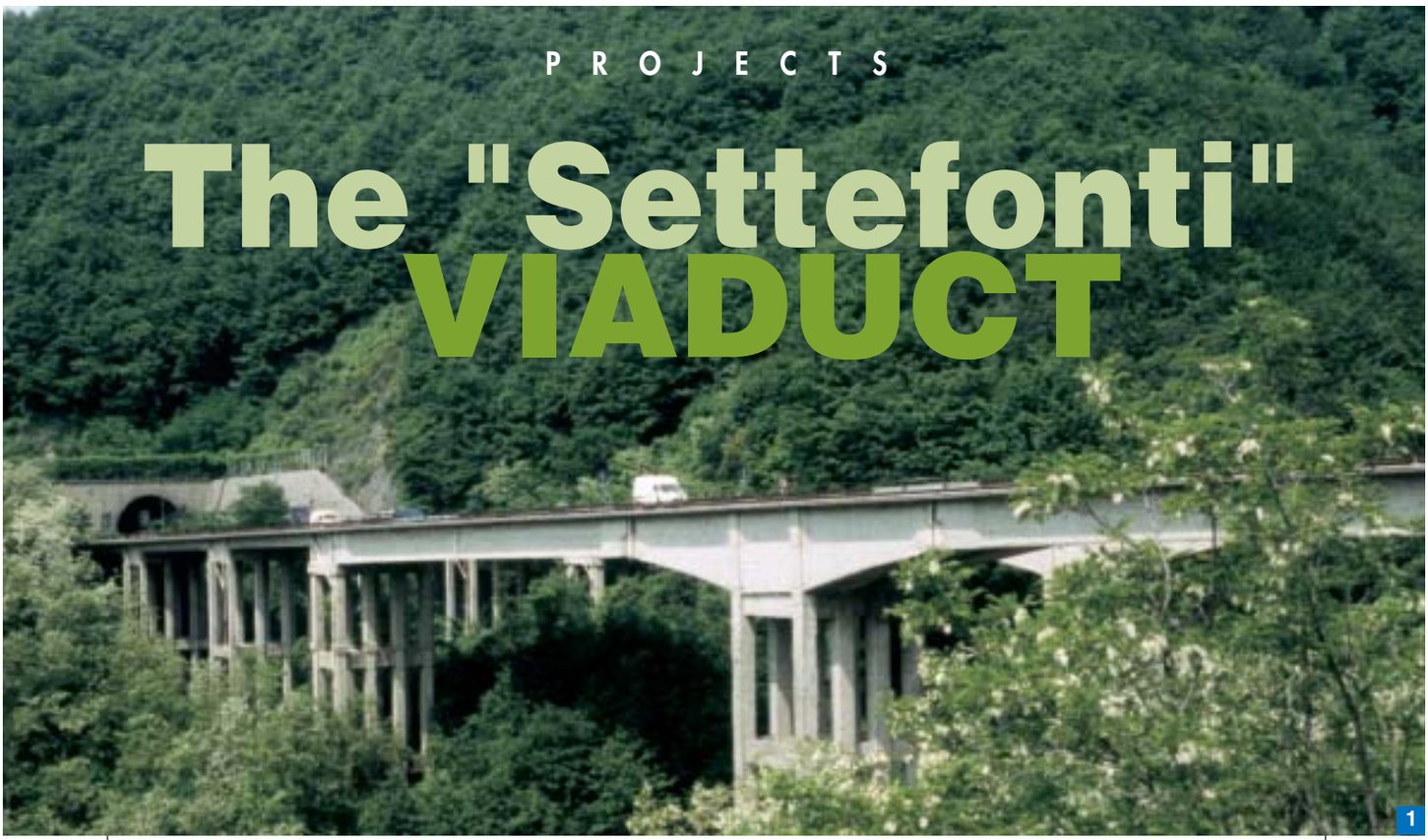
The "Settefonti" VIADUCT



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The Milan-Rome-Naples motorway connection is one of the most important Italian public works. The maintenance interventions on the infrastructures of the Autostrada del Sole are continuous. One of these regarded the Settefonti Viaduct, located on the Bologna-Florence segment in the Apennines.

