by metal gratings that limit the interior visibility, however ensuring the cross ventilation.

The entrance door separates the private from the semi-public space. It opens into a buffer space without direct view into the depth of the house. An off-centre or angular corridor will lead to the courtyard.

Among the religious values of the community, the issue of not exhibiting social differences between people is stressed. Most residential houses are thus generally similar in their form and spatial arrangement. Nothing on the blank exterior walls of these houses shows any celebration of the social or economic status, or the composition of the family inside. The space for the display of decorative elements is the internal courtyard.

10. To encourage social cohesion

The spaces for social cohesion are numerous, thanks to the presence of many shared services and facilities in all the districts of the medina: public ovens, *hammams*, wash houses, markets, public fountains, etc..

The mosque is the privileged place for men to meet, who in addition to performing religious rites go here to meet relatives and be informed of local news. The small lay-bys and squares are also places of meeting and exchange for men and the elderly.

In the public space, interaction is favoured by pedestrianization in the medina, so the streets and blind alleys lend themselves to encounters between adults and the safe play of children. Social interaction between family members and children is encouraged through courtyards and semi-private domains, such as *derbs*. In particular, the courtyard is traditionally the space for sharing, socialization and household labour. It is the place

PRINCIPLES

11 TO SUPPORT AUTONOMY

- Collective use of infrastructures and services (oven, hammam, fountains, mills,...)
- Local production
- Open spaces of the house (courtyard and ryad) as places for domestic production
- Domestic spaces for processing and storing food (*berchla*)

12 TO PROMOTE LOCAL ACTIVITIES

- Proximity and accessibility of goods and food
- Short chain and local trades
- Presence of spaces for productive activities at urban and architectural scale
- Presence of handicraft products made with local resources

13 TO OPTIMISE CONSTRUCTION EFFORTS

- Appropriate scale of the buildings
- Easy, flexible and functional buildings
- Optimising the use of materials
- Technical simplicity in building processes
- Use of local and low-transformed materials

14 TO EXTEND BUILDING'S LIFETIME

- Flexible buildings for possible changes and extensions
- Regular and collective maintenance of the buildings and the semipublic spaces
- Preventing erosion of building elements
- Strong and durable building structures

15 TO SAVE RESOURCES

- Reduction of land use, transportation and infrastructure costs thanks to the urban compact structure
- Walking as the main mode of transport
- Solar and heat gain and loss reduced thanks to the contiguity between the boundary walls of houses
- Cost of energy for climatising reduced thanks to the passive heating and cooling systems and strategies.

STRATEGIES

General principles and local strategies addressing socio-economic sustainability

urban and territorial scale

building scale

construction systems scale

for the reception of guests and the meeting place for the various members of the family throughout the day and during the most important religious festivities or family events. The climatic conditions of the place allow the residents to use both outside and inside spaces of the houses throughout the year and carry out a lot of their everyday activities in the courtyard. A series of productive activities, as well as domestic functions, such as cooking, looming, weaving and washing, took place in the protected area of the courtyard. The semi-open spaces of the house (i.e. porch and *maq'ad*) play an important functional role in the house: they are an extension of the courtyard and they are suitable for a number of social and intimate activities that may not be carried out in a totally open space. The gallery provides sitting, resting, working, socializing and circulation space that is intermediate between outdoors (i.e. the open space of the courtyard) and indoors (i.e. the main rooms of the house).

Understand socio-economic sustainability

Socio-economic sustainability refers to the capacity to produce, maintain and strengthen a local economy to ensure the social well-being of all members of the community. Within the medina of Chefchaouen, the principles described below have been maintained for centuries through some strategies that have been applied in the traditional socio-productive fabric.

11. To support autonomy

The organization of the medina presents activities and services capable of promoting the autonomy of the community and the capacity of self-sufficiency. Most of the productive activities are spread in the medina, or in its close proximity. The collective services, able to guarantee an answer to everyone's basic needs, are distributed in all the districts of the medina: ovens for baking bread that is kneaded at home, public baths, craft workshops, mills, schools, mosques, etc.

The open spaces of the house (courtyard and *ryad*) encourage autonomy and self-sufficiency through the possibility of including production areas such as self-cultivation gardens, domestic livestock, and spaces for any type of manual activities that need open space. The space located under the Andalusian pitched roof (*berchla*) is used for the storage, preservation and drying of food.

In addition to promoting autonomy, local production also increases the resilience of the community, as it helps it to guarantee food and production autonomy even in the event of an emergency.

12. To promote local activities

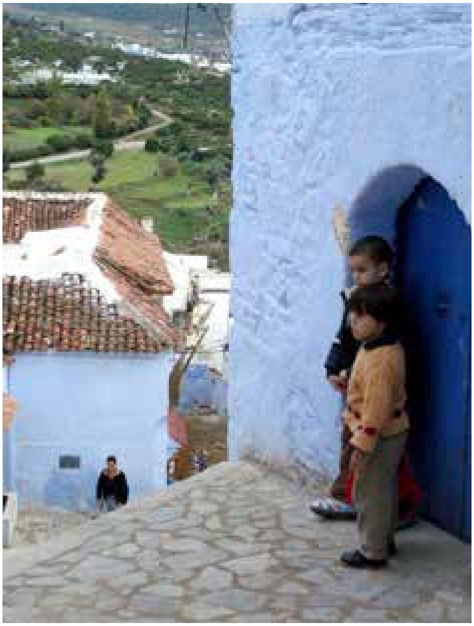
The traditional social and economic system of the medina is based on the principles of proximity and accessibility of goods and food. The compact urban structure reduces the distances for exchanges and relationships, stimulating economic and social dynamics. The distribution of basic activities over short distances helps to reduce carbon emissions which result from the transportation of goods.

Production is mainly based on agriculture and crafts, including construction, and ensures a response to basic tangible requirements. In the tradition, crafts and know-how are handed

Collective use of infrastructures and services: ***foundouk*** **and wash houses**

Short chain and local trades

opposite page
Walking as the main mode of transport



down from father to son, ensuring the preservation of intangible knowledge. The craft sectors in the medinas are grouped into well-defined areas or connected to a neighbourhood, also based on proximity to the resources necessary for carrying out the activity. Thus, for example, the flour mills are located near the river in the Sebbanine district, the carpentry and weaving workshops mainly in the Al Onsar district, the closest to the Ras El Maa source. The souks, the places of commerce, are distributed along the roads that branch off from the gates to the west of the medina, the point of contact between the medina and the roads that connect the city with the surrounding area and urban centres.

13. To optimise construction efforts

The spaces of the houses are modest in their sizes in relation to their use. This is mainly to ensure the principle of modesty and humility, which is a prevalent local cultural value. Spaces have mixed-functions, for example rooms such as living and dining rooms serve different purposes at different times of the day and night. The rooms are simply furnished with simple armless sofas arranged around the perimeter of the room. The inhabitants of the house and guests generally sit on the floor, on rugs or cushions, resuming a habit deriving from nomadic practices.

Collective maintenance of the semipublic spaces

The elevation is human in scale. The openings (doors and windows) are small in comparison to the wall areas. Traditional construction processes require few transformations, are simple to implement and optimize the use of the materials available.

14. To extend the building's lifetime

opposite page **Appropriate scale of the buildings**

Solar and heat gain and loss reduced thanks to the contiguity between the boundary walls of houses and the presence of small windows (© L. Lupi)

One of the features that can guarantee an extension of the building's lifetime is its flexibility. With the exception of the kitchen and the washroom no space in the Arab house has an explicit function assigned to it.

The facades of the buildings in the medina are constantly protected by lime plaster, especially in the most vulnerable parts: at the base and around the openings. lime painting is an operation traditionally carried out by the women of the house every six months. Maintenance practices of private and semi-public spaces are part of the habits of the inhabitants. The spaces of the houses are designed to maintain family ties when offspring get married, so the spatial arrangement could be extended horizontally in semi-independent sub-units, or vertically, in which case each generation occupies a storey.

15. To save resources

The compact structure of the city fosters proximity relationships; in fact most of the spaces necessary to satisfy the needs of the inhabitants can be reached by walking. This contributes substantially to the reduction of transportation and infrastructure costs and promotes walking as the main mode of transportation.

Compact human settlements result in reducing land use and lower unit cost of installation, development and management on the provision of services and infrastructure such as roads, sanitary system, piped water supply, electricity, et… In the compact structure of the medina courtyard houses allow the erection of buildings attached to each other, following a continuous building system. The houses are designed as part of the organic pattern, and they link to each other in clusters that are meant for a big family. The houses share boundary walls, reducing the solar and heat gain and loss. The passive heating or cooling systems strategies of the patio house reduce the cost of energy for space climatising.

The clustered layout provides mutual shading and is able to trap cool night air, unlike the standalone structure, that is subjected to direct sunlight with minimal shading from neighbouring houses.

