# TEMA

**Technologies**
**Engineering**
**Materials**
**Architecture**

**Journal Director:** R. Gulli

e-ISSN 2421-4574

**Vol. 6, No. 2 (2020)**

**Issue edited by Editor in Chief:** R. Gulli

**Cover illustration:** The west grandstand of the Flaminio Stadium in Rome, by P.L. and A. Nervi.


**Editorial Assistants:** C. Mazzoli, D. Prati

TEMA
Technologies
Engineering
Materials
Architecture

e-ISSN 2421-4574
**Vol. 6, No. 2 (2020)**
Year 2020 (Issues per year: 2)



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TEMA: Technologies Engineering Materials Architecture
Vol. 6, No. 2 (2020)
e-ISSN 2421-4574

# H-BIM OBJECTS FOR MODERN STONE FACING GENESIS AND INFORMATIVE CONTENTS FOR THE SHELL OF THE STATION OF MESSINA

TEMA Technologies Engineering Materials Architecture

e-ISSN 2421-4574

Vol. 6, No. 2 - (2020)

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*DOI: 10.30682/tema0602g*

**Highlights**

To keep track of interventions carried out, or to be carried out, on a stone material facing of an existing building shell with historical-artistic features, an H-BIM (Heritage-Building Information Modelling) object of the construction element has been conceived to reach a more detailed characterisation of slabs both from a technical, specifying the properties of each one, and historical point of view, associating the Construction History phase in which the laying occurred. Thus, the consideration of a virtual and informative Abacus of Stones has been undertaken to make it an effective tool of knowledge and management for future actions.

**Abstract**

The revolution of the BIM methodology lies in the informative component attributable to digital entities, more challenging to define for the historical buildings due to the need to resort to documentary sources and diagnostic investigations instead of datasheets or virtual "pre-packaged" objects. In line with a research about the shell stone facing of the Station of Messina, a stylistic feature recurring in the public buildings of the 1930s-1940s, this study aims to conceive specific "H-BIM objects" so that they can represent new channels for collection and processing of data, in support of adequate Building Dossier and Maintenance Plan for cultural heritage.

**Keywords**

BIM (Building Information Modelling), Heritage-BIM Object, Stone facing, Station of Messina, Building Dossier.

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## 1. TOWARDS THE DEFINITION OF "H-BIM OBJECTS"

The scenario that emerges with the introduction of the BIM (Building Information Modelling/Model/Management) methodology requires a different approach to the design practise aimed at the digitalisation of the construction process. Greater control of the project and management of the building through its life cycle is possible thanks to the so-called "BIM objects", virtual entities that can increasingly emulate the reality, interact and interface with each other, promptly highlighting the onset of any interferences and anticipating the construction site ones [1, 2]. However, there is a difference in application between new designs and existing buildings, perhaps deliberately denounced by the adoption of the two acronyms BIM and H-BIM (Heritage-BIM), which are worthy of conceptual and operative considerations.

Although the methodology is not yet widespread and the regulations are still being defined, the benefits that can derive from the use of architectural, structural, plant engineering and infrastructural modelling through parametric objects – in technical language called *system/loadable/local families* – are more and more evident and interesting [3].

The data baggage related to them allows us to overcome the limits of CAD (Computer-Aided Design), and therefore of the simple vectorial restitution of the project, thanks to the possibility of associating "informative" and not just geometric features.

The effectiveness of the use of these objects is registering a new operative trend that induces the sector companies to provide the diffusion of the virtual equivalents of their technological solutions, with the attached *portfolio* of information, to simplify project processing.

If this is really advantageous when the aim is new construction, when recovering an existing building there is a higher degree of difficulty due to the lack of finding adequate objects on web sites of companies or in the online sharing platforms, without prior modification of the geometry and redefinition of the parameters that may lead to consider the creation from scratch more convenient.

The informative contents of the virtual models for existing buildings should be inferred by interpolating the data deriving from:

• *Historical-critical analysis*, to retrace the Construction History through documentary and bibliographic sources;

• *Survey of the state of affairs*, to acquire geometric-dimensional specificities and to find out the materials that were adopted;

• *Diagnostic investigations*, to determine the overall behaviour of the construction elements as well as to characterise the used materials from the physical-chemical point of view.

Hence, the information to be collected for an edifice, especially if it belongs to the historical-architectural heritage, is not only of the parametric type and exclusively related to its current state.

In these cases, it is necessary to protect technical and cultural reasons that require a critical recognition of the building past; the latter should be retraced by identifying the interventions, due to natural or anthropic events, which have occurred over time and may have produced variations of the original configuration defined during the design phase, often with the loss of peculiarities that should have been protected.

In addition to an analytical description of the technical characteristics, there is, therefore, the need to narrate the evolution or involution of a building or its parts, associating documentary evidence to the families adopted in the modelling and attempting to parameterise the "time" factor to define all properties that an "H-BIM object" should have.

Such purposes are not different from those of the Building Dossier, the operative tool that should be useful for multidisciplinary edifice knowledge and more conscious management, predisposing to adequate Maintenance Plans [4]. Thus, this study aims to test the contribution of the BIM methodology employing the "autarchic" stone envelope of the Station of Messina, which dates back to the 1930s and is subject over time to changes that have altered its technical and formal qualities.

## 2. THE "MODERN" STONE FACING OF THE STATION OF MESSINA: THE NECESSITY OF A NEW METHODOLOGICAL APPROACH FOR THE RECOVERY

The public buildings of many Italian cities built during the 1930s-40s were renowned due to the stone material cladding of the vertical, horizontal, external, and internal surfaces. It was assumed as the distinctive and essential feature of an architectural language that had to satisfy the purposes of modernisation and economic autarky of the Fascist Regime. Among these edifices, there is also the Central and Maritime Station of Messina (Fig. 1), designed by Angiolo Mazzoni, an engineer, at the end of the 1930s and formally characterised by smooth Alcamo Travertine slabs, also shaped according to curved profiles, and installed with aligned joints on a mortar substrate (Fig. 2) [5, 6].

