LOWER CHURCHILL PROJECT

TECHNICAL REPORT

MF1310 – MUSKRAT FALLS SITE ACCESS REVIEW

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EXECUTIVE SUMMARY

Previously, a study was conducted which considered two different options for access to the Muskrat Falls site. One option was access from the north side of the dam via permanent access roads already constructed. The second option was from Happy Valley-Goose Bay (HVGB) via the Blackrock (T&W) Bridge and a temporary access road constructed on the south side of the river. It was concluded that a new dock in HVGB would be required to offload a 250 tonne power transformer and the T&W bridge would require extensive upgrading to permit the transport of a 250 tonne transformer across the bridge. NE-LCP has since decided access to the Muskrat Falls Project Site shall be via a new permanent access road from the TLH along the south side of the Churchill River to the project site.

With the completion of the TLH between HVGB and Cartwright, another option to transport heavy loads to the Muskrat Falls dam site is now available. This option includes utilizing the dock in Cartwright and transporting heavy loads via the TLH and the new permanent access road. The transport of a 250 tonne transformer was modelled as it is assumed to be the heaviest load which will need to be transported.

With respect to the dock at Cartwright, it was concluded that the transformer can be offloaded but it will be necessary to provide a temporary ramp when offloading the transformer. It was also noted that a general condition assessment should be performed on the ferry terminal, prior to offloading, to evaluate the condition of all fenders, mooring bollards and sheet piles present at the docking facility. Any deficiencies should be repaired and assumptions used in the analysis should be confirmed. It was also noted that any vessel used during offloading of the transformers, or any other material, should be of sufficient length to engage the waterside mooring dolphin. If not, then alternate mooring arrangements will be required. The dock at Cartwright is owned by the Department of Transportation and Works (T&W) and they will do their own assessment before giving permission to offload the transformer.

The TLH between Cartwright and the proposed access to Muskrat Falls has eight (8) bridges. Starting at Cartwright and proceeding west, the bridges are located on Dykes River, Southwest Brook, Beaver Brook, Paradise River, Otter Brook, Kenamu River, Traverspine Tributary and Traverspine River. The Paradise River and Kenamu River bridges are both constructed of steel while the rest are constructed

from concrete. The analysis revealed that the concrete bridges have sufficient strength to allow the passage of the truck and transformer.

Mabey Johnson who designed and supplied the steel truss bridge at Paradise River was engaged to analyse the transport of the transformer across the bridge. They concluded that the bridge at Paradise River is not capable of supporting the required load. The bridge is only capable of supporting a maximum of 190 tonnes of cargo for the assumed trailer weight of 48 tonnes. This means the trailer would have to be winched by cable across the bridge rather than being pulled by the tractor, which would add an additional 28 tonnes. Initially, Mabey Johnson stated that the bridge could not be strengthened because of the unique design of the steel panels. Subsequently, they said they would be willing to look at using temporary supports but with no guarantee that it is possible to do so.

The steel truss bridge on Kenamu River was designed, supplied and installed by Structal, a division of the Canam Manac Group. Structal used Roche Engineering to design the bridge. Roche was also engaged to do the current analysis of the Kenamu River Bridge. They concluded that the Kenamu River Bridge is not capable of supporting the transformer load, and is only capable of supporting a maximum load of 130 tonnes of cargo for the assumed transporter weight of 48 tonnes. It may be possible to reinforce the structure to support larger loads but this would require further analysis. The bridges are owned by T&W and they will no doubt do their own assessment before giving permission to transport the transformer.

The recommended access road route is Route 2A, as shown in drawing number 723469-MF1310-41DD-0002 in Appendix D, at a cost of $ due to lower user costs, proximity to granular deposits for road building materials, till for the cofferdams and a safer intersection with the TLH. A second option would be Route 2 since it has the lowest capital cost of $. One advantage of choosing Route 2, even though it is the option with the longest length, is that 4 km of forest access road have already been constructed allowing for quicker site access.

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1 INTRODUCTION

1.1 TERMS OF REFERENCE

The content of this report has been prepared in accordance with the scope of work outlined in the Nalcor Energy Lower Churchill Project (NE-LCP) Work Task Order (WTO) MF1310 for the Lower Churchill Project at Muskrat Falls dated June 24, 2010.

In brief, the work includes the following:

- A review of the docking facilities in Cartwright to determine if they can accommodate the transport of a 250 tonne heavy load;
- A review of the Trans Labrador Highway (TLH) from Cartwright to the proposed Muskrat Falls access road to determine if highway bridges and culverts can accommodate the transport of a 250 tonne heavy load; and
- A review of routing for the permanent Muskrat Falls access road from the TLH to the Muskrat Falls project site.

1.2 PREVIOUS STUDIES

This report is similar to a study completed in February 2008, MF1090 – Review of Access Roads and Transportation & Works (T&W) Bridges. The study considered two different options for access to the Muskrat Falls site. One option was access from the north side of the dam via permanent access roads already constructed. The second option was from Happy Valley-Goose Bay (HVGB) via the Blackrock (T&W) Bridge and a temporary access road constructed on the south side of the river. It was concluded that a new dock in HVGB would be required to offload a 250 tonne power transformer and the T&W bridge would require extensive upgrading to permit the transport of a 250 tonne transformer across the bridge.

1.3 CONTENT OF REPORT

NE-LCP has decided access to the Muskrat Falls project site shall be via a permanent access road from the TLH along the south side of the river to the project site. With the completion of the TLH between HVGB and Cartwright, another option to transport heavy loads to the Muskrat Falls dam site is now available. This option includes utilizing the dock in Cartwright and transporting heavy loads via the TLH and the new permanent access road to be constructed along the south side of the Churchill River to the project site.

As per the scope of work, this report includes the following:

- A review of existing docking facilities in Cartwright and, in particular, the Cartwright Ferry Wharf;
- Check the existing sheet pile wall for bending and stability when subjected to the provided axle loads for the Cartwright ferry wharf;
- Check existing anchor rod capacity of the ferry wharf;
- Verify that sheet pile embedment is adequate at the ferry wharf;
- Recommend solutions for any problems associated with the existing ferry wharf with respect to its capacity to handle the design loads;
- A review of highway bridges and culverts on the TLH between Cartwright and the proposed Muskrat Falls access road;
- A cost comparison of various route options for the Muskrat Falls permanent access road;
- Recommendations on which route alternative is deemed most acceptable along with positive and negative attributes of this choice; and
- Drawings to illustrate access road layouts and drainage areas.

1.4 DEFINITIONS & ACRONYMS

DL	Dead Load
Dle	Dead Load of Equipment
EL	Seismic Load
F.S.	Factor of Safety
GD	Granular Deposit
HVGB	Happy Valley-Goose Bay
K_{ah}	Coefficient of Active Soil Pressure
kg/m^2	Kilograms Per Metres Square
km	Kilometres

kN	Kilonewtons
kN-m	Kilonewton Metre
kN/m	Kilonewtons Per Metre
kN/m^2	Kilonewton Per Metres Square
kN/m^3	Kilonewton Per Metres Cube
K_{ph}	Coefficient of Passive Soil Pressure
LL	Live Load
m	Metres
mm	Millimetres
MPa	Megapascals
NE-LCP	Nalcor Energy-Lower Churchill Project
psf	Pounds Per Square Foot
RLU60	Rural Local Undivided 60 Kilometres Per Hour
RoRo	Roll on / Roll off
ROW	Right-of-Way
T&W	Transportation & Works
TD	Till Deposit
TLH	Trans Labrador Highway
WL	Wind Load
WTO	Work Task Order

2 CARTWRIGHT DOCKING FACILITIES

2.1 INTRODUCTION

This section outlines the methodology, assumptions and results obtained for the analysis of the Cartwright Ferry Wharf and its capacity to offload heavy transformers for the Muskrat Falls Development.

2.1.1 Facility Description

The Cartwright Ferry Wharf is a Roll on / Roll off (RoRo) type wharf. It was originally designed to load and offload vehicular traffic from ferry vessels. Typical traffic included both automobiles and large multi-axle freight trucks.

The wharf structure is comprised of a steel sheet pile bulkhead with concrete cap. A 150 mm thick reinforced concrete slab covers a majority of the wharf's surface. The water depth at the face of the wharf is approximately 5.5 m. A portion of the wharf ramps down to allow loading and unloading of vehicles from ferry vessels. Rubber fender elements are located around the wharf to aid in vessel berthing. For design drawings of the wharf, see Appendix A. The following photos show the existing ferry wharf.

Photo 2-1 - Cartwright Facility with Wharf and Dolphin Structure

Photo 2-2 - Cartwright Ferry Wharf

Photo 2-3 - Ferry Ramp with Fender Elements (Looking East)

Photo 2-4 - Ferry Ramp with Fender Elements (Looking West)

A breasting/mooring dolphin structure is located approximately 100 m from the wharf. This is a steel sheet pile cellular structure. The purpose of the dolphin is to help prevent lateral movement of a docked vessel. The photo below shows the dolphin structure.

Photo 2-5 - Breasting/Mooring Structure

2.1.2 References

Structural analysis and design will be based on the applicable parts of the latest revision of the following code:

CAN/CSA 16.1	Limit States Design of Steel Structures

The following drawings (included in the analysis package) were used for reference during the analysis:

DWG No.	Drawing Title
SR3	Ferry Ramp Borehole Location Plan and Borehole Log
SR6	Ferry Ramp Plan Sheet Pile Bulkhead

DWG No.	Drawing Title
SR7	Ferry Ramp Sections
0010027949-000-D-B02-1/1-01	Preliminary Transportation Concept for a 250 Tonne Transformer [sic] 12 Line Conventional Trailer

The following miscellaneous reference material (included in the analysis package) was used:

Reference Title	Reference Type
Z Profile Product Information	Sheet pile section technical specifications.
Geotechnical Design Criteria	Geotechnical parameters taken from a previous project in Labrador.
Typical Soil Properties	From an online source which outlines typical soil properties.

2.1.3 Units

All units are in accordance with the International System of Units (SI units).

2.2 ANALYSIS METHOD

ArcelorMittal software ProSheet 2.2 was used to analyze the existing sheet pile bulkhead wall. Soil parameters used in ProSheet were based on similar soils from another project in Labrador. All sheet pile sizes, anchor sizes, steel grades and wall design elevations were obtained from the design drawings noted in Section 2.1.2.

ProSheet was written for design and not analysis of sheet pile walls. However, by using the design results, a comparison can be made with the existing wall. This is achieved by selecting the sheet pile section used in the existing wall as the design section used in ProSheet.

Once an analysis is completed in ProSheet, it provides a factor of safety for bending based on the properties for the selected sheet pile section. If the factor of safety for bending is less than acceptable, the selected sheet pile section is inadequate for the analyzed load.

The embedment of the existing sheet pile is compared to the required embedment given by ProSheet based on the sheet pile section selected. A standard practice when using ProSheet is to add a minimum of 25 to 30 percent of the design embedment as a factor of safety. If the existing sheet pile wall is embedded the required amount shown in ProSheet, plus 30 percent, the embedment for the existing sheet pile would be acceptable.

Anchor rod forces obtained from ProSheet were used to determine structural adequacy of the existing anchor rods.

2.2.1 Analysis Data

Based on a Mammoet trailer configuration, the following design parameters were established:

- Ground bearing pressure = 5515.5 kg/m^2 = 54.1 kN/m^2 (1130 psf)
- Trailer Length = 18 m
- Trailer Width = 3 m

The following table, Table 2-1, illustrates soil parameters which were assumed for the sheet pile wall design:

Table 2-1 - Soil Parameters

Soil Type	Elevation (m)	Density Moist (kN/m^3)	Density Saturated (kN/m^3)	K_{ph}	K_{ah}	Phi (deg)	Cohesion (kN/m^2)
Dark Clayey Silt	+2.49 to -2.0	10	20	-	0.227	40	0
Sandy Silt	-2.0 to -5.45	17	27	-	0.799	9	20
Sand & Gravel	-5.45 to -11.13	10	20	-	0.398	27	0
Sand & Gravel	-11.13 to -40	10	20	3.056	0.323	32	0
Note the above K_{ph} and K_{ah} factors were automatically generated by ProSheet based on the other properties of the soil.							

The sheet pile section used for the analysis is an AZ26. This is equivalent to the Arbed BZ 26M 26-9 section specified in the design drawings. In ProSheet, 270 MPa and 320 MPa grades of sheet pile are available, but not the existing sheet pile grade of 300 MPa. Therefore, the wall was checked using the higher grade steel. The moments obtained from the analysis were compared to the calculated moment capacity of the sheet pile section. Hand calculations were completed to determine the moment capacity with 300 MPa yield strength steel using the following formula:

$$Moment\ Capacity\ (M_n) = \varphi S F_y$$

A factor of safety was calculated as follows:

$$Factor\ of\ Safety = \frac{Moment\ Capacity}{Applied\ Moment}$$

Factors of safety were also calculated for anchor rod capacities. This factor of safety (based on allowable stress) was:

$$Factor\ of\ Safety = \frac{Anchor\ Rod\ Capacity}{Applied\ Anchor\ Rod\ Force}$$

Factors of safety for both bending and anchor rod capacity should be greater than 1.5. However, they may be lowered depending on the type and duration of loading.

2.3 STRUCTURAL DESIGN REQUIREMENTS

2.3.1 Design Loads

2.3.1.1 Dead Loads (DL)

Dead loads include the weight of all fixed structural elements, and all permanent equipment loads (Dle).

2.3.1.2 Live Loads (LL)

Live loads include truck wheel loads, and personnel. Since truck loads far exceed loads produced by personnel, only truck loads are included as the live load in this analysis. The live load used for analysis was 54 kN/m^2.

2.3.1.3 Equipment Loads

No stationary equipment loads have been accounted for in this analysis.

2.3.1.4 Vertical Impact, Side Thrust, Traction and Vibration Loads

No dynamic analysis was performed. No impact factors have been used in this analysis. This was assumed since load transfer from the vessel will be at a very slow rate and load shifting will not occur.

2.3.1.5 Wind Loads (WL)

It is not expected that materials will be transported onto the dock during high winds. Thus, wind loads will be minimal and were not accounted for.

2.3.1.6 Seismic Loads (EL)

Seismic loads are not applicable in this analysis.

2.3.2 Loading Combinations

For steel structures, load combinations were in accordance with Canadian Standards.

2.3.3 Stability

Stability of structures was checked for all load conditions in accordance with NBCC or S6. A minimum factor of safety of 1.5 was used for stability checks.

2.3.4 Deflections

Deflection limitations were not accounted for in this analysis. Since it is a one time load application over a short duration, bending stresses were used to determine adequacy of the existing structure. However, in the analysis, if bending stresses did fall within acceptable limits but deflections were beyond what was felt to be adequate, the structure was deemed inadequate.

2.3.5 Corrosion

Effects of corrosion were considered. To account for corrosion in the analysis, a sheet pile section with a decrease in web and flange thickness of 1 mm was used. Typical corrosion rates in the splash zone are approximately 0.1 mm per year. However, maximum bending occurs below the splash zone where approximately 0.05 mm of corrosion occurs per year. Given the 26 year age of the bulkhead wall, the expected corrosion at the point of maximum bending is:

$$Corrosion = 0.05 \times 26 = 1.3mm$$

Thicknesses of the existing sheet pile sections should be checked to confirm corrosion rates.

2.4 MATERIALS

2.4.1 Structural Steel

Existing sheet pile sections are AZ26 with yield strength of 300 MPa. Existing anchor rods have a diameter of 75 mm with an upset diameter of 95 mm. Existing rod steel grade is 300WT.

2.5 ANALYSIS RESULTS

Table 2-2 summarizes the results of the analysis of sheet pile sections. Factors of Safety were determined for various sections, based on calculated versus allowable bending moments.

Table 2-2 - Safety Factors

Load Case	Sheet Section	Mr (kN-m)	Mu (kN-m)	F.S.
Load directly behind wall	AZ26	702.0	768.0	0.91
Load 6.5 m from face of dock	AZ26	702.0	492.4	1.43
Load 6.5 m from face of dock	AZ25*	675.0	492.4	1.37

* AZ25 sheet accounts for 1 mm of corrosion on web and flange of AZ26 sheet.

The applicable case above, to allow for offloading of the transformer, provides a factor of safety of 1.37. This is below the engineering standard of 1.5 for live loads. Typically, a live load factor of 1.5 is used due to potential variances and uncertainties in the loading. However, for this case, the load is very well defined, the potential for variances is minimal, and it is applied for a short duration. As well, the loading event occurs only five times during the life of the project, with significant time between each event. Therefore, it may be acceptable to use a lower factor of safety. Note the factor of safety above takes into account 1 mm of corrosion to the sheet pile. Sheet pile thicknesses should be verified to confirm assumed corrosion rates.

Sheet pile embedment into the sea floor was checked. Table 2-3 summarizes the results of the analysis for each load case. The required tip elevation was determined and compared to the existing tip elevation.

Table 2-3 - Embedment Requirements

Load Case	Sheet Section	Required Tip Elevation (m)*	Existing Tip Elevation (m)
Load directly behind wall	AZ26	-17.28	-18.00
Load 6.5 m from face of dock	AZ26	-16.46	-18.00
Load 6.5 m from face of dock	AZ25	-16.46	-18.00

* Required embedment includes ProSheet recommended embedment plus 30 percent of design embedment.

As shown in the above table, the existing tip elevation is deeper than the required tip elevation. The sheet pile wall is acceptable with respect to sheet pile embedment.

Anchor rod capacities were checked and are summarized in Table 2-4. Factors of Safety were determined for each load case, based on calculated anchor rod capacity versus allowable anchor force.

Table 2-4 - Anchor Rods

Load Case	Avg. Rod Spacing (m)	Anchor Force per M (kN/m)	Total Anchor Force (kN)	Rod Capacity (kN)	F.S.
Load directly behind wall	2.5	227.5	568.8	1192	2.10
Load 6.5 m from face of dock (AZ26)	2.5	131.7	329.3	1192	3.62
Load 6.5 m from face of dock (AZ25)	2.5	134.3	335.8	1192	3.55

Given an average rod spacing of 2.5 m, the factored load in the tie rod is less than the tie rod capacity. Factors of safety are well above 1.5. Therefore, existing anchor rod capacities are acceptable.

2.6 RECOMMENDATIONS

It will be necessary to provide a ramp when offloading the transformer at the Cartwright Ferry Terminal. This ramp should extend a minimum of 6.5 m inside the face of the dock. It should be noted that the ramp must not apply pressure on the surface of the dock between the face of the dock and the 6.5 m offset. The ramp shall be designed to handle all applicable loads. This ramp will be of a temporary nature and should only be used for the offloading of the transformer.

A general condition assessment should be performed to evaluate the current condition of all fenders and mooring bollards present at the docking facility. Any fenders that show excessive wear and tear, or are missing, should be replaced.

Sheet pile thicknesses should also be checked to confirm corrosion rates assumed in this analysis.

Any vessel used during offloading of the transformers, or any other material, should be of sufficient length to engage the waterside mooring dolphin situated approximately 100 m from the face of the dock. This dolphin must be used to stabilize the vessel and prevent movement while docked. If the unloading vessel is less than the prescribed 100 m, an alternate mooring arrangement will be required. The condition of the fenders and bollard at this dolphin should also be assessed and replaced if damaged or missing.

It should also be noted that the Provincial Government has recently announced that the ferry service into Cartwright is being terminated. If this is so, long term maintenance of the ferry terminal, and in particular to RoRo aspect of the dock, may become an issue. NE-LCP should liaison directly with the Department of Transportation and Works to discuss long term plans for maintenance of the dock.

3 CARTWRIGHT TO MUSKRAT FALLS ACCESS ROAD VIA TRANS LABRADOR HIGHWAY

3.1 GENERAL

The TLH between Cartwright and the proposed access to Muskrat Falls has eight (8) bridges. Starting at Cartwright and proceeding west, the bridges are located on Dykes River, Southwest Brook, Beaver Brook, Paradise River, Otter Brook, Kenamu River, Traverspine Tributary and Traverspine River.

At the time the Trans-Labrador Highway (TLH) was constructed between Happy Valley-Goose Bay and Cartwright, it was envisaged that access for heavy loads would be from the north side of Churchill River at the project site. As such, the bridges on this section of the TLH were not designed to accommodate the transport of heavy loads and equipment, such as transformers, to the future Muskrat Falls Hydroelectric Project. Therefore, it was necessary to evaluate the bridges for this exceptional purpose.

The bridge across Paradise River is an 81 m span, two-lane steel truss bridge. The bridge is an open truss panel bridge which was designed, supplied and installed for the Department of Transportation and Works (T&W), Government of Newfoundland and Labrador, by Mabey Johnson. Pictures of the bridge are shown in Photos 3-1 and 3-2. The bridge is one of Mabey Johnson’s standard steel panel bridges which they refer to as a Delta Bridge.

Photo 3-1 – Paradise River Bridge

Photo 3-2 - Paradise River Bridge

The bridge across Kenamu River is also an 81 m span, two-lane steel truss bridge. The bridge is not a panel design like the Paradise River Bridge, but a purpose designed, open truss steel bridge. The bridge was supplied and installed for T&W by Structal from Quebec City. The bridge was designed for Structal by Roche Engineering. Pictures of the bridge are shown in Photos 3-3 and 3-4.

Photo 3-3: Kenamu River Bridge

Photo 3-4: Kenamu River Bridge

The remaining six bridges are of similar design, each consisting of single span steel girders with a concrete deck.

3.2 ASSESSMENT OF CONCRETE BRIDGES

A structural review was undertaken to determine if the six girder bridges across Dykes River, Southwest Brook, Beaver Brook, Otter Brook, Traverspine River and Traverspine Tributary are capable of accommodating the passage of a 250 tonne transformer.

For the purpose of this evaluation it was assumed that the transport vehicle would be similar to that shown in Appendix A, 'Preliminary Transportation Concept for a 250 Tonne Transformer, 12 Line Conventional Trailer', as provided by Mammoet. The vehicle evenly distributes the cargo weight to all wheels such that there would not be any excessive large axle loads on the concrete deck of the bridge. The trailer is assumed to have 12 axles, each with eight (8) wheels, supporting approximately 25 tonnes each. The total weight of the pull tractor and cargo is assumed to be 326 tonnes.

Table 3-1 outlines the general characteristics of the six (6) bridges under review.

Table 3-1: Highway Bridges

Bridge Name	Dykes River	Southwest Brook	Beaver Brook	Otter Brook	Traverspine Tributary	Traverspine River
Year Built	2001	2001	2002	2008	2009	2008
Design Standard	CS 600-88	CS 600-88	CS 600-88	CL 625-06	CL 625-06	CL 625-06
Bridge Type	Concrete Deck, Steel Girder	Concrete Deck, Steel Girder	Concrete Deck, Steel Girder	Concrete Deck, Steel Girder	Concrete Deck, Steel Girder	Concrete Deck, Steel Girder
No. Spans	1	1	1	1	1	1
Span Length	21 m	21 m	20 m	25 m	25 m	20 m
No. Girders	6	6	6	6	5	5
Girder Spacing	2.06 m	2.06 m	2.06 m	2.06 m	2.39 m	2.371 m

The bridges were evaluated for the transport of the heavy loads in accordance with Section 14 of the Canadian Highway Bridge Design Code, CSA S6-06. This section provides the methodology to determine the factored capacity of existing bridges, and the factored load effects for permit vehicles. The evaluation results in a live load capacity factor, which is a ratio comparing the available live load capacity of the structure to the applied live load. If the ratio is greater than 1 then the bridge is considered acceptable for the passage of the permit vehicle and the associated load.

Section 14 provides for the use of refined methods in determining the load effects on the bridge. One such refined method, utilized during this evaluation, is the software program called SECAN4 to determine the lateral distribution of the vehicle load to each girder across the bridge, i.e., to determine the amount of the load that is carried by each of the girders. The software program is based on the semi-continuum method. For this evaluation, it is assumed that the permit vehicle will travel along the centerline of the bridge, which results in the best distribution of the load among the girders. The evaluation also assumes that no other vehicles will be on the bridge during the crossing, and that the vehicle speed will be reduced to less than 25 km/h.

For all six bridges identified above, the live load capacity factor is greater than 1, indicating that the bridges are adequate for the passage of the heavy load assuming the transport vehicle identified is utilized. If a different transport vehicle is used, then that vehicle will have to be evaluated.

Table 3-2 outlines the results of the evaluation of the permit vehicle under Section 14 of S6-06.

Table 3-2: Load Factors

Bridge Name	Dykes River	Southwest Brook	Beaver Brook	Otter Brook	Traverspine Tributary	Traverspine River
Factored Moment Resistance (kN*m)	4164	4164	4164	6475	6579	3880
Factored Dead Load Moment (kN*m)	766	766	695	1125	1273	775
Factored Live Load Moment (kN*m)	2186	2186	2065	2986	3489	2435
Live Load Moment Capacity Factor	1.55	1.55	1.68	1.79	1.52	1.27
Factored Shear Resistance (kN)	1567	1567	1567	2346	2346	2252
Factored Dead Load Shear (kN)	146	146	139	180	204	155
Factored Live Load Shear (kN)	610	610	600	699	888	768
Live Load Shear Capacity Factor	2.33	2.33	2.38	3.1	2.41	2.73

Checks performed on the transverse deck moments, crack widths and shear strength indicate that there is ample capacity in the deck for this transporter arrangement. No analysis of the foundations was performed. It should be noted that T&W would perform their own in-depth evaluation prior to final acceptance and issuance of the required permits.

3.3 ASSESSMENT OF PARADISE RIVER BRIDGE

The Department of Transportation and Works contracted Johnsons Construction from Pasadena, NL to design, supply and install a bridge across the Paradise River. Johnson's engaged Mabey Johnson to design, supply and provide the supervision for the installation of the bridge. The bridge is an 81 m, single span, steel truss panel bridge which Mabey Johnson refer to as their Delta Bridge. Mabey Johnson was contacted by SNC-Lavalin and they agreed to evaluate the bridge for the passage of a transport vehicle carrying a 250 tonne transformer.

For the purpose of this evaluation, it was assumed that the transport vehicle would be the same as described in Section 3.2 of this report and shown in Appendix A, "Preliminary Transportation Concept for a 250 Tonne Transformer, 12 Line Conventional Trailer", as provided by Mammoet.

Mabey Johnson did not provide a formal report of their analysis, however, the necessary information was provided in a series of emails (attached as Appendix B). In essence, Mabey Johnson concluded that the bridge is not capable of supporting the assumed loads.

As part of their evaluation, Mabey Johnson also examined the maximum permissible cargo weight that may be transported across the bridge, assuming the same transport vehicle. This calculation revealed that the bridge is capable of supporting only 190 tonnes of cargo for the assumed trailer weight of 48 tonnes. This assumes the trailer would be winched by cable across the bridge rather than being pulled by the tractor, which would add an additional 28 tonnes.

The initial indication from Mabey Johnson was that the bridge could not be strengthened to permit passage of the heavy load. In subsequent correspondence, they indicated they would be willing to look at using temporary supports beneath the bridge. This would take a considerable effort to investigate and should be a topic of further discussion if NE-LCP wishes to pursue the use of this bridge.

3.4 ASSESSMENT OF KENAMU RIVER BRIDGE

The Department of T&W contracted Structal, a division of the Canam Manac Group, to design and construct a bridge across the Kenamu River. The bridge is an 81 m, single span steel truss. Roche Ltd Consulting Group, an engineering firm in Quebec City, designed the bridge and was contracted by SNC-Lavalin to evaluate the bridge for the passage of a transport vehicle carrying a 250 tonne transformer.

For the purpose of this evaluation, it was assumed that the transport vehicle would be the same as described in Section 3.2 of this report and shown in Appendix A, “Preliminary Transportation Concept for a 250-tonne Transformer, 12 Line Conventional Trailer” as provided by Mammoet.

Roche has prepared a report, entitled “Passage of a Trailer Truck Carrying a 250 MT transformer on the Kenamu River Bridge near Goose Bay”, which outlines the results of their evaluation (attached as Appendix C). In essence, Roche concluded that the bridge is not capable of supporting the assumed loads, with the major weak link of the bridge structure being the main trusses. In addition, Roche concluded the transfer beams and stability frames would also require reinforcement.

As part of their evaluation, Roche also examined the maximum permissible cargo weight that may be transported across the bridge, assuming the same transport vehicle. This calculation revealed that the bridge is capable of supporting only 130 tonnes of cargo for the assumed transporter weight of 48 tonnes. Roche also noted that it may be possible to reinforce the structure to support larger loads; however, this would require further analysis.

Upgrading the bridge to meet the load requirement should be a topic of further discussion if NE-LCP wishes to still pursue the use of this bridge.

4 MUSKRAT FALLS ACCESS ROAD

4.1 INTRODUCTION

In this section, four different route options from the TLH to the Muskrat Falls project site were evaluated (Routes 1, 1A, 2 and 2A). These routes can be viewed on drawing 723469-MF1310-41DD-0001 found in Appendix D.

A site visit was conducted on August 17, 2010. The purpose of this visit was to view the various access road options as well as a newly constructed forest access road. This forest access road marks the beginning of one of the route options (Route 2).

It is suggested that the Muskrat Falls access road be constructed to the permanent access road standard (RLU60) suggested in the MF1090 report dated February 2008 (Reference 1). The road would have a 9.5 m wide top and 2:1 side slopes as per the typical section shown in Figure 4-1. Construction of this new road will include the following:

- Clearing and grubbing of road right-of-way (ROW);
- Environmental protection, including placement of silt traps;
- Cut and fill as required;
- Borrowing of fill material, common and rock;
- Supply and placement of 200 mm of road maintenance grade crushed material;
- Supply and placement of culverts and ditching as required;
- Construction of a bridge on the McKenzie River; and
- Supply and placement of guiderail as required.

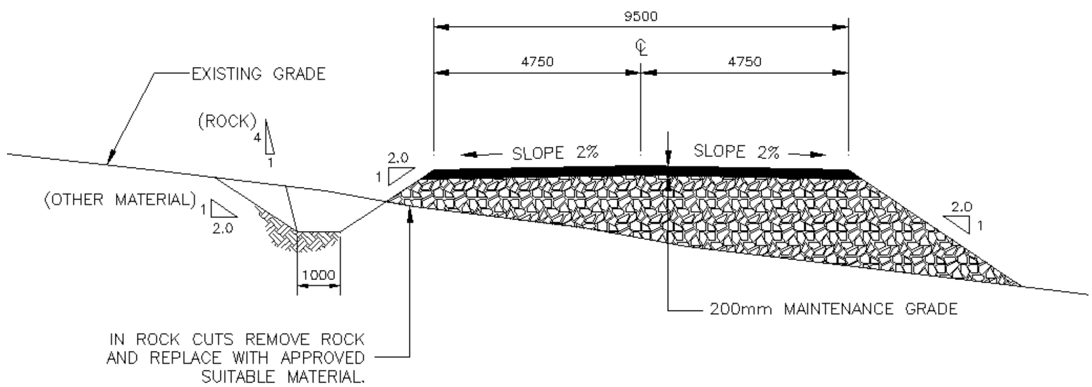


Figure 4-1 - Typical Section for New Permanent Road (Reference 1)

4.2 ROUTE OPTION COMPARITIVE COST ESTIMATES

Quantities for each of the routes were governed mainly by the length of the road as well as the surrounding terrain including drainage areas. It should be noted that the estimates presented in this report are for comparison purposes only. Detailed engineering shall be carried out to produce a more accurate estimate of the cost before issuing tenders for construction. It should also be noted that maintenance costs were not included in the estimates for the routes.

The culvert and new bridge requirements for these access roads were determined by assessing the existing drainage areas. Please refer to Appendix D for drawing 723469-MF1310-41DD-0003 illustrating the drainage areas for the recommended route, Route 2A. From these calculations, it was determined that one short span bridge, approximately 20 m, would be required at the McKenzie River for each of the routes. In the 2008 report, MF1090 (Reference 1), it was envisaged that a large arch style culvert would be suitable for the Caroline Brook crossing on the recommended route. Based on this year's site visit, and considering the road will be a permanent facility, a bridge would be more appropriate for Caroline Brook on Route 1. A bridge is not required for any of the other routes at Caroline Brook because the routes are designed such that the drainage area feeding into the brook is split into two smaller areas for which culverts will be sufficient.

Three large arch style culverts are required for Route 1. For Route 1A, five large arch style culverts are required. Route 2 and Route 2A both require four large arch style culverts. These culverts range in size from 3,730 X 2,290 mm to 7,620 X 4,240 mm.

