TAKING SHELTER IN THE

The renovation work on the out-fitting wharf at the Sestri Ponente shipyard testifies to how an analysis of the conditions causing deterioration of concrete and choosing specific products are vital in re-establish quality and durability.

The Sestri shipyard is an industrial structure for the design and construction of oil rigs and ocean-going tankers. The shipyard covers an area of 213,000 m², with 108,500 m² of state-owned waterfront leased by the Harbour Master Office of Genoa. Like other shipyards belonging to the Fincantieri Group, it has a world-wide reputation for its production capacity and for its skilled and experienced workers.

The state concession requires the company to look after the conservation and maintenance of the constructions around the bay, including the quays and a ship out-fitting wharf. Once the steel sheet hull of the ship is built and the sections are pre-assembled ashore, the ships are then assembled in dry docks before being fitted out and equipped for sea testing before delivery.

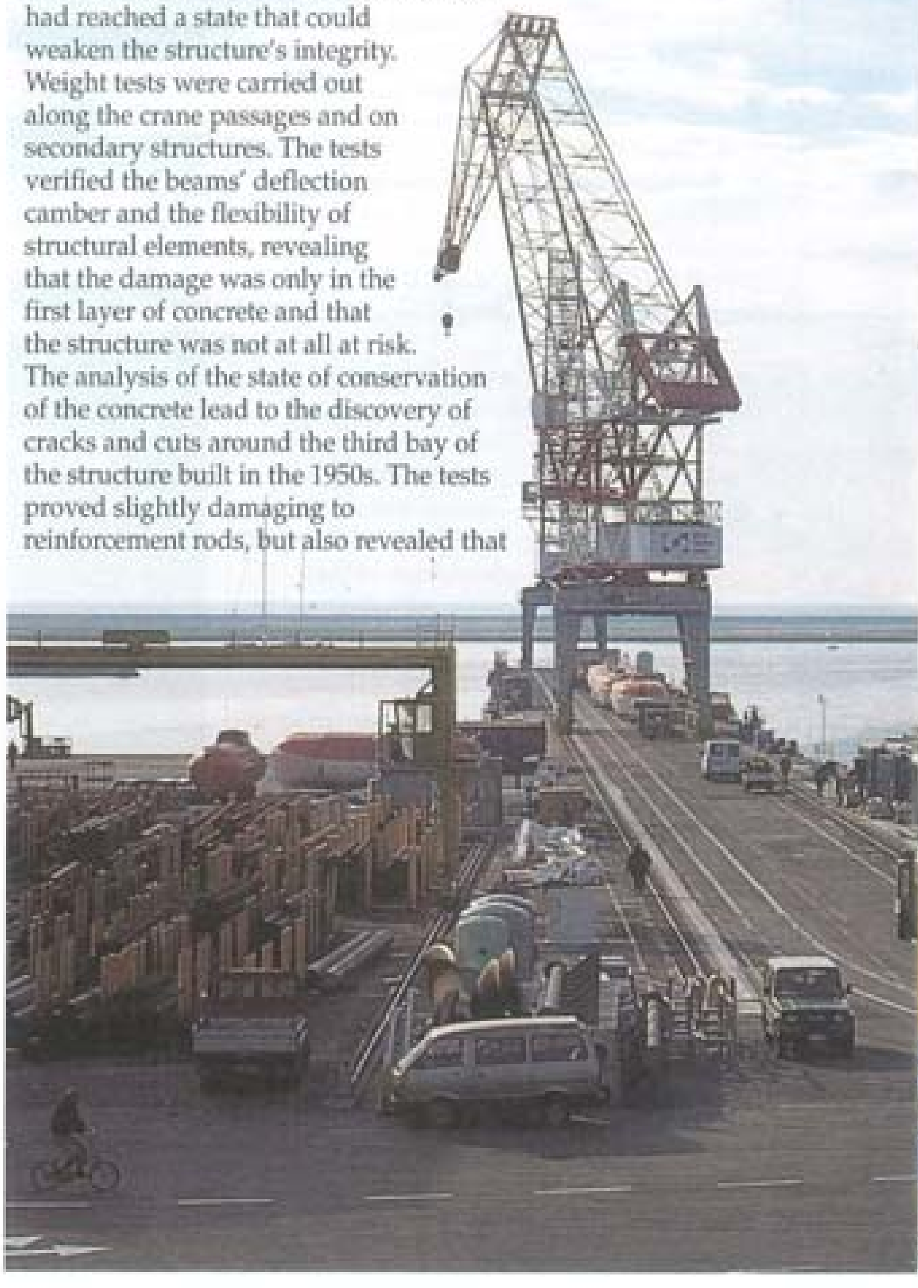
Today's particular market conditions mean that the yard has to undertake numerous orders simultaneously which, in turn, means locking up resources and manpower for years at a time. Such efforts require maximum organisation and highly efficient facilities.