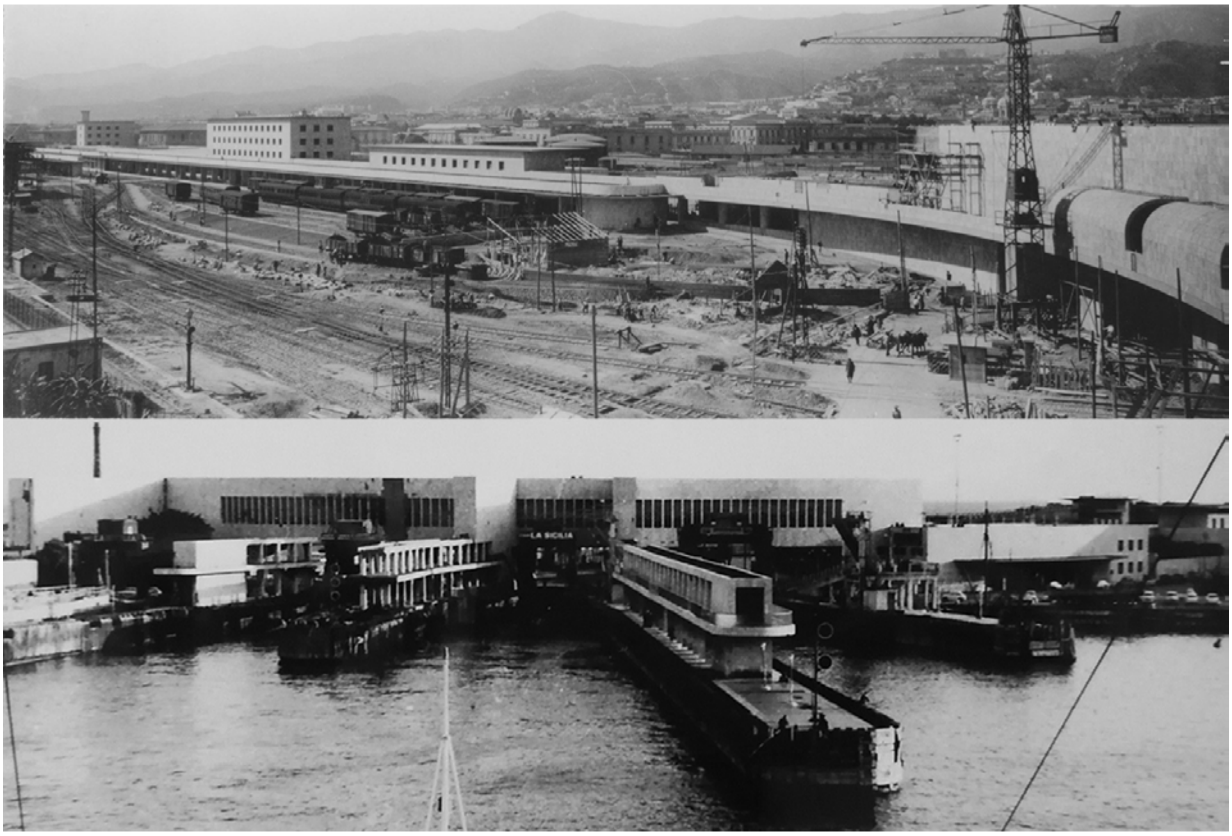


Fig. 1. *Central and Maritime Station of Messina with a view from the port area (MART, Fond "Angiolo Mazzoni", top; Collection of Laboratorio di Studi doCme 1908, down).*

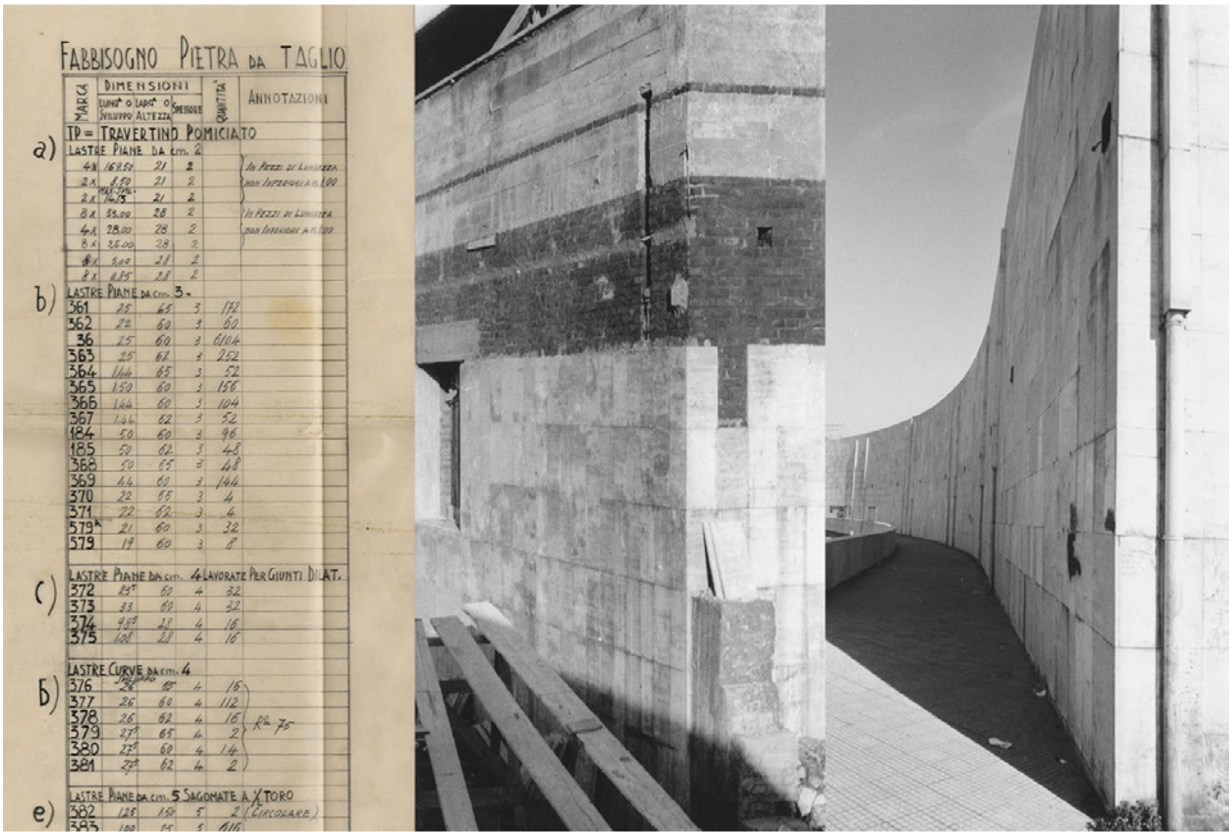


Fig. 2. *Specifications of the shell external facing of the Station of Messina (MART, Fond "Angiolo Mazzoni", left, centre; Collection of Laboratorio di Studi doCme 1908, right).*

