NINETY METERS HIGH

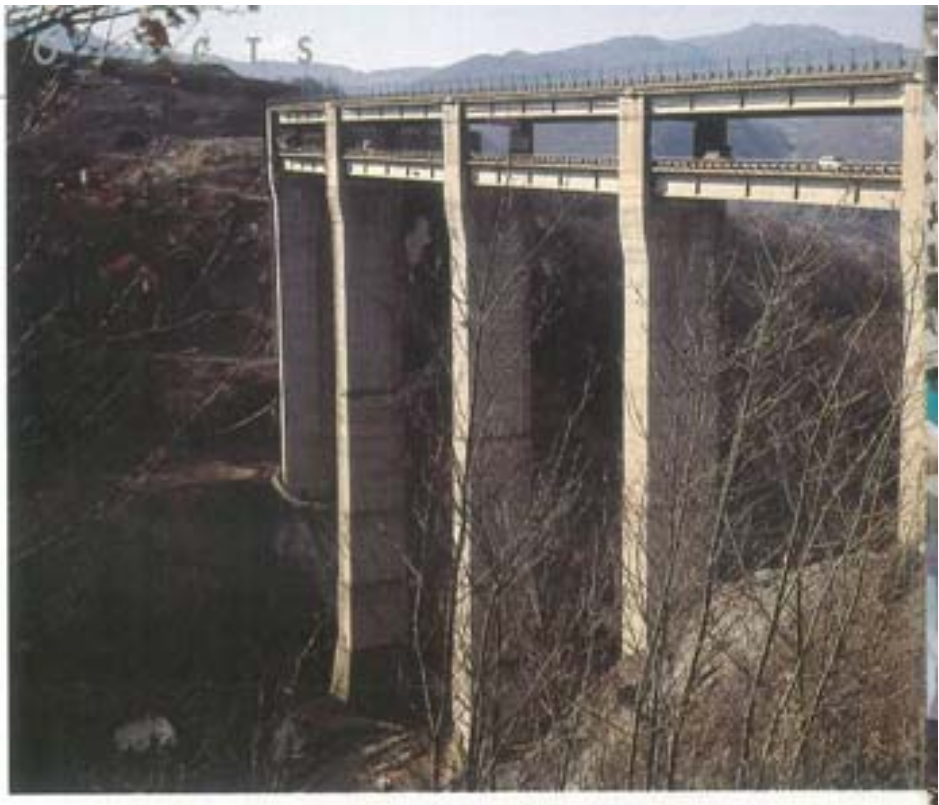
In a segment of the Cisa Motorway, a consolidation intervention has allowed the recovery of extremely high piers without the interruption of traffic.

When managing a motorway network, the concept of maintenance does not only regard a series of ordinary routine interventions; it's necessary to consider extraordinary operations as well.
The scope of these operations is to guarantee optimum operational conditions in time, and to ensure the integrity of structures (bridges, piers, abutments) and tunnels which, in our country and with few exceptions, are all made of reinforced concrete.
According to the most refined definition, this is a composite material composed of the structural union between concrete and steel. But concrete, like all construction

materials (including steel), ages and deteriorates. What's more, in various geographic areas it's necessary to consider the frequent freeze/thaw cycles that are extremely harmful to the concrete's integrity.
Deterioration is mainly due to the physiology of the structure, to the environmental conditions, and therefore to thermal variations, but also to the use of salts which dissolve in water when it percolates, damaging the underlying structures. Furthermore, during the sixties and seventies, the structures were designed with criteria that today are no longer in use, and were generally made of ordinary concrete, often without adequate internal reinforcing.
Through the years, this material has shown evident limits and has caused numerous problems.
To solve this series of problems it's necessary to organize an adequate program of recovery interventions, composed of a precise succession of phases: the determination of the deterioration's cause; the selection of the applicative techniques and materials; the selection of the operational guidelines

