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Strengthening of the Wooden Covering of the Archaeological Museum in Naples

Consolidation des couvertures en bois du musée d'Archéologie de Naples

Verstärkung der Holzbedeckung des archäologischen Museums, Neapel

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SUMMARY

The "Gran Salone" of the old building, nowadays seat of the National Museum in Naples, presents three orders of coverings realised in 1735. Damage occurring since the end of the 19th century, necessitated the demolition and the following construction of a new steel roof or lamellar wooden one. The project realised in 1993 saved the existing coverings by introduction of a reversible steel prosthesis and strengthening of masonry and wooden structures. The intervention was carried out without taking down the existing structures and in complete observance of the "Restoring Charter" dictates.

RÉSUMÉ

Le Grand Salon de l'ancien édifice, aujourd'hui siège du Musée National d'Archéologie de Naples, présente trois suites de couvertures en bois réalisées en 1735. Les dommages existants avaient entraîné, dès la fin du 19e siècle, la démolition et la construction d'un nouveau toit en acier ou en bois lamellaire. Le projet réalisé en 1993 a permis de sauver les couvertures existantes par l'introduction de prothèses réversibles en acier et la consolidation des structures de maçonnerie et de celles en bois. L'intervention a été exécutée sans démolir les structures existantes et en plein respect des principes de la "Charte de la Restauration".

ZUSAMMENFASSUNG

Der grosse Salon des alten Gebäudes, der heute die Stelle des nationalen archäologischen Museum von Neapel ist, zeigt drei Holzbedeckungsreihen, die 1735 realisiert wurden. Die bestehenden Zerrüttungen hatten, seit dem Ende des neunzehnten Jahrhunderts, den Abbruch und den Aufbau eines neuen Daches aus Stahl oder aus Lamellenholz bedingt. Das 1993 durchgeführte Projekt hat die bestehenden Bedeckungen durch die Einführung der reversiblen Stahlprothesen und die Verstärkung der Holz- und Mauerstrukturen zu bewahren erlaubt. Der Eingriff ist ausgeführt worden, ohne die bestehenden Strukturen abzubauen und unter Befolgung der Vorschriften der "Charta der Restaurierung".

1. SUBJECT OF THE INTERVENTION

The National Archeological Museum in Naples occupies a building founded in 1582 by the Naples Viceroy Don Pedro Giron. The most representative part of the monument is formed of a stately room of more than 20.000 cu.m. called "Gran Salone", whose roof was rebuilt in 1735 by arch. Giovan Antonio Medrano with three wooden covering orders .

Fig. 1 Outside view of "Gran Salone" covering.

The first upper order, represented by a roof realized through Palladian chestnut trusses with spans of about 23 m. The second intermediate one is formed by another roof of similar wooden trusses, alternate to the first ones, having impost height and pitches inclination smaller than that ones substaining the upper roof. The third lower one is formed of a depressed wooden vault with stiffening ribs hanged to the trusses, whose intrados is painted with valuable frescoes (Fig. 2) .
In the original project these structures had different functions: the upper roof constitued the covering, while the second trusses order supported the depressed vault below by suspensions. After more than two and half centuries, damages caused by time and men have deeply changed the structural behavior.
This covering has a great importance in the Technique of Construction history. It represents a rare example of great span wooden structure and after 250 years preserves, almost unchanged, its original aspect and technology.

