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MEMO

TITLE	**Suduroytunnel, alignment options, independent review**
DATE	9. January 2025
TO	Dan M. Knudsen, Advisor at the prime minister office
COPY	
FROM	Matthías Loftsson, geological engineer, Cowi
PROJECT NO	-

Introduction

Undersigned was asked to perform an independent review (3rd part review) of an alternative tunnel alignment for the Suduroy tunnel, a subsea tunnel between the islands Sandoy and Suduroy. The client is the prime ministry office in the Faroe Islands.

Several alignment options for the Suduroy tunnel have been discussed in the past but now two alignment options are under evaluation. These are alignment option 2, recommended by Landsverk (LV), the Faroes Public Works Agency, and alignment option 3, recommended by Suðuroyartunnel p/f (SuTu), an organization established to manage the design and construction of the tunnel. These two alignment options are shown on figure 1, on next page.

Alignment option 2 is about 25,65 km long tunnel, starting north of the village Sandur some 3 km from the Sandoy tunnel [1, 2]. LV´s argument is that this option will have less environmental impact on the local village Sandur as regards traffic. The tunnel portal is located between two small lakes some 500 m north of the Sandur village and the tunnel alignment continues from the portal toward the coast, close to the Sandur village, and reaches the coastline some 2 km from the portal.

Alignment option 3 is about 22,8 km long tunnel from Skarvanes on Sandoy [3,4]. Open road construction will be more in comparison with option 2 and the total distance from travellers through the Sandoy tunnel to Suðuroy will be about 5 km longer than for alignment option 2. SuTu argument is that shorter tunnel is less costly and project risk increases with longer tunnel. Also, by excavating a D&B tunnel at relative shallow depth near populated area will require special care and cost increasing measures such as shorter blasting rounds to reduce vibration, more grouting and more rock support.

Both alignment options end at the same location in Suðuroy.

Alignment 1, shown on figure 1, is a two-tunnel crossing with openings on Skugoy, a smaller island between Sandoy and Suduroy. This option was ruled out following risk analyses by SWECO, where it was concluded that likelihood of fire in vehicles in the tunnel was more for this alternative than in one tunnel solution, due to double number of steeper sections [4].

Alignment option 4 is the same as option 3, but with steep one lane tunnel connection to Skugoy. This is still under evaluation and thus not evaluated in this review. Population of Skugoy is only about 40 people and the island is on the Ramsar protection list due to rich birdlife and for being rat free island.

SINTEF has done risk analyse of the tunnel construction. The conclusion is that it is fully achievable to complete even this long tunnel with limited risk with good tender documents, procedures and follow-up during the construction. [5]

Focus of this review is mainly on technical issues and cost comparison between the different alignment options and not to environmental nor safety matters which have been dealt with by others in several reports.

