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New Visions

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Preface

The XXXVI IAHS World Congress on Housing Science is organized by the Department of Architecture and Regional Planning, Indian Institute of Technology (IIT) Kharagpur.

The Congress brings together the leading premier Institute IIT-the brand name of which is known the world over and IAHS – a leading non-profit organization, which is a member of both the United Nations and ECOSOC.

The Congress will cover the various national housing programmes that have evolved the world over. It will address the issues of urban development and urban environmentalism. The effects of globalisation on housing, innovative housing finance schemes will feature among discussions. An emphasis will be given on new building materials like nano and low energy materials, and construction management concepts like simulation based optimisation process and best fit approach. Classical issues of slum and squatter settlement up gradation and provision of urban infrastructure will also be covered. The XXXVI IAHS World Congress on Housing provides an excellent forum to interact among housing scientists, experts, policy makers, real estate developers, managers and academics, among others, and show the new visions. The Congress will give delegates a better understanding and global perspective on housing science and may go a long way to improve the overall housing situation.

The global housing programmes have undergone several changes in the approach. The early fifties, the post-war rehabilitation period, mainly saw the government as an architect, trying to build buildings for the war returned soldiers. The gap of supply and demand however, kept mounting.

The sixties were dubbed as the 'Development Decade' by the UN. The focus was on Master Plan approach, government assuming the role of a planner. This approach also, over time, proved to be unsatisfactory and too prescriptive in nature. Moreover, the actual development often swayed considerably, from that projected and proposed in master plans.

By the seventies cities were reeling under the pressure of slums and squatter settlements. The government assumed the role of a provider. Slum improvement schemes, site and services schemes, and land banking approaches, among others, were tried.

The inadequacies of this approach soon started surfacing. There was always a paucity of funds and the government on its own, could not meet the demand for housing. The concept of public-private partnership evolved with the government's role changed from that of a provider to that of an enabler in the eighties.

The need for peoples's participation and importance of community based programmes were soon identified as essential for the success of any housing programme. In the nineties the government tried to act as a regulator and stressed on community based approaches.

The present decade envisages to permanently solving the problem of slums and advocates the concept of slum-less cities. It visualizes emergence of smart cities and realizes that housing programmes are basically functions of market driven economics.

There is a wide range of topics that will be covered during the course of the housing congress. These include:

Urban Development- Urban environmentalism**,** Effects of Globalisation, Real Estate boom**,** Peri-urban development, Public private partnership in housing and urban development.

Innovative Financing Schemes-reverse mortgage, cash reserve ratio, FDI in townships, Special Economic Zones.

Building Materials- New materials**,** Use of local materials**,** Recycling of materials**,** Nano materials**,** Low energy materials.

Provision of Infrastructure- Community participation in infrastructure planning, implementation, O&M**,** Alternative techniques**,** financing infrastructure

Construction Management Concepts- Feasibility analyses of projects**,** Best fit approach**,** Decision support systems**,** Project cost optimization techniques**,** Construction scheduling**,** Simulation based optimization approaches.

Slum and Squatter Settlements-Slum up gradation approaches, Slum networking, Slum-less cities.

Environmental Aspects- Green technology**,** Ecological housing**,** Rating of buildings**,** Rain water harvesting, recycling waste water

The congress it is expected will provide the best technical forum for discussion and interaction among internationally acclaimed delegates and key speakers. It will showcase some of the best housing approaches through field visits.

Finally, the congress will be a forum to experience a touch of Indian culture and tradition along with its image as an economic powerhouse.

Together we strive towards making it an experience to remember fondly: technically rewarding, culturally fulfilling and professionally challenging.

