Rio Verde

An example of reinforced concrete

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A Great Viaduct but Slightly Aged

The Rio Verde viaduct, which is located along the Cisa A15 Motorway in Pontremoli, (in the Province of Massa Carrara, Italy), is an imposing structure made up of two decks which rest on pillars and with supporting abutments in common.

This viaduct has the second highest pillars in Europe, with two of them reaching up more than 140 metres.

Because of the level of deterioration of the concrete surfaces of the pillars, in 2005 the Autocisa motorway society laid down plans for a structural strengthening of the viaduct. This was part of a wider programme regarding the modernisation and upgrading of the entire Italian motorway network. As in most cases, the deterioration of the surface of the pillars was due to a combination of factors, including carbonatation and erosion by chlorides in de-icing salts used during the winter. These factors usually provoke oxidation of the reinforcement rods in the concrete, which leads to cracking and then detachment of the concrete around the rods. The restoration project of the two central pillars, the highest ones on the viaduct, included removal of 8-12 cm of the deteriorated concrete by hydro-scarifying, laying a reinforcement mesh and then repairing the damaged sections using self-compacting concrete poured into formwork around the pillars. Restoration of the other pillars used different materials and techniques, such as the use of MAPEGROUT EASY FLOW one-component, thixotropic, low viscosity mortar. This product is particularly suitable for repair operations requiring that the concrete feature easy pumping over long distance and constant high head. For further information regarding this product, please see the technical data sheet, which is also available on the web site www.mapei.com.

Innovative Products and Technology for a Special Project

The restoration of the two central pillars has been a complex operation, because special rheologic properties

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Photo 1.
Close-up of the deteriorated concrete surface of one of the pillars on the viaduct before the restoration operation.

Photo 2.
The two central pillars of the viaduct which were the subject of the restoration work with self-compacting concrete. On the right, the repaired pillar. On the left, the pillar which was still to be restored.

Viaduct


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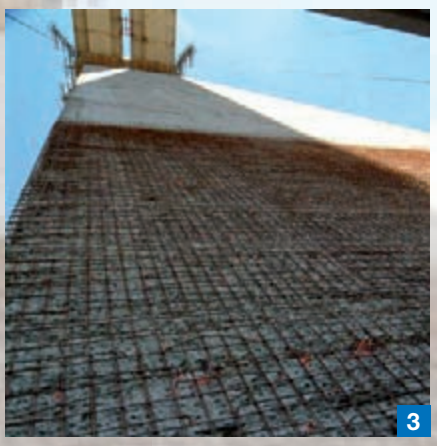
and long workability times of the self-compacting concrete must be guaranteed, under all types of climatic conditions. To make all the operations automatic and to help the workforce operate in complete safety, particularly innovative products and technology were chosen.
In fact, this is a "unique" site, where the application of special solutions are required.
There were two trump cards:
- the use of a special platform erected specially for this project, and which has been used during all the phases of the work;
- the use of dimensionally-stable self-compacting concrete for the deteriorated surfaces.
As far as the platform is concerned, ABC Costruzioni, the firm which carried out the work, was unable to find suitable equipment on the home and international markets which allowed all the operations to be carried out automatically, and which guaranteed safety and speedy work, with significant economic advantages.
Therefore, ABC Costruzioni designed a special platform called "Albert". This platform meets all operational requirements, such as moving form-work, reinforcement rods, scarifying equipment, perforation materials, etc., to high levels. It also had to be capable of guaranteeing different operations to be carried out simultaneously or in sequence, even in poor weather conditions. It also made it possible to carry out operations automatically, ensuring constant quality and optimising operational times and costs, while also reducing waste.
The platform consists of a suspended mobile steel frame structure, which can move along the pillar. It is made up of rectangular tubular steel, with four sliding walkways positioned around it. The platform is suspended using a system of cables which are anchored to the top of the viaduct, and is connected to the foot of the pillar by four

Photo 3.
Close-up of the pillar after laying the reinforcement mesh.

Photo 4
The self-compacting concrete used to repair the central pillars was made using STABILCEM SCC cementitious binder, EXPANCRETE special expansive agent, MAPECURE SRA shrinkage reducing admix and DYNAMON SP3 acrylic-based superplasticiser.



synchronised, electric pulleys.
The system also has an elevator which is used to transport the workers.
Once the platform had passed all the tests required by the European Union Standards, it was delivered to the site.
Another determining factor to guarantee successful operations on site was the use of innovative products which ensured that the concrete had excellent performance levels over long periods of time. In fact, good restoration operations are highly dependent on both the level of specialisation of the company which carries out the work, and the correct choice of materials to be applied.
Mapei products were chosen for this project, which were developed specially for large site operations and for the restoration of deteriorated concrete structures. Within the large range of products available, the following products were chosen: EXPANCRETE expansive agent, MAPECURE SRA curing admix and DYNAMON SP3 superplasticiser to make the self-compacting concrete.
The use of these materials allowed all the special requirements of this particular project to be fully met, while optimising the operational times and productivity. Working and environmental conditions for the workforce were also improved, which reduced the influence of workforce.