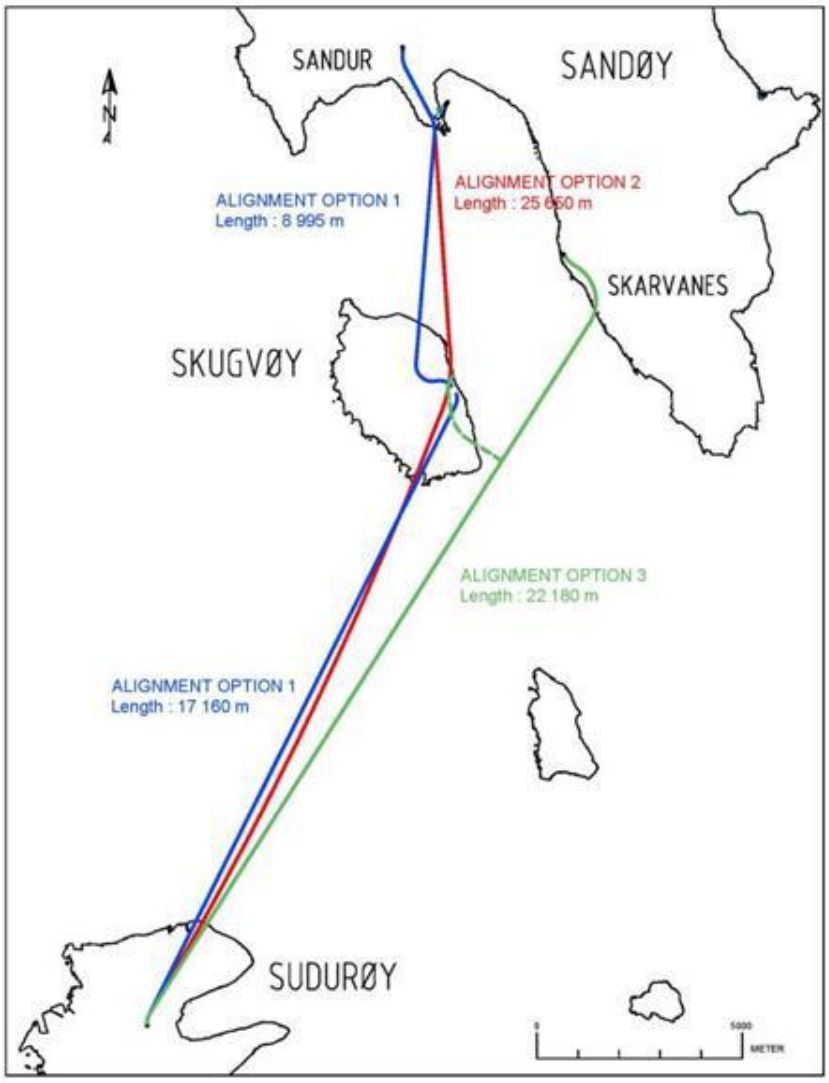


Figure 1. Tunnel alignments in discussion [4]

Prerequisites

The Norwegian standard for road tunnels requires that tunnel road line inclination is maximum 5% and that rock cover is minimum 50 m for subsea tunnels. This has been interpreted that the 50 m rock cover requirement will have to be gained when the tunnel reaches the coastline (has been accepted less under good rock conditions).

For subsea tunnels, tunnel portals must be in secure flood free areas. Rock cover at portal area should be minimum 5 m (half the tunnel with), pending geological conditions, and base level higher than maximum sea water level considering possible global warming. Suggested minimum base level of 5 m a.s.l. at the portal is a normal criterion and by adding tunnel height and minimum rock cover, bedrock level where the tunnel starts should be minimum 18 to 20 m a.s.l. The reviewer in not familiar enough with the local conditions to give statement on if this is fulfilled for suggested portal location in alignment option 2.

According to the predesign report from Norconsult, for alignment option 3, will 1/3 of the Suðuroy tunnel lie in the so-called Enni formation and of 2/3 will lie in the Malinstindur formation [3]. Both these two geological rock formations are well known and described from earlier tunnel construction in the Faroe Islands. Using average prices from other subsea tunnel projects in the Faroe Islands, for evaluation of cost for the Suduroy tunnel, is therefore a acceptable approach.

When rock cover is less than 2 to 3 times the tunnel width more rock support is required to secure stability. In the Norwegian Q-system for rock mass classification and rock support design, the Q-value shall be reduced in low rock cover areas by dividing by 2,5 to 5 (Stress Reduction Factor) to the calculated value. This means more rock support in low rock cover areas relative to the same rock with more rock cover.

Cost

The average unit price 153.000 DKK/m tunnel is, according to SuTu, based on data from other subsea tunnel projects in the Faroe Islands. The reviewer has no grounds to doubt that. This average unit price is used to compare cost difference of alternatives 2 and 3 in the table below from SuTU, figure 2. Reviewer points out that there is an error in the cost calculation for tunnel outside Sands village, should be 130 mDKK not 182 mDKK and the net additional cost thus correspondingly lower or close to 460 mDKK.

