The “A12 – Tor dè Cenci” Motorway: Geological Reference Model and design solutions in presence of soft soils.

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The link that connects the A12 "Roma-Civitavecchia" with the “Roma (Tor de 'Cenci) – Latina” motorway (today designed but not built) is a road infrastructure of considerable size and importance. It needs a very detailed Geological Reference Model, defined in each design phase through the analysis of numerous geological surveys and site investigation data. In the preliminary phase of the plan we found very useful to keep account of the considerable amount of data concerning the area surrounding the designed motorway. At a later stage we realized a very detailed geological survey and site investigation activity, especially referred to the scale of the main viaducts. This study has allowed us to define the sequence of the different lithofacies and their geometric relationships. The presence, in the subsoil, of highly deformable organic soils, with peat layers, characterized also by a low shear strength, has influenced the design solutions. In fact, throughout the development of the road axis, different interventions were used with the aim to reduce the settlements of the road body. So, the study of the plan was marked by the reduction of the applied load, keeping as low as possible the project level and the height of the embankments. At the same time it was necessary to design some embankments providing the use of very light materials (expanded clay, Polystirene) and particular solutions for the foundations design of the main bridges and viaducts.

Keywords: Geological Reference Model, Geological survey, Organic soils, Design solution, Low resistance.

1. Introduction

The design of the new connection between the A12 "Roma-Civitavecchia" and the “Roma (Tor de 'Cenci) – Latina” motorways (the last one still in project) was developed, on behalf of “ADL – Autostrade del Lazio SpA”, by “Direzione Centrale

Progettazione” of ANAS SpA (National Public Roads Company). It represents an example of a particularly detailed definition of the Geological Reference Model, as a prerequisite to the accomplished identification of geological problems and, finally, of consequent adoption of appropriate design measures.
This aspect is fundamental in order to build this kind of infrastructure, characterized by very important civil works (especially bridges and viaducts).The deepening of the MGR, achieved through the different stages of the project, has allowed us to define the sequence of the different lithofacies and their evolution, and their geometrical relationships. Starting from this modeling, the Geotechnical Reference Model, necessary for a correct evaluation of related design issue, was completely defined.
The road project extends for about 16 km, through the Roman countryside (Fiumicino Plain) and the hinterland. It is composed by 4 viaducts with considerable development, of which the longest exceeds 2.7 km and another one crosses the Tevere River, and one artificial tunnel.

2. Studies and geological surveys

The project corridor and the surrounding areas were already covered by existing infrastructure (Fiumicino Airport and Motorway, “Rome Trade Fair District”, Roma-Pisa Railway). For this reason, it was interested by several site-investigation activities; so that its subsoil appears, therefore, well-known from the geological and geothecnical point of view. Particularly, the bad features of the recent organic soils are just well-known.

During the preliminary design, the geological reference model was, therefore, essentially defined by using a massive amount of available data (65 boreholes; 27 static penetration tests (CPT and CPTU); 2 trenches and other 31 boreholes coming from preexisting investigations).

During the later stage of the design, it was realized a very detailed geological survey, together with a specific site-investigation campaign, especially referred to the scale of the main viaducts and bridges, in order to improve both the geological and geotechnical models.

This site investigation, carried out in 2012, consists of:

· 12 boreholes, including undisturbed sampling for laboratory testing;

· 11 static penetration tests with piezocone for interstitial pressure measurements (CPTU);

· 5 geophysical tests (Down Hole).

During the execution of borehole, a total of 75 dynamic penetration tests SPT and 38 undisturbed samples were carried out.

3. Local Stratigraphic Succession

The studies described above, together with bibliographic data, gave the opportunity to focus on the geological context of the project, in which various depositional and erosional stages in different genetic environments overlap each other, so that the sedimentary prevulcanic substrate consists first of marine units, then transitional ones and, finally, continental formations.

The oldest geological formation, as identified in the studied region, is represented by "*Monte delle Piche Formation*" *(MDP),* a marine-clayey deposit over which recent pyroclastic and alluvial sediments have been settled. These units are represented by "*Ponte Galeria Formation*": in particular, in the area, there are the "*Membro della Pisana"*, characterized by three lithofacies (1. conglomeratic-sandy lithofacies, PGL3a; 2. clayey-sandy lithofacies, PGL3b; 3. sandy lithofacies, PGL3c). These elder units have been splitted by a system of small faults with Apenninic directions, which have lowered the substrate according to a system of steps, with other antiapenninic system and north-south direction.

