Geological Reference Model in the design of the SS 182 "Traversale delle Serre" - Ionian Calabria

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In road design, the Geological Reference Model plays an important role, especially in presence of complex geological conditions. In these areas, especially where is evident the role played by tectonics in the determination of geological-stratigraphic framework, the Geological Reference Model can be completed during various phases of the project, together with the improvement of the knowledge context.

This case-history represents an example of application of this process.

The first reconstruction of the model has been developed through the analysis of the available literature, especially referred to the geological, geomorphological and site-investigation data. After, a first survey phase has been completed. It represented the conceptual base to plan specific site-investigation, geophysical and laboratory survey, especially referred to the most geological and design critical situations.

So that the Geological Reference Model has been gradually improved, highlighting particular tectonic structures, hardly detectable only by field geological and geomorphological survey.

Finally, the design solutions, adopted for the civil works situated along the path, have been determined according to the identified geological conditions.

Keywords: Geological Reference Model, Geostructural reconstruction, Site-investigation, Serre chain.

1. Introduction

As part of the upgrading of southern Italy road infrastructures, ANAS started the project to build the new S.S.182 “Trasversale delle Serre”, located in the central-southern Calabria. The aim is to connect, from west to east, the two great coastal roads: the A3 Salerno – Reggio Calabria motorway, wich runs along the tyrrenian coast, and the S.S. 106 “Jonica”, along the Ionian sea.

The project road shown in this work is composed by two lots, 4 and 5, with a total length of 7.5 km, connecting the towns of Gagliato and Soverato.

The land orography is, mainly, characterized by a series of mountain, which constitute the “Serre Chain”. The geological and geomorphological characterization of the soils influences, considerably, the development of the civil works along the road and the design solutions used. These are represented by: 12 viaducts, 3 bridges, 3 artificial and 1 natural tunnels.

2. Reconstruction of the Geological Reference Model

During the design of the road the Geological Reference Model has been developed, and it has been continuously improved through several phases of deepening of the knowledge framework of the area, from the geological point of view (geological, geostructural, geomorphological, hydrogeological survey, and site-investigation). At the beginning of the road design activity, a first survey phase has been completed. It represented the conceptual base to plan specific site-investigation, geophysical and laboratory surveys, especially referred to the most geological and design critical situation

2.1 Site-Investigation program

The site-investigation campaign consisted of 31 boreholes , 17 trenches, 13 Down-Hole tests and 2 Cross-Hole tests for seismic characterization of soils. On undisturbed and reworked samples, geotechnical laboratory and chemical tests, for the purpose of environmental characterization according to the new DM 161/12[1], were carried out. In addition, in order to optimize the management of the soils coming from the excavation, with undeniable environmental advantages, the design has provided the reuse, in the construction of embankments, not only of the sandy-gravel formations, but also of the silty-clay soils, after lime-treatment. So that, in an experimental way, we conducted a study on the suitability of that soils, determining the performance characteristics of the mixtures studied.

2.2 Local Stratigraphic Sequence

The geological-structural model, as defined, is characterized by the presence of a Paleozoic granitic substrate, on which Plio - Pleistocenic continental and marine formations lie with unconformity.

[1] Decreto del Ministero dell'Ambiente e della tutela del Territorio e del Mare 10 agosto 2012, n. 161 - Regolamento recante la disciplina dell'utilizzazione delle terre e rocce da scavo (G.U. n. 221 del 21 settembre 2012)

The upper part of the road crosses a mountain ridge, elongated in east-west direction. It is composed by conglomeratic deposits, generated from the dismantling of the crystalline substrate and deeply affected by extensional tectonics, which has faulted the structure, causing a framework made by blocks lowered towards the Ionian sea. The conglomeratic deposits (Cg) consist of large and eterometric granitic and tonalitic blocks, with dimensions of 2-3 meters, generally well rounded, embedded in a dark/brown sandy and sandy-coarse matrix of arkose nature. The conglomerates are moderately cemented and have interbedded by coarse sands.

Above, in stratigraphic continuity with them, there are the hold sands and sandstones (Ps) consisted of quartz – feldspathic/quartz-mica sands, from fine to coarse, with color varying from yellowish to brown, plane-parallel stratified, as well thickened to variously cemented.

At the top, the Plio-pleistocenic sequence ends with blue-gray hard clays, sometimes marly (Pa), which, mainly, outcrop in the lower part of the road, characterized by small hills, which often shows, above their slopes, landslides of various proportions.

Fig.2.2.1 - Outcrop of the hold sands and sandstones

2.3 Particular tectonic situations

Situations of particular interest have emerged by the detailed geological analysis of the road design. Of course they affected, consequently, the design solutions. Along the fluvial incision of the Fosso Turriti, for instance, in correspondence of the confluence with the River Ancinale, the crystalline bedrock turns out stepped by a complex fault system, that created a series of buried structural blocks, elongated in WNW-ESE direction. The main buried horst consists of granite and it is covered by the pliocenic clay and sandy formations, laying under a thick alluvial deposit. In this stretch of the road design, there is a viaduct with a wide curve of about 120°, intersecting the tectonic structure along multiple directions.

The central piles of the viaduct are placed above the buried horst, made by the crystalline substrate (granite), whose roof, highlighted by the survey, is positioned at a depth of about 20 meters. Along an hypothetical section that cuts transversally the valley, it is evident that this block represents a tectonic "step", structurally lowered in comparison with the SW ridge, but raised compared to the NE sector, which forms the basis of the graben, where the river has set its course. Above the granite, the marine series is represented by the gray-blue clays (Pa) and, under that, by the sandy formation (Ps) with a maximum thickness of 6 m. Obviously the series appears here condensed and reduced, because of the control practiced by the morphology substrate on the sedimentation. The bedrock and the marine formations are covered by a thick alluvial deposit (above all sands and gravels).

