CEMENTSTABILIZATION OF PEATMATERIAL IN ROAD CONSTRUCTION

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KEYWORDS

Cementstabilization, infrastructure, preloading.

ABSTRACT

Rv. 4 Roa – Gran grense is a 4.2-kilometer long motorway project that aims to replace the existing two-lane highway with a four-lane motorway between Roa and Gran grense in the southern part of Norway. The project includes the construction of six bridges, one culvert, extensive rock and soil cuts, and significant landfills. The ground conditions in the project area vary greatly, ranging from peat and till to areas with quick clay, moraine, and thin layers of gravel over bedrock.

Given the limited opportunities to adjust the road line, the complexity of the ground conditions and the focus on minimizing the impact on the surrounding area and climate, alternative solutions to conventional concrete bridges and extensive mass replacement have been explored. As a result, an innovative method has been developed to cross an area with peat over quick clay by stabilizing these materials with cement. Calculations conducted by the Norwegian Public Roads Administration have shown that this chosen solution leads to a 30% reduction in CO_2 emissions compared to a traditional low bridge for this specific case.

This method is considered an innovative approach to highway construction, as there were no previous references found for its use on such a scale in Norway.

1. INTRODUCTION

As a part of the National transport plan 2014-2023 the road connection between Oslo and Trondheim was to be strengthened. As a part of the strengthening that Norwegian road directorate (Statens vegvesen) tendered the corridor on Rv. 4 between Roa and Gran grense, where the current 2-lane road was to be upgraded to a 2x2-lane highway system, thereby increasing road safety, and accessibility.

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[1] COWI A/S

After tough competition, the construction companies Hæhre Entreprenør and Isachsen Anlegg, in a working community, together with the consulting company COWI, were chosen to perform a design and build contract for the road construction.

The alignment of the new road crosses an area with significant variations in the ground conditions, yield several challenges along the way.

One of the challenges was the crossing of an existing peat and soft soil area in the southern part of the project. In this area, the subsoil condition comprised an upper layer of peat with a thickness ranging from a few meters up to 10 m. Beneath the peat, a layer of clay and quick clay was encountered with a thickness of up to 17 m. Reference is given to Figure 1, which contains a longitudinal section of the road.

It was decided to use a combination of mass stabilization and geotextiles to ensure stability, settlement, and progress in the project.

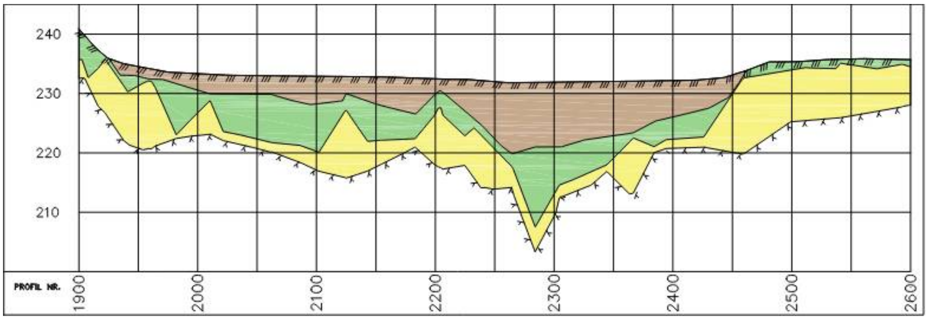

Figure 1: Sektion view of the entountered soil conditions, peat = brown, clay/silty clay = green, sand/gravel/till = yellow.

2. PROJECT INFORMATION

The Rv. 4 Roa – Gran grense project is located outside the town of Roa in the southern part of Norway, see Figure 2.

Figure 2:Location of Rv. 4 Roa-Gran grense.

The soil conditions at the project site have been investigated on several occasions in connection with previous assessments of the feasibility and zoning plan for a new road alignment.

Geotechnical investigations indicate subsoil conditions consisting of an upper layer of organic peat and gyttja, with a depth of up to 10 m, underlain by a layer of clay. In some places, the clay layer is quick, with a thickness ranging from 0 to 10 m.

In addition to the previously performed soil investigations, additional total sounding, CPTu tests, and boreholes were conducted. An example of the encountered soil conditions is shown in Figure 3.

