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Appendix 11.3

Review of Stabilising Techniques for Floating Road on Peat

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ENVIRONMENTAL IMPACT ASSESSMENT REPORT (EIAR) FOR THE PROPOSED SHANCLOON WIND FARM, CO. GALWAY

TECHNICAL NOTE FOR CONSTRUCTION OF PROPOSED FLOATING ROAD ON PEAT AND TECHNIQUES FOR STABILISING PEAT

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Date: **August 2025**

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1. INTRODUCTION

1.1 Overview

This technical note discusses the options relating to the construction of a 245m section of internal access track, which will be floated road type construction, within the proposed Shancloon Wind Farm. The section of access track is located within the periphery of the Cloonbar Bog, parallel the Black (Shrule) River (waterbody code WE_30B020200). The access track will encounter heavy vehicle movements during construction (and potentially operation) which will include haulage of spoil within the Site and delivery of large turbine components. As such this technical note considers options for the construction of a floated road with suitable stability and bearing capacity within the environmental context described above.

The location of the proposed access track is shown in Figure 2.2, Volume IV of the EIAR for the Proposed Development.

1.2 Site Context

Aerial imagery (captured in 2022) showing the access track location relative to Cloonbar Bog and the Black (Shrule) River is presented in Figure 1-1 hereunder.

Figure 1-1: Aerial Image of Proposed Access Road Location

In November 2022 Murphy Geospatial conducted a cross-section survey of the Black (Shrule) River channel and immediate adjacent lands, see Figure 1-2 hereunder. The proposed access track will be located adjacent to the right bank (RB) of the Black (Shrule) River, noting that Figure 1-2 is from a perspective looking downstream.

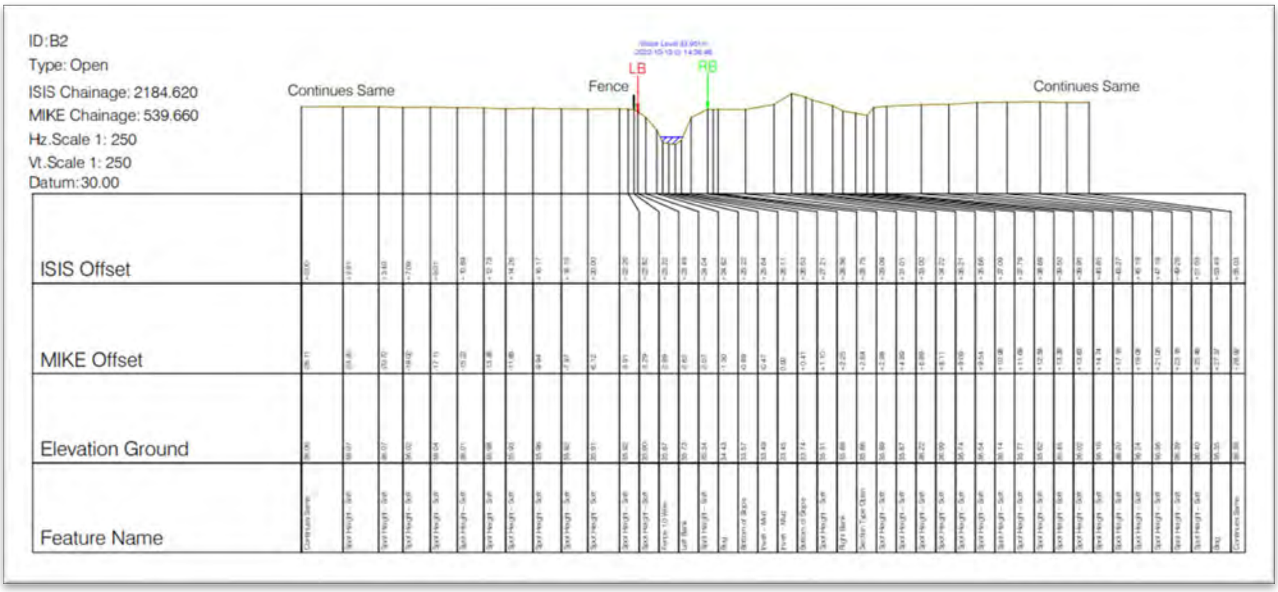

Figure 1-2: Cross section of the Black (Shrule) River

Examination of available geotechnical information for the Proposed Development lands (please refer to Chapter 11 - Soils, Geology and Hydrogeology for further details) indicates that the closest and most representative borehole undertaken to inform the EIA for the Proposed Development is PBH-16, which is located approx. 380m west of the section of access track being assessed. The geology in this borehole comprises very soft peat from the existing ground level (EGL) to 4m below EGL followed by 1.5m thick medium dense gravel with peat inclusions. Below this layer, medium dense to dense gravel layer up to 7.4m was encountered followed by 3.1m thick very stiff clay underlain by bedrock (LIMESTONE) up to the maximum drilled depth of 22m from ground level. The ground model assumed for this Technical Note is based on the findings at PBH-16 (coupled with peat probe data for the proposed access track location) and is shown in Figure 1-3. Such assumptions should be proven through site specific intrusive ground investigation at Detailed Design.

The groundwater is assumed to be at the existing ground level based on monthly groundwater monitoring at boreholes 16, 14 and 17 as presented in Chapter 11 - Soils, Geology and Hydrogeology.

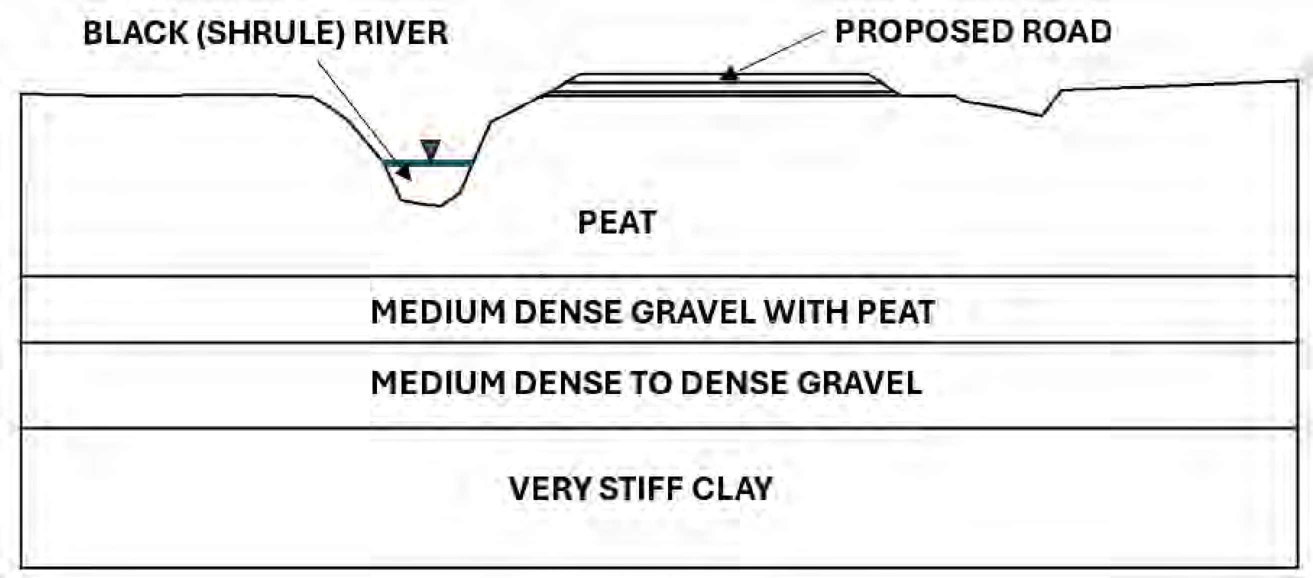

Figure 1-3: Ground Model Used in Options Assessment

1.3 Report Objectives

This report serves as the technical note setting out options for the construction of a turbine access track on the peat layer within Cloonbar Bog, adjacent to the Black (Shrule) River.