References

Abdulkareem H. A. 2016, *Thermal comfort through the microclimates of the courtyard. A critical review of the middle-eastern courtyard house as a climatic response*, «Procedia - Social and Behavioral Sciences», 216, pp. 662-674

Aldawoud A. 2008, *Thermal Performance of Courtyard Buildings*.«Energy and Buildings», 40, 5 (2008), pp.906-910.

Almhafdy A., Sabarinah I., Yahya J. 2015, *Thermal Performance Analysis of Courtyards in a Hot Humid Climate Using Computational Fluid Dynamics CFD Method*, «Procedia - Social and Behavioral Sciences», Volume 170, pp. 474-483.

Asquith L. 2006, *Lessons from the vernacular: Integrated approaches and new methods for housing research*, in Asquith L., Vellinga M., *Vernacular Architecture in the Twenty-First Century: Theory, education and practice*, Taylor & Francis, Oxon, p.128-144.

Benslimane N., Biara R.W. 2019, *The urban sustainable structure of the vernacular city and its modern transformation: A case study of the popular architecture in the saharian Region*, «Energy Procedia», 157, pp. 1241-1252.

Alexander C. 1979, *The Timeless Way of Building*, Oxford University Press, New York.

Alexander C., Ishikawa S., Silverstein M. 1977, *A Pattern Language: Towns, Buildings, Construction*, Oxford University Press, New York.

AlSayyad N., Arboleda G. 2011, *The sustainable indigenous vernacular: Interrogating a myth*, in Lee Sang S. (ed.), *Aesthetics of Sustainable Architecture*, 010 Publishers, Rotterdam, pp.134-181.

Caimi A., Moles O., Crété E. 2017, *Local Building cultures for sustainable & resilient habitats. Examples of local good practices and technical solutions*, CRAterre Editions, Grenoble

Correia M., Carlos G., Rocha S. (eds) 2014a, *Vernacular Heritage and Earthen Architecture: Contributions for Sustainable Development*, CRC Press, London.

Correia M., Dipasquale L., Mecca S. (eds.) 2014b, *VerSus: Heritage for the future. Vernacular knowledge fo sustainable architecture*, FUP, Firenze.

Dipasquale L., Mecca I. 2016, *Vernacular architecture as codified model for the contemporary sustainable project*, «TECHNE - Journal of Technology for Architecture and Environment», Nov. 2016, pp. 190-198.

El Harrouni K., Benaicha M., El Harrouni R. 2018, *Parametric Modelling and Traditional Architecture: Improving the thermal comfort of the traditional courtyard house in Morocco*, «MATEC Web of Conferences», 149/ 02051.

ENSAG-CRAterre 2014, *Lessons from Vernacular Heritage to Sustainable Architecture*, Editions CRAterre, Grenoble.

Fathy H. 1986, *Natural Energy and Vernacular Architecture: Principles and Examples with Reference to Hot Arid Climates*, The University of Chicago Press, Chicago.

Foruzanmehr A., Vellinga M. 2011, *Vernacular Architecture: Questions of Comfort and Practicability*, «Building Research and Information», vol. 39 (3),pp. 274–285.

Kazimee B.A. 2009, *Representation of vernacular architecture and lessons for sustainable and culturally responsive environment*, «International Journal of Design & Nature and Ecodynamics Volume 4, pp.337-350.

Olgyay V. 1963, *Design with Climate, Bioclimatic Approach to Architectural Regionalism*, Princeton, New York.

Oliver, P. (ed.) 1997, *Encyclopedia of Vernacular Architecture of the World*, Cambridge University Press, Cambridge.

Ozel B., Dipasquale L., Mecca S. 2013, *Architectural Heritage, Resilience and Urban Renewal: The courtyard house as resilient architectural model*, in *Proceeding of XXVIII Congresso Nazionale INU*, Salerno 24-26 ottobre 2013.

Oliver P. 2006, *Built to Meet Needs: Cultural Issues in Vernacular Architecture*, Elsevier, Oxford MA.

Rasulo M. 2003, *Vernacular architecture related to the climate in the Mediterranean Basin: A lesson we should learn*,«International Journal for Housing Science» vol. 27 (3), pp. 177-188.

Rapoport A. 1969, *House Form and Culture*, Prentice-Hall, Englewood Cliffs, N.J.

Rapoport A. 2006, *Vernacular Design as a model system in Vernacular Architecture*, in *The Vernacular Architecture in the Twenty-First Century: Theory Education and Practice*, Asquith L., Vellinga M., Taylor and Francis, Oxon, pp.179-198.

Ratti C., Raydan D., Steemers K. 2003, *Building form and environmental performance: archetypes, analysis and an arid climate*, «Energy and Buildings», 35(1), pp. 49-59.

Soflaei F., Shokouhian M., Abraveshdar H., Alipour A. 2017, *The impact of courtyard design variants on shading performance in hot- arid climates of Iran*, «Energy and Buildings», 143, pp. 71-83.

Soflaee F., Zhu W. 2011, *Sustainability of vernacular courtyard houses*, in *13th International Conference on Non-Traditional Materials and Construction Technology (NOCMAT13)*, Changsha, China.

Trombetta C. 2002, *L'attualità del pensiero di Hassan Fathy nella cultura tecnologica contemporanea*, Rubbettino, Catanzaro.

Weber W., Yannas S. 2014, *Lessons from Vernacular Architecture*, Earthscan, London.

Zhang D. 2013, *Courtyard Housing and Cultural Sustainability: Theory, Practice, and Product*, Ashgate/Routledge, Oxfordshire, UK.

TRADITIONAL BUILDING CULTURE FACING THE CHALLENGES OF RE-SHAPING OF ITS BUILT FORM AND SOCIETY

A heritage in transformation: a risk that should become an opportunity

The traditional heritage of Chefchaouen provides a good example of how a site may be exploited to benefit from climate and natural resources. It shows the optimisation, over many centuries, of the performance of locally available materials, designed to serve the specific needs of a local culture. The homogeneity of the site and the harmonic development of the settlements have been preserved for centuries, until the last few decades when it has undergone profound changes in the re-shaping of its built form and society. These changes are the result of the evolution of economical, political and social conditions. In the past, the expansion of traditional settlements responded quite well to the slow increase of population, while planning and design relied on traditional skills and knowledge.

A great disorder and a widespread loss of identity affects the medina today, as well as the new city and the new constructions in the suburbs. The historical centre of Chefchaouen in particular underwent a process of substitution, expansion and the addition of storeys to buildings, with a speed that over the past few decades became exponential.

Also the population has increased significantly over the past few decades, as has the flow of tourists. New needs have emerged in terms of safety, hygiene and functionality, which in order to be met require transformations to traditional building. However, the technical and architectural methods used in most cases are incompatible with the existing built heritage and greatly threaten both the identity and safety of the medina, both from the environmental and seismic points of view. The pre-modern city, built according to a system of traditional urban, architectural and building know-how, preserved and passed-on from generation to generation, is now under great economic and real estate pressure, which brings about a series of consequences on the preservation of the identity of the place: misguided renovation and maintenance interventions, the addition of storeys which alter the urban outline, replacement of traditional pitched roofs with terraced roofs, saturation of spaces and gardens, emphasising of the picturesque in the formal features of traditional architecture, and abandon-

FUP Best Practice in Scholarly Publishing (DOI 10.36253/fup_best_practice)

Recent restoration and transformation of historic buildings

ment of buildings in a state of disrepair while waiting for their market valorisation. Furthermore, the process of urban development outside the medina has resulted in an accelerated increase of new architectural and urban forms, to the detriment of traditional planning and design practices. The common belief that the traditional buildings of the medina are no longer suitable for a modern life, and the lack of trust in traditional techniques, has led to the introduction of modern solutions which often do not respond well to the local climate and customs.

Within the medina, the practice of introducing frame structures in reinforced concrete when expanding or adding storeys to a building has become widespread. The use of new building techniques, aimed at satisfying certain "modern" needs and at ensuring a greater stability and lifespan to the new buildings, is actually inadequate and non-compatible with the traditional structures in stones and earth, occasionally bringing about disastrous consequences. Many of the interventions on courtyard houses in the medina contemplate transformation operations, also through the adding of Andalusian decorative motifs, especially on the facades, yet without respecting proportions, structural behaviour and organisation of the spaces of the original building. The original materials and techniques, which constitute the true cultural heritage of the city of Chefchaouen, and the local traditional competencies and knowledge, both practical and operative, are thus deprived of their value and abandoned.

Over the past few decades a process has been going on which involves a progressive loss of value of traditional know-how, without, however, truly increasing the “modern” technological culture. To this must be added the lack of skilled labour: the area suffers an insufficiency of operators professionally trained in the use of traditional techniques and in the crafts linked to them, which are necessary for the proper maintenance and management of the built heritage.

Transformations aimed at the tourism sector have generated a growing process of gentrification: the historical inhabitants are forced to move to the new quarters, relinquishing their homes, which they can no longer afford, that are then converted into guesthouses, hotels, bars or restaurants. Many families, especially the less well-to-do, have had to move to the suburbs after decades of renting in the medina, thus abandoning as well their reference points and social relations (Bouchmal, F., 2015). The rush to the new suburban districts, caused by the increase in prices related to the process of gentrification, was also fueled by the illusion of obtaining in the new buildings outside the old city the comfort and fulfillment of new needs that their traditional habitat, too long neglected, was unable to provide.