Prof S. Chattopadhyay

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Local stone quality performance: the case of “Sassi di Matera” (Italy)

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Abstract
The relevance of energy question brought the designers to study the technological-constructive solutions that are able to satisfy the requirements for energy conservation and indoor comfort that today are required to housing.
In fact, the industrial society development has brought a new materials onto the market and has developed increasingly complex construction technologies, leaving, on the contrary, materials and traditional building techniques, even though effective in some of their features.
The masonry stone, in fact, that represents one of the oldest technological systems in building production, is able to offer quality and functional performance, certainly comparable with the most modern and innovative systems and sub systems of the building; it’s enough to think, for example, to low impact that it produced on the surrounding environment and the low CO_2 unloaded into the atmosphere during its life cycle.
The experimentation has been verified in a case study, the ancient “Sassi di Matera” (Italy), a rather homogeneous - but strongly articulated - fabric of the city, entirely constituted by a calcarenitic stone, called “tufo”, which characterizes and defines its particular building.
And through tests “in situ” to monitor the indoor comfort (as low requests UNI EN ISO 7730 2006 e UNI EN ISO 7726 2002 , by directive CEE n° 106/89), the study aims to show how this masonry, built with local stone, provide to guarantee significant performance requirements, working as a "natural regulators” of indoor microclimate.

1 Introduction

The man action not simply reproduces the existing environment, but it turns producing a stratification of interventions based on management of the space. This transformation process is an irreversible step; it is an action that permanently change the image of each place, till to change significantly its shape. The instrument of this anthropization process of space is the stone, with its unique technical characteristics and morphological-formal ones.
Afterwards, the development of industrial society has been placed on the market new materials and developed more complex construction technologies; at the same time it has been abandoned materials and traditional building techniques, although they are still effective for some of their characteristics.
The masonry realized using the stone, in fact, represents one of the oldest technological systems; it is able to offer quality performance and functional certainly comparable with the most modern and innovative building systems and sub systems.
The research - included in a broader still ongoing study - aims to define the methodological and operational aspects of recovery interventions of the ancient “Rioni Sassi di Matera”. It starts from this specific architectural context, and suggests to explore the possibility to obtain quality performance requirements - required by the contemporary standards - also in buildings realized using traditional technical features and constructive systems.

Through monitoring "in situ", the research aims to highlight how these walls, made with local stone, are able to guarantee performance requirements, acting as "natural governor of indoor microclimate". The masonry respond to the current European energy regulations, although built with local materials and using traditional building techniques.

2 Traditional masonry quality performance

The easy workability of the stone has always allowed the use of square blocks as structural elements. The stone masonries, in fact, are throughout the national territory; it presents recurring problems, despite the variety of materials and techniques used.
The performance characteristics of the masonry change in relation to the function they have to perform: from those purely structural, which regards the correct functioning of static structure, to those relating to indoor comfort of the produced environments [1].
Unlike the rough stone wall, where irregular stone flakes leave a gap between stone and stone that must be filled with mortar. Instead interior spaces between stone and stone are usually filled with slivers of good mortar - reestablishing the neglected monolithic nature of wall - or with inconsistent material, realizing a particular typology of masonry, called "muratura a sacco". This particular structural type utilizes the great masonry inertia primarily to achieve the indoor comfort in the realized spaces [2]. The cavity inside the masonry, in fact, even if partially filled with inconsistent material, improves the isolation and transpiration capacity of the masonry, but, at the same time, represents a point of weakness of the static structure [3].
However, it is necessary also to operate an assessment on energy efficiency and sustainability of this technological systems. It's enough to think, for example, to low impact that it produced on the surrounding environment and the low CO_2 unloaded into the atmosphere during its life cycle. Despite, the production phase (extraction and processing) is a critical not resolved issue as to intensive use of renewable resources, to the production of waste - while potentially reusable! - and to the impoverishment of the environment. Instead, in phase of life and abandonment, they have a good level of sustainability, as easily maintainable and totally recyclable [4].
From these considerations it is clearly understandable the overall effectiveness of this technological system, as to render its recovery highly desirable.

