THE COLISEUM

Completed in only four months, this unique rehab project gave new life to Rome's most celebrated ancient monument: a performance stage for the third Millennium.

Photo 1 - The corridor leading to the amphitheatre before the construction of the platform and connecting runway.

Photo 2 - A protective covering was applied over the original stone blocks before placing the new concrete supports for the wooden beams over them.

Photo 3 - A sample cube of the concrete formulated by Mapei to have the same characteristics as the original stone blocks. The smaller photo illustrates the composition of the concrete.

Photo 4 - Pouring the specially designed concrete mix into the forms.

After surviving countless wars, sacks, and reconstructions down through the ages, the Flavian Amphitheatre, popularly known as the Coliseum, has rediscovered its ancient origins in a project that gives new life to this priceless archeological treasure. In July of 2000 the Coliseum inaugurated a new era in its history as a venue for high profile theatrical and musical events with a production of the Oedipus Rex of Sophocles, directed by Vassilis Papavessileiou. Although the Emperor Titus entertained 75,000 spectators at the original inaugural celebration in 80 A.D., the productions of the new Millennium will be performed before a more select audience of only 700. The reason for so greatly restricting the number of seats was to protect the monument from the risks that building seating for a larger public would entail. A much wider audience will be reached by televising the new productions from the rehabilitated archeological site.

Only a quarter of the total surface of the floor of the arena was rebuilt, leaving the remains of the ingeniously constructed subterranean "backstage" areas exposed. In these vast labyrinthins were penned the exotic animals imported from the conquered provinces as they waited to make their entrance "on stage", as did the gladiators. Also located here was the machinery used to create special effects, such as the lifts that raised the animals to the level of the arena into which they leapt on cue from hidden doors that suddenly sprang open for maximum dramatic effect.

The new stage was built at the Flavian level of the extreme western end of the arena along with a runway leading to the very spot where the gladiators once entered, near their

gymnasium, the "Ludus Magnus". The modern platform, like the ancient one, was built of boards of wood laid over a dense network of plywood beams that were reinforced with aramid fiber composite material and AISI 304 stainless steel. It took years of research, deliberation and delays before the platform and runway were finally completed. The lengthy process, however, delivered a finished product that was the better for the in-depth research conducted before the work began. This research pinpointed the criteria for a reconstruction that proved a success both technically and structurally, and one that was compatible from an artistic standpoint with the Coliseum's status as a historical monument.

The project was an interdisciplinary effort by the Rome Archeological Commission, as represented by architect Giangiacomo Martines and Drs. Iacopi, Rea, and Conte, along with architect Piero Meogrossi, the Project Manager, and the Structural Engineering Faculty of La Sapienza University of Rome, coordinated by Prof. Maurizio Cerone, the principal architect of the project, and his staff, engineer Alberto Viskovic and architect Fabio Fumagalli, with the assistance of the Germanic Archeological Institute.

The project was a very delicate piece of engineering that involved first identifying the points that could serve as supports for the new construction. New structural elements would then be positioned onto the ancient blocks of decayed tuff and travertine, so that their original form and function would remain visible. In this way the restoration would respect the monument' s history. The basic concept

Photos 5 and 6 - New concrete bases were placed over the original stone blocks. The wooden beams were then placed on top of the concrete.

called for building a new structure of modern materials such as plywood reinforced with AISI 304 stainless steel and aramid fibers that could be combined with the archeological remains without damaging them. The contrast between the old and the new materials would remain visible in the completed project.

New supports for the stage were placed

Photo 7 - Some of the new concrete blocks were placed on top of ancient brick.

Photo 8 - Wooden columns supporting the new platform and runway. The smaller photo illustrates a detail of the plywood used for the beams, reinforced with aramid fiber composite material that can be seen here by its contrasting color.

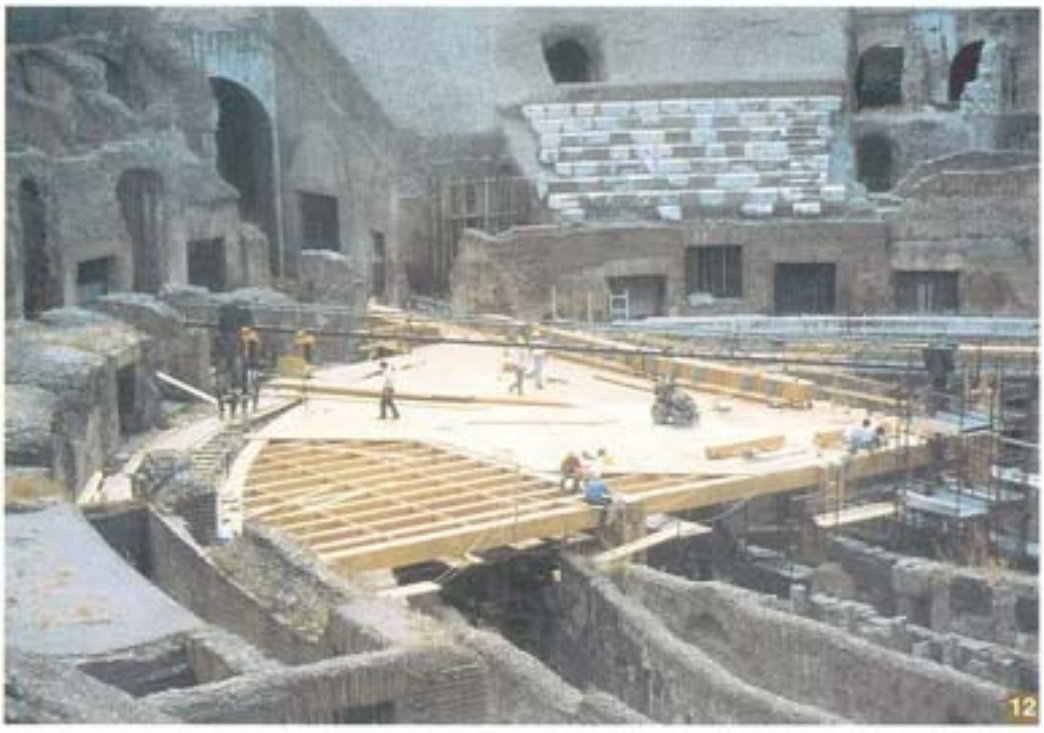
Photo 9 - A panoramic view of the construction site showing the dense network of wooden supports for the platform.