Ongoing public actions and projects for the rehabilitation of the medina

The theme of rehabilitation is of immediate relevance and considered a priority among the strategies for the development of the medina, also in view of the economic importance of

opposite page
Activities aimed af the enhancement of the cultural heritage of Chefchaouen at a territorial and urban level

	Cooperation and network activities at a territorial level	Activities at a urban level
2006	UNESCO recognition as Intercontinental Biosphere reserve, in cooperation with Spain.	
2008	Creation of Association Chaouenrural, leading to a strategic cooperation between tourism and agriculture.	
2009	UNESCO recognition as Intercontinental Biosphere reserve, in cooperation with Spain.	
2010	Start project of the Restaurateurs engages; cooperation between local restaurants and farmers. Elaboration of a Tourism Strategy for the province Chefchaouen.	Label UNESCO for Chefchaouen as Emblematic Community of the Med. Diet. Efforts to make Chefchaouen the first Eco-city of Morocco.
2011	Network of the four Emblematic Communities of the Mediterranean Diet: Chefchaouen-Morocco, Koroni-Greece, Cilento-Italy and Soria-Spain.	Plan to be recognized by UNICEF as Child-Friendly City. Member of the "Réseau Méditerranéen des Médinas" (RMM) Campaigns Laouacher for re-qualifying facades
2012		Member of the "Réseau Marocain des Anciennes Médinas" (REMAM)
2014		Start of participative processes for the assignation of public resources, promoted by municipality

tourism, which in turn is linked to the usage and enjoyment of the tangible and intangible heritage of Chefchaouen. During the past decade, several stakeholders, local, regional and international (public, semi-public, associations, private) initiated a series of activities aimed at the valorisation and re-qualification of the cultural heritage of the medina: re-qualification of public spaces, restoration of public spaces, upgrading of traditional equipment, etc.
At the municipal level, the "*Plan communal de développement (PCD, 2010-2016)*[1]" illustrates a political vision aimed at a strategic development based on prospects of sustainable development and a participative approach involving the local inhabitants. The programme expressed in the PCD involves material, social, environmental, communication and economic aspects. In particular, the plan establishes as central to the project certain aims concerning the sustainable development of the medina: promote a healthy and safe life; valorise the social, cultural and economic fabric, as well as the tangible and intangible heritage; strengthen the local knowledge and know-how of the inhabitants concerning crafts; promote the local knowledge and know-how of the inhabitants regarding the preservation of the tangible and

[1] In addition to the municipal council, also the Art Gold programme of UNDP and "The Andalusian Fund of Municipalities for International Solidarity" (FAMSI) contributed to the drafting of the PCD.

A lime-painted facade in the medina (© L. Lupi)

intangible heritage of the medina; consolidate the capacity of civil society and all aspects of participative management of the medina (Royaume du Maroc et al., 2010). Among the concrete initiatives undertaken in this respect by the municipal administration in collaboration with local associations, it is worth mentioning maintenance work carried out in public spaces and campaigns for painting the facade of houses[2].

In 2010, the town was recognised by UNESCO as one of the emblematic communities for the Mediterranean Diet, as part of the intangible cultural heritage of UNESCO, together with the communities of Soria in Spain, Cilento in Italy, and Koroni in Greece. In 2013, the municipality published the plan of action for the Mediterranean Diet in Chefchaouen, which is organised on four work lines: the preservation and valorisation of the local heritage, the strengthening of the local stakeholders, raising awareness and communication. Numerous initiatives which involved also the tangible heritage, were undertaken thanks to the signing of various agreements with local associations, as well as with regional, national and international organisations. The traditional ovens were re-

[2] The campaigns for re-qualifying facades, known as "Laouacher", are promoted by the municipality, who provides the materials (blue and white lime paint) for painting the exterior of the buildings of the medina and organises work days with the participation of the inhabitants (Giz and Moroccan Ministry of Interior, 2018)

covered, a thematic circuit on Mediterranean Diet was created, a brand of territorial quality, known as “Chefchaouen-Mediterranean Diet”, is in the process of been established, and there is a project for the creation of a museum of the Mediterranean Diet.

Also in 2010, Chefchaouen self-proclaimed itself as an “ecological city”. The municipal plan of action for the period 2017-2023 and the PAED 2017-2020 (Plan d’action en faveur de l’énergie durable de la Commune de Chefchaouen)[3] presented various programmed actions in favour of sustainable energy and the climate. In particular, the PAED 2017-2020 aims to accelerate the transition to renewable energy sources and to promote sustainable mobility. The municipality also belongs to the “EnergyCities” network, the European association of local entities involved in energy transition. Chefchaouen is also member of the network of 17 Moroccan municipalities working toward enhancing systems of energy management (Réseau Marocain de la Maitrise de l’Energie- REMME), supported by the Directorate General for Local Communities (DGCCL)[4].

Participation in networks of municipalities that share the same objectives was incentivised since 2011, when the municipal council initiated a new policy of cooperation through the participation in international networks of historical cities and collaboration agreements with foreign cities, especially from Spain.

In 2011 Chefchaouen joined the *Réseau Méditerranéen des Médinas* (RMM), which includes the new medinas of the Tanger-Tétouan region: Chefchaouen, Tétouan, Tanger, Ksar el-Kebir, Larache, Assilah, Kssar Majaz, Oued Lou, and Ouazzane. The purpose of this network,– which since 2013 is in partnership with the Agence pour la Promotion et le Développement des Provinces du Nord (APDN) – is that of strengthening the links between the nine medinas of the region and other areas of the Mediterranean, in order to promote development and protection. Since 2011 four forums have been organised for sharing actions and strategies for development and protection, and for strengthening the technical and operative capacities of the representatives, both political and technical. The *Réseau Marocain des Anciennes Médinas* (REMAM) was created in 2012 in collaboration with the *Direction Générale des Collectivités locales* (DGCL) of Morocco. Derived from the growing national awareness concerning the need to preserve and valorise the historical heritage, the network constitutes

[3] *Plan d’action en faveur de l’energie durable de la Commune de Chefchaouen*: https://mycovenant.eumayors.eu/docs/seap/21660_1513100315.pdf

[4] Morocco’s attention to topics regarding the fight against climate change during the past few years has manifested and crystallised through the development of institutional, legislative and financial initiatives. Concerning legistlation, Morocco’s commitment to the safeguarding of the environment materialised in the development of a framework law, established in place of the National Charter for the Environment and Sustainable Development. In 2017, the National Strategy for Sustainable Development (NSSD) was presented. It is based on the provisions of the said framework law which confers to it legal force and has allowed it to set the general orientation, coherent with the application of the economic, social and environmental action plans.

Interventions of rehabilitation ot the Ras EL Maa area and El Haouta square

a platform for dialogue and exchange of experiences and good practices regarding the re-qualification of the medinas, and is offered as a reference for national and international organisations interested in the safeguarding of the historical urban fabric.

As for sustainable tourism, of particular interest is the tourism strategy project developed by the local association ATED (*Association Talassemtane pour l'Environnement et le Développement*), in partnership with the Spanish foundation ETEA for cooperation and development and financed by the *Agencia Española de Cooperación Internacional para el Desarrollo* (AECID). ATED has brought together various public and private stakeholders from other local associations, from the municipality and the private sector. This pilot project in Morocco, includes, among other things, the creation of thematic circuits with rural houses in the province, and training for people active in the tourism sector. In addition, several tourism information boards and an information office in Chefchaouen have been established. However, the office is currently closed for financial reasons and to this date the tourism strategy for Chefchaouen has not been implemented.

A participative assessment project was initiated in 2014, aimed at involving the local population in the decision-making process regarding the assignation of public resources. The first actions identified for the medina of Chefchaouen through this process regard the installation of safety systems in the least safe locations in the medina, and the re-qual-

ification of the area surrounding the spring of Ras El Maa. The latter involved the re-definition of terraces and sitting areas, thus contributing to the development of an important place for social interaction and an attraction for both locals and tourists. The safety systems (handrails in timber and wrought iron and balustrades in reinforced concrete), although enhancing safety and accessibility along the river and in the most rugged sections of the medina, add elements that are not very coherent with the architectural heritage and thus do not integrate very well with the context.

Considerations regarding the current development model

The numerous actions undertaken reveal an increasing interest for the valorisation of the medina. Many of these, taken individually, appear as virtuous and worth using as models for the development of other medinas. In general, however, observing the actions undertaken by the various entities (national, international, local) with a critical perspective, it becomes evident that they were insufficiently coordinated and lacking an overall shared vision (Bouchmal, F., 2015). They solved specific problems (often stressing others), yet did not help the medina to undergo an objectively sustainable process.