Project indications

The project's directives regarding the products to use are quite clear, and state literally: "The rheo-plastic mixtures used, with compensated shrinkage, are supplied dry and premixed, and are mixed in special mixers with the amount of water recommended by the producer. The operation temperature of these materials is about 293 K, but temperatures between 278 and 308 K are also acceptable. These grouts are reinforced using electro-welded steel grids, which allow to compensate hygrometric shrinkage and the expansive actions of the grout itself. They contain (for resisting to particularly ventilated conditions, with low atmospheric humidity) plastic micro-fibers, uniformly distributed within the mix.
The concrete on which the grout is applied must be wet to refusal before the application of the covering.
The grouts must be laid without frameworks when the thickness of the recovery must not exceed 3 centimeters or when it's not required by the project. For greater thicknesses, it's possible to cast special concretes in non-wooden frameworks. These special concretes are obtained by mixing rheo-plastic premixed grouts, with compensated shrinkage, together with selected, washed, and correctly dimensioned aggregates (25 millimeters).
The grouts are applied with a trowel or with spraying equipment. The grouts are protected from evaporation with a layer of "curing" agent: the use of polyethylene transparent sheets is not allowed since they hinder the dispersion of hydration heat.
The grouts' contrasted expansion must not be lower than 0.4/1,000 after 7 days. After 28 days, the value of the expansion must not be lower than the value at 7 days, and must not be higher than the same value increased by 30%.
Testing adhesion to the support, determined by shearing, is to be conducted on 7x7x28 beams, composed in part by a concrete wedge with R_{ck} 45 N/mm^2 and seasoned at least 28 days, with a surface inclined at 20 degrees. Shearing resistance is required on the inclined surface.
Adhesion tests carried out through direct traction are to be done on samples with a 50 millimeter diameter".



that must be included in the specifications; the careful execution of each operational phase.

Control of the structures

Autocamionale della Cisa is the company that manages the motorway section that connects Parma with La Spezia, crossing the Tuscany-Emiliano Apennines. During the sixties and seventies (the last section was opened in 1975), about 140 structures (for a total of 450,000 square meters of bridges) and 14 tunnels were built. Recently the company has renewed the managing contract until 2010, and has presented a new plan of intervention with investments of about 1,000 billion lire.

The extraordinary maintenance done on the Roccaprebalza (Berceto -Parma) viaduct is the most significant intervention that the Autocamionale della Cisa has carried out in the last years: work (done by the Rabbiosi company of Bolzano) started in 1999 and was finished in autumn of 2000.

The cost of the intervention was of over 7.5 billion lire.

The viaduct is characterized by the extraordinary dimensions of the central piers, about 90 meters high at the intrados. In this segment, traffic is organized on two overlaid roadways, which create a double level sustained by 90 meter piers. During a preliminary check a percolation of brackish water, involving nine piers of the entire viaduct, was discovered. What's more, the deterioration was in an advanced state.

The main difficulty of the intervention consisted in the fact that, given the height of the pier, it was necessary to intervene at high

altitudes. In similar cases, the application of recovery techniques is complicated, and the use of top quality material, technologically advanced solutions and equipment, besides specialized workmanship, is extremely important.
The restructuring and reinforcement interventions consisted in specific activities:
- hydro-demolition of the piers, for an average penetration of about 7 centimeters (in some cases even 13 centimeters were reached), for the removal of the degraded parts;
- sandblasting of the reinforcement bars, totally cleaned and treated with anticorrosive products and "passivating" material;
- installation of an integrative reinforcement (fit to resist to a second category earthquake);
- laying of rheo-plastic grout;
- final treatment through the application of an elastic two-component cement grout, MAPELASTIC*, and successive laying of a polyurethane two-component system preceded by the application of an apposite primer.