Regardless of the ideological reasons, which with difficulty may be separated from "necessary" subjugations to the regime wills, the use of natural stone as a finish solution was real technological experimentation, in the desired opposition to its "artificial" version that in previous years had distinguished the majority of shells. The engineer Mazzoni, as a representative of the Work and Construction Service of the Ministry of Communications, included in his repertoire numerous designs of postal buildings and railway complexes in which he applied the stone facing [7, 8], firmly supporting the innovative application of this stylistic feature: "Stone, marble, granite have lost their weight, but have acquired the absolute beauty of their colour and their natural structure, of their soul. These load-bearing and architectural materials become decorative and protective. They make modern buildings beautiful and protect them from atmospheric agents. […] Our immediate predecessors […] resorted to artificial stone. Appearance, hypocrisy, democracy. I have these faults too. At that moment, I stammered, and I had not yet achieved that confidence, which now allows me to choose the good and the evil with certainty" [9].

Leaving behind the tectonic concept of the stone material led to the production of slabs of limited thickness and with complex shaping processes, that reproduce linear and curved profiles; besides, more often than not the trend was to reject the staggering joints because it was not necessary to even evoke correct laying criteria since the new "facing" function did not require it.

Similar to what Mazzoni did, many designers chose this lexicon that needed ability in architectural composition and technological knowledge. The planning had to be based on modularity criteria, deducible from the *Abacus of Stones* (where the geometric-dimensional and material characteristics of the modules were specified), and on the resolution of problems concerning the connection of slabs to the support, so the construction sites became the hotbed of innovation [10].

Therefore, there was a conspicuous architectural production that characterised the entire Italian territory, with examples in large or medium-sized cities, both of old establishment and born during the Fascist period. From Bolzano to Ragusa, from Rome to Littoria (nowadays Latina), there are numerous buildings with stone surfaces carried out by important people belonging to the Italian architecture field; in addition to Mazzoni, the generation of designers bonded by language analogies consists also of: Giuseppe Vaccaro for the *Palazzo delle Poste* in Naples (1928-35), Giuseppe Terragni for the *Casa del Fascio* of Como (1932-37), Adalberto Libera for the *Palazzo delle Poste* in Rome (1933-35), Mario Ridolfi for the one in Piazza Bologna (1933-35), Ernesto La Padula for the *Palazzo della Civiltà Italiana* (1937-43), Giuseppe Samonà together with Guido Viola for the *Casa del Fascio* of Messina (1940), and other architects and engineers that are part of a list that should be extended [10–12].

Hence, the stone shell of these buildings should be protected as technical culture evidence of the historical period in which they were conceived. However, this has not always been true for different reasons, specific to each case and context, which can only be deduced from a critical reading of Construction History.

Almost a century after its realisation, the cladding of the Central and Maritime Station of Messina presents conflicts in materials and composition that indict changes to the original configuration of the stone finish layer. The lack of documentary sources does not allow the reconstruction of the phases that characterised the past of the railway complex with an appropriate abundance of information, leaving doubts about dates, type, and extent of the interventions [13].

The damage caused by the bombardment in 1943 was certainly huge; less than a lustrum had passed since the end of the construction, dated March 31st 1940. For repairs, 10,000 $m^2$ of "travertine slabs and other marbles" were needed [14]. Although no distinction was made among stone elements necessary for vertical, horizontal, external and internal surfaces, thanks to the photographic documentation it is possible to assert that the more significant amount was used to restore the outer side of the envelope (Fig. 3). To comprehend the magnitude, bearing in mind the plan metric and altimetry dimensions of the railway complex – a frontage of about 600 m and an average height of 10 m – this quantity would correspond to the cladding of a façade with an extension of one kilometre.