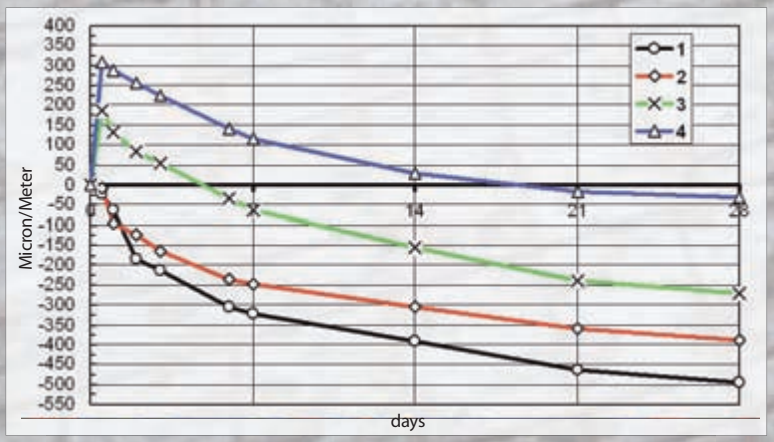
The Operational Phases
The following phases were planned:
- hydro-scarifying
- preparation of the anchoring holes
- laying the reinforcement mesh
- positioning the form-work
- pouring the concrete
- final sand-blasting
- application of a protective layer.

Hydro-scarifying was carried out using a battery of scarifying machines, applied and moved by carriages on the main platform.
Automatic boring machines were used to make the holes, which were mounted on carriages located on the upper platform.
Laying of the additional reinforcement mesh was carried out by workers who were positionated on the walkways.
The form-work was then positioned around the perimeter of the pillars, and the self-compacting concrete was poured in. The concrete was pumped from the bottom of the pillars towards the top along steel pipes fastended to the pillar. It was poured into the form-work by means of a distribution tube with a series of manually operated valves every 1.50 metres.
The self-compacting concrete was mixed using STABILCEM SCC cementitious binder, which is particularly suitable to make concrete mixes with no shrinkage, for beams, kerbs and viaduct pillars, and also bridges superstructures, hydraulic works and dry docks. Concrete made using this Mapei product offers numerous advantages both during pumping operations and once the work has been completed. In fact, it is easy to pump or pour into form-work, even if there is a dense network of reinforcement rods. It also guarantees a crack-free bind in the cementitious conglomerate, both during plastic shrinkage and once hardened. The concrete mix also ensures perfect compacting, and eliminates the risk of the formation of gravel clusters. It has low porosity and high mechanical strength, even after short curing periods.
Thanks to these properties, it guar-

Mix	1	2	3	4
STABILCEM SCC	578	558	550	548
0-15 mm aggregates	1624	1662	1644	1641
EXPANCRETE	0	0	30	24,9
MAPECURE SRA	0	5,1	0	5

(Values expressed in kg)

CONTROLLED EXPANSION VALUES OF THE CONCRETE DURING AIR CURING



Source: Mapei R&D Laboratory

The graph shows the synergic effect deriving from the combined use of EXPANCRETE and MAPECURE SRA, which guarantees that the mix has high expansion during air curing while, at the same time, extremely low hygrometric shrinkage, to avoid the risk of cracking.
Mix 1: *the self-compacting concrete does not contain either EXPANCRETE expanding agent or MAPECURE SRA shrinkage reducing admix. Notice the high shrinkage rate.*
Mix 2: *MAPECURE SRA was added to the self-compacting concrete. With this admix, shrinkage was only slightly reduced.*
Mix 3: *Only EXPANCRETE was added to the self-compacting concrete. The reduction in shrinkage was more pronounced, but the final amount was still high.*
Mix 4: *Both MAPECURE SRA and EXPANCRETE were added to the self-compacting concrete. The amount of expansion during air curing was high, while the level of shrinkage was extremely low.*

Photo 5.
A steel piping was laid along the pillar and used to distribute the concrete.

Photo 6.
Self-compacting concrete made using STABILCEM SCC, after pouring into the form-work.

