Comparing rock support in Vaðlaheiði tunnel to the Q-system

UNIVERSITY OF ICELAND
FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING

Vignir Val Steinarsson, Sigurður Erlingsson (University of Iceland) and Einar Hrafn Hjálmarsson (Ósafl)

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Introduction

Advances in tunnelling technology and better understanding of rock mechanics has in the last century made tunnels and tunnelling safer and more practical. Today rock support is put in place in accordance with rock mass quality, which is estimated before and during construction. The placing of rock support in Vaðlaheiði tunnel in the North of Iceland is done in accordance with the Q-system, as has become normal in tunnel construction in Iceland.

The object of this research project was to compare recommended rock support according to the Q-system to the rock support at three locations in Vaðlaheiði tunnel and to estimate the effectiveness of recommended rock support, using the FEM computer code RS^2.

Vaðlaheiði tunnel is a 7.2 km long road tunnel between Eyjafjörður and Fnjóskárdalur in the north of Iceland. The tunnel is designed to provide better travel conditions during winter and shorten travel times.

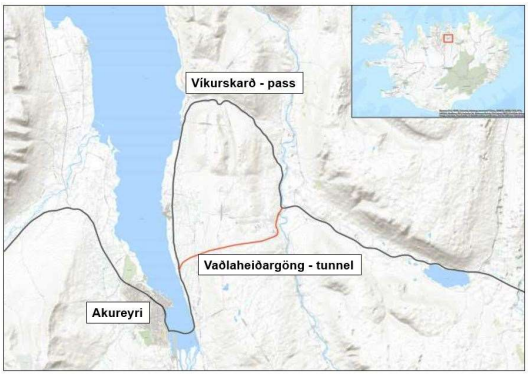

Figure 1: *Location of Vaðlaheiði tunnel project.*

Comparison with the Q-system

The Vaðlaheiði tunnel is still under construction. At present, the final rock support quantity in Vaðlaheiði tunnel has not yet been decided. Three areas along the tunnel have been analysed; research area 1 (good), 2 (fair) and 3 (poor).

In research areas 1 and 2 fewer rock bolts and more fibre reinforced sprayed concrete had been installed than the Q-system recommends. In research area 3 more rock bolts and lattice girders are installed than the Q-system recommends however the amount of sprayed concrete is the same.

Table 1: *Comparison of installed rock support with the Q-system.*

Research area 1 (Good)		Q-system	Installed	Difference
Rock bolts	[no.]	137	130	-5,4%
Sprayed concrete	[m^3]	33,9	51,8	34,5%
Research area 2 (Fair)				
Rock bolts	[no.]	216	114	-89,5%
Rock bolts (roof only)	[no.]	172	114	-51%
Sprayed concrete	[m^3]	48,9	81	40%
Research area 3 (Poor)				
Rock bolts	[no.]	196	234	16,2%
Sprayed concrete	[m^3]	130,4	129,5	-0,6%
Lattice girders	[no.]	6	8	25%

Numerical analysis

Research area 2, located between stations 1248.5 and 1297.5 in Vaðlaheiði tunnel, has been analysed with RS^2. It mostly consists of tholeiit with layers of sedimentary rock and scoria in the tunnel roof.

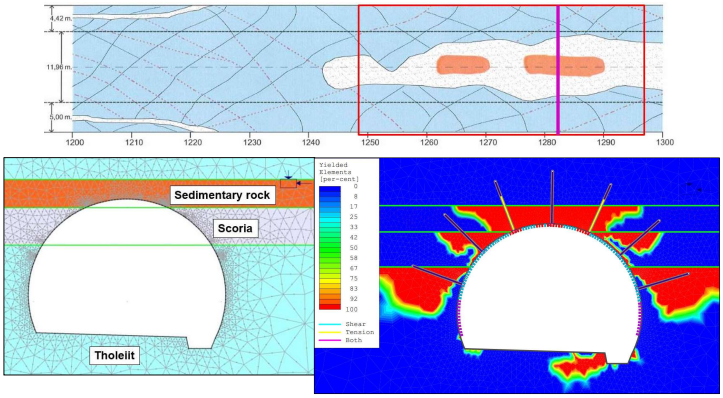

Figure 2: Top – *Overview of research area 2 (red square).*
Bottom left – *Location of computer model 2 (purple line).*
Bottom right – *Yielded elements in base model 2.*

The yielded rock- and rock support elements of the model are highlighted on the bottom right in Figure 2. The model shows that the sedimentary rock in the roof has yielded and would have broken loose if there were no rock support.

The rock bolts in the roof, that experience the largest axial force, have yielded within the sedimentary rock. However the ends of the bolts still have full load bearing strength and thus have not failed completely. The fibre reinforced concrete has yielded in areas close to the yielding rock bolts in the tunnel roof. This behavior can be observed in Figure 3.

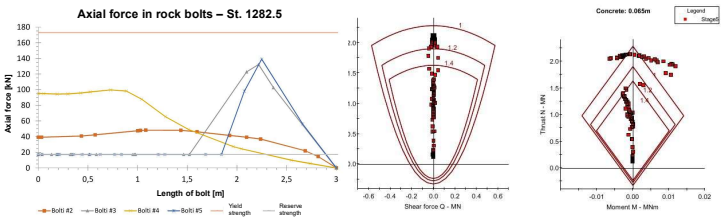

Figure 3: Left– *Axial force in rock bolts.*
Right– *Support capacity graphs for fibre reinforced sprayed concrete.*

Conclusion

- Installed reinforcements in the research areas differed from what the Q-system recommended.
  - More sprayed concrete used in all areas to smooth out rock surface.
  - More rock bolts used in unstable areas.
- The tunnel is still under construction and final reinforcement has not yet been decided in these areas.
- Numerical analysis of rock support according to the Q-system show that acceptable levels of safety are reached.
  - Yielding elements of rock bolts and sprayed concrete indicate that further rock support should be considered although not necessary (see Figure 3).

VEGAGERÐIN