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1.2.1. STUDY OF MOST USED MATERIALS IN ITALIAN CONSTRUCTION SECTOR

OERCO2
ONLINE EDUCATIONAL RESOURCE FOR INNOVATIVE STUDY OF CONSTRUCTION MATERIALS LIFE CYCLE

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Consortium members: Universidad de Sevilla (US), Asociación Empresarial de Investigación Centro Tecnológico del Mármol, Piedra y Materiales (CTM), CertiMaC Soc. Cons. a r. L. (CertiMaC), Centro Tecnologico da Ceramica e do Vidro (CTCV), Universitatea Transilvania din Brasov (UTBV), Asociatia Romania Green Building Council (RoGBC).

1. Introduction

Nowadays, construction sector is increasingly involved in environmental sustainability issues, due to the strong activity that this sector has experienced in the last years, causing an environmental deterioration through excessive natural resources consumption and massive amounts of energy required to produce construction products, from the raw materials extraction to the industrial process (drying, firing, etc.) to the final transport into the building site. Indeed, intensive use of natural resources, solid and liquid wastes generation, gas emissions through the entire process and demolition activities have very strong negative impact on the environment. Several relapses are now well estimated, such as: the progressive increase of the temperature (global warming) due to the CO2 emissions, the worsening of air quality, etc.

The building sector's environmental impact is enormous. It is responsible of:

- 40% of the natural resources extracted in the industrialized countries;
- consumption of 70% of the electricity generated at worldwide level;
- consumption of 12% of potable water;
- production of 45-65% of the waste disposed to landfills.

Moreover, it is expected to increase, due to the growth in global population from 6,5 billion in 2005 to approximately 9,0 billion in 2035 [1]. According to this scenario, the reduction of energy consumptions by means of energy efficiency measurements and the use of energy from renewable energy sources in buildings construction become of primary importance.

Relating to these issues, selection of construction materials is strictly involved in sustainability matters. In fact, materials are involved in the whole constructive process. For this reason, sustainability in constructions aims at achieving the minimum negative environmental impact necessary to obtain the same performances and functionalities usually requested to the buildings.

Environmental sustainability of buildings can be assessed from two different point of view. On one hand is possible to approach the environmental impact evaluation considering the building as a whole, as a complex system/organism itself, while on the other hand, it's possible to deepen the level of analysis investigating the environmental impact of construction technologies, building elements and components.

At this regard, considering the complexity of a building system, every aspect has to be considered to achieve a sustainable construction. Sustainable materials (e.g. natural or recycled materials) play an important role because of less energy is generally required for their production, usage and end-life management than the energy needed for conventional materials. Moreover, renewable energy sources implementation constitutes a key step in lowering the environmental

impact of the construction sector [2].

For this reason, sustainability in construction sector is achieved through the consideration of several factors, as utilization of sustainable materials, implementation of renewable energy sources and lower energy consumptions. At this regard, several European Regulations and Standards on sustainability of construction works were issued, established by Technical Committee CEN/TC 350 [15], in order to minimize environmental impact, greenhouse gas emission or consumptions of raw materials and improve energy efficiency. Italy adopted these technical standards, among which, for instance:

- UNI EN 15643:2010 on sustainability assessment of buildings; [16]
- UNI EN 15978 on environmental performances of construction works; [17]
- UNI EN 15804:2014 on environmental product declarations. [18]

Moreover, in European countries, EU directives have already introduced severe limits and restrictions on energy consumptions in building. For instance, residential building (both new building and refurbishment ones) have to comply with:

- EU Directive 2010/31/EU - known as “EPBD Recast”, that establishes minimum requirements of energy performances and introduces Nzeb (Near Zero Energy Buildings) definition; [19]
- EU Directive 2009/28/UE on the utilization of renewable energy sources. [20]

These European directives were then adopted by Italian legislation through the issue of Law Decree 63/2013 [21] - on energy performance in construction sector – and Legislative Decree 28/2011 [22] – on the utilization of renewable energy sources.

In this context, materials and constructive systems selection play a pivotal role in the achievement of environmental impact reduction resulting from construction sector.