A race.... towards testing

Continual maintenance is necessary to prevent problems from arising that could slow production. Such maintenance is necessary because of the vicinity of the sea – in other words, the constant exposure to aggressive environmental conditions - as well as the wear and tear on the structures that have to bear the loads of cranes moving to and fro along the wharf. The out-fitting wharf is subject to most wear because of constant contact with water as well as the ships docked alongside.

Two thirds of the structure was build in the 1950s while the last part, further out to sea, was added in the 1970s. It is 18 metres wide and 300 metres long. The main structure is composed of a pier on which eight huge beams rest. The beams adjacent to the passage of the crane are 60 cm wide and 215 cm high. The concrete slab and external stemming form an box-like structure for wiring and piping which can be inspected.

Over the years, certain areas of concrete in the structure have showed signs of deterioration especially in the extension built in the 1970s. The amount of damage differed depending on the area, position and exposure to salt-water erosion. The shipyard's technical department therefore decided to test areas and evaluate if the level of deterioration had reached a state that could weaken the structure's integrity. Weight tests were carried out along the crane passages and on secondary structures. The tests verified the beams' deflection camber and the flexibility of structural elements, revealing that the damage was only in the first layer of concrete and that the structure was not at all at risk. The analysis of the state of conservation of the concrete lead to the discovery of cracks and cuts around the third bay of the structure built in the 1950s. The tests proved slightly damaging to reinforcement rods, but also revealed that



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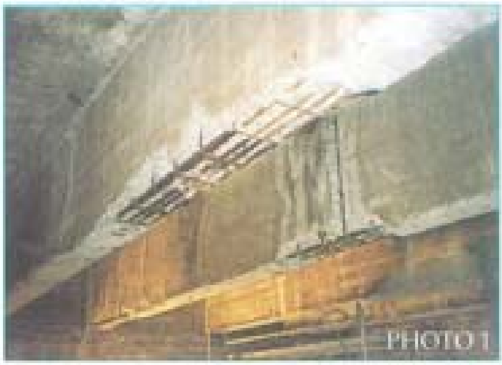
PHOTO 1


PHOTO 2

inspections to see the amount of deterioration had already been made in the past.

Concrete at sea

Constructions directly in contact with salt water are more subject to deterioration which, if not detected or dealt with in time, could create serious and irreversible damage. The European law ENV 206, known as UNI 9858 in Italy, prescribes that only Class 4 concrete can be used for constructions built near or by the sea, under water, partially submerged or those built near the coast where they are exposed to the so-called "saline fogs".

Sea water deteriorates concrete mostly through the presence of sulphates which react with the cement causing the formation of ethringite. Chlorides are very aggressive when in contact with reinforced rods which, if they are not well protected by the cortical layer of concrete, corrode very rapidly. These factors must be taken into consideration when repairing structures in marine environments. The products used must be highly resistant to penetration of dangerous salts with the goal of re-establishing the necessary protection for durability.

Cortical restoration of concrete

The state of conservation of the out-fitting wharf varied from one area to another. The worst hit was the concrete slab which was devoid of damp-proofing and was covered with porphyry flooring. Other parts of the structure were also affected as could be seen by cracks in the cortical layer of the concrete. During the initial discovery phase the engineers noticed a considerable difference in quality of the cover of the reinforcing rods (and quality of the casting itself) between the structure built in the 1950s and that built in the 1970s. The 1950s' structure was considerably better built. In both cases though, the inner surface of the girders and the concrete slabs were in bad condition. The concrete reinforcement rods were completely exposed and corrosion had reduced the section substantially (photo 1 and 2).