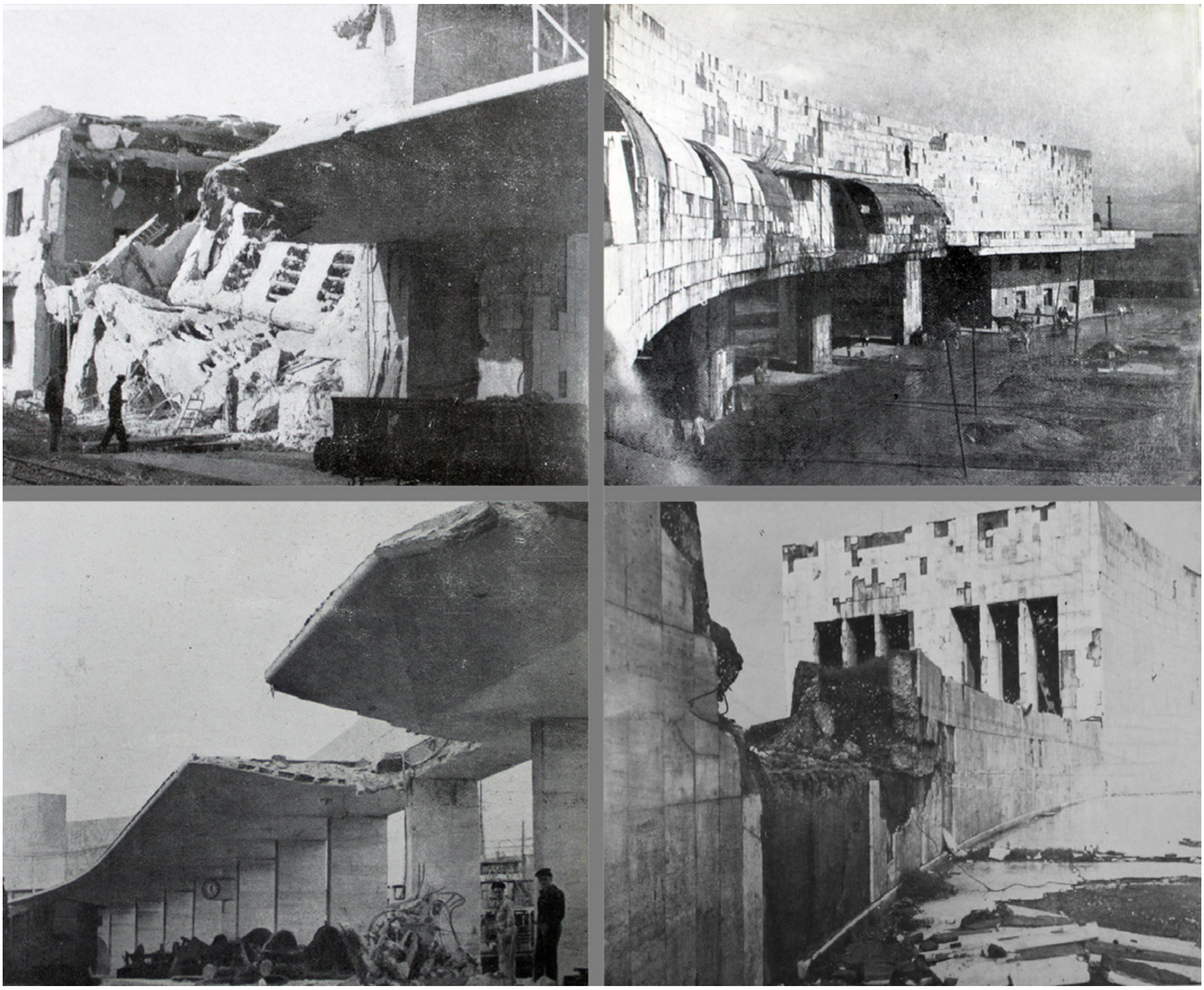

Fig. 3. *War damages to the covering of the Station of Messina (Scinia Collection) [14].*

There is only fragmentary evidence about subsequent interventions on the travertine slabs. However, from the comparison among the drawings of the original design, of the state of affairs in the 1980s, and of the extraordinary maintenance project carried out in 2001, some external and internal walls were added consequently to the modification of spaces; stone coverings were used to evoke the stylistic feature, often similar and using materials coming from different quarries. Even though it was easily deducible from a simple visual examination, it was discovered that specific actions on the finish layer with replacement or consolidation of slabs were performed over the years for natural and/or anthropic degradation amplified by the effects of vibrations generated by rail traffic. These works, which did not belong to maintenance programs, can neither be documentable nor datable.

This has unfortunately led to re-creations that are not always in line with the formal requirements defined by Mazzoni, perhaps succeeded by economic reasons and poor operative accuracy and supported by the absence of a protective restriction, which came only in 2002 and uniquely for the Maritime Station [15].

A portion of the Passenger Building of the Central Station is emblematic: originally it was a portico marked by pillars covered with travertine slabs; that over the time, due to its use, was closed proposing the "same" stone cladding of the existing shell; some slabs were replaced with others of a type of travertine dissimilar from that already employed, with different chromatic varieties

Fig. 4. *Front of the Passenger Building of the Central Station.*

and porosity degree that have influenced the aesthetic rendering; the choice of arranging the slabs with veins orthogonal to those of the pre-existing elements could instead be read as a sign of recognition of the intervention, since the same approach was also found in contemporary restoration solutions adopted in Messina for other buildings (Fig. 4).

Therefore, the failure to respect formal qualities can be attributed to an incorrect approach to maintenance, which is not often based on overall logics. The specific features of a building should be preserved, although it is not subject to protective restrictions, because they are an expression of cultural heritage. Greater control could be achieved if the interventions carried out over the time were traced to reach an accurate knowledge and management of the facing. In this sense, a result would be obtained with "H-BIM objects" to be considered as more complete data collection channels than traditional parametric objects. By processing the informative contents, it is possible not only to estimate the physical, mechanical, chemical and thermo-hygrometric behaviour but also to conduct assessments to guarantee the protection of technical-cultural reasons, to safeguard memory and function.

## 3. AN H-BIM OBJECT FOR A SHELL WITH STONE FACING: FROM THE SPECIFICATIONS OF THE MODEL TO THE "TIME" FACTOR

The portfolio of an H-BIM object should include the contents necessary to reconstruct the evolution or involution regarding the considered technical element. However, this presumes the creation of a model that is able to incorporate, return and process them and in which parameterising the "time" factor, providing the virtual entity also "archival" purposes to accept past, present, and future information of the real system it represents.

In the case of a shell with a stone material facing, the protection of material and technological specificities could be more effective if a precise knowledge of its elements and of the interventions carried out over the years was reached. Therefore, the related H-BIM objects should be modelled to satisfy these needs and originate more aware and proper maintenance actions.

The first step in defining a possible methodological approach has concerned the creation of the vertical closure model with external finish in travertine slabs of the Station of Messina, identified as an "excerpt" on which to test the course of the research, using software of BIM authoring for architectural modelling of the Autodesk® Revit type, currently in use, not excluding subsequent checks with other programs. In the BIM language, the vertical closure, as a technological unit, falls within the *system families*. Starting from the most similar type among the "basic walls" provided by the software, a modification has been made to reproduce the desired stratigraphy. For the variability of the geometric-dimensional characteristics of the construction elements deduced by the original design documents, a study configuration has been undertaken having:

- an external finish in flat slabs of Alcamo Travertine of 3 cm thickness;
- a layer of mortar of 2 cm;
- a resistant part in masonry or reinforced concrete of 30 cm;
- an internal plaster finish of 3 cm (so defined for simplicity of dissertation, although the adoption of stone slabs may also be observed for these surfaces).

