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CULTURE DU BÂTI DE QUALITÉ : RECHERCHE, INNOVATION ET ENTREPRISE POUR LA DURABILITÉ

Technology transfer achievements in the CUBÂTI project

edited by
Maria Luisa Germanà, Manfredi Saeli e Andrea D'Amore

cubati.org

CU BÂTI
CULTURE DU BÂTI DE QUALITÉ : RECHERCHE, INNOVATION ET ENTREPRISE POUR LA DURABILITÉ

The Italy-Tunisia Cross-Border Cooperation (CBC) Programme 2014-2020, adopted by the European Commission, aims to contribute to the overall ENI objective of progressing towards "an area of shared prosperity and good neighbourliness between EU Member States and their neighbours". The objective of the programme is therefore to promote fair, equitable and sustainable economic, social and territorial development in order to foster cross-border integration and enhance the territories and resources of the two participating countries.
Project No. C-5-2.1-16
CUBÂTI Culture du bâti de qualité : Recherche, Innovation et Enterprise pour la Durabilité
Programme Priority 2.1 - Promotion and Support of Research and Innovation in Key Sectors
Programme Thematic Objective OT2 - Support for education, research, technological development and innovation
Programme Outcome R2.1.b - Strengthening links between the business community and researchers working on innovation in key sectors

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Le Programme de Coopération Transfrontière (CT) Italie-Tunisie 2014-2020, adopté par la Commission Européenne, vise à contribuer à l'objectif global IEV de progrès vers « une zone de prospérité partagée et de bon voisinage entre les États membres de l'UE et leurs voisins ». Le but du Programme IEV de Coopération Transfrontalière Italie-Tunisie 2014-2020 est donc d'encourager un développement économique, social et territorial juste, équitable et durable, en vue de favoriser l'intégration transfrontalière et de valoriser les territoires et les atouts des deux Pays participants.

Projet N. C-5-2.1-16
CUBÂTI Culture du bâti de qualité : Recherche, Innovation et Enterprise pour la Durabilité
Objectif thématique du programme OT2 - Soutien à l'éducation, la recherche, le développement technologique et l'innovation
Priorité du Programme 2.1 - Promotion et appui à la recherche et à l'innovation dans les secteurs clés
Résultat du Programme R2.1.b - Liens renforcés entre le milieu des affaires et les chercheurs travaillant sur l'innovation dans les secteurs clés

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CULTURE DU BÂTI DE QUALITÉ : RECHERCHE, INNOVATION ET ENTREPRISES POUR LA DURABILITÉ

THE CUBÂTI PROJECT: CULTURE OF CONSTRUCTION AND COMMON

Maria Luisa GERMANÀ (Scientific Coordinator)

Culture du bâti de qualité: Recher- che, Innovation et Entreprise pour la Durabilité is a strategic research and innovation project co-financed by the European Union within the framework of the ENI Cross-border Cooperation Programme Italy-Tunisia 2014-2020. Proposed in 2019 and concluded in 2013, for the first time in this Programme CUBÂTI turned the spotlight on the construction sector: an activity of considerable relevance for the cross-border economy, sustainability and quality of life for all.

The first lever on which CUBÂTI has acted is the concept of 'construction culture', from which the very title given to the Project derives. In 2018, the European Ministers of Culture signed the Davos Declaration, emphasising that building is always a cultural act and that high-quality building culture (baukultur) depends first and foremost on a holistic approach to the processes of production, maintenance and transformation of the built environment. In the light of this concept, CUBÂTI looked jointly at the architectural heritage and contemporary architecture, with the ambition of activating a virtuous circle between different productive activities (construction, agriculture and fish farming, cultural tourism) tending to strengthen the links between Sicilian and Tunisian researchers, professionals and entrepreneurs in the field of sustainable construction and sensitising the institutions towards an indispensable programmatic and strategic renewal, in the direction of the circular economy and holistic vision.

The second lever on which CUBÂTI acted is the added value of cross-border cooperation between Sicily and Tunisia, based on certain material and non-material elements of the common identity that are most closely related to construction activities.

> The eight criteria for a quality building culture (Davos System). From: https://www.bak.admin.ch/bak/it/home/baukultur/qualitaet/davos-qualitaetssystem-baukultur.html.

> Fields of application to which CUBÂTI refers. Graphic elaboration by the author, on image: https://www.flickr.com/photos/marcocrupivisualartist/39367058165 (Creative Commons Licences).

In general, this common identity can be recognised both in the traditional and the contemporary, and it is not difficult to imagine that it will maintain its strength and recognisability in the future as well, against the backdrop of global scenarios. Sicily and Tunisia are located at the barycentre of an area that acts as a fault line between two macro-regions that are now more precariously balanced than ever: Europe and the MENA (Middle East and North Africa) area. A border that is the scene of fierce tensions, with two main critical flows: in the east-west direction, the huge economic interests driven by the Suez and Gibraltar routes, which connect the Indian and Atlantic oceans; in the south-north direction, the continuous waves of migration, driven by causes (climate change and conflicts) that cannot be easily resolved.

The Mediterranean, since the antiquity connective between civilisations, dominates the multifaceted set of criticisms and opportunities that characterises the common identity of Sicily and Tu- nisia. On the shores facing the Strait of Sicily, in the area where the two continents are close, parallel cultures and cultures have developed, nurtured by millennia of fruitful exchanges (flows of raw materials, products, people, knowledge). The e concept of quality building culture that inspired CUBÂTI is linked to the common identity between Sicily and Tunisia insofar as the project activities aimed at exploiting the opportunities offered by the common identity (with reference to local building materials and the architectural heritage), taking into account the orientation towards environmental sustainability, which is an indispensable condition for a high-quality built environment, where people can live well and reduce their ecological footprint.

> The Mediterranean area against the backdrop of the global scenario. Elaboration by the author based on image from: https://pxhere.com/it/photo/1262215?utm_content=shareClip&utm_medium=re- ferral&utm_source=pxhere (Licence Common

> The Mediterranean Sea. Composition from satellite photos (credits NASA). https://pxhere.com/it/photo/1262215?utm_content=shareClip&utm_medium=re-ferral&utm_source=pxhereThe Mediterranean Sea. Composition from satellite photos (credits NASA). https://pxhere.com/it/photo/1262215?utm_content=shareClip&utm_medium=re-ferral&utm_source=pxhere

CULTURE DU BÂTI DE QUALITÉ : RECHERCHE, INNOVATION ET ENTREPRISES POUR LA DURABILITÉ

TECHNOLOGY TRANSFER IN THE CUBÂTI EXPERIENCE

Maria Luisa GERMANÀ

Technology transfer refers to a process whereby knowledge gained in science finds application, but also further development, in the operational reality. In the field of sustainable construction, more than sixty years of research have produced a wealth of knowledge that, however, has only recently and still only partially found application. The obstacles that continue to hinder technology transfer in this field are of a technical, economic and cultural nature, and CUBÂTI, aware of the limitations of the opportunity, has tried to take multiple paths.

The three main groups of project activities listed below are three intertwined and interacting strands, in which all project par- ties collaborated:

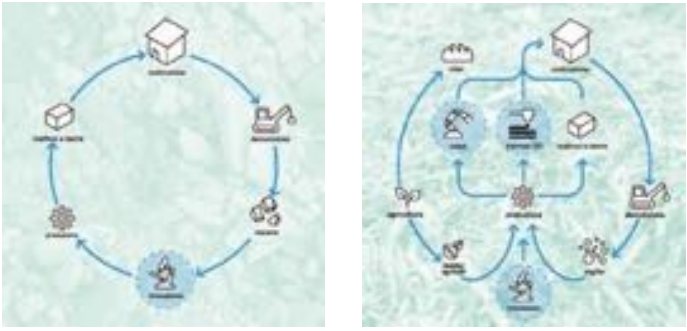
Technology transfer: joint experimentation of building materials linked to the common identity; demonstration of models, techno- libraries and small buildings in Tunisia using materials linked to tradition and the circular economy (agro-food waste).

Capitalisation and Mainstreaming: technical documents to facilitate the transfer of knowledge and technologies on sustainable building materials in Sicily and Tunisia; exchange of best practices at workshops, seminars, fairs and through publications; development of cooperation projects on the culture of quality construction.

Mobility and development of common knowledge: support for cross-border mobility for the development of human capital; creation of a web platform for content sharing; CUBÂTI award for entrepreneurs and professionals.

With the ambition to take into account culture, technology, production models and economic paradigms in a unified way, CUBÂTI has tried to contribute to the sustainable construction on the basis of two strong elements of the common identity between Sicily and Tunisia:

- the availability of local materials in the cross-border area, consistent with contemporary production realities: geo-materials with limited impact (gypsum and clay); bio-based materials (agro-food and fish farming waste); demolition waste (concerning the plague of unfinished buildings).
- a very rich architectural heritage (Sicily and Tunisia have respectively eight and nine sites on the UNESCO World Heritage List), which offers countless opportunities for ante litteram sustainability (in addition to the skilful use of local materials, such as passive heating and cooling solutions, i.e. not using energy systems).



> Left, diagram referring to technology transfer for the recycling of rubble in war crisis contexts. Right, diagram referring to the combination of agricultural residues and local materials for the production of building materials using different processes. From: Antoniol E., Ferrari M., Dalla crisi al futuro sostenibile.Processi di trasferimento tecnologico dall'Europa all'area MENA, in "TECHNE" no. 22/2021, pp. 55-62.

> Two elements of traditional architecture very common in Tunisia and Sicily that have now acquired the meaning of sustainability ante litteram: on the left the mashrabiya (Sidi Bou Said Tunis), on the right the persiana (Palazzina cinese, Palermo).

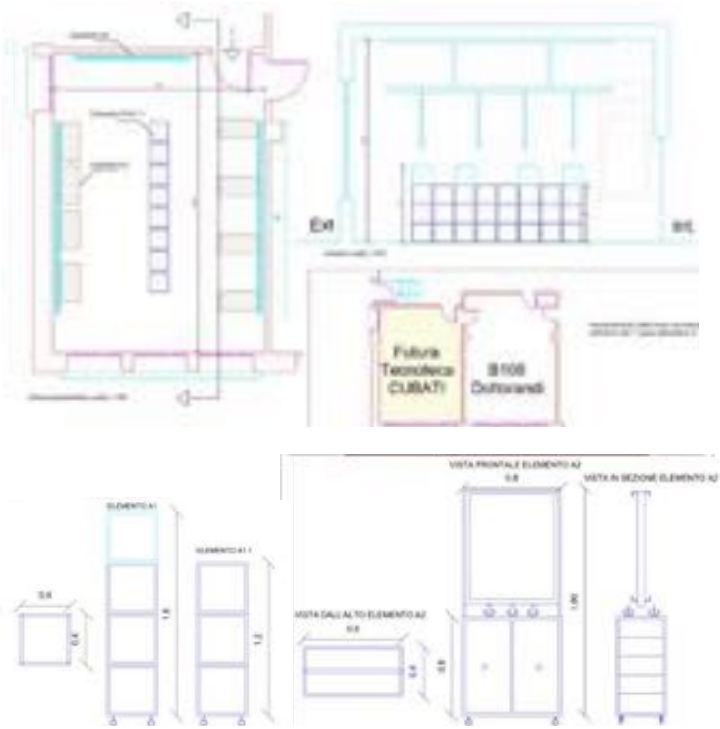
THE CUBÂTI TECHNOLOGY LIBRARY OF THE UNIPA ARCHITECTURE DEPARTMENT

Coordinators: **Maria Luisa GERMANÀ, Andrea D'AMORE, Fabrizio PROVENZA**

The CUBÂTI project made it possible to create a space dedicated to collecting and exhibiting models, materials and sustainable construction techniques related to the common identity between Sicily and Tunisia, representing the Mediterranean region. The Tecnoteca was initially conceived to house samples and demonstration models made during the CUBÂTI project, pre- valently using materials from agro-food waste. Subsequently, it was decided to extend the exhibition to include useful models for environmental design and donations from institutions or companies interested in the topic of building culture.

The Department of Architecture of the University of Palermo has made available a room in Building 8 in Viale delle Scienze, which already houses a valuable exhibition of models from the former Royal School of Applied Sciences for Engineers and Architects, formerly belonging to the Department of Building Design and Construction, to house the technology library.

On the basis of the allocated space, the CUBÂTI technology library was designed taking into account the possibility of easily moving the furniture (all made of chestnut wood) to allow flexible and easily transportable set-ups in other locations, for events and trade fairs related to the topics of quality construction, baukultur and green building..



> CUBÂTI techno-library set-up instructions.

> The furniture was made by the artisan firm Nudolegno Studio in Palermo; prints by Studio Tre Palermo. On the back, render by Fabrizio Provenza.

The CUBÂTI Technological Library represents a tangible and lasting result of the project, which aims to fulfil both a divulgative and educational function. This space, which will be open to students of all ages, intends to offer a place in which to get to know, approach and touch some aspects of the world of bio-building and quality construction focused on the Mediterranean and cross-border Italy-Tunisia dimension.

This result, therefore, intends to offer an instrument through which visitors can be made aware of the themes of quality construction, of an architecture that is aware of its role and of the importance of research processes that are able, over time and with the help of experiments, to open up new horizons in the building sector.