The construction of the Autostrada del Sole began in 1956. It was completed (a total length of about 800 kilometers) in only a few years, and allowed the great economical and industrial development after the second world war. The rapid intervention times, the magnitude of the operation, and the technical difficulties is encountered in the crossing of the Apennines in the Florence-Bologna segment, still today represent a boast of Italian Engineering. But through its forty years of history, the Florence-Bologna segment, about 100 kilometers long, saw its traffic grow exponentially, and far beyond the expectations of the designers of that period. This caused the early aging of the numerous structures that compose it. In fact, according to the estimates made in the fifties, motorway traffic on this segment should have grown from the initial 1,000 vehicles a day to 20,000 in the year 2000. Instead, real values are of about 43,700 vehicles a day (in the Bologna-Florence North segment), with peaks of over 80,000 vehicles near the urban area of Florence. While awaiting the completion of alternative passages for the impressive traffic in the North-South direction of Italy (the high speed Florence-Bologna railway, as well as the "Variante di Valico" motorway), the maintenance interventions on the infrastructures of the Autostrada del Sole are being carried out according to particularly strict programs.

Structure description

The Settefonti Viaduct is located in proximity of the Apennine pass, at an altitude of about 700 meters above sea level, in a II category seismic area. It's composed of two separate roadways, with seven bays on the south lane and six on the north one, with a distance between them that varies between 13.8, 20.8, and 85 meters.

The main bays (85 meters) are composed of 3 meter high beams in pre-stressed reinforced concrete, placed at a distance of 2.8 meters from each other, and stiffened by cross beams and a 15 centimeter slab. The bays - of 25.8 meters - have beams with height reduced to 1.3 meters. The piers of the main bays are made of shafts with eight 1.1 x 1.1 meter columns, strengthened about every 9 meters with connecting cross beams.

The lower piers, of the 20.8 meter bays, have 80x60 centimeter columns. At the top of the piers of the main bays there are 13.5 meters overhangs, made of four ribs in pre-stressed reinforced concrete, with a height that varies from 3 to 5.5 meters, connected by a slab. The supports, built according to the cinematic scheme of Gerber, are equipped with neoprene devices. Though a partial restoration intervention was carried out in the seventies, the Settefonti Viaduct recently underwent an anti-seismic intervention on the elevated structures. On the occasion, some supports were replaced as well, and the deteriorated concrete near the saddles was recovered.

Photo 1. Panoramic view of the Settefonti Viaduct in the green Apennines of the Tosco-Emiliano area.

Photo 2. The picture underlines the size of one of the piers, formed by four double-pilasters joined by curbs of the viaduct, but it also shows the advanced state of the previous deterioration.

Photo 3. The particular base of the piers is evident.

Photo 4. Even the supports, the dosserets and the scaffolding, as well as the vertical load-bearing elements, underwent recovery interventions

Work details

First of all, in order not to penalize traffic flow, almost all work was carried out without occupying the roadways. This was possible thanks to the recovery of the worksite road used for the original construction. Work was carried out according to the following program:

1) *preparation of the supports:*

- terrain excavation until the foundations were reached;
- hydro-demolition of the deteriorated concrete of the piers, for a thickness of about 5 centimeters;
- positioning of the new Fe B 44 K steel reinforcement rods, inserted in the foundations and connected to the existing ones that emerged during the hydro-demolition.

2) *Re-construction and reinforcement:*

- re-covering of the piers with a 15 centimeter layer of concrete with compensated shrinkage and a value of R_{ck} resistance of 50 MPa, prepared with STABILCEM* and selected aggregates;
- MAPECURE E* was then applied to the concrete surface to protect the casting from rapid water evaporation and therefore to allow correct humid

Photo 5. Detail of the deterioration of the viaducts structures. In particular, the emerging of the rods and their corrosion are evident.

Photo 6. Where necessary, high pressure hydro-demolition interventions were carried out on the concrete for a thickness of a few centimeters.

maturing;
- protection of existing reinforcement rods, where necessary, with MAPEFER*, and successive recovery of the deteriorated concrete in proximity of the brackets, the dosserets and the saddles with MAPEGROUT T60*, a thixotropic prepacked mortar with compensated shrinkage, reinforced with an electro-welded steel grid with improved adherence (Fe B 44 K).