Cost Comparison Table

Description	Unit Cost (DKK/m)	Length (m)	Total Cost (DKK)
Additional Cost solution from Landsverk			
Tunnel under Sands village	230.000	2.000	460.000.000
Tunnel outside Sands village	153.000	850	182.000.000
Road from LV tunnel to Sandoy tunnel	20.000	3.000	60.000.000
Sands Líð road upgrade (per plan)			50.000.000
Subtotal (Alternative Solution)			**752.000.000**
Savings			
Suðuroy Tunnel - Líðarendi	20.000	4.500	-90.000.000
Líðarendi - Sandoy Tunnel	20.000	7.500	-150.000.000
Subtotal (Savings)			**-240.000.000**
Net Additional Cost			**512.000.000**

Figure 2. Cost comparison of alignment options 2 and 3, by SuTu.

In the cost comparison SuTu assumes higher unit price for tunnel excavation near and underneath the Sand village, due to shorter pulls to reduce vibration and more grouting. Unit rate for excavation for reduced rounds (cost/m³ excavated) is often in tender bids 50 to 70% higher than for full rounds. Also, more rock support is needed in low rock cover areas as mentions earlier. Under these circumstances, where geological conditions are uncertain, it is not unnormal to assume cost of excavation and support up to 100% higher than in deeper sections of more solid rock and where surface vibration is of no concern. Cost of excavation and support is often about 50% of the total cost. If assuming that installation cost is the same through the tunnel, total cost of 230.000 DKK/m in the Sandur area relative to 153.000 DKK/m in other part of the tunnel is considered agreeable approach.

Requirements for shorter pulls and more grouting could also be the case in other section of the tunnel as for example was experienced in the Sandoy and Eysturoy tunnels and then presumably included in the average cost of 153.000 DKK per meter tunnel.

Reviewer has long experience from tunnel constructions in Iceland and, for different approach in the cost comparison of these two alignment options, looked at cost figures from projects in Iceland for comparison to cost figures used by SuTu in their estimation.

Geology in the Faroe Islands and in Iceland is similar. Basalt is the main geological unit interbedded with scoriaceous sections and sometime also sedimentary rock layers. Difference lies mainly in higher degree of fracturing in Icelandic rock making Icelandic rock more unstable and thus more permeable, requiring in general more rock support.

As in the Faroe Islands the Icelandic Road Authority (IRA) uses the Norwegian tunnel standard for tunnel design in Iceland. For tunnels in the same tunnel class and with same installation, cost of road tunnels should be similar or slightly higher in Iceland mainly due to

more rock support. Then assuming same outer conditions (salaries, taxes, transport cost etc.).

According to the Icelandic road tunnel construction plan, Jarðgangaáætlun, from the Icelandic Road Authority (IRA) cost of road tunnel is assumed about 170.000 DKK/m with VAT (VAT is 24% and 1 DKK ~ 19,5 ISK) [7]. For subsea tunnel the cost is somewhat higher, estimated about 230.000 DKK/km in preliminary design for second tube tunnel adjacent to the Hvalfjord tunnel. Unit rates in the referred "Jarðgangaáætlun" are updated to December 2024 values, using building index.

In the "Jarðgangaáætlun" open road construction is estimated about 7.100 DKK/m, which is by many considered too low. An updated cost estimate for road construction outside the Fjarðarheiði tunnel in east Iceland (13,5 km long T9,5 tunnel), presumably tendered late this year or next year, cost estimate for open road connections to the tunnel is about 14.500 DKK/m (11.700 DKK/m without VAT).

In preliminary evaluation where ground conditions are uncertain cost of a road tunnel can be assumed being 10 to 20 times higher than for open road the same distance. This is of course highly dependent on geological condition, location, landscape etc. The unit prices used in the SuTu comparison for different alignment options tunnel unit prices for road tunnels are 8 to 10 times higher than for the open road, whereas in Icelandic unit rates suggest 15 to 20 times higher cost of tunnels than open roads.