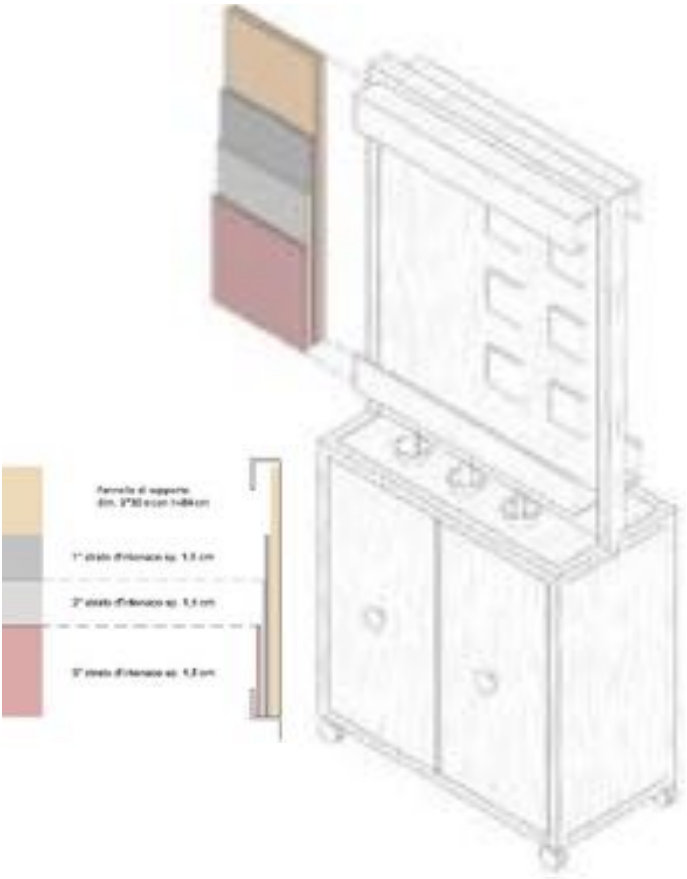
MATERIAL DEMONSTRATION MODELS OF EXPERIMENTS

Federica ZAGARELLA

Within the framework of the technological transfer actions of the CUBÂTI project, some demonstration models of the tested materials were designed and realised by the partner Consorzio Ecodomus. The aim of the realisation was to show the finishing materials experimented during the project, thanks to the fruitful cooperation between the partners Department of Architecture University of Palermo, Euro-Mediterranean Institute of Science and Technology of Palermo and Centre International des Technologies de l'Environnement of Tunis. The exhibition includes both the final formulations, which are considered to be the most promising due to their better technical characteristics and performance, and the numerous intermediate tests, which testify to the complexity of the experimentation process for the development of new materials.

An initial model "Panels and tiles of tested materials" is the result of a shared design (F. Zagarella; M.L. Germanà; F. Pro- venza; A. D'Amore, in coherence with the setting up of the new Tecnote- ca of the Department of Architecture of the University of Palermo) and includes two types of elements:

- laminated wood support panels (35 x 78.8 cm), on which the specialised plasters are laid;
- ceramic tiles (10 x 10 cm) as support for other plaster formulations tested during the project but excluded from the final results.



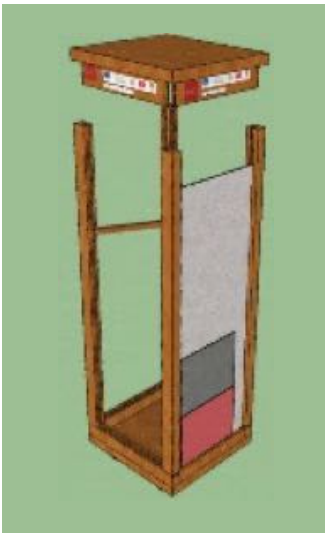
> Above, a moment of material experimentation carried out with a conditional propartners (CITET Laboratory, Tunis; photo by F. Zagarella 2023).Centre, axonometry of the model"Panels and tiles of the materials tested" inserted in the display of the Tech- noteca of the Department of Architecture, University of Palermo with the scheme of the plaster layers (drawings F. Provenza).

> tocol between the project

A second model, the "Totem of tested materials" was designed by the Ecodomus Consortium Partner (T. Avara and F. Zagarella) with the twofold objective of displaying the finishing materials tested in the course of the project and of creating the preconditions for future developments in the event of capitalisation. In fact, the to- tem is designed to support not only current experimentation, but also the results of future research, through the possibility of replacing the panels supplied with new ones.

In order to optimise this opportunity in the cross-border area, four totems were realised, destined for the Technologies of the Department of Architecture of the University of Palermo and the E- NAU (École Nationale d'Architec- ture et d'Urbanisme Tunis) and the Laboratories of IEMEST (Euro-Mediterranean Institute of Science and Technology of Palermo) and CITET(Centre International des Technologies de l'Environnement de Tunis).

The totem pole (40 x 40 x 165 cm) was designed after a careful analysis of similar products (maquettes of commercial stratigraphy) and a series of intermediate steps aimed at increasing its lightness, modifiability and coherence with the installations of the Technoteca of the Department of Architecture of the University of Palermo. It is made of laminated wood laths and elements with dry-laid joints and includes guides to accommodate the plasterboard panels on which the finishing materials are laid.Following a public call for tenders, the company 'PM Strutture in Legno' was commissioned to produce these models, which have both an educational value, as they are intended for university technology libraries, and a popular value, as they can be easily transported to trade fairs and professional and company meetings.



> The "Totem of tested materials" model. Representations of design and realisation (photo F. Zagarella, 2023).

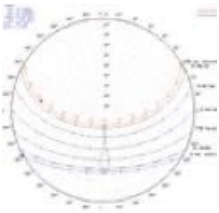
DEMONSTRATION MODELS ON ENVIRONMENTAL DESIGN APPLICATIONS

Maria Luisa GERMANÀ, Fabrizio PROVENZA, Federica ZAGARELLA

Within the framework of the CUBÂTI Project, on the initiative of the Scientific Responsible M. L. Germanà and the joint project of the partners Ecodomus Consorzio and the Department of Architecture of the University of Palermo, two demonstration models of environmental design applications were realised to be placed in the Technology Library of the same Department.

This is an attempt to clarify some basic tools for the application of the bioclimatic approach to architectural design. In spite of sixty years since Victor Olgyay's fundamental contribution 'Design with climate' and the current availability of software that allows for complex representations of environmental data, such as airflows and solar radiation, the realisation of tangible three-dimensional models has been considered a still didactically valid tool. On the other hand, it is known that low-impact materials (because they are local and oriented towards circular processes) are not sufficient to fully achieve a high-quality building culture (baukultur), if the bioclimatic approach, which is indispensable for the sensible reduction of energy requirements for the comfort of indoor and outdoor spaces, is not applied consistently.

The first model realised represents (on a plane of multi-layered birch wood with a diameter of 80 cm) a "polar sun diagram": the projection on the horizontal plane of the apparent solar path referring to the geographical coordinates of building 8 of the Department of Architecture of the University of Palermo (38°10551N; latitude; 13°3485067° longitude). This representation is fundamental for an optimal orientation of the buildings and for the design of passive systems (which do not use energy installations) as it helps to know the position of the sun during the seasons and times of day, understanding the interaction of the built environment with the sun's radiation. The diagram depicts the height of the sun with concentric circles and the azimuth (the distance from the N-S axis) with rays. The model represents the sun's trajectories in the summer and winter solstices and simulates the sun's irradiation with direct light with the help of a lamp. An additional device with an adjustable linear light source helps to simulate diffuse light.



> Above, solar polar diagram referring to the geographical coordinates of Building 8 of the Department of Architecture in Palermo, taken from www.sunearthtools.com and reworked by F. Provenza.Bottom, model of the solar diagram in the design and execution phase (render F. Provenza).

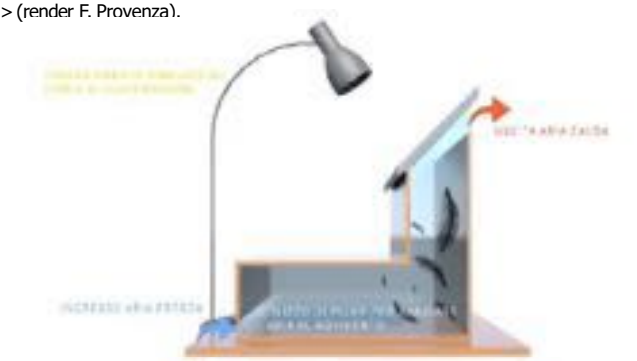
The second model is a 'solar chimney', a device that exploits the chimney effect (air flow triggered by a temperature and therefore pressure difference) mainly for 'passive ventilative cooling' of rooms (while at the same time constituting a form of direct solar gain, useful for passive heating in cold seasons).

Not to be confused with wind towers, traditional Persian elements brought up to date in some contemporary projects (which capture the prevailing cool winds and blow them inside), the Solar Fireplace, on the other hand, extracts warm air, activating an exchange and movement of air inside. The Solar Chimney works even in the absence of wind because it is activated by the temperature difference between the top of the chimney and the communicating room: this is why the model uses black colour for the sloping roof of the Solar Chimney, as the minimum albedo (index of incident solar radiation reflected in all directions) maximises heat absorption.

The model schematises the solar chamber with an L-section volume made of birch plywood (plan 33 x 33 cm and h 30 cm), with the two side faces made of transparent Plexiglas to allow observation of the interior. The sloping cover includes a heating element that allows the temperature to rise, triggering the release of air from inside the mo- ment. Operation is manifested by inserting a small amount of smoke material at the base of the model. A lamp projecting light onto the roof serves as a reminder that the mechanism is activated by solar radiation, without the aid of equipment.

The models of the solar diagram and the solar chimney were produced by the company 'Fablab Palermo APS', which was also entrusted with the executive design following a call for tenders.

> The 'Solar chimney' model. Design and executive representations
> (render F. Provenza).



CULTURE DU BÂTI DE QUALITÉ : RECHERCHE, INNOVATION ET ENTREPRISES POUR LA DURABILITÉ

ADOBE (UNFIRED EARTH BRICKS) IN TUNISIA

Fakher KHARRAT, Houda DRISS

DEFINITION

Adobe is a clay brick shaped by hand or with a mould, then dried for a few days in the open air or on covered areas. Clays, muds and sands are mixed with water to achieve a plastic state, and sometimes with fibres to reduce cracks during drying.

HISTORY

The origin of adobe coincides with the Neolithic revolution and the settling of humans in the Near East. Earthen bricks in the shape of bread, moulded by hand around 8000 BC, have been found in Gerico and Mureybet. The oldest moulded ones, about a thousand years later, were found in Çatal Höyük, Turkey.

BIBLIOGRAPHY

LEZINE, A. (1968), Carthage-Utique : études d'architecture et d'urbanisme

SLIM, H. (1985), La Tunisie. Dans Architectures de terre et de bois, DAF, 2, p. 35-45.

TERRA Award, premier prix mondial des architectures contemporaines en terre crue, lancé en 2015 sous l'égide de la chaire UNESCO « Architectures de terre, cultures constructives et développement durable ».

WAFER, R-Ph. (2010), L'adobe une solution durable pour la construction d'habitations écologiques dans une zone à forte activité sismique comme le Chili, Centre universitaire de formation en environnement, Université de Sherbrooke, Québec.

ADOBE A DISTANT LEGACY IN TUNISIA

The use of adobe is a very old building tradition in Tunisia, dating back to antiquity. Adobe has been found in Roman archaeological remains dating back to the second century BC in the region of El Jem-Thysdrus.

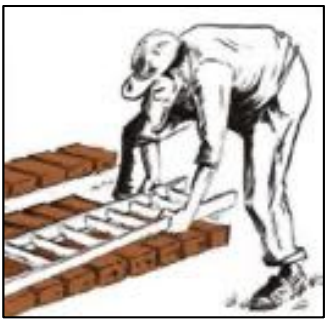
ADOBE MANUFACTURING STEPS

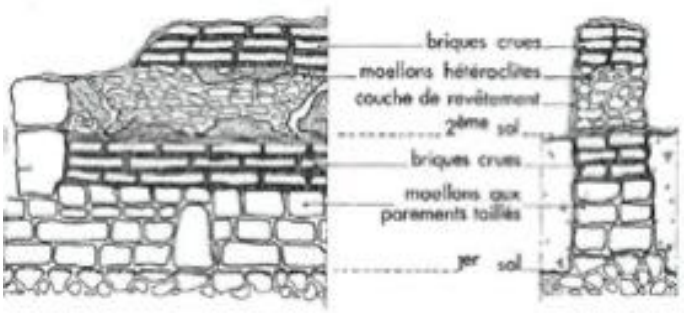
1. Mix the earth until the plastic state is achieved;
2. Put the mixture into a wooden mould with one or more holes;
3. Unmould the bricks and leave them to dry in the open air;
4. After a few days, position the cutting bricks for even drying.

ADVANTAGES OF BUILDING WITH ADOBE

Construction with adobe has several advantages:

- Hygrothermal regulation capability (regulating air humidity);
- Strong thermal inertia and ability to store heat;
- Reducing energy consumption and not producing pollution;
- 100% reusable, easy recycling and high sustainability;
- Inexpensive construction material;
- Excellent environmental balance: little or no processing or transport, no production of greenhouse gases;
- Good thermal and acoustic insulation;
- Simple craftsmanship;
- Ability to absorb odours and improve air quality.





> Section of wall:Stone basement and unbaked brick elevation, El Jem-Tysdrus.

BTC (COMPRESSED EARTH BRICKS)

Fakher KHARRAT, Houda DRISS

TECHNIQUE

Compressed earth blocks (BTC) are manufactured in manual or mechanised presses with moist, powdery earth, consisting of a balanced proportion of clay, mud, sand and small gravel. The addition of cement or lime is common to increase mechanical properties and water resistance.