If we observe the results of the past few decades in the development of the medina, they do not lead to an effective valorisation of the heritage, understood as the protection and safe-

Superelevation of buildin-gs and a transformed facade: the stone cladding hides a rein-forced concrete structure that rests on a tra-ditional stone wall

guarding of identity ascribing features, but rather reveal a greatly transformed historical centre in which it is difficult to perceive the principles that have given it its form and identity throughout the centuries. It is a heritage that is at risk from a technical-constructive point of view, especially in case of an earthquake, since the traditional devices, which originated in order to respond to local environmental and social needs (for example the pitched roof, few windows on the exterior facades, interior gardens and courtyards), have been transformed, or even eliminated so as to respond to new requirements: a wish for modernity, services for tourists, high dwelling density and the consequent need to create new dwellings (which result in ill-advised additions).

These interventions are also due to the progressive loss of traditional building techniques and know-how, which has resulted in recent years in original interpretations and revisitations, which mostly do not take into consideration the environmental, social and cultural reasons that had generated specific building and morphological solutions.

What is most striking is the transformation of the facades. The elements of the Andalusian architecture and the blue colour, two characteristics which have made Chefchaouen famous, have been "smeared" everywhere so as to mark in an exaggerated manner the distinctive features of the medina: the picturesque has taken the place of the authentic and the buildings of the medina have been transformed for pleasing the hypothetical expectations of the tourists, rather than the true needs of the residents.

This is a phenomenon we have witnessed in the historical centres of Western Europe, where habitats have too often been transformed in order to accommodate as many tourists as possible, in detriment of the local residents which have been forced out of the historical centre, thus depriving it of the social fabric necessary to keep the relationships, activities and basic services alive.

The management of transformations linked to tourism is often related to private initiative, whereas adequate regulations and funding would be necessary in order to ensure the existence of a tourism offer that is sustainable in terms of the social, cultural and environmental context of the medina, but also economic, since inadequate transformations could in time bring about negative repercussions precisely to the economy.

The recent Covid19 pandemics that afflicted the planet in 2020 leads us today to thinking that a model of development based on mass tourism is perhaps not the most appropriate. In the future, cities may not count on tourism as an economic resource as they have to this day, but will rather have to seek new forms of self-sufficiency and community solidarity in order to ensure the well-being of all. It is therefore worthwhile today to critically observe the vernacular model of development, so as to understand what are the principles which for years have guaranteed growth at the scale of the inhabitant, from a point of view of self-sufficiency based on an appropriate coexistence with the local resources.

References

Bigio A. G., Licciardi G. 2010, The urban rehabilitation of medinas, The World Bank Experience in the Middle East and North Africa, The World Bank, Washington, <https://openknowledge.worldbank.org/handle/10986/17382> (04/2020).

Bouchmal F. 2015, *La médina de Chefchaouen: aubaine culturelle ou proie de patrimoine en conflits (nord-ouest du Maroc)*, «Akros, Revista de Patrimonio», nº 14, 2015, pp.63-74.

Coslado E., Mcguinness J., Miller C. (eds.) 2013, *Médinas immuables? Gentrification et changement dans les villes historiques marocaines (1996-2010)*, Centre Jacques-Berque, Rabat <http://books.openedition.org/cjb/275> (01/2020).

Direction de l'Urbanisme et de l'Architecture 1997, *Schéma Directeur d'Aménagement Urbain de Chefchaouen: rapport final*, Rabat.

Gallardo E. (ed.) 2017, *La diète Méditerranéeenne a Chefchaoue*n, Famsi, Fonds Andalous de Municipalités pour la solidarité Internationale, Tanger.

Giz and Moroccan Ministry of Interior 2018, *Anciennes Médinas Réseau Marocain des État des lieux des médinas des villes membres*, <http://co-mun.net/cms/uploads/99d2ed98d7a6e-a897ee182fc6a85eec1d8bdaa30/%C3%89tat%20des%20lieux%20des%20m%C3%A9dinas.pdf> (01/2020).

Karkouri M. 2004, *Étude du Plan Local d'Habitat et du Developpement Urbain de la Ville de Chefchaouen*, Royaume du Maroc, Ministère de l'Aménagement du territoire, Tanger.

Ihem, Conseil Recherce Formation 2004, *Etude de faisabilité relative à la réhabilitation du tissu ancien de la médina de Chefchaouen*, Royaume du Maroc, Ministere delegue charge de l'Habitat et de l'Urbanisme, Tetouan.

Ingenieros Consultores (A.E.C.I.) 1997, *Schéma Directeur d'Aménagement Urbain S.D.A.U. Chefchaouen*, Royaume du Maroc, Ministère de l'interieur, Reino de España, Ministerio de Asuntos Exteriores.

Mecca S., Dipasquale L. 2013, *Chefchaouen, un patrimonio in pericolo*, «Contesti», 2012 (1), pp.68-74.

Royaume du Maroc, Ministère de l'intérieur, Province de Chefchaouen, Commune Urbaine Chefchaouen 2010, *Plan Communal de Développement Commune Urbaine Chefchaouen 2010-2016*, Imprimat Rabat, <https://issuu.com/artpublications/docs/pcd_chefchaouen> (11/2019).

Tagemouati N. L. 2010, *Diagnostic de l'économie du patrimoine culturel au Maroc. Sa situation présente et les possibilités d'exploitation et de promotion des ressources qu'il recèle*, Royaume du Maroc, <http://www.unesco.org/new/fileadmin/MULTIMEDIA/FIELD/Rabat/images/CLT/PDF/1939EconomieMaroc_Activites02_03_04p1.pdf> (11/2019).

We may nurture romantic notions about the technological qualities, even the superiority, of vernacular architecture but we shall learn little, and do little useful service to the advancement of building, if we are not also aware ozf its weaknesses, even its failures. (Oliver, 2006, *p.* 119)

A risk management approach applied to the cultural heritage

In this chaotic situation of accelerated transformation and poorly coordinated and less than effective actions for the safeguard of the medina, it is useful to adopt a risk analysis and management approach to make better decisions about the preservation of the cultural heritage of Chefchaouen. This kind of approach allows us to consider all the risks relative to each other in order to establish priorities and plan the resources better (ICCROM, 2016). Multi-hazard risk assessments are used to help disaster managers and heritage professionals design measures to mitigate and reduce the vulnerability of heritage, set priorities and make the economic case for investing in resilient habitats (UNISDR ET AL. 2013). In the *Guide to Risk Management of Cultural Heritage*" the impact of risk applied to cultural heritage is generally expressed in terms of the expected loss of value to the heritage asset. Types of risks to our cultural heritage vary from sudden and catastrophic events (such as major earthquakes, floods, fires, and armed conflict) to gradual and cumulative processes (such as chemical, physical, or biological degradation). The result is loss of value to the heritage asset" (ICCROM, 2016, *p.10*).

Certainly natural disasters because of their unpredictable character and the impact on human life are a top priority in risk management. However, cultural heritage sites are affected by other types of risks that come from human factors, such as urban development pressures, abandonment or mass tourism, that have a long-term or progressive impact, rather than a sudden impact, as is the case with natural disasters.

Due to the enormous impact of natural disasters, the majority of studies related to risk management in cultural heritage focus on natural hazards (ICCROM, 2016; ICCROM et al., 2010; Jokilehto, 2000; Stovel, 1998; UNESCO et al., 2015; UNESCO, 2007). However, within the cultural heritage context human factors should be taken into account since they undoubtedly have a great influence. An increase in attention regarding human risk factors can be observed over the last decades: "The current threats to our historic heritage are in-

FUP Best Practice in Scholarly Publishing (DOI 10.36253/fup_best_practice)

comparable to those of earlier times now that we live in a world that has been undergoing faster and faster change since the last decades of the Twentieth century" (ICOMOS, 2000).

The actual criteria for the inclusion of a world heritage asset on UNESCO´s List in Danger highlights main natural and human factors that might affect a site. Besides natural disasters and armed conflict initially topping the list, development and tourism pressures are included[1].

Cultural heritage sites should be considered as a system, where the material component is deeply linked to social and cultural elements. This deeply connection is clearly explained by Woodside (2006, p.8): "Although they are no doubt physical, in terms of being assemblages of built and organic materials, their significance is founded in social and cultural meanings and values. Furthermore, they are dependent on some form of social system for their management, maintenance and continuing sustainability".

The loss of value of tangible/material heritage also affects the intangible/immaterial sphere (traditional knowledge, practices, skills and crafts…), as pointed out by Michael Petzet, former ICOMOS president: "the loss of handicraft traditions – a loss which must be fought in the interest of sustainable development – monuments are endangered during rehabilitation work by the use of inappropriate methods and technologies when properly trained professionals and other preservation specialists are not available at all or in sufficient numbers and preservation know-how is missing" (ICOMOS, 2000).