2. Evaluation of Italian building heritage and most common materials and solutions used in construction sector.

2.1 Italian building heritage: current situation of existing building stock.

Italian building heritage can’t be defined as “recent” nor as efficient: some recent statistics show that the 63,8% of existing buildings were built before 1972 (equal to 7,2 million of buildings). This means that nowadays about 76% of existing building is more than 40 years old, age fixed as a threshold after which refurbishment or strong maintenance are necessary. [3]

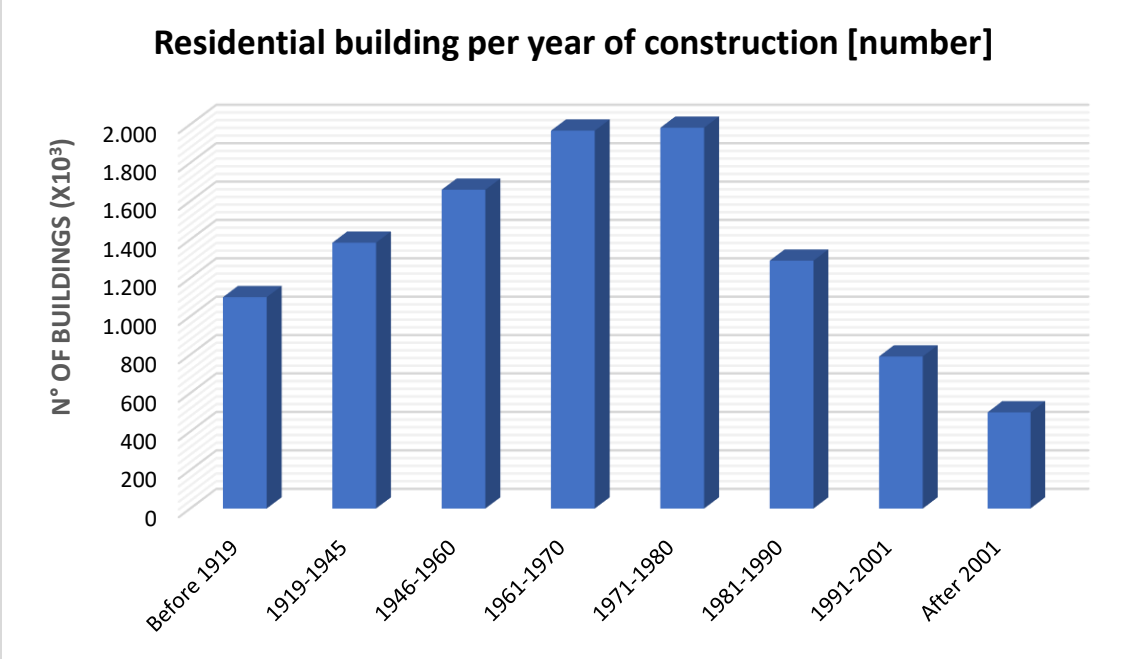

Table 1 – Number of residential building per year of construction. Source: CRESME

According to the last census made on 2011 by ISTAT – National Institute of Statistics- about 70% of Italian population lives in buildings with more than 30 years old. With reference to the year of construction, it's possible to define the correlation between population and buildings age (in percentage) [4]:

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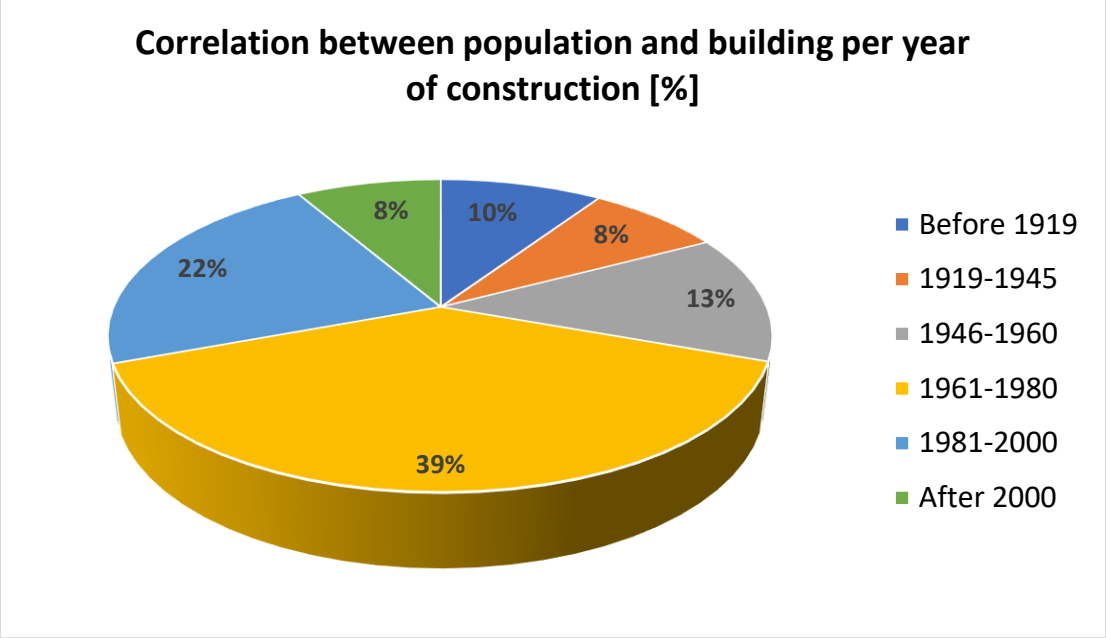


Table 2 – Correlation within Italian population and buildings per year of construction [%] – Source: assessment from Istat data by "Centro Studi sull'Economia Immobiliare – CSEI Tecnoborsa"

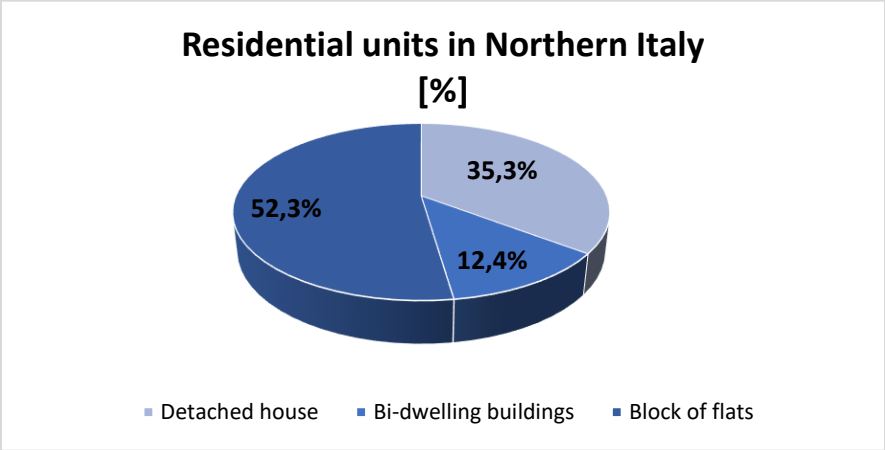
From data described above it's possible to deduce that Italian "construction boom" occurred within 60's and 80's.

According to ISTAT data (2011), Italian territory has 14.515.795 buildings as a whole, which 84,3% (equal to 12.187.698 of buildings) concerns to residential buildings, while the remaining no-residential buildings are subdivided as follows:

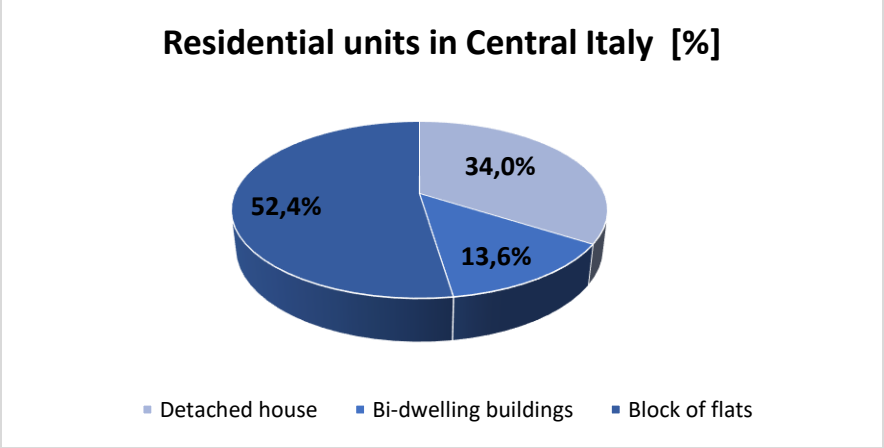
- 24% Trade sector (shops, supermarkets, etc.)
- 27% Schools and Office
- 30% Hospitals
- 19% Hotels and Restaurants