HISTORY

The compressed earth brick (BTC) is a relatively new material. The first hand-operated press by Colombian engineer Raul Ramirez conquered the international market around 1950 due to its simplicity and ease of use. After several trials, the technique gained momentum in the framework of economic settlement programmes in Africa and Latin America. BTCs also lend themselves to large buildings, as the Indian architect Satprem Maïni has demonstrated with a volume of more than 10 metres.

BIBLIOGRAPHY

BRUNO A., GALLIPOLI D., PERLOT-BASCOULES C., Perlot-Bascoules, MENDES J., SALMON N., Briques de terre crue : procédure de compactage haute pression et influence sur les propriétés mécaniques. Rencontres Universitaires de Génie Civil, May 2015, Bayonne, France. ffhal-01167676f.

HOUBEN, H., RIGASSI V., GARNIER Ph., (1996), Guide Blocs de terre comprimée, Equipements de production, CDI & CRATerre. EAG Carthage-Utique : études d'architecture, Bruxelles.

SOIB, Manuel de pose des briques de terre comprimée. https://soib.com.tn/wp-content/uploads/2019/08/Manuel-de-pose.pdf.

TERRA Award, premier prix mondial des architectures contemporaines en terre crue, lancé en 2015 sous l'égide de la chaire UNESCO « Architectures de terre, cultures constructives et développement durable ».

BTC PRODUCTION STAGES

1. Chop and sieve the earth to obtain a homogenous material;
2. Put the mixture into the press mould;
3. Compress the earth manually;
4. Unmould and carefully remove the block from the press;
5. Stack the blocks in an open-air storage area for 28 days.

BTC, A NEW EARTHEN CONSTRUCTION MATERIAL IN TUNISIA

BTC production in Tunisia started in 2008 with the company SOIB.

ADVANTAGES OF BUILDING WITH BTC

Building with BTC has many advantages:

- The manufacturing process requires little energy;
- Entirely recyclable material;
- Hygrothermal properties allow buildings to 'breathe' by absorbing or releasing moisture;
- Strong thermal inertia and regulation of the internal temperature of buildings;
- Reduced energy bills for air conditioning and heating.







ADOBE (UNFIRED EARTH BRICKS) IN ANCIENT SICILY

Maria Luisa GERMANÀ

For milennia, raw earth building techniques have maintained a character of immediacy: the absence of firing allows the material to be prepared in situ, without operational or logical mediation, as is the case with animals that use clay soil to build their nests.

The basic material is earth, extracted just below the arable layer, mixed with different types of aggregates (bio-based, such as straw, sawdust or other vegetable fibres, or mineral, such as sand or bitumen) to increase the mechanical resistance and reduce shrinkage during drying.

In the case of bricks (adobe), which are used to build walls and vaults, the mixture is placed in moulds and set using moulding techniques after drying; in the case of compacted earth, the mixture takes on consistency as it dries after being laid (inside formwork, as in pisé walls, or inter-layered in grids as in torchis, or laid as a surface finish in cladding or flooring).

Thanks to research financed by the Ministry of Education, University and Research (MIUR) within the framework of Projects of Relevant National Interest and carried out from 2005 to 2007, we can now state that Sicily makes a substantial contribution to tracing the ancient roots of unbaked earth architecture in Italy, offering a privileged field of observation. In fact, in some Sicilian archaeological sites there are numerous artefacts dating from prehistoric to Hellenistic-Roman times that can be traced back to various building types: fortifications and burial grounds as well as residential, religious, productive and commercial buildings. In addition, the examples of archaeological earthen construction in Sicily provide numerous points of interest for the effects of conservation and protection measures that have been carried out in the past

> Above, swallows' nests https://upload.wikimedia.org/wikipedia/commons/d/d0/Nidi_di_rondini_sottotetto.JPG (Licence Creative Commons).
Left, realisation of unfired brick (from https://www.romanoimpero.com/2020/03/il-mattone-crudo.html). Right, unfired earthen plaster finish https://www.guglielminocooperativa.it/intonaci-in-terracruda.

> M. L. Germanà (2011), Earth in ancient Sicilian architecture _ La terra cruda nelle costruzioni della Sicilia antica, in S. Mecca, L. Briccoli Bati, M. C. Forlani, M. L. Germanà (eds.), Earth/Lands. Earthen Architecture in Southern Italy _ Terra/Terre. Architetture in terra dell'Italia del Sud, ETS Pisa, pp. 166-188].

sixty years. The adobe technique (unbaked bricks) is the one most represented in the Sicilian archaeological heritage that has come down to us: it spread around the Mediterranean from the 7th century B.C. onwards, both in sites of Punic and Greek influence.

In Gela, there is precious evidence of adobe constructions (a technique used especially when quarries from which to extract stone materials were far away), which have come down to us in exceptional dimensions, thanks to the sandy nature of the ground that covered them for centuries.

In Mothia, a site of Punic influence, there are traces of adobe walls dating from the 6th to 5th century B.C., in artisanal buildings and in fortifications.

The patrician houses of Heraclea Minoa, a Selinuntian colony on a hill near the coast of Agrigento, date from later times (2nd or 1st century BC). Most of the walls, both perimeter and exterior, are made of unfired earth (adobe and pisé) with some sections still plastered.

In Solunto, a Hellenistic-Roman site on the east coast of the province of Palermo, the earthen remains are limited to a few examples, which in many cases result from modifications of buildings originally built entirely of stone.

> Gela (Caltanissetta). Above left, Archaic emporium at Bosco Littorio (6th c. BC). Bottom left and right, city walls at Capo Soprano 4th century BC. Photo by M. L. Germanà 2015.

> Above Mozia (Trapani), frame wall with adobe parts in craft settlement (6th-5th century BC); photo byM. Schiera 2007.Centre, Heraclea Minoa (Agrigento). Residential building 2nd-1st century BC; photo M.L. Germanà 2014.Below, Solunto (Palermo), Peristyle house, block VII, 2007 (photo by M. Schiera) and 2013 (photo by F. D'Amaro).

ADOBE (UNFIRED EARTH BRICKS) IN MODERN SICILY

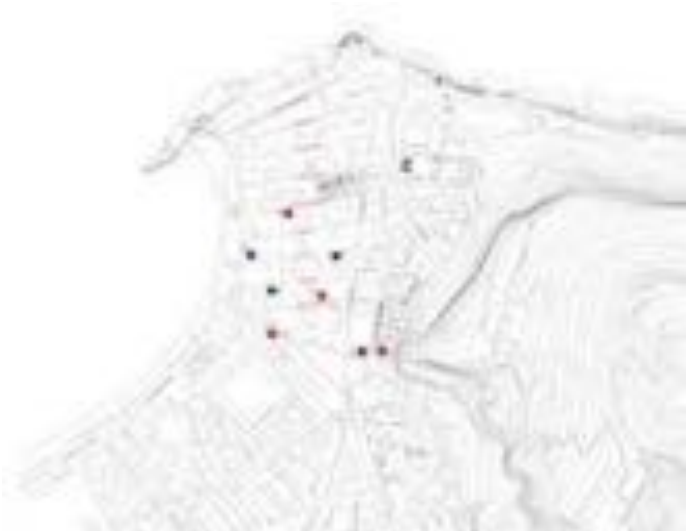
Maria Luisa GERMANÀ

Despite the fact that it is still used in many other places, and although it is increasingly appreciated for its environmental friendliness, in Italy raw earth is a building material that is foreign to the contemporary operating context. Impediments of a technical, regulatory and, above all, cultural nature prevent its spread.

In order to bring this material up to date, it would be useful to be able to trace its use back to the roots of the local building tradition, as is the case where it is present in vernacular and traditional architecture.

In Sicily, the archaeological constructions where unbaked earth has been found are not sufficient to support the hypothesis that this material is current because they are too remote. That is why the fortuitous discoveries of unbaked earth bricks in some buildings in the ancient part of Cefalù (Palermo) are of particular interest, even if they are of a very small scale: a superelevation and completion of walls in buildings in which the prevailing material is stone.

M. L. Germanà (2014), *Early modern period adobe in Sicily: recent finds*, in: C. Mileto, F. Vegas, L. Garcia Soriano, V. Cristini (cur.), *Earthen Architecture: Past, Present and Future* Proceedings of the International Conference on *Vernacular Heritage. Sustainability and earthen Architecture*, CRC Press Taylor & Francis Group, London, UK, pp. 163-168.



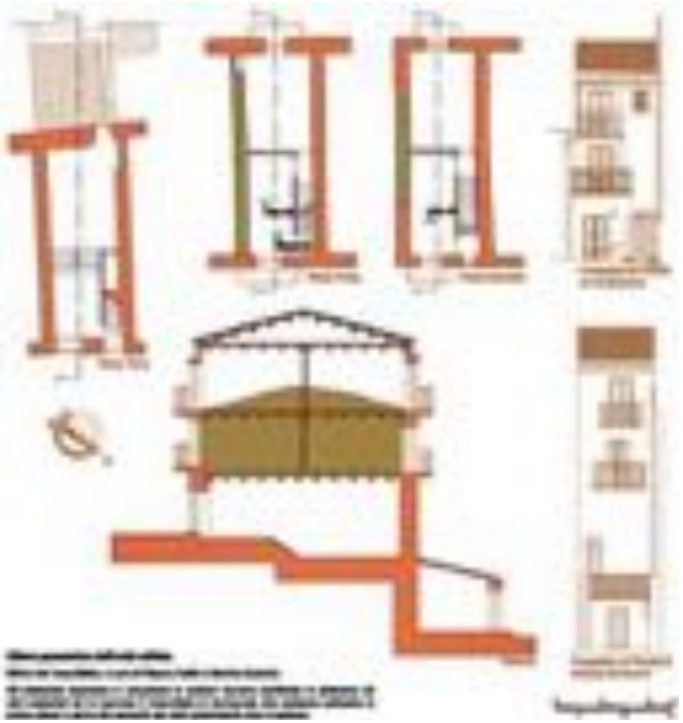
> Map of raw brick finds in Cefalù (Palermo) . From Master's thesis in Architecture "Repurposing raw earth in Cefalù for the improvement of the use of the UNESCO "Arab-Norman" site" by Federica Culotta (2019).

> Below left and right: construction site in Via Vanni in Cefalù (Palermo), photo by F. Vaccaro 2013.Unfired bricks used to close a room in an existing residential building: the same low-cost solution after about eighteen centuries.

In 2010, during renovation work on a building in Via S. Spinuzza in Cefalù, architects Mauro Caliò and Monica Guercio found a mud brick wall. Two years later, while studying for his degree thesis, Fabio Vaccaro analysed the find in more detail and analysed a sample of unbaked brick from the wall. The brick turned out to consist of clay soil, sand and three types of inert material: of vegetable origin (straw, cane fragments and wood); of animal origin (bone splinters, shells); and of artificial origin (fragments of clay material).

In addition to these components, the sample surprisingly revealed the presence of the head of a small papier-mâché crucifix, which is still recognisable after about four centuries (the brick was dated around 1640 by the carbon-14 method).

> Findings in the raw material sample found in the building in ViaS. Spinuzza in Cefalù. Below: the rest of the crucifix fragment (photo by Fabio Vaccaro 2012).



> Above: drawings from the degree thesis in Architectural Science"Cefalù in adobe: raw earth testimonies" by Fabio Vaccaro (2012). Centre: building in the urban context and mud-brick wall found during the restoration work carried out in 2010.Bottom left: the niche from which the sample analysed in 2021 was extracted.

SCRAPS FROM THE SEA

Francesco BERTOLINO, Federica G. CASSARÀ (scholarship holders CUTP)

The study aims to summarise the state of the art of tested and analysed materials from the marine world that can be used in construction. With a view to a circular economy, the focus was on those materials that are considered waste, but for which a second life can be imagined.

Posidonia oceanica, a marine phanero- gama endemic to the Mediterranean, is often found stranded on shorelines where it accumulates to form so-called banquettes. Beached Posidonia is sometimes considered waste and needs to be disposed of. Numerous studies show that, due to its properties, the 'waste' (essentially leaves) of Posidonia can be used as insulation material in construction.

Bivalve mollusc shells are also considered waste. Interest in the use of bivalve shells in construction is recent and the research is not very extensive, but the results are interesting. In fact, both the use of natural shell powder and the mixing of it with other compounds results in materials that can be used in buildings, even if they do not have a structural function.

BIBLIOGRAPHY

Abroug A., Jedidi M. (2020), "Valorization of Posidonia oceanica Balls for the Manufacture of an Insulating and Ecological Material", Jordan Journal of Civil Engineering, vol. 14 n. 3. pp. 417-430.

Abualsauod E. H., Halimi M.T., Hassen M. B., Otham A.M., Zannen S. (2022), "Development of a Multifunctional Wet Laid Nonwoven from Marine Waste Posidonia oceanica Technical Fiber and CMC Binder", Polymers, vol 14 issue 5 n. 865.

Backeljau T., Chapelle G., Morris J. P., (2018), "Shells from aquaculture: a valuable biomaterial, not a nuisance waste product", Reviews in Aquaculture, vol. 11, issue 1, pp. 42-57

Bamigboye G. O., Okara O., Bassey D. E., Jolayemi K. J., Ajimalofin D., (2020) "The use of Seniliasenilis seashells as asubstitute for coarse aggregate in eco-friendly concrete", Journal of Building Engineering, 32, 101811.

Calà A., Campisi T., Capela M. N., Colajanni S., Leone R., Saeli M., (2023), "Recycling mussel shells as secondary sources in green construction materials: a preliminary assessment", Sustainability, 15, 3547.