3 Thermal materials feature

The masonries are crossed from heat flow, that depends from the difference of temperature between the two sides of masonry; and this can be maintained constant over time (steady state) or variable over time (dynamic state).
In steady state it is introduced a global exchange parameter, called "specific thermal transmittance", that is defined as the relationship between the specific heat flow exchanged and the temperature difference between the two fluids that exchange heat.
The heat flow transmitted through the wall is directly proportional both to the difference of temperature and to the comparition between the thermal conductivity and thickness of the material. This ratio *(1)* is called "specific thermal conductivity"

$$C = \lambda / s \ [W/m^2 K] \quad (1)$$

and it indicates the capacity of each material to conduct the heat.
Instead the heat transmission in thermal dynamic state is a complicated phenomenon, as it involved the participation of the mass of material to determine the thermal range and, then, the heat flow exchanged. In this case, the mass is able to accumulate or dispose heat by altering the heat flow distribution (Φ incoming # Φ outgoing) *(2)*. Referring to a wall thickness and considering an mass elements "dm", the energy balance is:

$$\Phi incoming - \Phi outgoing = (\Phi incoming - \Phi outgoing) d\zeta = dm \ cp \ dT \quad (2)$$

where cp is the material specific heat and dT is the variations of temperature suffered from the same time dζ.
Another material features is the thermal diffusion *(3)* defined by the ratio:

$$\alpha = (heat\ transmitted\ by\ conduction)/(heat\ stored) = \lambda / \rho\ cp \qquad (3)$$

4 The case study: the “Sassi di Matera” (Italy)

The case study is in a complex and significant architectural area: the ancient “Rioni Sassi di Matera” (Italy); they are at 401 mt above sea level and are characterized by aggregation of elementary cells - called the “neighbourhood” [5]. Here there is an enormous architectural heritage abandoned for over forty years and now the place of slow - but careful - recovery interventions, under the sponsorship of UNESCO since 1993 [6]. The quantitative dimension of this recovery operation strongly suggest the methodological problems of recovery of the built heritage.
In this area it has been identified some type dwellings, built with load-bearing masonry, realized with calcarenitic stone blocks and arranged around a central atrium - the “neighbourhood” – that are exposed to the South [7]. The compilation of data collected “in situ” was carried out by Infoflux software that allows to calculate the thermal conductivity according to the method of progressive medium and to the method “black box”. Through the integration of instantaneous flow heat data - two surface internal temperatures and two external ones – it is possible to obtain the value of thermal conductivity of the wall. Before proceeding to process the measured data, by means of the “black box”, it is essential to calculate the time lag.
In this regard, it has been drawn up a spreadsheet in Excel, according to UNI EN ISO 13786, which makes thermal dynamic parameters of a wall including the time lag. The calculation of the time lag on the wall structure is 16h 20'. This made it possible to make the calculation by both methods and to consider the average value as a result.

5 The measurements

The measurements were realized “in situ”, using a thermal camera, a termoflux, four thermocouples and a “multiacqusitore”. In this way it is possible to measure the main thermal characteristics of the different conventional walls realized with local stone, called “tufo” [8] [9]. The use of these instruments has made it possible to derive the parameters of the thermal structure, using a non-invasive method.
The use of thermal camera is indispensable to identify the unhomogeneities that are in the masonry. In addition, it is possible to identify the best place to position the instruments to realize the measurements [10].
The tests were conducted on walls with different thickness, realized with calcarenitic blocks stone (tufo) connected between them and linked by mortar of lime and cement.
The types choices is similar in form and in technical constructive; they were analysed by a “multiacquisitore” E-Log who have some probes, which made it possible to measure the parameters of thermal structures. The final configuration of the instruments may be summarised as follows:
- a “multiacquisitore” of physical E-Log;
- a “termoflux” to measure of heat flow through the structure;
- two thermocouples PT100 to measure the interior surface temperatures;
- two thermocouples PT100 to measure the external surface temperatures.

This configured instrument is used to measure thermal transmittance “in situ”. These measurements are realized according to ISO 9869 standard "Thermal insulatio - Building elements - In situ measurement of thermal resistance and thermal trasmittance". This type of measurements are highly innovative and, now, also the only non-destructive technique that allows to get the thermo-physical properties of a wall [11] .
During the measurements, which lasted throughout the month of July 2007, was analysed a wall with thickness of 48 cm, realized through the combination of two blocks of local stone (tufo) connected between them using mortar lime and cement. This structure is part of a ipogea structure, and it is the only space in direct contact with outdoor air. On the same masonry were carried out three different measurements, each with a duration of 10 days. This methodology has allowed to compare results from different measurements, avoiding error in the data processing.
The analysis of the data and the evaluation of subsequent thermal performance (fig.1, fig.2 and fig.3)

has been carried out by a study of the system in transitory state, through the methodology of medium progressive and methodology of identification "black box". The use of a double methodology (fig.4 and fig.5) permits a detailed analysis by eliminating possible errors of results assessment and obtaining more precise values of the derived thermal parameters (fig.6).

