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Instability of road infrastructures: geological analysis in order to define intervention guidelines

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RIASSUNTO

Dissesti su infrastrutture stradali: dall'analisi geologica alla definizione delle line di intervento

Nel dicembre del 2010, al termine di un prolungato periodo piovoso, un evento deformativo di rilevante entità ha interessato un tratto di rilevato in terra rinforzata del Grande Raccordo Anulare di Roma, che ha portato alla parziale chiusura al traffico dell'arteria. La Direzione Centrale Progettazione dell'ANAS, incaricata di definire gli interventi progettuali di sistemazione provvisoria e definitiva di questo tratto autostradale dell'infrastruttura, ha pianificato una campagna di indagini geognostiche, e di monitoraggio dei luoghi, al fine di determinare il contesto geologico-geotecnico di riferimento e di studiare l'evoluzione del fenomeno. Il modello geologico ed idrogeologico così ricostruiti hanno permesso di individuare le possibili cause di dissesto e, conseguentemente, di definire gli interventi di messa in sicurezza definitiva del tratto stradale coinvolto.

KEY WORDS: *Geological Analysis, Geological Reference Model, Instability of road infrastructure, Soil Deformability.*

In presence of instability phenomena or heavy deformations involving road infrastructures, the fundamental premise is represented by a rather thorough geological analysis of the local context. In this way it is possible to reconstruct a detailed geological and hydrogeological model with which the roadway interacts. It's also possible to identify the causes that may have triggered such events and define guidelines to ensure the definitive safety of road's stretch involved.

Fig. 1 – Damage on the road as a result of the collapse occurred.

An example (*Fig.1*) in this regard is provided by part of the "*Grande Raccordo Anulare*" of Rome between the km 13+700 and 13+800, on external track, and represented by a section of the embankment reinforced soil. This area has been affected by a big deformation phenomenon (about 30 m in longitudinal direction and about 50 m in transverse direction, respect to the deformation), which occurred in December 2010, after a prolonged rainy period, and that has led to the partial closure of the traffic artery.

Fig. 2 – Provisional safety measures intervention: installation of metal gabions.

The Organizational Geotechnical and Equipment Unit of the Central Planning ANAS was appointed to study the situation, defining lines of action aimed at solving the problem and at the final arrangement of the infrastructure.

In the first phase of emergency, a temporary intervention was set up through a drainage system and an installation of metal gabions, in order to reduce interstitial overpressures and create an overload at the foot with stabilizing function (*Fig.2*).

To acquire all the necessary knowledge to understand the the geological and geotechnical reference context, a campaign of geological, monitoring, instrumental and topographical site-investigations was carried out. These activities are also oriented to achieve a correct definition of project interventions of this section of the motorway.

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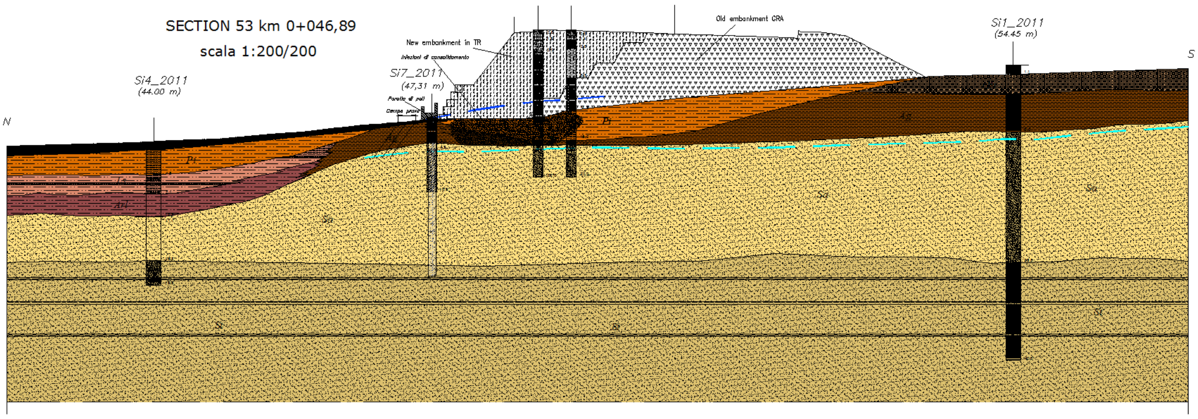

Fig. 3 – Geological section n.53. *Ri:* fill material; *Gh*: gravels; *Pi*: altered pyroclastic; *Ls*: sandy silt; *Arl*: silty clay; *Ag*: silty clay with layers of gravel; *Sa*: silty sand; *St*: sand with peat.