After having thoroughly analysed the problem and laid down all the parameters for the reconstruction project, the technical department decided to remove the layer affected by hydrodemolition in order to remove the chlorides that had penetrated the concrete over the years. The task called for a two-pronged approach: first, the removal of loose and deteriorated parts with electrodemolishers, second, high pressure hydroscaring (2,000 bar, 25 litres per minute) all surfaces. The use of high pressure hydrodemolition was especially

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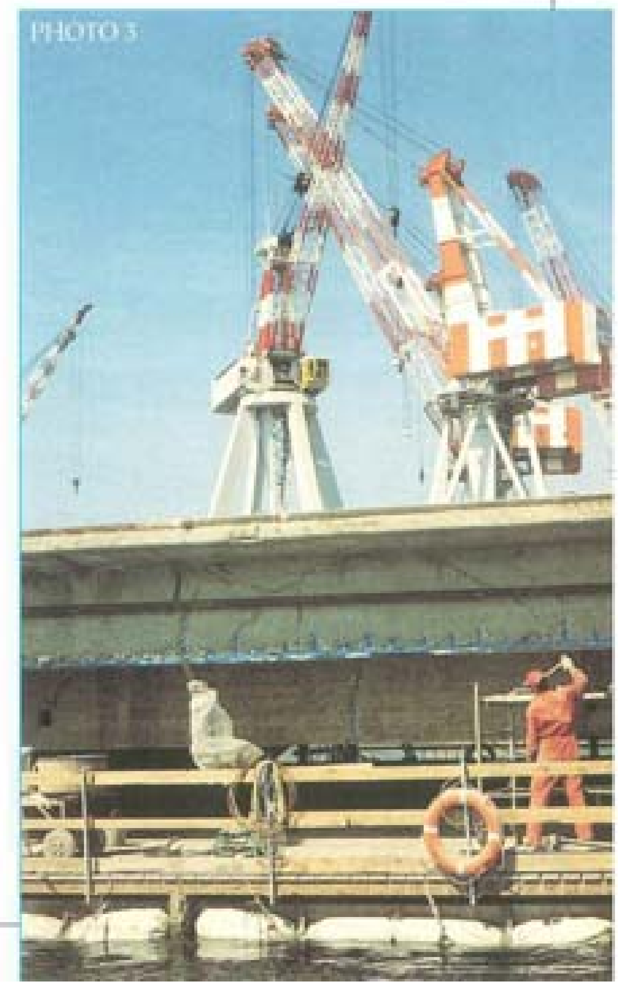


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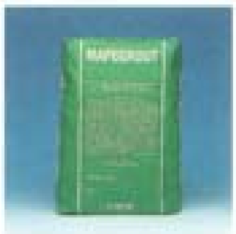


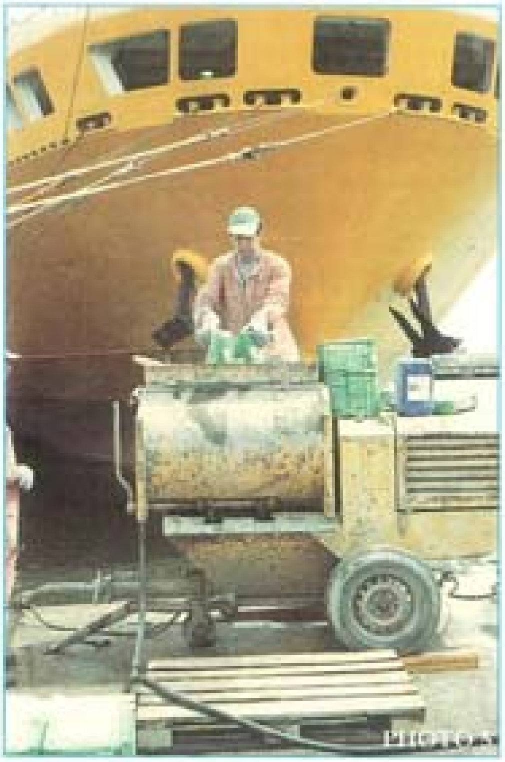
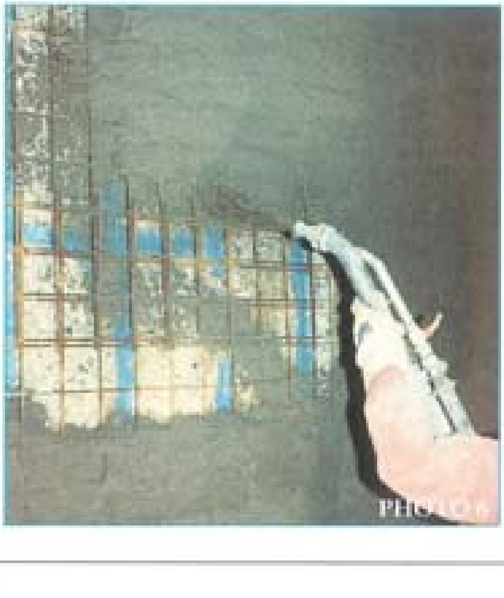


PHOTO 5

effective in some sections of the beams' inner surfaces. It revealed a higher degree of deterioration than expected, and fragments of concrete 7-8 cm thick were removed, exposing the steel reinforced framework.