During the work on the brackets and the supports of the longest bay, the beams were lifted with apposite hydraulic jacks, and held in position until the completion of the restoration operation of the dosserets and the replacement of the supports, without interrupting traffic on the lane above. A lane restriction was needed only during the interventions on some portions of the slab, which required an actual reconstruction. To minimize the effects of this intervention on the public, work went on "non-stop", even overnight, using a mixture of concrete with compensated shrinkage prepared with STABILCEM* and an appropriate addition of ANTIFREEZE S* (an accelerating chloride-free admixture for concretes prepared in cold climates). This technique allowed, in spite of the low temperatures of the Apennines, to limit the maturing cycle of the concrete within 36 hours and quickly reopen to traffic.

Tailored concrete

The most frequently used product was with no doubt

Photo 7. Detail of the consolidation and integration intervention (a new layer of concrete was applied) of the base of the viaduct piers using concrete with compensated shrinkage, carried out according to the above described procedures

Photo 8. The picture shows the detail of a portion of a structural element re-covered with a new layer of concrete; this increased the cross-section of the reinforcement rods thanks to the positioning of new elements.

Concretes prepared with STABILCEM in various proportions (350-450 kg/m³)									
Aggregate		STABILCEM Dosage	Water / STABILCEM ratio	Specific Volume	Initial Slump	Rcm (20°C) MPa			
(mm)	Dosage (kg/m³)	(kg/m³)		(kg/m³)	(cm)	1 day	4 days	7 days	28 days
0 – 22	1837	456	0.36	2455	26	35.8	59.9	62.3	81.0
0 – 22	1897	405	0.38	2454	24	34	53.8	58.5	73.6
0 – 22	1957	352	0.43	2460	23	25.1	50.1	54.5	69.2

STABILCEM*, a super-fluid expanding cement binder used to obtain injection slurries, mortars and concrete; the nearly 3,000 cubic meters of concrete with compensated shrinkage used on this work site were prepared with this solution. For defining the final mixture, some preliminary studies were carried out in collaboration with the company and in accordance with the indications from the director of works. In fact, tests were carried out on various concretes prepared with different proportions of STABILCEM*, from 350 to 450 kg/m³.

Photo 9 and 10. Works on the scaffolding for locally reconstructing the slab. The concrete prepared with STABILCEM was accelerated with ANTIFREEZE S to anticipate reopening to traffic.


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Photo 11. The viaduct at the completion of the recovery intervention.

The table shows the results of the research, and underlines the selected formula. It was therefore possible to determine the correct "mix design" for the concrete that would guarantee both design resistance as well as the workability and pumpability required on a work site of this importance.

TECHNICAL DATA

Settefonti Viaduct - A1 Motorway, segment FI-BO (Km. 248+383) - Italy
Project: structural restoration of the piers
Year of construction: 1956
Year of intervention: 1999/2001
Client: Società Autostrade SpA, Concessioni e Costruzione - Rome - Italy
Design: Giovanni Reggiani - S.P.E.A. Ingegneria Europea SpA, Milan
Directors of works: Lanfranco Bernardini and Giovanni Calusi - S.P.E.A. Ingegneria Europea SpA – IV° Section of Florence
Contractor: Baldassini & Tognozzi General Constructions S.p.A. - Florence; Technical director: Franco Carbone; Responsible of the worksite: Marco Baroncelli
Mapei products: STABILCEM, MAPEFER, MAPEGROUT T60, MAPECURE E, ANTIFREEZE S
Mapei coordinators: Fulvio Bianchi, Carlo Campinoti and Massimo Lombardi

** The products mentioned in this article belong to the "Building specialty" line and the "Admixtures for Concrete" line. The technical data sheets are contained in the "Mapei Global Infonet" CD and at the internet "www.mapei.com" website.*
Antifreeze S: *chloride-free antifreeze for cement mortar and concrete*
Mapecure E: *curing compound in water emulsion*
Mapefer: *two-component anti-rust mortar for reinforcement rods*
Mapegrout T60: *fiber-reinforced sulphate-resistant thixotropic mortar for the repair of concrete*
Stabilcem: *super-fluid expanding cement binder for injection slurries, mortars and concretes*