Calà, A, Leone, R, Saeli, M. (2023), "Bivalve mollusks shells valorisation and recycling: market potentiality and novel building products", Proceedings of ISER International Conference, pp. 9-15).

Calvo R. (2018), "Thermal insulation role and possible exploitation of Posidonia oceanica detritus in the Mediterranean area", Flora Mediterranea, vol, 28 pp. 279-285.

Chen D., Pan T., Yu X., Liao Y., Zhao H., (2020), "Properties of Hardened Mortars Containing Crushed Waste Oyster Shells", Journal of Cleaner Production, 266, 121729.

Del Grammastro L. (2018), "Gusci: la seconda vita dei molluschi bivalvi", Il Pesce: n° 2/2018

Gheith R., Hachem H., Jemni A., Mehrez I. (2022), "Valorization of Posidonia-Oceanica leaves for the building insulation sector", Journal of Composite Materials, vol. 56 issue 13 pp. 1973-1985.

Ibrahim A.S., Ul-Islam M., AL-Salmi A., AL-Abri S., ALNoobi A., (2020), "Optimize mechanical properties of Oman cement using bio waste of sea shell", Conference: 10th National Symposium on Engineering Final Year Projects.

Li H.Y., Wu H.S., Chou C., (2020), "Study on engineering and thermal properties of environment-friendly lightweight brick made from Kinmen oyster shells", Construction and Building Materials, 246, 118367.

Martínez-García, C.; González-Fontebo, B.; Carro-López, D.; Martínez-Abella, F., (2019), "Impact of mussel shell aggregates on air lime mortars. Pore structure and carbonation.", Journal of Cleaner Production, vol. 215, pp. 650–668.

Ramírez E.W.G, García A.E.G., (2020), "Uso de residuo de conchas de abanicocomo filler para la elaboración de concreto sostenible, Tesis para optar el Título de IngenieroCivil, Universidad de Piura, Perù.

SCRAP DESCRIPTION: POSIDONIA OCEANICA

Posidonia oceanica is a seagrass of high environmental value, the presence of which testifies to a healthy habitat and sustainable sites.

A fundamental characteristic of Posidonia is its high biomass production: it cyclically loses its leaves, which are deposited and accumulate on the shoreline.

The management of beached Posidonia is quite complex and the phenomenon of its beaching has always been perceived as a problem.

Italian legislation provides three options for its management, which are, in order of priority, on-site maintenance, removal/ accumulation and removal/transfer to landfill

Scraps are an interesting source of material for green building. In particular, suitable methods have been devised to transform the"egagropiles' (rounded structures formed by the aggregation of fibrous remains) into fibres that can be used as thermal insulation.

EXISTING APPLICATIONS

Insulating material

SCRAP DESCRIPTION: BIVALVE SHELLS

Bivalves or Lamellibranchs, have a shell that is always divided into two parts, the valves, hence the name bivalves. The two valves are hinged dorsally, firmly connected by a muscular-elastic structure, the adductor muscles. The shell of bivalves typically consists of three layers.

In Europe, the most traded species of bivalve molluscs are mussels, clams and oysters.

One of the problems associated with shellfish production is the production of waste. Bivalve mollusc waste comes from three sectors: the fishing and farming sector, the processing sector and the trade/consumer sector.

Various laboratory tests have also shown that the shells of these molluscs, even crushed, are capable of binding numerous heavy metals, and that they can therefore be used for the bio-remediation of complex aqueous matrices.

The possibility of using bivalve waste, consisting of the shells, in the building sector is given by the very composition of their structure, in fact, they consist mainly of calcium carbonate ($CaCO_3$).The use of the shells has been tested in mortars and conglomerates.

EXISTING APPLICATIONS

- Bio-remediation of complex aqueous matrices
- Aggregate in mortars
- Binder

THE CLIMATIC CHAMBER DARCH UNIPA BUILDING WORKSHOP

Maria Luisa GERMANÀ, Manfredi SAELI, Andrea D'AMORE

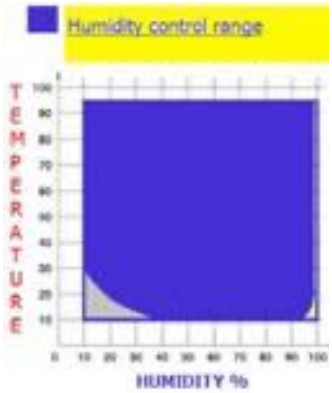
The CUBÂTI Project made it possible to acquire a climatic chamber that was indispensable for the research activities that the Project itself set out to carry out. Among these, of particular importance was the performance of durability tests on the experimental materials produced in order to validate a real applicability of the products in view of the principles of quality in construction.

The equipment is equipped with a hermetic chamber in mirror-polished AISI 304 stainless steel, totally welded steam-tight with internal lighting. Forced air circulation is obtained by means of helicoidal fans, which allow a constant and uniform flow over the entire volume of the internal chamber, thus guaranteeing an optimal distribution of microclimatic conditions to guarantee the tests being performed. The relative humidity is controlled by means of a high-precision electronic sensor with a high-efficiency thermoregulated humidity producer.

APPLICATIONS

- Accelerated ageing tests
- Sample care in a controlled environment
- Laboratory testing in a controlled environment

MODEL: Evolution Clima 300
MANUFACTURER: MSL srl
CHAMBER VOLUME: 300 litri
TEMPERATURE RANGE:
-50 - 180 °C
HUMIDITY RANGE:10-98 %



TESTS CONDUCTED IN THE EXPERIMENTAL PHASE

As part of the activities of the CUBÀTI project, accelerated ageing tests were carried out in the climatic chamber purchased for this purpose. The procedure followed makes it possible to analyse and predict the possible state of degradation and durability of the products developed during the project under certain conditions. In particular, the products based on common identity waste from Sicily and Tunisia, developed by the project partners (UNIPA, IEMEST and CITET), were exposed to the following microclimatic conditions for one month each: 1) 60°C, 30% RH and 2) 60°C, 75% RH. This made it possible to simulate the extreme temperatures and humidity values found in the two geographical areas, with a view to extreme conditions in order to accelerate the possible degradation of the material. In both cases, the samples showed no appreciable dimensional changes or signs of degradation (e.g. disintegration, cracks, loss of material, etc.).

In the pictures opposite, two sets of tested products showing their excellent state of preservation.

TECHNICAL SPECIFICATIONS

DESCRIPTION	UNIT	DATA
External dimensions(l× h x p)	mm	910x1800x1170
Inner dimensions(lxhxp)	mm	700x700x620
Usable volume	litri	300
Total load capacity	Kg	280
Temperature range	°C	-50÷ 180°C
Uniformity of time in space	°C	±1
Temperature constancy over time	°C	±0.3
Thermal gradient from180to-35°C*	°C/min	4.5
Thermal gradient from-40to180°C*	°C/min	5.0
Operating range relative humidity	%	10÷ 98
Humidity uniformity	%	±3
Climatic temperature range	°C	+10÷ +98
Thermoventilation units	n°	2
Insulation		Double-layered, steel woolHD and glass woolHD
Test Chamber Material		AISI304
Power supply	V	400/3/50Neutroe GND
Frequency	Hz	50
Maximum Electrical Absorption	KVA	8,1
Medium Electrical Absorption	KVA	5,2
Ecological Refrigerant	R	452a
Demineralised water	Maxlt/hr	20
Condensation		Aria
Sound emission at 1 metre	dBA	60
Empty chamber net weight	Kg	450

* the reported values refer to the test conditions in the laboratory, under controlled climatic conditions at 22°C ± 0.5°Ce60%HR, without additional internal charges that are not expressly stated in the standard quota.

CULTURE DU BÂTI DE QUALITÉ : RECHERCHE, INNOVATION ET ENTREPRISES POUR LA DURABILITÉ

THE SHARED PROCESS FOR MATERIALS TESTING / 1

Federica FERNANDEZ, Khitem MENSI

In order to be able to compare the results of the research, the part- ner laboratories of the project defined a shared process for laboratory testing of the various mortars.

Having identified the common objectives, i.e. the type of mortars, the various constituent elements and the performance parameters, the operational steps were defined. In particular, the methods of specimen manufacture, mix design, experimental tests to be carried out and the ageing protocols for the specimens were identified.

The work was conducted through the compilation of sheets, one for the aggregates and one for the mortar with the various tests performed. The method made it possible to share the results among the part- ners, creating a database for easy archiving and consultation of the tests carried out. The process developed and implemented during the project constitutes a model that can be replicated in other projects.

PHASES

Phase 1. Sorting and grinding waste

Phase 2. Sieving of rejects

Phase 3. Defining the mix design and packaging of the mortar

Phase 4. Production of samples (4x4x4, 16x4x4, 20x20x2 cm) and evaluation of the fresh mortar (spreading, workability, consistency etc.)

Phase 5. Curing (approx. 21 days)

Phase 6.tests (mechanical tests, thermal conductivity water absorption by capillarity, etc.)

Phase 7. Ageing in a climatic chamber

Phase 8. Re-testing Stage 4 to verify the maintenance of performance over time.

PHASE 1. Sorting and grinding waste

Various vegetable waste was sorted, prepared and ground in a mechanical grinder.

PHASE 2. Sieving of waste

During the grinding process, the product is sieved in order to divide it into at least three different grain sizes. This makes it possible to modulate the particle size curve of the material and to differentiate its application: substrate or finish.

PHASE 3. Mix design and mortar packaging

Starting with the binding matrix, gypsum or clay, numerous design mixes were tested by varying the percentages of aggregates and water. By measuring the spread of fresh mortar, it was possible to optimise the mix, with particular reference to the water content, and to assess the workability of the mix.

THE SHARED PROCESS FOR MATERIALS TESTING / 2

Federica FERNANDEZ, Khitem MENSI

PHASE 4. Fabrication of samples (4x4x4, 16x4x4, 20x20x2 cm) and evaluation of fresh mortar

The mixes with good workability were poured into moulds of various sizes, in order to make specimens of an adequate number and size for the various tests in the experimental phase in order to assess the performance of the manufactured mortars after staging (Phase 5).

PHASE 5. Seasoning

Before proceeding with the experimental tests, the test specimens were cured for 28 days at controlled humidity and temperatures in order to avoid cracking during setting.

PHASE 6. Test execution

1. MECHANICAL STRENGTH TEST

SAMPLE SIZE:4x4x16 cm
TYPES OF TESTING:
mechanical resistance to compression
mechanical resistance to bending

6.2 CONDUCTIVITY MEASUREMENTS

SAMPLE SIZE:20x20x2 cm
TYPES OF TESTING:
conductivity measurements (lambda)

6.3 OPTICAL MICROSCOPE OBSERVATIONS

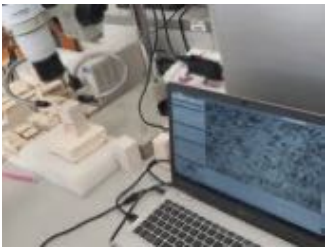
ENLARGEMENTS: 10x 20x 30 cm

6.4 WATER ABSORPTION BY CAPILLARITY

SAMPLE SIZE: 4x4x16 cm

> 6.1 Mechanical strength test.

> 6.2 Conductivity measurements.



> 6.3 Optical microscope observations.

> 6.4 Water absorption by capillarity.

PHASE 7. Climatic chamber ageing

SAMPLE SIZE : 4x4x16 cm

TEST CONDITIONS: 60 % humidity and 30 °C for 7 days30 % humidity and 60 °C for 7 days

PLASTER + MUSSEL SHELLS

Manfredi SAELI, Tiziana CAMPISI
with **Adriana CALÀ, Rosanna LEONE**

The Mussel is a bivalve equi- valve mollusc belonging to the family Mytilidae. It lives anchored in rocks and, due to its rapid spread, is considered an invasive species in many areas of the world. The shell is teardrop-shaped with a rounded edge on one side and a pointed, slightly curved edge on the other. It is composed mainly of CaCO3 and is usually black or purplish-black in colour, with radial and concentric circles of accretion extending on the outside. Inside, it has a smooth surface and appears pearly in colour. Farmed mussels live in more controlled conditions, in mussel farms anchored to ropes and nets hung from floating buoys. The best-known species in the world is the Mytilus Galloprovincialis, known as the Mediterranean mussel.

EXISTING APPLICATIONS

Human nutrition;
Livestock feed;
Soil and wastewater remediation;
Catalysts for biodiesel production;
Biomedical and cosmetic applications;
Environmentally sustainable building materials.

BIBLIOGRAPHY

Leone R, Calà A, Capela M.N., Colajanni S., Campisi T., Saeli M., *Recycling mussel shells as secondary sources in green construction materials: a preliminary assessment*. Sustainability 15(4), 2023, 3547.

Calà A, Leone R, Saeli M, *Bivalve Mollusks Shells Valorisation and Recycling: Market Potentiality and Novel Building Products*. International Journal of Advances in Science Engineering and Technology 11(1), 2023, 132-138.

12.1 IDENTIFICATION OF SCRAP

MATERIAL: Mussel shells

SIZE: 0-1 mm and 0-4 mm
PRODUCER: Sicilian fish company

SPECIFIC WEIGHT:13,293 N/m3 - 13,841 N/m3

12.2 SCRAP PREPARATION

1. Cleaning with running water;
2. Drying at 60 °C for 24h;
3. Mechanical shredding by means of an electric shredder;
4. Screening of untreated material;
5. Size composition.

12.3 MORTAR MIX DESIGN

(for 100 g of plaster)

- BINDING:
  PLASTER |100 g
- AGGREGATE :
  SHELL 0-1 E 0-4 mm | 150 g
- WATER | 80 g

12.4 PREPARATION OF MORTAR AND SPECIMENS

1. Insertion of powders and water into the mixer;
2. Mixing for 2 min at a speed of 140 rpm;
3. Insertion of the mortar into the moulds for packaging;
4. Curing for 7 days in a controlled environment.