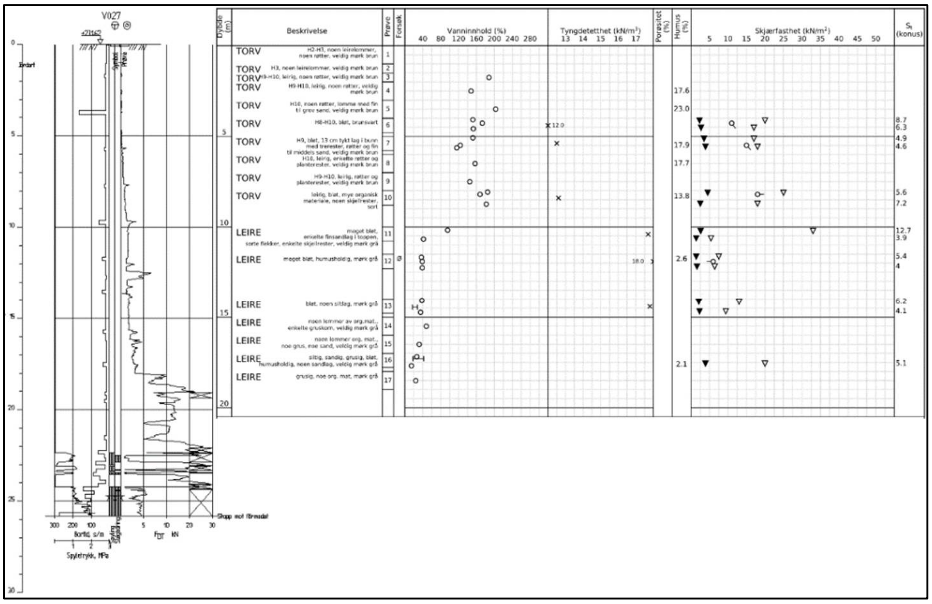

Figure 3 Totalsounding and adjacent borehole.

Considering the limited opportunities to adjust the road alignment due to the previously conducted zoning plan of the Statens vegvesen, the new road needed to cross the marshland. Initially, several methods for crossing the area were considered and discussed in the project team, including a low bridge, full excavation and replacement, and pre-loading. The solution had to take into account for the project's compressed time schedule, the need for the existing road to remain operational, and the requirement for a safe and cost-effective road. Furthermore, there was a general goal of reducing the project's carbon footprint.

It was decided to stabilize the soft soil through a combination of cement piles, pre-loading and a geotextile structure on top. This stabilization method was chosen because it satisfied the aforementioned requirements. It enabled the necessary work to be carried out without affecting the existing road. The stabilization provided both settlement reduction (SLS) and stability for the future road (ULS). Moreover, it allowed the surrounding area to be used as a fill area for excess material from the project.

In Figure 5 the layout of the stabilize of the subsoil is presented. A cross section of the proposed stabilization is presented in Figure 6.

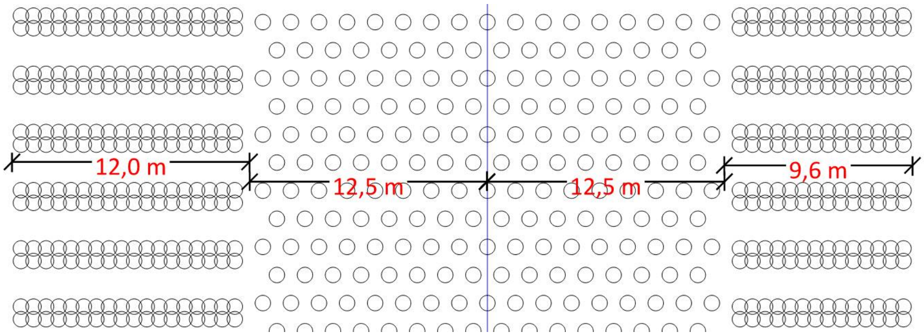

Figure 4 Layout of stabilization.

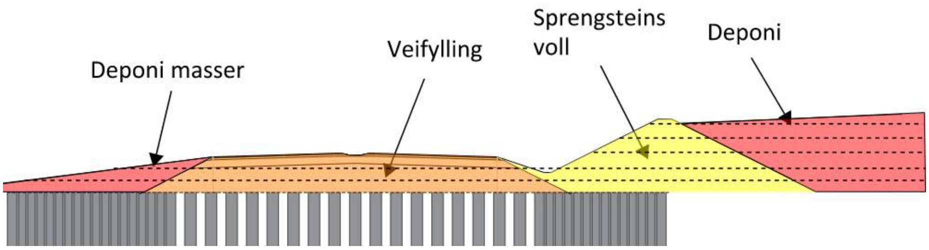

Figure 5 Cross section of the stabilization.

As shown in Figure 6, different stabilization patterns were chosen depending on the purpose of the areas. On the right side of the road, a pattern of interlocked rows of piles was selected to stabilize the noise barrier and land fill. Beneath the road, a pattern of stand-alone piles was chosen to reduce settlement. On the left side, a pattern of interlocked rows was placed to ensure stability. The size of the piles and the distance between rows and individual piles were initially determined using the guidelines provided in references [1] and [2].