Photo 10 - Steel cables on the perimeter were anchored with Mapefill.

Photo 11 - When the work was completed sophisticated measuring systems were used to test the stability of the new stage.

Photo 12 - Laying the wood flooring over the platform.

onto three types of the Coliseum's structural and foundation elements, all of them made of tuff and travertine. These typical materials of Central Italy are ideal for construction because they are easily worked but have poor resistance when exposed to the air. Some tuff blocks that formed part of the walls underneath the platform (and thus had not suffered from exposure) were used as bases for the new concrete blocks. In other sections pieces of travertine, because of their position, were used as spans for new concrete bearing blocks. The curving perimeter of the arena was partially levelled to conform to the height of the new concrete border supporting the beams of the new platform. Mapei was asked to design high strength mortars and concretes that would be compatible with the original stone. The project required mortar used to consolidate the blocks of tuff and a durable concrete mix used to cast the supports for the new stage. Materials were also needed to anchor the cables to the beams and bond the wood to its stone supports. MAPE-ANTIQUE F21* was used to consolidate and seal the cracks in the tuff blocks and columns. This product is a special non-cementitious hydraulic binder with a base of hydrated lime and pozzolanic materials that is compatible with the original stone. The mix remains fluid and can be easily poured into cavities before hardening gradually through a chemical reaction that does not interact with the tuff, so the stone is preserved. (The original stone was first sanded.) Research was conducted in the Mapei laboratories to determine a mix design for the concrete that could meet the criteria established by the Archeological Commission and the structural engineering team of the University of Rome. Not only did the mix have to be formulated for maximum durability and watertightness, it also had to reproduce the color of the tuff and travertine, even down to the subtle variations of shade the stone had acquired over 2000 years of aging. After various trials it was determined that the cement needed a pozzolanic base mixed with fine black pozzolan, crushed lapillo and basalt, and local volcanic materials found just outside Rome in the Tocchi quarries. MAPEFLUID PZ 500* was added to the mix. This admixture is ideal for low cement content mixes and



increases resistance to saline attacks from humidity and salts in the soil. It is also a super-plasticiser that increases the workability of lean concretes such as this one while maintaining a high level of mechanical strength.
In this mix MAPEFLUID PZ 500* was dosed to maintain the required slump (S4) from preparation to pour.
The concrete mix was formulated to have an R_{ck} of 27 kg/mm^2.
MAPEFILL* was selected for anchoring the cables in the perimeter beam of the platform. This product is a very fluid premixed mortar that can penetrate into even the narrowest spaces. It is composed of cements that are highly resistant and that more importantly can withstand even dynamic forces.
EPOJET* was used to fix steel plates to the concrete blocks. This very fluid epoxy resin-based product forms a monolithic bond and is specifically made for sealing and reinforcing bearing structures. Multi-axial aramid fiber fabric was used to reinforce the plywood beams along with marine-grade mahogany plywood and uni-directional carbonium plates. The commitment to research and experimentation by the team of experts enabled the Sacen srl Construction Company of Naples to execute the project safely and successfully, to the unreserved satisfaction of Project Manager Meogrossi and the Archeological Commission. It took only four months to complete one of the most important restoration and rehab projects undertaken as part of Rome's Jubilee 2000 celebration.

**The technical Data Sheets for the products mentioned in this article are contained in Mapei binder No. 3 "Building Line".*
Epojet: *Superfluid epoxy resin for injection*
Mape-Antique F21: *Superfluid fillerized hydraulic binder for injection and consolidation of stone, brick, and tuff structures*
Mapefill: *High-flow shrink-free grout for anchors*
Mapefluid PZ 500: *Superplasticising pozzolanic admixture for high quality concrete and mortar resistent to chemical attack*

TECHNICAL DATA

Flavian Amphitheatre (The Coliseum)
Rome - Italy
Project: partial reconstruction of the floor of the arena and consolidation of the bearing elements
Financing: Banca di Roma
Date of project: initiated 2 Feb. 2000, completed 20 June 2000
Design: Archeological Commission of Rome
Project Manager: architect Giangiacomo Martines
Project Supervisor: architect Piero Meogrossi
Scientific Consultants: Dr. Livia Irene Iacopi, Dr. Rossella Rea
Construction Company: Sacen srl, Naples, Italy
Technical Director: Dr. Umberto Battista
Structural Project: Faculty of Structural and Geotechnical Engineering of La Sapienza University of Rome
Architect: Prof. Maurizio Cerone in collaboration with Alberto Viskovic and Fabio Fumagalli
Historical consultant: Germanic Archeological Institute
Mapei products used: MAPE-ANTIQUE F21, MAPEFLUID PZ 500, EPOJET, MAPEFILL
Mapei co-ordinators: Renato Soffi and Aurelio Rossetti
Mapei photography co-ordinator: Pino Mancini