12.5 MORTAR PROPERTIES

LAVORABILITY: 11 cm - 14.25 cm

DENSITY: 1304 kg/m3 - 1400 kg/m3

RESISTANCE AND FLESSION:1.77 MPa - 2.61 MPa

RESISTANCE A COMPRESSIONE:6.70 MPa - 5.73 Mpa

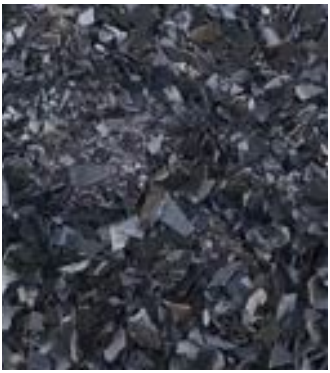
CONDUCIBILITY: ... W/mK

12.6 POTENTIAL APPLICATIONS

Rendering/render/finishing plaster;

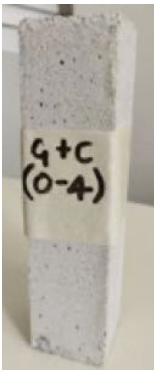
1. Thermo-acoustic insulation panel.

> Mussel shells 0-1 mm.



> Mussel shells 0-4 mm.

> Plaster



LIME + COFFEE POWDER

Manfredi SAELI

Coffee is a beverage obtained by grinding and roasting the seeds of tropical trees belonging to the Coffea genus of the Rubiaceae family. Among the most popular varieties for commercial purposes are robu- st, arabica and indica. Coffee is one of the world's most popular beverages in various forms (espresso, arabica, soluble coffee, cappuccino, ame- rican, etc.) and in terms of economic value is the most traded commodity after petroleum products.

The waste appears as a brownish powder that is strongly aromatic due to the amount of polyphenols present and strongly moist due to the beverage production process. The powder has a strong tendency to degrade very quickly (rot) and is an excellent substrate for mould; pre-treatment must therefore be quick and effective.

EXISTING APPLICATIONS

- Human nutrition;
- Livestock feed;
- Catalysts for biodiesel production;
- Fertiliser;
- Environmentally sustainable building materials.

1. SCRAP IDENTIFICATION

MATERIAL: Coffee powder
DIMENSION: <63 mm
SOURCE: organic domestic waste
SPECIFIC WEIGHT : 0.4 g/cm3

2. SCRAP PREPARATION

1. Drying at 60 °C for 24h;
2. Mechanical crushing by means of mortar and pestle;
3. Screening;
4. Size composition.

13.3 MORTAR MIX DESIGN (for 100 g of plaster)

- BINDING : NATURAL HYDRAULIC LIME | 100 g
- AGGREGATE : SILICON SAND 0-4 mm | 270 g
- FILLER: COFFEE POWDER
- <63 mm| 30 g
- WATER | 100 g

13.4 PREPARATION OF MORTAR AND SPECIMENS

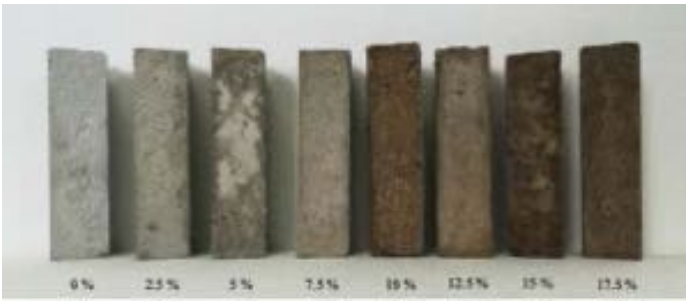
1. Insertion of precursors and water into the mixer;
2. Mixing according to EN 998-2:2016;
3. Formation of specimens;
4. Curing for 7 days in a controlled environment;
5. Curing for 21 days in air.

13.5 RESULTS

WORKABILITY : 18 cm
DENSITY : 1450 kg/m3
FLEXURAL STRENGTH: 1.50 MPa
COMPRESSIVE STRENGTH: 3.5 MPa
CONDUCTIVITY : 0.25 W/mK

13.6 POTENTIAL APPLICATIONS

1. Thermo-plaster;
2. Allurement mortar;
3. Lightweight screeds;
4. Thermal insulation board.



BIBLIOGRAPHY

Saeli M., Capela M.N., Piccirillo C. *et al.*, *Development of energy-saving innovative hydraulic mortars reusing spent coffee ground for applications in construction*. Journal of Cleaner Production 399, 2023, 136664.

Saeli M., Batra V.S., Singh R.K., Tobaldi D.M., Labrincha J.A., *The coffee-house: Up-cycling spent coffee grounds for the production of green geopolymeric architectural energy-saving products*. Energy and Buildings 286, 2023, 112956.

Saeli M., Capela M.N., Campisi T., Seabra P.M., Tobaldi D.M., La Fata C.M., *Architectural technologies for life environment: Spent coffee ground reuse in lime-based mortars. A preliminary assessment for innovative green thermo-plasters*. Construction and Building Materials 319, 2022, 126079.

Saeli M., Campisi T., Batra V.S., Labrincha J.A., *Novel green bio-composite geopolymeric thermo-plasters for innovative building applications: upcycling spent coffee ground*. In E. Dassori, R. Morbiducci (a cura di), Memoria e Innovazione, Monfalcone: EdicomEdizioni, 2022, 991-1006.

La Scalia G, Saeli M., Miglietta P.P., Micale R., *Coffee biowaste valorization within circular economy: an evaluation method of spent coffee grounds potentials for mortar production. The International Journal of Life Cyde Assessment* 26(9), 2021, 1805-1815.

CHALK + PRICKLY PEAR

Simona COLAJANNI, Tiziana CAMPISI
with **Vincenzo R. MARGIOTTA**

Opuntia ficus-indica, commonly known as prickly pear or nopal, is a plant belonging to the Cactaceae family. Native to Central and North America, it has been introduced to many other parts of the world for its many benefits and uses, especially within the Mediterranean basin in areas such as Sicily and North Africa. Its dif- fusion has been favoured by its high adaptability to arid climates and its ability to survive in poor soils. The plant is characterised by flattened, segmented stems, called cladodes, which can reach a length of several centimetres. These cladodes are covered with spines and small hairs and contain a juicy pulp. For fruit production, the plant is pruned of the cladodes, which produce a large amount of waste.

EXISTING APPLICATIONS

1. Human nutrition
2. Animal Nutrition
3. Dye production
4. Medicinal uses

BIBLIOGRAPHY

Harrak H., *Assessment of technological and nutritional qualities of the powder of prickly pear cladodes at four ages of growth* (2021);

Trabelsi A. et al., *Mechanical properties and impact resistance of a high-strength lightweight concrete incorporating prickly pear fibres* (2020);

Aquilina A, *The application of Natural Organic Additives in Concrete: Opuntia ficus-indica* (2018).

14.1 SCRAP IDENTIFICATION

MATERIAL: Prickly pear shovels

DIMENSION: 0 - 4 mm and 0 - 1 mm of shredded cladodes
PRODUCER : Sicilian Farm (Santa Margherita Belice and San Cono)
Ps 0-4 mm : 5395 N/m3
Ps 0-1 mm : 4826 Ps 0-1 mm : 4826

14.2 SCRAP PREPARATION

1. Drying in a static oven at 60 °C for 72 h;
2. Mechanical shredding by means of an electric shredder;
3. Sieving of untreated material.

14.3 MORTAR MIX DESIGN (for 100 g of plaster)

- PLASTER | 100 g
- P.P. 0-4 mm | 150 g
- WATER | 300 g

- PLASTER | 100 g
- P.P. 0-1 mm | 150 g
- WATER | 200 g

14.4 PREPARATION OF MORTAR AND SPECIMENS

1. Insertion of powders and water into the mixer;
2. Mixing for 2 min at a speed of 140 rpm;
3. Insertion of the mortar into the moulds for packaging;
4. Curing for 7 days in a controlled environment.

14.5 RESULTS

- WORKABILITY : 10 cm
- DENSITY : 676 kg/m3
- FLEXION : 1.48 MPa
- COMPRESSION : 0.30 MPa
- CONDUCTIVITY : 0.11 W/mK

- WORKABILITY : 10 cm
- DENSITY : 607 kg/m3
- FLEXION : 1.41 MPa
- COMPRESSION: 0.21 MPa
- CONDUCTIVITY : 0.09 W/mK

14.6 POTENTIAL APPLICATIONS

1. Rendering/plastering plaster;
2. Thermal-acoustic insulation panel;
3. Loose-fill insulation panel.

> Fico d'India 0-4 mm.

> Fico d'India 0-1 mm.

> Plaster + prickly pear (0-4 mm).

> Plaster + prickly pear (0-1 mm).

> Prickly pear 0-4 mm.

> Prickly pear 0-1 mm.

PLASTER + PISTACHIO SHELLS

2–4 mm I 0,5-2 mm I <0,5 mm

Federica FERNANDEZ
with **Maria Grazia INSINGA, Roberta BASILE**

According to FAOstat (2020) 2018 data, 90 per cent of pistachios are produced by the United States, Turkey and Iran, with an output of 1,239,007 tonnes per year. In Italy, a total of about 300,000 tonnes of nuts are produced per year and according to ISTAT data for 2017, the pistachio areas in Italy do not exceed 4,000 hectares, for a production of just under 4,000 tonnes, concentrated here exclusively in Sicily.

To date, pistachio shells still have no industrial use or significant economic value, which is why they are burnt or disposed of in landfills. The pistachio shell constitutes between 51 and 69% of the weight of the fruit. Furthermore, the weight loss of the pistachio shell is approximately 75-80% during the heating phase due to its high cellulosic structure.

EXISTING APPLICATIONS

- Human nutrition
- Biomass fuel
- Natural insecticide
- Decorative art

BIBLIOGRAPHY

Taghizadeh A., Rad-Moghadam K., *Green fabrication of Cu/pistachio shell nanocomposite using Pistacia Vera L. hull: an efficient catalyst for expedient reduction of 4-nitrophenol and organic dyes*. J. Clean. Prod. 198, 2018, 1105e1119;

Kazankaya, A., Balta, F., Ozturk, N., Sonmez, F., *Mineral composition of pistachio (pistaciavera) from Siirt/Turkey*. Asian J. Chem. 20, 2008, 2337e2343;

Putun, A.E., Ozbay, N., Varol, E.A., Uzun, B.B., Ates, F., *Rapid and slow pyrolysis of pistachio shell: effect of pyrolysis conditions on the product yields and characterization of the liquid product*. Int. J. Energy Res. 31, 2007, 506e514.

15.1 SCRAP IDENTIFICATION

MATERIAL: Pistachio shells
DIMENSION: <0,5 mm I 0,5 – 2mm I 2 – 4 mm
PRODUCER: Distretto Dolciario Sicilia
SPECIFIC WEIGHT: 2.4 g/cm3

15.2 SCRAP PREPARATION

1. Mechanical shredding by means of an electric shredder
2. Sieving of untreated material

MORTAR MIX DESIGN

(per 100 g dry matter)

- PLASTER | 60 g
- PISTACHIO SHELLS 2-4 mm: 40 g
- WATER | 50 g

RESULTS

Workability: 8/10
Density: 1,11 g/cm3
Flexion: 0.41 Mpa
Compression: 2.04 MPa
Conductivity: 0.235 W/mK

15.3.2 MORTAR MIX DESIGN

(for 100 g of dry matter)

- PLASTER | 80 g
- PISTACHIO SHELLS 0,5–2mm: 15 g
- SAND (0.075-0.6 mm): 5 g
- WATER | 70 g

RESULTS

Workability : 10/10
Density: 1.05 g/cm3
Flexion: 0.52 Mpa
Compression: 4.14 MPa
Conductivity: 0.231 W/mK

15.3.3 MORTAR MIX DESIGN

(for 100 g of dry matter)

- PLASTER | 80 g
- PISTACHIO SHELLS <0,5: 75 g
- SAWDUST OF FIR WOOD(< 0.5 mm) 7.5 g
- SAND (0.075-0.6 mm): 5 g
- WATER | 65 g

RESULTS

Workability: 10/10
Density: 1.04 g/cm3
Flexion: 1.72 Mpa
Compression: 4.72 MPa
Conductivity: 0.248 W/mK

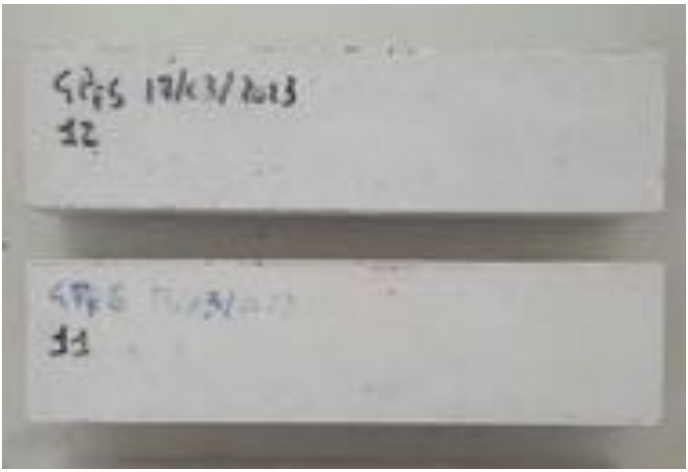
15.4 POTENTIAL APPLICATIONS

1. Rendering/plastering plaster
2. Thermal-acoustic insulation plaster

> Pistachio shells <0,5 mm.

