Tunneling
Spring semester 2014 - 2015
Akos Toth

Tunneling Course Project: Tunneling Project in the Bakony

The north – south Route 82 is the main connection between Gyor and Veszprem. This route is operating in almost full capacity because of the serpentine at Csesznek. There is a need to increase the capacity, but due to the topography, there is no possibility widen the lanes to fulfill the demand. Fortunately now there is a political agreement to build a tunnel to improve the main road access between Gyor and Veszprem.

The project corresponding to course of Tunneling will be focused on the planning and project of such a tunnel.

Exercise 1- Choice of three possible alignments

As a primary step, a preliminary draft of the tunnel alignment be studied. For this, three different possible solutions must be chosen. When determining these three options, the following aspects must be taken into account:

Functional aspects:

- Maximal allowed speed: V_{max} = 90 km / h
- Horizontal radii of curvature:
    - Minimal horizontal radii of the tunne: R_{min} = 1500 m
    - Ideal horizontal radii of the tunnel: R_{ideal} = 3000 m
- Ideal vertical radii of the tunnel: R_{vert} = 5500 m
- Maximum slope: i_{max} = 5%

The positions of the tunnel portals are proposed, but they can be modified if proper explanation is given.

Evacuation space must be provided in every 500 m of the tunnel. In every 1500 m section a turn-around possibility is needed for evacuation purposes in case of emergency.

Topographical aspects:

The alignments of the tunnel must also take into account the configuration of the topography.

Geological aspects:

The alignments of the tunnel must consider the geological formations (kind of ground, fault zones, etc) that exist in the area, as a longer tunnel through a more suitable geological formation might be more appropriate than a shorter tunnel through especially problematic geology.

Tunneling
Spring semester 2014 - 2015

Akos Toth

Economic aspects:

The length of the tunnel, the overburden, the nature of the ground to be excavated and the excavation planning (supply sites, multiple fronts of excavation?) will have an impact, in terms of budget and time, on the construction of the final tunnel.

Social and Environmental aspects:

The planned tunnel should be connected to the existing infrastructure. As the positions of portals are not only determined by engineers, but also influenced by politics, not all of them are in the ideal place. Portals can be moved, when proper explanation is given.

The situation of the stations and supply sites will try to minimize the social and environmental impact on the area. Therefore the tunnel construction should have minimal impact in the daily life and the environment. Trees should be saved and the disturbance of the natural habitat must be kept minimal.

The purpose of this first exercise will be to determine the exact positions of the portals, supply sites and possibility of various excavation fronts and then propose a close-to-the-optimum route for the tunnel. This route should ideally minimize risk, cost and construction time.

You are required to justify your choice in a brief report accompanying the situation plan, a profile plan, and identifying potential risks to be taken into account along the tunnel.

Students should provide layout of three different alignments according to the proposed station. One of these alignments should be selected. Detailed layout and longitudinal plan of the selected alignment should be prepared by the students.

Tunneling
Spring semester 2014 - 2015

Akos Toth

Exercise 2 - Comparison and analysis of the three selected proposals for the tunnel alignment

Once several possibilities for the tunnel alignment have been chosen (exercise 1), a written analysis and comparison of them will be made in order to select the optimum solution.

For this, the aspects already mentioned on the exercise 1 will be taken into account:

- Functional aspects
- Topographical aspects
- Geological aspects
- Total Length of tunnel, position of tunnel portal and supply sites
- Environmental impact and social aspects

The assessment of the geological implications of each of the solutions will be made from a qualitative point of view.

For each of the solutions, the geological and environmental risks corresponding to each of the stretches will be cited. For this, the students might make use of the tables given by AFTES and SIA 199 (they will be provided on the webpage of the course).

On the basis of the assessment of all aspects, the student will provide a written concise memory with:

- Analysis of each of the solutions for the tunnel alignment obtained in the Exercise 1, in terms of the above mentioned aspects.
- Identification of the geological risks that might be encountered along each of the proposed solutions, based on the students' knowledge on general geology, soil mechanics, tunnel design, etc. These geological risks will take into account aspects like:

  eg.: Instabilities around the stations, shafts, supply sites; Instabilities along the tunnel: fault zones, flowing ground, settlement, instabilities, etc; Ground water problems; Karst and thermal water; etc

Reason the selection of the optimum selected solution that will be taken as final alignment.