Below is a cost comparison of alignment options 2 and 3 using both unit rates from SuTu and from the IRA tunnel plan. Results are similar. Alignment option 2 costs about 460 to 560 mDKK more than alignment option 3.

Suðuroy tunnel, alignments, cost comparison in DKK					
		Faroes unit rates		**Icelandic unit rates**	
	Length (m)	Cost (DDK/m)	Total (DKK)	Cost (DDK/m)	Total (DKK)
Alignment option 2, recommended by LV:					
Road from Sandoy tunnel to Suduroy tunnel portal	3.000	20.000	60.000.000	12.000	36.000.000
Tunnel (T9,5) from Sandoy to Skugoy, near and under Sand village	2.000	230.000	460.000.000	230.000	460.000.000
Tunnel (T9,5) from Sandoy to Suduroy, next 23,65 km	23.650	153.000	3.618.450.000	185.000	4.375.250.000
Road in Sandslíð, upgraded (*)	1.600	31.000	49.600.000	31.000	49.600.000
(*) According to LV estimation			4.188.050.000		4.920.850.000
Alignment option 3, Recommended by SuTu:					
Road from Sandoy tunnel to Líðarendi	7.500	20.000	150.000.000	12.000	90.000.000
Road from Líðarendi to Suðuroy tunnel	4.500	20.000	90.000.000	12.000	54.000.000
Tunnel (T9,5) from Sandoy to Suduroy	22.800	153.000	3.488.400.000	185.000	4.218.000.000
			3.728.400.000		4.362.000.000
	Difference, 2 - 3:		**459.650.000**		**558.850.000**

Figure x. Cost comparison, of alignment options 1 to 4, by reviewer

With alignment option 3 travel distance from Sandoy to Suduroy will be about 5 km longer than for alignment options 2. Shorter routes are on long term basis economically

beneficial. This might be an issue worth looking into, in comparison with the investment cost.

Conclusion

Despite difference in unit rates for construction of road tunnels and open roads, cost comparison using Faroes and Icelandic unit rates give similar results. Tunnel along alignment option 2 costs close to 500 mDKK more than along alignment option 3.

According to preliminary design report, geology on the tunnel route of the Suðuroy tunnel is similar to other tunnels in the Faroe Islands. Using average prices from other subsea tunnel projects in the Faroe Islands, for evaluation of cost for the Suduroy tunnel, is therefore acceptable approach.

In the cost comparison Suðuroytunnel p/f assumes higher unit price for tunnel excavation near and underneath the Sand village, due to shorter pulls to reduce vibration and more grouting and rock support. This is normal, but as always pending geological conditions. Cost per meter tunnel could be 25% to 50% more.

For subsea tunnels, tunnel portals must be in secure flood free areas. Rock cover at portal area should be minimum 5 m (half the tunnel with), pending geological conditions, and base level higher than maximum sea water level considering possible global warming. Suggested minimum base level of 5 m a.s.l. at the portal is a normal criterion and by adding tunnel height and minimum rock cover, bedrock level where the tunnel starts should be minimum 18 to 20 m a.s.l.

Shorter routes are on long term basis economically beneficial. This might be an issue worth looking into, in comparison with the investment cost for options 2 and 3.

Regards

Matthías Loftsson
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Reference data

1 Alternativ linjuføring av Suðuroyartunli norðanfyri Sand.pdf

2 Alternative alignments UK-translation of reference 1.docx

3 Suðuroyarleiðin. Forprosjekt, Norconsult

4 Linjuføringar PF Suðuroyartunnil.pdf

5 SINTEF Risikovurdering byggeperiode.pdf

6 Uppskot til løgtingslóg um Suðuroyartunnilin við tilhoyrandi tunnilskervum og vegakervum - Løgmansskrivstovan

7. Jarðgangaáætlun. Tillaga að forgangsröðun jarðgangakosta. (IRA Tunnel plan)