For what concerns residential units in Italy, they are currently of about 31.208.161, which are subdivided in Italian territory as following:

- 41,8% Northern Italy
- 16,5% Central Italy
- 41,7% Southern Italy



Graph 1 – Percentage of residential units in Northern Italy – Source: assessment from Istat data by "Centro Studi sull'Economia Immobiliare – CSEI Tecnoborsa"



Graph 2 - Percentage of residential units in Central Italy – Source: assessment from Istat data by "Centro Studi sull'Economia Immobiliare – CSEI Tecnoborsa"

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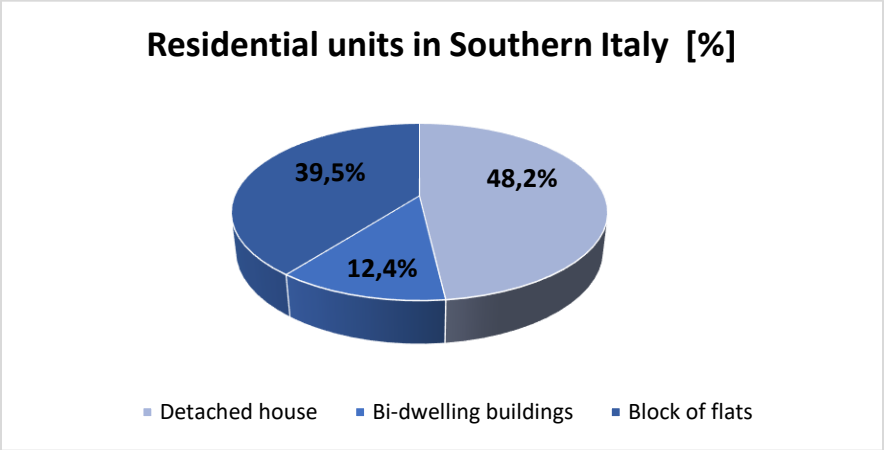

Graph 3 - Percentage of residential units in Southern Italy – Source: assessment from Istat data by "Centro Studi sull'Economia Immobiliare – CSEI Tecnoborsa"

With reference to the number of floors, buildings are subdivided in:

- 37% Buildings with 2 floors
- 40% Buildings with 3 – 5 floors
- 14% Buildings with more than 5 floors

The trend of construction buildings per year described above confirms the old state of Italian building heritage, and according to this it's possible to define the correlation between year of construction and constructive techniques most used:

- up to years 1920-1930, constructions have been built only with load bearing masonry,
- from 1930 to 1970, load bearing masonry began to be replaced even more often by reinforced concrete frames;
- after 1970, a predominance of reinforced concrete frame is registered.

Moreover, it's possible to correlate materials mainly used with the period of construction. For instance, until 40's, the most commonly used materials were bricks – for load bearing masonry – and wood – used in flooring system. After 50's, reinforced concrete has replaced bricks for constructive solution and flooring system.

The number of buildings (in percentage) can be approached furthermore per year of construction and constructive technique as follow (in this case data referring to ISTAT census of 2001) [5]:

Year of construction	Constructive solution		
	Load bearing masonry	*Reinforced concrete frame*	*Other*
Before 1919	2.026.538	0	123.721
1919-1945	1.183.869	83.413	116.533
1946-1960	1.166.107	288.784	204.938
1961-1971	1.056.383	591.702	319.872
1972-1981	823.523	789.163	370.520
1982-1991	418.914	620.698	250.890
1991-2001	228.648	394.445	167.394
Total	**6.903.982**	**2.768.205**	**1.554.408**