Stabilization of clay and quick clay is well-documented in Norway, with established guidelines regarding the required amounts of stabilization material, achievable strength levels, and suitable methods. However, there is significantly less experience with the stabilization of highly organic material. To reduce uncertainty and assess the appropriate method, quantity, and expected strength levels, a test area on site was established before the production piles.

The test field

The test field consisted of both single piles and interlocked pile rows, utilizing various pile diameters, amounts of material, and installation speeds. A sketch of the test area is presented in Figure 6. A total of 95 piles were installed. To evaluate the impact of the quantity of material used, pile diameter, installation method, and the time elapsed between installation and testing, a test schedule was established. Strength tests were proposed to be conducted using FKPS, and core drilling.

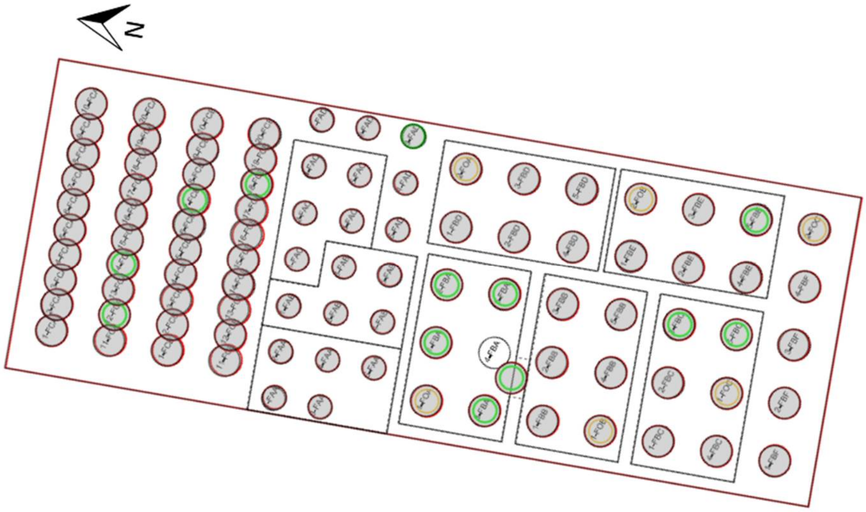

Figure 6 Test area for stabilization.

During the testing phase, it was observed that core drilling yielded poor results, and as a result, only FKPS tests were utilized in the final design. Based on the test area outcomes and considering the expected soil conditions, a material ratio was determined, with an allocation of 20-30% more material for organic soils compared to clay and quick clay at the site.

Furthermore, based on the results from the test piles regarding strength development over time, a testing scheme was established for the production piles. Approximately 1% of the installed production piles were tested to evaluate the achieved strength.

Additionally, a monitoring scheme was implemented to track the settlement of the newly stabilized areas.

Installation and testing

The installations of the cement and the FKPS testing were performed by Soil Mixing Group AB (SMG), as can be seen in *Figure 7*.

Figure 7 Soilmixing performed by SMG. Credit T. Bjørhusdal.

Following the installation, a sandwich construction consisting of geotextiles and crushed rock was placed on top. This was then topped off with a final layer of preloading. The size of the preloading was determined based on the strength results obtained from the test area and calculations of the internal capacity of the piles. Settlement plates were also installed within the preloading area.

Monitoring and mitigating actions

Results of the FKPS test in the southern part of the area showed consistent results as can be seen in *Figure 9*. The following monitoring also found that the settlement curves in the course of 3 months where starting to level out, as can be in *Figure 8*, with settlements ranging from 0 – 12 cm.

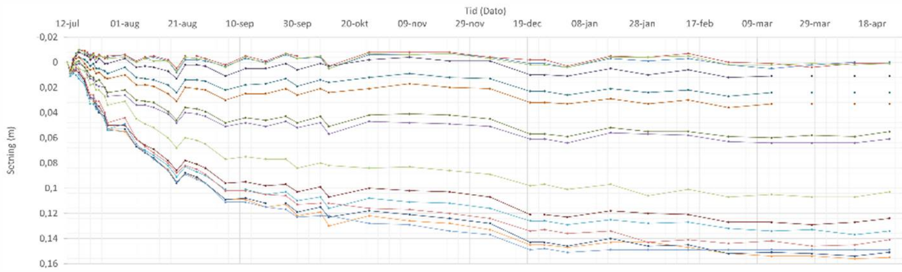

Figure 8 Settlement of the southern part of the stabilized area.

In the northern part of the stabilized area, a significantly larger scatter was observed in the achieved strength parameters, as depicted in *Figure 9*. Furthermore, it was noted that the attained strength parameters did not meet the expected values. To address the lack of strength in certain piles, additional piles were added, and an extended period of preloading was implemented. As shown in *Figure 10*, a wider range of measured settlement, ranging from 2 cm to 25 cm after 2 months, was observed.