Nevertheless, a limit has been found during the definition of the multifunctional package: each layer can be represented and described, but it is not possible to differentiate the properties within it. This is particularly restrictive for a stone material facing because, although it is allowed to define its thickness and give information on the adopted stone variety, the slabs can be reproduced only graphically attributing a pattern to show their step in the horizontal section of the layer (Fig. 5). Such configuration does not satisfy the expected results of the research that aims to create a model through which a more detailed characterisation of this finish type should be achieved.

Therefore, the modelling of a virtual "data container" has had to be conceived from scratch, because suitable solutions have not even been found in the online sharing platforms of parametric virtual objects that were consulted [16]. This confirms that for existing buildings it is not always possible to benefit from one of the advantages advertised by users of BIM software that is the possibility of employing already "pre-packaged" informative objects, provided by companies that develop computer programs or by those that design technological solutions.

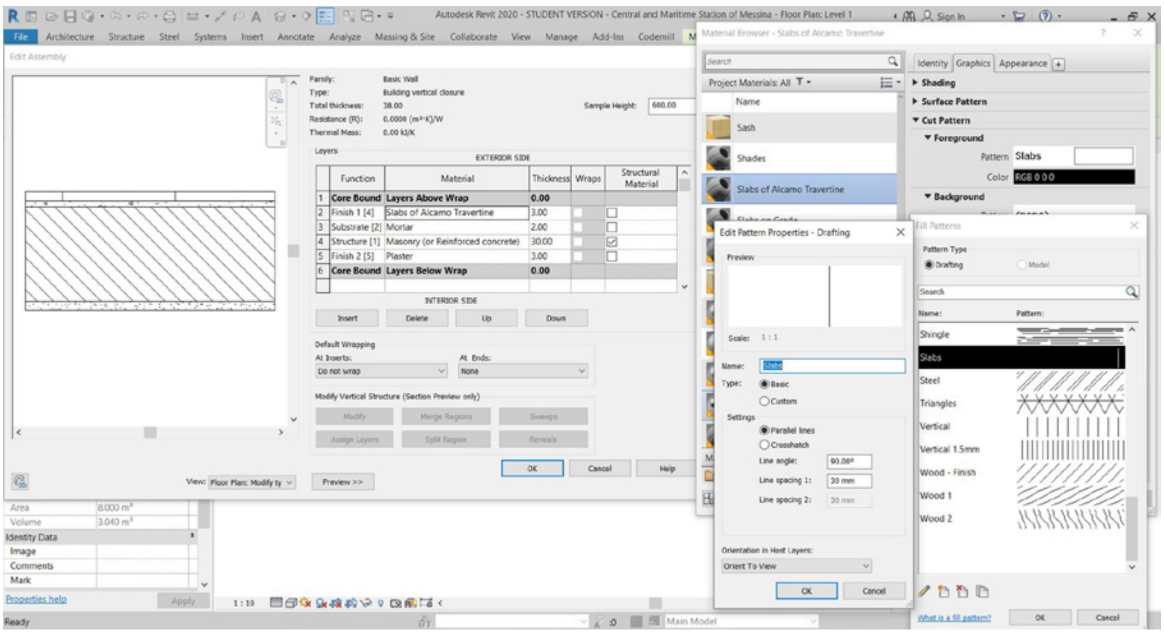


Fig. 5. *Stratigraphy of the vertical closure obtained by modifying the "basic wall" more similar to that of the Station of Messina in which the facing slabs can be represented only with a pattern.*

Conversely, a more functional model of a wall with a stone coating could be obtained considering it as the composition of two families: a *system* one, to reproduce its stratigraphy except for the external finish layer, and others *loadable*, one for each type of slab.

Indeed, the original design drawings of the Station of Messina's envelope show that slabs with different morphology were conceived according to the linear or curved profiles of the construction elements to be covered. Therefore, some have a rectangular cross-section and others were shaped so that the face of the stone element follows the concavity or convexity of the non-linear portions of the wall to increase, in the absence of metal fastening devices, the surface of adherence slab/mortar.

By considering for simplicity a stone element with a rectangular section, the *loadable* family has been created starting from the *metric generic model wall based*, recommended if it is necessary to reproduce components to be inserted within a wall or on its external or internal surfaces.

Although the front part of the Station of Messina has joints of about 2-3 mm filled with mortar, and therefore their graphic representation could be neglected, the BIM object has been designed to be applied even if they have larger dimensions.

To facilitate the process, it has been considered proper to create inside the basic wall of the *loadable family* – having non-specific stratigraphy, materials, and thicknesses – a slot, obtained using a *void extrusion*, in which to insert the modelled slab as a *solid extrusion*. The parallelepiped has been constrained to six reference planes containing its faces, whose relative distances have been parameterised to manage, through the *family parameters*, the dimensions of the virtual object, namely width, height, and thickness (Fig. 6).