The following key challenges have been considered in this Technical Note:

- Settlement and differential settlement over time in peat environment
- Stability and bearing capacity of floated road under traffic loads
- Long-term performance and environmental considerations (dewatering, carbon emissions)
- Location of the proposed floated road adjacent to the Black (Shrule) River

2. TECHNIQUES FOR CONSTRUCTION OF FLOATING ROADS ON PEAT

Since there is an existing river parallelling the proposed floated road and due to the likely low strength of the peat layer[1] within Cloonbar Bog, there is a potential for slope instability if traffic loads are imposed directly onto the peat. Therefore, ground stabilisation is advised before the construction of the road. This can be done by various means which are examined in this technical note and include excavation and replacement, piled solutions, retaining structures and soil improvement/stabilisation. A single method may not be feasible and hence a combination of techniques may be required to stabilise and construct the road.

2.1 Peat Removal and Replacement

Partial or full excavation of peat and replacement with more stable material (sand, gravel, or other fills).

In some cases, a hybrid approach is used where only the upper layers of peat are removed and replaced with stronger materials, while lower layers remain undisturbed.

In either case, sheet piles or other temporary support will be required to stabilise and support the excavation. Based on the groundwater flow, dewatering might be necessary for any peat removal.

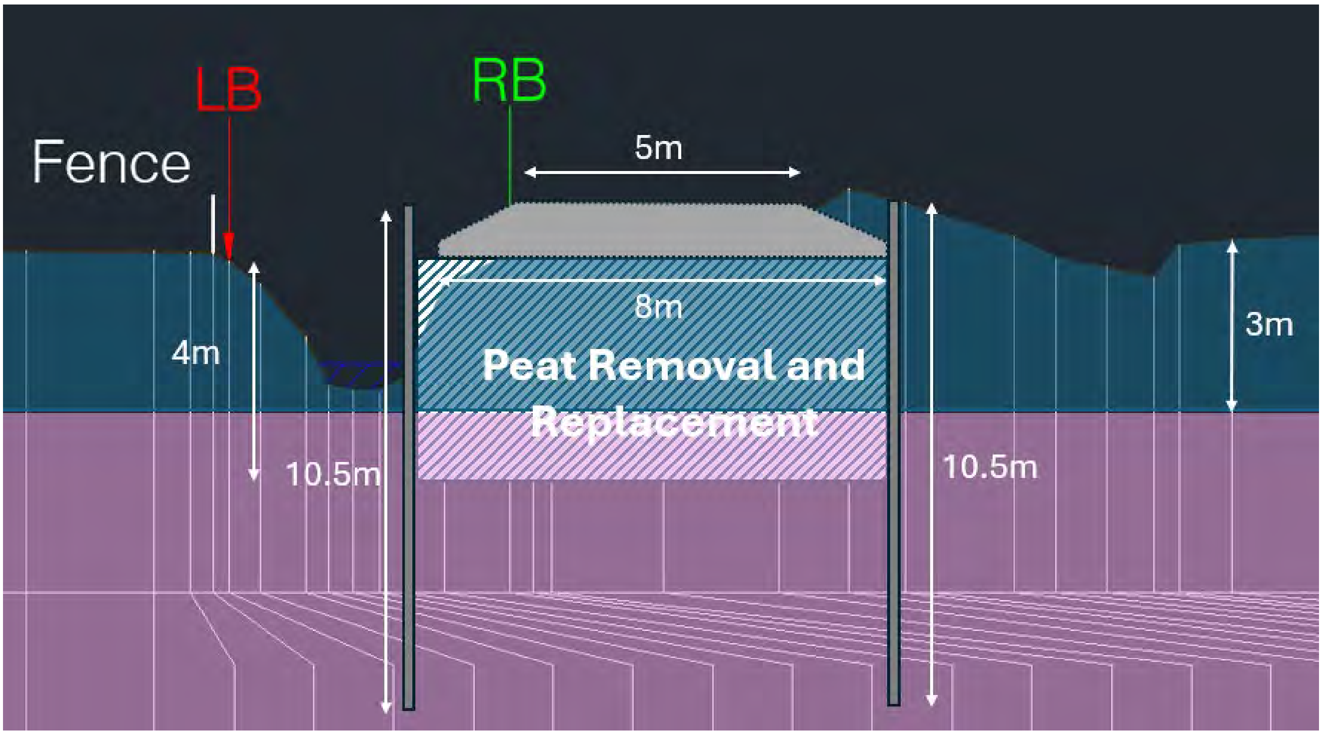

Figure 2-1: Peat Removal and Replacement

[1] Peat it is frequently weak and highly compressible due to its organic and water content.

Advantages: Enhances long-term road stability.

Disadvantages: This may lead to a high cost since peat depth is around 4m and the required volume of engineered fill material will be high (around 15,600 cu.m). There are environmental concerns in that there would be an increased requirement for haulage of material to the site. This option also presents a potential increased risk of sedimentation of the adjacent Black (Shrule) River due to the level of peat disturbance required, coupled with the potential for runoff from imported fill material. The peat must be removed and either stored in an on-site deposition area or removed from site as such requiring greater land take in the deposition areas or resulting in increased haulage. Noted also is that this option will also require stabilising the face of the Black (Shrule) River by piling or similar technique.

In the case of partial replacements, there will still be significant settlements, which can have implications for construction programme and operation and maintenance needs.

2.2 Preloading and Surcharging

Involves placing a temporary load (surcharge) on the peat to pre-compress it, expelling water and reducing its compressibility.

This technique accelerates consolidation and minimises future settlement. Often combined with vertical drains (e.g., sand drains or wick drains) to expedite water removal.