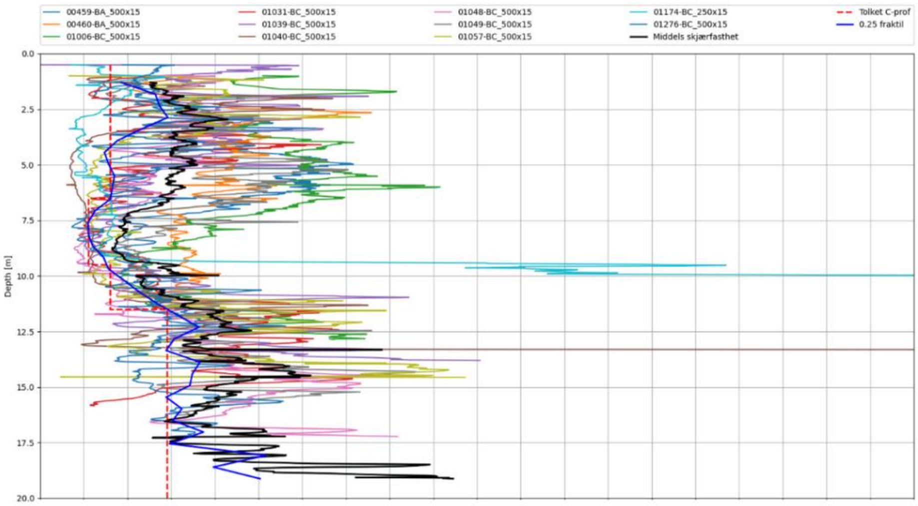

Figure 9 Measured strength distribution with depth including assed design profile.

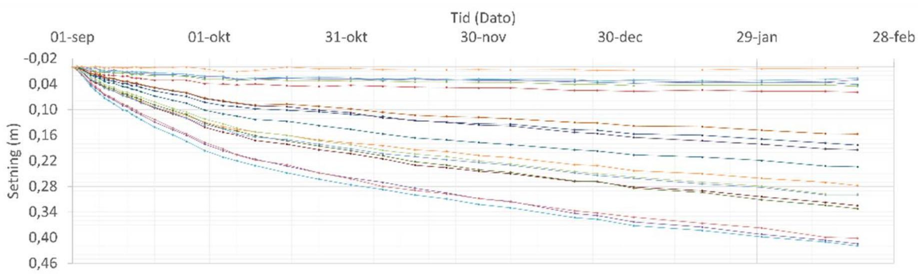

Figure 10 Settlement curves of the northern part of the stabilized area.

The settlement development was continuously monitored in the following months, and additional preloading was applied to expedite settlement, thus reducing the remaining settlement when the preloading would eventually be removed.

Findings and reflections

During the monitoring of the stabilized areas, a majority of the area exhibited settlement within 2 to 4 months after the preloading was implemented. However, there was a shorter stretch of approximately 50 meters where the rate of settlement decreased over time but did not come to a complete standstill.

Further examination of this area suggests several possible reasons, with the most likely one being that this area had the thickest layer of organic material, as well as the thickest layer of underlying clay. The increased settlement levels observed in this area could be attributed to the shear thickness of the stabilized material.

To minimize the final settlement of the road after completion, additional measures were taken in the form of a LWA (Lightweight Aggregate) mass replacement in the area where the largest settlements were encountered.

3. EFFECT ON SURROUNDING AREA

In addition to the geotechnical monitoring and mitigation measures, the local river Vigga is being closely monitored to assess the potential effects of the stabilization on the surrounding area, such as material washout or leaks. The surveillance conducted as of winter 2023 indicates positive results in terms of the impact on the river and local wetlands, according to Statens Vegvesen (the Norwegian Public Roads Administration). Furthermore, a continued test program will be implemented to evaluate the pH levels and presence of heavy metals in the area around the stabilization, in order to assess any long-term effects over time.

4. CONCLUSIONS

In the Rv. 4 Roa – Gran grense project, it was concluded that stabilizing organic material with cement is a viable method for crossing areas with a significant amount of soft organic soil.

The method was found to be versatile, particularly when stabilizing larger areas, as it effectively increased stability and reduced settlement. The flexibility of this method allowed for adjustments in the amount of stabilization as needed in specific areas. Traditional monitoring techniques, such as settlement plates and pore pressure measurements, were employed to inform appropriate actions, fostering close collaboration between the contractor and client.

It is worth noting that this project has been carried out parallel to the innovation partnership KlimaGrunn, and the experience and methods gained from that collaboration have not been incorporated. However, the experience and methods from KlimaGrunn can be advantageously utilized in future projects.

ACKNOWLEDGEMENT

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REFERENCES