EHV Cables in Subsea Road Tunnels – Vision or Reality?

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ABSTRACT

Installation of critical electrical infrastructure in future Norwegian subsea road tunnels offers an opportunity to exploit synergies such as rationalising of territorial resources, reduction of costs and environmental advantages. This paper evaluates the potential for combining a 16 km long subsea road tunnel with six 420 kV underground insulated cables. Many of the implications of a combined tunnel are presented, such as tunnel and cable requirements, vehicle accidents and fires, cable repair time and ampacity. Different branches of engineering have been involved in the discussion of tunnel designs and cost estimates.

KEYWORDS

Subsea road tunnel, vehicular tunnel, EHV power cables, shared tunnel, combined tunnel.

INTRODUCTION

In recent years, local and national authorities have expressed a need to increase the number of subsea road tunnels across the Norwegian fjords. In the national long-term "Ferry Free E39" project, removal of seven ferry services and improved roads will reduce the travel time along the West Coast (1100 km) from 21 to 10 hours, [1]. Simultaneously, new HV and EHV power systems are being planned. Integration of such electrical infrastructures in the new tunnels and subsea road tunnels offers the opportunity to exploit synergies and limits the use of subsea power cables and large EHV transmission towers, which have received strong opposition by the public, [2].

Subsea road tunnels and tunnels for EHV cables are separately very common. Each of them has strict and invariable requirements with respect to installation, operation, reliability, safety and admission, making a combination challenging. Considerations as for other multipurpose tunnels (e.g. corrosion and interference) must be evaluated, [3, 4], but this is not covered in this paper. Other electrical aspects are considered in [5].

Several combined road or railroad and EHV power cable tunnels have been evaluated in the past but nearly none of the projects have been realized, [6-8]. Some prominent evaluated projects are the gas insulated transmission lines (GIL) in the 65 km long Gotthard tunnel, [9], the 320 kV HVDC link between France and Italy, [8] and the 320 kV link in the Frejus-tunnel between Italy and France. The only combined EHV tunnel (>230 kV) known to the authors is the upcoming 51 km 320 kV HVDC link in the Channel Tunnel, scheduled to 2019, [10].

This paper evaluates on a principal background the potential of combining a subsea road tunnel with an underground EHV cable installation in Norway, using a typical Norwegian fjord crossing as an example. Technical tunnel and cable requirements and costs are presented for six 420 kV-cables for the fjord crossing given in Fig 1.

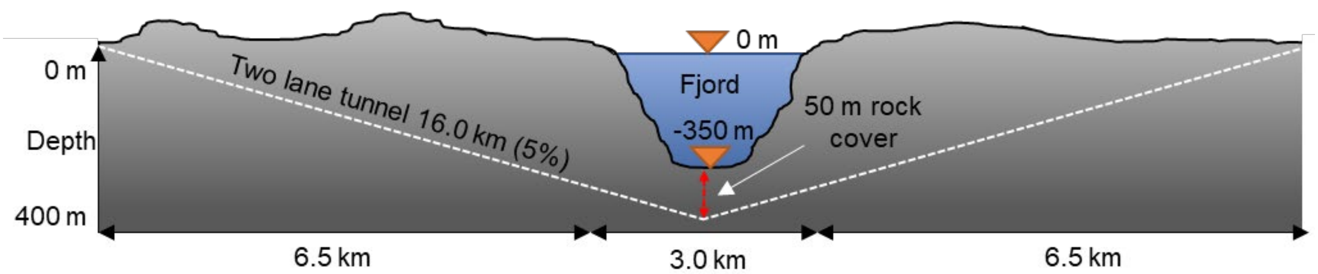

Fig. 1: Subsea road tunnel crossing a 350 m deep fjord. The two-lane tunnel is 16 km long and has 5% incline. Axes are not to scale.

TUNNEL REQUIREMENTS

There are many requirements, guidelines and best practices when designing and building subsea road tunnels. In Norway, these are described in the Handbook N500, provided by the Norwegian Public Roads Administration, [11]. One of the most important numbers when designing the tunnel is the traffic density, which separates the various tunnel classes and required safety systems. In this specific case, the annual average daily traffic density is less than 4000 vehicles the coming 20 years, which is the upper boundary for tunnel class H3. Consequently, the road must be dimensioned for a speed limit of 90 km/h and with a tunnel profile T9,5. The profile is shown in Fig. 2.

A list of some key requirements and guidelines from the N500 is given in Table 1. All the items listed in the table may restrict where the cable can be installed. Of especially importance are the breakdown and turn around niches, which are located at regular intervals at each side of the tunnel profile, as indicated in Fig. 3.