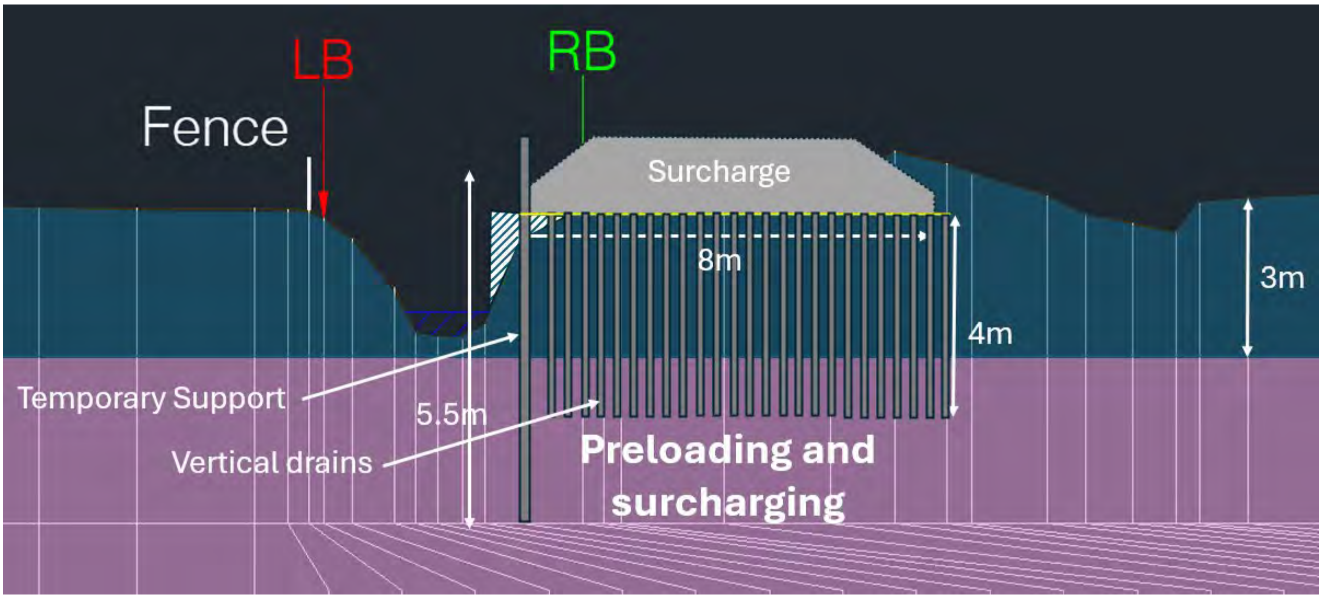

Figure 2-2: Preloading and Surcharging

Advantages: Reduces long-term settlement and improves stability. Reduces the need for high levels of peat excavation.

Disadvantages: This will incur cost of bringing the material, installation of drains and will have an implication for construction programme as the surcharge shall be at least kept for 1 year before the construction of the road plus the cost of stabilising the face of the Black (Shrule) River. Also, a temporary working platform will be required for the vertical drainage rigs which are significant in size as these rigs will be loaded essentially on existing peat. This temporary working platform will be similar to the proposed road itself. Moreover, there are more risks during surcharging as we are loading the peat adjacent to a slope which will cause lateral squeezing of the peat layer and potential instability to the face of the river. Also, there are environmental issues with drainage of peat which also impacts the surrounding hydrology / hydrogeology.

2.3 Vertical Drains and Vaccum Preloading

Vertical drains (such as prefabricated wick drains) expedite the consolidation of peat by providing a drainage path for pore water, allowing the peat to compress more rapidly under load.

Vacuum preloading is an advanced method of consolidating peat using negative pressure to enhance water removal.

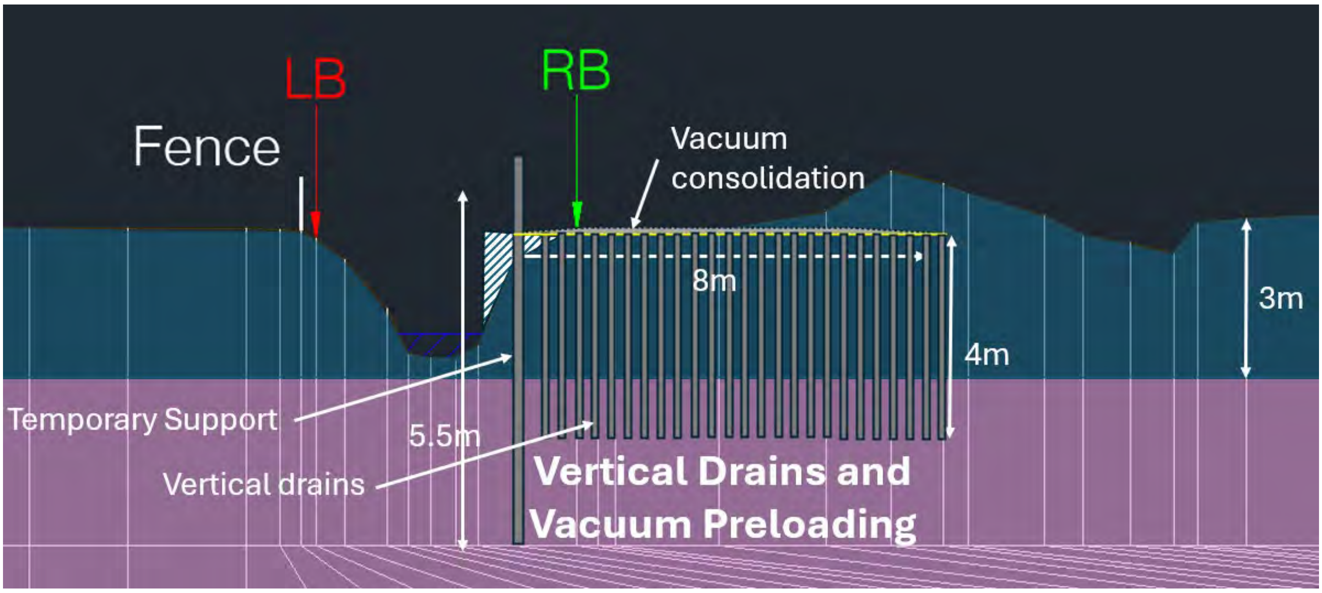

Figure 2-3: Vertical Drains and Vaccum Preloading

Advantages: Effective for long-term stability, especially in large-scale projects with thick peat layers. Minimises the need for material importation.

Disadvantages: This will incur a cost of bringing the material, installation of drains and will have a programme implication as the vacuum consolidation shall be at least kept for 1 year before the construction of the road plus the cost of stabilising the face of the Black (Shrule) River. In addition, there is a high cost involved in installation of vertical drains and vacuum preloading. Also, a temporary working platform will be required for the vertical drainage rigs which are significant in size as these rigs will be loaded essentially on existing peat. This temporary working platform will be similar to the proposed road itself. Moreover, there are more risks during vacuum consolidation as we are loading the peat adjacent to a slope which will cause lateral squeezing of the peat layer and potential instability to the face of the river. Also, there are environmental issues with drainage of peat which also impacts the surrounding hydrology / hydrogeology.

2.4 Deep Soil Mixing (DSM)

Cement or lime is mixed with peat in situ to create a series of columns or walls of stabilized material. This increases the bearing capacity and reduces settlement.

The technique requires specialized equipment but offers excellent results in improving peat's mechanical properties.

