MESSINA'S HISTORICAL BUILDINGS AFTER THE EARTHQUAKE OF 1908: ENERGY AND ENVIRONMENTAL ANALYSIS THROUGH A GLOBAL SCREENING METHODOLOGY

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ABSTRACT

Messina’s historical heritage rebuilding after the earthquake of 1908 was almost exclusively directed both to ensure the static safety of structures and casings and giving new dignity through a rich aesthetic language and preserving the historical identity of the urban fabric. This approach did not keep into account all the buildings energetic response and the optimization of occupants comfort. From here, the need to prepare swift and exhaustive methodology of analysis of the building performance level both in terms of conservative asset than energy performance. Once you have identified the overall criticalities through the monitoring campaign, the scenery is enriched by data derived from indoor comfort perception, obtained by administering an appropriate survey. In this paper it was analyzed the Palazzo dei Leoni’s energy vulnerability, the current seat of the Province of Messina, subject of reconstruction in 1914 after the earthquake and chosen as a case study. The validity of the suggested screening methodology lies in potential applicability to any fine building , subject to post-conflict or post-seismic, needing an energy retrofit, supported by a preliminary investigation of the building’s potential decays performance and of the level of indoor comfort.

1. INTRODUCTION

The present work deals with historical-architectural Messina’s energy vulnerability after the earthquake of 1908 through the development of an original screening methodology that takes into account building current response performance, with particular regard to the occupants’ welfare. This need derives from the particular planning process leading the post-earthquake reconstruction during the twentieth century’s first decade.

This was attended by two main factors: first of all the aesthetic language revival of Messina’s ancient splendor and buildings structural safety ensuring, as second.

The only one aspect to be totally underestimated was the one regarding buildings energy sustainability, considering the imminent need of giving back to the city its lost identity, as soon as possible.

Once established special commissions, a very quick and rational urbanization program plan was soon developed. It had intended to identify most appropriate tools for new buildings seismic safety, including the “*baraccata*” technique, a sort of confined masonry and prefabricated systems, in addiction [**1**].

To date, this kind of approach is the expression of an architectural heritage of great value not only from pure aesthetic and formal point of view but also technical and manufacturing one.

2. ENERGY VULNERABILITY OF POST-RECONSTRUCTION BUILDINGS

As already mentioned, the technical approach reserved for severely damaged existing architectural was not linked with a real attention to the related issues of energy sustainability. The energy performance consideration after reconstruction was mainly settled in buildings enclosure response above all in terms of passive thermal inertia (compactness of the wall texture and thickening of the extensive decorative equipment) [**2**].

The technical solutions taken, in spite of the changes and additions accumulated over time, are now inadequate to meet the performance requirements imposed by Community rules and regulations.

In this scenario an energy-performance evaluation obtained both by the diagnostic screening and the assessment of indoor wellness are therefore settled to examine the weight of each building anomaly detected, making this information easily accessible in graphical form.

3. DIAGNOSTIC SCREENING METHOD APPLIED TO A SELECT CASE STUDY

With this spirit, a new screening environment method has been developed.

This new approach takes into account both the physical and technological system response (Par 3.2) and the perception of those living the confined environmental system (Par 3.3).

3.1 The study case: il Palazzo dei Leoni

Within the scenario of Messina architectural after reconstruction the case study detected has been the Palazzo dei Leoni (1912) now seat of the Province of Messina. Shown below an indication of the floor plan complex with areas being monitored identification (Fig. 1).

The originality of the method proposed lies in its distinctive characteristics: over all versatility and flexibility in relation to the building use function.

The speed management by the operator - through an application form - and the possibility of immediate detection of problems and strengths of the environments dampens costs and times of long and detailed investigation thorough instrumental control of microclimatic conditions [3] [4], typical of indoor environmental monitoring focused on preservation of cultural heritage.