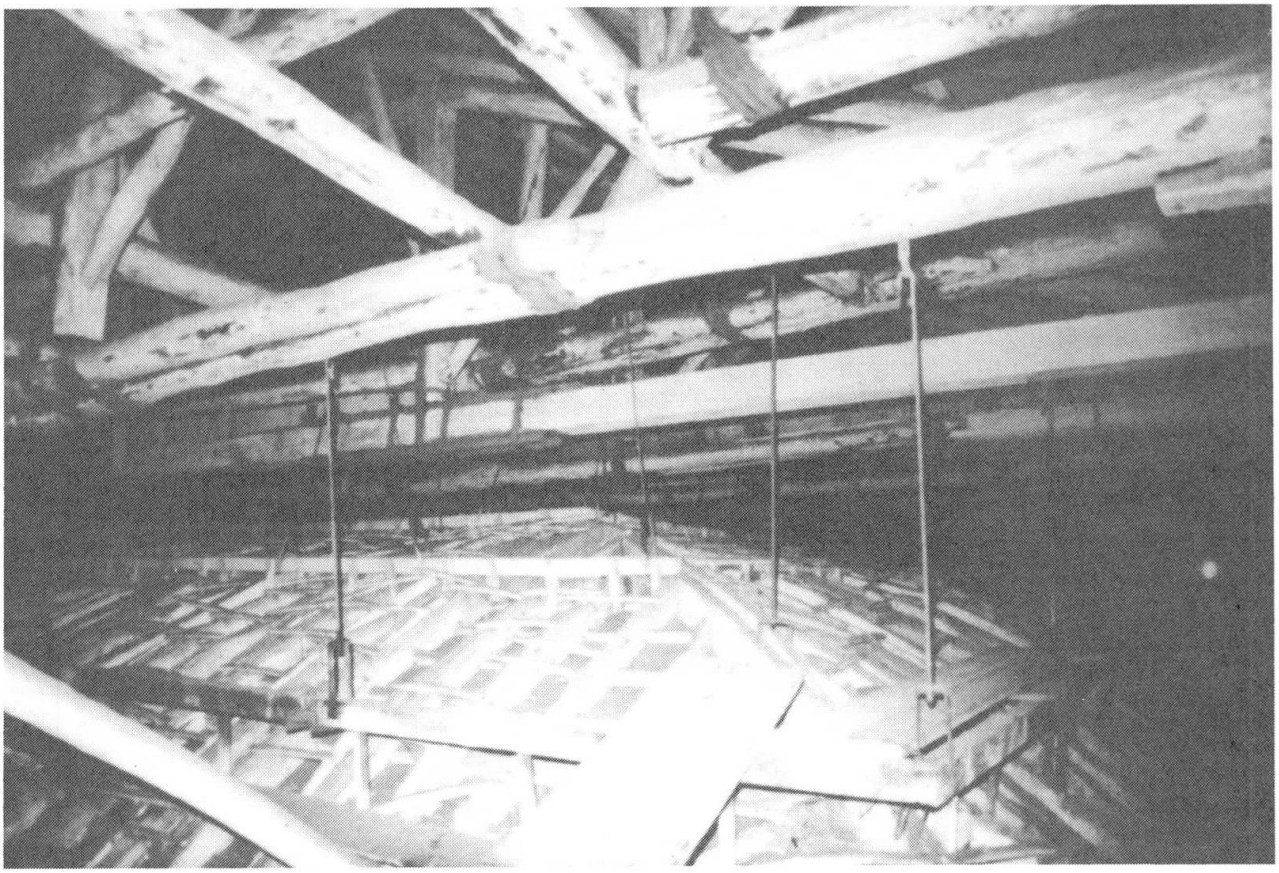

Fig. 2 Inner structure of wooden covering: lower trusses and depressed wooden vault with stiffening ribs before intervention.

2. DIAGNOSIS OF THE DAMAGES

The difficult choice between preserving existing structures and their replacement engaged many engineers since the end of the last century. For the roof of the "Gran Salone" a long research allowed to identify the most important diseases: great deformations in the vault, an elongation of 15 cm in the tie beams, partly disjointed knots and greatly deformed elements in the trusses, significant settlements of the bearing walls. A finite element analysis of the structures demonstrated that the above damages are partly due to the seismic events occurred during the past two centuries and half, and partly to some inadequate past interventions. Particularly, studying the original covering system and the next transformations, the author came to the conclusion that the horizontal differential movement, happened during the seismic oscillations between the main walls where trusses lean, caused most of the slidings between the wooden tie beams (which were already subject to the dead load strains and to relaxation of the joints); these slidings caused a lot of the observed damages.
In 1911, then, the vault was overhanged to the upper trusses to replace some of the lower tie beams. In this way, both the upper trusses and the lower ones were damaged.