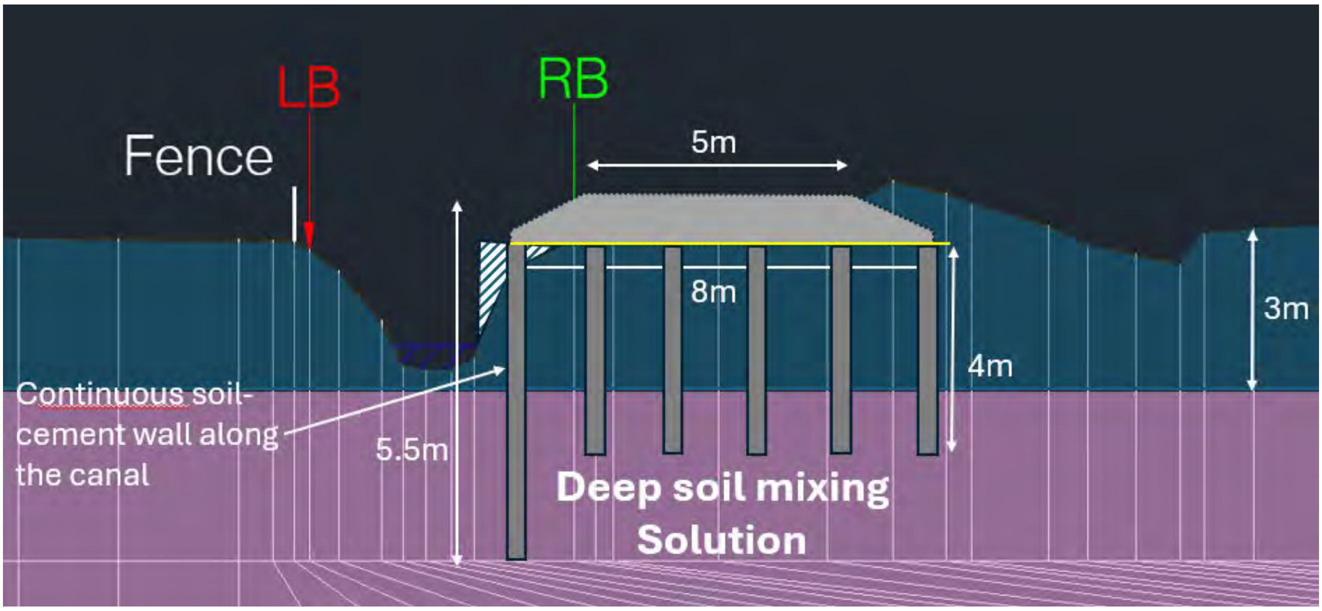

Figure 2-4: Deep Soil Mixing

Advantages: Substantial strength improvement, long-term stability, and suitability for thick peat layers. The deep soil mixing itself will act as a retaining wall to stabilise the face of the Black (Shrule) River when drilling continuously along the channel face. Also, a temporary working platform will be required for the soil improvement rigs to work on, however after the improvement is made to certain extent, the improved areas can be used as a working platform which significantly reduces the cost and material requirements for temporary works.

Disadvantages: The cost need to be determined based on the grid intervals for the deep soil mixing as special design is required for this technique, hence the cost may be high. The time for construction depends on the grid intervals of the column but is likely to be lengthy given peat stability. Environmental constraints due to the potential for polluting water during cement injection.

2.5 Chemical Stabilisation

Peat can be chemically stabilized by adding lime, cement, or other binders that react with the organic material and water in the peat to form a more solid mass.

This technique improves the strength and reduces settlement but is less common due to environmental concerns and variable effectiveness.

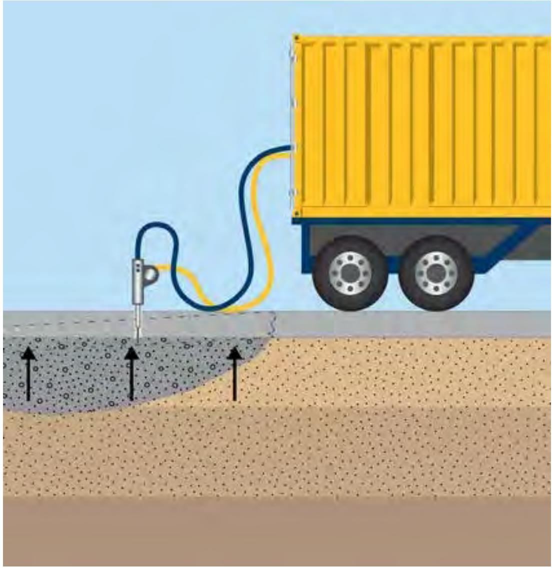

Figure 2-5: Chemical Grouting

Advantages: Can be effective in smaller areas or combined with other methods.

Disadvantages: Limited effectiveness in peat, high cost, durability issues, environmental concerns when lime or cement are used adjacent to the watercourse, emission of significant amount of carbon, moisture sensitivity and maintenance challenges.

2.6 Gabion Wall

Gabion walls are structures made from wire mesh or cages filled with materials like rocks, stones, or other similar elements.

Widely used for stabilizing slopes and preventing erosion, especially in areas where soil stability is a concern.

It can be an effective solution in a variety of civil engineering and landscaping applications.

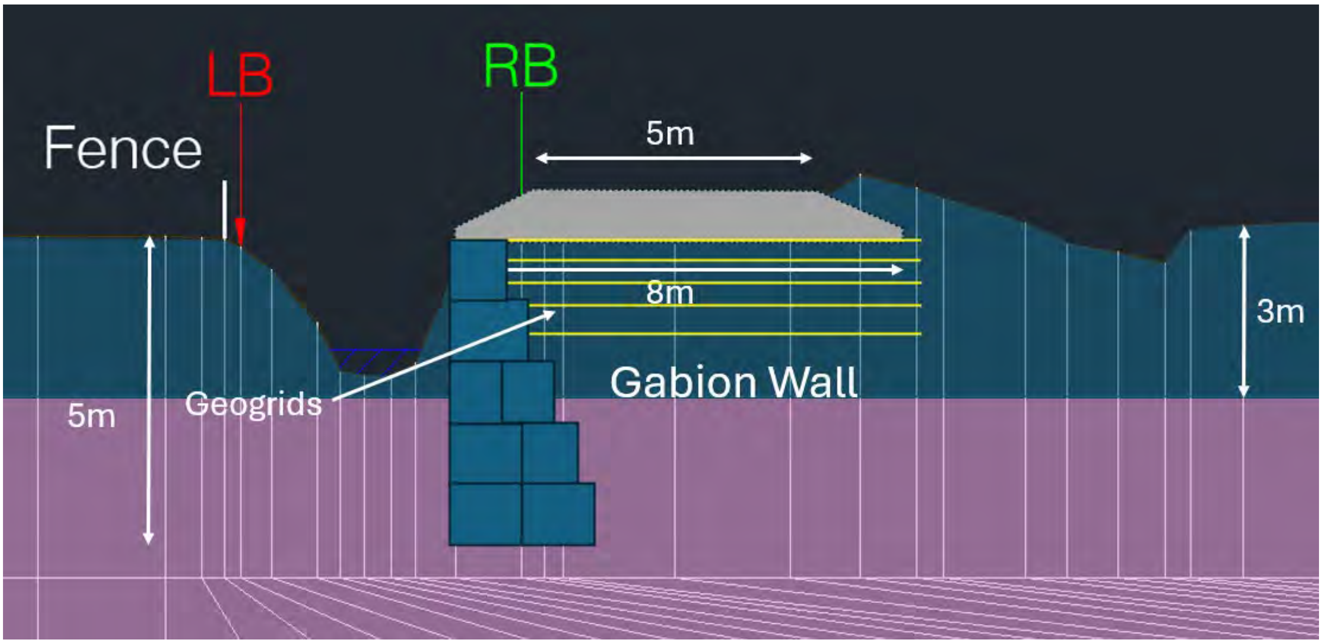

Figure 2-6: Gabion Wall

Advantages: Cost effective, high permeability and drainage, flexibility, adaptability, easy to install.

Disadvantages: Deep digging to reach competent ground: estimated that excavation a minimum of 5m depth is required to install. Initial high labour cost, maintenance may be required, wire cages are prone to corrosion due to organic material. Temporary works slopes during excavation must be shallow to maintain stability during construction. A significant volume of peat to be removed which incur high cost and significant peat management needs. A proper structural fill material has to be placed behind the wall which needs to be imported, and peat will need to be deposited elsewhere on site. There is a direct impact on the Black (Shrule) river during construction due to the need to excavate the right bank and part of the bed. The excavation required will likely necessitate temporary fluming of the watercourse, or temporary river diversion. Gabion wall will produce a differential settlement issue in the peat where one side is supported and the other is not.