Cost estimates were determined for each of the routes and are summarized in the following table:

Table 4-1: Summary of Cost Estimates for Route Options

Section Description	Route 1 (19.1 km)	Route 1A (21.8 km)	Route 2 (22.0 km)	Route 2A (21.4 km)
ENVIRONMENTAL REQUIREMENTS				
Silt Fence				
CLEARING & GRUBBING				
Clearing				
Grubbing				
ROADWAY EXCAVATION, EMBANKMENT &				
Mass Excavation & Backfill				
Rock				
Common				
SELECTED GRANULAR BASE & SUB-BASE				
Road Maintenance Grade				
SUPPLY & INSTALLATION OF GUIDE RAIL				
Standard Type Guide Rail				
PIPE CULVERTS				
Supply & Placement of Pipe Culvert				
7620 X 4240 mm CMP 3.5 mm				
6250 X 3910 mm CMP 3.5 mm				
4370 X 2870 mm CMP 3.5 mm				
3730 X 2290 mm CMP 3.5 mm				
2400 mm CMP 2.8 mm				
2000 mm CMP 2.8 mm				
1800 mm CMP 2.8 mm				
1600 mm CMP 2.8 mm				
600 mm CMP 2.0 mm				
BRIDGES[1]				
McKenzie River				
Caroline Brook				
Existing Forest Access Road[2]				
Grand Total				

As can be seen from the above table, the most costly route is Route 1A followed by Route 1. The least costly alternative is Route 2 followed by Route 2A. However, in relative terms there is very little difference in the cost of the various options. More detailed estimates for each of the options can be found in Appendix E.

[1] Estimate is for steel panel or steel girders on treated timber abutments and wooden deck designed to accommodate the transport of a 250 tonne transformer load. A bridge with concrete abutments, steel girders and concrete deck is estimated to cost $

[2] Estimated salvage value of forest access road is $ km.

4.3 RECOMMENDATIONS

Based on the cost summary in the previous section as well as a number of other factors which will be discussed in this section, the recommended choice is Route 2A at a cost of . See drawing number 723469-MF1310-41DD-0002 in Appendix D. A second option would be Route 2 since it has the lowest capital cost of There are advantages and disadvantages to choosing either of these options.

The primary reason for choosing Route 2A over Route 2 is due to user costs. Even though Route 2 has the lowest capital cost, traffic out of HVGB will have to travel an extra 7 km each way to get to the project site at Muskrat Falls. The majority of the construction traffic is expected to come from HVGB and the extra user cost may prove significant over the life of the project.

One advantage of choosing Route 2 even though it is the option with the longest length is that 4 km of forest access road have already been constructed. This forest access road will need to be upgraded to the permanent standard but the remainder of the road from the end of the forest access road to the Muskrat Falls site can be constructed first with upgrades being made later, allowing earlier access to the site. Upgrading existing road also contributes to cost savings rather than building new roads. If more forest access road is constructed before the Muskrat Falls access road begins, it will lead to even more significant cost savings, further lowering the capital cost, however, the long term user costs should be considered before choosing this route.

There are a number of arguments why the route from the 2008 report (Reference 1), Route 1 in this report, has not been chosen. One is the requirement for a bridge at Caroline Brook.

Another reason for choosing Route 2A or 2 over Route 1 is that the 2010 site investigations have revealed that there are granular materials along Route 2A and 2. TD-5 shown on drawing 723469-MF1310-41DD-0002 is a good granular deposit. Depending on the final borrow quantity, the amount of common material may increase and the amount of rock may decrease from those used for comparative cost purposes. This would result in a lower cost for the road than indicated in the comparative cost summary. Also, the site visit revealed there are granular materials available along the forest access road.

The 2010 site investigation has determined that till for the coffer dam will come from borrow areas TD-4, TD-6 and TD-7 also indicated on drawing 723469-MF1310-41DD-0002. Route 2 or 2A will provide less costly access to these deposits. Also, GD-8 is a good granular deposit and, if it proves necessary to access this deposit, Route 2 or 2A will again provide the less costly access.

Materials along Route 1 are anticipated to be sandier. While sand is acceptable as a road building material, it requires the use of more rock to stabilize the sand.

Finally, the intersection of Route 1 with the TLH is not ideal. Due to the fact that it is located on the outside edge of a sharp curve in the highway, the sight distance for traffic turning onto the TLH from the access road, or traffic making left turns onto the access road coming from Cartwright, is limited. The sight distance available is acceptable as long as the TLH remains a gravel road. However, now that the Muskrat Falls access road shall be permanent, and the fact the TLH will be paved someday, traffic speeds will increase, making the intersection less safe. Sight distances for Routes 2A and 2 are much more favourable.

REFERENCES

1. *MF1090 – Review of Access Roads and T&W Bridges*, SNC-Lavalin, February 2008

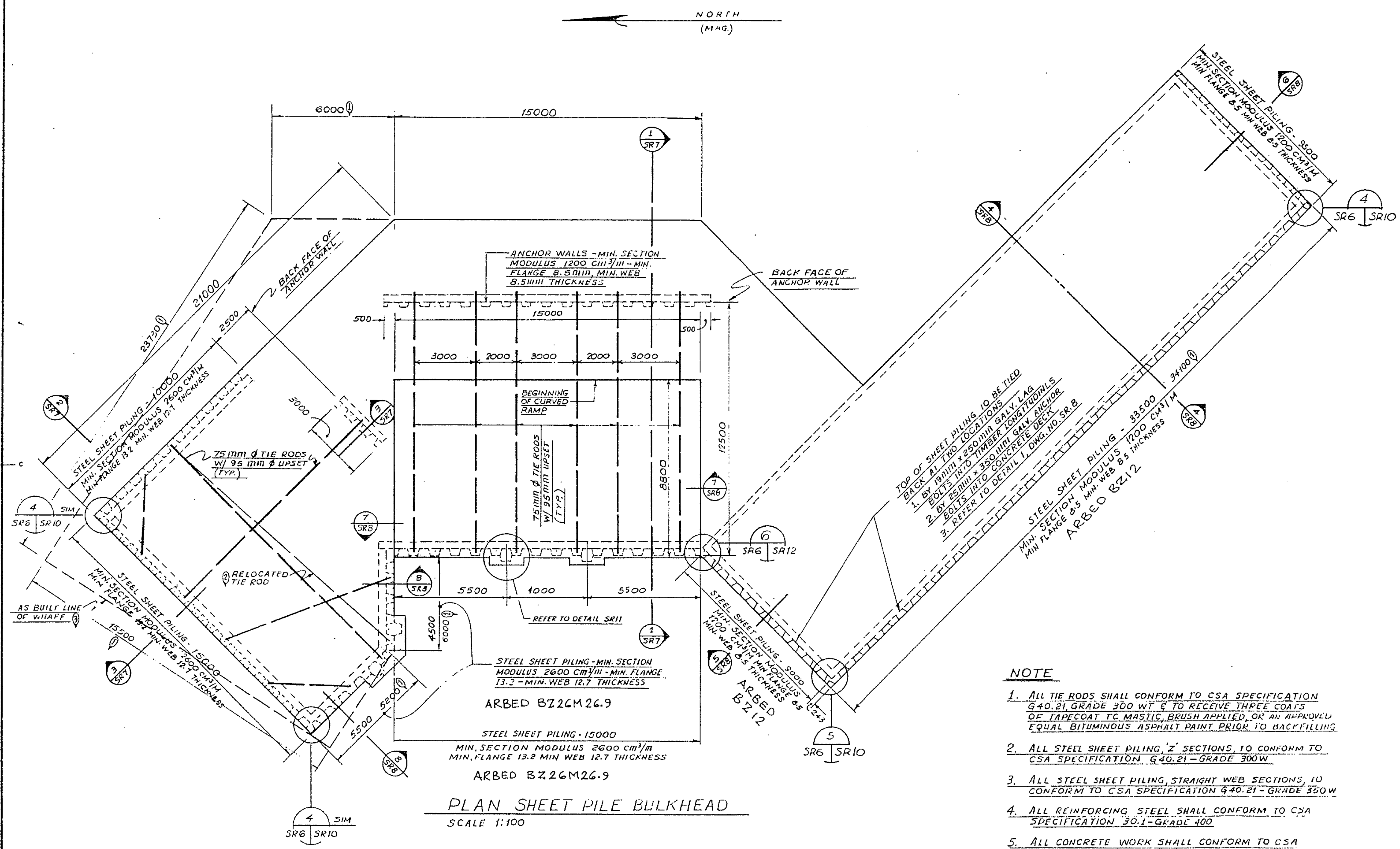
APPENDIX A

CARTWRIGHT DOCKING FACILITY

SKETCHES AND CALCULATIONS

c-02-16 (6)

Public Works Canada / Travaux publics Canada



PLAN SHEET PILE BULKHEAD
SCALE 1:100

NOTE

1. ALL TIE RODS SHALL CONFORM TO CSA SPECIFICATION G40.21, GRADE 300 WT & TO RECEIVE THREE COATS OF TAPECOAT TC MASTIC, BRUSH APPLIED, OR AN APPROVED EQUAL BITUMINOUS ASPHALT PAINT PRIOR TO BACKFILLING
2. ALL STEEL SHEET PILING, 'Z' SECTIONS, TO CONFORM TO CSA SPECIFICATION G40.21 – GRADE 300W
3. ALL STEEL SHEET PILING, STRAIGHT WEB SECTIONS, TO CONFORM TO CSA SPECIFICATION G40.21 – GRADE 350W
4. ALL REINFORCING STEEL SHALL CONFORM TO CSA SPECIFICATION 30.1 – GRADE 400
5. ALL CONCRETE WORK SHALL CONFORM TO CSA SPECIFICATION A23.1-M77 & HAVE A 28 DAY COMPRESSIVE STRENGTH OF 28MPa W/ AIR ENTRAINMENT OF 5% - 6% BY VOLUME
6. ALL WELDS TO BE IN ACCORDANCE W/ CSA SPECIFICATION W59
7. IF RIP-RAP, BOULDERS OR OTHER UNDESIRABLE MATERIAL IS ENCOUNTERED WHERE PILING IS TO BE DRIVEN IT IS TO BE REMOVED PRIOR TO DRIVING PILES

Mid Ocean Engineering Limited
Consulting Engineers-Project Managers
St. John's, Newfoundland

revisions:
- AS BUILT LINE OF WHARF
- AS BUILT DIMENSIONS

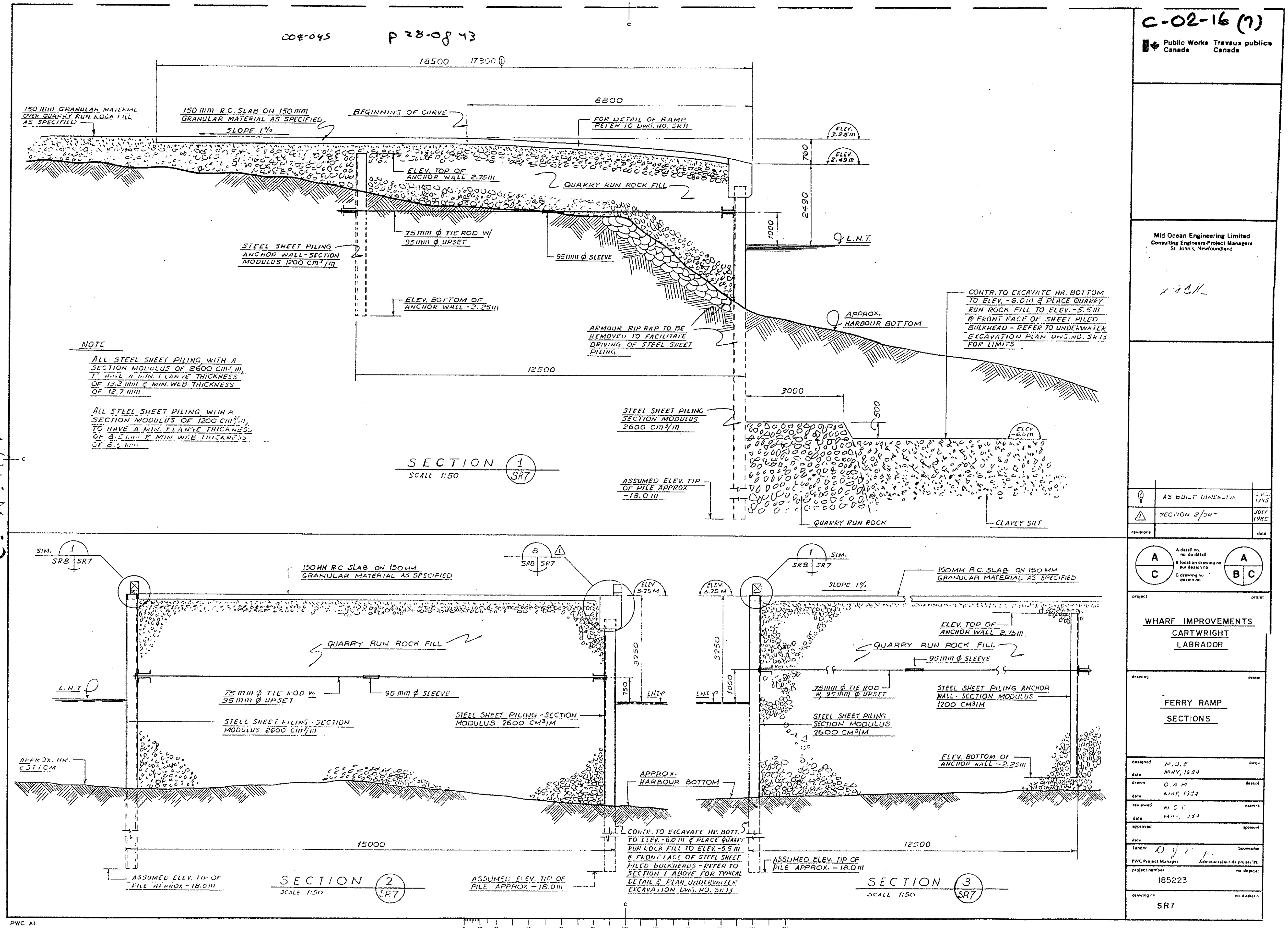
project: WHARF IMPROVEMENTS
CARTWRIGHT
LABRADOR

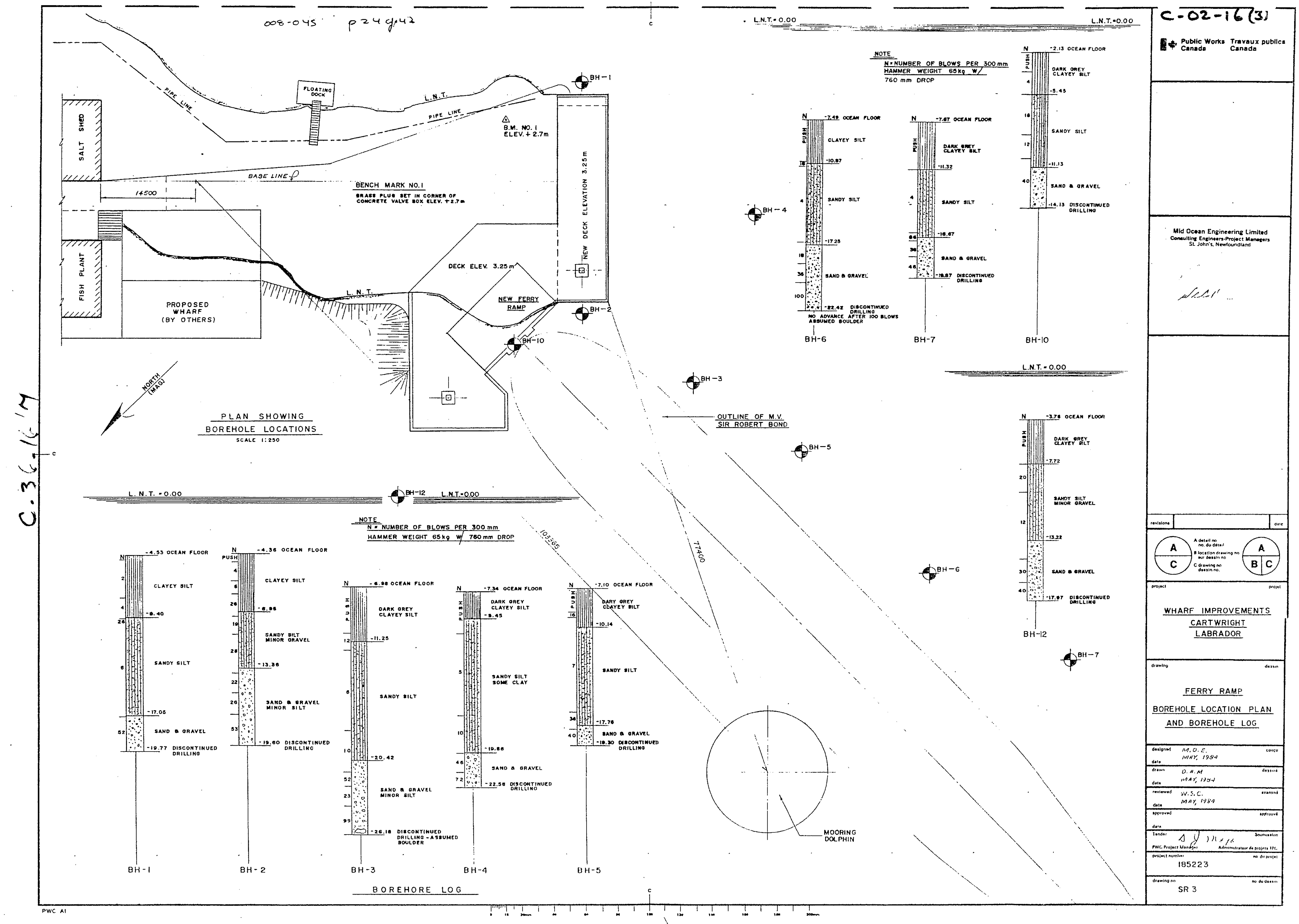
drawing: FERRY RAMP
PLAN SHEET PILE BULKHEAD

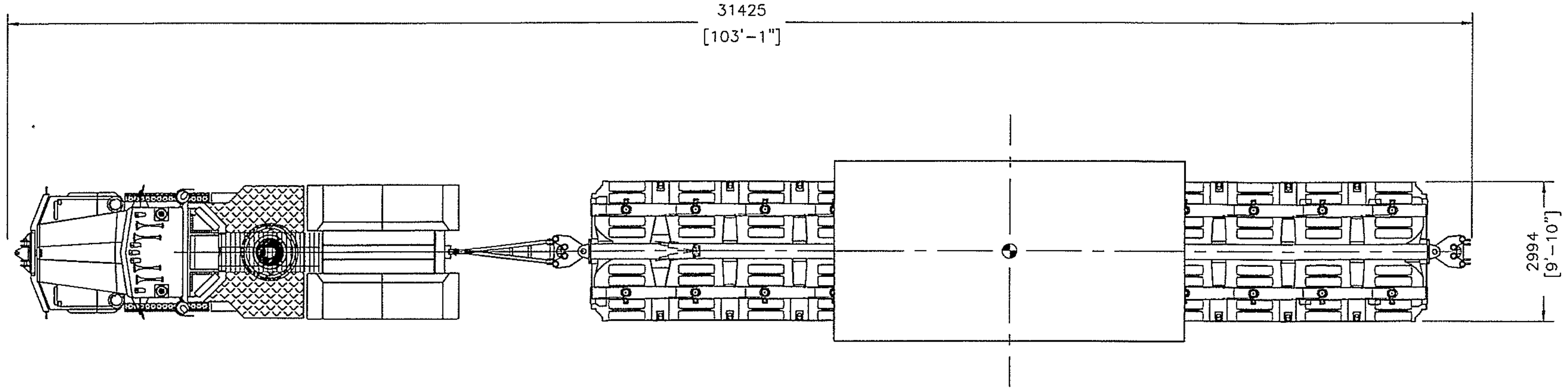
designed: M.O.E — date: MAY, 1984
drawn: D.A.M — date: MAY, 1984
reviewed: W.S.C. — date: MAY, 1984

project number: 185223
drawing no: SR6

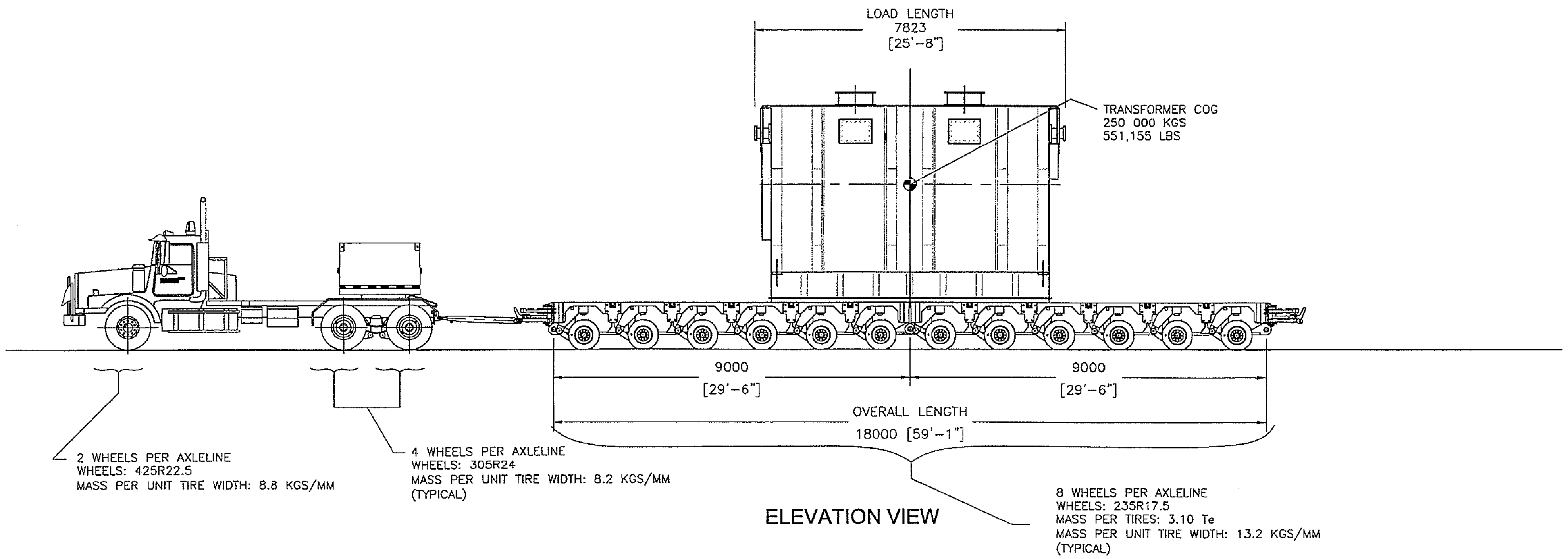
PWC A1


C-02-16 (7)
Public Works Canada Travaux publics Canada
Mid Ocean Engineering Limited
Consulting Engineers-Project Managers
St. John's, Newfoundland
18500
8800
150 mm GRANULAR MATERIAL OVER QUARRY RUN ROCK FILL AS SPECIFIED
150 mm R.C. SLAB ON 150 mm GRANULAR MATERIAL AS SPECIFIED
SLOPE 1%
BEGINNING OF CURVE
FOR DETAIL OF RAMP REFER TO DWG. NO. SK11
ELEV. 3.25 m
ELEV. 2.49 m
760
2490
1000
L.N.T.
ELEV. TOP OF ANCHOR WALL 2.75 m
QUARRY RUN ROCK FILL
75 mm ϕ TIE ROD w/ 95 mm ϕ UPSET
95 mm ϕ SLEEVE
STEEL SHEET PILING ANCHOR WALL - SECTION MODULUS 1200 cm³/m
ELEV. BOTTOM OF ANCHOR WALL -2.25 m
ARMOUR RIP RAP TO BE REMOVED TO FACILITATE DRIVING OF STEEL SHEET PILING
APPROX. HARBOUR BOTTOM
CONTR. TO EXCAVATE HR. BOTTOM TO ELEV. -6.0 m & PLACE QUARRY RUN ROCK FILL TO ELEV. -5.5 m @ FRONT FACE OF SHEET PILED BULKHEAD - REFER TO UNDERWATER EXCAVATION PLAN DWG. NO. SK13 FOR LIMITS
12500
3000
500
ELEV. -6.0 m
STEEL SHEET PILING SECTION MODULUS 2600 cm³/m
ASSUMED ELEV. TIP OF PILE APPROX. -18.0 m
QUARRY RUN ROCK
CLAYEY SILT
NOTE
ALL STEEL SHEET PILING WITH A SECTION MODULUS OF 2600 cm³/m, TO HAVE A MIN. FLANGE THICKNESS OF 13.2 mm & MIN. WEB THICKNESS OF 12.7 mm
ALL STEEL SHEET PILING WITH A SECTION MODULUS OF 1200 cm³/m, TO HAVE A MIN. FLANGE THICKNESS OF 8.5 mm & MIN. WEB THICKNESS OF 8.5 mm
SECTION 1 SR7
SCALE 1:50
AS BUILT DIMENSION
SECTION 2/SR7 JULY 1985
SIM. 1 SR8 SR7
150 MM R.C. SLAB ON 150 MM GRANULAR MATERIAL AS SPECIFIED
QUARRY RUN ROCK FILL
75 mm ϕ TIE ROD w. 95 mm ϕ UPSET
95 mm ϕ SLEEVE
STEEL SHEET PILING - SECTION MODULUS 2600 cm³/m
ELEV 3.25 M
3250
750
APPROX. HR. BOTTOM
15000
CONTR. TO EXCAVATE HR. BOTT. TO ELEV. -6.0 m & PLACE QUARRY RUN ROCK FILL TO ELEV. -5.5 m @ FRONT FACE OF STEEL SHEET PILED BULKHEADS - REFER TO SECTION 1 ABOVE FOR TYPICAL DETAIL & PLAN UNDERWATER EXCAVATION DWG. NO. SK13
ASSUMED ELEV. TIP OF PILE APPROX. -18.0 m
SECTION 2 SR7
SCALE 1:50
SLOPE 1%
ELEV. TOP OF ANCHOR WALL 2.75 m
95 mm ϕ SLEEVE
STEEL SHEET PILING ANCHOR WALL - SECTION MODULUS 1200 CM³/M
STEEL SHEET PILING SECTION MODULUS 2600 CM³/M
ELEV. BOTTOM OF ANCHOR WALL -2.25 m
12500
SECTION 3 SR7
SCALE 1:50
WHARF IMPROVEMENTS
CARTWRIGHT
LABRADOR
FERRY RAMP
SECTIONS
designed M.O.E. MAY, 1984
drawn D.A.M. MAY, 1984
185223
SR7
PWC A1

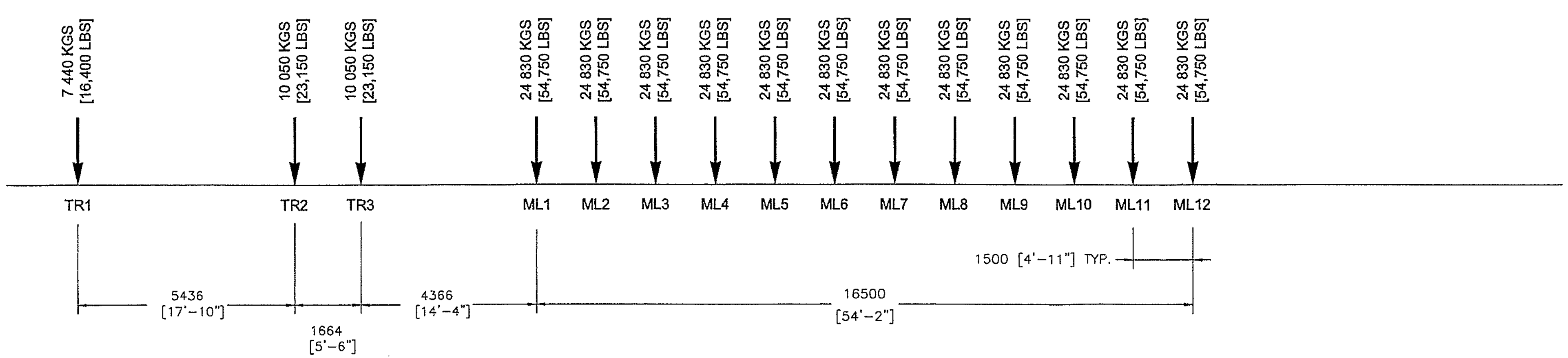

C-02-16(3)
Public Works Canada Travaux publics Canada
Mid Ocean Engineering Limited
Consulting Engineers-Project Managers
St. John's, Newfoundland
PLAN SHOWING BOREHOLE LOCATIONS
SCALE 1:250
NORTH (MAG)
SALT SHED
FISH PLANT
PROPOSED WHARF (BY OTHERS)
FLOATING DOCK
PIPE LINE
L.N.T.
BASE LINE
14500
BENCH MARK NO. 1
BRASS PLUG SET IN CORNER OF CONCRETE VALVE BOX ELEV. +2.7 m
B.M. NO. 1 ELEV. + 2.7m
NEW DECK ELEVATION 3.25 m
DECK ELEV. 3.25 m
NEW FERRY RAMP
OUTLINE OF M.V. SIR ROBERT BOND
MOORING DOLPHIN
BH-1
BH-2
BH-3
BH-4
BH-5
BH-6
BH-7
BH-10
BH-12
103265
77400
L.N.T. = 0.00
NOTE
N = NUMBER OF BLOWS PER 300 mm
HAMMER WEIGHT 65kg W/ 760 mm DROP
CLAYEY SILT
DARK GREY CLAYEY SILT
SANDY SILT
SANDY SILT MINOR GRAVEL
SANDY SILT SOME CLAY
SAND & GRAVEL
SAND & GRAVEL MINOR SILT
OCEAN FLOOR
DISCONTINUED DRILLING
DISCONTINUED DRILLING - ASSUMED BOULDER
NO ADVANCE AFTER 100 BLOWS ASSUMED BOULDER
PUSH
BOREHORE LOG
WHARF IMPROVEMENTS
CARTWRIGHT
LABRADOR
FERRY RAMP
BOREHOLE LOCATION PLAN AND BOREHOLE LOG
designed M.O.E. MAY, 1984
drawn D.A.M. MAY, 1984
reviewed W.S.C. MAY, 1984
project number 185223
drawing no SR 3
PWC A1



PLAN VIEW



ELEVATION VIEW



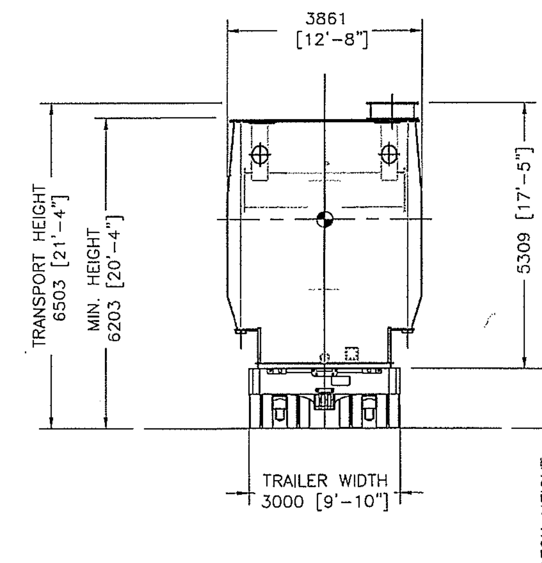
LOADINGS

OVERALL WEIGHTS:

TRACTOR:		
PULL TRACTOR TARE WEIGHT:	13 690 KGS	30,180 LBS
PULL TRACTOR BALLAST WEIGHT:	14 210 KGS	31,330 LBS
TRAILER AND EQUIPMENT:		
TRAILER TARE WEIGHT:	48 000 KGS	105,820 LBS
EQUIPMENT WEIGHT (BEAMS):	0 KGS	0 LBS
CARGO:		
TRANSFORMER WEIGHT:	250 000 KGS	551,155 LBS
TOTAL WEIGHT:	325 900 KGS	718,485 LBS

GROUND BEARING PRESSURE:

TOTAL TRAILER WEIGHT:	298 000 KGS	656,975 LBS
TRAILER LENGTH:	18 000 MM	59'-1"
TRAILER WIDTH:	3 000 MM	9'-10"
GBP:	5515.5 KGS/M²	1130.3 PSF



END VIEW

Preliminary

REV.	DESCRIPTION:	DATE:	DRAWN:	CHECKED:	APPROVED:
00	FIRST RELEASE	10OCT07	DW	GA	

CLIENT: SNC - LAVALIN

PROJECT: LOWER CHURCHILL PROJECT

TITLE: PRELIMINARY TRANSPORTATION CONCEPT FOR A 250 TONNE TRANSOFORMER 12 LINE CONVENTIONAL TRAILER

VAN SEUMEREN GROUP

MAMMOET

MAMMOET Canada Eastern Ltd.
170 Turnbull Court, Cambridge, Ontario, Canada, N1T 1J2
Tel. +1 (519) 740-0550 / Fax. +1 (519) 740-3531
www.mammoet.com

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SCALE: - SIZE: B

SAP No:

DRAWING NUMBER

PROJECT No:	SUB:	DOC:	PART:	SHT.	REV.
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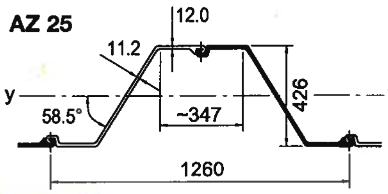
Product information

Z profile piles - Dimensions and properties

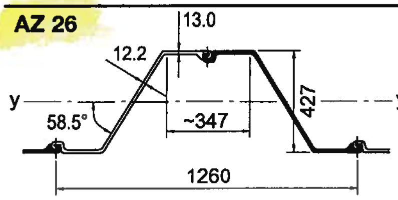
Table 1.13.1c

AZ 25



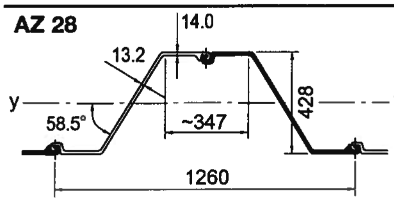
Section	S = Single pile D = Double pile	Sectional area cm²	Mass kg/m	Moment of inertia cm⁴	Elastic section modulus cm³	Radius of gyration cm	Coating area* m²/m
AZ 25	Per S	116.6	**91.5**	32910	**1545**	16.80	0.90
	Per D	233.2	**183.0**	65820	**3090**	16.80	1.78
	Per m of wall	185.0	**145.2**	52250	**2455**	16.80	1.41

AZ 26



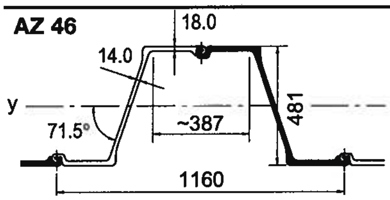
Section	S = Single pile D = Double pile	Sectional area cm²	Mass kg/m	Moment of inertia cm⁴	Elastic section modulus cm³	Radius of gyration cm	Coating area* m²/m
AZ 26	Per S	124.6	**97.8**	34970	**1640**	16.75	0.90
	Per D	249.2	**195.6**	69940	**3280**	16.75	1.78
	Per m of wall	197.80	**155.2**	55510	**2600**	16.75	1.41

AZ 28



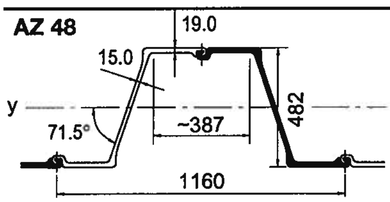
Section	S = Single pile D = Double pile	Sectional area cm²	Mass kg/m	Moment of inertia cm⁴	Elastic section modulus cm³	Radius of gyration cm	Coating area* m²/m
AZ 28	Per S	133.0	**104.4**	37130	**1735**	16.71	0.90
	Per D	266.0	**208.8**	74260	**3470**	16.71	1.78
	Per m of wall	211.1	**165.7**	58940	**2755**	16.71	1.41

AZ 46



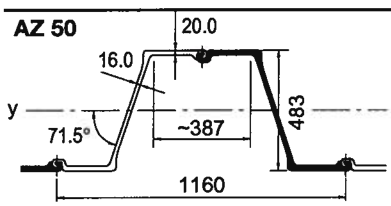
Section	S = Single pile D = Double pile	Sectional area cm²	Mass kg/m	Moment of inertia cm⁴	Elastic section modulus cm³	Radius of gyration cm	Coating area* m²/m
AZ 46	Per S	168.9	**132.6**	64060	**2665**	19.48	0.95
	Per D	337.8	**265.2**	128120	**5330**	19.48	1.89
	Per m of wall	291.2	**228.6**	110450	**4595**	19.48	1.63

AZ 48



Section	S = Single pile D = Double pile	Sectional area cm²	Mass kg/m	Moment of inertia cm⁴	Elastic section modulus cm³	Radius of gyration cm	Coating area* m²/m
AZ 48	Per S	177.8	**139.6**	67090	**2785**	19.43	0.95
	Per D	355.6	**279.2**	134180	**5570**	19.43	1.89
	Per m of wall	306.5	**240.6**	115670	**4800**	19.43	1.63

AZ 50



Section	S = Single pile D = Double pile	Sectional area cm²	Mass kg/m	Moment of inertia cm⁴	Elastic section modulus cm³	Radius of gyration cm	Coating area* m²/m
AZ 50	Per S	186.9	**146.7**	70215	**2910**	19.38	0.95
	Per D	373.8	**293.4**	140430	**5815**	19.38	1.89
	Per m of wall	322.2	**252.9**	121060	**5015**	19.38	1.63

* One side, excluding inside of interlocks.