> Pistachio shells 2-4 mm.

> Plaster



PLASTER + ORANGE PEEL

2–4 mm I 0,5-2 mm I <0,5 mm

Federica FERNANDEZ
with **Maria Grazia INSINGA, Roberta BASILE**

Oranges are the most cultivated fruit in the world and account for about 50-60% of the total citrus fruit production. Every year, more than 76 million tonnes of oranges are consumed worldwide and the processing generates an enormous amount of waste, mostly consisting of peels. By-products from citrus fruit waste are mainly used for energy production, as a source of nutrients or in the pharmaceutical, food and cosmetic industries. The chemical composition of citrus peel, in general, is influenced by external climatic conditions, cultivation method and fruit type and consists mainly of cellulose, pectin, sugar, acids, lipids, mineral elements, essential oil and vitamins.

EXISTING APPLICATIONS

- Human nutrition
- Animal nutrition
- Energy production
- Pharmaceutical production

BIBLIOGRAPHY

Satari, B.; Karimi, K. Citrus processing wastes: Environmental impacts, recent advances, and future perspectives in total valorization. *Resour. Conserv. Recycl.*, 2018, 129, 153–167.

16.1 SCRAP IDENTIFICATION

MATERIAL: Dried and ground orange peels
DIMENSION:
<0,5 mm 0,5 – 2mm 2 – 4 mm
PRODUCER: SunPro Srl

16.2 SCRAP PREPARATION

1. Drying in a static oven at 60 °C for 72 h
2. Mechanical shredding by means of an electric shredder
3. Material sieving

16.3 MORTAR MIX DESIGN (for 100 g of dry matter)

- Inserting the powders and water into the mixer
- Mixing for 2 min at a speed of 140 rpm
- Placing the mortar in the moulds for packaging
- Curing for 7 days in a temperature- and humidity-controlled environment

16.4.1 PREPARATION OF MORTAR AND SPECIMENS

PLASTER |80 g
DRIED ORANGE PEELS
<0,5 mm | 7,5 g
SAWDUST FIR WOOD
<0,5 mm | 7,5 g
SAND 0,075 – 0,6 mm | 5 g
WATER | 70 g

RESULTS

Workability : 10/10
Density: 0.97 gr/ cm3
Flexion : 0,84 Mpa
Compression: 2,80 MPa
Thermal conductivity : 0,153 W/m·K

16.4.2 PREPARATION OF MORTAR AND SPECIMENS

PLASTER |80 g
DRIED ORANGE PEELS
0,5 -2 mm | 15 g
SAND 0,075 – 0,6 mm | 5 g
WATER | 70 g

RESULTS

Workability : 8/10
Density: 0,92 gr/ cm3
Flexion: 0,45 Mpa
Compression: 1,36 MPa
Thermal conductivity : 0,155 W/m·K

16.4.3 PREPARATION OF MORTAR AND SPECIMENS

PLASTER |80 g
DRIED ORANGE PEELS
2-4 mm | 7,5 g
SAWDUST FIR WOOD
<0,5 mm | 7,5 g
SAND 0,075 – 0,6 mm | 5 g
WATER | 70 g

RESULTS

Workability : 7/10
Density: 0,96 gr/cm3
Flexion: 0,53 Mpa
Compression: 1,45 MPa
Thermal conductivity : 0,150 W/m·K

16.6 POTENTIAL APPLICATIONS

1. Rendering/plastering plaster;
2. Thermal-acoustic insulation plaster.

> Plaster

> Orange peels 2-4 mm.

> Orange peels <0,5 mm.

CLAY + PISTACHIO SHELLS

0,5-2 mm I <0,5 mm

Federica FERNANDEZ
with **Maria Grazia INSINGA, Roberta BASILE**

According to FAOstat (2020) 2018 data, 90 per cent of pistachios are produced by the United States, Turkey and Iran, with an output of 1,239,007 tonnes per year. In Italy, a total of around 300,000 tonnes of nuts are produced per year and according to ISTAT data for 2017, the pistachio areas in Italy do not exceed 4,000 hectares, for a production of just under 4,000 tonnes, concentrated almost exclusively in Sicily.

To date, pistachio shells still have no industrial use or significant economic value, which is why they are burnt or disposed of in landfills. The pistachio shell constitutes between 51 and 69% of the weight of the fruit. Furthermore, the weight loss of the pistachio shell is approximately 75-80% during the heating phase due to its high cellulosic structure.

EXISTING APPLICATIONS

- Human nutrition
- Biomass fuel
- Natural insecticide
- Decorative art

BIBLIOGRAPHY

Achenza M., Sanna U., *I manuali di recupero dei centri storici della Sardegna - Il manuale tematico della terra cruda*, Tipografia del Genio Civile.

Mattone M., *Intonaci in terra e gesso per la protezione delle costruzioni in terra cruda*, VIII Congreso de Tierra en Cuenca de Campos, Valladolid, 2011.

Putun, A.E., Ozbay, N., Varol, E.A., Uzun, B.B., Ates, F., *Rapid and slow pyrolysis of pistachio shell: effect of pyrolysis conditions on the product yields and characterization of the liquid product*. Int. J. Energy Res. 31, 2007, 506e514.

17.1 SCRAP IDENTIFICATION

MATERIAL: Pistachio shells
DIMENSION: <0,5 mm I 0,5 – 2mm
PRODUCER: Distretto Dolciario Sicilia
SPECIFIC WEIGHT: 2.4 g/cm3

17.2 SCRAP PREPARATION

1. Mechanical shredding by means of an electric shredder
2. Sieving of untreated material

17.3 PREPARATION OF MORTAR AND SPECIMENS:

1. Insertion of powders and water into the mixer
2. Mixing for 2 min at a speed of 140 rpm
3. Insertion of the mortar into the moulds for packing without compression
4. Curing for 21 days in a controlled environment.

17.4.1 MORTAR MIX DESIGN

(for 100 g of dry matter)
CLAY| 75 g
PISTACHIO SHELLS 0,5-2 mm | 0,5 g
SAWDUST FIR WOOD<0,5 mm | 2,5 g
SAND (0.075-0.6 mm): 20 g
WATER | 30 g

RESULTS

Workability: 8/10
Flexion: 0.26 Mpa
Compression: 1.13 MPa
Conductivity: 0.267 W/mK

17.4..2 MORTAR MIX DESIGN(for 100 g of dry matter)

CLAY| 75 g
PISTACHIO SHELLS <0,5 mm : 5 g
SAND (0.075-0.6 mm): 20 g
WATER | 30 g

RESULTS

Workability: 8/10
Flexion: 0.19 Mpa
Compression: 0.89 MPa
Conductivity: 0.286 W/mK

17.5 POTENTIAL APPLICATIONS

1. Rendering/plastering plaster
2. Thermal-acoustic insulation plaster11

> Clay.

> Pistachio shells 0,5-2 mm.

> Pistachio shells <0,5 mm.

CLAY + ORANGE PEEL

<0,5 mm

Federica FERNANDEZ
with **Maria Grazia INSINGA, Roberta BASILE**

Oranges are the most cultivated fruit in the world and account for about 50-60% of the total citrus fruit production. Every year, more than 76 million tonnes of oranges are consumed worldwide and the processing generates an enormous amount of waste, mostly consisting of peels. By-products derived from citrus fruit waste are mainly used for energy production, nutrient sources or pharmaceutical, food and cosmetic industries. The chemical composition of citrus peel, in general, is influenced by external climatic conditions, the method of cultivation and the type of fruit and is mainly composed of cellulose, pectin, sugar, acids, lipids, mineral elements, essential oil and vitamins.

EXISTING APPLICATIONS

- Human nutrition
- Animal nutrition
- Energy production
- Pharmaceutical production

BIBLIOGRAPHY

Achenza M., Sanna U., *I manuali di recupero dei centri storici della Sardegna - Il manuale tematico della terra cruda*, Tipografia del Genio Civile.

Satari, B.; Karimi, K. Citrus processing wastes: Environmental impacts, recent advances, and future perspectives in total valorization. *Resour. Conserv. Recycl.*, 2018, 129, 153–167.

1. SCRAP IDENTIFICATION

MATERIAL: Dried and ground orange peels

DIMENSION: <0,5 mm

PRODUCER: SunPro Srl

2. SCRAP PREPARATION

1. Drying in a static oven at 60 °C for 72 h
2. Mechanical shredding by means of an electric shredder
3. Material sieving

18.3 MORTAR MIX DESIGN (for 100 g of dry matter)

- Inserting the powders and water into the mixer
- Mixing for 2 min at a speed of 140 rpm
- Insertion of the mortar into the moulds for packing without compression
- Curing for 21 days in a temperature- and humidity-controlled environment.

18.4 PREPARATION OF MORTAR AND SPECIMENS

CLAY | 70 g

DRIED ORANGE PEELS <0,5 mm | 5 g

SAND 0,075 – 0,6 mm | 25 g

WATER | 37,4 g

RESULTS

Workability: 8/10

Flexion: 0,12 Mpa

Compression: 0,38 Mpa

Thermal conductivity: 0,212 W/m·K

18.5 POTENTIAL APPLICATIONS

1. Rendering/plastering plaster;
2. Thermal-acoustic insulation plaster.

> Clay.

> Orange peels <0,5 mm.

MATERIAL EXPERIMENTS IN TUNISIA

Fadhel M'HIRI
with **Khitem MENSI, Cheima BENNASR**

GENERAL PRESENTATION:

The date palm (Phoenix dactylifera L.) is a monocotyledonous plant species of the Arecaceae (Palm) family, which has been exploited and cultivated for several millennia in the Middle East and North Africa. This species has adapted very well to Saharan climates and the driest regions of the earth. In Tunisia, palm groves are mainly found in Kebili (58%), Tozeur (21%), Gabes (16%) and Gafsa(5%).

USES :

The date palm is characterised by a variety of uses, it essentially provides

- Dates consumed fresh, dried or in the form of derived products;
- logs and leaves for roofs and fences;
- the kernels are used to feed the livestock;
- the sap dripping from the stem is used as wine to be consumed fresh or fermented.

BIBLIOGRAPHY

A. Chehma et HF. Longo (2001): *Valorisation des Sous-Produits du Palmier Dattier en Vue de leur Utilisation en Alimentation du Bétail*

Tuan Anh Phung (2018): *Formulation et caractérisation d'un composite terre-fibres végétales: la bauge*

Muriel Gros-Balthazard, Claire Newton, Sarah Ivorra, MargaretaTengberg, Jean-Christophe Pintaud et Jean-Frédéric Terral (2019): *Origines et domestication du palmier dattier* (*Phoenix dactylifera* L.)

BELLEL Nadjoua (2021): *Elaboration et Caractérisation Physico Chimique des Matériaux Biosourcés*

IDENTIFICATION

- Palm fibres obtained from date palm leaves,
- Fibre size: thickness variable between 0.5 - 1 mm and length variable between 1 - 5 mm
- Colour: greenish

MODUS OPERANDI

- Drying in an oven at a temperature of 120°C for 72 hours
- Crushing by means of a grinder - blade blender
- Sieving

COMPOSITION

- 60 – 70% plaster
- 2 – 4% di palm fibre
- Water

MIX

1. Dry mixing of gypsum with palm fibres
2. Adding the amount of water and mixture
3. Inserting the mixture into the moulds
4. Drying at room temperature

FINISHED PRODUCTS

- Bricks of size: 4*4*16 cm
- Bricks of size: 4*4*4 cm
- Coating test on compressed earth bricks (BTC)

RISULTATI

Performance:

- Self-blocking bricks during demoulding
- Tightly bonded coating on compressed earth brick

Appearance

Whitish bricks stained with pigments in shades of green and grey

Touch sensation: smooth

Conductivity: 0,33 W/mk








UTIQUE ARCHAEOLOGICAL SITE IN TUNISIA

THE EXPERIMENTAL BUILDING

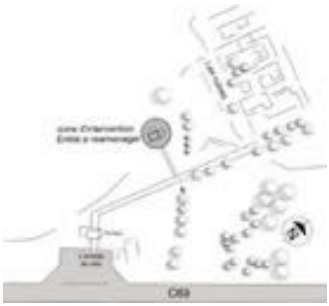
Mazigh BECHIR
with **Kais CHANIOUR**

UTIQUE: SITE HISTORY AND SURROUNDINGS

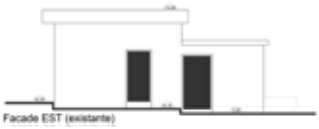
Utique is the first Phoenician settlement in Tunisia, the foundation of which probably dates back to the year 1001 B.C. and is considered to be the antenate of the famous city of Carta-gine, and both were part of the trade poles, founded in the context of the Phoenician trade activities of Tyr. The archaeological site of Utique was the subject of an initial project with the Italy-Tunisia cross-border cooperation programme 2007-2014, called APER, which dealt with the topic of domestic architecture in Punic, Roman and Hellenistic times. Later on, within the framework of the Italy-Tunisia 2014-2020 programme, the CUBATI project, wanted to make the same site benefit from an experimental building in which the results obtained from research into construction techniques and materials, an aspect the project dealt with, would be 'visualised'. This will is part of a logical continuation between the two projects APER and CUBATI, seeking to enhance ideas and objectives in relation to quality architecture and the built heritage.