To summarise, cultural heritage and its values are constantly jeopardized by a multiplicity of aspects (Matiz López, 2016). On the one hand, cultural heritage is threatened by natural disasters: earthquakes, fires, and effects of climate change such as floods, landslides, winds, or the rise of temperatures. On the other hand, social hazards (the after-

[1]Today, according to UNESCO´s Operational Guidelines (UNESCO, 2019, p. 51), a World Heritage site might be in danger if the asset faces:
a) Ascertained danger: the asset is faced with a specific and proven imminent danger, such as:
i) serious deterioration of materials;
ii) serious deterioration of structure and/or ornamental features;
iii) serious deterioration of architectural or town-planning coherence;
iv) serious deterioration of urban or rural space, or the natural environment;
v) significant loss of historical authenticity;
vi) important loss of cultural significance.
b) Potential danger: the property is faced with threats which could have deleterious effects on its inherent characteristics. Such threats are, for example:
i) modification of juridical status of the asset diminishing the degree of its protection;
ii) lack of conservation policy;
iii) threatening effects of regional planning projects;
iv) threatening effects of town planning;
v) outbreak or threat of armed conflict;
vi) threatening impacts of climatic, geological or other environmental factors.

math of war, abandonment, loss of social reputation, demographic pressure, urban pressure and industrialisation, mass tourism) and anthropic hazards (carelessness and negligence, lack of protection and maintenance, pollution, etc.) also affect the conservation of cultural heritage.

For all fields of application (project management, insurance, security, public health, safety, etc.), risk management is a process that helps "decision-making by taking into account uncertainty and the possibility of future events or circumstances and their effects on agreed objectives" (ISO, 2007, p.v). The World Bank defines risk management as "the process of identifying, analyzing and quantifying the probability of losses in order to undertake preventive or corrective actions" (World Bank, 2014, p. 4).

In the PMBOK guide (Project Management Institute, 2017), Risk Management includes the processes of conducting risk management planning, identification, analysis, response planning, response implementation, and monitoring risk on a project. The objectives of project risk management are to increase the probability and/or impact of positive risks and to decrease the probability and/or impact of negative risks.

The phase of risk identification aims to understanding the threat posed by hazards. It is the first step in the evaluation and delineation of priorities. This step seeks to recognize each hazard, known as a risk source or risk factor. In addition to identification, this phase also aims to describe the context and the potential impacts of each hazard, as well as possible causes and scenarios. The assessment phase, qualitative or quantitative, is aimed at creating a priority scale between risks, for the identification of key problems, needs and priorities.

Risk evaluation can be global or specific, and it allows to identify what interventions to plan in order to reduce the most harmful impacts on the heritage. Numerous assessing methods exist, according to the context and the type of risk, even if in almost cases the evaluation depends by the magnitude of potential impacts and the likelihood of a hazard´s effects. Risk evaluation process assigns a value to each risk factor. Having a scale from most threatened factor will allow the prioritization of actions for the risk treatment process.

The in-depth analysis carried out on Chefchaouen has allowed to determine a clear picture of the cultural heritage of the medina. The definition of the context is the preliminary step for risk analysis, which permits passing to the level of identification of the main vulnerabilities and risk factors of the heritage.

Therefore the main risk factors for the cultural heritage of the medina of Chefchaouen can be classified into the following categories.

The medina and its relationship with the surrounding environment

Environmental risks factors

Environmental factors regard natural disasters, including climate change effects or natural resources in distress. The province of Chefchaouen is located in an area of instability and risk linked to hydrogeological and seismic hazards.

Hydrogeological risks

The superficial formations of the territory of the province is subject to active erosion. When looking at the eastern side of the medina, upstream from Ras el Maa spring, there are evident signs of hydric erosion, especially along the riverbeds that drain superficial flows.

Seismic risks

The province of Chefchaouen is in an area of seismic instability, since it is located in the area where the African and Euroasiatic plates clash. The convergence between the African and Eurasian plates causes the recurrence of seismic episodes in the area. Morocco has undergone more than 3,500 seismic episodes between 1993 and 2005, caused by the clash of these tectonic plates. The last large earthquake (MW 6.3), which happened in 2004, caused 600 victims and destroyed 12,000 houses in the region of Al Hoceima (Cherif, 2017; Rovero & Fratini, 2013).

Climate change

Further risks related to climate change must be considered. For example, the recent transformation of the pitched roofs into terraces can represent a vulnerability, especially in view of a possible increase in temperature (as a result of greater heat caused by a flat roof). Furthermore, the transformation interventions on the medina do not include any special attention regarding the disposal of rainwater, or its collection in cases of drought.

Recommendations to reduce environmental risks

Interventions on the buildings of the medina should involve the structural restoration with greater seismic safety, as determined by the *Règlement De Construction Parasismique*, the reference regulation in Morocco, in force since 2002 (RPS, 2002), which was established as a consequence of the damages that resulted from the seismic events of the past few decades, the last of which occurred in 2004 in the area of Al Hoceima. This regulation, however, refers to interventions in reinforced concrete and steel, and totally neglects the relationship between traditional building techniques and new interventions.

The stance of the regulation is that of referring exclusively to interventions carried out with modern materials and techniques, thus overlooking the original building; the underlying idea is that the only possible solution is that of superimposing on the existing built asset, adopting methodologies of intervention that often reveal to be inadequate.

In order to reduce the hydrogeological risk, the system for channeling superficial waters that already exists in the area of Ras El Maa river could be extended, and specific interventions should be planned for channeling both superficial and underground waters and for reforesting the slopes to the east of the medina.

Regarding climate change, the current public interventions, aimed at reducing energy waste and fostering the use of alternative energy sources, are steps in the right direction. However, it is necessary to act so as to enhance the passive behaviour of traditional buildings (isolation, thermal inertia, natural ventilation, reduction of energy dispersion), also enhancing the mechanisms which are already present in traditional architecture and promoting the use of local materials, thus contributing to the preservation and fair management of the available resources.

Cultural and socio-economic risks factors

This category includes all the risk factors derived from the socio-economic, cultural and political contexts of the settlement. In general, over the past few years it has been observed how, from a political point of view, many actions undertaken for the preservation of the medina attempted to involve the inhabitants. The result was not always positive due to the lack of coordination between the actions and to a disregard for the building methods of the traditional habitat.

Lack of awareness

Lack of awareness could be one of the most important risk factors, and in fact it produces a loss of identity and the detachment of communities from their own heritage (Matiz López, 2016). The aspiration of many families to have a "modern house" outside the medina, also with the aim of bettering their social status, has led to a lack of maintenance and neglect of the traditional architecture of the medina. Recognition of the values of a site by a community guarantees its preservation.

Lack of participation of local community

Socio-economic risks include the lack of participation of local communities and governance. In recent years, many steps forward have been made for sharing governance, involving stakeholders and local communities in the preservation of the medina. The actions carried out so far should be encouraged by local administrations and through the support of associations, in order to promote actions aimed at involving the inhabitants in the decision-making processes for the rehabilitation and conservation of the medina.

Lack of conservation policies and regulations.

The lack of adequate policies is another factor that puts the value of the heritage of the medina at risk. It includes a lack of guidelines, procedures and programmes intended to protect the architectural heritage, or inadequate actions for conservation, maintenance or restoration. In the case of Chefchaouen, there are no clear procedures for interventions on historical buildings, regulations concerning the criteria to be applied during the interventions and/or restrictions concerning the buildings of the medina.

Loss of constructive know-how

The lack of technical competencies concerning interventions on traditional architecture, also as a result of the loss of building know-how transmitted orally in the past by the *maalem*. These figures are disappearing, and being replaced by enterprises which often build following reasons of greater economic profit. It is currently difficult to find expert professionals and labour with the necessary knowledge for adequately intervening on the built heritage of the medina.

Mass tourism

The increase in mass tourism is another factor that puts the traditional heritage at risk. Cultural heritage tourism can bring positive socio-economic effects, it can provide communities with the possibility to develop activities related to heritage in a sustainable way. It can also be an excellent way to raise awareness and develop financial resources. However, tourism becomes a hazard when a large number of people visit a place in a short period of time and exceed the capabilities of the site in terms of space, management, administration, human resources and commodities (Matiz Lopez P., 2016). The medina of Chefchaouen continues to loose its inhabitants, whose ancient homes are transformed into hotels and restaurants for tourists, in detriment of traditional crafts and the maintenance of an active social fabric. If the growing tourism flows are not anticipated and managed, they may put the environment, public assets and the community life of tourism destinations at risk. In addition the tourism-related services and the infrastructures are often overlooked: for instance, the management of energy, water, waste and their infrastructures must be upgraded to meet the demand of both tourists and residents.

Recommendations to reduce cultural and socio-economic risks

The first step for safeguarding the heritage and for opposing the trend of lack of awareness is knowledge, since what is not known is not appreciated. For this reason, it is fundamental to have a systematic knowledge of the material and intangible heritage. Systematic knowledge means making the local know-how explicit, more easily accessible and shared. To put in writing the set of objectively defined building rules, even unwritten ones, which are entrusted to the knowledge of building craftsmen, to be used for controlling the coherence of the individual constructions. The work undertaken in this book operates in this direction, and is the base for establishing a code of practices for maintenance and preservation, which regulates interventions on the historic built heritage. The guidelines for the preservation and maintenance should pay close attention both to the upgrading of installations, functions and forms, making explicit good practices for innovation concerning the local features of architectural typologies, and to interventions aimed at bettering and restoring built systems, determining the materials and techniques which are compatible with the original structure.