RESULTS METHOD OF PROGRESSIVE AVERAGE

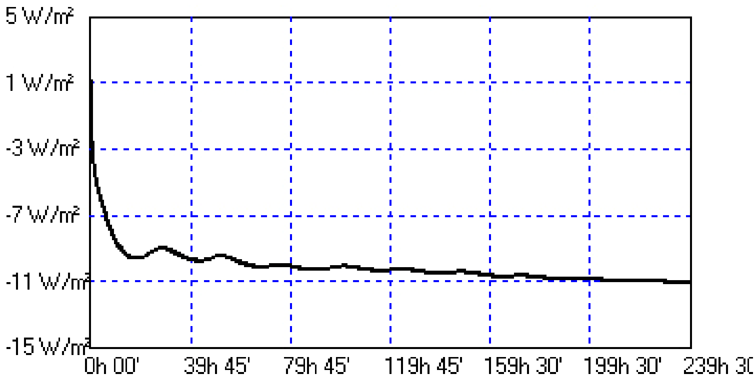

Figure 1 – Average Flow

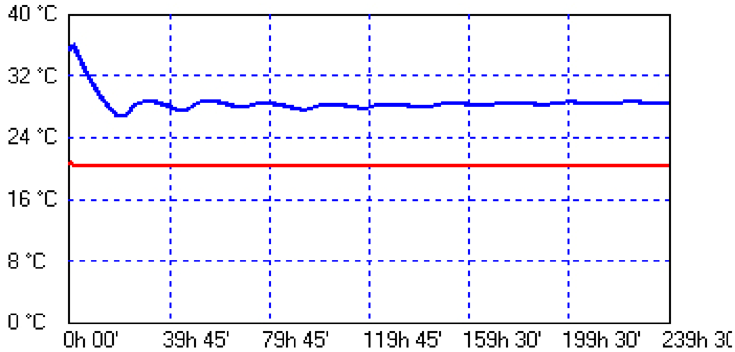

Figure 2 – Average Temperature

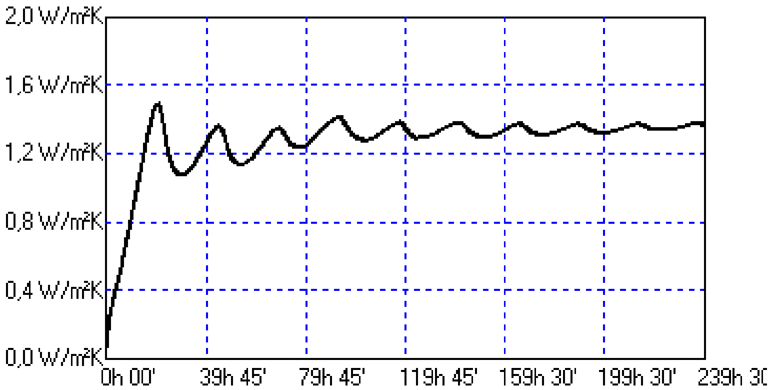

Figure 3 – Average Conductance

Given the lag time value in 16h 20', it is possible to consider as the results, the average value of the derived values with the two methods. So the final value *(4)* of transmittance is:

$$C = (1,36 + 1,16) / 2 = 1,26 \qquad (4)$$

The slight difference of the two values is due to the closeness in the applicability of the two methods. It knows the thickness of the wall and the value of transmittance *(5)*, it is possible to derive the specific conductivity, using the following operation:

$$\lambda = C \times s = 1{,}26 \times 0{,}48 = 0{,}605 \qquad (5)$$

Value		
Thermal Flux	-11,0374	W/m²
Indoor temp.	20,3271	°C
Outdoor temp.	28,4086	°C
Conductance	1,3658	W/m²K

