RØLDAL TUNNEL: CONSTRUCTION OF THE THIRD LONGEST ROAD TUNNEL IN NORWAY AND EXPERIENCE WITH ZERO-EMISSION TUNNELLING

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ABSTRACT: The E134 Røldal–Seljestad project comprises the construction of the 12.4 km long Røldal Tunnel, which will become the third longest road tunnel in Norway upon completion. Delivered under a Design & Build contract, the project presents a number of technical and organizational challenges – ranging from complex geological conditions and high overburden, to advanced ventilation requirements and harsh climatic conditions. A key feature of the project is the implementation of strict environmental requirements, particularly the use of zero-emission construction equipment, treatment and recycling of wastewater and sediments, reuse of excavated rock material, and additional measures aimed at reducing the overall carbon footprint of the project. This paper presents the main technical solutions, construction organization, and practical experience gained during execution, including cooperation with the client, the Norwegian Public Roads Administration (Statens vegvesen), and design partners in achieving sustainability objectives.

1. INTRODUCTION

Norway has long been recognized as a global leader in road tunnel construction. Its unique geographical conditions, characterized by deep fjords, mountainous terrain, and extreme climate, have led to extensive use of tunnels as a key component of transport infrastructure. The Norwegian road network currently includes more than one thousand tunnels of varying length and complexity. Modern tunnel construction in Norway is increasingly focused not only on technical performance and safety, but also on minimizing environmental impact.

One of the most significant ongoing infrastructure projects is the E134 Røldal–Seljestad section, which includes the construction of the 12.4 km long Røldal Tunnel. Upon completion, the tunnel will rank as the third longest road tunnel in Norway and will significantly improve transport connections between the eastern and western parts of the country. The Design & Build delivery model introduces a range of technical, logistical, and environmental challenges typical for modern tunnelling projects in Nordic conditions.

The aim of this paper is to present the key technical aspects of the project, the organization of construction, and in particular the experience gained from implementing zero-emission technologies and other measures aimed at reducing the environmental footprint of construction.

2. PROJECT CHARACTERISTICS – E134 RØLDAL–SELJESTAD

The E134 highway is one of the main transport corridors connecting eastern and western Norway. The route passes through challenging mountainous terrain and is frequently affected by adverse weather conditions during winter.The E134 Røldal–Seljestad project is part of a long-term strategy to modernize this corridor, with the objective of improving safety, reliability, and traffic capacity.

The key element of the project is the construction of the 12.4 km long Røldal Tunnel, which will significantly reduce travel time and eliminate the most exposed mountain sections of the existing road.

The tunnel is designed as a two-lane road tunnel equipped with modern safety and technological systems, fully compliant with current Norwegian standards for long road tunnels.

The project is delivered under a Design & Build contract model, integrating design and construction within a single contractual framework. This approach allows for flexible adaptation to geological conditions and optimization of technical solutions during construction. The client, the Norwegian Public Roads Administration (Statens vegvesen), places strong emphasis on close cooperation between the client, designers, and contractors.

3. GEOLOGICAL AND CLIMATIC CONDITIONS

Geological conditions represent one of the key factors influencing both design and construction. The tunnel alignment runs predominantly through metamorphic rock formations, mainly gneiss and phyllite, which exhibit significant variability in mechanical properties. Locally, tectonically disturbed zones, highly fractured rock masses, and sections with increased groundwater inflow may occur.

A further challenge is the high overburden, which exceeds several hundred meters in certain sections. These conditions require careful geotechnical monitoring and a flexible approach to the design of primary support.

Climatic conditions also present significant challenges. The area is characterized by long winters, low temperatures, and substantial precipitation, all of which impact construction logistics and equipment operation. Special attention is therefore given to site organization, winter maintenance of access roads, and protection of technical equipment.

4. TUNNELLING TECHNOLOGY

Excavation of the Røldal Tunnel is carried out using the conventional Drill & Blast method, which has long been the standard approach for long road tunnels in Norwegian rock conditions. This method enables efficient progress in variable geological conditions while providing high flexibility to adapt excavation procedures to the actual rock mass behavior.

The excavation cycle includes face drilling, charging and blasting, ventilation, mucking and transport of excavated material, followed by geotechnical stabilization and installation of primary support. Depending on rock quality, various support measures are applied, including shotcrete, rock bolts, and reinforced shotcrete arches. Given the tunnel length and safety requirements, the ventilation system represents a critical component of the design. It must ensure adequate air quality during both construction and operation.

During construction, a temporary ventilation system is used, consisting of high-capacity fans and ventilation ducts with diameters of up to 2.8 meters. The ventilation concept was also one of the evaluated criteria during the tender phase.

5. ZERO-EMISSION EQUIPMENT AND ENVIRONMENTAL MEASURES

Minimizing environmental impact is one of the key aspects of the project. The client has established strict requirements for reducing greenhouse gas emissions and other pollutants during construction. Additional benefits include reduced noise levels and improved working conditions within the tunnel.

A significant role is therefore played by the use of zero-emission equipment. Electrically powered construction machinery is deployed to replace traditional diesel-based technologies.

On one side of the tunnel, all mucking and transport operations are carried out fully electrically. Excavated material is loaded using battery-electric or cable-powered loaders and transported by battery-electric trucks to the final disposal site. Energy consumption planning was one of the evaluation criteria during the tender phase. The plan tracks electricity and diesel consumption over time and location and is continuously monitored during construction.

These energy consumption data are subsequently incorporated into the overall CO_2 footprint calculation of the project. Another important measure is the treatment and recycling of wastewater generated during tunnelling. Water used for drilling, dust suppression, and other processes is collected and directed to sedimentation and treatment facilities, where solids are removed and contaminants neutralized. Part of the treated water is reused in the construction process.

The project also emphasizes efficient management of excavated rock material. Muck is reused to the maximum extent possible as construction material, for embankments, landscaping, or as raw material for aggregate production. This reduces the need for importing new materials and minimizes transport-related impacts. All these parameters contribute to the overall reduction of CO_2 emissions.

6. CONSTRUCTION ORGANIZATION AND PROJECT COLLABORATION

A project of this scale requires complex construction management and close cooperation among all stakeholders. The Design & Build model enables efficient coordination between design teams and construction units, which is particularly important when addressing unforeseen geological conditions.

A key element is also the active cooperation with the client, Statens vegvesen, which emphasizes transparent communication, knowledge sharing, and continuous optimization of technical solutions. This approach supports innovation in sustainable construction and facilitates the practical implementation of environmental measures.

In addition to technical aspects, significant attention is paid to occupational health and safety. Tunnelling projects involve numerous risks, and therefore strict safety standards, regular training, and systematic monitoring of the working environment are implemented on site.

7. CONCLUSION

The E134 Røldal–Seljestad project and the construction of the Røldal Tunnel represent a major step in the modernization of Norwegian road infrastructure. With a length of 12.4 km, the tunnel will rank among the longest road tunnels in Norway and will significantly improve transport connections between the eastern and western regions of the country.

Beyond its technical complexity, the project is notable for its strong emphasis on environmental sustainability. The implementation of zero-emission equipment, efficient water and material management, and other measures aimed at reducing the carbon footprint represent an important step toward more sustainable infrastructure construction.

The experience gained from this project can serve as a valuable reference for future tunnelling projects, not only in Norway but also internationally. The combination of advanced technologies, innovative organizational approaches, and a strong focus on environmental protection demonstrates the direction in which modern infrastructure construction is evolving.

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