Along Tiber'plan, with an unconformity, there are more recent soils of alluvial and marsh and lacustrine environment (*"Sintema del fiume Tevere"),* with high organic content, divided into different lithofacies: SFTa, sandy gravel and gravelly coarse sand; SFTb, sands, silty sands and sandy silts; SFTc, organic cohesive deposits and peats.

In correspondence of the hills, other unconformities separate the succession MDP/PGL from subsequent pyroclastic soils, of the Colli Albani volcanic apparatus (*"Tor dè Cenci Unit", TDC,"Pozzolane Rosse", RED, "Villa Senni Formation/Pozzolanelle", VSN*$_2$*).* Alternating with these terms there are continetale and fluvial soils, called: *"Valle Giulia Formation" (VGU), "Fosso del Torrino Formation" (FTR), "Castelporziano Unit" (CLZ).*

The upper fluvial-lacustrine deposits, with an high content of organic matter, have features of high deformability and low resistance.

4. The major Viaducts ("Tevere Viaduct" and "Interconnessione Viaduct")

The "Tevere Viaduct" is 1424.86 m long; it is placed above the alluvial deposits belonging to Tiber River Syhntem, covered by recent alluvial soils. Here the substrate is characterized by a "steps" conformation, due to the presence of a series of faults, aligned NNE-SSW, that have displaced it, causing its deepening from a depth of about 25-30 m ad the edge of the main valley, near to the confluence of Fosso del Torrino, towards west, where it lies regularly at more than 65-70 m.

The viaduct is divided into two parts, a first composed by 13 spans variable from 30 m to 150 m, while the second one is composed by 11 spans from 30 m (for the spans of the shore) to 40 m (for intermediate spans).

For the first part of the bridge, the foundations are direct compensated or indirect with driven piles, outside the embankment of the river; they are indirect, with diaphragms, inside the levees.

For the last part all foundations are indirect with large diameter bored piles (D = 1500 mm); piles are circular for hydrodynamic problems, related to the presence of a River Tiber tributary.

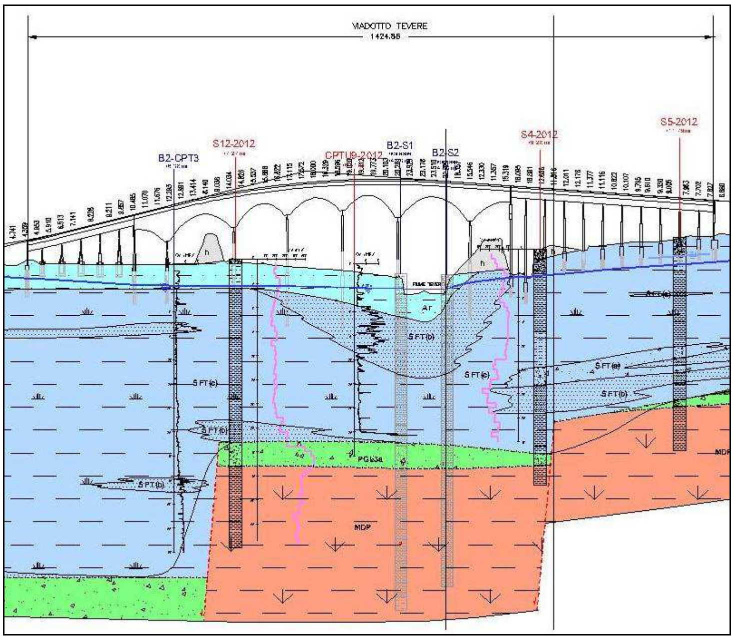

Fig. 4.1 - Tevere Viaduct

The “Interconnessione Viaduct” stretches for about 2250 m. The geological units under the viaduct are almost entirely represented by the alluvial deposits that extend in a uniform manner, for the whole extension of the viaduct. Here the substrate is regular and it’s located below, at depths greater than 70 m.

This viaduct is composed by 62 spans on the northbound carriageway and 65 spans on the southbound carriageway, with variable ports from 26 m to 126 m.

In general, the foundations are direct, compensated, with protruding plinth on the terrain surface; in correspondence of spans more than 40/45 m wide, the foundations are not compensated, but deep, with piles of 70 m, for obvious load problems.