West	105
Northwest	111

4.14 Geotechnical Parameters

Geotechincal analysis will be based on data obtained during previous soils investigation (12 boreholes described in a report by Newfoundland Geosciences Ltd. dated December 1997 – PM77-01 to 08 and PM97-A to D inclusive), supplemented by additional boreholes as determined by the geotechnical consultant. Based on existing data, soil properties are assumed to be as follows.

An analysis of the information indicates a layer of loose to compact silty sand, a layer of silt to clay, more silty sand with gravel, and a layer of cobbles and boulders, over bedrock having an irregular surface. The thickness of overburden is about 23 m, at the face of the dock.

The bedrock appears to be sloping seaward at a rate of about 1 in 6. The depth from the top of the overburden to dense competent material is about 12 m at the face of the dock and about 8 m at the back of the cells.

There is no evidence of permafrost in the shipping dock area.

Geotechnical	Stratum				
Parameter	Silty Sand	Silt to Clay	Silty Sand with Gravel	Cobbles and Boulders	Rockfill
Unit Wt. (sat.) ?sat. (kN/m^3)	20	27	20	22.5	20
Unit Wt. (eff./sub.) ?^{1} (kN/m^3)	10	19	10	12.5	10
Angle Shear Resistance (Ø) (°)	27	9	32	32	40
Ka (Horizontal Surface) Coefficient of Active Earth Pressure	0.37	0.37	0.3	0.3	0.22
Kp (Horizontal Surface) Coefficient of Passive Earth Pressure	2.7	2.7	3.3	3.3	4.6

4.15 Materials

Refer to Structural Design Criteria 334350-0000-42EC-0002-1 with the following additional requirements:

Typical Soil Properties

Bulk Unit Weight (γ)

This is typically 15 kN/m^3 for many top soils but can vary between 11 kN/m^3 for a loose dry soil to 18 kN/m^3 for dense wet soils. Figure 1 shows a range of typically recorded values.

Cohesion (c)

This is almost zero for dry loose sandy soils and can rise to over 100 kN/m^2 for hard dry clay soils. Friable (moist) sandy loam soils are typically in the range 5 to 15 kN/m^2 and moist plastic clay soils 10 to 40 kN/m^2.

Angle of Internal Friction (ϕ)

Theoretically a pure clay would have a value of 0° and ϕ would rise with increasing sand content and density to approximately 40° for a compact sandy loam soil. Loose sands range between 25 to 30°. As pure clays are rarely found in top soils the typical value for a 'clay' soil would be in the range 5 to 10°.

Angle of Soil-Metal Friction (δ)

These values are also related to the frictional content of the soil and linked to the 'roughness' of the surface finish. Typical values of δ for a sandy loam soil sliding over a steel surface are 20 to 22°, however, these values can fall as the surface finish becomes 'polished' to 15°. These results suggest that the value of δ would lie between 0.5 to 0.7 of the value of ϕ.

Adhesion (Ca)

This can be considered negligible in all but wet "sticky" soils, with high clay contents. As this is a special case the value should be measured directly for any particular study.

Typical default values

The following values are suggested for use if further information is not available.

	Sandy Loam	Loam	Clay loam
Bulk Unit Weight (γ)	15 kN/m^3	15 kN/m^3	14 kN/m^3
Cohesion (c)	10 kN/m^2	20 kN/m^2	30 kN/m^2
Angle of Internal Friction (ϕ)	35°	20°	10°
Angle of Soil-Metal Friction (δ)	22°	10°	6°
Adhesion (Ca)	0	0	0

EXISTING WALL WITH SURCHARGE DIRECTLY BEHIND WALL

The following ProSheet analysis is based on the original design conditions utilizing the AZ26 sheet pile section. Wall is anchored at location shown on drawings.

Surcharge of 54.1 kN/m from trailer wheels is applied directly behind the wall.

Soil properties used based on BH10 soil sample. Please see Table 2.1 for soil parameters.

Sheet Pile Design According to Blum-Method

Project Name:	Lower Churchill - Cartwright Ferry Landing Load Check
Date:	2010-09-09
Author:	Christopher Fudge
Company:	
Comment:	Analysis of the current ferry landing at Cartwright during offloading of equipment for Lower Churchill development.

Project Name: Lower Churchill - Cartwright Ferry Landing Load Check
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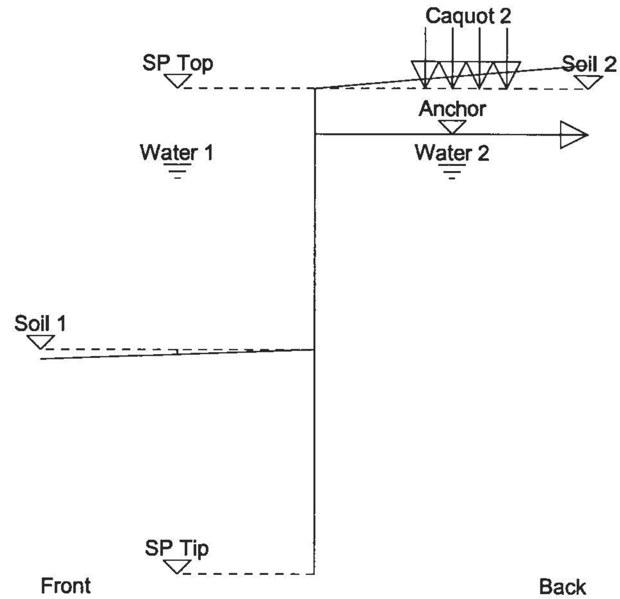
Geodata

	Unit
Sheet Pile Top Level [m]	-2.490
Sheet Pile Tip Level [m]	13.280
Soil Level in Front [m]	6.000
Soil Level behind [m]	-2.490
Anchorlevel [m]	-1.000
Water Level in Front [m]	0.000
Water Level behind [m]	0.000
Soil Surface Inclination in Front [Deg]	-2.000
Soil Surface Inclination behind [Deg]	5.000
Caquot Surcharge in Front [kN/m2]	0.000
Caquot Surcharge behind [kN/m2]	54.100
Anchor Inclination [Deg]	0.000
Earth Support	Fixed



Soil Layers

Layers in Front

	Layer Tip [m]	Density Moist [kN/m3]	Density Submerged [kN/m3]	Kph	Phi [Deg]	Delta [Deg]	Cohesion [kN/m2]
Layer 1	40.000	10.000	20.000	3.056	32.000	0.000	0.000

Layers behind

	Layer Tip [m]	Density Moist [kN/m3]	Density Submerged [kN/m3]	Kph	Phi [Deg]	Delta [Deg]	Cohesion [kN/m2]
Layer 1	2.000	10.000	20.000	0.227	40.000	0.000	0.000
Layer 2	5.450	17.000	27.000	0.799	9.000	0.000	20.000
Layer 3	11.130	10.000	20.000	0.398	27.000	0.000	0.000
Layer 4	40.000	10.000	20.000	0.323	32.000	0.000	0.000

Pile Section

Name	AZ 26
Inertia [cm4/m]	55509.996
Modulus [cm3/m]	2600.000
Area [cm2/m]	197.800
Mass [kg/m2]	155.200
Steel Grade [N/mm2]	320.000
Requested Safety	1.500

All Values

Depth [m]	Deflection [m]	Rotation [Rad]	Cross Force [kN/m]	Moment [kNm/m]	Total Pressure [kN/m2]	Earth Pressure in Front [kN/m2]	behind [kN/m2]	Water Pressure [kN/m2]	Userdefined Pressure [kN/m2]
-2.490	0.033	-0.022	0.000	0.000	12.273	0.000	12.273	0.000	0.000
-2.240	0.027	-0.022	3.139	0.389	12.840	0.000	12.840	0.000	0.000
-2.240	0.027	-0.022	3.139	0.389	12.840	0.000	12.840	0.000	0.000
-1.990	0.022	-0.022	6.420	1.581	13.407	0.000	13.407	0.000	0.000
-1.990	0.022	-0.022	6.420	1.581	13.407	0.000	13.407	0.000	0.000
-1.740	0.016	-0.022	9.843	3.611	13.974	0.000	13.974	0.000	0.000
-1.740	0.016	-0.022	9.843	3.611	13.974	0.000	13.974	0.000	0.000
-1.490	0.011	-0.022	13.407	6.514	14.541	0.000	14.541	0.000	0.000
-1.490	0.011	-0.022	13.407	6.514	14.541	0.000	14.541	0.000	0.000
-1.240	0.005	-0.022	17.113	10.327	15.108	0.000	15.108	0.000	0.000
-1.240	0.005	-0.022	17.113	10.327	15.108	0.000	15.108	0.000	0.000
-1.000	0.000	-0.022	20.805	14.874	15.653	0.000	15.653	0.000	0.000
-1.000	0.000	-0.022	-227.500	14.874	15.653	0.000	15.653	0.000	0.000
-0.750	-0.005	-0.022	-223.516	-41.506	16.220	0.000	16.220	0.000	0.000
-0.750	-0.005	-0.022	-223.516	-41.506	16.220	0.000	16.220	0.000	0.000
-0.500	-0.011	-0.022	-219.390	-96.872	16.787	0.000	16.787	0.000	0.000
-0.500	-0.011	-0.022	-219.390	-96.872	16.787	0.000	16.787	0.000	0.000
-0.250	-0.016	-0.021	-215.122	-151.189	17.354	0.000	17.354	0.000	0.000
-0.250	-0.016	-0.021	-215.122	-151.189	17.354	0.000	17.354	0.000	0.000
0.000	-0.022	-0.021	-210.713	-204.422	17.921	0.000	17.921	0.000	0.000
0.000	-0.022	-0.021	-210.713	-204.422	17.921	0.000	17.921	0.000	0.000
0.250	-0.027	-0.021	-206.091	-256.528	19.056	0.000	19.056	0.000	0.000
0.250	-0.027	-0.021	-206.091	-256.528	19.056	0.000	19.056	0.000	0.000
0.500	-0.032	-0.020	-201.185	-307.443	20.190	0.000	20.190	0.000	0.000
0.500	-0.032	-0.020	-201.185	-307.443	20.190	0.000	20.190	0.000	0.000
0.750	-0.037	-0.019	-195.996	-357.097	21.324	0.000	21.324	0.000	0.000
0.750	-0.037	-0.019	-195.996	-357.097	21.324	0.000	21.324	0.000	0.000
1.000	-0.042	-0.018	-190.523	-405.418	22.458	0.000	22.458	0.000	0.000
1.000	-0.042	-0.018	-190.523	-405.418	22.458	0.000	22.458	0.000	0.000
1.250	-0.046	-0.018	-184.767	-452.335	23.593	0.000	23.593	0.000	0.000
1.250	-0.046	-0.018	-184.767	-452.335	23.593	0.000	23.593	0.000	0.000
1.500	-0.050	-0.017	-178.727	-497.777	24.727	0.000	24.727	0.000	0.000
1.500	-0.050	-0.017	-178.727	-497.777	24.727	0.000	24.727	0.000	0.000
1.750	-0.054	-0.015	-172.403	-541.675	25.861	0.000	25.861	0.000	0.000
1.750	-0.054	-0.015	-172.403	-541.675	25.861	0.000	25.861	0.000	0.000
2.000	-0.058	-0.014	-165.796	-583.955	26.995	0.000	26.995	0.000	0.000
2.000	-0.058	-0.014	-165.796	-583.955	59.368	0.000	59.368	0.000	0.000
2.250	-0.061	-0.013	-150.280	-623.493	64.764	0.000	64.764	0.000	0.000
2.250	-0.061	-0.013	-150.280	-623.493	64.764	0.000	64.764	0.000	0.000
2.500	-0.064	-0.012	-133.414	-658.983	70.160	0.000	70.160	0.000	0.000
2.500	-0.064	-0.012	-133.414	-658.983	70.160	0.000	70.160	0.000	0.000
2.750	-0.067	-0.010	-115.199	-690.088	75.557	0.000	75.557	0.000	0.000
2.750	-0.067	-0.010	-115.199	-690.088	75.557	0.000	75.557	0.000	0.000
3.000	-0.070	-0.009	-95.636	-716.470	80.953	0.000	80.953	0.000	0.000
3.000	-0.070	-0.009	-95.636	-716.470	80.953	0.000	80.953	0.000	0.000
3.250	-0.071	-0.007	-74.723	-737.793	86.349	0.000	86.349	0.000	0.000
3.250	-0.071	-0.007	-74.723	-737.793	86.349	0.000	86.349	0.000	0.000
3.500	-0.073	-0.005	-52.461	-753.719	91.745	0.000	91.745	0.000	0.000
3.500	-0.073	-0.005	-52.461	-753.719	91.745	0.000	91.745	0.000	0.000
3.750	-0.074	-0.004	-28.851	-763.911	97.141	0.000	97.141	0.000	0.000
3.750	-0.074	-0.004	-28.851	-763.911	97.141	0.000	97.141	0.000	0.000
4.000	-0.075	-0.002	-3.891	-768.032	102.537	0.000	102.537	0.000	0.000
4.000	-0.075	-0.002	-3.891	-768.032	102.537	0.000	102.537	0.000	0.000
4.250	-0.075	0.000	22.418	-765.744	107.934	0.000	107.934	0.000	0.000
4.250	-0.075	0.000	22.418	-765.744	107.934	0.000	107.934	0.000	0.000
4.500	-0.075	0.001	50.076	-756.711	113.330	0.000	113.330	0.000	0.000
4.500	-0.075	0.001	50.076	-756.711	113.330	0.000	113.330	0.000	0.000
4.750	-0.075	0.003	79.083	-740.594	118.726	0.000	118.726	0.000	0.000
4.750	-0.075	0.003	79.083	-740.594	118.726	0.000	118.726	0.000	0.000
5.000	-0.074	0.004	109.439	-717.057	124.122	0.000	124.122	0.000	0.000
5.000	-0.074	0.004	109.439	-717.057	124.122	0.000	124.122	0.000	0.000
5.250	-0.073	0.006	141.144	-685.762	129.518	0.000	129.518	0.000	0.000
5.250	-0.073	0.006	141.144	-685.762	129.518	0.000	129.518	0.000	0.000
5.450	-0.071	0.007	167.479	-654.914	133.835	0.000	133.835	0.000	0.000
5.450	-0.071	0.007	167.479	-654.914	84.335	0.000	84.335	0.000	0.000

Depth [m]	Deflection [m]	Rotation [Rad]	Cross Force [kN/m]	Moment [kNm/m]	Total Pressure [kN/m2]	Earth Pressure in Front [kN/m2]	behind [kN/m2]	Water Pressure [kN/m2]	Userdefined Pressure [kN/m2]
5.700	-0.069	0.008	188.812	-610.388	86.323	0.000	86.323	0.000	0.000
5.700	-0.069	0.008	188.812	-610.388	86.323	0.000	86.323	0.000	0.000
5.950	-0.067	0.010	210.641	-560.467	88.311	0.000	88.311	0.000	0.000
5.950	-0.067	0.010	210.641	-560.467	88.311	0.000	88.311	0.000	0.000
6.000	-0.067	0.010	215.066	-549.824	88.708	0.000	88.708	0.000	0.000
6.000	-0.067	0.010	215.066	-549.824	88.708	0.000	88.708	0.000	0.000
6.250	-0.064	0.011	235.582	-493.424	75.415	-15.281	90.696	0.000	0.000
6.250	-0.064	0.011	235.582	-493.424	75.415	-15.281	90.696	0.000	0.000
6.500	-0.061	0.012	252.774	-432.310	62.122	-30.562	92.684	0.000	0.000
6.500	-0.061	0.012	252.774	-432.310	62.122	-30.562	92.684	0.000	0.000
6.750	-0.058	0.013	266.643	-367.314	48.829	-45.842	94.671	0.000	0.000
6.750	-0.058	0.013	266.643	-367.314	48.829	-45.842	94.671	0.000	0.000
7.000	-0.055	0.013	277.188	-299.266	35.535	-61.123	96.659	0.000	0.000
7.000	-0.055	0.013	277.188	-299.266	35.535	-61.123	96.659	0.000	0.000
7.250	-0.051	0.014	284.410	-228.997	22.242	-76.404	98.646	0.000	0.000
7.250	-0.051	0.014	284.410	-228.997	22.242	-76.404	98.646	0.000	0.000
7.500	-0.048	0.014	288.309	-157.338	8.949	-91.685	100.634	0.000	0.000
7.500	-0.048	0.014	288.309	-157.338	8.949	-91.685	100.634	0.000	0.000
7.750	-0.044	0.015	288.885	-85.119	-4.344	-106.966	102.622	0.000	0.000
7.750	-0.044	0.015	288.885	-85.119	-4.344	-106.966	102.622	0.000	0.000
8.000	-0.040	0.015	286.137	-13.172	-17.637	-122.247	104.609	0.000	0.000
8.000	-0.040	0.015	286.137	-13.172	-17.637	-122.247	104.609	0.000	0.000
8.250	-0.037	0.015	280.066	57.672	-30.930	-137.527	106.597	0.000	0.000
8.250	-0.037	0.015	280.066	57.672	-30.930	-137.527	106.597	0.000	0.000
8.500	-0.033	0.015	270.672	126.584	-44.224	-152.808	108.585	0.000	0.000
8.500	-0.033	0.015	270.672	126.584	-44.224	-152.808	108.585	0.000	0.000
8.750	-0.029	0.014	257.954	192.731	-57.517	-168.089	110.572	0.000	0.000
8.750	-0.029	0.014	257.954	192.731	-57.517	-168.089	110.572	0.000	0.000
9.000	-0.026	0.014	241.914	255.284	-70.810	-183.370	112.560	0.000	0.000
9.000	-0.026	0.014	241.914	255.284	-70.810	-183.370	112.560	0.000	0.000
9.250	-0.023	0.013	222.549	313.411	-84.103	-198.651	114.548	0.000	0.000
9.250	-0.023	0.013	222.549	313.411	-84.103	-198.651	114.548	0.000	0.000
9.500	-0.019	0.012	199.862	366.282	-97.396	-213.932	116.535	0.000	0.000
9.500	-0.019	0.012	199.862	366.282	-97.396	-213.932	116.535	0.000	0.000
9.750	-0.016	0.012	173.851	413.065	-110.690	-229.212	118.523	0.000	0.000
9.750	-0.016	0.012	173.851	413.065	-110.690	-229.212	118.523	0.000	0.000
10.000	-0.014	0.011	144.517	452.931	-123.983	-244.493	120.510	0.000	0.000
10.000	-0.014	0.011	144.517	452.931	-123.983	-244.493	120.510	0.000	0.000
10.250	-0.011	0.010	111.860	485.047	-137.276	-259.774	122.498	0.000	0.000
10.250	-0.011	0.010	111.860	485.047	-137.276	-259.774	122.498	0.000	0.000
10.500	-0.009	0.009	75.879	508.583	-150.569	-275.055	124.486	0.000	0.000
10.500	-0.009	0.009	75.879	508.583	-150.569	-275.055	124.486	0.000	0.000
10.750	-0.007	0.007	36.575	522.709	-163.862	-290.336	126.473	0.000	0.000
10.750	-0.007	0.007	36.575	522.709	-163.862	-290.336	126.473	0.000	0.000
11.000	-0.005	0.006	-6.052	526.594	-177.156	-305.617	128.461	0.000	0.000
11.000	-0.005	0.006	-6.052	526.594	-177.156	-305.617	128.461	0.000	0.000
11.130	-0.004	0.006	-29.532	524.291	-184.068	-313.563	129.495	0.000	0.000
11.130	-0.004	0.006	-29.532	524.291	-208.240	-313.563	105.323	0.000	0.000
11.380	-0.003	0.005	-83.300	510.258	-221.904	-328.843	106.940	0.000	0.000
11.380	-0.003	0.005	-83.300	510.258	-221.904	-328.843	106.940	0.000	0.000
11.630	-0.002	0.004	-140.484	482.356	-235.568	-344.124	108.556	0.000	0.000
11.630	-0.002	0.004	-140.484	482.356	-235.568	-344.124	108.556	0.000	0.000
11.880	-0.001	0.003	-201.084	439.731	-249.232	-359.405	110.173	0.000	0.000
11.880	-0.001	0.003	-201.084	439.731	-249.232	-359.405	110.173	0.000	0.000
12.130	-0.001	0.002	-265.100	381.530	-262.896	-374.686	111.790	0.000	0.000
12.130	-0.001	0.002	-265.100	381.530	-262.896	-374.686	111.790	0.000	0.000
12.380	0.000	0.001	-332.532	306.897	-276.561	-389.967	113.406	0.000	0.000
12.380	0.000	0.001	-332.532	306.897	-276.561	-389.967	113.406	0.000	0.000
12.630	0.000	0.000	-403.380	214.979	-290.225	-405.248	115.023	0.000	0.000
12.630	0.000	0.000	-403.380	214.979	-290.225	-405.248	115.023	0.000	0.000
12.880	0.000	0.000	-477.644	104.922	-303.889	-420.528	116.639	0.000	0.000
12.880	0.000	0.000	-477.644	104.922	-303.889	-420.528	116.639	0.000	0.000
13.086	0.000	0.000	-541.405	0.000	-315.148	-433.120	117.971	0.000	0.000

Extremal Values

	z Min [m]	Min	z Max [m]	Max
Deflection [m]	4.250	-0.075	-2.490	0.033
Cross Force [kN/m]	13.086	-541.405	7.750	288.885
Moment [kNm/m]	4.000	-768.032	10.970	526.696

Pile Check

		Depth [m]
Name	AZ 26	
Inertia [cm4/m]	55509.996	
Modulus [cm3/m]	2600.000	
Area [cm2/m]	197.800	
Mass [kg/m2]	155.200	
Steel Grade [N/mm2]	320.000	
Minimal Moment [kNm/m]	-768.032	4.000
Maxmimal Moment [kNm/m]	526.696	10.970
Normal Forces at Max. Moment [kN/m]	0.000	4.000
Normal Forces at Min. Moment [kN/m]	0.000	10.970
Deflection at Min. Moment [m]	-0.075	4.000
Deflection at Max. Moment [m]	-0.005	10.970
Min. Stress at Min. Moment [N/mm2]	-295.397	4.000
Max. Stress at Min. Moment [N/mm2]	295.397	4.000
Min. Stress at Max. Moment [N/mm2]	-202.575	10.970
Max. Stress at Max. Moment [N/mm2]	202.575	10.970
Safety < Req. Safety = 1.500	1.083	
Sheet Pile Top Level [m]	-2.490	
Sheet Pile Tip Level [m]	13.280	
Sheet Pile Length [m]	15.770	
Included OverLength [m]	0.194	
Vertical Equilibrium [kN/m]	0.000	
Anchor Force (horiz.) [kN/m]	-248.305	

HIGHER GRADE

<1.5 WITH HIGHER GRADE STEEL. NOT ACCEPTABLE.

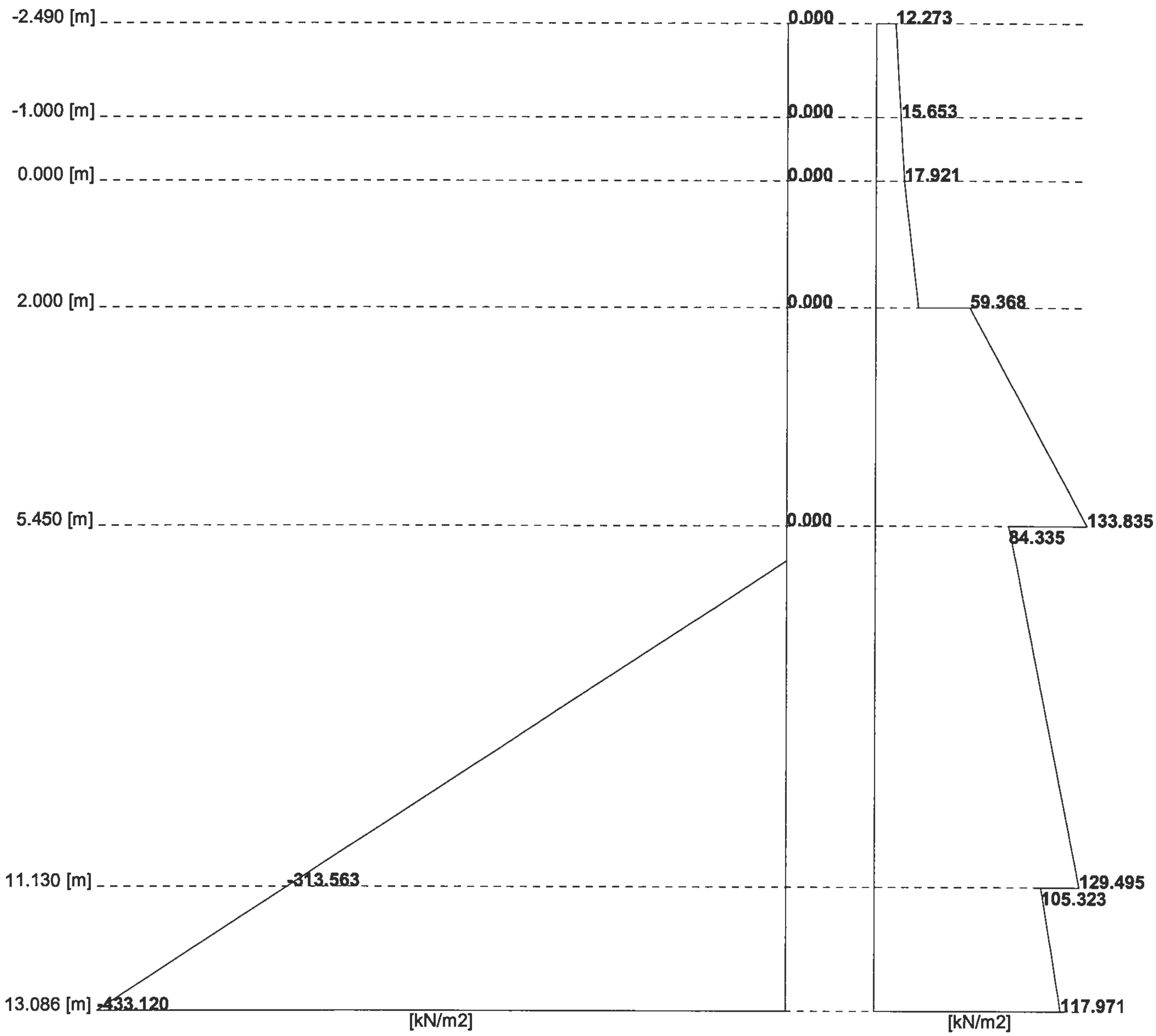
30% OF DESIGN TIP

TIP ELEVATION REQ'D = 13.28+(-4) = -17.28M

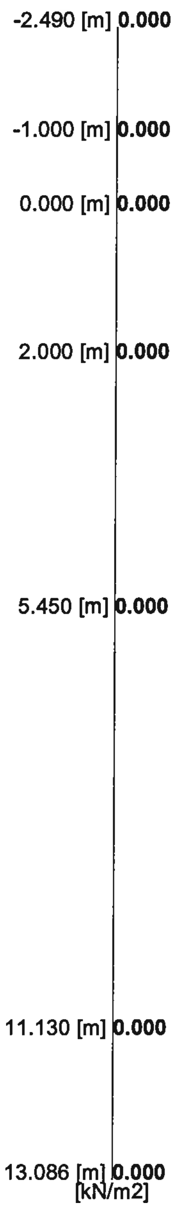
EXISTING TIP EL. = -18M > -17.28M

OK.

