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Geosynthetic solutions for road stabilization and railway ballast optimization over frost susceptible and expansive clays: A case study of the Cargill Canola processing facility

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Abstract. The Cargill Canola processing facility, a $350 million project, began construction in July 2022 and is set to be operational in 2025. The site's geology primarily consists of fine-grained glaciolacustrine sediments, mainly silts and clays. A significant geotechnical challenge was the presence of a weak upper silty clay soil layer, approximately 10 metres thick, which was susceptible to frost heave during freezing temperatures and volumetric changes due to water exposure. Spring melt also raised concerns about excess water accumulation weakening the subgrade, leading to structural damage. The high plasticity index of the subgrade increased the potential for swelling in warmer conditions, complicating the design challenges during seasonal transitions. To address these issues, geosynthetics were employed. Three types were used: a moisture management woven geotextile to provide hydraulic and mechanical stabilization in the rail and road structures, an integrated high-modulus woven geotextile to provide ballast reinforcement, and a biaxial geogrid for base reinforcement in the access roads. The integrated high-modulus woven geotextile was also used in staging areas and gravel pavements to reduce the amount of granular base material required. This case study offers valuable insights for geosynthetic solutions in stabilizing roads and optimizing railway ballast over frost-susceptible and expansive clays. It demonstrates the effectiveness of geosynthetics in mitigating challenges posed by weak soils, frost susceptibility, and expansive clays, contributing to more resilient infrastructure designs.

1 Project Background

Cargill embarked on a significant development aimed at enhancing its production capacity to meet the growing global and domestic demand for canola, a versatile crop used in both food and fuel markets. The project, strategically located in Regina, Saskatchewan, Canada, will have an annual production capacity of one million metric tonnes, making it a substantial contributor to the global canola market.

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Cargill's project officially commenced in July 2022, and its completion is anticipated by 2025. The facility will encompass a range of critical structures, including seed storage bins, large oil tanks, internal rail tracks, roadways, parking lots, multiple buildings, utility bridges, underground structures, overpass bridges, a wastewater treatment facility, and a storm pond. The site's strategic location within the Global Transportation Hub industrial park places it conveniently between the Canadian National Railway and Canadian Pacific Kansas City mainlines, ensuring efficient transportation logistics. The site enjoys easy access to major highways, facilitating the seamless movement of canola seed from producers to the facility and onward to key markets in Asia and the United States.

2 Site Characteristics and Soils Investigation

This 120-hectare site is situated on a glaciolacustrine deposit, featuring accumulations of sand, silt, and clay. The site investigation consisting of 40 drilled boreholes to a depth of up to 61 metres revealed an upper layer of high plasticity (PI~50) silty clay ranging from 0.5 metres to 11.3 metres in thickness. Moisture contents ranged between 16% and 40%, and SPT counts were as low as 5, indicative of a low California Bearing Ratio (CBR) of less than 1.5%. Some of the challenges associated with this location and these soils include: (1) frost susceptibility during cold weather, leading to frost heave and potential damage to road surfaces and railbeds; (2) thaw-weakening when the soils thaw, causing the soils to become saturated and weakened; (3) increased maintenance requirements for roads and rail tracks due to the expansive clay's propensity for volumetric change, resulting in higher maintenance costs; (4) additional construction costs for special foundation treatments, drainage systems, and ongoing maintenance [1].

3 Design Objectives

The primary design objective was clear: Build linear infrastructure that could withstand the adverse effects of the clay's volumetric changes and frost heave. This called for a multifaceted approach. (1) The foundation design had to effectively distribute loads, account for the expansive nature of the soil, and resist frost heave induced uplift forces. (2) Efficient drainage systems were critical to mitigate the swelling and contraction of clay due to seasonal changes. These systems had to be strategically placed to manage excess moisture effectively. Careful consideration was required in selecting materials for road and rail construction, ensuring they would be resilient, frost-resistant, and capable of accommodating soil movement [1].

There were three options considered for the site preparation of grade supported structures on the high swelling potential subgrade soils: (1) Replacement of existing native high plasticity clay with low plastic imported clay fill; (2) Soil cement stabilization; (3) Moisture control and subgrade reinforcement with geotextile and geogrid. Option 1 was rejected as it would result in the highest cost for construction as well as the longest construction period. Option 2 was also rejected due to concerns that this approach would not last for the design period as it would deteriorate with surface water infiltration, weather cycle and potential chemical attack in the soil [1].

Option 3 was selected and after several conversations between the designer and the manufacturer of the geosynthetics (Solmax), a solution was arrived upon which addressed remaining concerns that an unpredictable amount of swelling could lead to a shorter service period and higher maintenance costs by using the initially proposed geogrid solution.

4 Rail Component

4.1 Moisture Management Geosynthetic

Solmax proposed **MIRAFI** H_2Ri, a moisture management geosynthetic (MMG) be used to provide stabilization at the subgrade/sub-ballast interface. The MMG provides mechanical stabilization due to its high-modulus yarns and has unique hygroscopic yarns that remove moisture through capillary suction in both liquid and vapour forms. It also removes moisture in both saturated and unsaturated soils which is a characteristic unique to this product. Finally, the MMG was also chosen as it mitigates the formation of a capillary break which can cause soils to become saturated before draining. This ability to manage moisture is referred to as hydraulic stabilization [2].