Student should identify the influenced buildings and make a settlement contour plan of the chosen alignment / section.

This exercise should take into account not only the main tunnel alignment, but also supply sites and ventilation shafts to have. Given the length of the tunnel, the solution might comprise two or three supply sites.

Tunneling
Spring semester 2014 - 2015
Akos Toth

Exercise 3 - Excavation planning, Ground improvement and Temporary support

Once the alignment and profile for the tunnel has been chosen amongst several possibilities, the next step will be the planning of the excavation of the tunnel.

The tasks to be carried out in this exercise will be:

- Identifying the different excavation sections
  - In order to optimize excavation time, supply sites must be planned.
  - How many and where will they be placed?
  - Is there a possibility to build sections of the tunnel parallel to shorten the constriction time?
- Providing a suitable excavation scheme, identifying the excavation steps:
  - How the excavation process will be executed in time?
  - Which are the excavation phases to follow?
- Selecting for each of the excavation steps a proper excavation procedure:
  - Traditional excavation and/or mechanized excavation (NATM, TBM, Cut&Cover)?
- Identifying the particular risks related to each of the excavation methods in relation to the existing geology
- Giving an estimation of the tunnel construction duration, and provide a construction plan using the technique of linear planning

In order to tackle these points, the following aspects must be taken into account:

- The clearance of the tunnel is given to the students
- Niches, evacuation routes
- Ventilation shaft should be built for any section longer than 3000 m
- When TBM's are considered for excavation, proper schemes for the assembly, disassembly and refurbishment of the machines must be taken into account.
- For security reasons, crossover should be placed in every 2.5 km. This crossover will enable cars to be redirected to the parallel tunnel in case of major accident (fire, derailment)

In order to plan the excavation process, an estimation of advancement rates for different kind of excavation methods is given to the students:

Excavation method	**Average Advancement rate (m/day)**		
	Bad conditions	Average conditions	Good conditions
Drill and blast	2	6	12
Roadheader	1	5	10
Gripper TBM	1-2	13	30
Shield TBM	10	15	30
Double Shield TBM	10	20	40

** These advancement rates correspond to 2 shifts of 10 hours per day*

Tunneling
Spring semester 2014 - 2015
Akos Toth

In order to unify results and provide a consistent solution, borehole data will be given to the students, and a geological longitudinal section should be compiled. The geomechanical parameters can be found on the borehole data plans.

In order to complete this exercise, the student might take into account the material given during the course, and the following documents, that will be provided:

Recommendations about the selection of mechanized excavation means:

- Choosing mechanized tunnelling techniques by the AFTES
- Recommendations for the selection of TBM's by the ITA
- Selection of TBM criteria (Germany)

In order to serve as guidance, draft documents with information about excavation planning, cross sections, layout of crossover and junctions between the tunnels have been provided to the students. These documents provide real examples; the students might simplify the solution, since this is an academic exercise.

Once the alignment for the tunnel has been selected, the planning of the different excavation steps obtained and the decision about the excavation methods to be used along the different parts of the tunnel has been taken, in this exercise the students will analyze the different techniques to be used concerning ground treatment, temporary support during excavation.

The following topics will be covered by the student in the final report:

- Explanation about the selected methods of ground treatment, if needed, for the different parts of the tunnel. It should be taken into account the geology of the tunnel, the excavation method, etc…
- Where conventional excavation methods have been selected, the students will identify the ideal excavation method (Cut&Cover, partial face or full face, etc.). The students might use the recommendations based on the geomechanical classification RMR or Q (document given to the students).
- Analysis of the different support methods to be used as temporary support. For this, the student might use well-known empirical methods, like those based on the geomechanical classifications of Beniawsky and Barton (RMR and Q, respectively).

