TWO DAY MEETING

“EGNATIA ODOS TUNNELS”

The experience of the Category III checking of the Final Tunnel Designs of the Egnatia Odos Project

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”EGNATIA ODOS S.A.“

& E.E.S.Y.E

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1. INTRODUCTION

When completed, the Egnatia motorway will form an integral part of the Trans European Roadway project. About 49 kilometres of the full length of 688 km are twin-tube tunnels in almost different and sometimes very difficult rock conditions.
The design of the tunnels is generally shotcrete method as this method can be well adapted to the proposed rock conditions. Very important for choosing a technical and economical optimised solution is to interpret the geo-technical behaviour very close to realistic conditions.

2. GENERAL PRINCIPLES FOR THE TUNNEL DESIGNING

In order to achieve technically and economically optimised constructions one needs the following items:

- a good general tunnel design layout, which doesn't force the tunnel constructions to be based into the worst conditions one can find at the project's area.

- investigations and exploration which have to clarify all details of soil- and geo-mechanical behaviour before the design phase starts.

- a design which should adapt well to all steps of execution, while the lifetime of the construction should be guaranteed by taking into account all the in situ conditions or influences.

3. THE ROLL OF EGNATIA IN THE DESIGN AND THE CONSTRUCTION OF THE TUNNELS

To guarantee this procedure EGNATIA has to organize and check step by step the different stages from the very beginning to the completion of works.

To me it seems very important that EGNATIA should have in mind that it is the only authority responsible for the estimated ground conditions.

All ground risk should be with EGNATIA – unless the contractor doesn't handle the ground conditions correctly.

Therefore EGNATIA should have an essential interest to know all details of the underground material at the time the constructor comes into play.

The basis for an all-including design of the tunnels is given by EGNATIA through the O.S.M.E.O.

Most of the projects I was involved in so far are design and build-contracts, which means that on the base of a general design the contractor has to work out the exploration programme to write the geo-technical report with description of the geo-technical behaviour and to choose the input data for the statical analysis.

4. CHECKING OF THE TUNNEL DESIGN

The design is checked and commented in several steps EGNATIA until the final design is accepted.
All through this stage the CAT III checker becomes part of the procedure.
All documents, which are the basis for the final design,

- geological report
- geo-technical reports
- drawings of the construction
- statical analysis

and the comments of EGNATIA will be handed over to the checker. The duties of the checker are also specified in the O.S.M.E.O. guidelines.

Generally I myself start with studying the geological and geo-technical reports to get a feeling for the rock mass which the tunneler has to deal with in the different RMR-classes.

The first step of my studying of the reports, is pointing out and collecting all the input data of the statical analysis.
The high standard of this part of the design is formulated in O.S.M.E.O. §*6.1.1.3* Primary Lining and Secondary (Permanent) Lining in Bored Tunnels

"The Designer shall consider the 'tunneling system' as an integrated unit, i.e. the design and installation of the primary / secondary linings and the method(s) of tunnel excavation being inextricably linked."

and under *6.1.3.1 Bored Tunnels*

"After evaluation off all available data relating to ground conditions, a distinct identification of main parameters which shall be taken into con-sideration shall be undertaken. This identification should include possible dangers which could affect the temporary support during construction and also dangers which could affect the structure in the long term."

especially to Analytical/Numerical Design one can read at 6.1.4.2

"The Designer shall submit details of his proposed method of analysis/computer programs to EOAE for approval prior to commencing the design (refer to the Specific Terms of Design and / or Construction)."

This means that the programmes have been approved by EGNATIA.

A further part of the design should be as follows:

"The designer shall undertake sensitivity analyses and take care for a monitoring system which is pointed out as an important and integral part of the design procedure. During the construction phase the designer is responsible for refining the numerical simulation."
In my understanding this is a solid base for the observational method.
This also is my understanding of checking.

Generally the engineer's language are the drawings and the statical analysis. So in most cases it is rather easy to come to an understanding between the different parties. What needs translation and interpretation are the reports about geological conditions and geo-technical behaviour, as these reports are the responsible documents for finding the input data. Sometimes there are discussions about the best framework needed to avoid misunderstandings by language mis-interpretation.

To find out the level of the designed support measures and the final lining I normally do my independent statical analysis as close as possible to the designer's one, but attempting also to reach alternative suggestions, I consider data of my own understanding from the geo-technical repeort.

5. SPECIAL COMMENT DERIVED FROM MY EXPERIENCE OF THE CHECKED DESIGNS

Now I would like to point out some details which might be of interest for further projects.

In Germany we successfully involve the checker in an early stage of the design so that he can influence the statical analysis and can find an agreement about the best adapted method with the designer. In case of unclear descriptions or disagreement, EGNATIA can be asked for a final decision.
By this way the final design will not differ in major positions from the checker's considerations. Also this possibility is given in the description of the "scope of works of Tunnel design checker", under checking procedure "when EGNATIA estimates that the checker can work from the beginning of the design, the checking procedure can start before the end of the design with gradual submissions. In that case the designer and the checker work jointly".

To my opinion this possibility should be taken into account more often by EGNATIA:

Some of the tunnels I had to check have been designed as a horseshoe profile with straight or steep primary support sidewalls. Especially in case of higher horizontal load a more rounded sidewall in combination with bolting leads to a much safer and more economic solution.

In tunnels where an invert is needed the connection between bench and invert should be rounded smoothly, otherwise this edge will crash under small load.

Also the temporary invert of a top heading should be connected smoothly with the walls and not with an edge.

In tunnels where an invert is needed the connection between bench and invert should be rounded smoothly, otherwise this edge will crash under small load.

Also the temporary invert of a top heading should be connected smoothly and not with an edge as far as it concerns the inner shape of the section.

Another point of differences to my experience is the K_0-factor.
Comparing to similar conditions in our country the Greek values are much higher, sometimes factor 2! I have the feeling that the influence of the overburden height is too high in the analysis!

Such high horizontal stresses may lead to the safety factors about $\eta = 1$, which you can find at the case of the straight side walls, in the analysis for the primary support.

As normally the rock quality in one tunnel varies widely, especially the cores of the lower rock quality, it is difficult to classify them in order to achieve a well adapted excavation and support class (RMR).

For example that happens in the case of the “cauliflower” limestone. In my opinion the chemical bonding of the single pieces of the rock mass is obviously much better in situ at the face than it is at the core samples.

In accordance with O.S.M.E.O. the designer (and the contractor) is obliged to study the monitoring results and refine his analytical studies to come to a better understanding of the geo-technical conditions in order to achieve a more economic adaptation.
T think that these studies are a good instrument for strengthening the sensitivity of the designs.

6. SUMMARY OF MY EXPERIENCE FROM THE TUNNEL CHECKING

Finally I would like to state that I had no statical analysis to check so far which was unsafe or not really constructable. It is obviously much better to have a safe design than to be too close to the limits.
However I think that the monitoring results can be used and exploited in a higher degree in order to refine the design if we really want to make use of the observational method.