Photo 1. Close-up of degraded concrete

Photo 2. One of the deteriorated piers of the viaduct, the 7th

Photo 3. The structure's new reinforcement

Photo 4. Machine laying of the MAPEGROUT T60C grout*

Photo 5. Grout finishing with a plastering trowel, and application of MAPECURE E anti-evaporation agent*

Mapei's role

Before its use, the material destined to the recovery and reinforcement of the structures undergoes special tests carried out by the contractor, as well as by the supplier of the products.
Mapei, after the tests done by the Autocamionale della Cisa, personally carried out a further certification of final quality. Using a laboratory installed on the conctruction site and equipped with all the necessary instrumentation, tearing tests and mechanical and elastic performance verifications were carried out.
Mapei's policies, as well as its constant presence on the construction site, underline once more the importance of a strong collaboration between the contractor and the product supplier. Previously sharing information allows to avoid useless and expensive damaging or unsuccessful interventions.
In general, a recovery grout used for this type of intervention requires specific characteristics. It must adhere perfectly to the support and must guarantee limited shrinkage to avoid cracking; furthermore, it must be impermeable and able to resist to chemical aggression. Of course, the material selected must present an adequate mechanical resistance and elastic module. In this case, as previously mentioned, attention was focused on the recovery of 90 meter high piers, in particular weather conditions and in the presence of significant vibrations. For the occasion, Mapei research laboratories created a specific product, called MAPEGROUT T60C* (the "C" stands for "Cisa"). It's a premixed thixotropic single-component cement-based grout, composed of sulfate-resistant hydraulic binders, synthetic polyacrylnitril fibers, an organic corrosion inhibitor, selected aggregates and special water retaining admixtures. This solution substantially derives from the already known MAPEGROUT T60* grout, used for recovering structures in degraded concrete in general and for protecting reinforced concrete from sulphate aggression. What reason required the creation of this specific product? "The material had to guarantee adequate pumping at great heights, even with high temperatures, and appropriate mechanical characteristics". Moreover, it was possible that the grout remain inside the tubes for long periods of time (even an hour): for this reason the product had to be fluid enough to avoid obstructing the tubes.
After removing the degraded parts and spray cleaning the surfaces with water to remove impurities and contamination, MAPEFER* was used for preparing the supports. This two-component anticorrosive cement grout, (based on polymers in water dispersion, cement binders and corrosion inhibitors), is specifically used for protecting the

concrete's reinforcement bars.
The application of this product is fundamental for protecting the structure in time from corrosion and carbonation, therefore guaranteeing durability.
A water-based anti-evaporation product, MAPECURE E*, was then applied to allow better curing of the grout applied.
This product was then removed by means of sandblasting before the application of a protective finishing. Finally, MAPELASTIC* grout was chosen for the final protective layer of the recovery: this two-component cement product is particularly flexible, and is able to support movements of up to one millimeter without cracking; it's totally impermeable, and creates a special "elastic skin" on the surface treated.

In the picture on this page: one of the viaduct piers after the recovery interventions. (The picture is courtesy of the "Nuovo Cantiere" magazine).

"The products mentioned in this article belong to the line "Building specialty line". The technical data sheets are contained in the Mapei Global Infonet CD and in its Internet site www.mapei.com. "
Mapecure E: *curing compound in water emulsion*
Mapefer: *anti-rust mortar for reinforcing rods*
Mapelastic: *two-component flexible cement mortar for waterproof protection of concrete, swimming pools and balconies*
Mapegrout T60: *sulphate-resistant thixotropic fibrous mortar for the repair of concrete (Mapegrout T60C is a special formulation, specially studied for this type of intervention).*

TECHNICAL DATA

Roccaprebalza Viaduct - Berceto (Pr)
Intervention: structural consolidation
Year of construction: 1970
Year of intervention: 1999/2000
Design: Mr. Giuseppe Mancini
Design coordinator: Mr. Nicolai Zanettini
Technical assistant: Mr. Marco Martini
Director of works: Mr. Corrado Zanichelli (Autocamionale della Cisa Spa); Director of works assistant: Mr. Giuseppe Bernazzoli
Contractor: Rabbiosi, Bolzano
Contractor Technical Director: Mr. Luciano Fogolari
Construction site director: Riccardo Vidrih
Construction site Capo: Mr. Iago Manera
Hydro-demolition: Mosconi Brothers, Edolo (BS)
Plastering machines: Pützmeister; technical assistance: Mr. Gervasoni
Mapei products used: MAPEGROUT T60C, MAPEFER, MAPELASTIC, MAPECURE E
Mapei coordinators: Fulvio Bianchi, Carlo Campinoti, Carlo Alberto Rossi, Pasquale Zaffaroni