Actions aimed at the dissemination of knowledge among the public at large and among specialists are also to be encouraged, so as to oppose the lack of awareness. In addition to the publication of books and technical manuals, also seminars, forums, and the dissemination of knowledge on the web and social networks are to be promoted, as well as educational and training actions for young people and children. It is fundamental to attract the interest of the inhabitants so as to generate the awareness of being the safe-keepers of a heritage to be preserved and passed on.

The active involvement of the inhabitants is to be encouraged, also by favouring and promoting the activities of local associations working on the heritage. The association Rif Al Andalus, for example, has been promoting for years the safeguarding of the traditional architecture, involving the inhabitants in educational and cultural activities (exhibitions, conferences, field trips, etc.), and promoting the rehabilitation of architectural structures with historical and artistic value.

The creation of associations and/or networks capable of coordinating the various parts involved in the management and preservation of the heritage could orient in a more efficient manner the safeguarding, valorisation and recovery actions. The monitoring of the state of preservation of the historical fabric and of the interventions carried out on the heritage are useful for determining intervention priorities and assessing the efficiency of the actions undertaken.

In order to counteract the gradual loss of building know-how, it is advisable to promote the training of technicians and craftsmen capable of providing the adequate specialised labour and competencies. The preservation of the intangible heritage linked to traditional building systems is possible through the intergenerational transmission of knowledge, and therefore through encouraging learning, training and apprenticeship agreements, and the creation of artisan networks. Incentives for the development of small enterprises operating in the sectors involved in restoration and in the valorisation of traditional building techniques, would also be useful.

opposite page **Deterioration mechanisms of the wall:** erosion, detachment and loss of plaster coating, efflorescence

In order to limit the negative effects of mass tourism, it is necessary to further promote cultural tourism, also outside the medina (an action which has already been initiated), limit gentrification, valorise the local crafts (traditional carpentry, ironmongery, wool upholstery), incentivise maintenance interventions, as well as those aimed at the upgrading of the buildings to modern needs.

Material - technical risks factors

Based upon an in-depth analysis of the problems found in the building systems of the medina of Chefchaouen, four different levels of technical criticality can be identified in the buildings, different in terms of their nature and of their consequences on the overall structure.

Deterioration mechanisms

These concern all the problems involving decay related to the action of time and of atmospheric agents and to the lack of regular maintenance. Cases of the following are quite widespread in the medina: erosion, detachment and loss of plaster coating from external walls, biological colonisation, efflorescence and deposits of exogenic material, superficial cracks, deterioration or partial collapse of floors and roofs.
The impact of this type of hazard is not great if the intervention aimed at stopping the deterioration mechanisms is carried out in a manner that is compatible with the building, and before the damages bring about the serious weakening of the entire structure.

Building elements features

This factor springs from the intrinsic characteristics of a structure or building, or of the site where it was constructed. It concerns all problems related to defects in the implementation of the building elements, and therefore to issues that are intrinsic to the elements from the very outset. In particular, when considering the building systems observed and described in the previous chapters, we can classify the problems linked to construction features into the following three categories:

- *masonry defects:* small-sized elements, lack of transverse or crosswise elements, mortar that is not coherent or resistant enough. These types of defects interfere on the degree of monolithicity of the wall and on the resistance to specific and horizontal stress.



Problems linked to construction feature lack of connecttion between adjacent buildings; cracks caused by the concentrated load of the horizontal beams of a Berber roof; lack of connecting devices between the timber elements of a floor

- *floor defects*: lack of linking devices between the components of the structure, and with the vertical masonry; lack of load distribution devices on the vertical masonry, and small dimensions of load-bearing elements. For example, in those cases where the beams of a floor are not inserted deep enough into the wall, they are vulnerable to slippage if subjected to a horizontal thrust; the poor connection between its elements reduces the efficiency of the overall performance.
- *roof defects*: lack of connecting devices between the elements of the structure, insufficient connection to the masonry; lack of load distribution devices on the vertical masonry; insufficient dimension of the load-bearing elements. It is important to highlight in particular the critical issues regarding the Berber roofs, already pointed out in the description of the building system: the pressure of the truss is too strong on the wall, which causes passing lesions or extended fissures on the masonry at the point where the beams are placed.
- *defects of the box-like wall structure*: insufficient connection between the walls, between floor or roof and wall, and between buildings. In particular, many buildings lack anchoring to the adjacent ones. The typological study of the medina in fact highlighted the evolution of the urban fabric through the clogging of free spaces. Constructions built successively are placed adjacent to the previous ones, in many cases without any anchoring to the original structure.

opposite page **Examples of demolition of traditional building systems, replacement and use of incompatible techniques and materials**

Inadequate replacement and use of incompatible techniques and materials

The common practice today when intervening on a historical building in the medina is to replace the traditional materials with industrial imitations, instead of repairing. The re-

covery of the original elements of the structure through specific restoration interventions, or their replacement with an analogous structure, seem to be solutions which are more expensive and more difficult to carry out.

From a structural point of view the new interventions, since they generally do not relate to the existing structure, produce dangerous incongruities between parts and/or buildings with rigidity and resistance levels that are very different. If two adjacent buildings are of a different height and were constructed with different materials, they are more subjected to reciprocal hammering in the event of an earthquake. The safety of the walls, which have a limited resistance capacity, is put at risk. For example, if a wooden floor is deteriorated and no longer capable of fulfilling its load-bearing function, the usual practice is to replace it entirely with a brick and cement structure, in which some hollow bricks are placed among the steel beams. This is a precarious and dangerous solution from the static point of view, which modifies the structural behaviour of the building. The use of bricks placed horizontally and side-by-side is also replicated in the construction of architraves, which as a consequence are no longer capable of providing the necessary support.

Traditional materials and techniques, as well as the labour capable of carrying out the work, have almost entirely disappeared due to the dramatic decrease of demand over the past few decades. Construction workers lack adequate knowledge concerning modern building techniques; the reference models appear to be western yet there seems to be no adequate training regarding the said techniques, which are often used incorrectly.

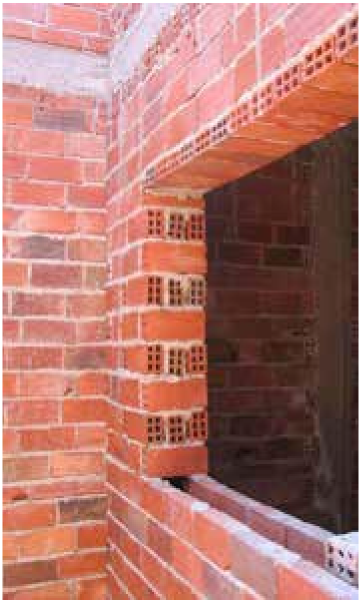
This type of intervention has a negative impact also on the cultural level, since the loss of building techniques translates into the loss of cultural diversity and of the shared material and intangible heritage.

Examples of improper structural and typological transformations

Improper structural and typological transformations

The lack of a widespread technical culture means that transformation interventions in the medina, especially in the case of the re-usage of courtyard houses and their re-adaptation for tourist purposes, has caused deep alterations to the typological and building features of the buildings, occasionally bringing about a radical distortion of the original structures. The structural and typological incompatibility between the original buildings and subsequent alterations represents the greatest risk for the medina, both in terms of seismic safety and of the image of the city and of the preservation of the heritage. During the past few years, in fact, reconstruction operations have been increasingly aggressive, to the point of bringing about the loss of some original features, including cultural, historical and architectural values.

The most common practice for increasing the capacity of an house is that of building one or more additional storeys above the original volume. These interventions, in addition to being dangerous for the safety of the inhabitants, are also devastating in terms of architectural identity. The urban outline has in fact changed noticeably over the past few decades, due to the transformation of pitched-roofs into terraces, and to the increase in height of many buildings. From a structural point of view the risk of adding stories lies first of all in the excessive increase in the volumes and loads on the masonry structures,



which were conceived for buildings with different shapes and sizes. Additional storeys have a negative impact on the structural safety of the building, which thus has new vulnerabilities in case of an earthquake: the presence of high density masses on the upper storeys, the lack of efficient connections between the old and new structures (the separation is often underlined by decorative brick frames), and the juxtaposition of pillars in reinforced cement on stone and earthen walls which are totally inadequate for receiving strong and concentrated stress.

Recommendations to reduce physical - technical risks

In general, the interventions aimed at solving technical problems involving a building or part of it, must be compatible with the existing heritage and with the local resources. There are, in this respect, several categories of compatibility.

Technological compatibility: it is necessary that the intervention be coherent with the technological context in which it is inserted. In fact the juxtaposition of different building techniques generates reciprocal relationship problems, both structural and energy-efficient (e.g. the creation of thermal bridges can occur).