Photo 7.
The pillar during the restoration operation, carried out using the special platform Albert. Notice the difference between the repaired surface of the lower section and the deteriorated section above the platform.

antees higher durability for repaired structures, which are also waterproofing and resistant to aggressive agents and freezing.
In general, the use of self-compacting concrete (with high fluidity and no segregation) allows application times to be reduced and, since there is no need to vibrate the concrete, the workers may operate more safely.
Self-compacting concrete has to have a special super-plasticising admix, which reduces the water/cement ratio and maintains workability over long periods, without compromising its performance levels after brief curing periods. The water/cement ratio has a high influence on the porosity, shrinkage rate and waterproofing of the concrete. These factors have a high effect on the durability of the material.
Mapei acrylic-based superplasticiser DYNAMON SP3 was chosen in this case. When added to the mix, it guarantees a reduced water/cement ratio and, as a result, high mechanical strength after brief curing times, even if the temperature is very low. MAPECURE SRA chloride-free, special liquid curing admix was also added to the concrete. This product has been specially developed to drastically reduce final hydrometric shrinkage in repair mortar, standard and self-compacting concrete, repair concrete mixed using STABILCEM SCC to eliminate cracks. The advantages of using MAPECURE SRA are further enhanced if used in combination with EXPANCRETE expansive agent, which allows the concrete to expand, even if air-cured, during the first days of hardening, and to have an extremely low level of shrinkage.
The combination of these two products creates a synergic effect, so that the concrete acquires properties which are normally impossible with traditional cementitious systems.
The concrete used for this job was made using the aforementioned Mapei products in a mobile concrete mixing station with a production capacity of 12-14 m/hour, with silos and a special feeding system for the aggregates stored on site.
All the operations described above were repeated for each section of the pillar until the entire height was completely covered.
Once the concrete had been poured, a final sand-blasting operation was carried out, followed by the application of a protective layer of MAPELASTIC flexible cementitious mortar.
The repaired pillars now have a perfect concrete surface with no air bubbles, cavities or gravel clusters.
It has excellent mechanical properties, and is destined to last for a very long time.
Thanks to the materials used, carbon dioxide and chlorides are no longer able to penetrate into the pillar.

CLOSE COLLABORATION FOR THE RIGHT MIX

As already explained in this article, apart from correct execution of the restoration work, the accurate tuning to develop a formula for self-compacting concrete capable of meeting all the specific requirements of the project was a determining factor.
To develop the precise formulation, Mapei technicians and employees of ABC Costruzioni worked closely together to check the various phases of mixing the concrete.
First, mixer trucks transported the inert materials right up to the foot of the pillars. STABILCEM SCC was then added to the inert materials, together with water, EXPANCRETE expansive agent and, in two successive steps, DYNAMON SP3 super-plasticiser and MAPECURE SRA admix. Once the mixing phase was completed, a sample of the concrete was taken from each mixer and was tested for spreading by a slump-flow test, to make sure that the mix had the required fluidity characteristics, and that it could completely fill the form-work without bleeding or segregation phenomenon. The final result was a concrete which was easy to pump even up to extreme heights, which maintained its workability for long periods and which had high mechanical characteristics.
This meant that the form-work was removed after only 14 hours, which helped in speeding up the operations.



Sequence of the various phases of the slump-flow test, which indicates the consistency of the concrete.

Mapei Products: *the products referred to in this article belong to the "Building Speciality Line" and "Admixtures for Concrete" ranges.*
The technical data sheets are available at the web site: www.mapei.com.
Dynamon SP3 (CE 934-2): *superplasticiser based on modified acrylic polymer for pre-cast concrete with low water/cement ratio and very high mechanical strengths at early age in winter time without steam curing treatment.*
Expancrete: *expansive agent for concrete.*
Mapecure SRA: *curing admix with the property of reducing hydraulic shrinkage and the formation of micro-cracking.*
Mapelastic: *two-component, flexible cementitious mortar for waterproofing concrete, balconies, terraces, bathrooms and swimming pools.*
Stabilcem SCC: *cementitious binder for manufacturing dimensionally stable self-compacting concrete mixtures to repair concrete structures.*

Photo 8.
Close-up of the central pillar of the viaduct, completely restored using self-compacting concrete. The remaining pillars that can be seen were instead repaired with MAPEGROUT EASY FLOW, using different methods.

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TECHNICAL DATA

Rio Verde Viaduct, Cisa A15 motorway, Pontremoli (Massa Carrara, Italy)
Intervention by Mapei: repairing the pillars' deteriorated concrete surfaces
Year of the Intervention: 2005-2007
Designer: Prof. Giuseppe Mancini
Client: Società Autocamionale della Cisa (Cisa Motorway Society)
Contractor: ABC Costruzioni Generali
Mapei Coordinator: Pasquale Zaffaroni, Mapei SpA