3. INTERVENTIONS OF STRENGTHENING

The design solution, proposed by the author, and accepted by the Italian Ministry of Works which provides its execution, is based on two fundamental principles: to assure the safety of people and of the archeological treasures, and to warrant the conservative recovery of the existing covering complex.
The intervention philosophy consists in making the three structures statically independent. Through the proposed strengthening interventions, the two trusses orders could separately support their own weight and the overloads strictly pertinent to them. On the contrary the vault structure was not even able to substain itself. Neither it was possible to retrofit the existing trusses and to secure the vault load to then, since it would have upset their original organism. To integrate the vault self-supporting capacity, a spatial steel structure (prosthesis) endowed of adequate resistance and stiffness, but little visible in the structural contest, has been introduced (Fig. 3) . It was designed so as to be assemblable on site and compatible with the existing wooden structures. This avoided the demolition of the existing structures which would have disturbed the equilibrium and depreciated the historical value of the covering.

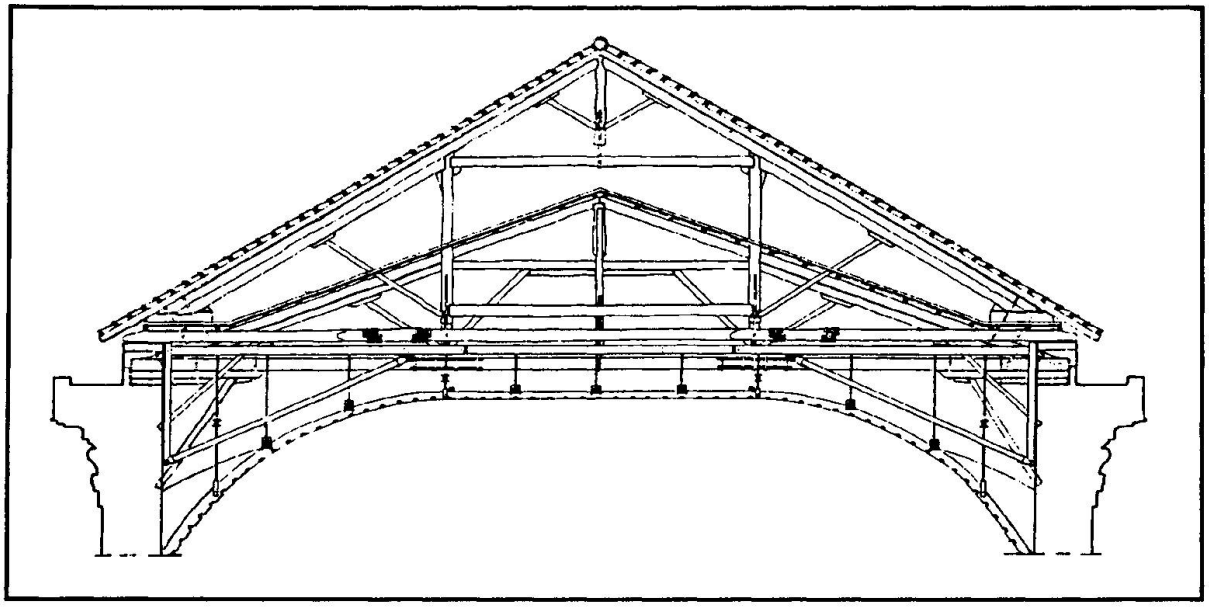

Fig. 3 Covering section after intervention: in evidence (down from above) upper trusses, lower trusses, steel prosthesis and the wooden vault now suspended to them.

On the other hand, it wouldn't be possible to carry out a shoring underneath which would have damaged the frescoes and the stuccoes of the vault. Anyway every other intervention had higer cost. The project solution proposed takes in two different interventions:
- strengthening and static improvement of the wooden and masonry structures;
- realization of the prosthesis sustaining the vault and connected structures.

