STADATA

STRUCTURAL SOFTWARE

SOFTWARE and **SERVICES**
for **STRUCTURAL DESIGN**

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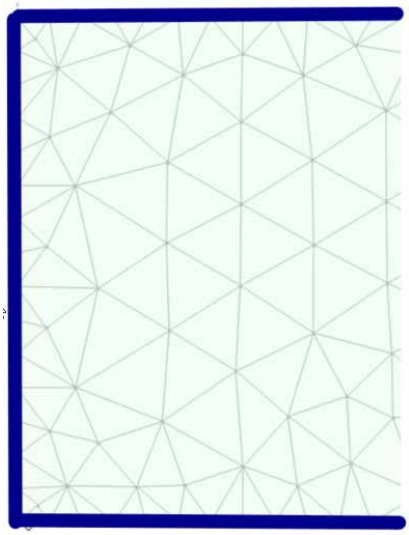
3Muri Project 14.2

Masonry static verification with FEM approach: Calculation evolution with local contributions

Enhancement of the mesh options with real editing that allows to create mesh refinements along the edges (as seen in the figure) or around the nodes.

Very often, the irregularities of the structure generated by openings, niches or a concentrated load on the beams can produce tension peaks in some points. To improve the quality of the results and the verification of the masonry piers, it may be useful to thicken the mesh (mesh refinment) in some points in order to have a more accurate result without weighing too much on computational times.



Along the edges highlighted in blue the mesh appears denser than in the center of the panel.

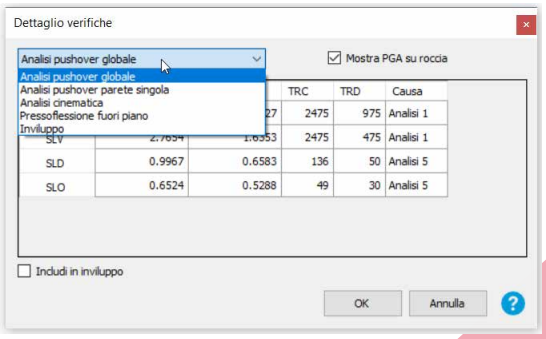
Possibility to apply loads directly on the mesh nodes:
This is to be understood as an additional load and has the possibility of it being applied at any point of the structure, even when it cannot be attributed to the structure environment.
This function allows to overcome any load insertion limits currently present.

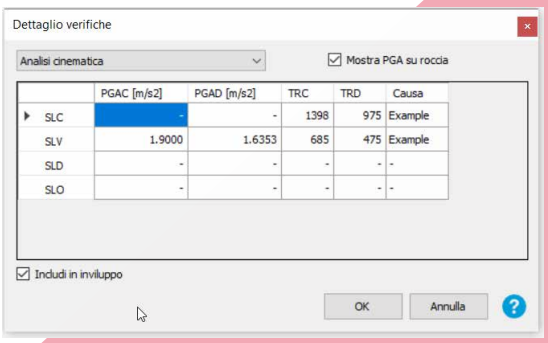
Buildings with a high level of irregularity: Walls modeled using vertical plane input which is the most powerful tool for creating irregular conformations such as the facades of monumental buildings. With this new function they will become objects that can be transformed into meshes and therefore calculable.

Verification results summary window

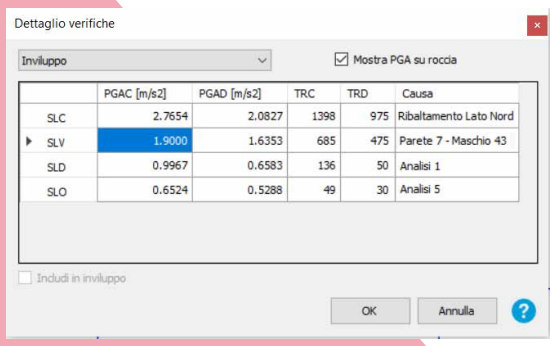
In professional practice, the outcome of the verification must include all the verifications conducted on the model, global analysis, single wall pushover, kinematic analysis, out-of-plane bending, etc.

It is certainly difficult to have an overall picture of all the verifications, so this new visualization and consultation method becomes fundamental. On this feature, safety factors are shown for each analysis.