This geognostic investigation has performed by means of no 11 non-destructive and no 2 destructive rotary boreholes three piezometers, one inclinometer and one assestimeter respectively, with cadenced readings, aimed at identifying the slightest deformation of the road surface.

Obtained data made it possible to outline a detailed geological reference model of the involved area (*Fig.3*). The oldest terrains interfering with the project are represented by geological formations belonging to a pre-volcanic sedimentary sequence, consisting of sand and gravel deposits alternating with clayey and silty levels, oxidized horizons and peaty levels, referred to varying from beach to infralittoral, brackish water and fluvial environments. These soils are followed by

Table 1 – Correlation between the terms defined in this study and the reference formational units for the Rome area.

References to literature (CARG)		ANAS Investigation	
Abbrevation Formational	Lithofacies	Abbreviation	Lithofacies
SKF	Sacrofano stratified tuffs: lapilli and cineritic pyroclastic deposits in layers containing slag and centimeter lava stone from relapse, intercalated with reworked volcaniclastic levels, and limnos-marsh deposits	Pi	Sandy-clayey silts of pyroclastic/epivolcanic, brown, containing volcanic minerals
FCZ	Gravels in sandy-quartz matrix with subrounded elements. River environment	Gh	Gravel in brown clayey matrix with rounded elements
	Greenish-blu clays with *Cerastoderma*	Ag	Silty gray clay with remains of shells
	Yellow quartz sands with interbedded sandstones and bioclastic sandsotne bench ("*Yellow Sands of M. Mario*")	Sa	Fine havana silty sand with ocher patina of oxidation
MTM	Gray micaceous quartz sands with *Arctica islandica*	St	Fine gray-black sand with peat and remains of shells
MTM1	"Farneto Member": gray sandy clay withmacrofossils, sandy silt and gray clayey sands, with oxidized horizons and peat levels		
MVA	Monte Vaticano Formation ("*Argille azzurre*" Auctt)		

pyroclastic fall deposits in cineritic and pumice matrix containing, at times, slags and lava stones as well reworked volcanoclastic levels (*Tab.1*) (Funiciello R. et alii, 2008).

Reconstructed geological and hydrogeological models showed that in the whole sandy bank there is an appreciable groundwater circulation, influencing the road structure equilibrium.

This aquifer, considered a kind of semiconfined one because enclosed between a clayey Pliocene substrate and a superior layer of silty clay, as a result of prolonged supply, has developed hydraulic overpressures and a rising of the piezometric surface.

These conditions, in the presence of discontinuities of the upper clay layer, have determined upwards filtration phenomena into the body of the overlying road embankment.

After having acquired all this information, interventions for the definitive safety structure have been prepared.

A bulkhead of large diameter piles, with interventions of consolidation and improvement of the soil strength and deformability (injections of expansive cement mixtures through pipes in VTR), immediately underlying the surface layer of the embankment, as well as the groundwater collecting and conveying, were deemed suitable interventions in order to achieve the stability (*Fig.4*).

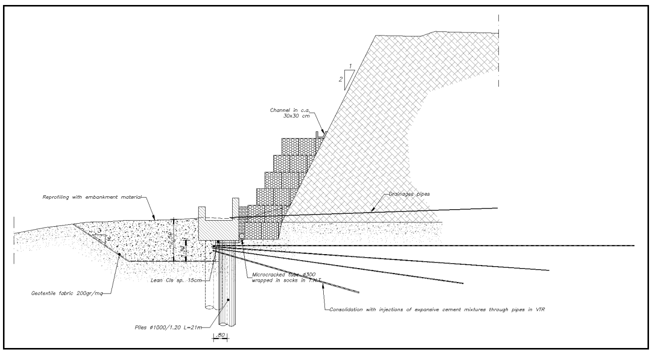

Fig. 4 – Interventions for the safety definitive of the structure.

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