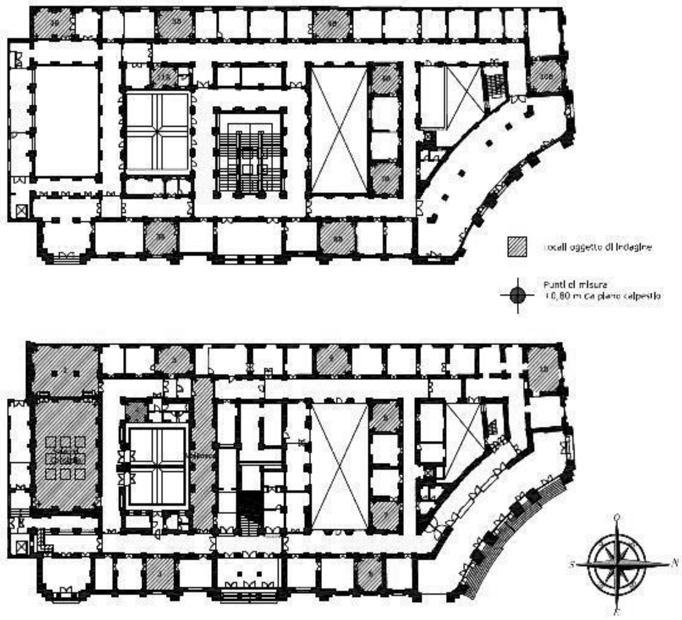

Fig 1. Palazzo dei Leoni, Messina - Plan of the complex with identification of areas monitored

3.2 Overall building condition analysis through diagnostic screening

The baseline screening is defined through a preprinted application form: a sort of "template" able to analyze the actual artifact preservation conditions per sub-components [5], through its virtual decomposition.

The form is founded on the virtual building decomposition in constructive elements (foundations, structures in elevation, roofing, vertical connections), decorative ones (floors, walls, inside and outside decoration), fixtures and frames.

Such graphic organization follows the tracing developed by italian ICR (Istituto Centrale per il Restauro) [6].

This allows the integration and the compatibility of data collected with those belonging to the "Risk Map", unifying and simplifying cataloguers' activities.

The experimental application on the study case proposed is shown in Table 1 : the item (I) indicates the level of inspectionability of the specific element by the operator.

The scale ranges from 0 to 5, whether if in part or in toto: 0 = impossibility of inspecting, 1 = 1-20%, 2 = 21-40%, 3 = 41-60%; 4 = 61-80%, 5 = 81-100%.

For each sub-component investigated it has been also identified a potential cause of the degradation factor (mechanical, physical or biological) and the intensity level of damage estimated, thus referring to well-known parameters: Severity, Extent of damage, Urgency.

For an immediate reading, different emergency levels have been identified with three colors: green (meaning action required but not priority), yellow (meaning average intensity of damage, requiring not a priority action but liable to negative developments), red (serious damage, compromising the considered element use) and numerical levels.

As can be seen, the application form provides a vacant space in which the operator can record the presence of any critical specific assessments and/or the degree of global conservation level to support and enrich the analysis led by the previous scheme [7].

Tab. 1. Palazzo dei Leoni: screening application form

					SEVERITY			EXTENTION %						URGENCY		
	TIPOLOGY	I	SITE	EXPOSITION	0	1	2	L/D	20	40	60	80	100	1	2	3
CONTET	ZONE	0		Industrial Zone												
		1		Coastal area												
		2		Metropolitan Area												
		3		Altitude >1000m												
		4		Note:												
		5														
INSTALLATIONS	WATER SUPPLY	0		Absence												
		1		Inefficiency												
		2		Inadequacy												
		3		Note:												
		4		Toilet present and working												
		5														
	ELECTRICITY	0		Absence												
		1		Inefficiency												
		2		Inadequacy												
		3		Note:												
		4		Lighting system present and working												
		5		Video surveillance system does not exist												
	AIR TREATMENT	0		Absence												
		1		Inefficiency												
		2		Inadequacy												
		3		Note:												
		4		Air treatment system absent												
		5														
STRUCTURES	FOUNDATIONS	0		Generic degradation												
		1		Materials												
		2		Humidity												
		3		Biological attacks												
		4		Superficial Alteration												
		5		Missing parts												
	VERTICAL	0	B	Generic degradation				L								
		1		Materials				L								
		2		Humidity				L								
		3		Biological attacks												
		4		Superficial Alteration				L								
		5	A	Missing parts				L								
	HORIZONTAL	0		Generic degradation				L								
		1		Materials				L								
		2		Humidity				L								
		3	C	Biological attacks												
		4		Superficial Alteration				L								
		5		Missing parts				L								