2.7 Piled Embankments

In this approach, piles (steel, concrete, or timber) are driven through the peat into more stable ground beneath, creating a stable foundation for road embankments.

The road rests on these piles, bypassing the weak peat layer entirely.

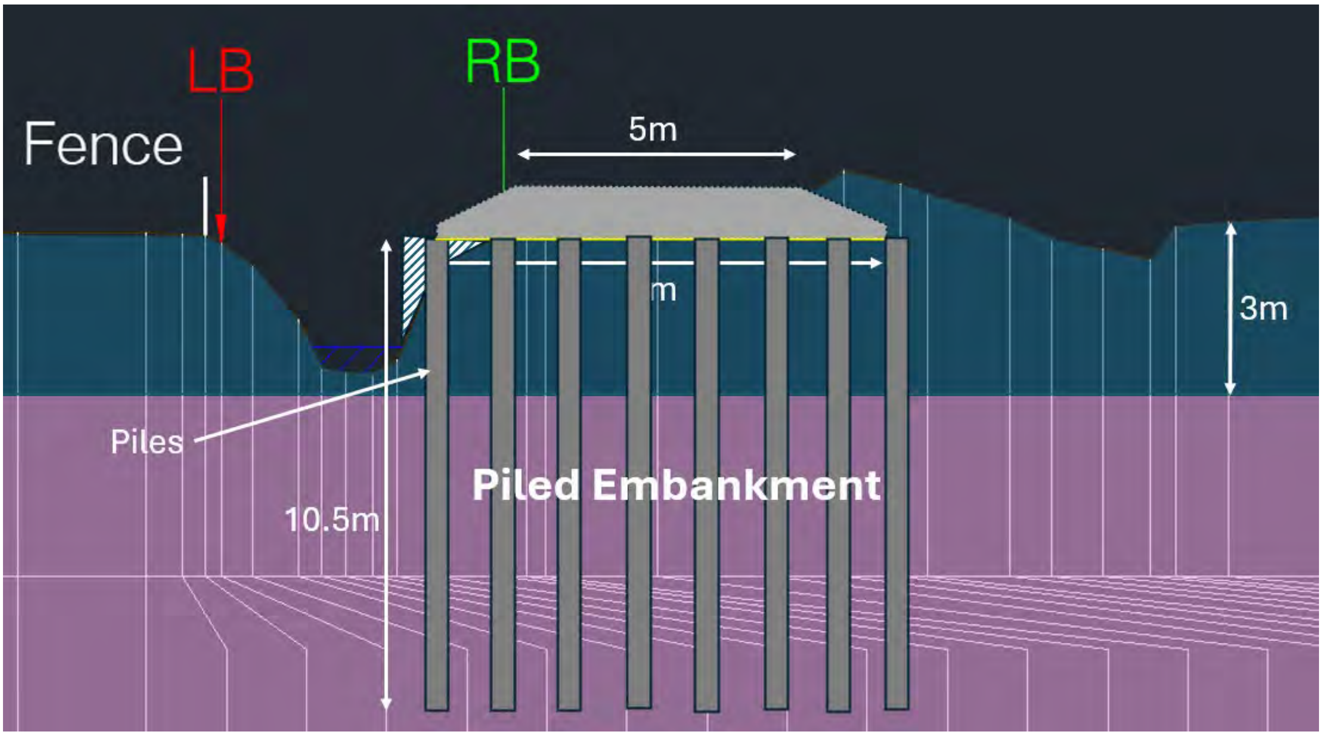

Figure 2-7: Piled EmbankmentFigure

Advantages: High load-bearing capacity, suitable for heavy traffic or high embankments.

Disadvantages: The cost of installation of piles will be high and this is time consuming process. Moreover, the lateral capacity is required to resist shear due to peat movements which is a drawback from peat (i.e. due to the poor shear strength of peat, even after installation of piles, if there is no support on the face of the river, there are chances of peat failing due to the disturbance of peat during piling). Also, a temporary working platform will be required for the piling rigs to work on which significantly increases the cost as this works as a load transfer platform. Potential for "Egg box" effect (peat failing between piles) due to the limited height of the embankment here. Environmental constraints due to the potential for polluting water during cement injection.

2.8 Sheet Pile Wall

Permanent sheet piles are structural elements used for long-term applications to stabilize slopes, retain soil, and control erosion.

Often made of durable materials like steel, vinyl, or concrete, and are designed to remain in place for the lifetime of a project.

Commonly used in marine environments, infrastructure projects, and areas prone to soil instability.

The sheet pile wall considered for the Proposed Development are of two types:

1. Single sheet pile wall - on the right bank of the Black (Shrule) River - due to the soft nature of the peat, the sheet pile wall cannot act independently and hence require anchors to be stable

2. Double sheet pile wall - on either side of the road - due to the soft nature of the peat, the sheet pile wall cannot act independently and hence require ties to be stable.

Single sheet pile wall with anchors

Single sheet pile wall with anchors can be used to stabilise the face of the river, however due to the surcharge on the peat, the sheet tends to move laterally. Hence the anchors have to be used to restrict the lateral movement of sheet pile which have to be socketed into a hard stratum which are at deeper depths.

