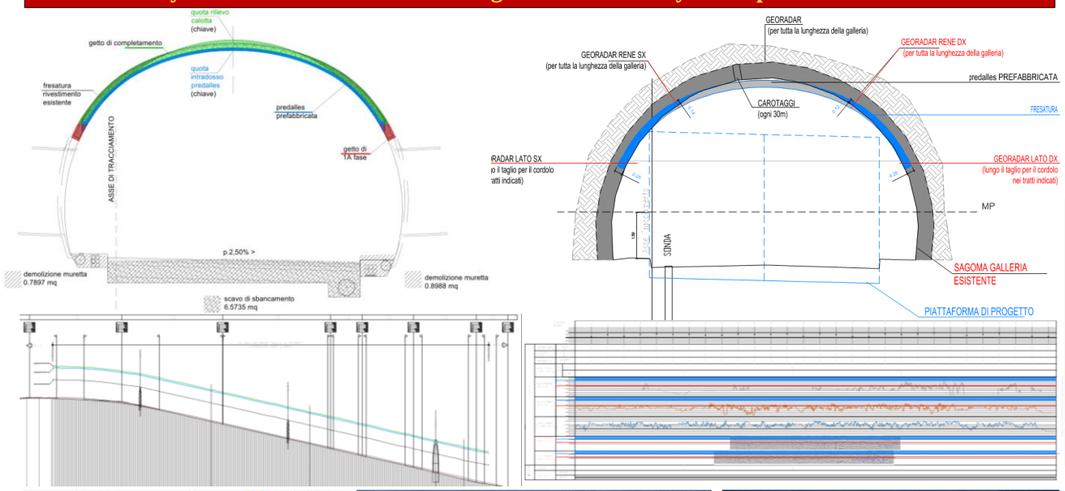
FEATURE OF TECHNICAL SERVICE

Subject	Detailed and Executive design of artificial tunnels, roadways, hydraulic works, environmental mitigations and minor works in Ca of Maxilotto 2 - Completion works of the Perugia-Ancona route: SS.318 «Valfabbrica» section of Pianello-Valfabbrica, SS.76 «Val d'Esino» sections of Fossato di Vico-Cancelli and Albacina-Serra San Quirico and «Pedemontana delle Marche» section of Fabriano-Muccia-Sfercia.
Carried out by	SGAI srl di E. Forlani & C.
Client	Dirpa 2 Scarl
Service length	2015 – 2019
Value of works	€ 316’071’173,03
Category values	V.03 € 21’852’549,29 D.05 € 21’540’329,00 S.04 € 19’774’412,48 P.01 € 19’774’412,48 S.05 € 25’122’888,20

Existing Tunnel - Design issues and their resolution

The main design problems were encountered in the **evaluation of the improvement and adaptation works of the existing tunnels of the SS.76 lots**, which at the same time allowed to guarantee the **gabarits and the free heights required by regulation**. In detail, the interventions developed on the various tunnels provide for the **reinforcement of the final shell covering by means of prefabricated predalles** with concrete of resistance R_{ck} 40 MPa. To assess the thickness of the final lining in the existing tunnels and identify the presence of any injuries or defects in the casting of the same lining and reinforcement, **Georadar surveys** were carried out. The GPR methodology through the use of electromagnetic waves, allows the definition of the profiles, thickness and internal characteristics of the investigated object. This allowed to evaluate the optimal positioning of the prefabricated predalles on the basis of the profiles and cross sections obtained.

Surveys with GEORADAR on existing tunnels and study of adaptation interventions



Artificial and Natural Tunnel of new constructions - Design issues and their resolution

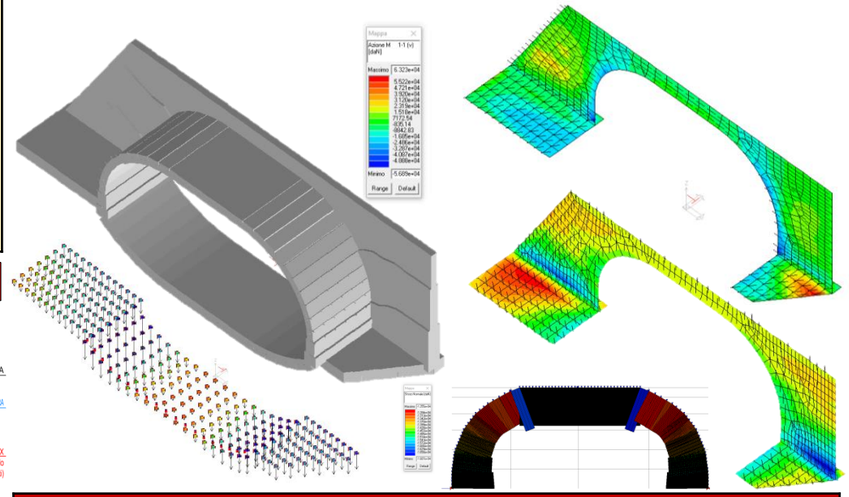
As part of the **completion works of the Perugia Ancona - Maxilotto 2**: Marche-Umbria road axis and Quadrilatero of internal penetration - the detailed and executive design was carried out for the **SS.318** section **«Pianello-Valfabbrica»** (**sub-lot 1.2**) and for the **SS.76 «Val d'Esino»** in the sections **«Fossato di Vico-Cancelli»** (**sub-lot 1.1A**) and **«Albacina-Serra San Quirico»** (**sub-lot 1.1B**). In detail, the road alignment of the SS.318 has a development of **8.5 km**, and it is entirely newly built, whose main works are: **N°2 interchanges** (Pianello and Valfabbrica), **N°4 Natural Tunnels** (San Gregorio North/South and Collemaggio North/South), **N°2 Artificial Tunnels** (Della Donna North/South) and **N°13 Viaducts** (with decks in mixed steel-concrete section and in C.A.P.). Also, the road layout of the two sub-lots of the SS.76 has a development of **21.0 km**, and the new construction of some sections of the road (including interchanges), the adjustment and improvement of existing roadways have been planned. The main works envisaged are: **N°5 interchanges** (Cancelli, Borgo Tufico, Valtreara, Camponocecchio and Serra S. Quirico), **N°22 Natural Tunnels**, **N°2 Artificial Tunnels** and **N°24 Bridges and Viaducts** (with decks in mixed steel-concrete and in C.A.P.).