Figure 4 – Progressive average table

Test model	
na	0 - 10
nb1	1 - 5
nb2	64 - 80
Tollerance	0.05

Figure 5 – Black-box results

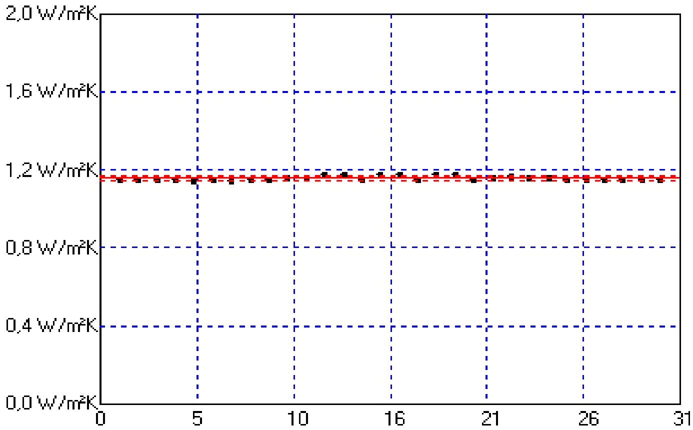

Figure 6 - Conductance

6 The analysis and measurements made in laboratory

In addition to the measurements “in situ”, it is carried out a series of laboratory analysis, that aims to measure the conductivity, diffusivity and thermal capacity of stone materials, that form the architectural structures of "Sassi di Matera”. The analyses are performed on three samples of local stone (tufo) derived from a single stone block. It is taken directly from the site and is size 145x80x40 cm. The tests performed are:

1. determination the volume weight;
2. determination the specific weight;
3. determination of water content;
4. determination of thermal conductivity λ (W/mK)
5. determination of thermal diffusività α (m²/sec)
6. determination of thermal capacity cp (J/m³K)

To realize the tests 4,5 and 6, it is used an instrument that uses the method of flat source or TPS method (Transient Plane Source) to measure the thermal properties of a material.
The analyses carried out in laboratory, in addition to thermal conductivity have also returned values of thermal diffusivity and thermal capacity. In this way it is possible to result the parameters regarding the inertial characteristics of the material. These parameters are indispensable when there are structures with high thermal inertia, like the "Sassi di Matera”.
Moreover, the thermal diffusivity and thermal capacity are very important parameters to calculate the lag factor (thermal lag, measured in hours), which is representative of the lag time of the element to leave the accumulated heat to the surrounding environment and attenuation coefficient or decrease

factor, that is the ratio between the width of thermal oscillation of average internal and external air temperature and the dominant cycle of 24 hours. From these two parameters it is estimated the wall thermal capacity, which is calculated experimentally by testing in the laboratory. In the following tables (table 1, table 2 and table 3), it is reported the synthesis of the results, obtained during the laboratory analysis on three samples of "tufo".

Table 1 – The results

Sample	Initial weight	Dry weight with Al	Dry weight after cooling with Al	Dry weight after cooling without Al	Volume	densità	H_2O
A	697,37	697,45	697,84	696,41	463995,3186	1501	1,35
B	779,56	779,54	780	778,52	503899,9532	1545	1,5
C	741,34	741,46	741,94	740,23	477621,3071	1550	1,59

Table 2 – The results

w% b.w.	w [kg/m³]		W% acquired after cooling
0,19	2,91	1,43	0,06
0,19	2,98	1,48	0,06
0,21	3,33	1,71	0,06

Table 3 – The results

conductivity	diffusivity*10^6	roci*10^-6	Tm [°C]
0,716	0,477	1,51	25,47
0,679	0,475	1,43	25,85
0,578	0,398	1,45	26,43
0,609	0,431	1,41	24,83
0,554	0,393	1,41	25,49
0,663	0,445	1,49	24,29
0,633	**0,437**	**1,448**	**25,4**

7 Conclusions

The first result is to have verified the constant trend of internal surface masonry temperatures (20°C, constant throughout the period). This value corresponds to a minimum outside, reached during the period. Indeed against a trend of external surface temperatures, ranging from a maximum of 41°C to a minimum of 20°C, the internal temperature remained constant (20°C), less than small daily oscillations (± 0.3°C) (fig.7, fig.8 and fig.9).
This permits to affirm that the local stone is excellent to accumulate heat and that it is able to balance the high diurnal external heat. In fact, the high lag heat lag (> 16°C) permitts to this material to accumulate heat during the day and to return it to the surrounding environment during the night.