With the envelope option, the results of all analysis types are overlaid, showing only the most significant values for each limit state. The column on the right shows the "Cause" with the description of the type of verification and analysis that caused the criticality.



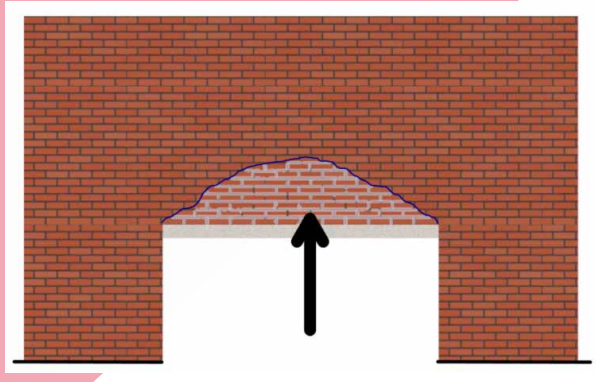
	PGAC [m/s2]	PGAD [m/s2]	TRC	TRD	Causa
SLC	2.7654	2.0827	1398	975	Ribaltamento Lato Nord
SLV	1.9000	1.6353	685	475	Parete 7 - Maschio 43
SLD	0.9967	0.6583	136	50	Analisi 1
SLO	0.6524	0.5288	49	30	Analisi 5

Equivalent frame modelling: Evolution of the contribution of transversal connections

In the case of large openings loaded by “false walls”, what is the load share that directly involves the lintel or arch?

Certainly not the masonry pier for its entire height since the connection between the masonry blocks causes the load to be distributed partly laterally and not in the central part affected by the opening.

It is not even possible to pretend that this portion of the wall does not exist because it would correspond to assuming that no portion of the load produced by the masonry involves the beam.



The technical bibliographies claim that this portion can be identified with a load triangle with angles of 45° or 60° but this too is only a simplified schematic.

To correctly know this contribution, modeling with extremely small finite elements calculated in a non-linear field would be necessary but this, obviously, would make the calculation too heavy.

Very often these problems are examined for localized verifications of beams and we tend to forget that this effect is even more important for global purposes. A different estimate of this effect produces a different positioning of the loads both planimetrically and altimetrically and this has repercussions on the seismic load and consequently on the outcome of the verifications.

In the equivalent frame approach used for seismic verifications, this contribution can be taken into account with an appropriate calibration of the connection elements that complete the frame. This operation will not be the responsibility of the user but of the program which, given the geometric conformation and mechanical properties of the masonry, will be able to calibrate these parameters independently.

New modules

Global static verification of steel/R.C. beams and columns

Until now, the beam and column elements have always been considered as "secondary" to the masonry, this allowed them to be verified with a local approach but this depends on two factors

- **How significant the presence of such elements is:** The greater the presence of such elements, the less likely it is that they can be examined independently.
- **How these elements connect to the structural complex:** The presence of false beams or pillars, on other beams or pillars, and important framed structures present multi-hyperstatic calculation schemes.

The more significant the factors described above become, the less suitable the local verification approach appears, making us lean towards a global approach.

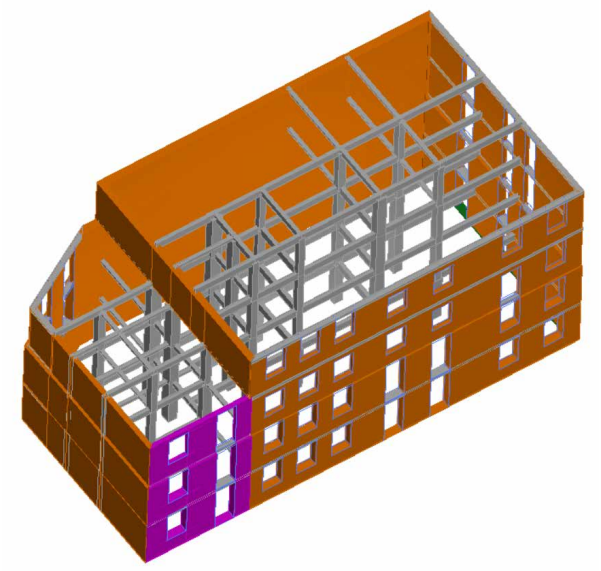


Figure 1: Structure with significant presence of reinforced concrete elements.