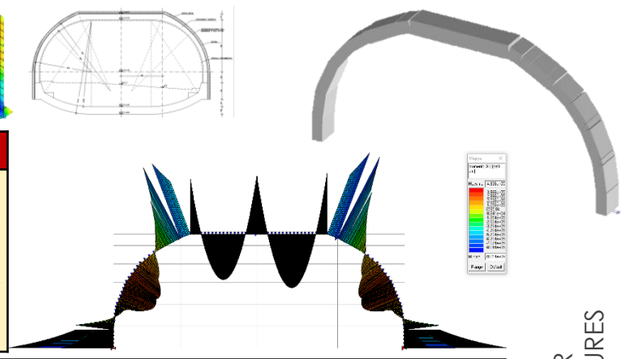
In detail, the executive design involved both the construction of new underground works and the adaptation and consolidation of existing ones, given the expansion of the road platform envisaged in the project.

The main design issues were encountered in the verification and sizing of the **Cancelli South tunnel**. This has a portal of **span equal to about 20m and a height of 11m**, due to the presence of the exit ramp of the Cancelli interchange and enlargements for visibility on the inner edge. The structural analyzes and checks were carried out through **FEM modeling** (PROSAP), assessing the strength and stability of the temporary and definitive structures in all the executive phases, with particular attention to the casting phase.

The Cancelli South natural tunnel (L = 345m) has the particularity of having a stretch of about 100m widening for reasons of visibility on the overtaking lane and on the deceleration and exit lane of the nearest Cancelli interchange. Therefore, the verification and sizing of the lining in the enlargement section was performed, **simulating the progress of the excavation in enlargement by stages and the effects on the rock mass** (Plaxis).

FEM modeling of the portal and of the artificial tunnel CANCELLI SOUTH CARRIAGEWAY

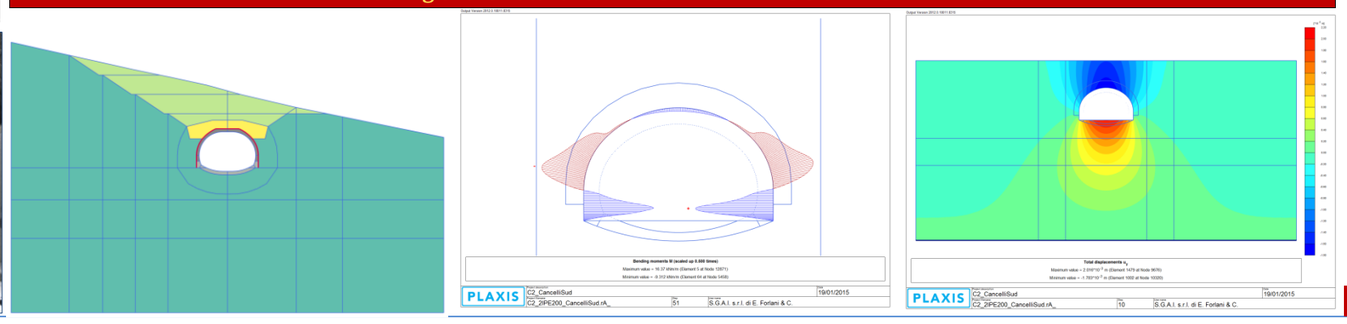




Computational aspects - Simulation, results and checks

The analyzes were conducted by **simulating the structure with a finite element 3D numerical model**, thus solving the problems related to the progress of the excavation fronts and the execution of all the underground works, reconstructing in detail the lithostatic conditions of the rock mass, constantly modeling and monitoring the **evolution of the stress-strain framework with 2D and 3D models** (Plaxis).

FEM modeling of the natural tunnel CANCELLI SOUTH CARRIAGEWAY



TUNNELS AND MAJOR UNDERGROUND STRUCTURES