At first it needed to confer to the perimeter walls of the "Gran Salone" the necessary strength to stand both vertical and horizontal actions transmitted by wooden existing structures and steel prosthesis. To this end, the strengthening of the whole western and eastern masonry faces was carried out by injecting cement mixtures with volumetric stability to improve compression strength.

Afterwards, a reinforced concrete beam was made, at intervals, on the top of the main walls but under the existing trusses to join the walls and support the existing lower trusses and the new steel prosthesis.
The wooden trusses were reinforced, temporarly, by windbracing placed in the vertical plane of the king posts, in the pitch planes and in some horizontal planes of the tie beams.
Eighteen space beams, realized with elements compatible for weigth and dimension with the existing wooden structures, made up the new supporting structures of the vault.
Every prosthesis is made up by two lateral beams (composed with 2 NPU240 and 2 O 159/4) and a central one (composed with 2 NPU240) . At first, they were calculated in exercise and breaking conditions under the action of permanent loads, thermic variations and seismic actions. Afterwards, a prosthesis prototype, assembled in the "Gran Salone" temporarly, was subject to a load test .

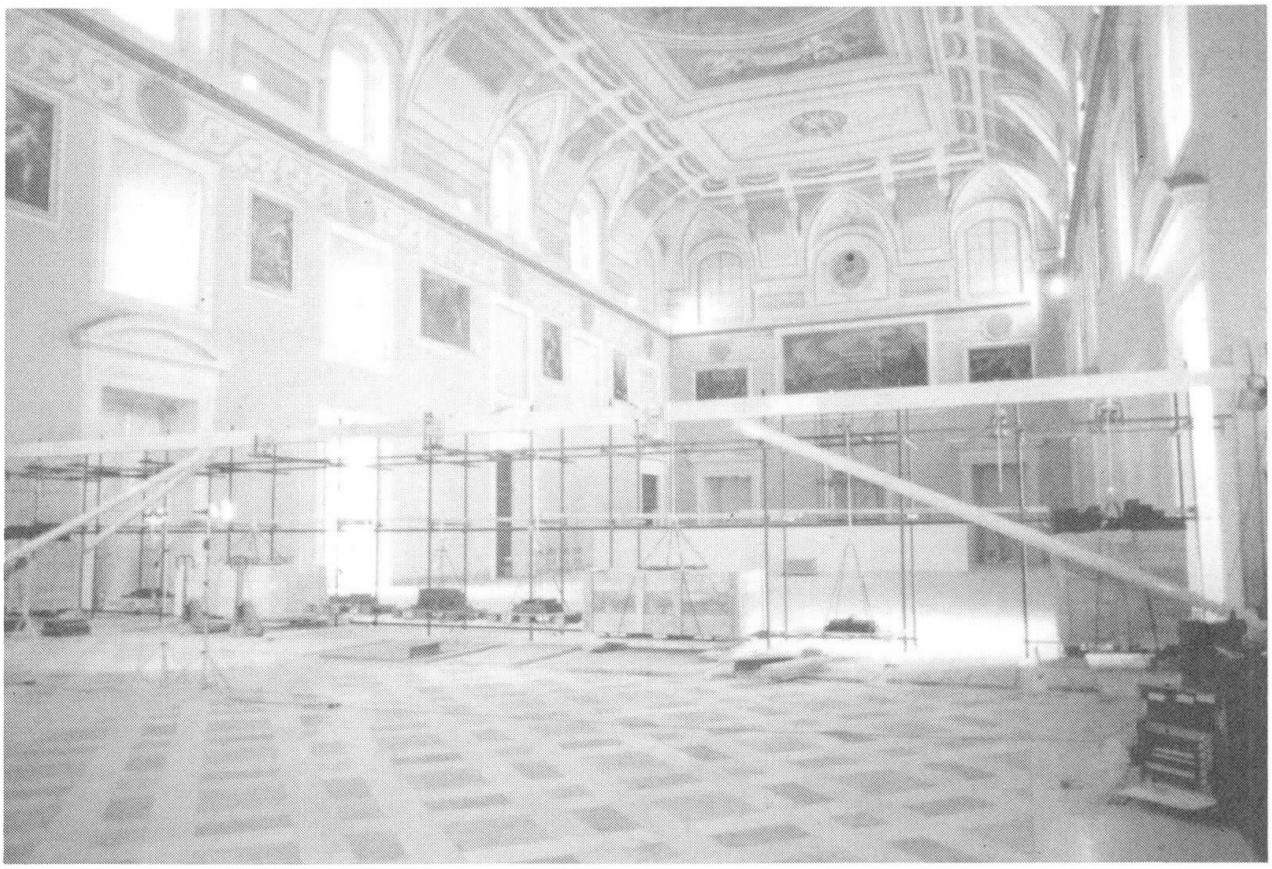

Fig. 4 Inside view of "Gran Salone" where a prosthesis prototype has been subjected to a load test.

These structures were assembled joining the costraint systems (relized with stainless steel) to the new reinforced concrete beam and to the existing masonry and, subsequently, assembling every prosthesis with pieces lifted and transported one by one . After the assemblage of all the prosthesis, the new suspensions were put under tension checking the painted vault movements by monitoring its strains . In this way, it was possible to eliminate the old joints between wooden trusses and vault. The reinforcement of the existing wooden structures has been obtained by completely restoring the disjointed connections in the trusses, replacing the broken elements, adding braces in the horizontal, vertical and pitch planes, disinfesting all the trusses by wooden parasites.