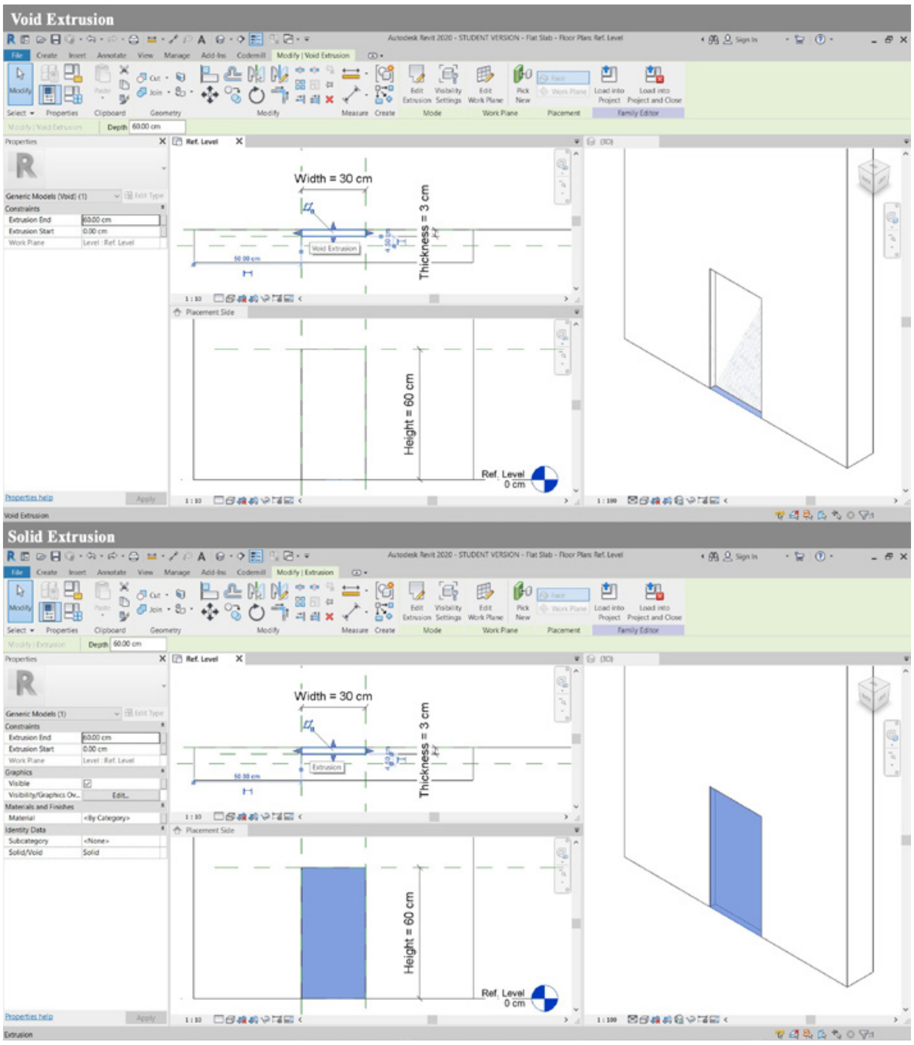


Fig. 6. *Flat slab, a "Loadable Family" constituted by a void extrusion and a solid one.*

Hence, the BIM object becomes the virtual minimum unit of the cladding that, loaded in the *project file*, can be modified "as a type", to permit the dimensional variations of the rectangular cross-section slabs, and "as an instance", to differentiate the properties of each element that can be changed over the time compared to the original homogeneous configuration (for example a different variety of travertine adopted in case of replacement of damaged or degraded stone elements) (Fig. 7).

The procedure, replicated for the other two types of slabs with concave and convex faces, will allow the re-creation in the BIM software of the *Abacus of Stones*, present in the drawings of the executive project, in which each type of slab is identified through a code called "marca" (Fig. 8).

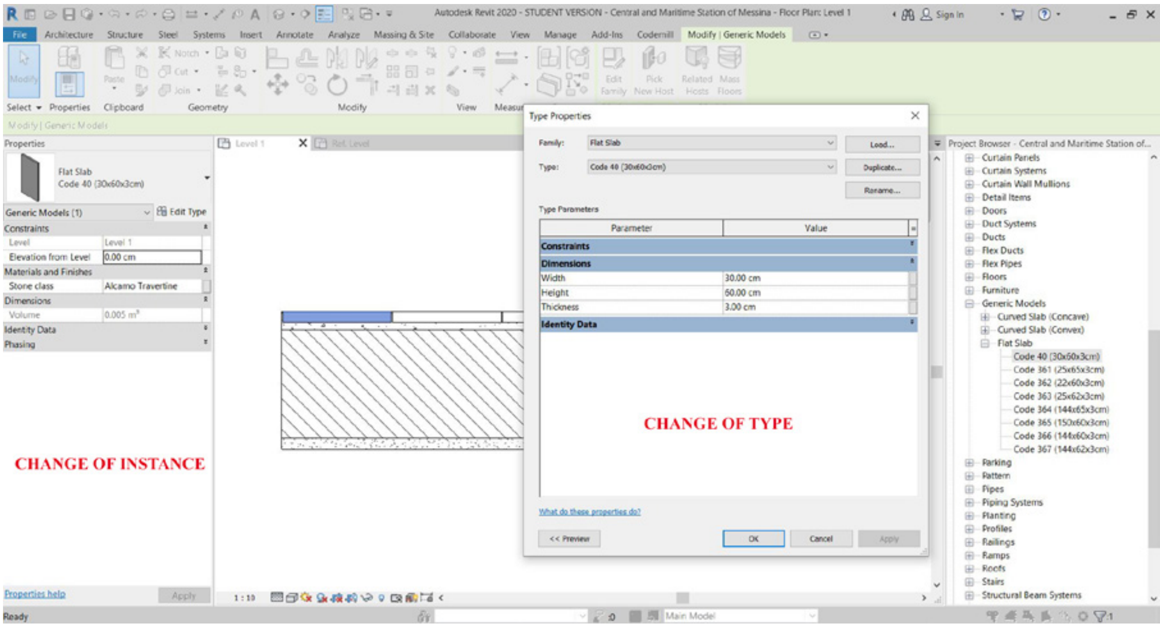


Fig. 7. *The Flat Slab in the project file, changes "of type" and "of instance".*