					SEVERITY			EXTENTION %						URGENCY		
	TIPOLOGY	I	SITE	EXPOSITION	0	1	2	L/D	20	40	60	80	100	1	2	3
DECORATIONS	COVERAGE WATERS AND DISPOSAL	0		Generic degradation				L								
		1		Materials disintegration				L								
		2		Humidity												
		3		Biological attacks												
		4		Superficial Alteration				L								Superficial
		5		Missing parts												Missing parts
	EXTERNAL FLOORS	0		Generic degradation				L								
		1		Materials disintegration												
		2		Humidity												
		3		Biological attacks				L								Biological
		4	E	Superficial Alteration				D								Superficial
		5		Missing parts												Missing parts
	INTERNAL FLOORS	0		Generic degradation												
		1		Materials disintegration												
		2		Humidity												
		3		Biological attacks												Biological
		4		Superficial Alteration				L								Superficial
		5		Missing parts												Missing parts
	COATINGS AND INTERNAL DECORATIONS	0		Generic degradation												
		1	F	Materials disintegration				L								
		2		Humidity												
		3		Biological attacks				L								
		4		Superficial Alteration				L								
		5		Missing parts												
	INTERIOR WINDOWS	0		Generic degradation				L								
		1		Materials disintegration												
		2		Humidity												
		3		Biological attacks												
		4		Superficial Alteration												
		5		Missing parts												
	EXTERIOR WINDOWS	0		Generic degradation				L								
		1		Materials disintegration				L								
		2		Humidity												
		3	G	Biological attacks												
		4		Superficial Alteration				L								
		5		Missing parts												
	Note:															

3.3 Indoor comfort analysis

If the analytical screening is quite useful to frame the criticalities in the first instance, the subsequent study of the microclimate is configured as a key step to analyze the well-environment interactions.
The thermal index reflecting physical and physiological variables' influence mentioned above in a more accurately way is the PMV, ie the Predicted Mean Vote.
By PMV derives a second index called PPD, predicted percentage of unsatisfied, which quantifies the percentage of unsatisfied people in any case.
With reference to PPD, UNI ISO 7730 classified buildings into three classes: A - Stricter thermohygrometric conditions (-0,2 ≤PPD≤+0,2), B - Intermediate thermohygrometric conditions (-0,5≤PPD≤+0,5) and C- Optimum thermohygrometric conditions (-0,5 ≤PPD≤+0,5).
For each the norm has set the values considered optimal for temperature and air velocity [8].

Tab. 2. Hygrothermal indicators and individual well-being parameters shown for each environment under investigation.

Room	Ta (°C)	RH (%)	T_{mr} (°C)	As (m/s)	Clo	Met	PMV	PPD
Boardroom	26,15	53,42	27,8	0,035	1	1,2	**1,3**	**39,2**
2	24,92	56,97	24,5	0,042	1	1,2	**0,8**	**19,2**
3	25,37	47,87	25,5	0,025	1	1,2	**0,9**	**22,3**
4	25,67	54,47	25,0	0,025	1	1,2	**0,9**	**23,7**
5	24,80	57,65	24,2	0,040	1	1,2	**0,8**	**17,6**
6	25,15	53,52	24,6	0,025	1	1,2	**0,8**	**19,5**
7	25,52	58,90	25,0	0,035	1	1,2	**1,0**	**24,4**
8	26,00	56,40	25,0	0,032	1	1,2	**1,0**	**26,1**
9	25,62	57,12	25,0	0,027	1	1,2	**1,0**	**24,2**
10	25,12	57,52	24,9	0,015	1	1,2	**0,9**	**21,4**
Library	24,02	51,40	24,9	0,017	1	1,2	**0,7**	**15,3**
2B	24,675	55,35	25,3	0,275	1	1,2	**0,6**	**12,7**
3B	24,95	52,60	26,0	0,022	1	1,2	**0,9**	**23,7**
5B	25,37	47,67	26,4	0,017	1	1,2	**1,0**	**26,0**
6B	25,80	55,40	27,1	0,015	1	1,2	**1,2**	**34,0**
7B	26,17	51,17	26,1	0,032	1	1,2	**1,1**	**30,1**
8B	26,30	47,97	26,1	0,022	1	1,2	**1,1**	**29,5**
9B	25,30	45,95	26,2	0,015	1	1,2	**1,0**	**24,2**
10B	25,35	54,80	25,6	0,057	1	1,2	**1,0**	**24,5**
11B	27,12	49,30	27,5	0,015	1	1,2	**1,3**	**42,3**
Mirror Room	25,80	53,70	25,5	0,035	1	1,2	**1,0**	**26,3**