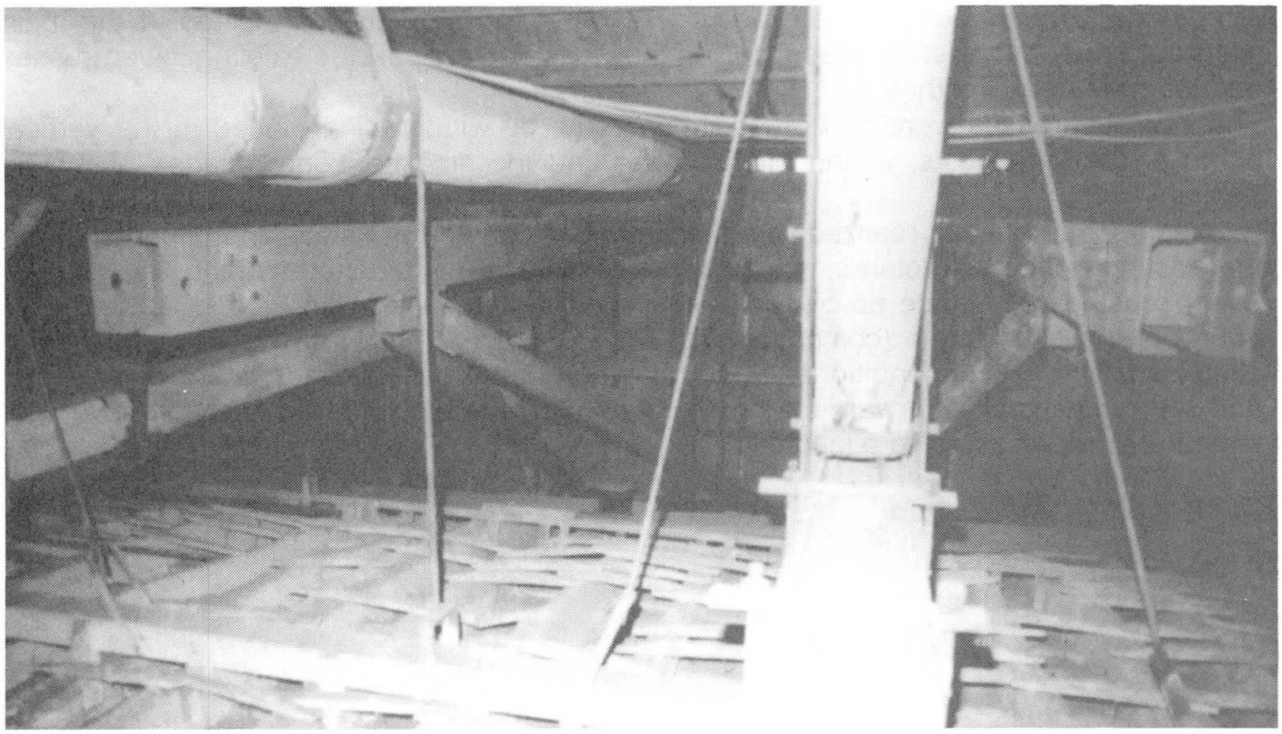

Fig. 5 Assemblage stages of prosthesis lateral beams.