Seawater resistant materials

The materials and application methods employed heavily influence the quality and durability of this kind of repair works. The rate of deterioration of concrete that has been repaired depends on how the new material bonds with both the reinforcement framework and the existing concrete, its strength, reduced shrinkage during the curing stage and waterproof characteristics of the concrete used. Beside these indispensable qualities, the materials employed must ensure good plasticity in a wide range of temperatures. This last property is particularly important when considering the environment in which the repair work is undertaken and the different types of surfaces encountered. Not all the surfaces are smooth and flat, but most are highly irregular calling for differing thicknesses to be applied.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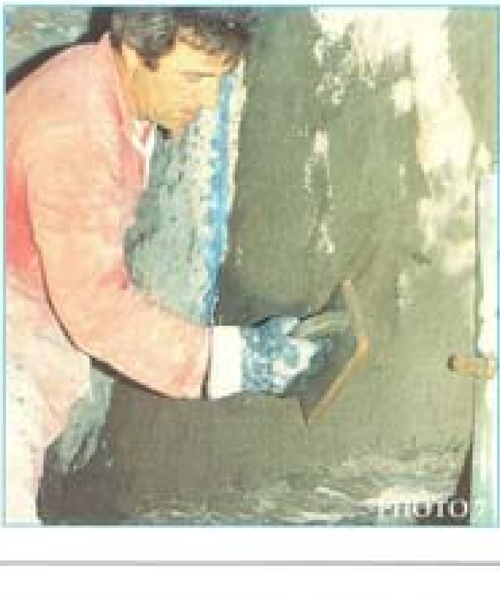