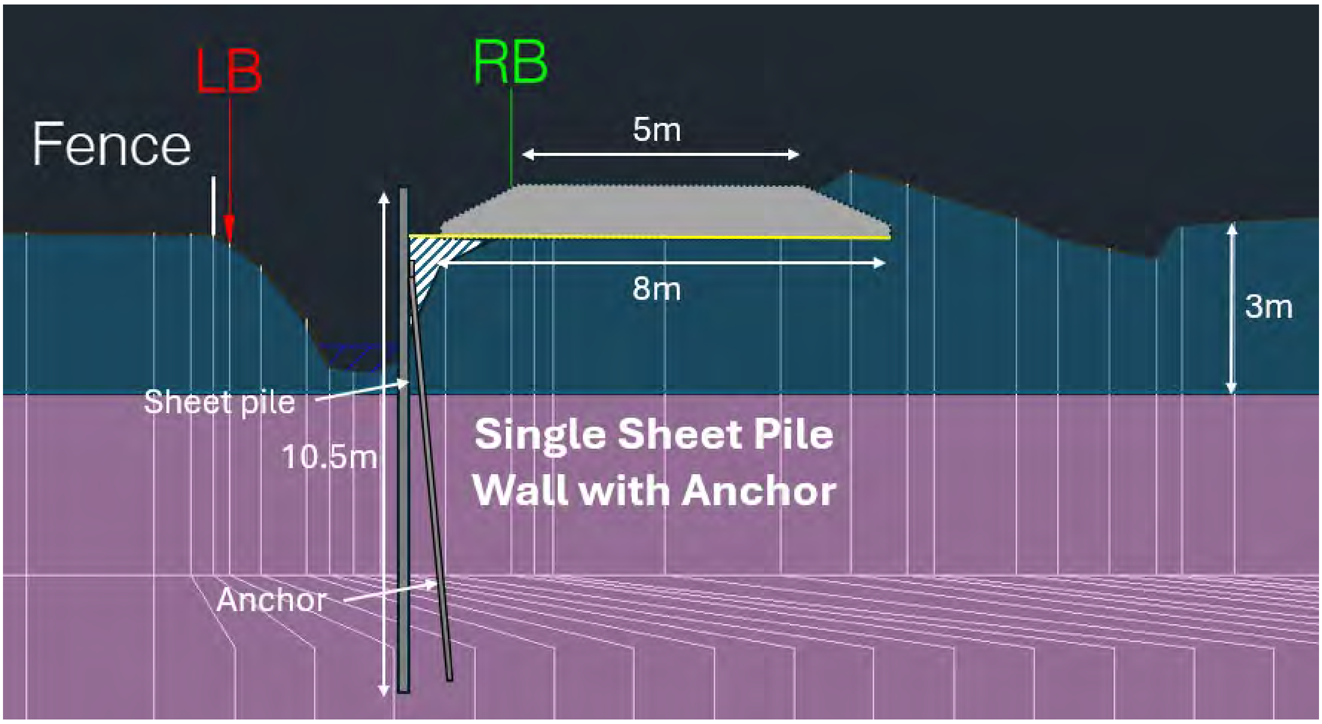

Figure 2-8: Single sheet pile wall with anchors

Double sheet pile wall with ties

Single sheet pile wall will be installed at both end of the road width and connected with ties to restrict the lateral movement of the sheet piles. The ties are very important as the sheet piles tends to have lateral movement within the peat layer. The ties will be installed at certain depth below the ground level and regular interval along the road corridor. By installing the this, the differential settlement will be controlled by allowing the peat to move only in vertical direction.

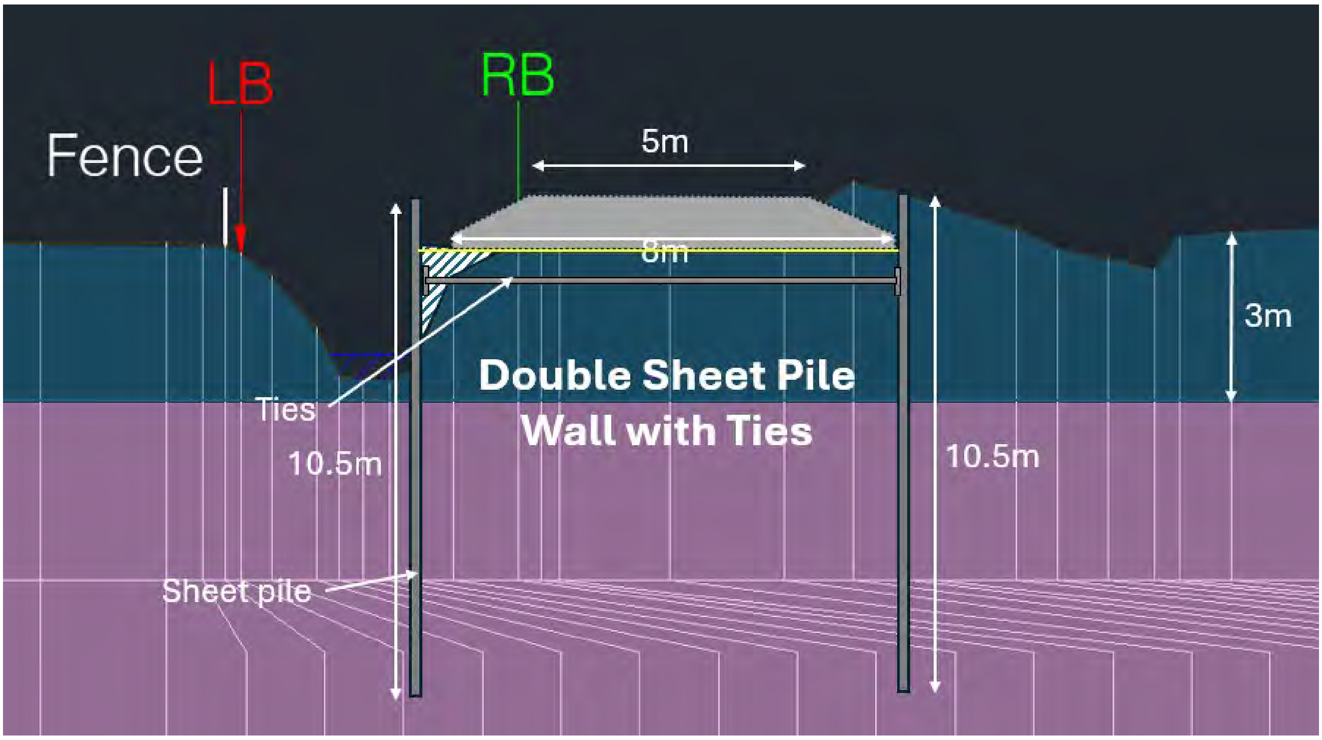

Figure 2-9: Double Sheet pile wall with ties

Advantages: Easy to install, saves space, reduced need for peat and spoil management, high load bearing capacity, minimal maintenance, reduces ground movement.

Disadvantages: High initial cost, complex design requirements that may require specialist contractor, prevents water seepage locally (however this will have a positive effect on the adjacent Cloonbar bog which has been subject to drying due to drainage), potential for long-term deformation which can be overcome by using thick steel sections, will have construction programme implications.

2.9 Other stabilising methods which can be used in combination with the above techniques.

Geosynthetics Reinforcement

Geogrids or Geotextiles are used to distribute loads across a wider area, reducing localized pressure and preventing rutting or settlement.

Geocells: 3D honeycomb-like structures filled with aggregate can help stabilize peat, distributing loads and limiting vertical deformation.

Figure 2-10: Various types of Geosynthetics reinforcement

Advantages: Geosynthetics are lightweight, easy to install, and provide immediate reinforcement.

Disadvantages: High initial cost, require good design and skilled labour to install, deformation over time, maintenance and monitoring required.

Lightweight Fill Materials

Use of lightweight materials like expanded polystyrene (EPS) blocks, foam concrete, or lightweight aggregates (pumice, expanded clay) reduces the overall weight exerted on the peat.

By minimizing load, the risk of settlement is reduced, allowing the road to "float" on the soft peat surface.

Figure 2-11: Various types of Lightweight fill materials

Advantages: These materials significantly reduce vertical stresses and settlement rates.

Disadvantages: High cost, limited bearing capacity as it may not withstand heavy vehicle load, susceptibility to water damage, environmental concerns like material maybe petroleum based, thermal sensitivity as it may brittle in freezing conditions, limited recycling options, uneven road settlement due to peat.

Floating Road Embankment

Cushion layer of granular material (gravel) placed directly on the peat surface. The layer distributes the load, allowing the road to float on the peat.

This approach uses multiple geotextile layers to stabilize the foundation and is often combined with geosynthetic reinforcement for additional strength.

Figure 2-12: Floating Road Embankment

Advantages: Relatively simple and economical for smaller-scale projects.

Disadvantages: High maintenance cost, sensitive to large loads, complex design and construction, water clogging issues, shorter life span as it need to regular road top ups, sedimentation risk to local watercourse where friable stone material is used.

3. ASSESSMENT OF ALTERNATIVE TECHNIQUES

From the above techniques, different combinations have been adopted to assess the site conditions and their solution as stated below.

- Sheet pile wall with geosynthetic reinforcement up to 2m
- Double Sheet pile wall with reinforced ties
- Sheet pile wall with reinforced ties along with dig and replace to 2m
- Gabion wall with geosynthetic reinforcement up to 2m
- Deep soil mixing with 0.5 or 1m grid spacing

The below table details the outcomes from the assessment carried out for different options and the preference for Proposed Development.