THE INTERVENTION/EXPERIMENTAL BUILDING:

The initial idea was to construct a new building, but this process was abandoned in favour of another one consisting of the renovation of an existing entity qualified as anarchic. This change would have spared the site yet another construction, likely to alter the already precarious balance (quantitatively speaking) between the modern buildings and the visible and visitable archaeological remains. However, this entity to be renovated presented serious problems, such as dampness, mould and non-existent thermal comfort.



The renovation project consists of cladding the old rooms with compressed earth blocks (BTC), a product with a fairly high inertia, and obviating the lack of work space by constructing two new cells (an office and a guardhouse) the whole will be aesthetically harmonious and meet the building standards for adequate thermal comfort. The renovation project will provide a minimum of thermal comfort and ensure healthy, breathable air for users.The experimental building could not be constructed in Utique, however, the two experimental buildings will be constructed at the International Centre of Technology and the Environment in Tunis (CITET).Compressed earth blocks or BTC: this is a product being manufactured in Tunisia, it is based on raw earth, with some additives (in very low quantities), the mixture obtained is compressed mechanically, the blocks do not need to be fired. It is a product derived from nature, which has very weak traces of car- bones (non-energetic at the time of manufacture), its installation on the building site is simple, like LEGO toys, as the blocks fit into each other. Tests have proven the product's stability and weather resistance; it is praised for its ecological and energy-saving qualities tested in the laboratory. Manufactured from a natural product, raw earth, these blocks combined with plasters of the same nature can only be beneficial to our health. Today, in our living spaces (made with standard building market materials) we breathe air polluted by polyphenols, toxins that are spread in our enclosed spaces due to chemicals in plasters, lead-based paints, of resins and in composite woods. Studies have shown that sleeping in one's room in the presence of these toxic products is equivalent to the air we would breathe if we were on the street at midday during a traffic peak!What is the future for our developments, in archaeological sites: today, some of our installations intended for the exploitation of archaeological sites are dying, so it is time to revisit them, but from a different angle. In the future, we want quality buildings, environmentally friendly, user-friendly, intelligent buildings, energy autonomous. The AM-VPPC is preparing to enter this decarbonisation path, a global scourge that affects all sectors of activity, in order to leave a natural heritage intact for future generations.


Facade EST (existante)

Plan relevé de l'existant

CONSTRUCTION OF DEMONSTRATION BUILDINGS IN TUNISIA

Fadhel M'HIRI
with **Khitem MENSI, Cheima BENNASR**

GENERAL PRESENTATION

Ecological construction or sustainable building is gaining momentum in Tunisia, reflecting the country's commitment to sustainable development. This approach favours the use of sustainable and local materials, thus contributing to the conservation of the country's natural resources. Energy efficiency is at the heart of green building in Tunisia, with buildings designed to minimise energy consumption through the use of advanced insulation techniques.

These projects also integrate rainwater harvesting systems, water-saving devices and environmentally friendly landscaping practices.

OBJECTIVE OF THE PROJECT:

construct an 81 m² ecological building at CITET. This project aims at the creation of a material library specifically designed for the display of sustainable and innovative materials.

BIBLIOGRAPHY

Dorra Ismail(2009), *La pensée en architecture au "risque" de l'événementialité.*

Jean-Claude Mengoni (2011), *La construction écologique*.

Jean-Pierre Oliva, Samuel Courgey (2023), *L'isolation thermique écologique. Conception, matériaux, mise en œuvre*.

BUILDING COMPONENTS:

- Entrance and reception area (2m x 1.5m).
- Storage warehouse with office and shelving (3m x 4m).
- Dedicated exhibition room (7m x 5m).

CONSTRUCTION MATERIALS:

Compressed earth bricks, wood, gypsum, palm fibre, granulates made from a Tunisian process of recycling construction and demolition waste, natural origin materials tested in the CITET laboratories, etc.

ECOLOGICAL CONSTRUCTION AT THE SERVICE AND THE CIRCULAR ECONOMY:

- Integration of existing trees.
- Optimised, eco-energy lighting.
- Sewage recovery system.
- Recycling of construction waste.
- Utilisation and valorisation of construction and demolition waste.

FINANCING:

45,000 euro allocated by the EU through the IEV Italy-Tunisia Cooperation Programme 2014-2020.

ARCHITECTURAL SPECIFICITIES OF THE BUILDING:

- Openness to the environment, life and nature.
- Transparency and natural ventilation of interior spaces.
- Optimised functionality for people with reduced mobility.
- Ecological construction with compacted materials and thermal insulation.
- Multifunctional design with reception, office and exhibition area.

SECURITY :

- Protection against fungal and insect attack for wooden structures.
- Compliance with fire safety regulations.

PRODUCTION OF EXTERIOR EARTHENWARE PLASTER

Giuseppe GUGLIELMINO
with **Fabrizio RAGUSA**

EARTHENWARE PLASTERS

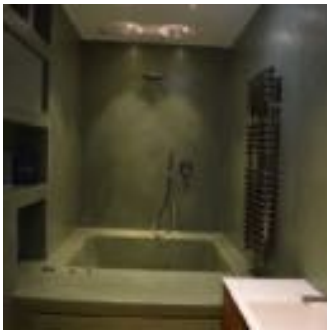
The 'Cocciopesto Gugliel- mino' plaster, based on national hydraulic lime and earthenware, consists of three well-co-operating layers that together form a 'plaster system' that protects and beautifies masonry. It is particularly suitable for the recovery and restoration of buildings in historic city centres as well as for new architectural solutions.

OTHER ADVANTAGES OF EARTHENWARE

Earthenware Cocciopesto Guglielmino is produced from soft bricks and therefore has a lower specific weight and a high porosity. These characteristics give the mixes a high level of breathability and favour the hygrometric regulation of the indoor environment, thus ensuring better liveability and healthiness.

BIBLIOGRAPHY

"...Perché gli intonaci possano avere una buona durata e non siano difettosi è necessaria una sgrossatura a base di cocciopesto e calce, che funge da collante tra le parti"
(Vitruvio "De Architettura", libro VII cap. IV, I sec. A.C.).



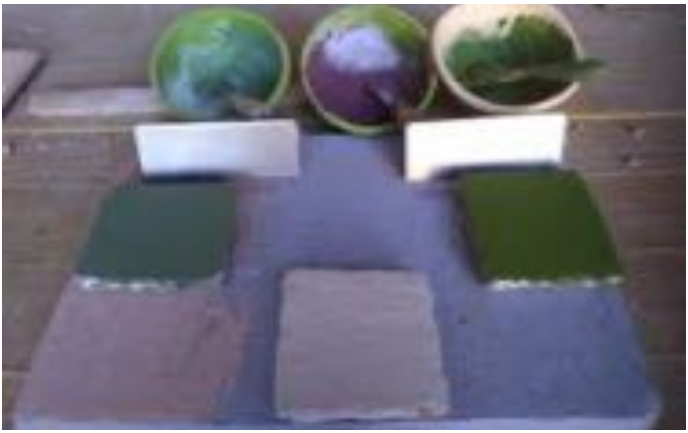
GUGLIELMINO
Malte naturali per la bioedilizia

GUGLIELMINO LABORATORY

The company uses an in-house laboratory in order to design mixes for mortars to be used in specific cases.

Projects that can be requested on an ad hoc basis are:

- Colours on request;
- Mortars with specific functions: breathability, dehumidification, consolidation... ;
- Stratigraphy by design;
- Production of sample products;
- Testing of innovative raw materials.



PRODUCTION OF EARTHENWARE PLAINTS

Giuseppe GUGLIELMINO
with **Fabrizio RAGUSA**

EARTHENWARE WROUGHT

The Guglielmino cocciopesto earthenware floor, based on natural hydraulic lime and cocciopesto, can be worked and laid using two different techniques, depending on the customer's needs and the characteristics of the environment:

- Double-layer beaten earthenware cicciopesto floor;
- Single-layer terracotta-tiled floor.

OTHER ADVANTAGES OF EARTHENWARE

Cocciopesto Guglielmino is produced from soft bricks and therefore has a lower specific weight and a high porosity. These characteristics give the mixes a high level of breathability and favour the hygrometric regulation of the indoor environment, thus ensuring better liveability and healthiness.

BIBLIOGRAPHY

The Romans called this execution technique 'opus signinum' (after the name of the city of Signiu, today's Segni). A 'terrazzo' floor (or Western earthenware) where a layer of high-quality mortar is mixed with terracotta powder, fired clay particles and individual white stones (usually limestone).

GUGLIELMINO
Malte naturali per la bioedilizia

EARTHENWARE MASH-UP

GUGLIELMINO" type cocciopesto paving, composed of a mixture of cocciopesto of various grain sizes, siliceous sands, volcanic fragments, carbonate sands, NHL 3.5 natural hydraulic lime, anti-shrinkage and structural fibres and a special water-retentive additive. The colours and grain are specially designed for the technical and environmental requirements and characteristics of the place where they will be laid.

Normally the finishing layer of pastellone is laid on a 'screed' with non-shrink characteristics.

PRODUCTION OF RAW EARTH PLASTER

Giuseppe GUGLIELMINO
with **Fabrizio RAGUSA**

ADVANTAGES OF RAW EARTH PLASTERS

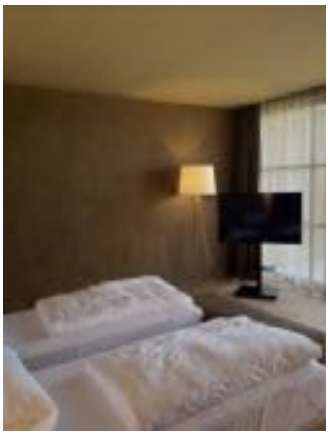
The main advantages of the 'unfired earth element' construction system can be summarised as follows:

- minimal use of fossil fuels;
- reduction of CO emissions;
- reductions in pollutant emissions (SO, NO, HF);
- optimal indoor climate, thanks to a high mass and a high capacity to regulate humidity;
- full recyclability.

LAYING TECHNIQUES

Worldwide, there are more than twenty traditional techniques based on the use of raw earth for building construction; however, these techniques can be grouped into two main types:

- The "wet" techniques The use of earth/clay/rammed earth formed in situ using formwork and water;
- The 'dry' techniques: the use of unfired clay bricks produced off site, industrially, and assembled on site.



GUGLIELMINO
Malte naturali per la bioedilizia

USES OF RAW EARTH

Walls with load-bearing capacity, dividing walls or external walls with a high degree of thermal insulation can be realised.In all cases, the wide range of installation techniques uses a mixture of gravel, sand, silt and clay in varying percentages. The consistency of this mixture varies from plastic to liquid, or the earth may be just a little damp.

OTHER ADVANTAGES OF RAW EARTH

For example, its good breathability allows for condensation-free walls. It has the ability to regulate air humidity, when the air is too dry or too humid. Indoor pollutants are absent, making it suitable for creating healthy environments. Also remarkable is its thermal inertia, i.e. its heat storage capacity and high thermal insulation coefficient. A quality that saves on heating running costs.








STRAW BRICK PRODUCTION

Giuseppe GUGLIELMINO
with **Fabrizio RAGUSA**

ECOPA PRODUCTS

ECOPA® products are designed with a view to sustainable building and a circular economy, and therefore essentially involve products made from natural, healthy materials and aggregates with very low energy consumption. These materials, in particular, have the advantage of being 0 km, easily available, low environmental impact, low emissivity, recyclable and/or recycled, biodegradable and easy to dispose of, thus limiting environmental risks.The ECOPA® proposal includes ideas and solutions suitable for insulation, construction, cladding and interior and exterior design.

GUGLIELMINO
Malte naturali per la bioedilizia

ECOPA®

Bioedilizia Mediterranea

BRICK ECOPA 2.0

It is a block consisting of two components: straw and natural lime mortar. In its appearance, it looks like an eco-brick in which the straw constitutes the raw material, the main mass, and the lime mortar the binder: the result is a high-performance insulating material with remarkable capacities.

As an eco-brick, it fulfils the main requirements such as mechanical strength, thermal conductivity, vapour permeability, fire resistance, strength-to-weight ratio and environmental sustainability.

The dimensions are 40x20x10 cm, so the eco-brick is lightweight, easily transportable and has excellent flexibility of use.

THE BASIC PROPERTIES ARE:

- Thermal insulation
- Acoustic insulation
- Breathability
- CO2 capture
- Decarbonisation
- Fire resistance
- Recyclability
- Healthiness

HOUSE THEATRE 'MARCELLO': WOOD AND STRAW

Danilo SCHININNÀ

BALES OF STRAW:

We use straw bale as an insulated brick, to build structures with high energy performance, exploiting the potential of a material that is actually waste in the food production chain. The sustainable house par excellence. Alternatively, we use wood fibre, cork, sheep's wool, etc.

DETAILS :

A wood and straw structure is the construction technique used for the building, plastered with raw earth from the site.

Ours is an ongoing research that spans time, as we revaluate many other materials used in the past. We have resumed the use of canapulo, a material that is well known in Italy, which, mixed with slaked lime, creates a simple but ec- ctionally effective thermal plaster.

We specialise in the use of unfired earth for plastering and flooring, and techniques such as tadelakt, an ancient Moroccan practice, which allows the imagination to run free in the creation of designer bathrooms.

> Raw earth floor.

MARCELLO HOUSE PLANTS:

The building has a dual significance: a house designed for living/living with contemporary comforts but with an eye on the great civilisations of times gone by.

MARCELLO THEATRE PLANTS:

A theatre in which there is Greece with the tiers of seats, there is Rome with the ellipsis, there is the Italian theatre, eli- sabettian, the Olimpico in Vicenza, EUR etc.