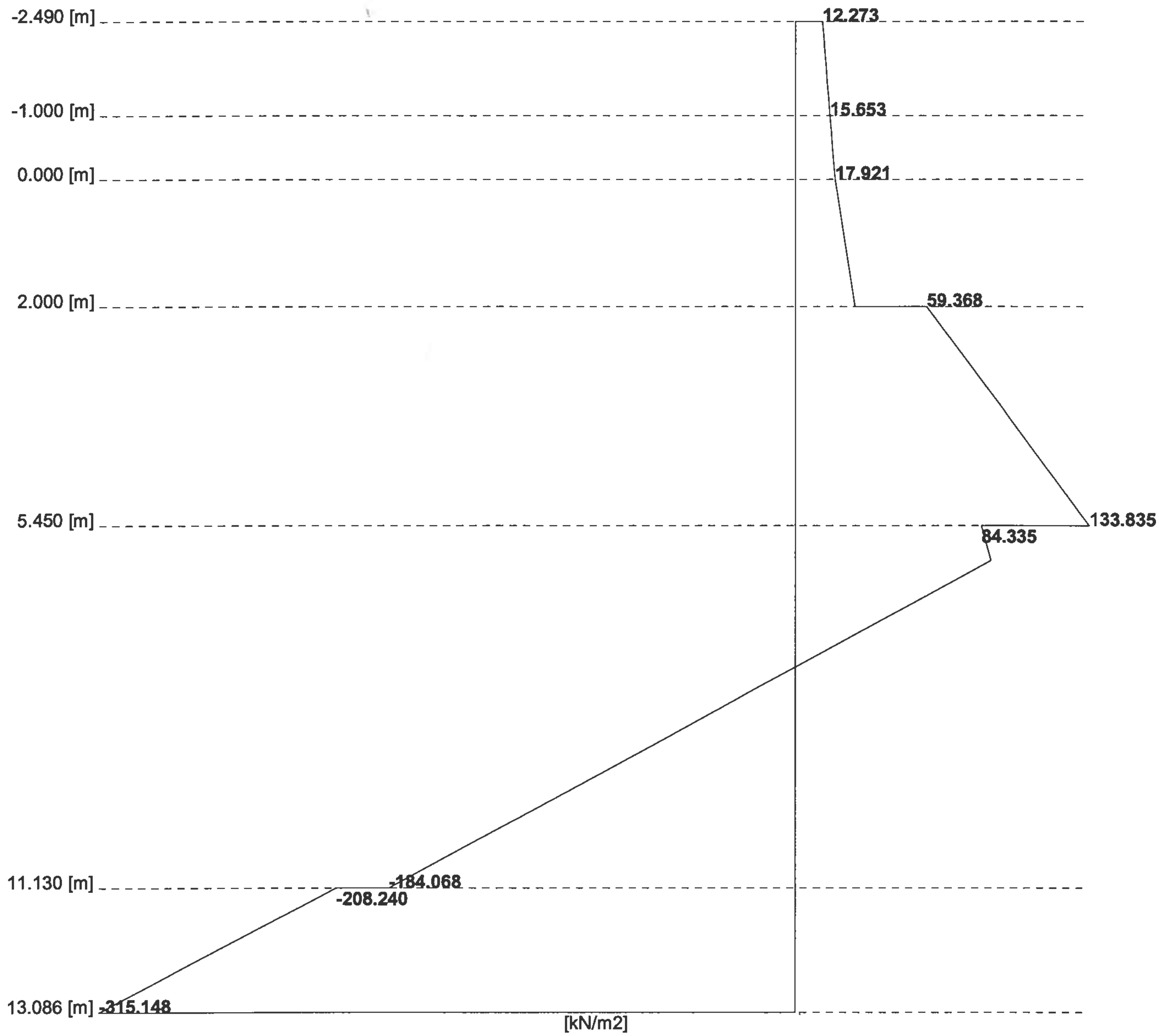
Earth Pressure Diagram



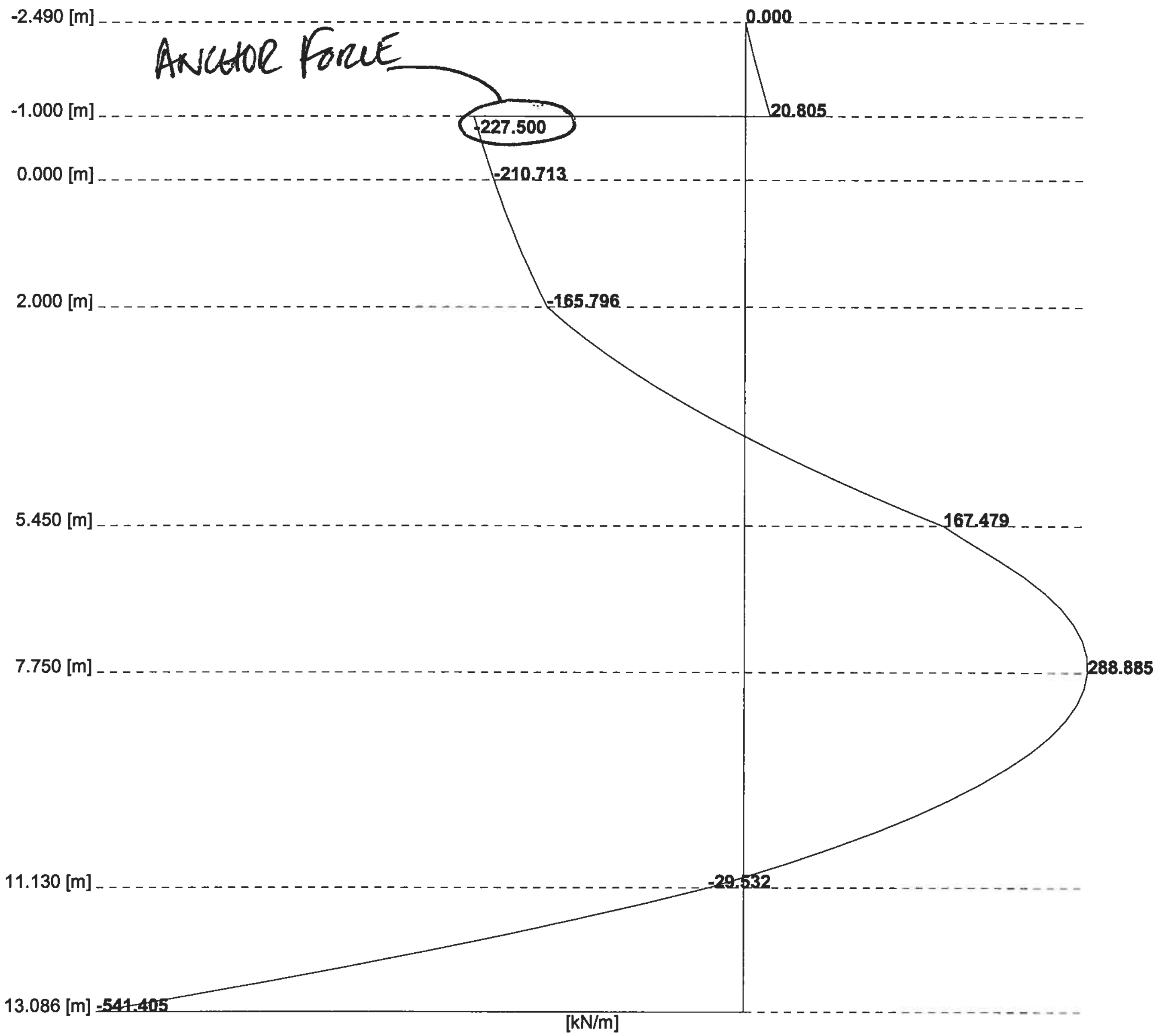
Water Pressure Diagram



Total Pressure Diagram



Cross Force Diagram



$T_r = \phi A_{rod} f_y$

$= 0.9 (0.075)^2 \frac{\pi}{4} (300000)$

$= 1192$ kN

75 mm ϕ RODS (GR. 300WT)

$A_{rod} = (0.075)^2 \frac{\pi}{4} =$

$f_y = 300$ MPa

$\phi = 0.9$

SAFETY FACTOR ↓

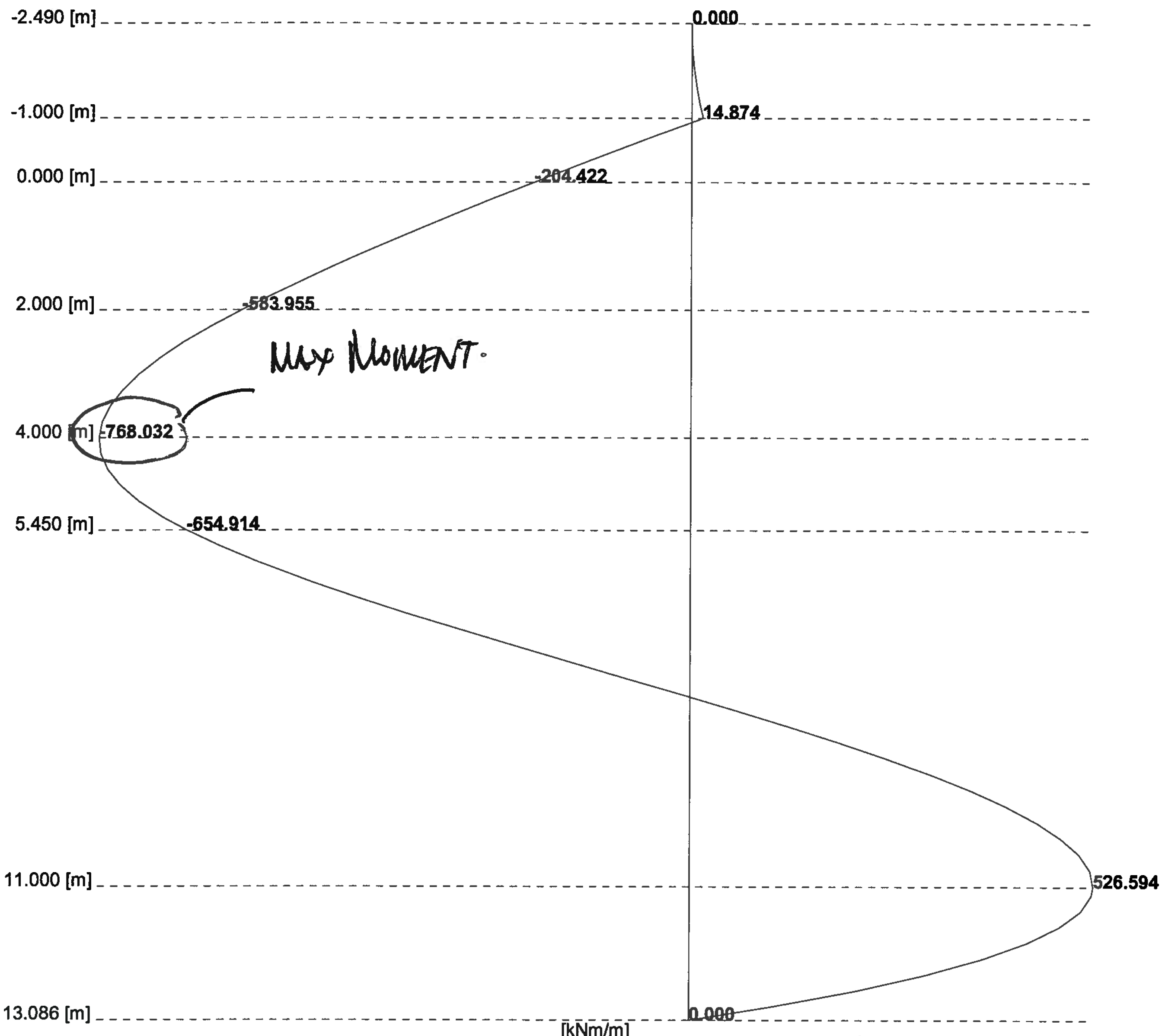
$T_f = 227.5$ kN/m $\times 2.5 \times 1.5$

$= 569$ kN $\times 1.5$

$= 854$ kN $< T_r$ OK.

ROD SPACING $= \frac{3m + 2m}{2} = 2.5$ m

Moment Diagram



ASSUME AZ26 SHEETS.

$S = 2600\ cm^3$
$= 0.0026\ m^3$

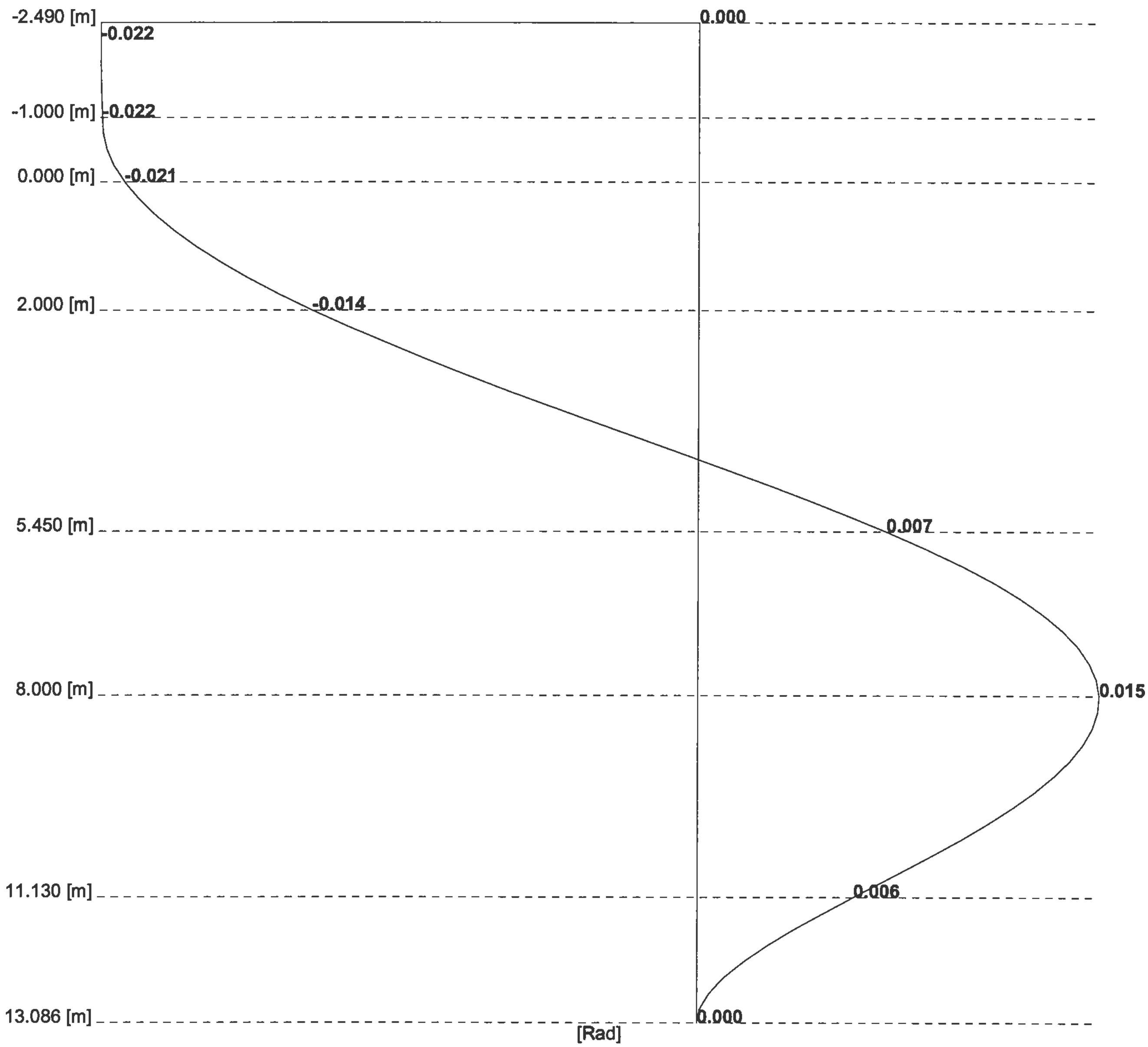
$f_y = 300$ MPa
$\phi = 0.9$

$M_r = \phi S F_y$
$= (0.9)(0.0026)(300000)$
$= 702$ kN·m

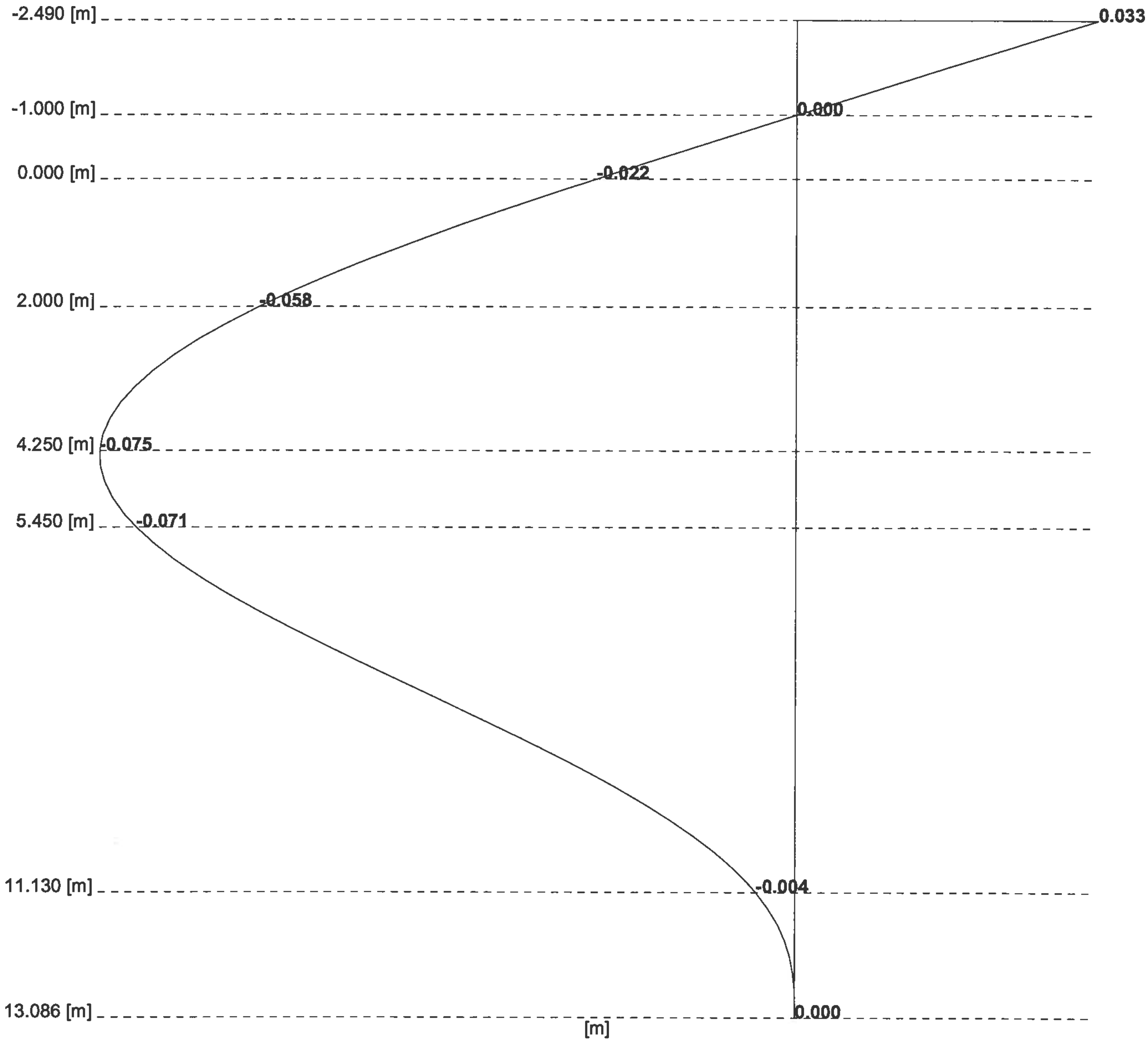
↑ FOR 300MPa STEEL. < M_u NOT GOOD.

$F.S. = \frac{702}{768} = 0.91$

Rotation Diagram



Deflection Diagram



EXISTING WALL WITH SURCHARGE 6.5 METRES BEHIND WALL

The following ProSheet analysis is based on the original design conditions utilizing the AZ26 sheet pile section. Wall is anchored at location shown on drawings.

Surcharge of 54.1 kN/m from trailer wheels is applied 6.5 metres behind the wall.

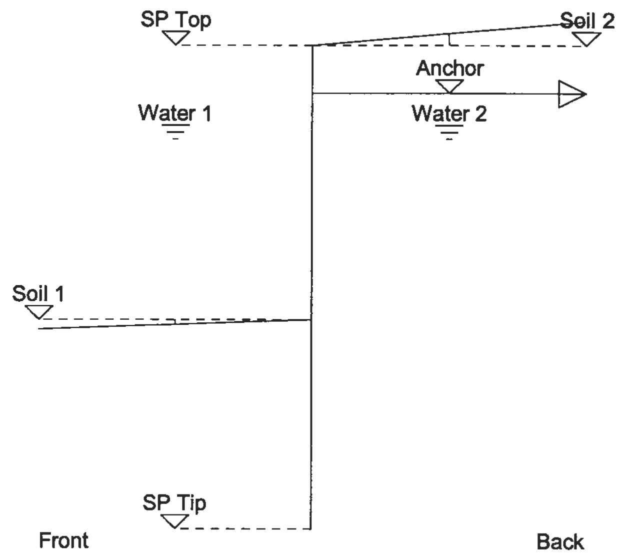
Soil properties used based on BH10 soil sample. Please see Table 2.1 for soil parameters.

Sheet Pile Design According to Blum-Method

Project Name:	Lower Churchill - Cartwright Ferry Landing Load Check
Date:	2010-09-09
Author:	Christopher Fudge
Company:	
Comment:	Analysis of the current ferry landing at Cartwright during offloading of equipment for Lower Churchill development.

Geodata

	Unit
Sheet Pile Top Level [m]	-2.490
Sheet Pile Tip Level [m]	12.464
Soil Level in Front [m]	6.000
Soil Level behind [m]	-2.490
Anchorlevel [m]	-1.000
Water Level in Front [m]	0.000
Water Level behind [m]	0.000
Soil Surface Inclination in Front [Deg]	-2.000
Soil Surface Inclination behind [Deg]	5.000
Caquot Surcharge in Front [kN/m2]	0.000
Caquot Surcharge behind [kN/m2]	0.000
Anchor Inclination [Deg]	0.000
Earth Support	Fixed



Soil Layers

Layers in Front

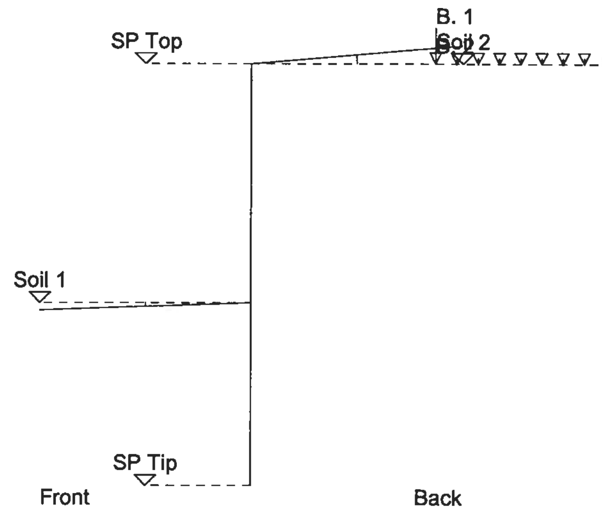
	Layer Tip [m]	Density Moist [kN/m3]	Density Submerged [kN/m3]	Kph	Phi [Deg]	Delta [Deg]	Cohesion [kN/m2]
Layer 1	40.000	10.000	20.000	3.056	32.000	0.000	0.000

Layers behind

	Layer Tip [m]	Density Moist [kN/m3]	Density Submerged [kN/m3]	Kph	Phi [Deg]	Delta [Deg]	Cohesion [kN/m2]
Layer 1	2.000	10.000	20.000	0.227	40.000	0.000	0.000
Layer 2	5.450	17.000	27.000	0.799	9.000	0.000	20.000
Layer 3	11.130	10.000	20.000	0.398	27.000	0.000	0.000
Layer 4	40.000	10.000	20.000	0.323	32.000	0.000	0.000

Boussinesq

	Distance Wall [m]	Width Surcharge [m]	Depth Surcharge [m]	Surcharge [kN/m2]
Bousq. 1	6.500	0.500	-2.490	324.000
Bousq. 2	6.500	12.000	-2.490	54.000



Pile Section

Name	AZ 26
Inertia [cm4/m]	55509.996
Modulus [cm3/m]	2600.000
Area [cm2/m]	197.800
Mass [kg/m2]	155.200
Steel Grade [N/mm2]	320.000
Requested Safety	1.500

All Values

Depth [m]	Deflection [m]	Rotation [Rad]	Cross Force [kN/m]	Moment [kNm/m]	Total Pressure [kN/m2]	Earth Pressure in Front [kN/m2]	behind [kN/m2]	Water Pressure [kN/m2]	Userdefined Pressure [kN/m2]	Bousq. 1 [kN/m2]	Bousq. 2 [kN/m2]
-2.490	0.020	-0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-2.240	0.016	-0.013	0.071	0.006	0.568	0.000	0.567	0.000	0.000	0.000	0.000
-2.240	0.016	-0.013	0.071	0.006	0.568	0.000	0.567	0.000	0.000	0.000	0.000
-1.990	0.013	-0.013	0.284	0.047	1.139	0.000	1.134	0.000	0.000	0.003	0.002
-1.990	0.013	-0.013	0.284	0.047	1.139	0.000	1.134	0.000	0.000	0.003	0.002
-1.740	0.010	-0.013	0.642	0.160	1.718	0.000	1.701	0.000	0.000	0.009	0.008
-1.740	0.010	-0.013	0.642	0.160	1.718	0.000	1.701	0.000	0.000	0.009	0.008
-1.490	0.006	-0.013	1.145	0.380	2.308	0.000	2.269	0.000	0.000	0.022	0.018
-1.490	0.006	-0.013	1.145	0.380	2.308	0.000	2.269	0.000	0.000	0.022	0.018
-1.240	0.003	-0.013	1.797	0.745	2.911	0.000	2.836	0.000	0.000	0.041	0.034
-1.240	0.003	-0.013	1.797	0.745	2.911	0.000	2.836	0.000	0.000	0.041	0.034
-1.000	0.000	-0.013	2.567	1.266	3.504	0.000	3.380	0.000	0.000	0.068	0.056
-1.000	0.000	-0.013	-131.770	1.266	3.504	0.000	3.380	0.000	0.000	0.068	0.056
-0.750	-0.003	-0.013	-130.814	-31.561	4.140	0.000	3.947	0.000	0.000	0.105	0.087
-0.750	-0.003	-0.013	-130.814	-31.561	4.140	0.000	3.947	0.000	0.000	0.105	0.087
-0.500	-0.007	-0.013	-129.698	-64.128	4.793	0.000	4.514	0.000	0.000	0.151	0.128
-0.500	-0.007	-0.013	-129.698	-64.128	4.793	0.000	4.514	0.000	0.000	0.151	0.128
-0.250	-0.010	-0.013	-128.415	-96.396	5.465	0.000	5.082	0.000	0.000	0.206	0.177
-0.250	-0.010	-0.013	-128.415	-96.396	5.465	0.000	5.082	0.000	0.000	0.206	0.177
0.000	-0.013	-0.013	-126.963	-128.321	6.155	0.000	5.649	0.000	0.000	0.271	0.235
0.000	-0.013	-0.013	-126.963	-128.321	6.155	0.000	5.649	0.000	0.000	0.271	0.235
0.250	-0.016	-0.012	-125.265	-159.857	7.429	0.000	6.783	0.000	0.000	0.343	0.303
0.250	-0.016	-0.012	-125.265	-159.857	7.429	0.000	6.783	0.000	0.000	0.343	0.303
0.500	-0.019	-0.012	-123.247	-190.927	8.720	0.000	7.917	0.000	0.000	0.422	0.380
0.500	-0.019	-0.012	-123.247	-190.927	8.720	0.000	7.917	0.000	0.000	0.422	0.380
0.750	-0.022	-0.012	-120.903	-221.453	10.025	0.000	9.051	0.000	0.000	0.508	0.466
0.750	-0.022	-0.012	-120.903	-221.453	10.025	0.000	9.051	0.000	0.000	0.508	0.466
1.000	-0.025	-0.011	-118.232	-251.352	11.343	0.000	10.186	0.000	0.000	0.598	0.559
1.000	-0.025	-0.011	-118.232	-251.352	11.343	0.000	10.186	0.000	0.000	0.598	0.559
1.250	-0.028	-0.010	-115.231	-280.542	12.672	0.000	11.320	0.000	0.000	0.692	0.660
1.250	-0.028	-0.010	-115.231	-280.542	12.672	0.000	11.320	0.000	0.000	0.692	0.660
1.500	-0.030	-0.010	-111.896	-308.939	14.009	0.000	12.454	0.000	0.000	0.788	0.767
1.500	-0.030	-0.010	-111.896	-308.939	14.009	0.000	12.454	0.000	0.000	0.788	0.767
1.750	-0.032	-0.009	-108.225	-336.461	15.354	0.000	13.588	0.000	0.000	0.885	0.880
1.750	-0.032	-0.009	-108.225	-336.461	15.354	0.000	13.588	0.000	0.000	0.885	0.880
2.000	-0.035	-0.008	-104.218	-363.024	16.703	0.000	14.723	0.000	0.000	0.983	0.998
2.000	-0.035	-0.008	-104.218	-363.024	23.098	0.000	16.119	0.000	0.000	3.462	3.517
2.250	-0.037	-0.008	-97.673	-388.292	29.263	0.000	21.515	0.000	0.000	3.801	3.947
2.250	-0.037	-0.008	-97.673	-388.292	29.263	0.000	21.515	0.000	0.000	3.801	3.947
2.500	-0.038	-0.007	-89.586	-411.732	35.433	0.000	26.911	0.000	0.000	4.134	4.388
2.500	-0.038	-0.007	-89.586	-411.732	35.433	0.000	26.911	0.000	0.000	4.134	4.388
2.750	-0.040	-0.006	-79.956	-432.957	41.602	0.000	32.307	0.000	0.000	4.457	4.839
2.750	-0.040	-0.006	-79.956	-432.957	41.602	0.000	32.307	0.000	0.000	4.457	4.839
3.000	-0.041	-0.005	-68.785	-451.581	47.766	0.000	37.703	0.000	0.000	4.768	5.295
3.000	-0.041	-0.005	-68.785	-451.581	47.766	0.000	37.703	0.000	0.000	4.768	5.295
3.250	-0.042	-0.004	-56.074	-467.221	53.920	0.000	43.100	0.000	0.000	5.066	5.755
3.250	-0.042	-0.004	-56.074	-467.221	53.920	0.000	43.100	0.000	0.000	5.066	5.755
3.500	-0.043	-0.003	-41.827	-479.490	60.061	0.000	48.496	0.000	0.000	5.349	6.216
3.500	-0.043	-0.003	-41.827	-479.490	60.061	0.000	48.496	0.000	0.000	5.349	6.216
3.750	-0.044	-0.002	-26.046	-488.006	66.186	0.000	53.892	0.000	0.000	5.617	6.677
3.750	-0.044	-0.002	-26.046	-488.006	66.186	0.000	53.892	0.000	0.000	5.617	6.677
4.000	-0.044	-0.001	-8.736	-492.386	72.291	0.000	59.288	0.000	0.000	5.869	7.134
4.000	-0.044	-0.001	-8.736	-492.386	72.291	0.000	59.288	0.000	0.000	5.869	7.134
4.250	-0.044	0.000	10.097	-492.247	78.376	0.000	64.684	0.000	0.000	6.104	7.588
4.250	-0.044	0.000	10.097	-492.247	78.376	0.000	64.684	0.000	0.000	6.104	7.588
4.500	-0.044	0.001	30.449	-487.211	84.438	0.000	70.080	0.000	0.000	6.322	8.036
4.500	-0.044	0.001	30.449	-487.211	84.438	0.000	70.080	0.000	0.000	6.322	8.036
4.750	-0.044	0.002	52.313	-476.897	90.477	0.000	75.477	0.000	0.000	6.523	8.477
4.750	-0.044	0.002	52.313	-476.897	90.477	0.000	75.477	0.000	0.000	6.523	8.477
5.000	-0.043	0.003	75.684	-460.928	96.491	0.000	80.873	0.000	0.000	6.709	8.909
5.000	-0.043	0.003	75.684	-460.928	96.491	0.000	80.873	0.000	0.000	6.709	8.909
5.250	-0.042	0.004	100.556	-438.930	102.479	0.000	86.269	0.000	0.000	6.878	9.333
5.250	-0.042	0.004	100.556	-438.930	102.479	0.000	86.269	0.000	0.000	6.878	9.333
5.450	-0.041	0.005	121.529	-416.737	107.252	0.000	90.586	0.000	0.000	7.002	9.664