Functional compatibility: it is necessary to adopt technical solutions capable of both satisfying and bettering the functional requirements of the element in question. An intervention is considered as bettering when it contributes added capacities to the levels of safety, hygiene

Synthesis of the risk factors for the built heritage of the medina

and liveability. Invasive techniques which are not very reversible should be avoided since they do not ensure good levels of functionality throughout time, yet responding in concrete and effective terms to the needs related to a good structural behaviour.

Dimensional compatibility: interventions which are wholly incoherent with the form and size of the buildings, and which, in addition to the visual degradation, present an effective risk to the stability of the building;

Typological compatibility: the intervention must relate to the building itself, as well as to the local building traditions, the can-do spirit, the social context, and confront itself with typologically similar buildings and with the context of reference.

In the case of deterioration mechanisms it is possible to repair the damage by applying maintenance interventions aimed at rehailitate and repairing the damaged structures and to enhance their material and mechanical properties.

As for the walls, the type of intervention must be assessed based upon the typology and quality of the masonry. Interventions must use materials with physical, chemical and mechanical characteristics that are compatible with the materials of the structure in question. The insertion of materials that are different to those of the masonry, and particularly the use of reinforced concrete elements, must be used with caution, and only where the correlation between the efficiency obtained and the resulting impact is lesser than with other types of intervention.

In the case of erosion, for example, including the detachment and loss of plaster coating, it is possible to superficially repair the wall by washing the spaces between the stones with a high pressure water jet and then carefully sealing them with lime mortar and earth, and then whitewashing the wall with lime plaster.

In the case of crumbling of the mortar between the joints, a good practice would be to fill the cavities in the wall with injections of lime mortar inserted at low pressure, after having accurately cleaned the wall with the use of a steel spatula, a chisel and water jets.

In the case of defects in the construction features, more specific interventions are required, which must be regulated by practice codes. For example, in order to better the degree of monolithicity and resistance of the walls it is possible to introduce joining elements between the two facades (bond courses). In order to repair any existing deep fissures, it may be advisable to replace the masonry using the *cuci-scuci*, or patching technique in an area approximately 40-50 cm around the lesion.

The consolidation of floors and roofs is fundamental because it is related to the static behaviour of the whole building: the horizontal timber structure, in fact, fulfills a support function for the transversely stressed wall. The interventions must be aimed at ensuring a good overall behaviour of the building, through a good toothing between the walls and efficient connections of the horizontal structures to the rest of the construction.

In case of the lack of a connection between the structural elements of a floor, anchoring elements (for example metal plates) can be used in order to ensure a box action and to avoid the slippage of timber elements. Moreover, chaining applied to the floors and roofs, serves to link the walls to the transverse elements, so as to oppose collapsing in the event of an earthquake. Ring beams on the top of the walls can help enhance the structural behaviour, since they reduce the stress on the roof beams, distribute vertical loads, connects orthogonal masonry, and favours box action.

In the case of improper transformation and restorations, excluding the demolition of all incompatible added storeys and interventions carried out during the past few years, the need arises to act on two levels:

- a first level consists in promoting interventions aimed at reducing the degree of danger of the built additions, devising where possible actions that are efficient in compatible for each specific case. This implies acting to respond to damages that have already occurred.
- a second level of intervention acts rather on the socio-economic level and is aimed at halting the current trend, in other words to ensure that the same errors are not repeated. It is fundamentally a question of activating a process of architecutral heritage valorisation and of educating to its recovery and to the use of appropriate technologies. It is necessary to demonstrate the advantages of such an approach, looking at its long-term convenience and efficiency. This should concern not only builders or other “technicians” of architecture, but the entire population, since it is the safe-keeper of a heritage that is currently at great risk but must be passed on to future generations. It is necessary to develop new *maalem*, and to share the guidelines for the compatible and sustainable recovery of the historical built heritage.

An integrated strategy to mitigate risks impact based on traditional knowledge

The ICOMOS Climate Change and Heritage Working group (ICOMOS CCHWG, 2019) identifies a path for appropriate management of heritage risk, which in turn is based on the approach identified by the United Nations to reduce loss and damages caused by climate change (Executive Committee of the Warsaw International Mechanism for Loss and Damage, 2019). This approach to risk mitigation, which takes into account the mobilisation of local and indigenous knowledge for risk mitigation, can be adapted to the case of Chefchaouen in the following ways:

1. Identifying and prioritising the various Risks to heritage according to the factor of risks

The identification of the danger of each threat, as already mentioned, is the fundamental operation to establish priorities for interventions and better manage the resources to be employed. The analysis of risk factors must therefore be followed by an assessment on a qualitative or quantitative approach

2. Mobilising Local Knowledge to manage risks to cultural heritage

2.1 Documenting, systematising and making local knowledge about vernacular heritage accessible

The systematisation of knowledge on traditional building, often unknown, is the first step to identify and manage risks, as well as to identify ways of improvement and innovation. It is the purpose of this work. Computer technologies and software based on GIS-BIM systems could provide a basis for collecting, processing and comparing data on vernacular architectural heritage and its preservation.

2.2. Using collaborative community processes to enhance appropriate knowledge

Minimising loss of important know how and information, preserving examples of past technologies, commemorating, representing and interpreting the sites, places and cultural land and seascapes left behind for future generations. Therefore community participation is necessary for obtaining appropriate solutions, which fit user's requirements and may avoid wastes in resources with non asked performances. Participation is a process based on dialogue and empowerment of a community to identify its problems and contribute to decide how to solve them (De Filippi & Balbo, 2005).

2.3 Learning from similar experiences elsewhere in the world

Promoting the study of traditional technologies and materials and enquiring on their potential nowadays application, on compatibility with the requirements of contemporary living,

opposite page **Steps of an integrated strategy to mitigate risks impact based on traditional knowledge**

enhancing and improving their performance and sustainability both in terms of energy consumption, of safety and of maintenance. Digital systems and approaches related to the ICT field, as GIS-BIM approaches could be implemented to provide a basis for collecting, elaborating and confronting data and knowledge on vernacular architectural heritage and its preservation.

2.4 Developing the role of heritage in community based strategies for enhancing coping capacity and developing stakeholder-driver strategies for managing heritage resources

Architecture is intricately related to the social and cultural context of its users (Oliver, 2006). To understand how a building, its building rules and how it works, the inhabitants, decision-makers and larger public should first appreciate its inherent qualities, to manage and transform it correctly, and to benefit from its environmental and economic values

1. Identifying and prioritising the various risks to heritage according to the factor of risks	1.1 Identifying the risk factors
	1.2.Assessment of the risk factors on a qualitative or quantitative approach
2. Mobilising local knowledge to manage risks to cultural heritage	2.1 Documenting, systematising and making local knowledge about vernacular heritage accessible
	2.2. Using collaborative community processes to enhance appropriate knowledge
	2.3 Learning from similar experiences elsewhere in the world
	2.4 Developing the role of heritage in community based strategies for enhancing coping capacity and developing stakeholder-driver strategies for managing heritage resources
3. Building long-term resilience by learning from cultural practices/ vulnerable populations and communities	3.1 Promote training, dissemination and education
	3.2. Direct involvement of the population in the rehabilitation process
	3.3. Encourage transformation and adaptation processes in a manner compatible with the authenticity of the building
4. Addressing immaterial heritage in local strategies for risk management and conservation plans, as well as other related plans	4.1. Integrate the principles of sustainability expressed by vernacular architecture in conservation practices.
	4.2 Developing rehabilitation plans built on cultural precedents while also employing the tools of modern and digital technology

(De FIlippi & Balbo, 2015). The value of heritage originates in the socio-cultural processes and the capacity of the subjects to reinterpret it. Therefore it is necessary to develop awareness-raising methods and participatory techniques and thinking about resources management actions integrating capacity at the local level and among public authorities.

3. Building long-term resilience by learning from cultural practices/vulnerable populations and communities

3.1 Promote training, dissemination and education

The most important thing to preserve this type of assets is to create the sense of ownership throughout society (the heritage belongs to all of us), and the necessity of protecting it for future generations. This is only possible by implementing education and dissemination policies.

This change of approach to the value of vernacular architecture, from considering its conservation and maintenance as a burden to understanding it as an important asset for society, must be carried out together with educational actions and successful practices. All initiatives carried out need to be supported by empirical evidence and by the practical demonstration of their impact on the economic, cultural and social improvement of the surrounding area.

3.2. Direct involvement of the population in the rehabilitation process

To encourage participatory planning processes and facilitate endogenous development pathways that allow people to access knowledge systems on traditional architecture. To promote the empowerment of the community, encouraging the understanding of tangible and intangible heritage through practice, knowing that culture is dynamic and heritage has to be built and reinvented day by day, approaching the buildings and its rehabilitation and restoration processes. What is understood, can be taken care of, protected and preserved with a pride to share it with other people, or with generations to come. Culture, heritage and the use of its activations can contribute greatly to the progress of society and to strengthen its collective identity. Also, it promotes the inclusion of the community, weaves intergenerational bridges, and stimulates the learning of traditional trades that can generate sources of work linked to the conservation of heritage or to venturing into innovation on its foundations. These processes can be activated from university experiences, or association, or public institutions, in close connection with the communities: they should show to new generations the great possibilities that can be opened in ancestral trades, the need to rely on them for the protection of existing heritage, or for the creation of new elements, new relevant architecture and connected with cultural sites and each community's own sensibilities. As the ICOMOS Charter of the Built Vernacular Heritage states: "the appreciation and successful protection of the vernacular heritage depend on the involvement and support of the community, continuing use and maintenance" (ICOMOS, 1999).