4.2 High-Modulus Woven Geosynthetic

An integrated high-modulus woven geosynthetic (**MIRAFI** RS580*i*) was placed between the sub-ballast and the ballast layers, to provide ballast reinforcement. This geosynthetic has similar physical characteristics as the MMG, without the same level of hydraulic stabilization. This product was chosen for its integration of tensile modulus, ability to separate and high filtration performance [3]. Figures 1 and 2 show the placement of both geosynthetics in the railway structure.

Fig. 2. Placement of MMG on subgrade of railway structure

Fig. 1. Placement of high-modulus woven geosynthetic between ballast & sub-ballast

4.3 Design of Rail Component

Both the non-stabilized and geosynthetic stabilized rail structures were evaluated using the Talbot equation following the methodology outlined in the AREMA Manual for Railway Engineering [3]. As a design check, the sub-ballast was evaluated to act as a temporary haul road for construction activities using the Giroud-Han method [4].

The non-geosynthetic rail structure required 229 mm of ballast and 915 mm of sub-ballast. The geosynthetic stabilized and reinforced rail structure maintained the same ballast thickness, however the sub-ballast was reduced to 305 mm. This 55% reduction in thickness provided a significant reduction in construction time, granular material and hauling costs, as well as an appreciable reduction in the carbon footprint of the project. The geosynthetic stabilized section provided a 20% overall cost savings compared to the non-geosynthetic rail structure.

5 Road Section

Several different pavement sections were required throughout the site including a heavy-duty access road, internal truck routes, a light-duty parking lot, a truck staging area (gravel), and internal maintenance roads (gravel). For brevity, only the heavy-duty access road is discussed in further detail. Solmax suggested the MMG to provide stabilization and moisture management at the subgrade and that a layer of biaxial geogrid (**MIRAFI** BXG120) provide reinforcement of the base layer. The AASHTO Guide for Design of Pavement Structures 1993 [5] was chosen to evaluate various pavement structure options. Incorporating the MMG into the AASHTO 93 methodology provides both mechanical and hydraulic stabilization to the granular layer directly overlying the geosynthetic. Both stabilization components have been calibrated to site specific conditions by Solmax through third-party testing. The mechanical stabilization depends on the thickness of the granular layer overlying the geosynthetic, as well as on the subgrade stiffness and anticipated trafficking conditions. The hydraulic stabilization is site specific and depends on the frequency and duration of saturation rain events, as well as regional climatic conditions. The MMG provides a Hydraulic Improvement Factor which is applied to the granular layer overlying the geosynthetic and is incorporated into the AASHTO 93 equation.

The AASHTO 93 model assumes that the subgrade will provide a relatively firm roadbed. In weak ground conditions, a working platform is often required to support pavement construction activities and ensure that the subgrade will adequately support the pavement structure under service loads. The Giroud-Han method [4] was chosen to develop the construction platform which was incorporated into the pavement structure as part of the subbase. The pavement structure had to accommodate 2.6 x 10^6 Equivalent Single Axle Loads (ESAL's). To allow for this loading, the non-geosynthetic section was 170mm asphalt, 180 mm granular base, and 840 granular subbase (Total thickness of 1190 mm). The geosynthetic stabilized/reinforced section was 170mm asphalt, 170 mm granular base, and 310 granular sub-base, which provided an overall reduction of 540 mm. The geosynthetic stabilized section for the heavy-duty access road also provided a 20% overall cost savings compared to the original non-geosynthetic design.

6 Conclusion

As Cargill's canola production facility in Regina, Saskatchewan nears completion, it has overcome challenges tied to the site's soil and tight construction schedule. The project team's unwavering commitment led to innovative geosynthetic solutions for moisture management and stabilization, reducing costs, construction time, and environmental impact while enhancing infrastructure resilience. Cargill's dedication has transformed a challenging site into a sustainable canola production leader. This success is a testament to innovation, determination, and an unwavering pursuit of excellence. Geosynthetics have become a cost-effective standard in civil and environmental projects, reinforcing the potential for creative solutions in the face of challenges.

References

1. WSP, *Queen GTH West Site Preliminary Geotechnical Investigation Report*, Geotechnical Report, Calgary (2021)
2. https://www.tencategeo.us/en-us/products/woven-geotextiles/mirafi-h2ri
3. AREMA, *AREMA Manual for Railway Engineering*, Volume 4 (2022)

4. J. P. Giroud, Jie Han, *Design Method for Geogrid-Reinforced Unpaved Roads. I Development of Design Method*, Journal of Geotechnical and Geoenvironmental Engineering, (ASCE 2004)
5. American Association of State Highway and Transportation Officials, *AASHTO Guide for Design of Pavement Structures*, (1993)