Depth [m]	Deflection [m]	Rotation [Rad]	Cross Force [kN/m]	Moment [kNm/m]	Total Pressure [kN/m2]	Earth Pressure in Front [kN/m2]	behind [kN/m2]	Water Pressure [kN/m2]	Userdefined Pressure [kN/m2]	Bousq. 1 [kN/m2]	Bousq. 2 [kN/m2]
5.450	-0.041	0.005	121.529	-416.737	71.117	0.000	62.829	0.000	0.000	3.482	4.806
5.700	-0.039	0.006	139.590	-384.109	73.376	0.000	64.817	0.000	0.000	3.552	5.007
5.700	-0.039	0.006	139.590	-384.109	73.376	0.000	64.817	0.000	0.000	3.552	5.007
5.950	-0.038	0.007	158.215	-346.895	75.623	0.000	66.804	0.000	0.000	3.616	5.203
5.950	-0.038	0.007	158.215	-346.895	75.623	0.000	66.804	0.000	0.000	3.616	5.203
6.000	-0.038	0.007	162.008	-338.889	76.071	0.000	67.202	0.000	0.000	3.627	5.241
6.000	-0.038	0.007	162.008	-338.889	76.071	0.000	67.202	0.000	0.000	3.627	5.241
6.250	-0.036	0.008	179.394	-296.146	63.022	-15.281	69.190	0.000	0.000	3.683	5.430
6.250	-0.036	0.008	179.394	-296.146	63.022	-15.281	69.190	0.000	0.000	3.683	5.430
6.500	-0.034	0.008	193.517	-249.464	49.960	-30.562	71.177	0.000	0.000	3.731	5.613
6.500	-0.034	0.008	193.517	-249.464	49.960	-30.562	71.177	0.000	0.000	3.731	5.613
6.750	-0.032	0.009	204.373	-199.660	36.887	-45.842	73.165	0.000	0.000	3.774	5.790
6.750	-0.032	0.009	204.373	-199.660	36.887	-45.842	73.165	0.000	0.000	3.774	5.790
7.000	-0.029	0.009	211.959	-147.551	23.801	-61.123	75.153	0.000	0.000	3.811	5.961
7.000	-0.029	0.009	211.959	-147.551	23.801	-61.123	75.153	0.000	0.000	3.811	5.961
7.250	-0.027	0.009	216.272	-93.953	10.704	-76.404	77.140	0.000	0.000	3.843	6.125
7.250	-0.027	0.009	216.272	-93.953	10.704	-76.404	77.140	0.000	0.000	3.843	6.125
7.500	-0.025	0.009	217.309	-39.687	-2.404	-91.685	79.128	0.000	0.000	3.870	6.283
7.500	-0.025	0.009	217.309	-39.687	-2.404	-91.685	79.128	0.000	0.000	3.870	6.283
7.750	-0.022	0.009	215.069	14.428	-15.523	-106.966	81.115	0.000	0.000	3.892	6.435
7.750	-0.022	0.009	215.069	14.428	-15.523	-106.966	81.115	0.000	0.000	3.892	6.435
8.000	-0.020	0.009	209.547	67.573	-28.652	-122.247	83.103	0.000	0.000	3.910	6.581
8.000	-0.020	0.009	209.547	67.573	-28.652	-122.247	83.103	0.000	0.000	3.910	6.581
8.250	-0.018	0.009	200.741	118.928	-41.792	-137.527	85.091	0.000	0.000	3.924	6.721
8.250	-0.018	0.009	200.741	118.928	-41.792	-137.527	85.091	0.000	0.000	3.924	6.721
8.500	-0.016	0.009	188.650	167.670	-54.941	-152.808	87.078	0.000	0.000	3.934	6.855
8.500	-0.016	0.009	188.650	167.670	-54.941	-152.808	87.078	0.000	0.000	3.934	6.855
8.750	-0.013	0.008	173.269	212.979	-68.100	-168.089	89.066	0.000	0.000	3.941	6.982
8.750	-0.013	0.008	173.269	212.979	-68.100	-168.089	89.066	0.000	0.000	3.941	6.982
9.000	-0.011	0.008	154.599	254.031	-81.268	-183.370	91.054	0.000	0.000	3.945	7.104
9.000	-0.011	0.008	154.599	254.031	-81.268	-183.370	91.054	0.000	0.000	3.945	7.104
9.250	-0.009	0.007	132.635	290.003	-94.444	-198.651	93.041	0.000	0.000	3.945	7.220
9.250	-0.009	0.007	132.635	290.003	-94.444	-198.651	93.041	0.000	0.000	3.945	7.220
9.500	-0.008	0.007	107.375	320.073	-107.629	-213.932	95.029	0.000	0.000	3.944	7.330
9.500	-0.008	0.007	107.375	320.073	-107.629	-213.932	95.029	0.000	0.000	3.944	7.330
9.750	-0.006	0.006	78.819	343.416	-120.821	-229.212	97.017	0.000	0.000	3.939	7.435
9.750	-0.006	0.006	78.819	343.416	-120.821	-229.212	97.017	0.000	0.000	3.939	7.435
10.000	-0.005	0.005	46.964	359.208	-134.022	-244.493	99.004	0.000	0.000	3.933	7.535
10.000	-0.005	0.005	46.964	359.208	-134.022	-244.493	99.004	0.000	0.000	3.933	7.535
10.250	-0.003	0.004	11.807	366.623	-147.229	-259.774	100.992	0.000	0.000	3.924	7.629
10.250	-0.003	0.004	11.807	366.623	-147.229	-259.774	100.992	0.000	0.000	3.924	7.629
10.500	-0.002	0.004	-26.652	364.837	-160.444	-275.055	102.979	0.000	0.000	3.914	7.718
10.500	-0.002	0.004	-26.652	364.837	-160.444	-275.055	102.979	0.000	0.000	3.914	7.718
10.750	-0.002	0.003	-68.415	353.022	-173.665	-290.336	104.967	0.000	0.000	3.902	7.802
10.750	-0.002	0.003	-68.415	353.022	-173.665	-290.336	104.967	0.000	0.000	3.902	7.802
11.000	-0.001	0.002	-113.485	330.353	-186.892	-305.617	106.955	0.000	0.000	3.888	7.882
11.000	-0.001	0.002	-113.485	330.353	-186.892	-305.617	106.955	0.000	0.000	3.888	7.882
11.130	-0.001	0.002	-138.228	314.002	-193.773	-313.563	107.988	0.000	0.000	3.880	7.921
11.130	-0.001	0.002	-138.228	314.002	-216.133	-313.563	87.831	0.000	0.000	3.156	6.443
11.380	0.000	0.001	-193.963	272.549	-229.751	-328.843	89.448	0.000	0.000	3.143	6.502
11.380	0.000	0.001	-193.963	272.549	-229.751	-328.843	89.448	0.000	0.000	3.143	6.502
11.630	0.000	0.001	-253.104	216.736	-243.374	-344.124	91.064	0.000	0.000	3.129	6.557
11.630	0.000	0.001	-253.104	216.736	-243.374	-344.124	91.064	0.000	0.000	3.129	6.557
11.880	0.000	0.000	-315.651	145.713	-257.001	-359.405	92.681	0.000	0.000	3.115	6.609
11.880	0.000	0.000	-315.651	145.713	-257.001	-359.405	92.681	0.000	0.000	3.115	6.609
12.130	0.000	0.000	-381.605	58.627	-270.632	-374.686	94.298	0.000	0.000	3.099	6.657
12.130	0.000	0.000	-381.605	58.627	-270.632	-374.686	94.298	0.000	0.000	3.099	6.657
12.276	0.000	0.000	-421.698	0.000	-278.595	-383.610	95.242	0.000	0.000	3.090	6.683

Extremal Values

	z Min [m]	Min	z Max [m]	Max
Deflection [m]	4.250	-0.044	-2.490	0.020
Cross Force [kN/m]	12.276	-421.698	7.500	217.309
Moment [kNm/m]	4.000	-492.386	10.250	366.623

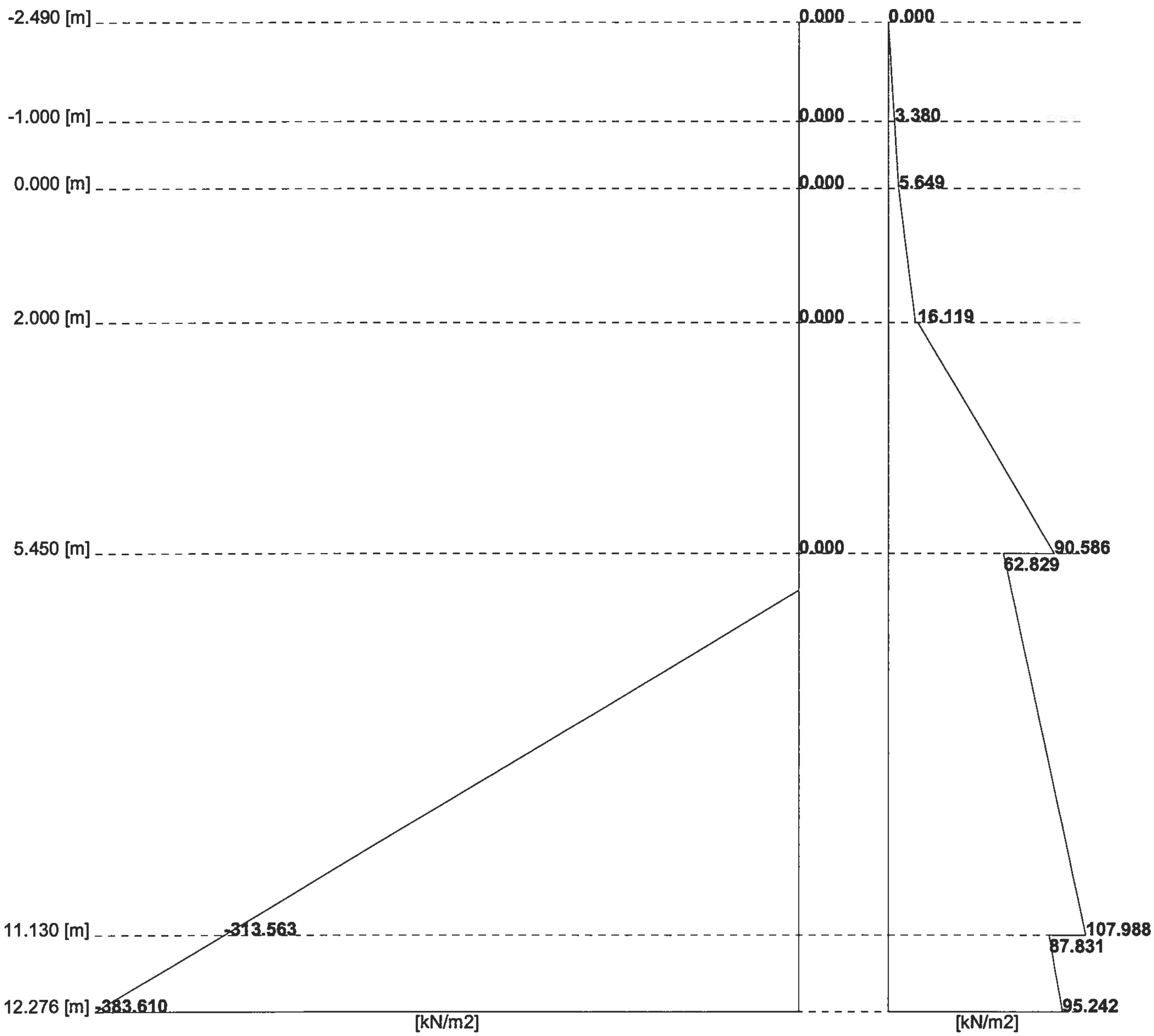
Pile Check

		Depth [m]
Name	AZ 26	
Inertia [cm4/m]	55509.996	
Modulus [cm3/m]	2600.000	
Area [cm2/m]	197.800	
Mass [kg/m2]	155.200	
Steel Grade [N/mm2]	320.000	
Minimal Moment [kNm/m]	-492.386	4.000
Maxmimal Moment [kNm/m]	366.623	10.250
Normal Forces at Max. Moment [kN/m]	0.000	4.000
Normal Forces at Min. Moment [kN/m]	0.000	10.250
Deflection at Min. Moment [m]	-0.044	4.000
Deflection at Max. Moment [m]	-0.003	10.250
Min. Stress at Min. Moment [N/mm2]	-189.379	4.000
Max. Stress at Min. Moment [N/mm2]	189.379	4.000
Min. Stress at Max. Moment [N/mm2]	-141.009	10.250
Max. Stress at Max. Moment [N/mm2]	141.009	10.250
Safety > Req. Safety = 1.500	1.690	
Sheet Pile Top Level [m]	-2.490	
Sheet Pile Tip Level [m]	12.464	
Sheet Pile Length [m]	14.954	
Included OverLength [m]	0.188	
Vertical Equilibrium [kN/m]	0.000	
Anchor Force (horiz.) [kN/m]	-134.337	

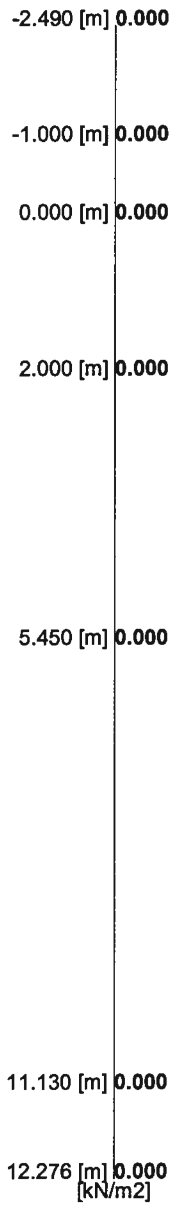
>1.5 FOR 320MPa STEEL
(THIS F.S. DOES NOT ACCOUNT FOR ϕ OF 0.9)

REQ'D TIP EL = -12.46 - 4 = -16.46m.
EXISTING TIP EL = -18m OK.

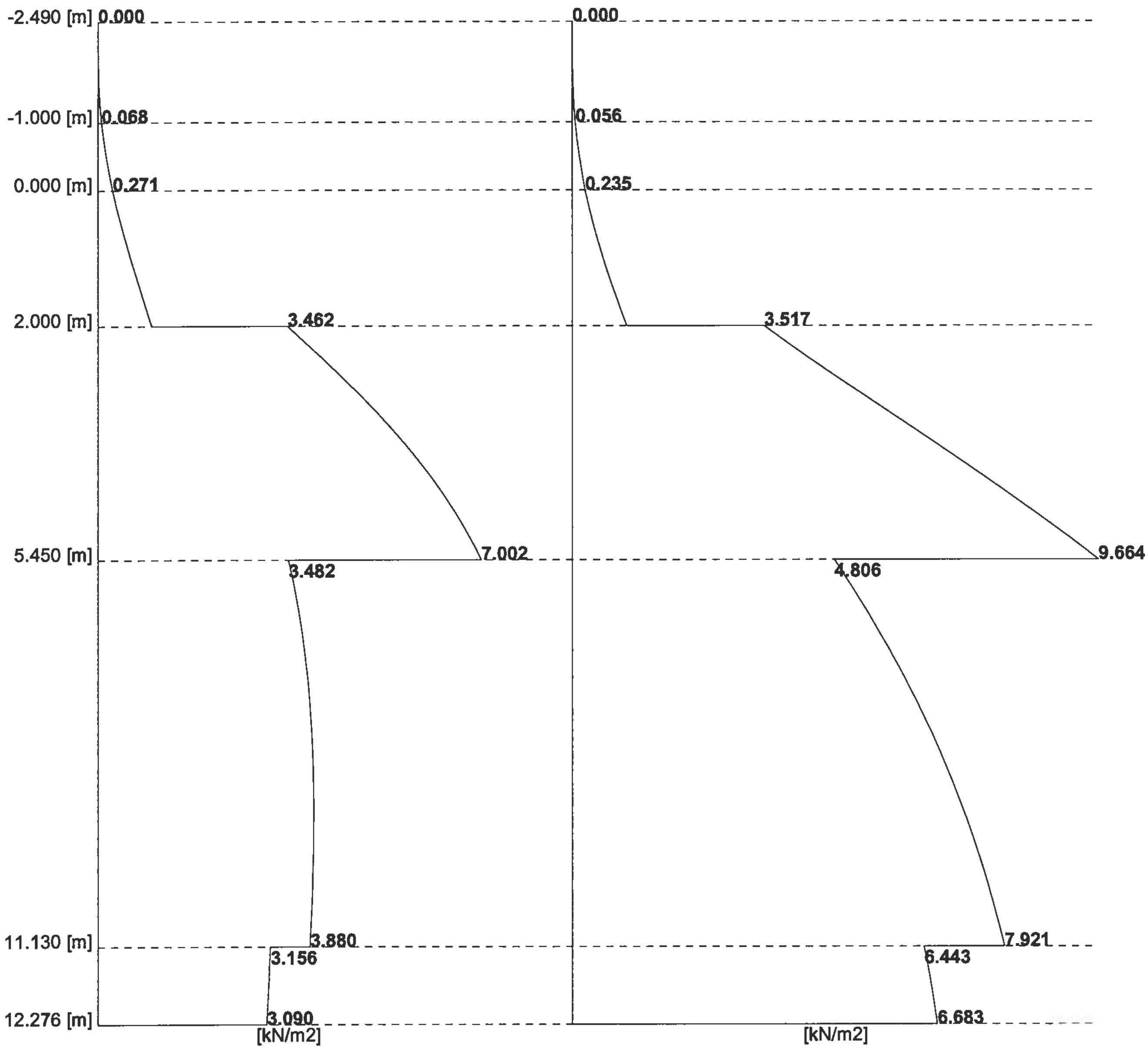
Earth Pressure Diagram



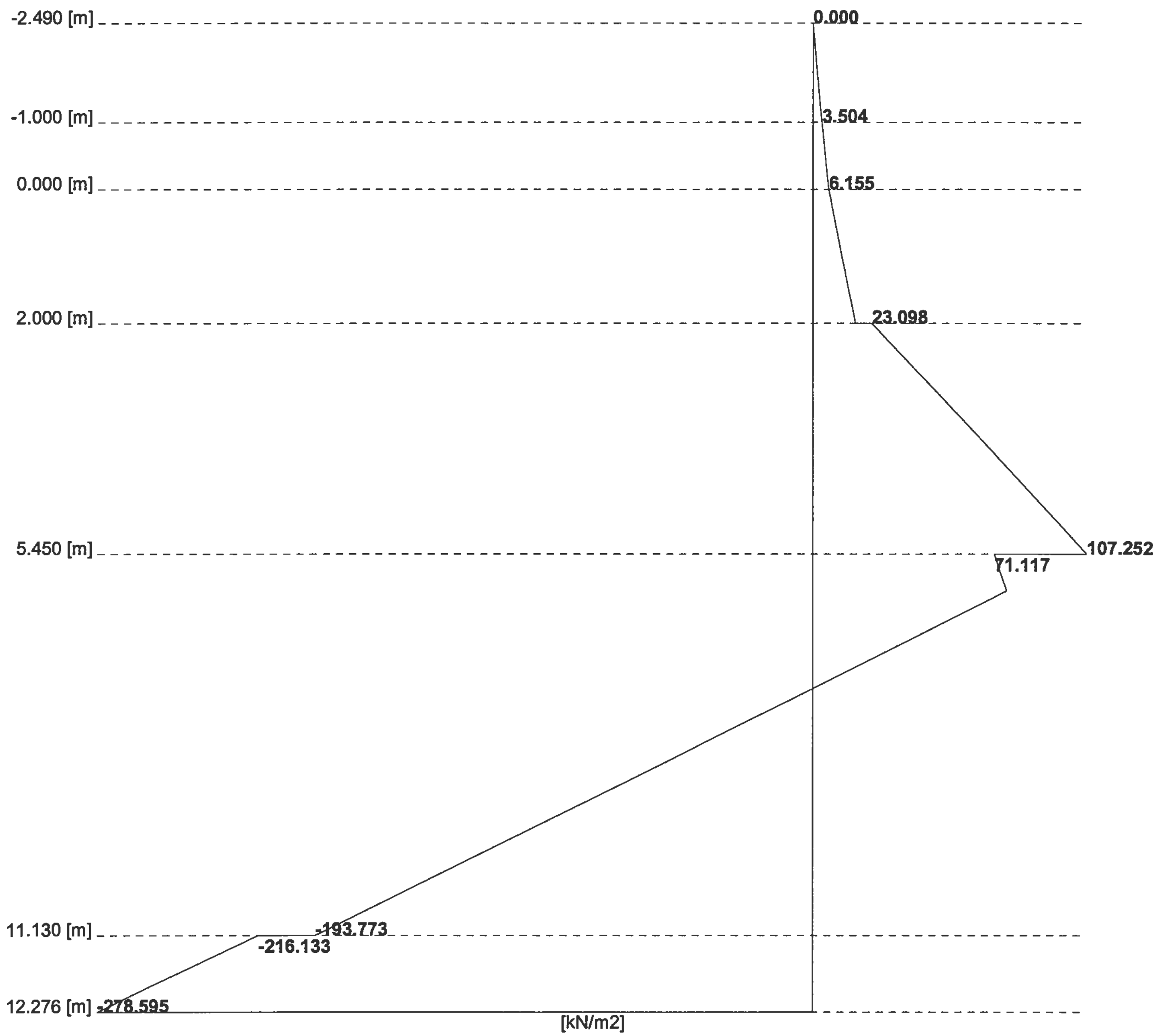
Water Pressure Diagram



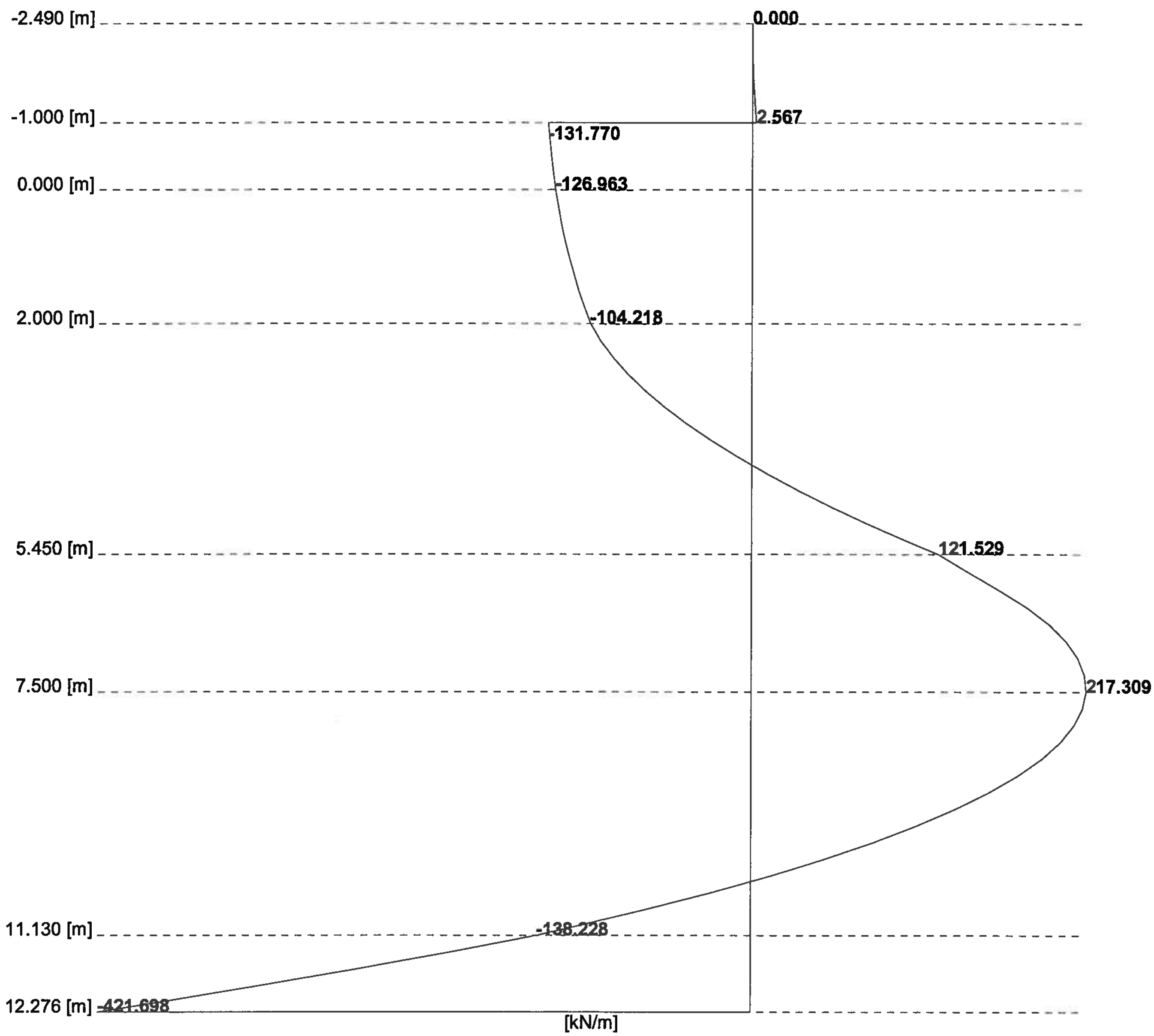
Boussinesq Diagram



Total Pressure Diagram



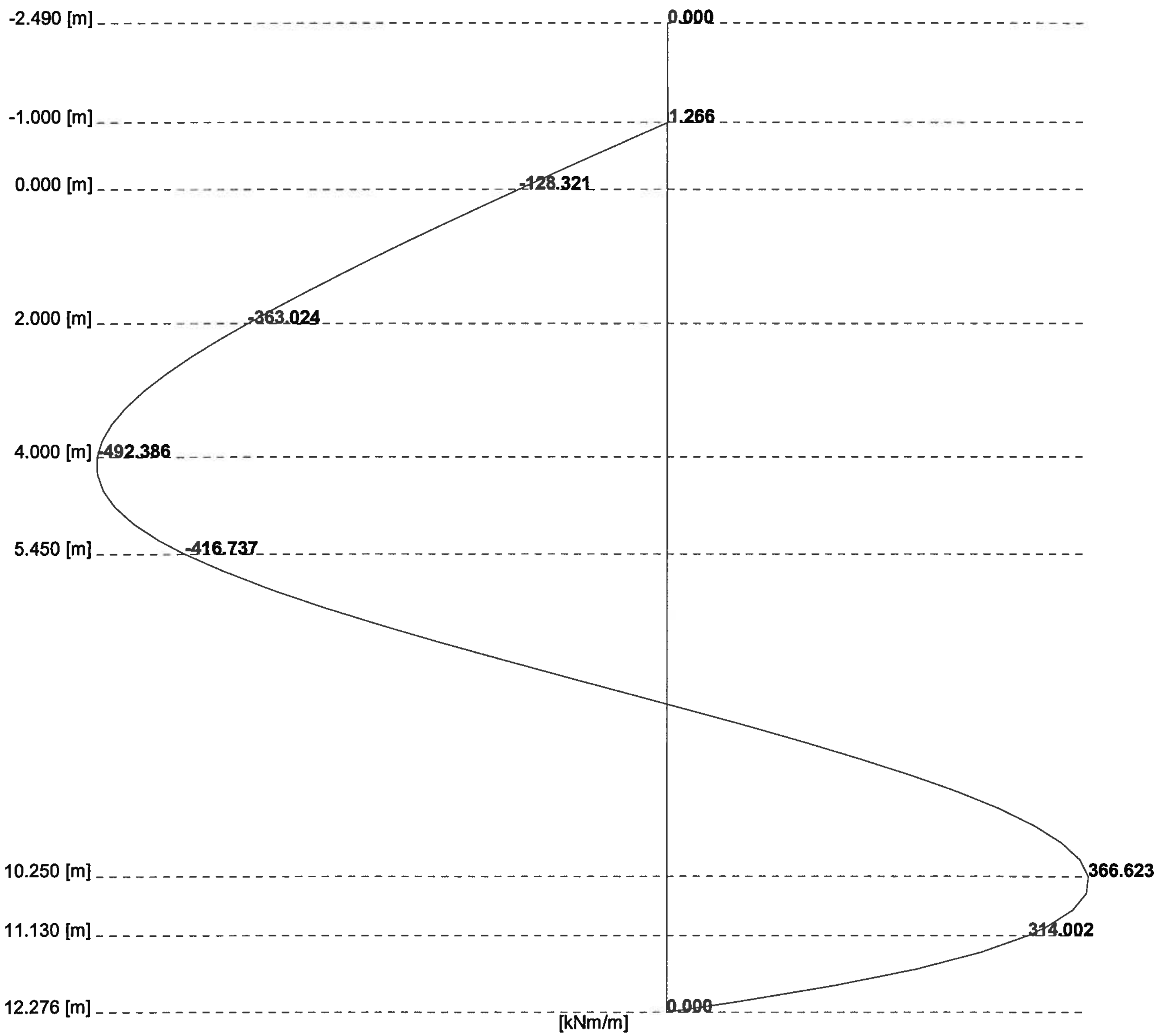
Cross Force Diagram



T_r = 1192 kN (FROM PREVIOUS CALCS)

T_f = 131.7 kN/m × 2.5m
= 329.3 kN × 1.5
= 493.9 kN < T_r OK.

Moment Diagram



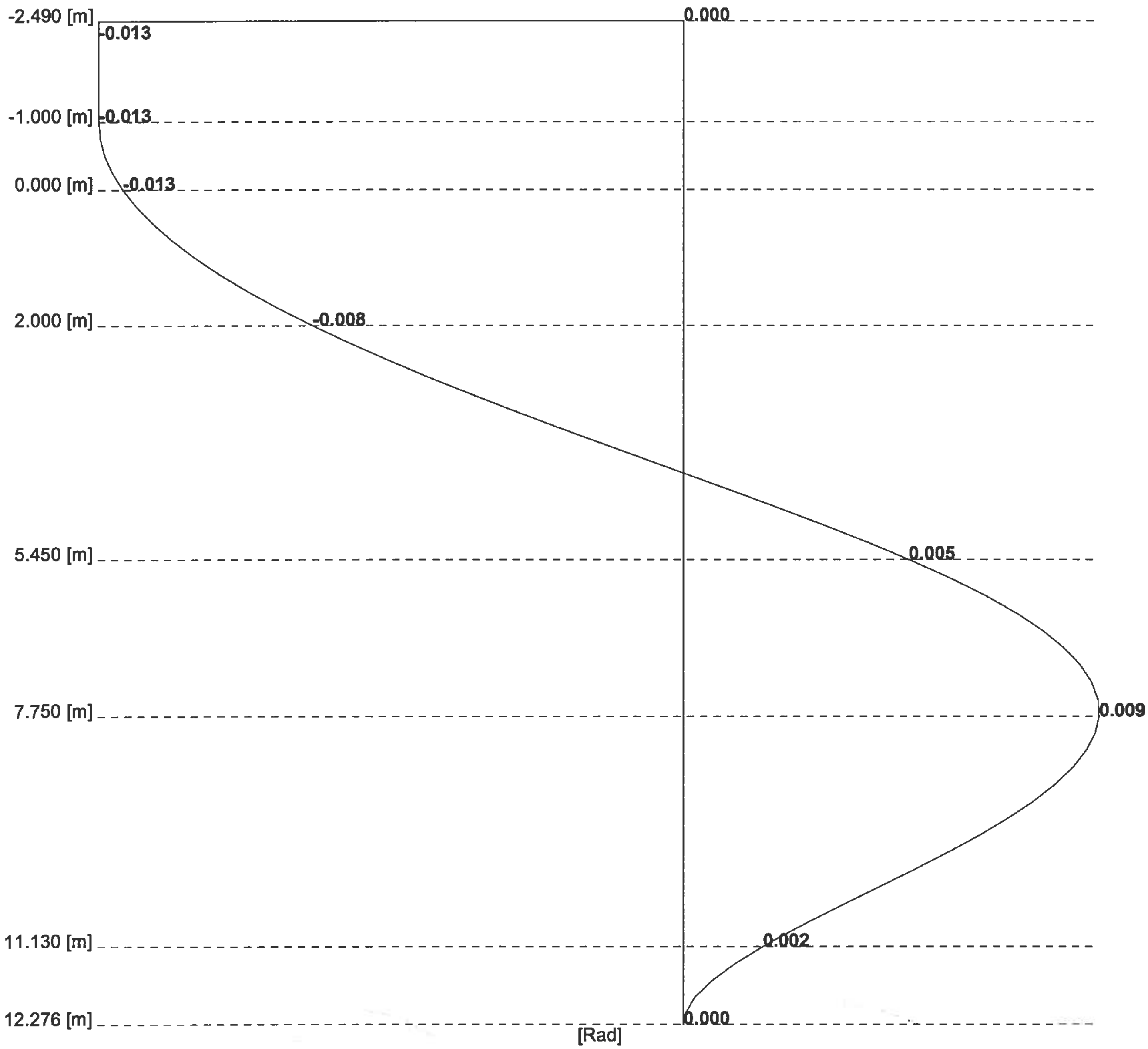
M_r = 702 kN·m (FROM PREVIOUS CALCULATION)

M_u = 492.4 kN·m.