A special attention should be paid to the promotion of gender balance: in Chefchaouen women have a key role in actions of protection, maintenance and valorisation. For example, they are responsible for the whitewashing and maintenance of the public space adjacent to the house.

3.3. Encourage transformation and adaptation processes in a manner compatible with the authenticity of the building

Buildings are the subject of constant adaptation based on cycles of uses or changing needs. Buildings and their contexts transform over time, in a continuous dialectical process, the one influencing the other. Any change in social, economic or political relationships, as well as in environmental conditions, will inevitably be accompanied by changes in architecture: sometimes gradual, and almost imperceptible; sometimes instant, and very obvious. The process of production or making of architecture, the materials, design and size of buildings, all play a part in the definition and constitution not just of buildings, but the social and cultural relationships and identities that they are intricately related to (Orbasli & Vellinga, 2020. The changes should be should follow guidelines concerning the the transformation of buildings, maintaining and improving safety, sustainability and energy performance, while still upholding its architectural, historical, and cultural values.

4. Addressing immaterial heritage in local strategies for Risk Management and Conservation plans, as well as other related plans.

4.1. Integrate the principles of sustainability expressed by vernacular architecture in conservation practices

Compliance with the principles of sustainability in rehabilitation and restoration interventions, in addition to bringing benefits in terms of thermo hygrometric, social and economic well-being, can strengthen the cultural-historical and architectural values of the buildings, since all these values are connected to each other.

4.2 Developing rehabilitation plans built on cultural precedents while also employing the tools of modern and digital technology

Even though materials and techniques which once were cheap and self-provided within the community may today be sometimes quite expensive and less efficient compared to industrialised ones, it is necessary to inquire on their possible present use and compatibility with the requirements of modern living, enhancing them where needed and on their environmental sustainability both in terms of energy consumption and of maintenance. It is necessary to innovate the technologies used: technology is conceived as made up of sets of methods and tools, scientific knowledge and technical and organisational skills, which are capable of producing goods and services relevant to satisfying human needs. Applied research should be directed to identify appropriate technology, using local materials and techniques, but also technological hybridisation combining local and low cost materials and advanced technologies. Protecting built heritage requires an attitude to learn from the past, from traditions, and the willingness to develop and carry out systematic research to tie innovation and tradition.

References

De Filippi F., Balbo R. 2015, *Vernacular architecture. identification, preservation and upgrading principles*, *Proceedings of CIPA 2005 XX International Symposium*, 26 September – 01 October, 2005, Torino.

ICCROM 2016, *A Guide to Risk Management of Cultural Heritage*, ICCROM, Canadian Conservation Institute, <https://www.iccrom.org/wp-content/uploads/Guide-to-Risk-Managment_English.pdf> (06/2020).

ICOMOS 2000, *ICOMOS World Report 2000 on Monuments and Sites in Danger*, <http://www.international.icomos.org/risk/world_report/2000/intro_eng.htm> (06/2020).

ICOMOS Working Group 2019, *The Future of Our Past. Engaging Cultural Heritage in Climate Action*, <https://indd.adobe.com/view/a9a551e3-3b23-4127-99fd-a7a80d91a29e> (06/2020).

Jokilehto J. 2000, *ICCROM's Involvement in Risk Preparedness*, «*Journal of the American Institute for Conservation*», 39(1), pp.173-179.

Matiz López P. J. 2016, *Integrated Risk Assessment for Cultural Heritage Sites: a holistic support tool for decision-making*, PhD. thesis in Management and Development of Cultural Heritage, IMT School for Advanced Studies, Lucca.

Mecca S., Biondi B. 2005, *Architectural Heritage and Sustainable Development of Small and Medium Cities in South Mediterranean Regions. Results and strategies of research and cooperation*, ETS, Pisa.

Oliver P. 2006, *Built to Meet Needs: Cultural Issues in Vernacular Architecture*, Elsevier, Oxford MA.

Project Management Institute 2017, *A guide to the project management body of knowledge*, (PMBOK® GUIDE) Sixth Edition, Project Management Institute, Newton Square, PA.

RPS (Royaume du Maroc, Ministère de l'Habitat et de la Politique de la Ville) 2000, *Règlement de Construction Parasismique*, RPS 2000-Version 2011, Décrét n. 2-02-177 du 9 hija 1422 (22/02/2002), RPS, Djibouti, Africa.

Rovero L., Fratini F. 2013, *The Medina of Chefchaouen (Marocco): A survey on morphological and mechanical features of the masonries*, «Construction and Building Materials» 47, pp. 465-479.

Stovel H. 1998, *Risk Preparedness: A Management Manual for World Cultural Heritage*, ICCROM, Rome, <http://www.iccrom.org/pdf/ICCROM_17_RiskPreparedness_en.pdf> (04/2020).

ICCROM, ICOMOS, UNESCO 2010, *Managing Disaster Risks for World Heritage*, <*https://whc.unesco.org/en/documents/115730*> (04/2020)

UNESCO 2007, *Strategy for Reducing Risks from Disasters at World Heritage properties*, Paris, UNESCO World Heritage Centre, <https://whc.unesco.org/archive/2007/whc07-31com-72e.pdf> (06/2020).

UNESCO 2010, *Glossary of basic terminology on disaster risk reduction*, <https://unesdoc.unesco.org> (06/2020).

UNESCO 2010, *World Heritage Convention and Sustainable Development*, UNESCO World Heritage Centre, Paris, <http://whc.unesco.org/archive/2010/whc10-34com-5de.pdf>

UNESCO 2019, *Operational Guidelines for the implementation of World Heritage convention*, Paris, UNESCO World Heritage Centre, <https://whc.unesco.org/en/guidelines/> (06/2020).

UNESCO, ICCROM, & Agency for Cultural Affairs of Japan 2005, *Cultural Heritage Risk Management*, Proceeding of the World Conference on Disaster Reduction, Kobe, Japan.

UNISDR 2009, *Global Assessment Report on Disaster Risk Reduction Risk and poverty in a changing climat*, United Nations, <http://www.undp.org/content/dam/rbap/docs/Research%20&%20Publications/CPR/APRC-CPR-2009-GAR-DRR.pdf> (04/2020).

UNISDR, UNESCO, Marsh United Kingdom, ICOMOS, ICORP & ICCROM 2013, *Heritage and Resilience: Issues and Opportunities for Reducing Disaster Risks*, UNISDR, *<https://www.undrr.org/publication/heritage-and-resilience-issues-and-opportunities-reducing-disaster-risks*> (06/2020).

United Nations 2009, *Risk and poverty in a changing climate*, <http://www.undp.org/content/dam/rbap/docs/Research%20&%20Publications/CPR/APRC-CPR-2009-GAR-DRR.pdf> (06/2020).

Woodside R. 2006, *World heritage and climate change: developing a framework for assessing vulnerability*, M.Sc. Built Environment: Sustainable Heritage, University College London, London.

World Bank 2013, *Building Resilience : Integrating Climate and Disaster Risk into Development*, Washington, DC, <https://openknowledge.worldbank.org/handle/10986/16639> (06/2020)."

ricerche | architettura, pianificazione, paesaggio, design

Published Books

1. Alessandro Brodini, *Lo Iuav ai Tolentini: Carlo Scarpa e gli altri. Storia e documenti*, 2020

FSC
www.fsc.org
MISTO
Carta
da fonti gestite in
maniera responsabile
FSC® C124462

Finito di stampare da
Officine Grafiche Francesco Giannini & Figli s.p.a. | Napoli
per conto di FUP
Università degli Studi di Firenze

The medina of Chefchaouen represents an architectural heritage of great value and its building culture constitutes a repertoire of knowledge to be safeguarded as an expression of cultural diversity in the relationship between society and nature. The volume presents the results of an in-depth research on the knowledge system that constitutes the local building culture of the medina, highlighting the characteristics of the construction systems, the risks to which the traditional heritage is subject, and its contribution to the development of a sustainable habitat. The book addresses the theme of the built heritage of the medina with an interdisciplinary approach, which includes architecture as part of a system that has to be studied along with the natural, social and cultural contexts.

Letizia Dipasquale is an architect, PhD in Technology of Architecture and Design, Senior Researcher at DIDA, Department of Architecture, University of Florence. She participated in many research projects and she has published on the topics of vernacular architecture, earthen architecture and sustainable innovation of local building systems.

ISBN 978-88-5518-177-8 (Print)
ISBN 978-88-5518-178-5 (PDF)
ISBN 978-88-5518-179-2 (XML)
DOI 10.36253/978-88-5518-178-5