For each the norm has set the values considered optimal for temperature and air velocity [8].
In Palazzo dei Leoni, the threshold values have been acquired through the assessment of two different aspects: the objective one by measurements of physical and technical quantities - obtained by the multi-datalogger tool "Babuc" - and the subjective one through the individual perception of welfare conditions by administering targeted questionnaires to the occupants.
The questions, relating to the perception of overall environmental subjective tolerability, are focused on the individual sensation felt about thermal and visual comfort, noise and air quality [9].The monitoring of thermo-hygrometric parameters was conducted in May-June 2012. For each environment, Table 2 on the left side shows the experimental data of thermo-hygrometric parameters recorded.
These gathered data are completed by the individual well-being parameters collected: occupants' metabolic activity (Met), thermal resistance of their clothing (Clo), and thermal comfort indexes which are PMV and PPD, referred to above.
Rooms examined for environmental monitoring, dashed (previous Fig.1), were then sampled as representative for morphology and function: the Council Hall, the Library on the ground floor and the Hall of Mirrors at first.
Other rooms on both floors have been identified as interested thanks to their different exposures, mainly occupied by offices.
The following table (Table 3) shows the data on the subjective feeling of indoor comfort derived from questionnaires given and related to UNI 7730 requirements. The allowable values are identified in green, the critical values in yellow and impermissible values in red, not appreciable in present publication.
From the examination done and despite the experimental measurements campaign was conducted during the spring / summer – with thermohygrometric conditions not particularly critical - the various rooms monitored turn out to be not always adequate, in different ways.
For them, PMV and PPD values deviate from the optimal ones indicated in Standard.

Tab. 3. Answers' distribution of the sample interviewed

	SAMPLE PEOPLE INTERVIEWED ANSWERS' DISTRIBUTION												
		THERMOHYGROMETRIC COMFORT			A	**ACOUSTIC** COMFORT			B	**VISUAL** COMFORT			C
	ROOM	Feeling	Comfort	Preference	Tolerability	Feeling	Comfort	Preference	Tolerability	Feeling	Comfort	Preference	Tolerability
FIRST FLOOR	Boardroom	-	-	-	-	-	-	-	-	-	-	-	-
	2					-	-	-	-	-	-	-	-
	3	0	-1	0	0	-2	-1	-1	0	0	-1	0	0
	4	2	-1	-1	0	0	0	0	0	2	0	-1	0
	5	0	-1	0	0	-1	0	0	0	0	-1	1	0
	6	2	-1	-1	0	-1	-1	-1	-1	0	0	0	-0,5
	7	0	0	0	0	-1	-1	-1	0	0	0	1	0
	8	0,66	-0,33	-0,33	0	-0,6	-0,6	-0,6	-0,33	0	0,33	0,33	-0,33
	9	1	-1	0	0	-3	-2	-1	0	-2	-1	2	0
	10	0,4	-0,4	-0,4	-0,2	-1,8	-1,4	-1,8	-1	0,6	-0,4	-0,8	0
SECOND FLOOR	Library	1	-1,4	-0,8	-0,8	-0,4	-0,4	-0,4	0	-1,6	-1,2	1,4	-1
	2B	0	0	-1	-1	-2	-2	-2	-1	0	0	1	0
	3B	2	-1	-1	-1	0	-1	-1	-1	2	0	0	0
	5B	0	0	0	0	-1	-1	-1	0	0	0	0	0
	6B	0	0	0	0	0	0	0	0	0	0	0	0
	7B	1	-1	-1	0	0	0	0	0	2	0	0	0
	8B	2	-2	0	-1	-2	-2	-3	-1	3	-1	0	-1
	9B	1	-1	-1	0	0	0	0	0	2	0	0	0
	10B	0	0	0	0	-1	-1	-1	-0,5	0	0	0	0
	11B	1	-1	-1	0	0	0	0	0	0	0	0	0
	Mirror Room	-	-	-	-	-	-	-	-	-	-	-	-

4. CONCLUSIONS

The validity of the screening methodology proposed lies in the potential applicability to any fine building subjected to historical-architectural or post-conflict or post-seismic. Towards them, it is often necessary an energy retrofit, supported by a preliminary investigation of both the potential performance decays and levels of indoor comfort.
Such energy vulnerability assessment of existing buildings - whether they are subjected to restriction themselves, containers of goods to be preserved or hosting special functions - may be applied by operators with extreme rapidity. This new approach achieves a desirable savings of economic resources in the face of a better exhaustiveness of the data collected and identified criticals types.
The methodology contributes to the definition of the basis for a correct programming of any energy strategies of action later. For example, a potential action for this type of buildings could consist in proposing technical solutions aimed at optimizing the radiative exchanges through the installation of low emissivity glass in the context of large surfaces existing window.

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