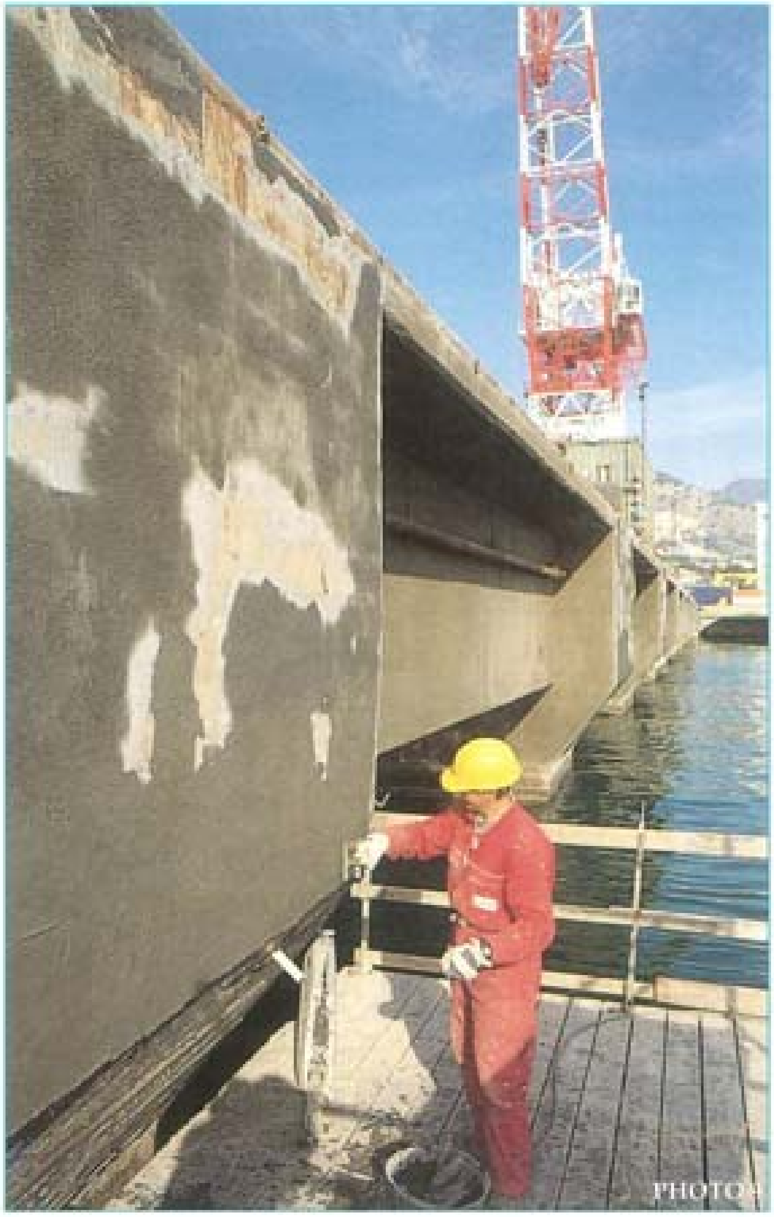
PHOTO 7

After a careful analysis of the problem, the technical department and contractor decided that the best results would be achieved with three products. Each product would fulfill a particular requirement and would guarantee quality concrete, and increase its

TECHNICAL DATA FOR MAPELASTIC

Adhesion to concrete:	0.8 N/mm² (cohesive break of the product)
Modulus of elasticity:	480 N/mm² (after 28 days at 23°C)
Positive Waterproof:	limited to 3 atm positive push (DIN 1048)
	limited to 1 atm negative push (DIN 1048)
Water permeability:	absent at 1 atm (UNI 8202 – point 21)
Resistance to vapour (μ):	1,500
Resistance to freeze/thaw cycles on concrete:	more than 300 cycles (UNI 7087)
Flexibility tests on ties:	25.5% (DIN 53504 modified)
Crack-bridging tests:	cracks more than 1mm (Austrian recommendation RVS)
Resistance to calcium chloride (after 60 days in 30% CaO_2 solution)	loss of compressive strength on a sample protected with MAPELASTIC – none
Resistance to sodium chloride (after 60 days in 10% NaCl solution):	NaCl<2 mm ion penetration
Resistance against carbonisation (after 60 days in 30% CO_2 solution):	penetration of carbonisation < 2.5 mm


PHOTO 8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durability.

MAPEFER - a mortar based on polymers in water dispersion, cement binders and corrosion inhibitors - was brushed on the reinforcing rods (photo 3 and 4). Besides being an effective corrosion inhibitor, MAPEFER also improves adhesion of the concrete. The concrete was then reconstructed using MAPEGROUT MS, a pre-mixed micro-silicate-based fibre-reinforced thixotropic mortar (photo 5, 6, and 7).

MAPEGROUT MS is composed of high-strength cements, special additives with pozzolanic action (needed to provide the durability required), selected aggregates and synthetic fibres. In areas where thicknesses over 4 cm were necessary, gravel was added and extra reinforcing rods were placed in those areas most subject to deterioration.

MAPELASTIC - a two-component plastic cement - was used to coat the entire structure including those areas where concrete was in good condition with a layer just millimetres thick for complete protection (photo 8). Once dry, the MAPELASTIC gave the surface a good-quality finish that is completely impermeable to carbon dioxide, chloride , and sulphates.

In some areas unaffected by deterioration of the concrete such as, for example parts of the pier where hydroscarified surfaces were particularly irregular and covered with pits 1-2 cm deep, MAPEGROUT MS had to be