Table 3-1: Summary of the Assessment

Options	Assessment Remarks	Conclusion
Sheet pile wall with geosynthetic reinforcement up to 2m	Risk of large lateral displacement of sheet pile due to peat movement with associated environmental risk tot eh Black (Shrule) River and the integrity of the Cloonbar bog.	Not preferred
Double Sheet pile wall with reinforced ties	Controlled lateral displacement. Limited need for peat excavation and spoil management. Double piles retain hydrological integrity of adjacent bog. The floated road requires top up of road material due to peat settlement. Risk of sedimentation of the river can be controlled by ensuring use of clean fill material for floated road.	**Preferred**
Sheet pile wall with reinforced ties along with dig and replace to 2m	Controlled lateral displacement. But the cost is very high to dig and replace the peat. Also issue with peat storage and implications on adjacent bog hydrology due to depth of dig.	Not preferred

Options	Assessment Remarks	Conclusion
Gabion wall with geosynthetic reinforcement up to 2m	No solid ground and need to excavate at least to 5m to place the gabion wall. Issues with lateral displacement of peat and gabion wall. Also need for large quantities of peat storage. Implications for hydrology of adjacent bog, with associated risk of drying out.	Not preferred
Deep soil mixing with 0.5 or 1m grid spacing	Best solution to retain the peat and control the settlement allowing high load bearing. However, use of large quantities of concrete adjacent to the Black (Shrule) river in a wet peat environment has an associated high potential for impact on water quality.	Not preferred

4. ASSESSMENT OF PREFERRED TECHNIQUE - DOUBLE SHEET PILE WALL WITH REINFORCED TIES

A detailed assessment has been undertaken for the preferred technique for stabilising the peat for the construction of the access track and the findings of the analysis are presented below.

The model was undertaken in Plaxis software with a 2D analysis using Mohr coulomb failure criterion. For analysis purpose, a probable design scenario of a sheet pile of 10.5m length with section PU 28 -240 steel is considered. Figure 4-1 presents the model adopted for the Plaxis analysis. For analysis purposes, a uniformly distributed load of 50 kN/m2 is considered.

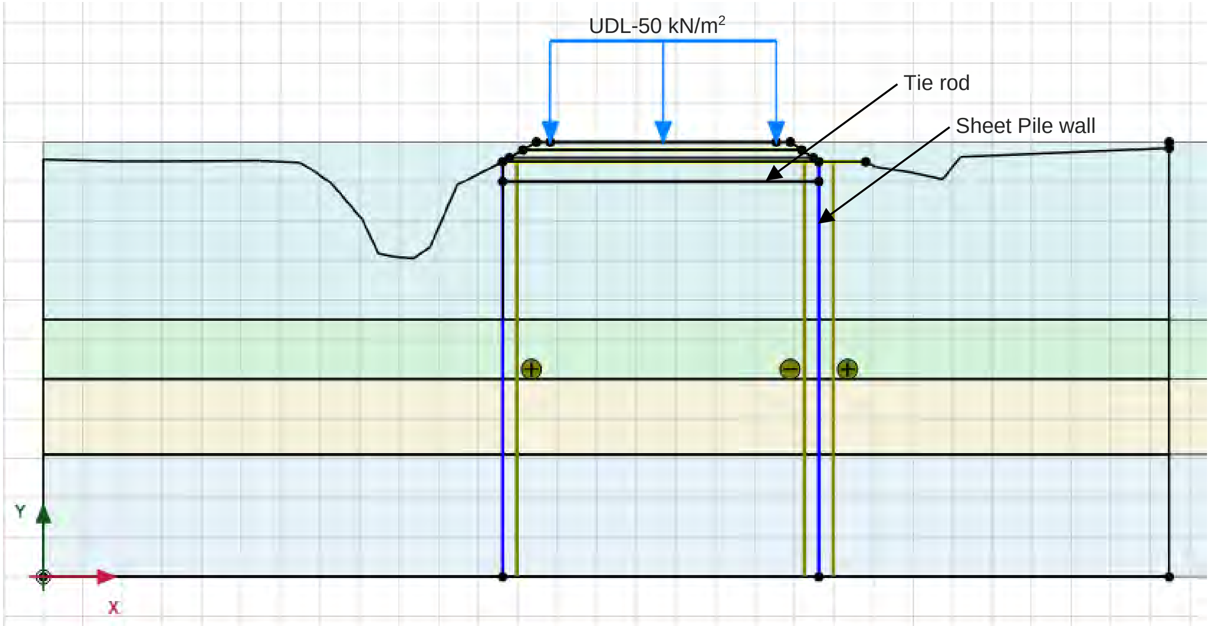

Figure 4-1: Plaxis Model of Double Sheet pile wall with reinforced ties

From the analysis, the results are favourable with a maximum vertical displacement of 75mm and with a maximum lateral displacement of 45mm. Having regard to available geotechnical data for the Proposed Development, the sheet piles are assumed to be embedded in a very stiff clay layer having a maximum lateral movement of 17mm. It should be noted that this is an assumption based on the best available data which will need to be confirmed through intrusive site investigation at Detailed Design.

Results from the Plaxis analysis are presented in Figure 4-2, Figure 4-3 and Figure 4-4 displaying the vertical and lateral displacement of the model and the maximum displacement of the sheet pile respectively.