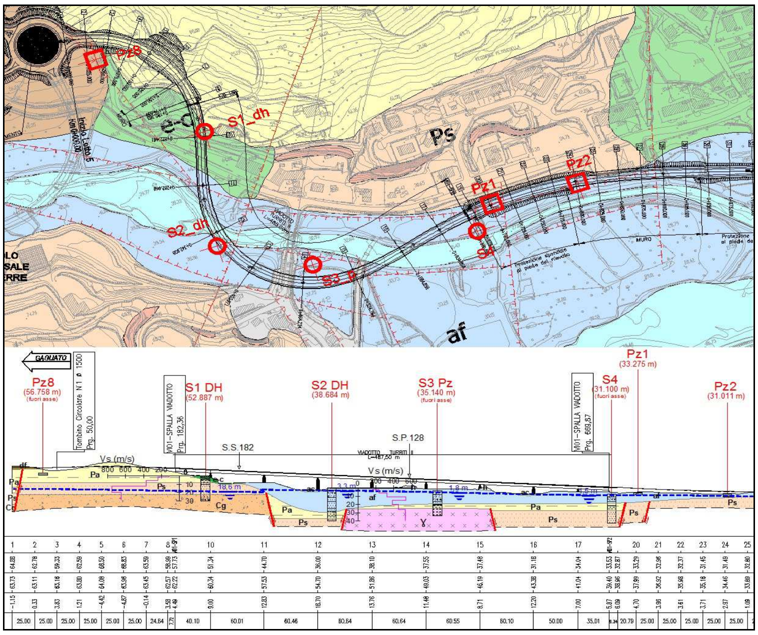

Fig.2.3.1- Geological section along the tectonic structure of the Turriti Viaduct.

3. Design solutions

The critical situations derived from different local geological settings, highlighted by a detailed geological analysis, have suggested the adoption of different design solutions for the civil works along the road in project.

The most important viaducts, such as the “Turriti Viaduct” and the “Ancinale Viaduct”, set to the tectonic structure analyzed before, have been provided with deep foundations in relation to the not exactly optimal geotechnical characteristics of the outcropping deposits.

For this purpose, the use of foundational wells, instead of large diameter piles, turns out to be more efficient also from the operational point of view. In fact, the strong heterogeneity of soils, especially of the alluvial and conglomeratic deposits, is a severe limit to executive technology of the "classics" structural foundational elements, without forgetting that the movement of machinery on the slopes requires the prior construction of site roads and non-trivial size temporary civil works. The geometric conditions of use of supporting structures, which are mostly set on strong transversal escarpment, require the use of flexible structures such as reinforced soil. Furthermore the achievement of the global stability conditions requires the realization of overseeing works on the foot, composed by "light" and resistant elements as the micropiles.

4. Lime treatment of clay coming from excavations

Clay materials, coming from the trenches excavations, will be reused in embankment, after their stabilization with lime, based on the studies specifically realized.

This study, in addition to determining the suitability to the treatment of the excavation soils, has compared the performance of different blends, comparing the variability fields of the most significant geotechnical parameters with the variation of lime percentage and the ripeness degree. The percentage of lime to be included was assessed from ICL (initial consumption of lime) +0.5 % up, forming 3 different mixtures with different lime content: 2.5% - 3.0% - 3.5%. Each mixture was also tested for two different maturation states (after 1 day and after 14 days). In particular, from the AASHO mod. test performed on mixtures, we can observe a significant flattening of the compaction curve with the increase of the content in lime. It constitutes one of the main benefits for machinability of the treated material. The same test has shown how the intermediate mixture with 3.0 % of lime is those that provides the best performance benefit in relation to the amount of binder added, because the transition to the richer mixture does not provide an appreciable improvement of quality performance.

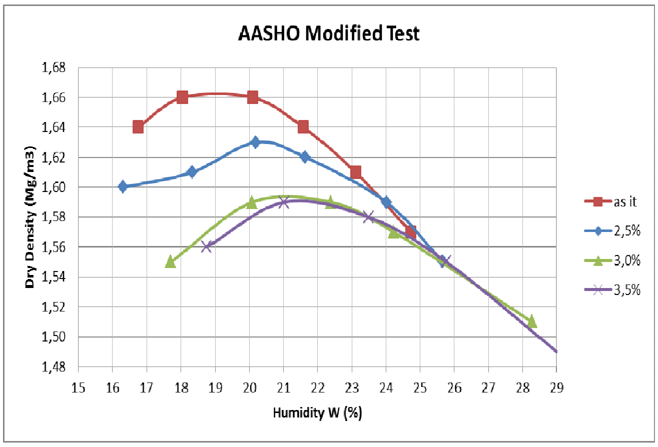

Fig.4.1- Curve compaction of the AASHO mod. test performed on mixtures.

5. Conclusions

Of course the design of a road infrastructure, of whatever extent, needs, from the early stages of study, a careful reconstruction of the reference geological model.

It allows, starting from the general geologic framework of the wide area, to have a detailed framework that permits to get the geotechnical characteristics of the soils involved by the road project and to make appropriate choices about the design elements to be introduced.

The definition of the geological reference model is obtained from the analysis of data provided by the geological surveys in the area or those suitably programmed. Particular situations, such as the geostructural setting through the Ancinale river, have been descripted by the deepening of the model, due to the site investigation data.

As described in this paper, sometimes, on the basis of specific design choices, specific studies are very important, such as the study of lime treatment, useful for the evaluation of reuse in embankment of clayey materials from excavations in the trenches.

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