EAST ELEVATION, WEST ELEVATION, CROSS SECTION:

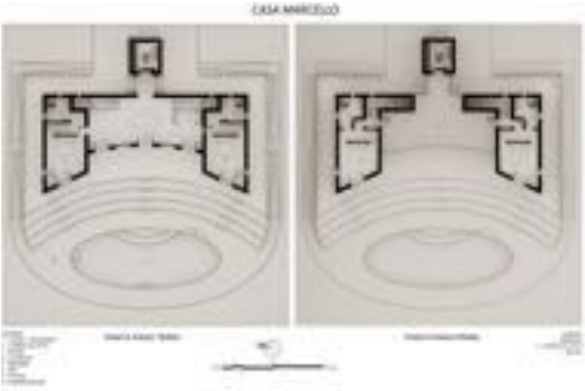
Theatre needs to embrace the stage. There is a need for everyone to see, a need for everyone to feel a man-made event or what nature gives us at every sunset.

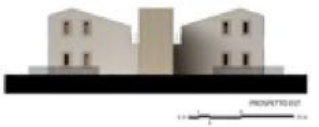
OVERVIEW, THEATRE VIEW 2:

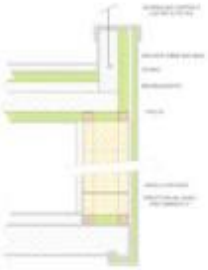
Marcello Theatre House, in memory of Marcello Perracchio.

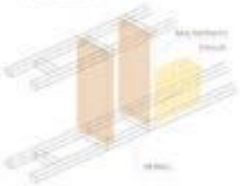
ENTRANCE VIEW:

It is positioned high up overlooking the sea. With the pool/spillway facing west. Because it is from the west that the thermal cooling comes. Because it is towards the west that the spectacular tragic event t









PRODUCTION OF BLOCKSIN COMPRESSED RAW EARTH

Abdelmalek GHANNEM

The SOIB factory produces the compressed and stabilised earth blocks. The production cycle lasts 28 days and goes through several stages such as sieving, kneading, pressing, cleaning and packaging.

SOIB is a joint-stock company under Tunisian law that was created in July 2009, its promoter is Abdelmalek GHANNEM, a former university professor who benefited from a leave of absence for business creation within the framework of the 2007 law on economic initiative. It started production in September 2010.

Raw earth is of interest to the building world today because it is a relevant response to the need for decarbonisation. But it also offers inertia and hygrometric qualities that contribute to thermal comfort.

The aim is therefore to use waste from mines, quarries and construction sites to turn it into building resources, i.e. to produce raw earth materials. Based on the logic of the supply chain, this makes it possible to realise buildings with low car- bones that are part of a more competitive economic process.

1. THE PRODUCT :

the SOIB industry manufactures the compressed and stabilised earth blocks. The shape of each brick allows it to be used without mortar; it is like playing LEGO. Brick is laid on top of brick without mortar. For this reason, drywalling can also favour self-construction and the presence of a technician will only serve to facilitate the first construction site.

The thickness of the blocks varies from22 cm for the boundary or outer wall of the house up to 6 cm for partitions. The 22 cm blocks replace the conventional fired brick wall of approximately 40 cm (in double partition

with anchor layer and internal and external plaster) this results in a 20% gain in living space for the customer who builds his house with blocks. He can gain an extra room.

2. THE ADVANTAGES OF ECOLOGICAL AND SUSTAINABLE BLOCKS:

1. RESPECT FOR THE ENVIRONMENT AND VALORISATION OF RAW EARTH WASTE

The blocks are produced under high compression, without the need for a baking oven. Drying takes place in the open air without the need for dryers. The raw material received can be 100 per cent utilised to manufacture the blocks. The large stones coming out of the sieve can be ground and returned to the production cycle.

The company sources its raw material from sites in the region (the waste from the old mine in Ghezala, the waste from the quarry in Sidi Salem, El Alia, Zouaouine and the waste from the iron mine in Tamra.

AN INNOVATIVE AND COST-EFFECTIVE SOLUTION:

SOIB construction is three times faster than conventional construction. The cost per square metre of masonry is considerably lower than the cost of conventional bricks. A bricklayer can easily lay 800 SOIB blocks (21 m² of wall) per day.

- Mortar is largely eliminated in the walls as the blocks are self-locking and dry laid, except in foundations and boundary walls.
- It does not require skilled labour.
- High strength has been demonstrated in SOIB structures, proving that they are considerably stronger than those built with traditional bricks. SOIB walls are highly resistant to earthquake damage.
- Excellent thermal properties.
- Very elegant finishes.
- The simplicity of the co-struction system.

4. AN ECONOMICAL SOLUTION IN ENERGY:

savings are translated by the negligible consumption of water (maximum 1.2 M³/day) and electricity (a simple 50 Amp meter), following the survey conducted by the National Energy Management Agency the company SOIB won the National Energy Efficiency Award in 2013.

TECHNOLOGICAL DESIGN FOR UNFINISHED BUILDINGS

Maria Luisa GERMANÀ, Francesca ANANIA

The phenomenon of unfinished buildings occurs in all conti- nents with varying degrees and frequency. Some examples are well known for their out-of-the-ordinary dimensions, but most of the time they are anonymous constructions, widely scattered throughout the territory, which disfigure the landscape and significantly lower the quality of the built environment.

In the Mediterranean region in particular, unfinished buildings are part of everyday life and can almost be understood as a symbol of a 'non-quality' building culture, which does not spare landscapes, historical cities and even archaeological sites.

They can be of public or private commit- tion, of varying consistency and level of completion, but some recurring technical characteristics can be summarised in the following points:

- In most cases, aerated concrete is the structural building material;
- no maintenance action took place after the work was stopped;
- surface finish layers are frequently omitted, which amplifies the typical physiological decay;
- Low-quality executions aggravate an already worrying pathological picture.
- The presence of unfinished buildings in Sicily is so high that a collective of artists has used the expression 'Sicilian Unfinished' to refer to the phenomenon, as if it were a 'style', regardless of location.

> Città dello sport in Rome, the most famous unfinished public work in Italy, designed by Santiago Calatrava for the 2009 World Swimming Championships.

> Utique is one of the Tunisian archaeological sites studied on the occasion of the APER Project Ar- chitecture domestique punique, hellénistique et romaine (financed by the Programme Italie Tunisie 2007-2013) and contains, in addition to important patrician residences, a number of burials in which the use of mud bricks is evidenced. An unfinished structure has stood at the entrance of the site for several years (photo M.L. Germanà, April 2023).

For a few years now, the ARCHSUD_LAB (Architectural Sustainable Design Laboratory) of the Department of Architecture of the University of Palermo has been conducting research on unfinished buildings, which has included design experiments on possible ways of completing some identified unfinished buildings.

In Tunisia, there is still a lack of studies investigating the phenomenon of unfinished constructions, which can be appreciated even by a non-observant observer..

The CUBÂTI Project has identified the phenomenon of unfinished buildings as a test bench that certainly and concretely sums up the concept of a quality construction culture and that deserves to be further explored, also from a cross-border perspective.

The circumstance of two PRIX CUBÂTI assigned, one in Sicily to TEM LAB and one in Tunisia to REG, has in particular allowed us to investigate the diagnostic methods of structural elements and the possibilities of reuse of demolition waste in the form of aggregates, such as concrete widely found in unfinished buildings.

The topic of unfinished buildings is still open, but the CUBÂTI Project has attempted to make a pragmatic contribution. In particular, in fact, the Project took advantage of the PRIX CUBÂTI assigned to TEM LAB to investigate the methods and instruments of analysis referring to an investigation protocol, still experimental, based on sensors aimed at assessing the state of deterioration of the structures of two unfinished buildings located respectively in Sicily, in Terrasini (PA), and at the CITET headquarters in Tunis.

> Unfinished construction and completion hypothesis (dissertation Project for the completion of the unfinished structure housing the former Magistrate's Court of Aragona by F. Vella 2017).

> Application of the TEM experimental protocol based on sensors for the detection of pH and chloride concentration in Terrasini and at the CITET site in Tunis (photo F. Anania, September 2023; M.L. Germanà, September 2023)

INNOVATIVE DIAGNOSTICS IN THE FIELD OF STRUCTURAL HEALTH MONITORING (SHM)

Angelo MULONE with **Fabio DI GANGI**

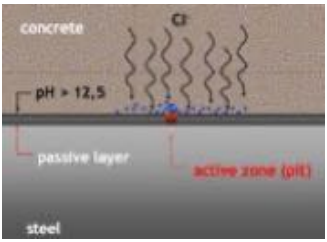
MONITORING THE RISK OF CORROSION AND DETERIORATION OF BUILDING STRUCTURES AND SAFEGUARDING THE HISTORICAL AND CULTURAL HERITAGE

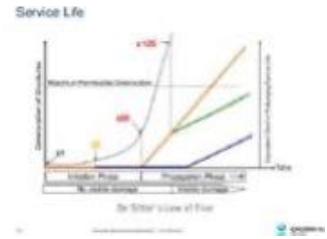
Predictive diagnostics using sensors

- Promoting smart and minimally invasive methods
- Remote and continuous monitoring of the health status of facilities
- Conservation and maintenance of structures for sustainable and lasting growth

BIBLIOGRAPHY

IL MONITORAGGIO DEL RISCHIO CORROSIONE DELLE ARMATURE MEDIANTE SENSORI INSERITI NEL CALCESTRUZZO. Dott. Angelo Mulone, Dott. Renato Giarrusso, Ing. Antonio Mulone, Dott. Mirko Andrea Vizzini Geolab srl Ing. Lorenzo Ceraulo, Dott. Antonio Mancino TEMLab srl Ing. Manuela Ceraulo, Ing. Rosalinda Inguanta, Prof. Francesco Paolo La Mantia Università di Palermo, Dipartimento di Ingegneria – INSTM
https://www.ingenio-web.it/pdfs/il-monitoraggio-del-rischio-corrosione-delle-armature.pdf





> Monitoring the condition of materials exponentially reduces repair and functional restoration costs. Sensor-based surveying also reduces survey costs by providing a functional service life forecast. The graph shows how a one-unit time delay in maintenance results in a 5-fold increase in repair costs.

> A concrete artefact instrumented with sensors for measuring pH and chlorine ions. The research conducted in the Geolab laboratories enabled the experimental verification of the accuracy of the measurements and the reliability of the procedure.

> Project MImeSIS 2022 SMART SENSORISED AND SUSTAINABLE MATERIALS FOR HISTORIC CONSTRUCTIONHISTORIC Experimental research in collaboration with the CNR of Faenza for the chemical-physical monitoring of historical mortars and plasters. In collaboration with Dr. Macchiarola Michele of the CNR-ISSMC-Faenza

TEMLAB

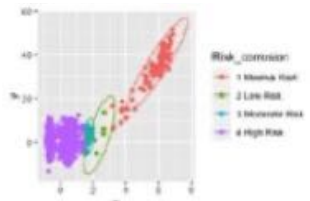
Team: L. Ceraulo, M. Di Maria, E. Gulli, F. P. La Mantia, A. Mancino, M. Vizzini

> Sensor covers.

> Viaduct Sharja - Dubai.

> Dashboard Grafana. ph and Cl monitoring online.

> Eng. pH Daniel Llort – Ministry of Energy and Infrastructure in UAE – Dubai – Sala controllo e monitoraggio con sensori TEMLAB.



> Gradients of sensors pH and Cl monitoring Ponte - Budapest.

RECYCLING OF WASTE FROM CONSTRUCTION DEMOLITION IN CONCRETE

Zakaria JAOUADI

TEXT 1: DEVELOPMENT AND VALIDATION OF AN ENVIRONMENTALLY FRIENDLY CEMENT BASED ON RECYCLED PRODUCTS FOR CONSTRUCTION APPLICATIONS: A SPECIALISED TREAD STUDY

Preparation of a mixture with 1 m³ of recycled products from construction waste and 100 kg of CPA cement, requiring the addition of water for impa- sibility.

Careful mixing to as- sure a uniform cement distribution and cohesion between the recycled waste particles.

- Achieving a homogeneous mix suitable for various construction or renovation applications.
- Casting a 1-square-metre tread with a thickness of 15 centimetres.
- Preparation of six standardised test tubes from excess cement for cleaning tests.
- Cleaning tests carried out by CETEC confirm the cement's ability to maintain its strength and integrity under cleaning procedures and different stresses.
- Positive results reinforce the quality and sustainability of the cement in the experimental tread, validating its use for specific applications due to its robustness against various conditions.

TEXT 2: VALORISATION OF RECYCLED CONSTRUCTION WASTE: FROM SEALING TO QUALITY WALL CLADDING

Sifting process of recycled construction waste, grain size 0/20, through a 0/4-gauge sieve=> Producing a clean, calibrated 0/4-gauge sand.

- Separation of elements <4 mm to obtain a fine, homogeneous sand, suitable for various applications.
- Preparing mortar for plaster and wall coverings:
- Mixture of 1 m³ of 0/4 calibrated sand with 100 kg of CPA cement.
- Incorporating water to achieve an ap- propriate consistency.
- Application of the mixture on a specific portion of the wall to reactivate and renovate the existing covering.

TEXT 3: OPTIMISATION OF ROAD RESURFACING: INNOVATIVE USE OF FRISA FOR A SOLID AND DURABLE BASE

- Use of frisa to obtain 0/14 grain size granules.
- Creation of a 10 to 15 cm layer along the surface of the roadway.
- Levelling and installation of the layer, followed by compaction over the entire surface.
- Heating of the mixture containing a percentage of cement to ensure cohesion of the granules by the bitumen.
- Result: A bitumen-impregnated surface used as the basis for a single- or double-layer bituminous coating.