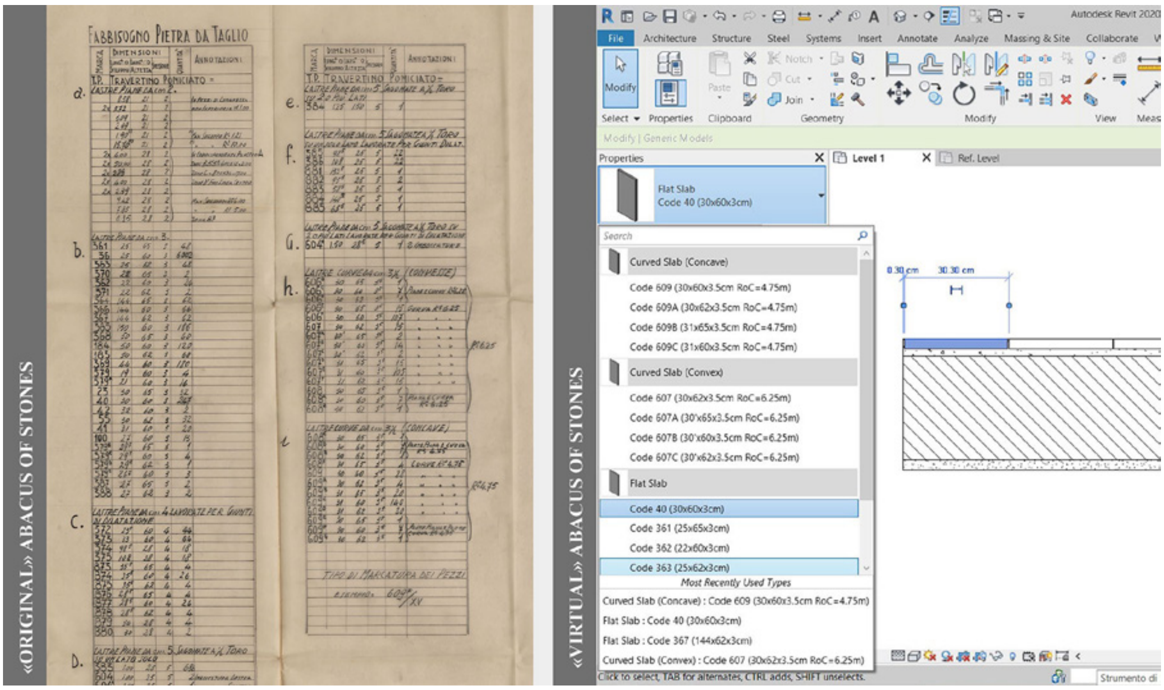


Fig. 8. *From the "Original" Abacus of Stones to the "Virtual" one: the choice of slabs by the Type Selector (MART, Fond "Angiolo Mazzoni", left).*

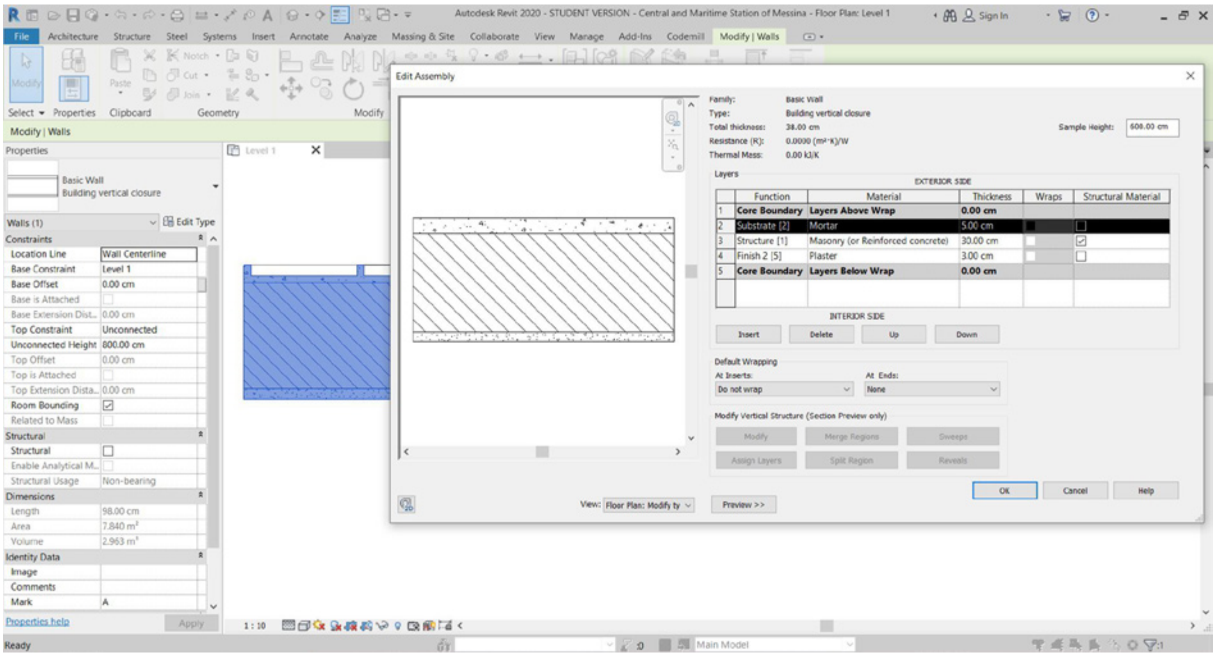


Fig. 9. *Configuration of the shell, a proposal to consider mortar joints.*

The *system family* used to reproduce the "stratigraphy of the envelope except for the finish layer" must be shaped to accommodate the slabs inside and also to consider, expanding the fields of application, the mortar used for the joints. Therefore, a virtual thickness has to be attributed to the mortar layer that must also include the depth of the slabs; in this way, the latter will find their place in the substrate thanks to the void extrusion created in the loadable family (Fig. 9).

A more suitable model has thus been prepared for the management of a stone material facing with the possibility of querying the individual slabs, investigating their properties at a greater level of detail than that of the entire coating system.

However, it is necessary to understand how to attribute diachronic informative contents, thanks to which to confer the qualification of "H-BIM" to a virtual object modelled for existing buildings. The question is how to return and provide documentary evidence of the succession of interventions that have affected the shell and in particular the coating.

One possibility could be glimpsed in the *project phases*. More commonly, this function is used in the case of renovations to highlight demolition and reconstruction operations and therefore to move from a state of affairs to a project configuration. Nevertheless, their application to trace the interventions conducted over time still does not seem so effective [17]. Indeed, although through the *Manage/Phases* command it is possible to introduce those recognised in the Construction History of a building, only one phase can be assigned to an object, without the opportunity of attributing information about actions carried out after the moment of "creation", such as maintenance and restoration. The application for the cladding of the Station of Messina, damaged during the Second World War and subject to several changes in the following decades, has demonstrated the limits of the use of phases to narrate its historical evolution or involution (Fig. 10).

If it is therefore tricky to parameterise the "time" factor, changes of a construction element could be documented by inserting images in the *Properties Panel*. Although this option can be presented as a chance to testify the phases by associating the relative technical and photographic documentation, it is actually a simple collection of digital products that cannot be either organised according to appropriate sorting criteria or described to highlight the peculiarities. This would result in an unstructured data container that would not satisfy the "archival" purposes required to an H-BIM object.