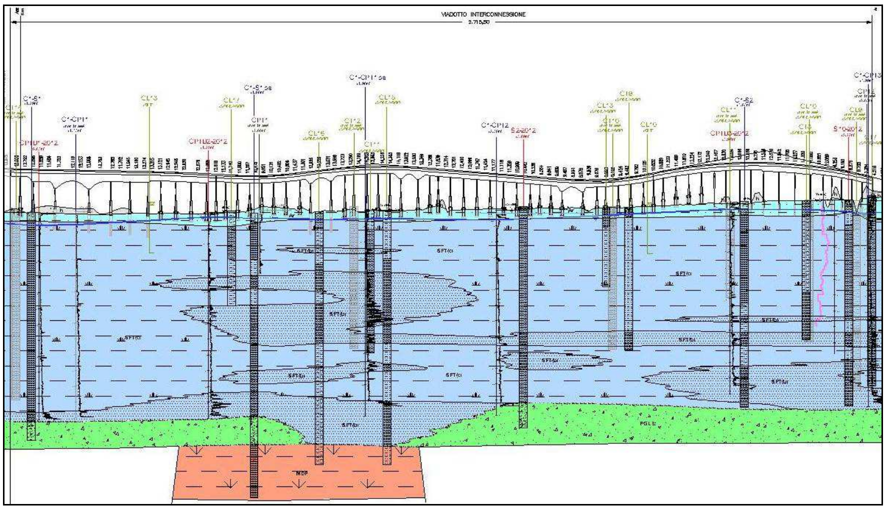

Fig. 4.2 - Interconnessione Viaduct

5. Design Solutions

The high deformability and low resistance features of the upper deposits have influenced the design solutions developed along the axis road.

Therefore, different types of intervention, aimed at reducing the probable subsidence of the road body, also delayed in time, have been used. So, the study of geometry road body was marked by the reduction of overload transmitted, lowering the project level and the height of the embankments. At the same time some of the hightest embankment have been made of lightened material, in different ways for different traits: 1) insertion of metal pipes ARMCO type; 2) adoption of sintered expanded polystyrene (EPS) in preformed blocks; 3) use of expanded clay for the construction of the embankment. The application of a geogrid reinforcement has been envisaged to improve the resistance of the laying surface, below the remediation layer.

The foundational solutions, adopted for the principal viaducts, are also differentiated, related to the local context: compensated direct foundations, deep foundations of diaphragms, deep foundations of large diameter piles, deep foundations on beaten precast piles.

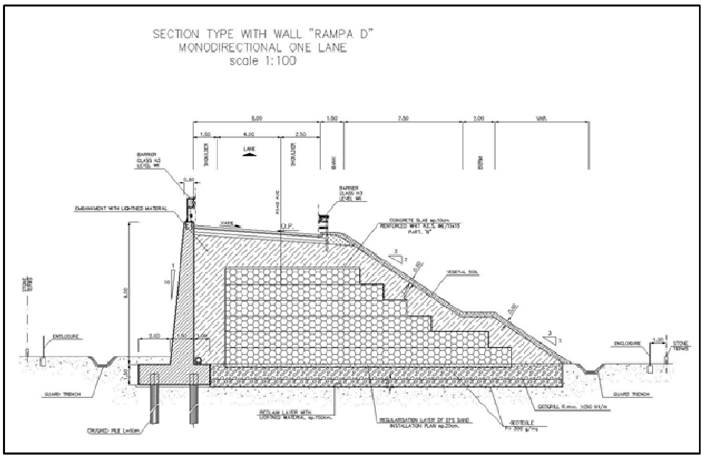

Fig. 5.1 - Example of section used

6. Conclusions

As is known, the evaluation of the characteristics of the soils on which a road infrastructure will be located has a fundamental importance . This is because, very often, there are geological complex situations and geotechnical soils with specific responses to stress.

The characterization of these soils derived from progressive cognitive insights and careful site investigation and testing on site and on laboratory on samples taken during the execution of different boreholes.

The study shows that, in the development of the various phases of the project, we have reached to a progressive deepening of the Reference Geological Model, based on the implementation of the knowledge framework. The modeling thus defined, according to the evolutionary context in terms of the gestructural and stratigraphic structure, has allowed to define in detail the particular aspects of the subsoil involved by the road project and its relationship with the marine units of the substrate. The subsoil, in fact, is characterized, mainly, by significant thicknesses of recent soils with poor geotechnical characteristics (low strength and high deformability). It has finally allowed to transfer to the geotechnical design all the necessary elements for the proper engineering design of interventions.

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