In order to unify results and provide a consistent solution, the students will continue to use the geological and the topographical profile will obtained during the previous exercises.

In order to complete this exercise, the student might take into account the material given during the course, and the following documents, that will be provided:

- Document from Hoek about the geomechanical classifications and its use for the empirical design of temporary support
- Recommendations from the AFTES for the design of temporary support

Tunneling
Spring semester 2014 - 2015

Akos Toth

- Extract about permanent support from the book “Tunnelling” from Professor Kolymbas, Innsbruck (Austria)
- Recommendations from the US Army Corps of Engineers for permanent support and lining

The student will tackle the above mentioned points by means of a written report that will be part of the final report to be handed in and presented by the students at the end of the course.

Schematically drawings of thee proposed temporary lining should be attached to the final report.

Supplementary documents:

- Choosing mechanized tunnelling techniques by the AFTES
- Recommendations for the selection of TBM’s by the ITA
- Selection of TBM criteria (Germany)
- Geomechanical classifications by the Hoek
- Recommendations from the AFTES for the design of temporary support
- Extract about permanent support from the book “Tunnelling” from Professor Kolymbas, Innsbruck (Austria)
- Recommendations from the US Army Corps of Engineers for permanent support and lining

Tunneling
Spring semester 2014 - 2015

Akos Toth

Exercise 4 - Water proofing, drainage, Permanent lining

In this step, the students will analyze the water proofing and drainage techniques to be followed in the construction of the tunnel. The idea is to give, on a qualitative basis, the general guidelines about the waterproofing and/or drainage techniques.

The students will analyze the permanent support to be implemented in the construction of the tunnel and will complete the report by giving a list of activities for ensuring a safe tunnel operation on the long term.

Water proofing, drainage

The students will cover, in a short written memory, the general technique to be followed along the different sections of the tunnel in terms of water management and drainage. Specifically, the following questions will be asked:

- Which solution will be used along the tunnel: “Umbrella” solution or “Submarine” solution? Why? Give some critical explanation.
- Selection of the techniques used for dealing with water inflows into the tunnel.
- Techniques used to the achievement of the waterproofing and/or drainage. At this point, the students have to provide a schematic drawing with the different elements that constitute the waterproofing and/or drainage system.

The students will continue to use the geological profile obtained for the previous exercises, where hydrogeological information was given for each of the geological formations.

In order to complete this exercise, the student should take into account the material given during the course. Therefore, and as supplementary assistance, the following documents are provided:

- Extract about waterproofing and drainage techniques from the book “Tunnelling” from Professor Kolymbas, Innsbruck (Austria).
- Recommendations from the AFTES for waterproofing and drainage of underground constructions.
- Recommendations from the US Army Corps of Engineers for the waterproofing and drainage of underground constructions.
- Recommendations from SIKA, BASF, etc..

The student will tackle the points above mentioned by means of a short writing memory that will be part of the final project to be handed and presented by the students at the end of the course.

Permanent support

In the final chapter of the report the permanent support has to be described. The students will have to:

- Select and justify the best solution for the final lining of the tunnel and the additional structures.
- Provide a drawing of the selected solutions.

Tunneling
Spring semester 2014 - 2015

Akos Toth

In order to complete this exercise, the students should take into account the material given during the course. Therefore and as supplementary assistance the following documents are also provided:

- Extract from the book "Tunnelling" from Professor Kolymbas, Innsbruck (Austria) about permanent support.
- US Army Corps of Engineers recommendations about permanent support and lining (pages 5-40 to 5-43)

Supplementary documents:

- Extract about permanent support from the book "Tunnelling" from Professor Kolymbas, Innsbruck (Austria)
- Recommendations from the AFTES for waterproofing and drainage of underground constructions
- Recommendations from the US Army Corps of Engineers for the waterproofing and drainage of underground constructions
- Recommendations from SIKA and BASF for different technologies in waterproofing
- Extract from the book "Tunnelling" from Professor Kolymbas, Innsbruck (Austria) about permanent support.
- US Army Corps of Engineers recommendations about permanent support and lining