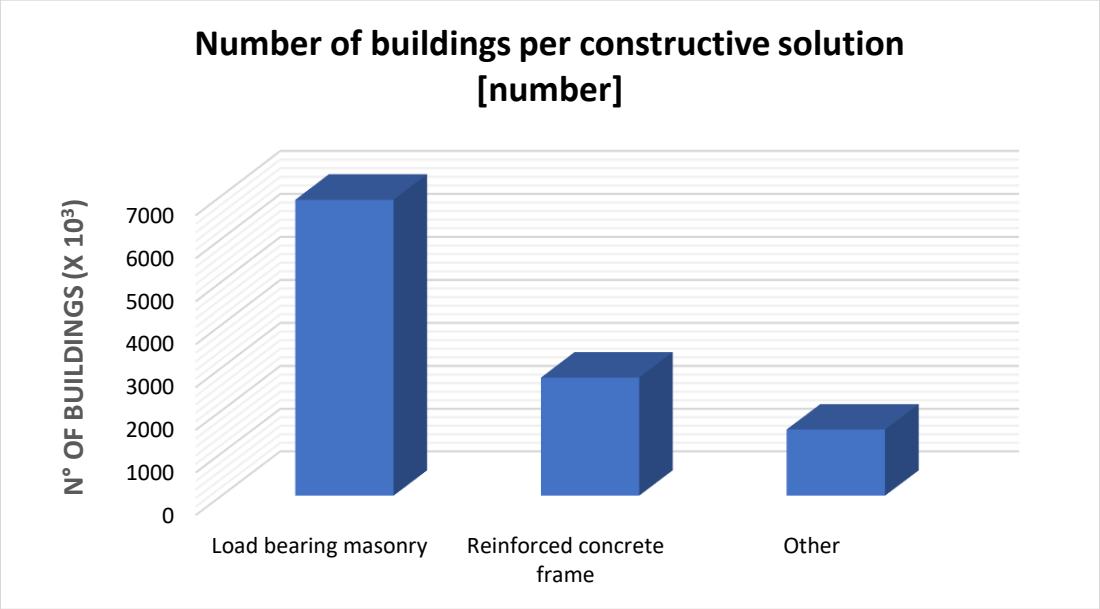

Table 3 – Number of buildings per constructive solution – Source: CRESME

Related to previous information about number of buildings per year of construction and according to the market trends and foresight scenarios in buildings, it's possible to estimate that on next 50 years, the 98% of buildings (today already built) will still be functional and inhabited, while only 2% will consist in new constructions. Indeed, Italian building heritage is one of the oldest in central Europe, and more than 20% of buildings are situated in old towns or in historical areas without any possibility of refurbishment, due to the environmental and regulation

constraints in these areas [8].

Such situation highlights the crucial role of retrofitting into Italian context. At this regard, several studies and statistics were developed and addressed to figure out trends and tendencies. One of these, is a research realized by CRESME on 2012 [6], focused on restoration/refurbishment analysis. The research asserts that restauration and refurbishments between 2002 and 2011 have been concerned 58,6% of existing buildings. Taking into account the average value, were done refurbishment for about 1,2 million of buildings per year in 90's, while the interventions increased until 1,8 million of buildings per year in 2000s.

Despite these results, the current renovation rate (per year) is about 1,2% , too low if related to the average age of existing buildings and to the request of the European policies that fixes a target of about, at least, 2-3 % per year.

2.2 Analysis of most used materials in Italian construction sector

For what concern the constructive solutions described below, the most commonly used materials in Italy for new buildings and refurbishment activities are:

- Concrete (bearing and not bearing)
- Structural or reinforcement steel
- Fired clay products (masonry or facing bricks, roof tiles, beam and block floor, pavers)
- Insulating materials (organic or mineral wool based)
- Ceramic tiles for pavers and coverings
- Wood for pavers and coverings
- Cementitious materials for render, plasters, screed and other several finishing
- Paintings

From an environmental point of view, many of these materials are responsible of a high level of environmental impact.