The functions offered by parametric modelling software for existing constructions, especially if historical,

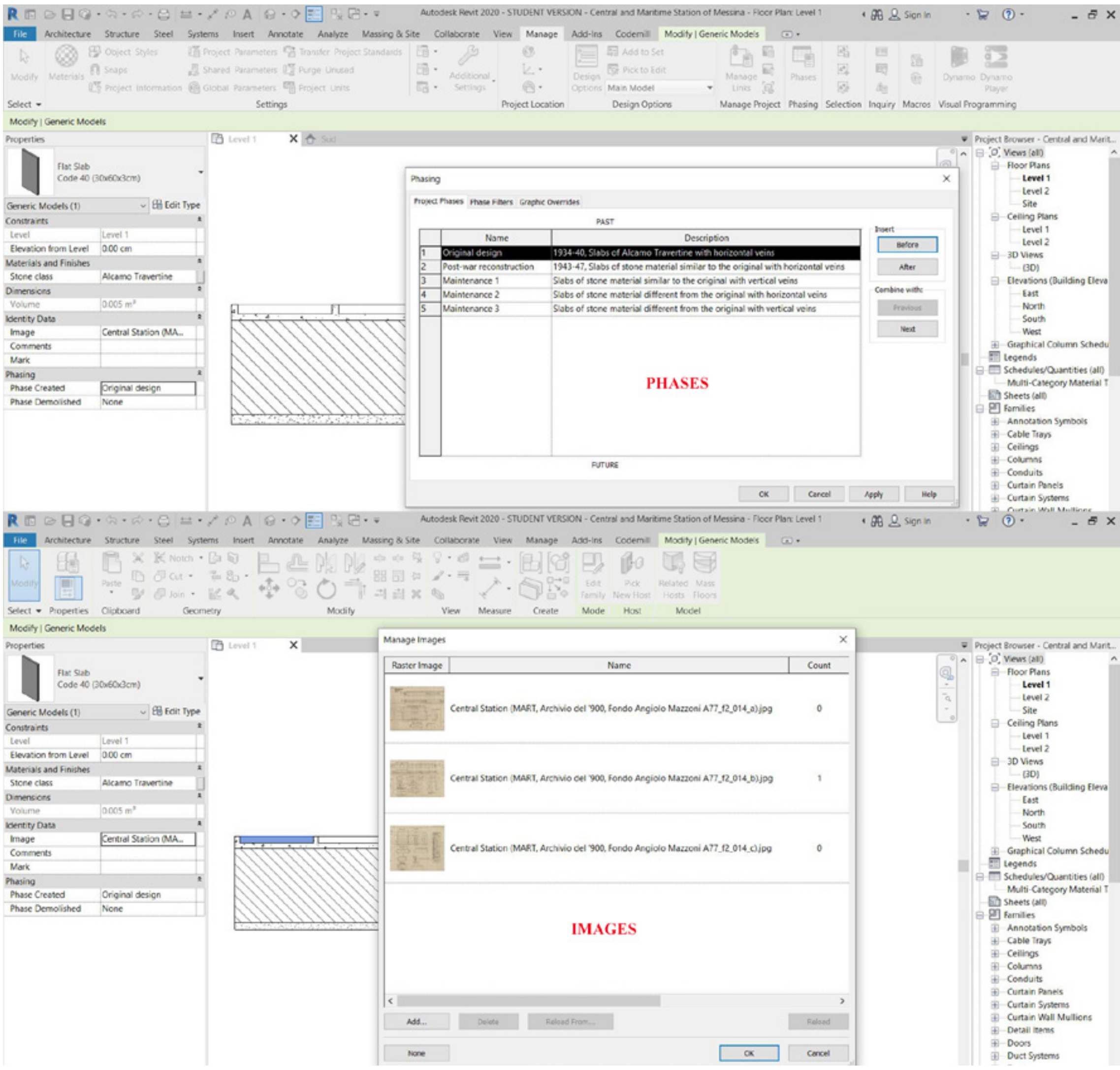


Fig. 10. *The potential "Construction History" in BIM environment: the phases and the images as instance properties.*

are still unfortunately insufficient. The problem does not lie so much in the creation of the virtual equivalent of the construction element as in the type of informative contents that it can accommodate, especially concerning the building past. Tracing interventions would allow conducting, already in the BIM environment, more aware evaluations on which to base and plan the maintenance actions.

## 4. HERITAGE-BIM, AN OPPORTUNITY FOR THE BUILDING DOSSIER?

A Building Dossier should be configured as a tool for multidisciplinary knowledge of an edifice to analyse its many aspects (structural, technological, and plant engineering), reconstruct its history from origins to the current state of affairs, and benefit from a guide for future interventions. Despite recognising the advantages that would derive from its introduction, it is difficult to proceed with the regulatory implementation due to detractors that underline the burden of its redaction especially for the existing historical buildings [4].

New scenarios seem to emerge with the support of BIM, whose informative inclination is compatible with the necessity of "geometric-dimensional and technical-construction description" required by the operative tool. It is not a coincidence that the Italian standard regarding this methodology, UNI 11337 *Edilizia e opere di ingegneria civile - Gestione digitale dei processi informativi delle costruzioni* (Construction and civil engineering works - Digital management of building informative processes), has dedicated its ninth part to the Building

Dossier. However, its contents are not known because this section has not been published yet [18].

However, it will be necessary to understand whether the "chronicle" needs of interventions carried out over a period can also be contemplated in the modelling. A productive field of experimentation of the interaction between the operative tool and the information technology (IT) one could be represented by the cultural heritage that, in addition to being described from a physical point of view, needs to show history and its changes.

Therefore, Heritage-BIM is not a variation of the BIM methodology but represents a complete approach that satisfies the further need for a more effective "management" of the building and prepares for more adequate Maintenance Plans.

## 5. ACKNOWLEDGEMENTS

The pictures of the Central and Maritime Station of Messina, used to compose figures 1 and 2, have been kindly provided by the Laboratorio di Studi doCme 1908 of the Engineering Department of the University of Messina. The documentation related to the railway complex and produced in the last decades has been cordially offered by the Direzione Territoriale Produzione S. O. Ingegneria di RFI (Rete Ferroviaria Italiana).

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