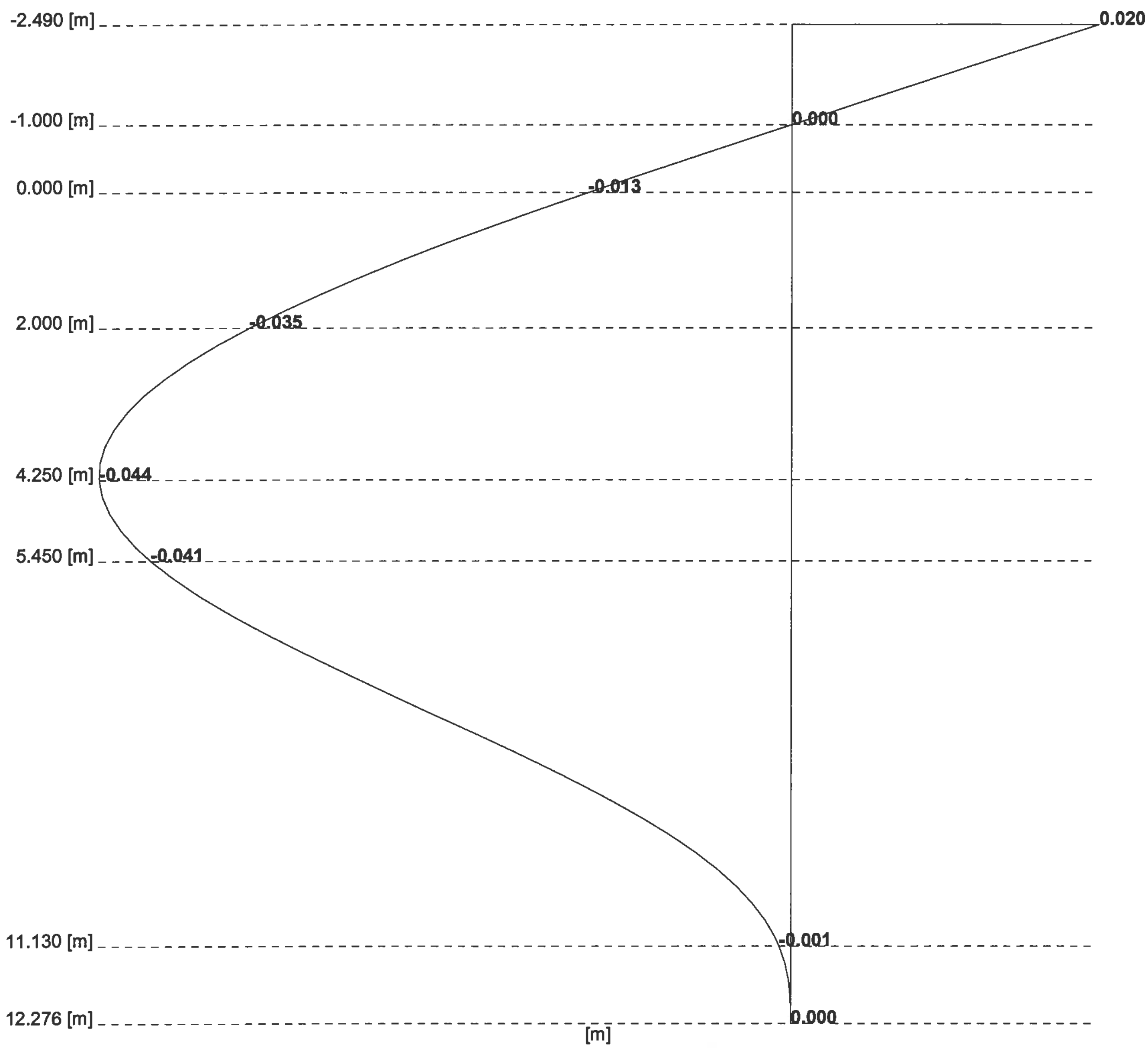
$$F.S. = \frac{702\ kN\cdot m}{492.4\ kN\cdot m} = 1.43 < 1.5 \quad \text{N.G.}$$

GIVEN THAT LOAD IS TEMPORARY AND ONE TIME ONLY, 1.43 F.S. IS ACCEPTABLE.

Rotation Diagram



Deflection Diagram



CORRODED WALL WITH SURCHARGE 6.5 METRES BEHIND WALL

The following ProSheet analysis is based on the existing wall conditions utilizing the AZ25 sheet pile section. AZ25 sheet pile section accounts for 1 mm of corrosion in web and flange of an AZ26 sheet pile section.

Surcharge of 54.1 kN/m from trailer wheels is applied directly behind the wall.

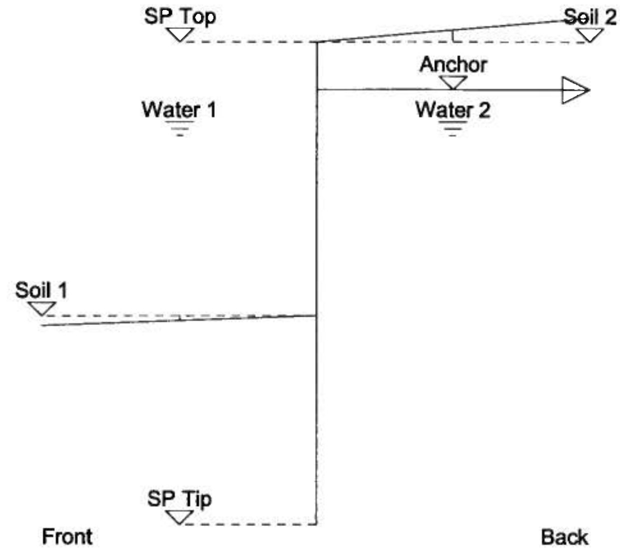
Soil properties used based on BH10 soil sample. Please see Table 2.1 for soil parameters.

Sheet Pile Design According to Blum-Method

Project Name:	Lower Churchill - Cartwright Ferry Landing Load Check
Date:	2010-09-27
Author:	Christopher Fudge
Company:	
Comment:	Analysis of the current ferry landing at Cartwright during offloading of equipment for Lower Churchill development.

Geodata

	Unit
Sheet Pile Top Level [m]	-2.490
Sheet Pile Tip Level [m]	12.464
Soil Level in Front [m]	6.000
Soil Level behind [m]	-2.490
Anchorlevel [m]	-1.000
Water Level in Front [m]	0.000
Water Level behind [m]	0.000
Soil Surface Inclination in Front [Deg]	-2.000
Soil Surface Inclination behind [Deg]	5.000
Caquot Surcharge in Front [kN/m2]	0.000
Caquot Surcharge behind [kN/m2]	0.000
Anchor Inclination [Deg]	0.000
Earth Support	Fixed



Soil Layers

Layers in Front

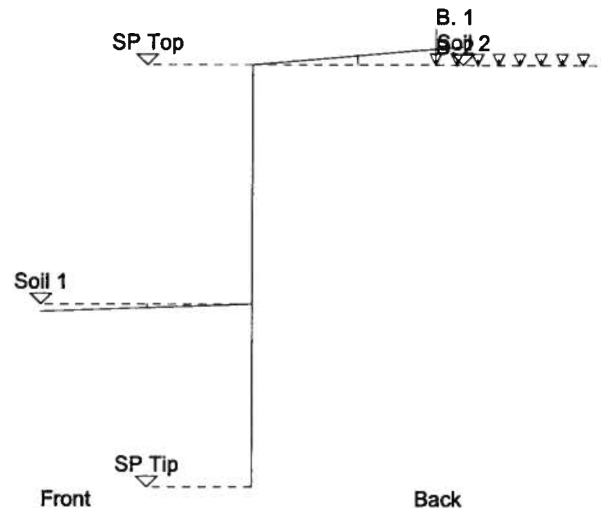
	Layer Tip [m]	Density Moist [kN/m3]	Density Submerged [kN/m3]	Kph	Phi [Deg]	Delta [Deg]	Cohesion [kN/m2]
Layer 1	40.000	10.000	20.000	3.056	32.000	0.000	0.000

Layers behind

	Layer Tip [m]	Density Moist [kN/m3]	Density Submerged [kN/m3]	Kph	Phi [Deg]	Delta [Deg]	Cohesion [kN/m2]
Layer 1	2.000	10.000	20.000	0.227	40.000	0.000	0.000
Layer 2	5.450	17.000	27.000	0.799	9.000	0.000	20.000
Layer 3	11.130	10.000	20.000	0.398	27.000	0.000	0.000
Layer 4	40.000	10.000	20.000	0.323	32.000	0.000	0.000

Boussinesq

	Distance Wall [m]	Width Surcharge [m]	Depth Surcharge [m]	Surcharge [kN/m2]
Bousq. 1	6.500	0.500	-2.490	324.000
Bousq. 2	6.500	12.000	-2.490	54.000



Pile Section

Name	AZ 25
Inertia [cm4/m]	52250.004
Modulus [cm3/m]	2455.000
Area [cm2/m]	185.000
Mass [kg/m2]	145.200
Steel Grade [N/mm2]	320.000
Requested Safety	1.500

All Values

Depth [m]	Deflection [m]	Rotation [Rad]	Cross Force [kN/m]	Moment [kNm/m]	Total Pressure [kN/m2]	Earth Pressure in Front [kN/m2]	behind [kN/m2]	Water Pressure [kN/m2]	Userdefined Pressure [kN/m2]	Bousq. 1 [kN/m2]	Bousq. 2 [kN/m2]
-2.490	0.021	-0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-2.240	0.017	-0.014	0.071	0.006	0.568	0.000	0.567	0.000	0.000	0.000	0.000
-2.240	0.017	-0.014	0.071	0.006	0.568	0.000	0.567	0.000	0.000	0.000	0.000
-1.990	0.014	-0.014	0.284	0.047	1.139	0.000	1.134	0.000	0.000	0.003	0.002
-1.990	0.014	-0.014	0.284	0.047	1.139	0.000	1.134	0.000	0.000	0.003	0.002
-1.740	0.010	-0.014	0.642	0.160	1.718	0.000	1.701	0.000	0.000	0.009	0.008
-1.740	0.010	-0.014	0.642	0.160	1.718	0.000	1.701	0.000	0.000	0.009	0.008
-1.490	0.007	-0.014	1.145	0.380	2.308	0.000	2.269	0.000	0.000	0.022	0.018
-1.490	0.007	-0.014	1.145	0.380	2.308	0.000	2.269	0.000	0.000	0.022	0.018
-1.240	0.003	-0.014	1.797	0.745	2.911	0.000	2.836	0.000	0.000	0.041	0.034
-1.240	0.003	-0.014	1.797	0.745	2.911	0.000	2.836	0.000	0.000	0.041	0.034
-1.000	0.000	-0.014	2.567	1.266	3.504	0.000	3.380	0.000	0.000	0.068	0.056
-1.000	0.000	-0.014	-131.770	1.266	3.504	0.000	3.380	0.000	0.000	0.068	0.056
-0.750	-0.003	-0.014	-130.814	-31.561	4.140	0.000	3.947	0.000	0.000	0.105	0.087
-0.750	-0.003	-0.014	-130.814	-31.561	4.140	0.000	3.947	0.000	0.000	0.105	0.087
-0.500	-0.007	-0.014	-129.698	-64.128	4.793	0.000	4.514	0.000	0.000	0.151	0.128
-0.500	-0.007	-0.014	-129.698	-64.128	4.793	0.000	4.514	0.000	0.000	0.151	0.128
-0.250	-0.010	-0.014	-128.415	-96.396	5.465	0.000	5.082	0.000	0.000	0.206	0.177
-0.250	-0.010	-0.014	-128.415	-96.396	5.465	0.000	5.082	0.000	0.000	0.206	0.177
0.000	-0.014	-0.013	-126.963	-128.321	6.155	0.000	5.649	0.000	0.000	0.271	0.235
0.000	-0.014	-0.013	-126.963	-128.321	6.155	0.000	5.649	0.000	0.000	0.271	0.235
0.250	-0.017	-0.013	-125.265	-159.857	7.429	0.000	6.783	0.000	0.000	0.343	0.303
0.250	-0.017	-0.013	-125.265	-159.857	7.429	0.000	6.783	0.000	0.000	0.343	0.303
0.500	-0.020	-0.013	-123.247	-190.927	8.720	0.000	7.917	0.000	0.000	0.422	0.380
0.500	-0.020	-0.013	-123.247	-190.927	8.720	0.000	7.917	0.000	0.000	0.422	0.380
0.750	-0.023	-0.012	-120.903	-221.453	10.025	0.000	9.051	0.000	0.000	0.508	0.466
0.750	-0.023	-0.012	-120.903	-221.453	10.025	0.000	9.051	0.000	0.000	0.508	0.466
1.000	-0.026	-0.012	-118.232	-251.352	11.343	0.000	10.186	0.000	0.000	0.598	0.559
1.000	-0.026	-0.012	-118.232	-251.352	11.343	0.000	10.186	0.000	0.000	0.598	0.559
1.250	-0.029	-0.011	-115.231	-280.542	12.672	0.000	11.320	0.000	0.000	0.692	0.660
1.250	-0.029	-0.011	-115.231	-280.542	12.672	0.000	11.320	0.000	0.000	0.692	0.660
1.500	-0.032	-0.010	-111.896	-308.939	14.009	0.000	12.454	0.000	0.000	0.788	0.767
1.500	-0.032	-0.010	-111.896	-308.939	14.009	0.000	12.454	0.000	0.000	0.788	0.767
1.750	-0.034	-0.010	-108.225	-336.461	15.354	0.000	13.588	0.000	0.000	0.885	0.880
1.750	-0.034	-0.010	-108.225	-336.461	15.354	0.000	13.588	0.000	0.000	0.885	0.880
2.000	-0.037	-0.009	-104.218	-363.024	16.703	0.000	14.723	0.000	0.000	0.983	0.998
2.000	-0.037	-0.009	-104.218	-363.024	23.098	0.000	16.119	0.000	0.000	3.462	3.517
2.250	-0.039	-0.008	-97.673	-388.292	29.263	0.000	21.515	0.000	0.000	3.801	3.947
2.250	-0.039	-0.008	-97.673	-388.292	29.263	0.000	21.515	0.000	0.000	3.801	3.947
2.500	-0.041	-0.007	-89.586	-411.732	35.433	0.000	26.911	0.000	0.000	4.134	4.388
2.500	-0.041	-0.007	-89.586	-411.732	35.433	0.000	26.911	0.000	0.000	4.134	4.388
2.750	-0.042	-0.006	-79.956	-432.957	41.602	0.000	32.307	0.000	0.000	4.457	4.839
2.750	-0.042	-0.006	-79.956	-432.957	41.602	0.000	32.307	0.000	0.000	4.457	4.839
3.000	-0.044	-0.005	-68.785	-451.581	47.766	0.000	37.703	0.000	0.000	4.768	5.295
3.000	-0.044	-0.005	-68.785	-451.581	47.766	0.000	37.703	0.000	0.000	4.768	5.295
3.250	-0.045	-0.004	-56.074	-467.221	53.920	0.000	43.100	0.000	0.000	5.066	5.755
3.250	-0.045	-0.004	-56.074	-467.221	53.920	0.000	43.100	0.000	0.000	5.066	5.755
3.500	-0.046	-0.003	-41.827	-479.490	60.061	0.000	48.496	0.000	0.000	5.349	6.216
3.500	-0.046	-0.003	-41.827	-479.490	60.061	0.000	48.496	0.000	0.000	5.349	6.216
3.750	-0.047	-0.002	-26.046	-488.006	66.186	0.000	53.892	0.000	0.000	5.617	6.677
3.750	-0.047	-0.002	-26.046	-488.006	66.186	0.000	53.892	0.000	0.000	5.617	6.677
4.000	-0.047	-0.001	-8.736	-492.386	72.291	0.000	59.288	0.000	0.000	5.869	7.134
4.000	-0.047	-0.001	-8.736	-492.386	72.291	0.000	59.288	0.000	0.000	5.869	7.134
4.250	-0.047	0.000	10.097	-492.247	78.376	0.000	64.684	0.000	0.000	6.104	7.588
4.250	-0.047	0.000	10.097	-492.247	78.376	0.000	64.684	0.000	0.000	6.104	7.588
4.500	-0.047	0.001	30.449	-487.211	84.438	0.000	70.080	0.000	0.000	6.322	8.036
4.500	-0.047	0.001	30.449	-487.211	84.438	0.000	70.080	0.000	0.000	6.322	8.036
4.750	-0.046	0.003	52.313	-476.897	90.477	0.000	75.477	0.000	0.000	6.523	8.477
4.750	-0.046	0.003	52.313	-476.897	90.477	0.000	75.477	0.000	0.000	6.523	8.477
5.000	-0.045	0.004	75.684	-460.928	96.491	0.000	80.873	0.000	0.000	6.709	8.909
5.000	-0.045	0.004	75.684	-460.928	96.491	0.000	80.873	0.000	0.000	6.709	8.909
5.250	-0.044	0.005	100.556	-438.930	102.479	0.000	86.269	0.000	0.000	6.878	9.333
5.250	-0.044	0.005	100.556	-438.930	102.479	0.000	86.269	0.000	0.000	6.878	9.333
5.450	-0.043	0.005	121.529	-416.737	107.252	0.000	90.586	0.000	0.000	7.002	9.664

Depth [m]	Deflection [m]	Rotation [Rad]	Cross Force [kN/m]	Moment [kNm/m]	Total Pressure [kN/m2]	Earth Pressure in Front [kN/m2]	behind [kN/m2]	Water Pressure [kN/m2]	Userdefined Pressure [kN/m2]	Bousq. 1 [kN/m2]	Bousq. 2 [kN/m2]
5.450	-0.043	0.005	121.529	-416.737	71.117	0.000	62.829	0.000	0.000	3.482	4.806
5.700	-0.042	0.006	139.590	-384.109	73.376	0.000	64.817	0.000	0.000	3.552	5.007
5.700	-0.042	0.006	139.590	-384.109	73.376	0.000	64.817	0.000	0.000	3.552	5.007
5.950	-0.040	0.007	158.215	-346.895	75.623	0.000	66.804	0.000	0.000	3.616	5.203
5.950	-0.040	0.007	158.215	-346.895	75.623	0.000	66.804	0.000	0.000	3.616	5.203
6.000	-0.040	0.007	162.008	-338.889	76.071	0.000	67.202	0.000	0.000	3.627	5.241
6.000	-0.040	0.007	162.008	-338.889	76.071	0.000	67.202	0.000	0.000	3.627	5.241
6.250	-0.038	0.008	179.394	-296.146	63.022	-15.281	69.190	0.000	0.000	3.683	5.430
6.250	-0.038	0.008	179.394	-296.146	63.022	-15.281	69.190	0.000	0.000	3.683	5.430
6.500	-0.036	0.009	193.517	-249.464	49.960	-30.562	71.177	0.000	0.000	3.731	5.613
6.500	-0.036	0.009	193.517	-249.464	49.960	-30.562	71.177	0.000	0.000	3.731	5.613
6.750	-0.034	0.009	204.373	-199.660	36.887	-45.842	73.165	0.000	0.000	3.774	5.790
6.750	-0.034	0.009	204.373	-199.660	36.887	-45.842	73.165	0.000	0.000	3.774	5.790
7.000	-0.031	0.010	211.959	-147.551	23.801	-61.123	75.153	0.000	0.000	3.811	5.961
7.000	-0.031	0.010	211.959	-147.551	23.801	-61.123	75.153	0.000	0.000	3.811	5.961
7.250	-0.029	0.010	216.272	-93.953	10.704	-76.404	77.140	0.000	0.000	3.843	6.125
7.250	-0.029	0.010	216.272	-93.953	10.704	-76.404	77.140	0.000	0.000	3.843	6.125
7.500	-0.026	0.010	217.309	-39.687	-2.404	-91.685	79.128	0.000	0.000	3.870	6.283
7.500	-0.026	0.010	217.309	-39.687	-2.404	-91.685	79.128	0.000	0.000	3.870	6.283
7.750	-0.024	0.010	215.069	14.428	-15.523	-106.966	81.115	0.000	0.000	3.892	6.435
7.750	-0.024	0.010	215.069	14.428	-15.523	-106.966	81.115	0.000	0.000	3.892	6.435
8.000	-0.021	0.010	209.547	67.573	-28.652	-122.247	83.103	0.000	0.000	3.910	6.581
8.000	-0.021	0.010	209.547	67.573	-28.652	-122.247	83.103	0.000	0.000	3.910	6.581
8.250	-0.019	0.010	200.741	118.928	-41.792	-137.527	85.091	0.000	0.000	3.924	6.721
8.250	-0.019	0.010	200.741	118.928	-41.792	-137.527	85.091	0.000	0.000	3.924	6.721
8.500	-0.017	0.009	188.650	167.670	-54.941	-152.808	87.078	0.000	0.000	3.934	6.855
8.500	-0.017	0.009	188.650	167.670	-54.941	-152.808	87.078	0.000	0.000	3.934	6.855
8.750	-0.014	0.009	173.269	212.979	-68.100	-168.089	89.066	0.000	0.000	3.941	6.982
8.750	-0.014	0.009	173.269	212.979	-68.100	-168.089	89.066	0.000	0.000	3.941	6.982
9.000	-0.012	0.008	154.599	254.031	-81.268	-183.370	91.054	0.000	0.000	3.945	7.104
9.000	-0.012	0.008	154.599	254.031	-81.268	-183.370	91.054	0.000	0.000	3.945	7.104
9.250	-0.010	0.008	132.635	290.003	-94.444	-198.651	93.041	0.000	0.000	3.945	7.220
9.250	-0.010	0.008	132.635	290.003	-94.444	-198.651	93.041	0.000	0.000	3.945	7.220
9.500	-0.008	0.007	107.375	320.073	-107.629	-213.932	95.029	0.000	0.000	3.944	7.330
9.500	-0.008	0.007	107.375	320.073	-107.629	-213.932	95.029	0.000	0.000	3.944	7.330
9.750	-0.006	0.006	78.819	343.416	-120.821	-229.212	97.017	0.000	0.000	3.939	7.435
9.750	-0.006	0.006	78.819	343.416	-120.821	-229.212	97.017	0.000	0.000	3.939	7.435
10.000	-0.005	0.006	46.964	359.208	-134.022	-244.493	99.004	0.000	0.000	3.933	7.535
10.000	-0.005	0.006	46.964	359.208	-134.022	-244.493	99.004	0.000	0.000	3.933	7.535
10.250	-0.004	0.005	11.807	366.623	-147.229	-259.774	100.992	0.000	0.000	3.924	7.629
10.250	-0.004	0.005	11.807	366.623	-147.229	-259.774	100.992	0.000	0.000	3.924	7.629
10.500	-0.003	0.004	-26.652	364.837	-160.444	-275.055	102.979	0.000	0.000	3.914	7.718
10.500	-0.003	0.004	-26.652	364.837	-160.444	-275.055	102.979	0.000	0.000	3.914	7.718
10.750	-0.002	0.003	-68.415	353.022	-173.665	-290.336	104.967	0.000	0.000	3.902	7.802
10.750	-0.002	0.003	-68.415	353.022	-173.665	-290.336	104.967	0.000	0.000	3.902	7.802
11.000	-0.001	0.002	-113.485	330.353	-186.892	-305.617	106.955	0.000	0.000	3.888	7.882
11.000	-0.001	0.002	-113.485	330.353	-186.892	-305.617	106.955	0.000	0.000	3.888	7.882
11.130	-0.001	0.002	-138.228	314.002	-193.773	-313.563	107.988	0.000	0.000	3.880	7.921
11.130	-0.001	0.002	-138.228	314.002	-216.133	-313.563	87.831	0.000	0.000	3.156	6.443
11.380	0.000	0.001	-193.963	272.549	-229.751	-328.843	89.448	0.000	0.000	3.143	6.502
11.380	0.000	0.001	-193.963	272.549	-229.751	-328.843	89.448	0.000	0.000	3.143	6.502
11.630	0.000	0.001	-253.104	216.736	-243.374	-344.124	91.064	0.000	0.000	3.129	6.557
11.630	0.000	0.001	-253.104	216.736	-243.374	-344.124	91.064	0.000	0.000	3.129	6.557
11.880	0.000	0.000	-315.651	145.713	-257.001	-359.405	92.681	0.000	0.000	3.115	6.609
11.880	0.000	0.000	-315.651	145.713	-257.001	-359.405	92.681	0.000	0.000	3.115	6.609
12.130	0.000	0.000	-381.605	58.627	-270.632	-374.686	94.298	0.000	0.000	3.099	6.657
12.130	0.000	0.000	-381.605	58.627	-270.632	-374.686	94.298	0.000	0.000	3.099	6.657
12.276	0.000	0.000	-421.698	0.000	-278.595	-383.610	95.242	0.000	0.000	3.090	6.683

Extremal Values

	z Min [m]	Min	z Max [m]	Max
Deflection [m]	4.250	-0.047	-2.490	0.021
Cross Force [kN/m]	12.276	-421.698	7.500	217.309
Moment [kNm/m]	4.000	-492.386	10.250	366.623

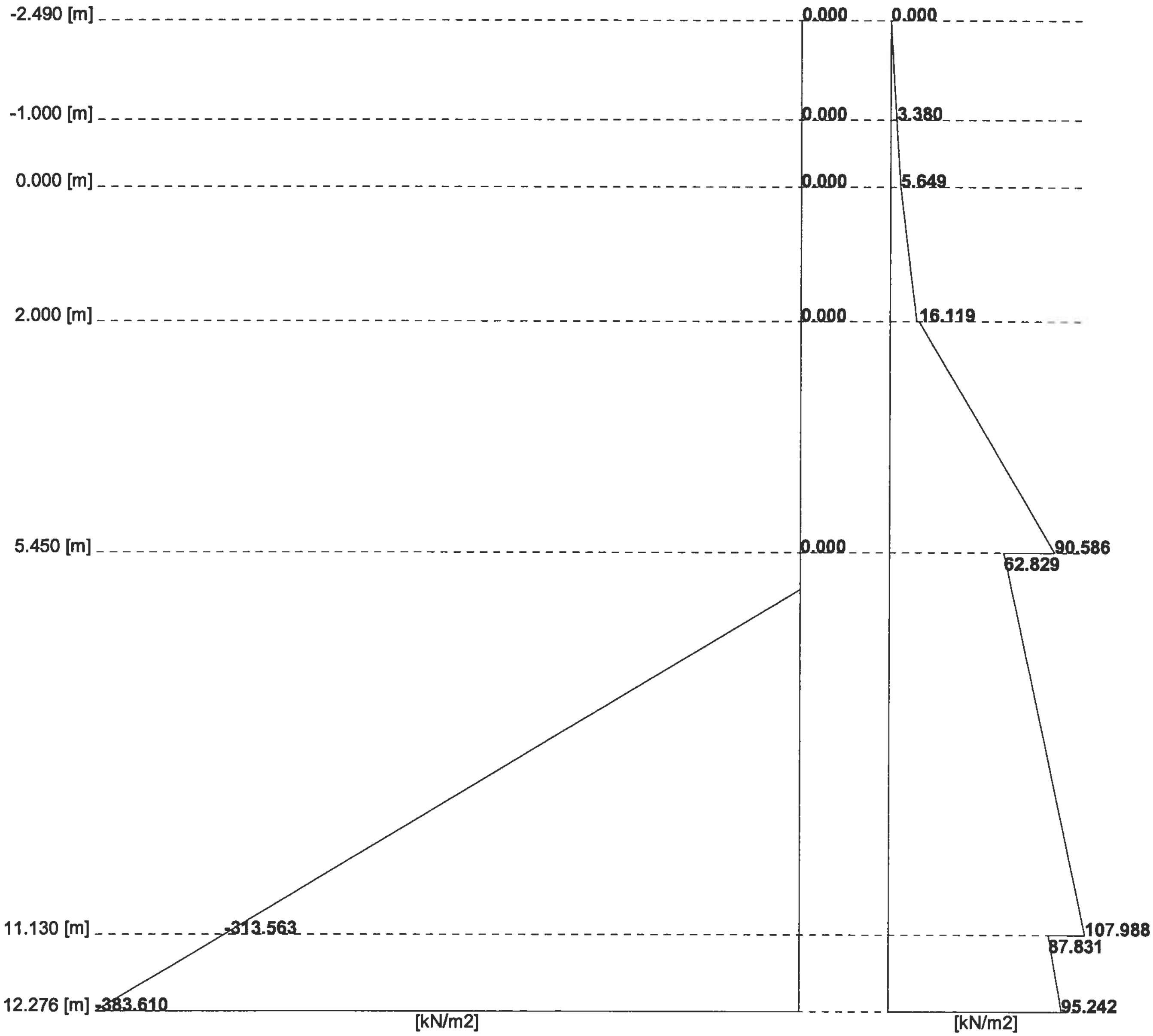
Pile Check

		Depth [m]
Name	AZ 25	
Inertia [cm4/m]	52250.004	
Modulus [cm3/m]	2455.000	
Area [cm2/m]	185.000	
Mass [kg/m2]	145.200	
Steel Grade [N/mm2]	320.000	
Minimal Moment [kNm/m]	-492.386	4.000
Maxmimal Moment [kNm/m]	366.623	10.250
Normal Forces at Max. Moment [kN/m]	0.000	4.000
Normal Forces at Min. Moment [kN/m]	0.000	10.250
Deflection at Min. Moment [m]	-0.047	4.000
Deflection at Max. Moment [m]	-0.004	10.250
Min. Stress at Min. Moment [N/mm2]	-200.564	4.000
Max. Stress at Min. Moment [N/mm2]	200.564	4.000
Min. Stress at Max. Moment [N/mm2]	-149.337	10.250
Max. Stress at Max. Moment [N/mm2]	149.337	10.250
Safety > Req. Safety = 1.500	1.595	
Sheet Pile Top Level [m]	-2.490	
Sheet Pile Tip Level [m]	12.464	
Sheet Pile Length [m]	14.954	
Included OverLength [m]	0.188	
Vertical Equilibrium [kN/m]	0.000	
Anchor Force (horiz.) [kN/m]	-134.337	

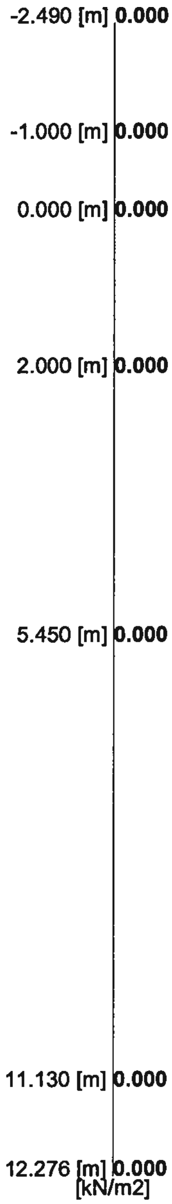
→ > 1.5 USING 320 MPa STEEL.

REQ'D TIP EL. = -12.46 - 4 = -16.46m
EXISTING TIP EL. = -18 m OK.