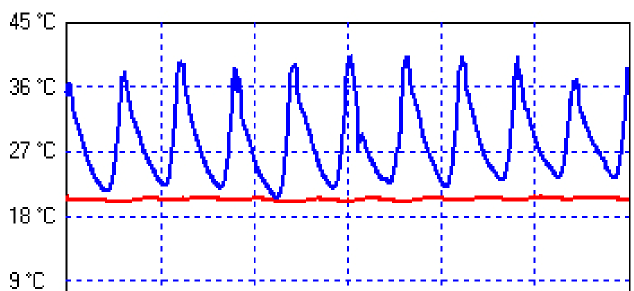

Figure 7 – Results of temperature data

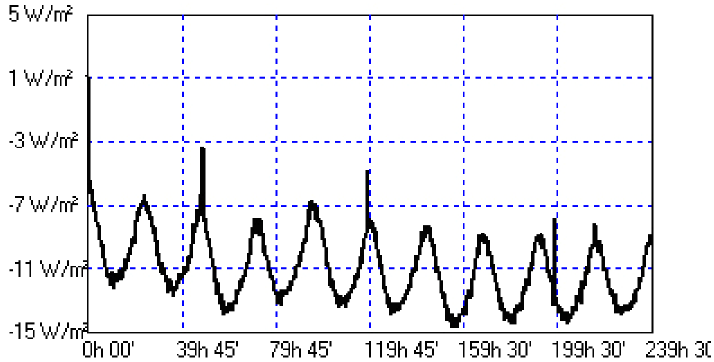

Figure 8 – Results of flux data

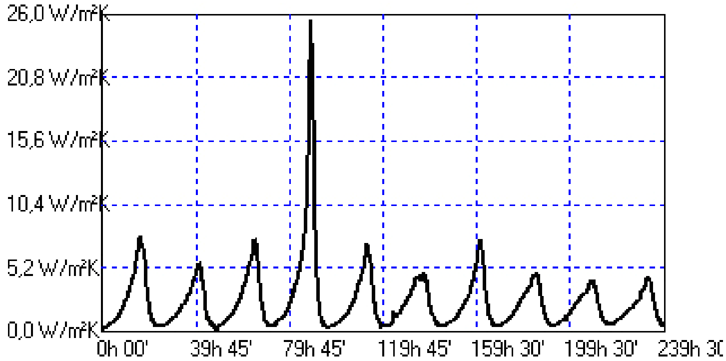

Figure 9 – Results of instant conductance data

Another interesting result is that the measures carried out in this study are very precise, since the parameters deviations of thermal transmittance are the order of 5%; and considering the great number of used variables, this mistake is the smallest ones, so it is fully acceptable. Moreover, the measurements, compared to those in the laboratory, can better describe the actual behaviour of the structure exposed to the different external climate condition, because this condition is hardly reproducible in the laboratory.

Finally, through laboratory testing is possible to derive the specific parameters that regards the thermal inertia of material, the diffusivity and the specific heat, indispensable to carry out any investigation in a dynamic system.

The analysis of these parameters allows to affirm that the local stone of Matera (tufo) has an excellent thermal behavior, because it has a good relationship between the thermal conductivity and thermal capacity. So it is enough having a wall of 45 cm to realize a structure that meets the current regulations regarding insulation and, at the same time, to have an excellent response to the high thermal loads in summer. Indeed a wall built with limestone blocks with a thickness of 45 cm has the minimum of thermal transmittance parameters required by current legislation and, at the same time, has a heat capacity and thermal diffusivity that are able to damp the high summer. In conclusion it is possible to say that the structures of the "Sassi di Matera" fully respond to current thermal-humidity requirements required by modern building envelopes.

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