Above all, considering that ordinary concrete is the most used material in Italian construction, a specific focus could be addressed. In buildings with concrete structures, 90% of energy is consumed in primary raw materials production (clinker development, combustion of limestone and clay, etc). The remaining 10% is consumed due to packaging and transport. For instance, for clinker production 900 kg of CO2 per tonne are produced. Because of the difficulty to not use concrete in construction process for its adaptability and mechanical characteristics, manufacturer and researchers are moving on actions in order to minimize the environmental

impact and to implement innovative solutions towards eco-cement or sustainable alternatives (e.g. geopolymeric binders, etc). [9]

Italian concrete industry, with a thermal replacement level of non-renewable fossil fuels with alternative fuels amounted to only 8%, is reducing its CO2 emissions of about 4%. Moreover, researchers have developed and are developing concrete made with waste products from industrial processes: fly ash, silica fume and other mineral additives that can replace part of cement and that aim at reducing waste and energy consumption and preserving mechanical characteristics. [14]

For what concerns external/internal building envelope, bricks are the most used materials. Generally, bricks are considered as sustainable products, due to its derivation from clay, sand and other natural raw materials. However, extraction and production stage are very impactful respectively due to the environmental effects on lands and quarries and the very high energy consumptions related to drying and firing process. From about 490 kWh/m3 to 1730 kWh/m3 is the estimated energy consumed to produce 1 m3 of product.

Other products with a high level of usage and implementation in construction are insulating materials, which can be generally constituted by synthetic/organic, natural or mineral raw materials.

The use of these type of materials is quite recent in Italy, despite the adoption of the Ordinary Law n° 373/1976 [5], regarding energy consumption reduction in building. Indeed, until 1991, when it entered in force Law n° 10/1991 [6], the main part of buildings was still constructed without insulating materials.

Currently, the most common insulating materials used in Italian buildings are the synthetic ones: expanded or extruded polystyrene and polyethylene panels. These products provide high level of thermal insulation of building, but their productive process involves a lot of negative impacts on environment and human health, due to oil processing, expanded agents utilised, etc. In the last few years, there was a huge increase in insulating materials use in building envelope and most synthetic products are replaced by natural or mineral ones, such as:

- mineral wool panels;
- wood fibre, obtained from woodworking scraps and sawdust;
- cork panels, obtained from the cork trees (grown in Italy in several regions: Sicily, Sardinia and Tuscany);
- insulating materials hemp based.

These last three types of products can be considered as more sustainable due to their natural primary raw materials. [10]

Referring to sustainable constructive solutions, wood has been considered as a natural material with lower environmental impact. In Italy, wood as a structural material was used until 20's. Later, with the introduction of reinforced concrete, its utilization has decreased. Only after 2008, wood was considered again as a structural material, although its use in Italy is still very limited and concentrated in the north of Italy.

The following table shows, as an example, the list of some sustainable materials produced in Italy. For each material are indicated its environmental characteristics, which, in construction works, represent the main parameters to define environmental impact level.

Company	***Material***	***Final intended use***	***Environmental characteristics***
Cnm Greentech	CANAPAlithos® 1000 – insulating material hemp based	External and internal building envelope insulation	Natural Recyclable LCA
Gruppo M. SAVIOLA	LEB/IDROLEB – recycled wood panel	External/internal coating walls covering or wall self-bearing	Natural Recyclable LCA
TECNOSUGHERI srl	CORKPAN 100% natural – cork panel	External and internal building envelope insulation	Natural Recyclable Recycled LCA
Naturalia BAU/Pavatex	PAVATHERM – wood fiber panel	External and internal building envelope insulation	Natural Recyclable Recycled LCA
EQUILIBRIUM srl	Biomattone® – eco-brick composed by hemp, wood and lime	Masonry brick	Recyclable Recycled

			LCA
Ceramiche COEM	Ceramiche ECO – ceramic tiles made with 30% of recycled glass	Pavers and coverings	Recyclable Recycled LCA
Euchora SRL	ISOLCELL – cellulose fibre obtained by means of recycled paper as primary raw material	External and internal building envelope insulation	Recyclable Recycled
Manifattura Maiano S.p.A.	SINTHERM FR – polystyrene panels obtained by means of recycled PET (post-consumer polyethylene terephthalate)	Internal acoustic insulation	Recyclable Recycled LCA

3. Conclusions

The consideration reported above substantiate the key role that the material's selection plays in the building design process for the achievement of sustainability in construction works.

However, a univocal and universally accepted definition of "green building materials" still doesn't exist. There isn't a perfect green building material in opposition to not-green material, because the manufacturing, transportation, placing and disposing/recycle of materials always imply a not zero impact. For this reason, in every design process the most green materials should be chosen among the market available ones, on the basis of the best available technologies and the required materials performance, taken into account its impact on environment and human health.

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