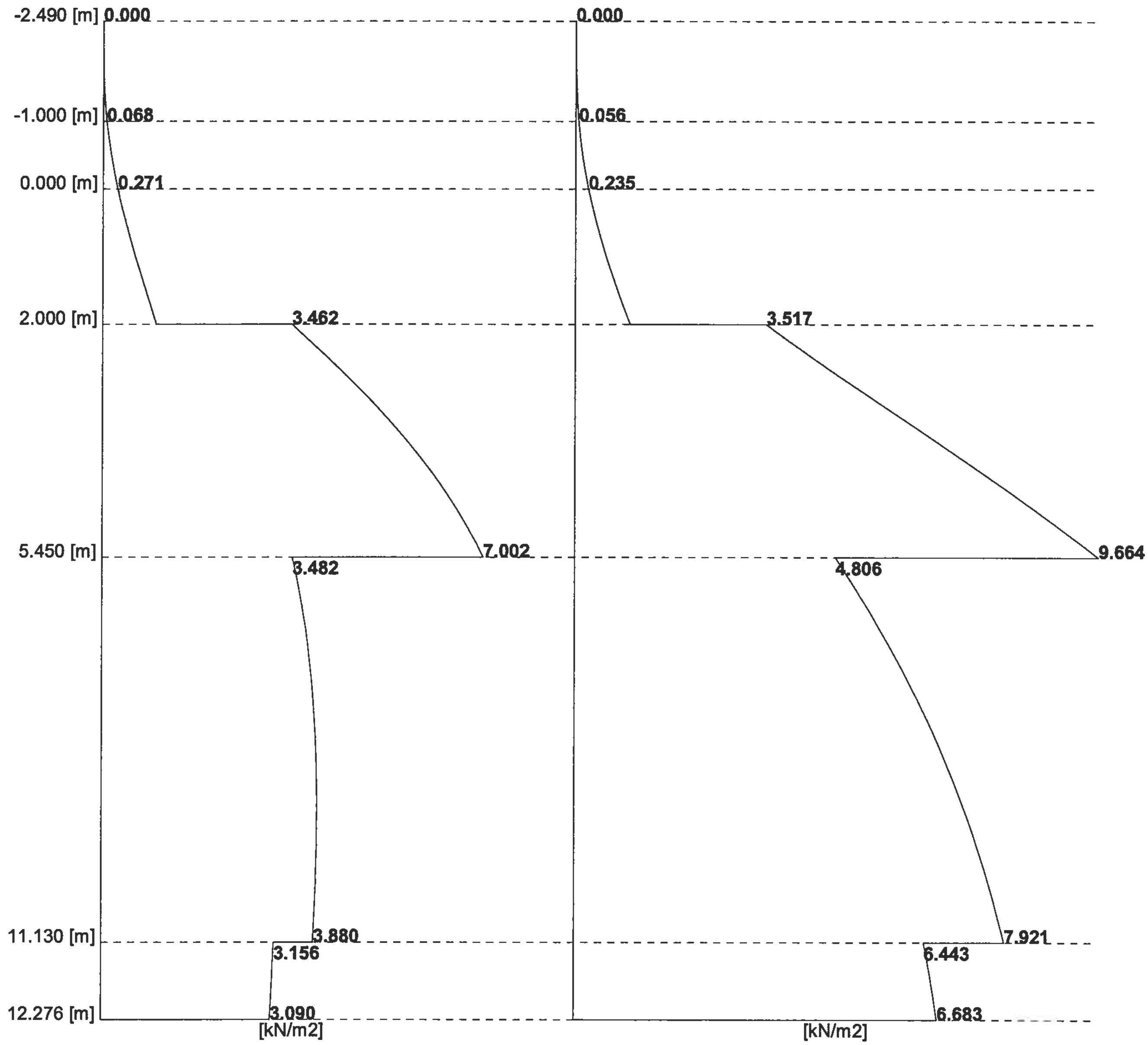
Earth Pressure Diagram



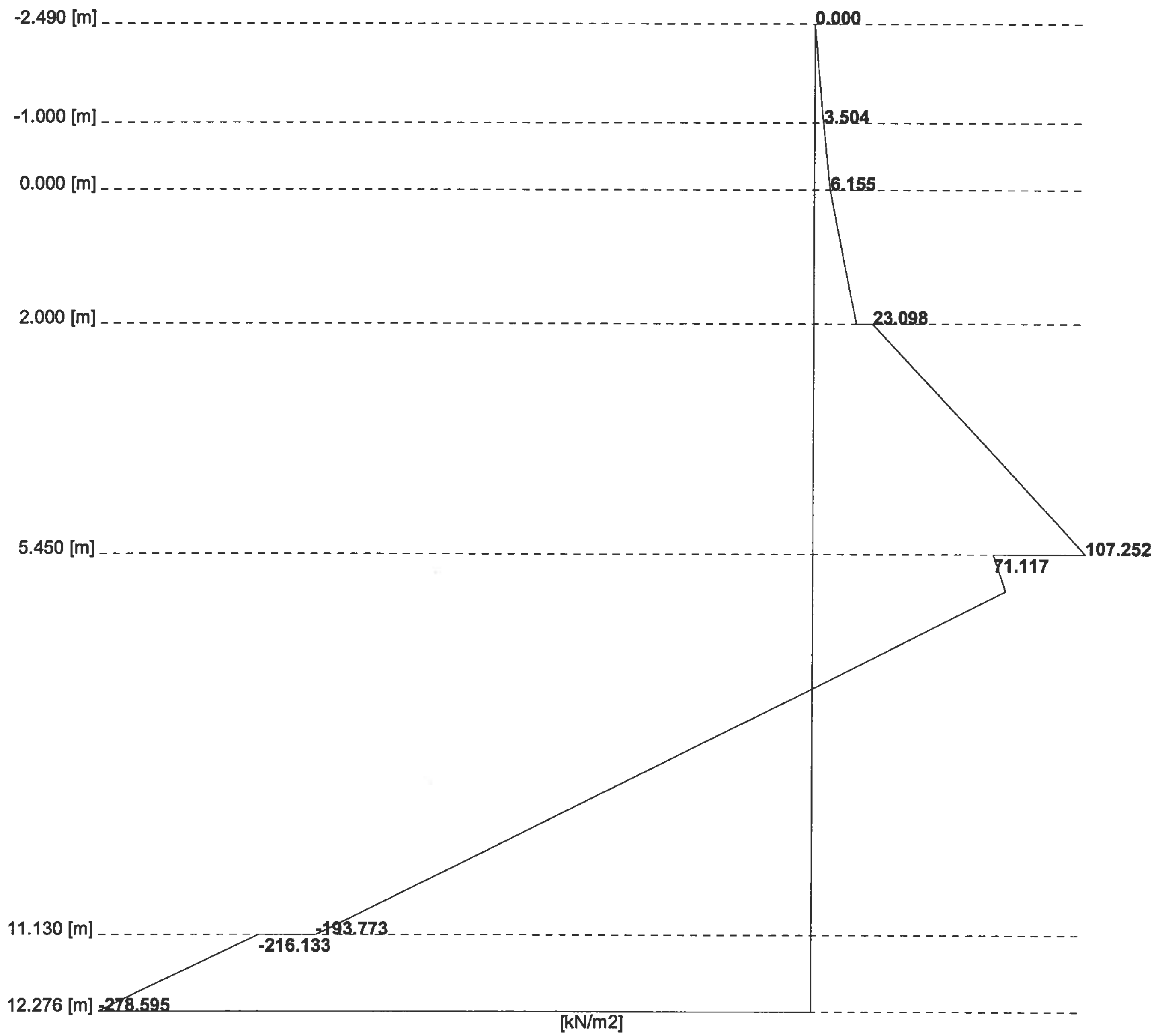
Water Pressure Diagram



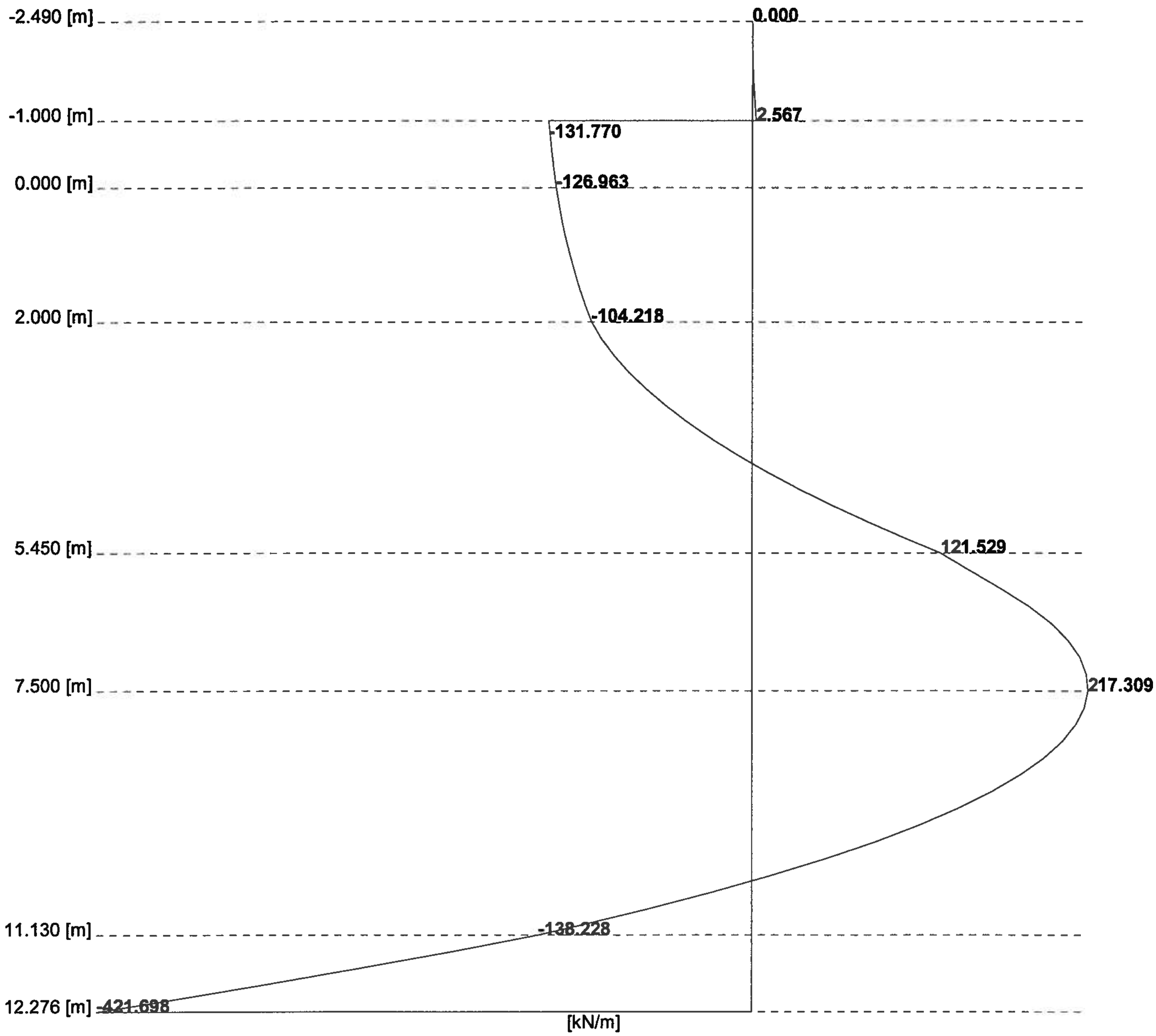
Boussinesq Diagram



Total Pressure Diagram

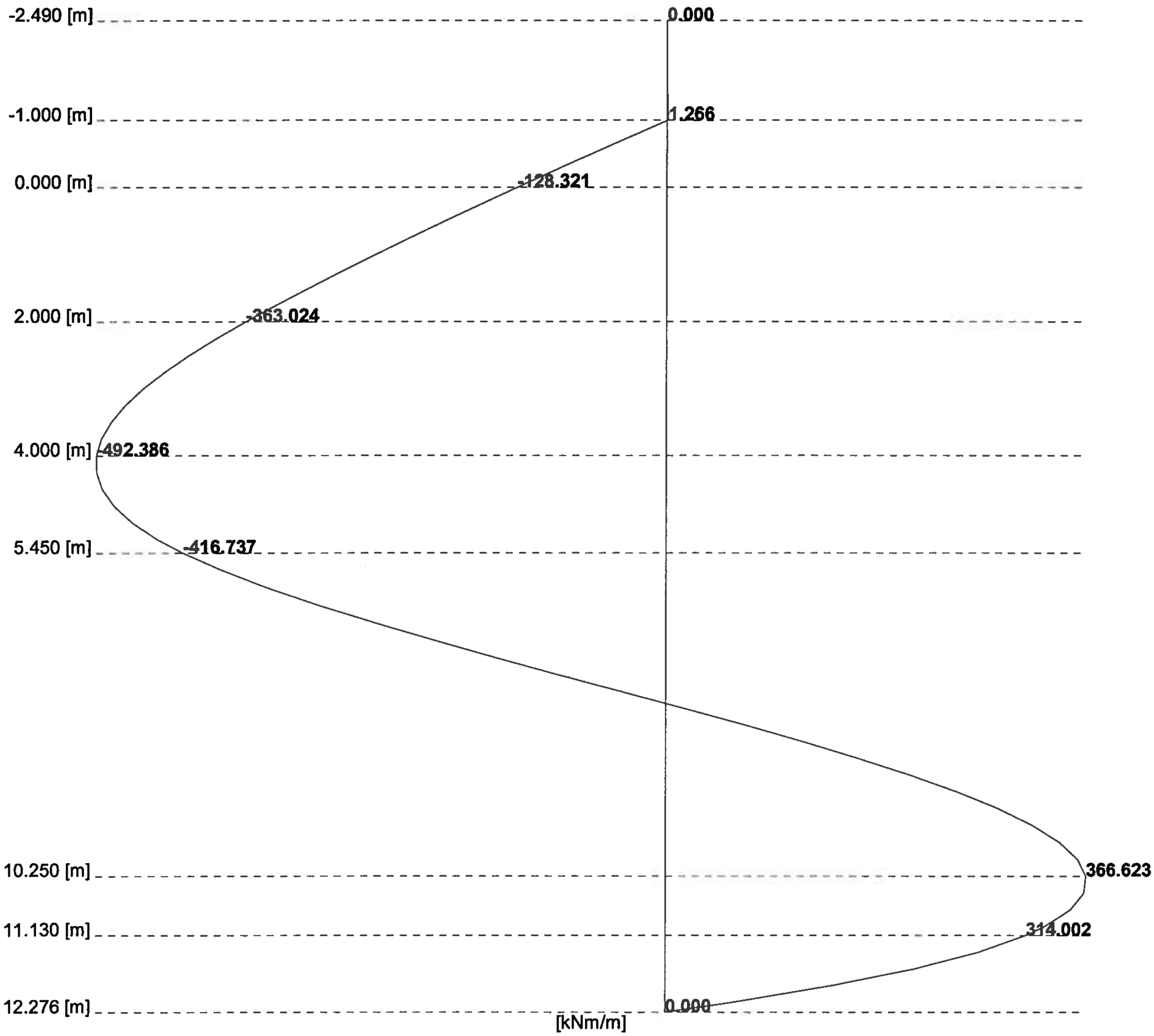


Cross Force Diagram



SAME AS PREVIOUS.

Moment Diagram



$M_r = \phi S F_y$

$M_r = 0.9(2500)(300)$

$= 675$ kN·m.

$F_y = 300$ MPa.

$S = 2500\ cm^3$ (AZ25)

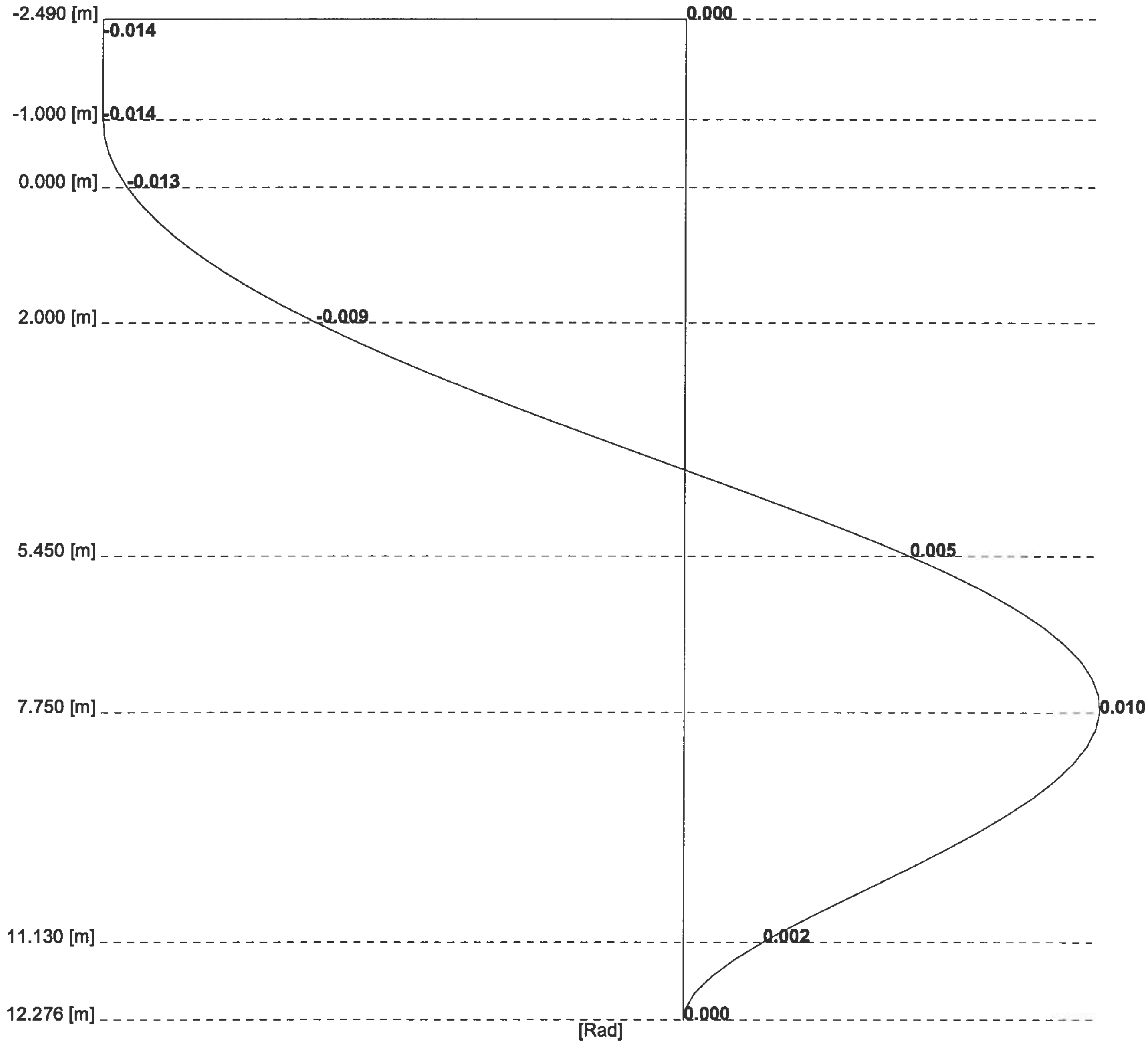
$\phi = 0.9$

$M_u = 492.4$ kN·m.

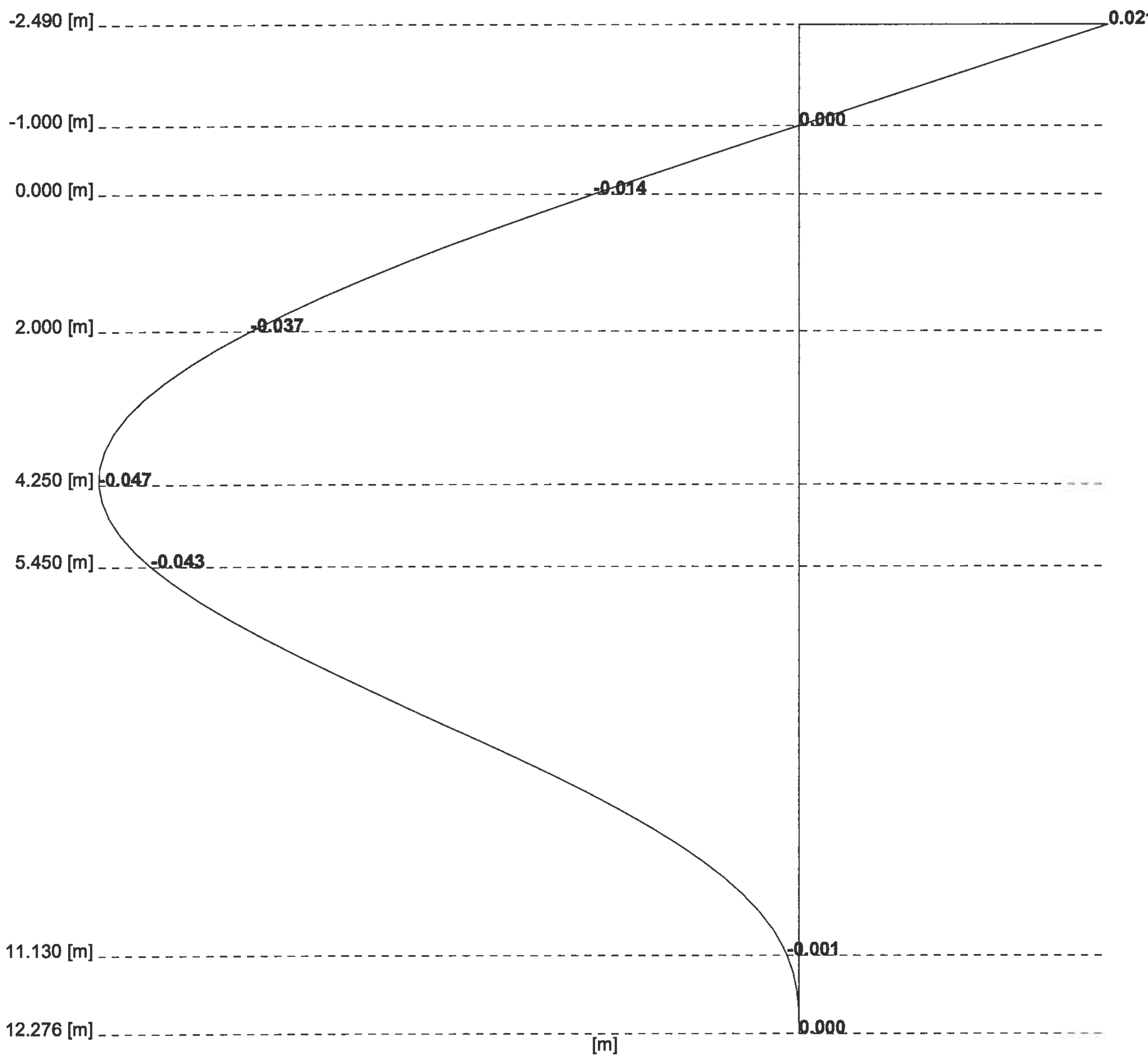
$F.S. = \frac{675}{492.4} = 1.37 < 1.5$

HOWEVER, GIVEN TEMPORARY ONE TIME NATURE OF THE LOAD, F.S. >1.3 IS ACCEPTABLE.

Rotation Diagram



Deflection Diagram



APPENDIX B

MABEY JOHNSON CORRESPONDANCE

Subject: RE: Proposal for Heavy Load Transport across the Paradise River Bridge

---

From: Smith, Todd
Sent: October 21, 2010 2:46 PM
To: David Gillard
Cc: Graham Wilkinson (E-mail); Nick Iannetta; McCarthy, Terry
Subject: RE: Proposal for Heavy Load Transport across the Paradise River Bridge

David,
Thanks for the information. We will have to give some thought to the idea of intermediate supports as these would have to be permanent - although the work is being done to determine the transportation limitations for the project construction, we will also have to maintain this ability for the life of the operation of the facility in case of failure of any of the heavy components.

Thanks again,
Todd

From: David Gillard [mailto:David.Gillard@mabeybridge.co.uk]
Sent: October 21, 2010 2:41 PM
To: Smith, Todd
Cc: Graham Wilkinson (E-mail); Nick Iannetta; McCarthy, Terry
Subject: RE: Proposal for Heavy Load Transport across the Paradise River Bridge

Todd,

The 205 tonnes in my earlier email was for cargo only, so the total weight of cargo plus trailer would be about 253 tonnes. The safety factor that I gave for that load was with the tractor pulling the trailer, giving a total combined load of about 280 tonnes. At this load, with a factor of safety against failure of about 1.31, which is lower than we like to go, we would have some concerns that deformation could occur local to some of the holes (for bolts or "pegs") in the bridge, which might give rise to damage to the galvanised coating in these areas. However, we would not expect the future performance of the bridge, in terms of either load capacity or fatigue life, to be adversely affected. We would feel more comfortable if the factor of safety did not go below 1.36 (an overstress of 25%). To achieve this, the payload would need to be reduced to 190 tonnes, with cargo plus trailer then being about 238 tonnes and the total with the tractor unit being about 265 tonnes.

Further to Nick Iannetta's earlier email, I had a look at Limit State analysis to BS5400, but this didn't seem to help.

One other thought has come up following discussions with some of my colleagues - would it be possible to construct some temporary supports beneath the bridge? If so, we would have to think about how loads could be transferred out of the bridge and into these supports satisfactorily, as we would be dealing, in effect, with a multi-span continuous Delta, which is not something that we claim to be able to do.

Regards,

David

-----Original Message-----
From: Smith, Todd [mailto:Todd.Smith@snclavalin.com]
Sent: 21 October 2010 14:26
To: David Gillard
Cc: Graham Wilkinson (E-mail); Nick Iannetta; McCarthy, Terry
Subject: RE: Proposal for Heavy Load Transport across the Paradise River Bridge

David,
After some review and discussion, we have decided not to pursue further investigation into the bridge capacity under Part 14 of CSA S6. We will use the information and safety factors as you presented them earlier for the work we are performing at this time, with the understanding that there is no way to strengthen the bridge, and we appreciate your assistance to this point.

However, could you clarify a couple of points that you made in your earlier correspondence. Please confirm that the 205 tonnes allowable cargo weight is for the cargo only, and thus the total weight including the trailer would be 253 tonnes? Also, could you confirm if the safety factor for this load is with the tractor pulling the trailer or with the trailer being winched?

Thanks,
Todd

From: Smith, Todd
Sent: September 30, 2010 10:01 AM
To: 'David Gillard'
Cc: Graham Wilkinson (E-mail); Nick Iannetta; McCarthy, Terry
Subject: RE: Proposal for Heavy Load Transport across the Paradise River Bridge

David,
Please submit a proposal with a fee for determining the live load capacity factor in accordance with Part 14 of CSA S6. We would like for this to be completed within two weeks of acceptance of your proposal (this would have to be forwarded to our client for approval).
The load will not be crossing any time soon, as this work is being performed as part of a study to determine any issues and upgrades that might be required to the proposed transport route for an upcoming project.
I am available to assist you in interpreting the code.

Also, I have a couple of additional questions. Could you confirm that the 205 tonnes cargo weight is for the cargo only, and thus the total weight including the trailer would be 253 tonnes? Could you confirm if the safety factor is with the tractor pulling the trailer of with the trailer being winched?

Thanks,
Todd

From: David Gillard [mailto:David.Gillard@mabeybridge.co.uk]
Sent: September 29, 2010 2:22 PM

To: Smith, Todd
Cc: Graham Wilkinson (E-mail); Nick Iannetta
Subject: RE: Proposal for Heavy Load Transport across the Paradise River Bridge

Todd,

Sorry for the delay in replying - I haven't had a chance to get to grips with this yet. I did scan through your email and the attachment when it first came in and I have the impression that it won't be a five minute job as it's all new to me. While we're happy to give some advice free of charge, I feel that we might have reached the point where we will have to charge you for any further work. Please let us know whether this will be acceptable and, if so, my manager, Nick Iannetta, will be in touch with you to discuss the details.

Please can you also let us know the timescale involved for sorting this out - when would the heavy load be crossing, if it is possible for it to do so?

Regards,

David

-----Original Message-----
From: Smith, Todd [mailto:Todd.Smith@snclavalin.com]
Sent: 27 September 2010 13:28
To: David Gillard; grahamwilkinson@rogers.com
Cc: Eric Snelgrove; Nick Iannetta; McCarthy, Terry; Hugh Blunt
Subject: RE: Proposal for Heavy Load Transport across the Paradise River Bridge

David,
I have attached some of the relevant sections of the code as they relate to the load factors for evaluation. The factors depend on a number of things, including system and element behaviour, and inspection, which are used to determine a reliability index, which in turn is used to determine the load factors from various tables. For this case, I see the system behaviour as S1 because it is essentially a two girder system. I see the element behaviour as E3 for a ductile system (although maybe this should be E1 if bolt shear governs). I see the inspection level to be INSP2. This then yields a target reliability index, beta, for PC traffic as 2.75 from Table 14.6. The dead load factor depends on the item itself, where factory produced components fall under category D1, the dead load factor is then 1.06 from Table 14.7. The live load factor is 1.13 from Table 14.12. The resistance adjustment factor in Table 14.15 depends on the failure mechanism - if it is failure by compression or tension on the gross section (assuming truss behaviour) then U=1.01; if it is in the bolts then U=1.2. The dynamic load allowance (impact factor) is taken from article 14.9.3 depending on the assumed speed of travel. The live load capacity factor is then calculated using article 14.15.2.1. Note that A is ice accretion, which I think can be taken as zero for this evaluation - we would have to re-evaluate if we actually encounter this at a later date. Please verify the assumptions above.
If you have any questions, please advise.
Regards,
Todd

From: David Gillard [mailto:David.Gillard@mabeybridge.co.uk]

Sent: September 24, 2010 8:13 AM
To: Smith, Todd; grahamwilkinson@rogers.com
Cc: Eric Snelgrove; Nick Iannetta; McCarthy, Terry; Hugh Blunt
Subject: RE: Proposal for Heavy Load Transport across the Paradise River Bridge

Todd / Graham,

1) My assessment of "Factor of Safety" is based on the total of the unfactored dead load and live load effects compared to the capacity of the structure. Note that live load effects include a factor of 1.1 for the combined effects of dynamic impact and maldistribution (eccentricity), i.e. they assume that the load passes dead slow down the centreline of the bridge, but do not include load factors. We establish the strength of our bridges by full scale testing. In simplistic terms, we define the capacity of one of our bridges as being the failure bending moment or shear divided by 1.7, which is the "Factor of Safety". These capacities are what we use to determine the construction required for "normal" civilian loadings (we also look at fatigue, deflection and other "service" requirements as necessary). For exceptional loads, such as this one, we allow an "overstress" on the calculated capacities, resulting in a reduced factor of safety. We commonly allow an overstress of 1.133, which equates to a factor of safety of 1.5; if we are confident that the load is accurately defined and that the crossing will be well controlled we sometimes let the overstress go as high as 1.25 or, exceptionally, 1.3 - a factor of safety of 1.31. While we don't feel that load factor design is appropriate for our pinned panel "Bailey" type bridges, it is more appropriate to Delta as used at Paradise River. If you let me have the appropriate load factors I'll have a look and see what answer that approach gives. Note that by overstressing the bridge, there is a chance that the friction grip splices in the bottom chord could slip, which would reduce the amount of pre-camber in the structure.

2) I've had a quick look and I estimate that a cargo weight of 205 tonnes should get the factor of safety up to just over 1.31, based on my normal approach as outlined above. I'd need to have a more considered look at this to confirm it.

Best regards,

David

> -----Original Message-----
> **From:** Smith, Todd [mailto:Todd.Smith@snclavalin.com]
> **Sent:** 22 September 2010 19:34
> **To:** grahamwilkinson@rogers.com
> **Cc:** Eric Snelgrove; David Gillard; Nick Iannetta; McCarthy, Terry
> **Subject:** RE: Proposal for Heavy Load Transport across the Paradise River Bridge
>
> Graham,
> Thanks for the information. We do have a couple of things we would like more information on.
>
> 1 - The Canadian bridge code, section 14 for evaluation of permit loads, refers to a live load capacity factor, which is the ratio of the factored resistance less the applied dead load to the factored live load. If this value is more than one, then theoretically the load is acceptable. Could you ask David to elaborate on what ratio is used to determine the factor of safety (eg.

total resistance / total load)? Is he referring to the live load capacity factor interchangeably with the factor of safety? If he is, then 1.2 seems adequate since it is more than 1.0.

2 - We are wondering, if the 250T transformer is too heavy, then is it possible to determine, or estimate, an acceptable weight for the cargo which would be transported on the same carrier as previously provided.

If there is a fee for this work, please advise.

Thanks again,
Todd

From: Graham Wilkinson [mailto:grahamwilkinson@rogers.com]
Sent: September 16, 2010 11:07 AM
To: Smith, Todd
Cc: 'Eric Snelgrove'; 'David Gillard'; 'Nick Iannetta'
Subject: FW: Proposal for Heavy Load Transport across the Paradise River Bridge

Todd,

Please see the comments below from Mabey's engineering department.....

Let me know if you need us to check anything else out.

Graham Wilkinson

ALGONQUIN BRIDGE INC.
Tel. 905-990-2911 Mississauga office
Fax 905-990-2944 Mississauga office
Cell. 416-666-3955
Email: graham@algonquinbridge.com

From: David Gillard [mailto:David.Gillard@mabeybridge.co.uk]
Sent: Thursday, September 16, 2010 7:42 AM
To: Graham Wilkinson (E-mail)
Cc: Hugh Blunt; Nick Iannetta; Carlos Arias
Subject: FW: Proposal for Heavy Load Transport across the Paradise River Bridge

Graham,

One further thought - we have based our analysis on the axle loads given in the diagram, which give about 298 tonnes for the 250 tonne transformer plus the trailer. Are these the correct axle loads for this combination?

Regards,

David

-----Original Message-----
From: David Gillard
Sent: 16 September 2010 12:32
To: 'grahamwilkinson@rogers.com'
Cc: Hugh Blunt; Nick Iannetta; Carlos Arias
Subject: RE: Proposal for Heavy Load Transport across the Paradise River Bridge

Graham,

With the load as advised and assuming that no additional dead load (e.g. surfacing) has been added to the bridge, then even with a controlled crossing dead slow down the centreline of the roadway, the factor of safety we calculated was less than 1.2. I think this is not adequate. Our "controlled crossing" assumptions were, if anything, rather optimistic - we limited the combined effects of impact and eccentricity to 10%.

I don't think there is any way to strengthen the bridge, either.

The only suggestion we can come up with is to winch the load across without the prime mover. Even then, if impact and, more relevantly, eccentricity can be kept to a combined 10%, the factor of safety is still less than 1.25.

Best regards,

David

-----Original Message-----
From: Graham Wilkinson [mailto:grahamwilkinson@rogers.com]
Sent: 16 September 2010 11:51
To: David Gillard
Subject: RE: Proposal for Heavy Load Transport across the Paradise River Bridge

David,

I didn't hear anything back.

In speaking with Todd smith last week, I got the impression that the load could not be reduced much. He was wondering if there was any way to strengthen the Delta. I advised at the time that to the best of my knowledge, at 81m the Delta at Paradise River is already maxed out.

I'd appreciate any comments from your end so that I can reply back to Todd.

Thanks

Graham

From: David Gillard [mailto:David.Gillard@mabeybridge.co.uk]
Sent: Thursday, September 16, 2010 4:04 AM
To: grahamwilkinson@rogers.com
Cc: Carlos Arias; Hugh Blunt
Subject: RE: Proposal for Heavy Load Transport across the Paradise River Bridge

Graham,

Yes, Carlos put up an enquiry, which we sent back on Monday, so I'm surprised you haven't been given the results: it's way too heavy. We couldn't get close to making it work, even with a controlled crossing at a reduced factor of safety.

Is there any chance they can break the big load down?

Regards,

David

> -----Original Message-----
> **From:** Graham Wilkinson [mailto:grahamwilkinson@rogers.com]
> **Sent:** 15 September 2010 20:02
> **To:** David Gillard
> **Subject:** FW: Proposal for Heavy Load Transport across the Paradise River Bridge
>
> Dave,
>
> Did you ever get a chance to take a look at this?
>
> Graham
>
> ---
>
> **From:** Smith, Todd [mailto:Todd.Smith@snclavalin.com]
> **Sent:** Wednesday, September 01, 2010 7:04 AM
> **To:** grahamwilkinson@rogers.com
> **Cc:** David Gillard
> **Subject:** Proposal for Heavy Load Transport across the Paradise River Bridge
>
> Graham,

We would like you to provide a proposal to analyze the Paradise River Bridge (KM 828.2, Route 500, NL) for the transport of a heavy load across the bridge. The bridge was provided by Algonquin Bridge to the Government of Newfoundland and Labrador in 2005, drawing # S01346/001, dated 3/11/2005. Attached is the arrangement for the transporter and the associated axle loads. The scope of work would include updating your structural models with the loads as attached, check member capacities accounting for the provisions of chapter 14 of the CHBDC S6, provide an estimate of the maximum permissible load if the attached loads are too heavy (assuming the same transporter), and provide a report outlining your results. Please provide a schedule for completion of this work with your proposal.