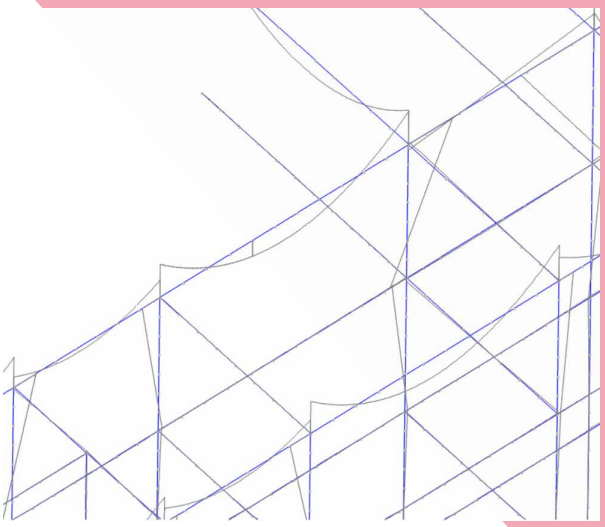


Figure 2: Stress diagrams of the solved hyperstatic frame scheme

Once the stress levels of the elements are known, it will be possible to move on to the verification modules for the two main categories of materials.

- **STEEL FEM STATIC VERIFICATION**
- **R.C. FEM STATIC VERIFICATIO**

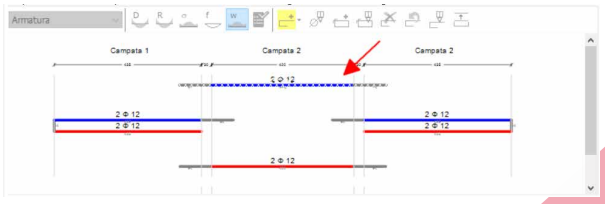


Figure 3: Girder reinforcement calculated starting from the stresses on the 3D frame

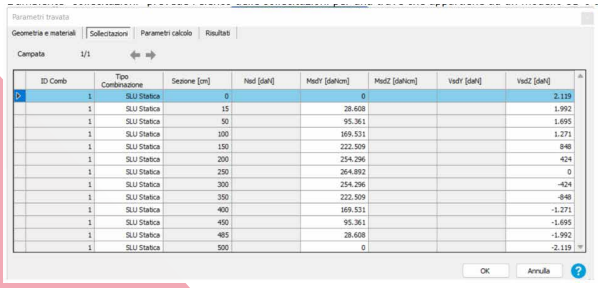


Figure 4: Stresses of a steel element obtained from 3D frame stresses

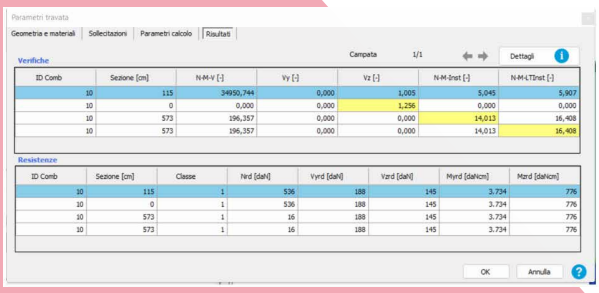


Figure 5: Verification of steel posts

Figure 6: Verification diagrams of steel posts

New local verification interface

In our structures, local verifications are as important as global verifications and can sometimes even be the predominant analysis.

A new interface allows for a more accurate overview with more viewing and filtering options.

Local verification of encirclements

The insertion of the encirclements of one or more openings contains within it two different contributions

- **Global Contribution:** improves the performance of the structure as a whole, even when we do not want to have an improvement but simply make up for the lack of masonry because a wall has been drilled to insert a new opening, and we need to verify that a structural detriment does not occur. Performing the local verification requires checking not only the opening with the encirclement locally, but also how its effect influences the wall and the floor of interest, to avoid extending the verifications to the entire building.

- **Local Contribution:** Once the user is sure that the opening in question does not cause a structural detriment in the global behavior, the user must verify that the single encirclement can provide the necessary stiffness, resistance and ductility.

The modules distributed for years by 3Muri verify that the posts can provide the necessary contribution to the structure. This new module allows to join the crossbars and steel connection nodes to this contribution, allowing to completely verify the encirclements locally and ensure greater precision in the calculation of the global contribution