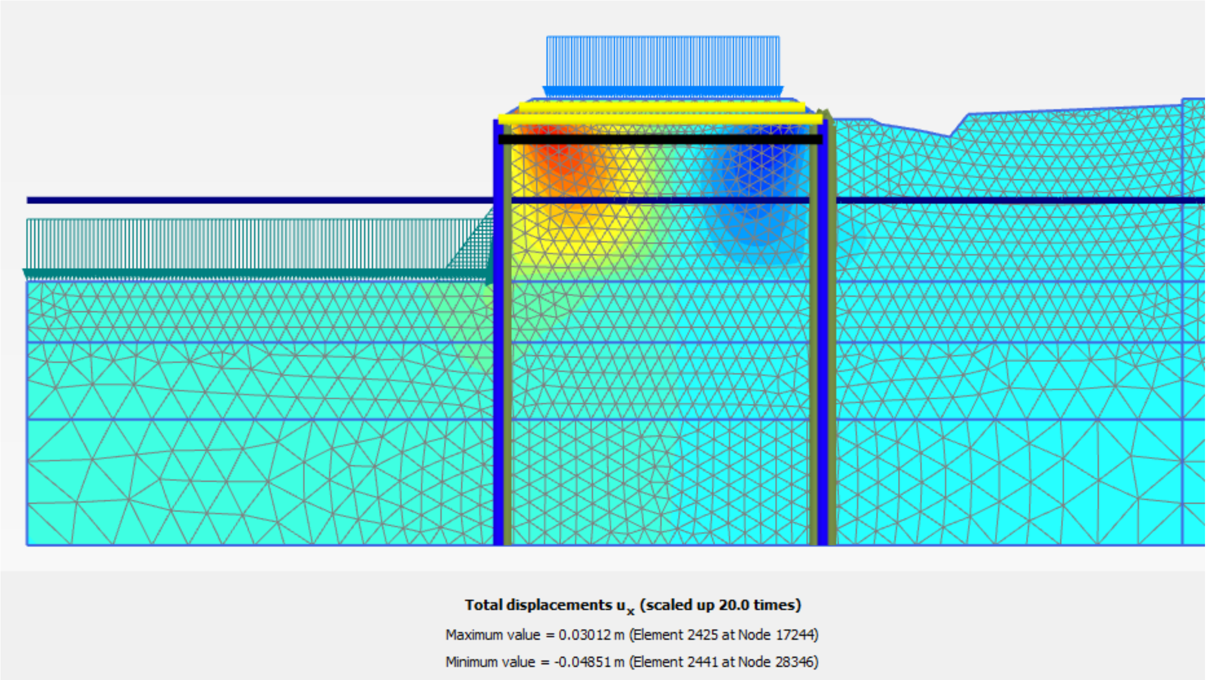

Figure 4-2: Output from Plaxis Model showing Lateral Displacement

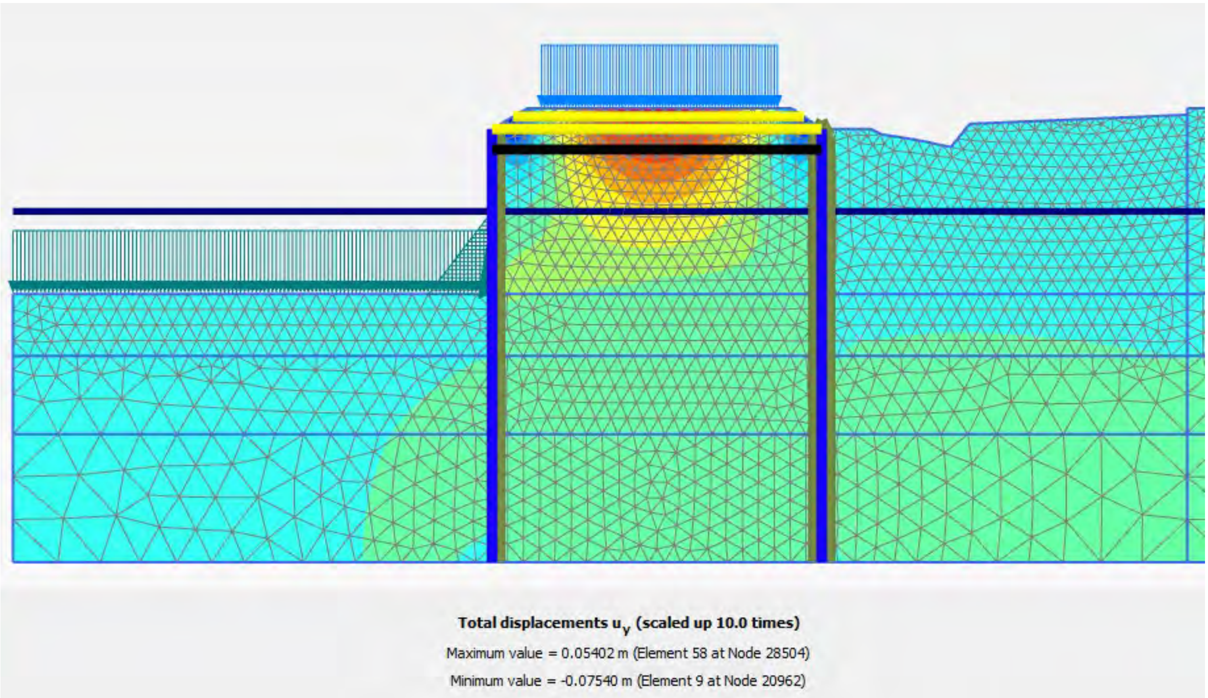

Figure 4-3: Output from Plaxis Model showing Vertical Displacement

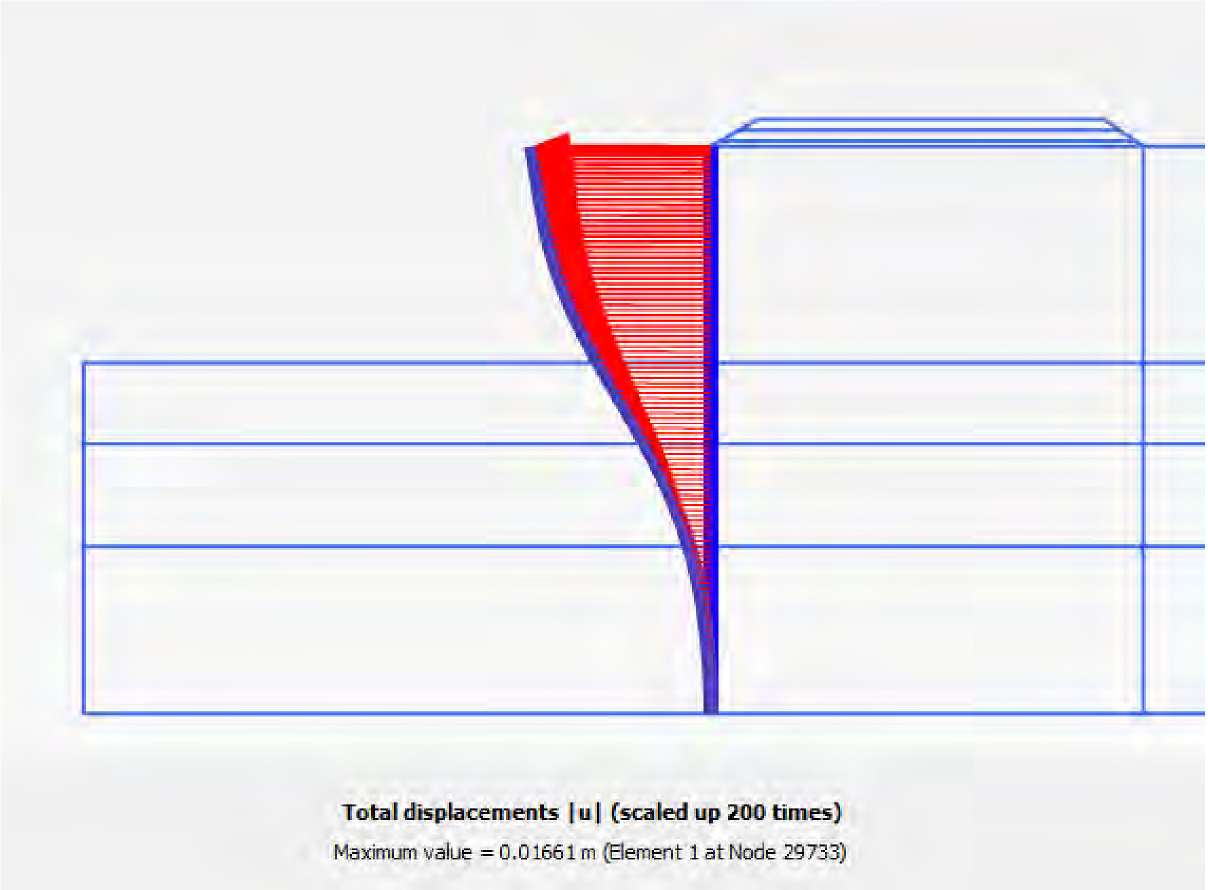

Figure 4-4: Output from Plaxis Model showing Max. Displacement of Sheet pile wall

5. CONCLUSION

The construction methods on peat require a combination of stabilization techniques to address the inherent weaknesses of peat. Common approaches include geosynthetic reinforcement, lightweight fill materials, and stabilised/reinforced walls. The choice of technique depends on factors such as the thickness of the peat layer, environmental constraints, load requirements, and long-term performance objectives.

Different techniques have been assessed, and the outcomes are presented in Table 3-1. A double sheet pile wall with reinforced ties is proposed as the preferred technical approach to floated road construction on the subject section of on-site access track given local ground conditions and environmental considerations.

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