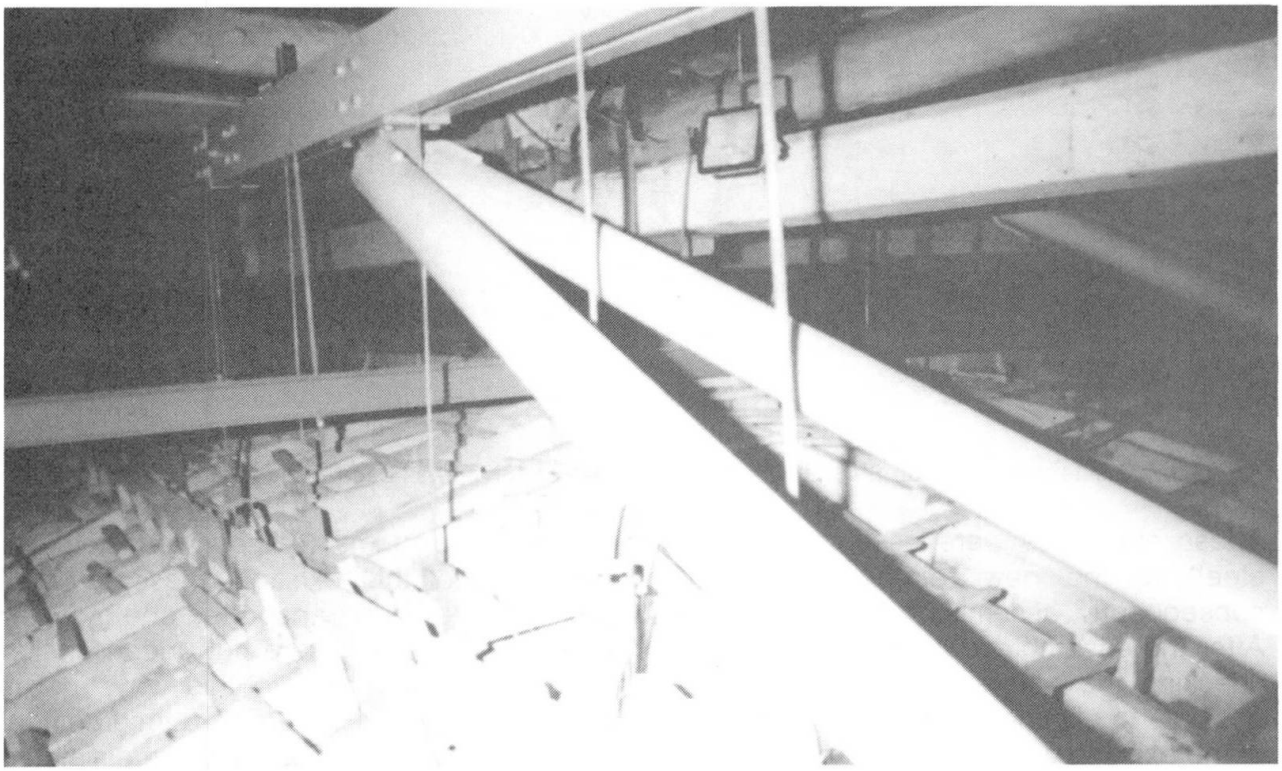

Fig. 6 New suspensions to steel prosthesis of the wooden vault after intervention.