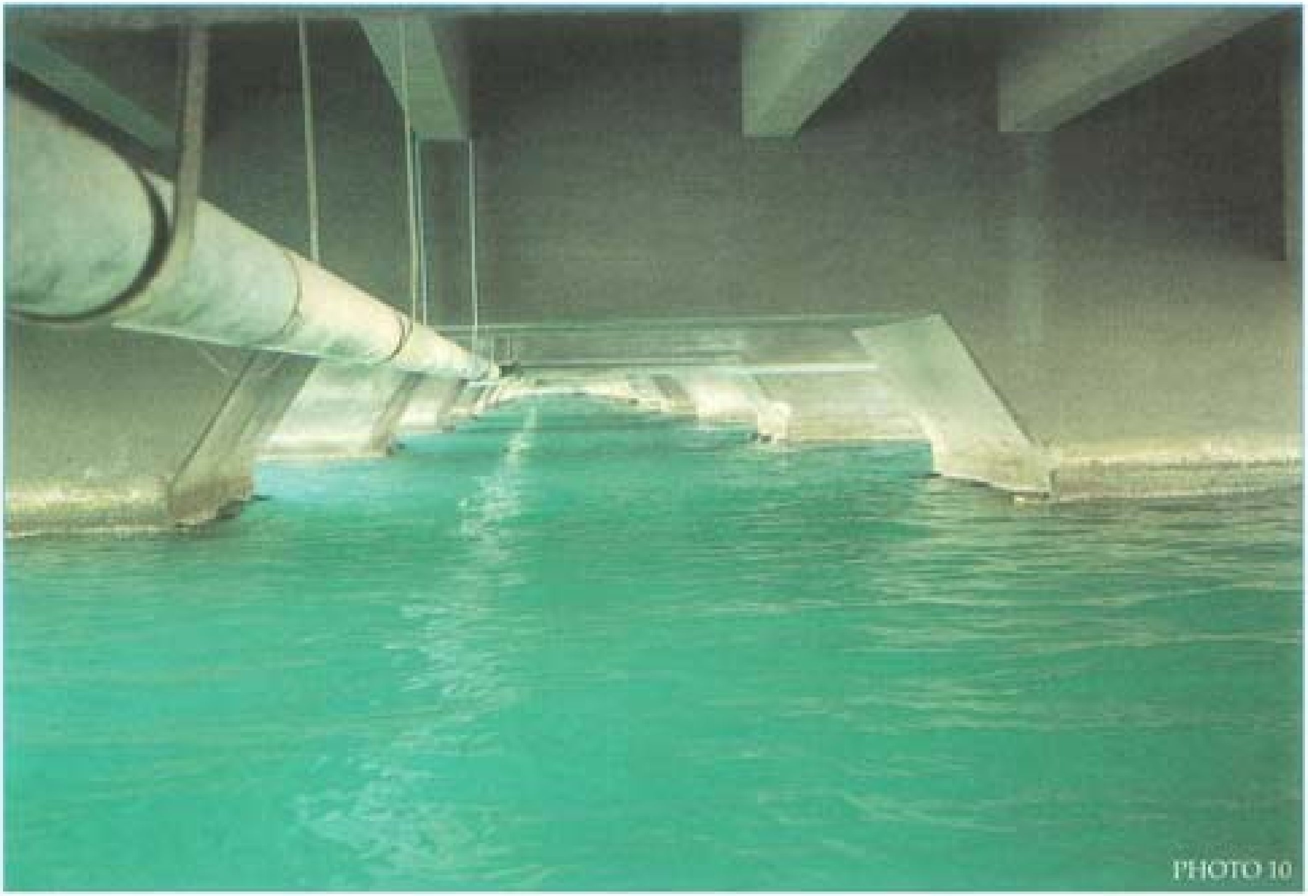
PHOTO 10

applied before the MAPELASTIC in order to level the surface of the hydroscarified concrete. Applying MAPELASTIC alone would have meant forming layers too thick for a product designed to be only millimetres thick.

Structural reinforcement by cladding

During repair, the technicians discovered that the stability at the intersection between the dock and the out-fitting wharf was very precarious. This point was almost inaccessible because the gap between the water surface and the inner surfaces of the three scaffolding beams was only 50 cm. As the bays couldn't be reached from the side or from below, access hatches were built to inspect for possible cracks in the beams and to repair the concrete where necessary. Inspection revealed vertical cracks along the 3 metre high, 10 metre long and 80 metre thick beams around the supports. Repair called for reinforced structural cladding made from three 10 mm layers of sheet iron. The sheet iron was first sandblasted and then bond to the beams with ADESILEX PG1, a thixotropic epoxy adhesive for structural bonding. The iron cladding effectively substituted the concrete's iron reinforcement rods which had proved insufficient in sustaining the work loads. To render the cladding even more structural, holes were drilled through the girders and threaded rods inserted and bolted at either end. MAPELASTIC was then applied to the whole structure.

Now the out-fitting wharf can be considered virtually bomb-proof (photo 10).

TECHNICAL DATA

Sestri Cantiere navale, Gruppo Fincantieri
Sestri Ponente (GE)

Year Built: 1950s and 1970s

Year Repaired: 1998

Structural Manager: Eng. Donatella Mascia

Project Manager: Renato Manara

Contractor: Mosconi Srl. – Edolo (Brescia)

Mapei Products used for repairing the concrete:
MAPEFER
MAPEGROUT MS
MAPELASTIC
ADESILEX PG1

Mapei coordinator: Eng. Fulvio Bianchi

We would like to thank the magazine "Costruzioni Due" which supplied some sections of the text for this article.

The Technical Data Sheet for the products mentioned in this article are contained in Mapei binder No. 3, "Building Speciality Line".