If you require any additional information, please advise.

Regards,
Todd

From: Graham Wilkinson [mailto:grahamwilkinson@rogers.com]
Sent: August 31, 2010 5:08 PM
To: Smith, Todd
Cc: 'David Gillard'
Subject: RE: Contact for Graham Wilkinson

Todd,

We can review the load.

We need to know the following:

Axle loads .... in kN
Axle spacings.... in meters
# of wheel per axle and footprints c/w lateral spacings.

Graham Wilkinson

ALGONQUIN BRIDGE INC.
Tel. 905-990-2911 Mississauga office
Fax 905-990-2944 Mississauga office
Cell. 416-666-3955
Email: graham@algonquinbridge.com

From: Smith, Todd [mailto:Todd.Smith@snclavalin.com]
Sent: Tuesday, August 31, 2010 2:24 PM
To: grahamwilkinson@rogers.com

Subject: RE: Contact for Graham Wilkinson

Graham,
I have tried to call but so far no response. I have a drawing for the Paradise River Bridge which was sealed by you Dwg S01346/001, dated 3/11/2005). I need a review performed for a heavy load to be transported across the bridge. Is that something that you would perform, or was the bridge designed by Mabey in which case perhaps they would perform the review. If you are the right person, I will forward some more information requesting a proposal from you. If not you, could you provide the appropriate contact for this work?

Thanks,
Todd

From: Graham Wilkinson [mailto:grahamwilkinson@rogers.com]
Sent: August 31, 2010 2:01 PM
To: Smith, Todd
Subject: RE: Contact for Graham Wilkinson

graham@algonquinbridge.com

Graham Wilkinson

ALGONQUIN BRIDGE INC.
Tel. 905-990-2911 Mississauga office
Fax 905-990-2944 Mississauga office
Cell. 416-666-3955
Email: graham@algonquinbridge.com

From: Smith, Todd [mailto:Todd.Smith@snclavalin.com]
Sent: Tuesday, August 31, 2010 12:13 PM
To: info@algonquinbridge.com
Subject: Contact for Graham Wilkinson

Hi,
I am trying to contact Graham Wilkinson, could you please provide his e-mail address?
Thanks,
Todd Smith, P.Eng.
BAE-Newplan Group Ltd.
1133 Topsail Road
Mount Pearl, NL
A1N 5G2
709-368-0118

APPENDIX C

PASSAGE OF A TRAILER TRUCK CARRYING A 250 MT TRANSFORMER ON THE KENAMU RIVER BRIDGE NEAR GOOSE BAY

ROCHE

BAE-NEWPLAN GROUP LIMITED

PASSAGE OF A TRAILER TRUCK CARRYING A 250 MT TRANSFORMER ON THE KENAMU RIVER BRIDGE ON ROUTE 500 IN THE PROVINCE OF NEWFOUNDLAND AND LABRADOR

FEASIBILITY STUDY

REGISTERED PROFESSIONAL ENGINEER
PROVINCE OF NEWFOUNDLAND
AND LABRADOR
PEG
Newfoundland
and Labrador
FRANCOIS JUTRAS
P. ENG.
LICENSEE
2004

DECEMBER 2010

TABLE OF CONTENT

1. TERMS OF REFERENCE

BAE Newplan Group Limited a company owned by SNC-LAVALIN INC requests the professional services of Roche Ltd Consulting Engineers for carry out a feasibility study regarding the passage of a trailer truck carrying a 250 metric ton transformer on the Kenamu River Bridge located at KM 62.75 on Route 500 in the province of NL . Roche was awarded his mandate under contract 723469 dated October the 6th 2010. More specifically, we have to answer two questions :

1) Can the bridge support safely one (1) passage of the trailer truck with the 250 metric tons transformer ?

2) If not what should be the payload limitation ?

The study is undertaken under the supervision of Mr François Jutras, P Eng licensed in the Province of Newfoundland and Labrador. Roche was the firm who designed the bridge in 2009 .

2. METHODOLOGY

A design parameter document was first prepared by Roche in order to clearly identify what are the guidelines of the study and to ascertain that our client understand what are the safety factor related to the analysis.

The study was therefore carried out using the following parameters :

- Truck will be running on the center of bridge roadway width. Curbs or lines will limit the corridor ;
- Speed limit : MAX 10 km/h
- Truck configuration : illustrated in appendix
- Number of passage : 1
- Impact allowance : 10% according to S6-06 Chapter 14
- Loads and analysis : As per S6-06 Chapter 14 Permit PC
- Field supervision to be provided by the client during the passage on the bridge
- If bridge is unable to resist the passage , evaluate the max payload that could be allowed.
- Each trailer axle to carry the same load
- Trailer weight : 48000 kg
- αD : 1.09 (D1) 1.18 (D2) 1.45 (D3)
- αL : 1.28

From thereon , we use the structural model we made when we designed the bridge and the launching procedure. The commercial software used for modeling is ADA from Graytec Ltd .

3. BRIDGE DESCRIPTION

We enclosed, in the appendix, a view of the entire bridge which essentially is a 81m single span spatial steel structure made of two 4.3m tall pony-warren trusses supporting tranfer beams at panel nodes upon which are connected 4 main stringers supporting cross – beams and a steel grating . This is a two-lane bridge with a roadway width of 8 m . The bridge is all galvanized . We point out below the different parts of the bridge and how the loads transfer to the main trusses.

4. ANALYSIS

We studied one situation which is the trailer truck running in the centerline of the bridge . From our analysis , we found out that the bridge is far from having the capacity to support the passage of the trailer truck without temporary reinforcement over several part of bridge. We have enclosed in the appendix the brief notes resuming some of the calculations and investigations. For clarity purpose and as we found it irrelevant, we have not included all the output, code checks and results from our computer analysis of the main trusses. Here is a short summary of the overall study :

Truck on centreline

- **Cross Frames : no reinforcement**
- **Main Stringers : no reinforcement**
- **Transfer Beams : reinforcement required**
- **Stability frames : reinforcement required for the horizontal section**
- **Main trusses : almost every member should be reinforced**

A table showing the actual capacity of the different part of the bridge is included in appendix as the first page of the brief notes

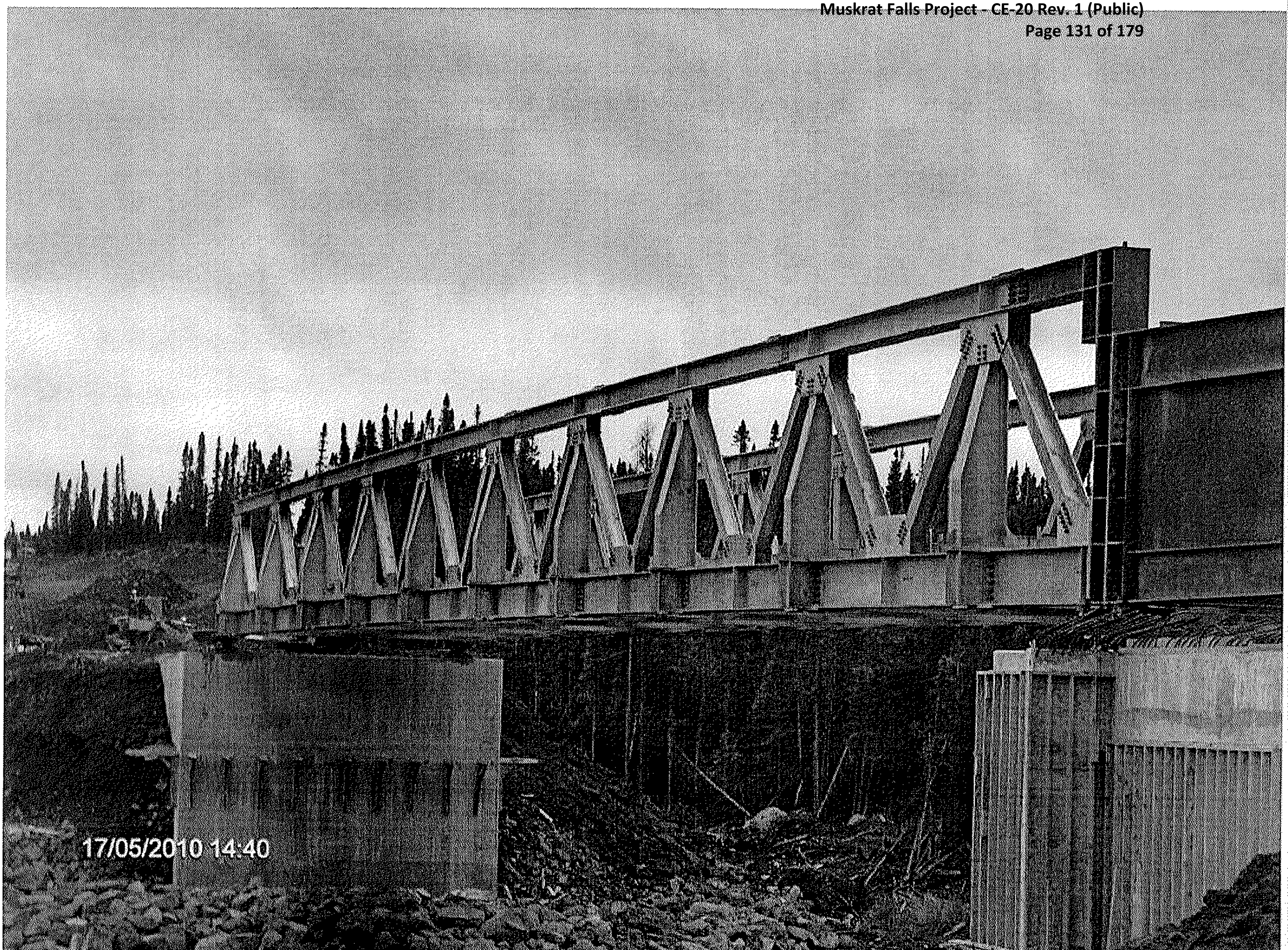
5.0 CONCLUSIONS

The bridge crossing the Kenamu River Bridge cannot withstand the passage of a trailer truck carrying a transformer weighting 250 metric tons without major reinforcement even when running through the centerline. The main trusses are the most affected and governs the allowable capacity . We have to limit the weight of the payload (transformer) to **130 metric tons**.

APPENDICES

- PICTURES
- BRIEF NOTES
- BRIDGE ELEVATION
- TRUCK CONFIGURATION
- SUPERSTRUCTURE ELEMENT IDENTIFICATION

PICTURES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BRIEF NOTES

62 240-001

CAPACITY OF THE DIFFERNT PARTS OF THE KENAMU BRIDGE UNDER SPECIAL 250MT LOADING

EVALUATION DES ÉLÉMENTS DU PONT KENAMU LORS DU PASSAGE D'UN CONVOI SPÉCIAL AU CENTRE DU PONT

LOCATION	ELEMENT	DESIGNATION	Mx (kN.m) Mr	Mx Mf	Mx %	My (kN.m) Mr	My Mf	My %	AXIAL (kN) Cr	AXIAL Cf	AXIAL %	% Interaction	TOTAL WEIGHT (ton)	ALLOW TRANSFO (ton)
FLOOR	CROSS BEAMS	W250@33	122	67.9	55.66								326.4	250.0
	MAIN STRINGERS	W410@124	397	302.1	76.09								326.4	250.0
	TRANSFER BEAMS	W690@125	1333	1551	116.31	181.55	2	0.85	4231	624	14.75	131.91	195.4	147.4
MAIN TRUSSES	BOTTOM CHORD	B1	3 497	578	16.54	728	8.2	1.13	11 638	7 115	61.14	78.81	326.4	250.0
		B2	3 618	600	16.60	728	13.9	1.91	12 635	10 505	83.14	101.65	316.3	239.8
		B3	3 800	749	19.71	729	16.8	2.31	14 131	12 807	90.63	112.65	256.0	179.6
		B4	4 990	854	17.12	1 380	21.3	1.54	15 787	13 957	88.41	107.07	284.9	208.5
	TOP CHORD	T1	2 130	169	7.93	693	103.0	14.85	9 202	9 085	98.72	121.50	223.1	146.7
		T2	3 090	374	12.10	1 477	84.3	5.71	12 050	11 950	99.17	112.88	237.3	160.9
		T3	3 426	349	10.18	1 684	131.0	7.78	13 450	13 668	101.62	114.94	227.5	151.1
		T4	3 499	380	10.87	1 694	132.5	7.82	13 828	14 237	102.96	116.89	218.8	142.4
	DIAGONALS	W310@143	788	-	0.00	369	5.51	1.49	3 528	3 872.97	109.76	110.66	262.0	185.5
		W310@97	459	-	0.00	159	3.7	2.34	2 331	2 859	122.63	124.97	205.9	129.5
		W310@97 (*)	479	-	0.00	159	2	1.50	4 090	3 338	81.63	83.13	326.4	250.0
STABILITY FRAME	System Rigidity	Système Transversal							5824.0	6294.9	108.08		302.0	225.5
	TRANSFER BEAM	WWS 800	2262.6	2127.4	94.03								326.4	250.0
	VERTICAL KINGPOSTS	WWS 700	1923.9	576.6	29.97								326.4	250.0
														129.5

CONCLUSIONS: LIMIT THE PAYLOAD TO 130MT

CR

BRIEF NOTES

ROCHE INGÉNIEURS-CONSEILS	NOTES DE CALCUL	Projet n° 62 240-001
	PROJET KENAMU BRIDGE	Page 1 de
		Par
	SUJET SPECIAL LOAD ANALYSIS	Date 5 NOV. 2010
		Vérifié CR.

Basic Assumptions: ◦ PASSAGE OF THE TRAILER TRUCK sur IN THE CENTERLINE OF THE BRIDGE FE = 0.5

REFERENCES: NDC 58 268.000 de CR
NDC CRB Transformer
FILE ADA 62 240-001 STR / CALCULATIONS AND ANALYSIS

DEAD AND LIVE LOAD FACTOR + IMPACT

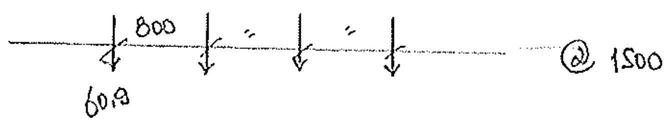
$$IMPACT = 0.25 \times 30\% = 0.075 \approx 0.08$$

$$\alpha_L = 1.28$$

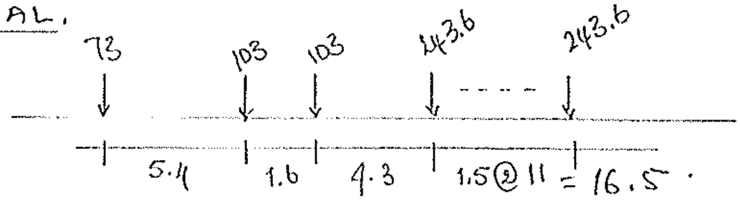
$$\alpha_D = 1.09$$

TRUCK AXLE CONFIGURATION

TRAILER AXLE (TYP)



LONGITUDINAL



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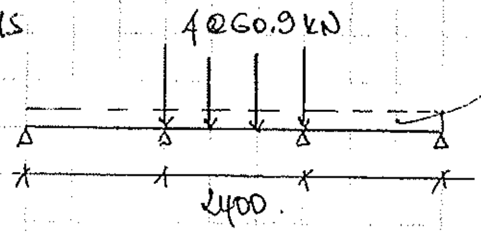
1) FLOOR

A - CROSS BEAMS

MODEL



Grating: 2,4 kPa × 1.35 (width)
PP: 0.3 kN/m
} 3.54 kN/m

Live loads: $M_L = 60.9 \times 0.8 = 48.8$ kN.m
$V_L = 60.9$ kN

Dead loads: $M_D = 0.5$ kN.m
$V_D = 9.4$ kN.

Moments / Shears (factored):
$M_f = 1.09 \times 0.5 + 1.28 \times 1.08 \times 48.8 = 68$ kN.m
$V_f = 1.09 \times 9.4 + 1.28 \times 1.08 \times 60.9 = 94.4$ kN

Check resistance of: W250×33 voir HB p.5-98

$M_r = 122$ kN.m pour $L_u = 2.5$ m → $\frac{M_f}{M_r} = \frac{68}{122} = 0.56 < 1$ (OK!)

$V_r = 323$ kN → $\frac{V_f}{V_r} = \frac{94.4}{323} = 0.29 < 1$ (OK!)

CR

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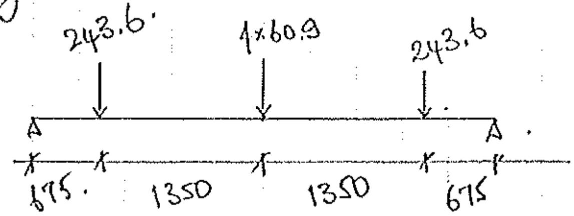
B _ Main stringers

Model :



Live loads :

$$M_L = \left(2 \times \frac{33.75}{100} + \frac{101.25}{100}\right) \times 243.6 \times 0.5 = 205.6 \text{ kN.m}$$

$$V_L = 1.5 \times 243.6 \times 0.5 = 182.7 \text{ kN}$$

Dead loads :

$$M_D = 16.4 \text{ kN.m}$$

$$V_D = 17 \text{ kN}.$$

Moment and shear _

$$M_f = 1.09 \times 16.4 + 1.28 \times 1.08 \times 205.6 = 302 \text{ kN.m}$$

$$V_f = 1.09 \times 17 + 1.28 \times 1.08 \times 182.7 = 271.1 \text{ kN}.$$

Check of a resistance . W410 Ø 60 voir HB p. 5-96

$M_r = 397$ kN.m pour $L_u = 1.35$ m $\rightarrow \frac{M_f}{M_r} = \frac{302}{397} = 0.76 < 1$ (OK!)

$V_r = 642$ kN $\rightarrow \frac{V_f}{V_r} = \frac{271.1}{642} = 0.42 < 1$ (OK!)

CR

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C – <u>Transfer beams</u>.

On distingue 3 sortes :

1. Celles reliées aux montants : elles seront traitées au chapitre de la validation du Cadre : il s'agit des poutres du type TB 1
2. Celles aux extrémités du pont (du type TB 2)
3. Celles reliées aux diagonales (entre les poutres de type TB 1).

We have three types :

1. Those part of the ~~stability~~ frames TB 1
2. At bridge end : TB2
3. Intermediate between the stability frames

CR

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POUTRE RELIEE AUX DIAGONALES. TYPE 3 (Between stability frames)

Voir NDC ADVANCE. Etats limites: la résistance est insuffisante
Limit states
Refer to complete mef note from ADA
Not enough resistance

Δ = portion du poids du fardier admissible par la poutre de transfert
max fraction of trailer allowable

$$\Delta = \frac{1 - \frac{M_{Dx}}{M_{rx}} - \frac{M_{Dy}}{M_{ry}} - \frac{C_D}{C_r}}{\frac{M_{Lx}}{M_{rx}} + \frac{M_{Ly}}{M_{ry}} + \frac{C_L}{C_r}} = 0.656$$

W_{far} = Poids du fardier admissible par la poutre de transfert
allowable trailer load

$W_{far} = \Delta \times W_F = 0{,}656 \times 298 = 195.4$ tonnes.
tons

allowable transfo load.

W_{adm} = Charge admissible sur le fardier sollicitant efficacement la poutre de Transfert:

$W_{adm} = W_{far} - W_{roue} = 195.4 - 48 = 147.4$ ton.

LR

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$M_{D/L\,x}$ = Moment du aux charges mortes/vives suivant axe X-X
Moment from DL/LL according to X-X axis

$M_{D/L\,y}$ = Moment du aux charges mortes/vives suivant
Moment from DL/LL according to Y-Y axis

$C_{D/L}$ = Effort Normal du aux charges mortes/vives.
Axial effort from DL/LL

$M_{r\,x/y}$ = Moment résistant P/R axe X-X / Y-Y
Resisting moments according to X-X / Y-Y axis

C_r = Résistance à la compression
Compression resistance

W_F = Poids du fardier
Trailer load (including the transfo)

W_{roue} = Poids des roues du fardier.
Trailer load (empty)

CR

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Transfer beams at bridge ends

Nous ne jugeons pas pertinente leur étude car elles sont 2 fois moins chargées que les poutres W 690@125 et ont une résistance supérieure

$S_x = 7{,}024 \cdot 10^6\ mm^3 \rightarrow M_r = 2180.9\ kN.m$

We did not perform exhaustive calculations since these members have half the loads of the other and have evidently sufficient resistance

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NOTES DE CALCUL

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2) Main trusses
Validation is carried out using ADA software. Brief notes are enclosed at the end of this section
La validation des membrures est effectuée à l'aide de Visual Design. les notes sont joints au présent document.
To the exception of the bottom chord B1, all the other members are overloaded to different level.
Exception faite de la membrure sur la corde inférieure de type B1 toutes les membrures du treillis ont une résistance insuffisante aux états limites.

Pour la détermination de W_{adm} = charge admissible sur le fardier sollicitant efficacement la membrure voir page 5

on utilise $W_{convoi} = 326.4$ ton au lieu et place de W_{far}

et $W_{tracteur} = 28.44$ ton en plus de W_{roue}.

On applique des coefficients 0.85 à $\frac{M_{Dx}}{M_{rx}}$ et 0.6 $\frac{M_{Dy}}{M_{ry}}$ suivant la classe de la membrure et son type de sollicitat° (voir NDC advance).

Voir Feuille Excel pour les W_{adm}.

CR

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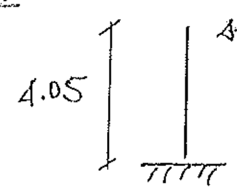
3) STABILITY FRAME

A) King Posts

Model : 

$1\% F_m = 1\%$ max sollicitation sur les cordes.
of effort in the topchord

we have:

on a $F_M = 14\,237$ kN (incluant α_L; α_D et CMD).

$\rightarrow M_f = 142{,}37 \times 4.07 = 576.6$ kN

$S_x = 6107{,}52 \cdot 10^3$ mm^3 $\rightarrow$ $M_r = 0.9 \times 0.35 \times 6107.52 = 1923.9$ kN.m

$\frac{M_f}{M_r} = \frac{576.6}{1923.9} = 0.3 < 1$ (OK!).

B). Horizontal Part (transfer beams)

We have to add to gravity loads the moment transfered from the King Posts to the transfer beams part of the stability frame.

Elle a une sollicitation identique à celle du W 690 @ 125 en flexion mais il faut lui adjoindre également le moment issu du montant

$M_f = 576.6 + 1551 = 2127.4$ kN.m

$S_x = 7182{,}78 \cdot 10^3$ mm^3 $\rightarrow$ $M_r = 0.9 \times 0{,}35 \times 7182{,}78 = 2\,262.6$ kN.m

LR

ROCHE
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$$\frac{M_f}{M_r} = \frac{2129.4}{2262.6} = 0.94 < 1 \quad \text{OK!}$$

c) Frame rigidity

Rigidité Offerte

$$C_{off} = \frac{E}{h^2\left\{\frac{h}{3I_c} + \frac{b}{2I_B}\right\}} = \frac{200'000}{4050^2\left\{\frac{4050}{3\times 1{,}137.10^9} + \frac{8400}{2\times 2{,}873.10^9}\right\}} = 5824 \text{ kN/m}$$

Rigidité Requise

$$C_{req} = \frac{F_S \times F_m}{b} = \frac{3{,}714 \times 14237}{8400} = 6294.9 \text{ kN/m}$$

$$\frac{C_{req}}{C_{off}} = \frac{6294.9}{5824} = 1.08 > 1 \quad ⚠$$

Pour $W_{convoi} = 326.4$ ton on a $C_{req} = 6294.9$ kN/m

si $C_{req} = 5824$ kN/m on veut W_{fas} ..

$$\rightarrow W_{fas} = \frac{5824}{6294.9} \times 326.4 = 302 \text{ ton.}$$

GR

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$W_{adm} = 302 - 48 - 28.44 = \underline{225.5 \text{ ton}}$.

Conclusions

Refer to the summary table

Tous les résultats sont résumés sur la page de fichier Excel joint en annexe.

Nous sélectionnons la moindre des charges admissibles sur le fardier qui correspondra à la charge du Transformateur admissible sur le fardier.

On a $\underline{W_{adm} = 129.5 \text{ ton}}$.

POIDS CONVOI = 326.4 tm

POIDS FARDIER = 298 tm

POIDS TRANSFO = 250 tm

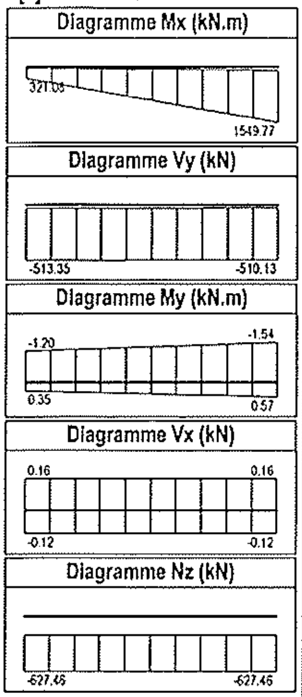
POIDS CONVOI VIDE = 76.4 tm

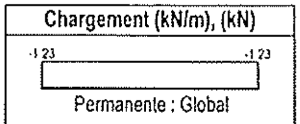
POIDS FARDIER VIDE = 48 tm.

CR

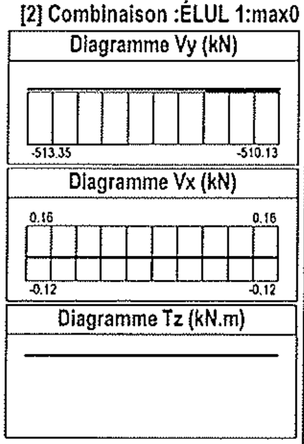
GRAITEC	**Notes de calcul**	No de projet :
	Nom de projet : Pont Kenamu_convoi special	62240-001
	Membrure : Transfert050 Groupe :	Vérifiée par : CR
	Préparé par : Dieudonné YAPO, ing.jr.	Date :

[1] Combinaison :ÉLUL 1:max0





[2] Combinaison :ÉLUL 1:max0



Déformée axe fort (mm)

Déformée axe faible (mm)

Capacité de la section W690x125 - CAN/CSA S6-06

Propriétés de la section : W690x125
I_x =1190.00 10e6mm4, I_y =44.10 10e6mm4, J = 1.18 10e6mm4, C_w =4830.00 10e9mm6
Aire = 16000.00 mm², Aire nette = 16000.00 mm², Longueur : 2400.00 mm
Aire (cis.x) =7007.93 mm², Aire (cis.y) =7658.69 mm²

Propriétés du matériau 350G/W/WT/AT
Module E = 200000.00 MPa, F_y =350.00 MPa, F_u =450.00 MPa

Efforts pondérés maximums contrôlant le design de la membrure

[1] Efforts combinés - Combinaison :ÉLUL 1:max0 : 1.09D+1.28Lm01

Dans le système d'axes orthogonal de base
M_{fx} = 1549.77 kN.m, V_{fy} = -510.13 kN, M_{fy} = -1.54 kN.m, V_{fx} = 0.16 kN
N_{fz} = -627.46 kN (compression), T_{fz} = 0.00 kN.m

[2] Cisaillement - Combinaison :ÉLUL 1:max0 : 1.09D+1.28Lm01

Dans le système d'axes orthogonal de base
V_{fy} = -513.35 kN, V_{fx} = 0.16 kN, T_{fz} = 0.00 kN.m

La membrure est en compression

La section est de classe 2

Valeur de KL/r (max) = 45.7 < 200 Ok

Valeurs de M_r avec et sans déversement latéral
$M_{rx}(L_u=0)$ =1333.32 kN.m, $M_{rx}(L_u>0)$ =1333.32 kN.m, L_{ux}=2400.00 mm, ω_1 =1.46
$M_{ry}(L_u=0)$ =181.55 kN.m, $M_{ry}(L_u>0)$ =181.55 kN.m, L_{uy}=0.00 mm, ω_y =1.00

Analyse incluant les effets non linéaires PΔ et Pδ($U1_x$ = $U1_y$ = 1.0)

Article 10.9.4.1 a)
$C_f/C_r + M_{fx}/M_{rx} + M_{fy}/M_{ry}$ <= 1.0 (sans déversement latéral)
627.46/5040.00 kN + 1549.77/1333.32 kN.m + 1.54/181.55 kN.m = 129.53 % > 100.00 % Pas Ok

Article 10.9.4.1 b)
$C_f/C_r + M_{fx}/M_{rx} + M_{fy}/M_{ry}$ <= 1.0 (sans déversement latéral)
627.46/4720.38 kN + 1549.77/1333.32 kN.m + 1.54/181.55 kN.m = 130.38 % > 100.00 % Pas Ok

Article 10.9.4.1 c)
$C_f/C_r + M_{fx}/M_{rx} + M_{fy}/M_{ry}$ <= 1.0 (M_{ry} sans déversement latéral, C_r=C_{ry})
627.46/4230.57 kN + 1549.77/1333.32 kN.m + 1.54/181.55 kN.m = 131.91 % > 100.00 % Pas Ok

Résistance à la compression seulement (10.9.3.1)
C_f/C_r <= 1.0 (avec KL/r max)
627.46/4230.57 kN = 14.83 % <= 100.00 % OK

Flexion bi-axiale (10.10.2, 10.10.3, 10.9.4.4)
$M_{fx}/M_{rx} + M_{fy}/M_{ry}$ <= 1.0 (avec déversement latéral)
1549.77/1333.32 kN.m + 1.54/181.55 kN.m = 117.08 % > 100.00 % Pas Ok

Article 10.10.5.1
$V_{fy}/V_{ry} + T_{fz}/T_{rz}$ (incluant l'effet de torsion)
513.35/1521.89 kN = 33.73 % <= 100.00 % OK

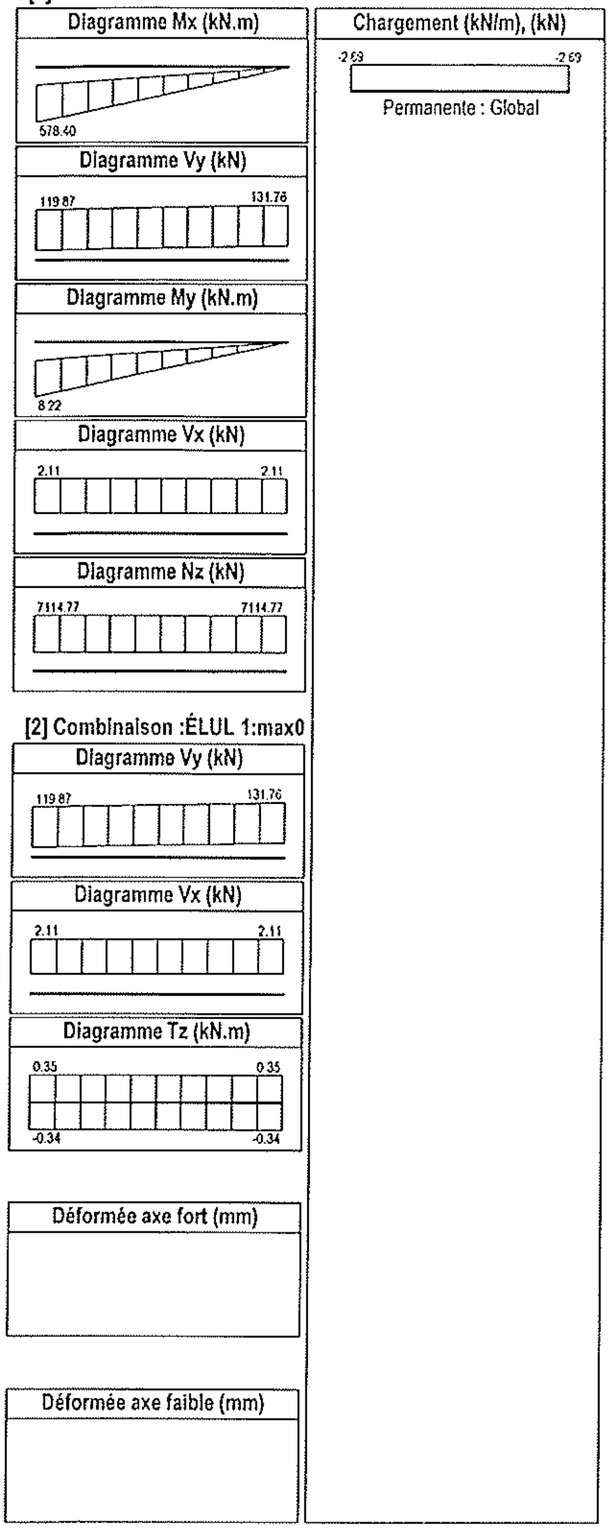
Article 10.10.5.1
$V_{fx}/V_{rx} + T_{fz}/T_{rz}$ (incluant l'effet de torsion)
0.16/1212.14 kN + 0/15.87 kN.m = 0.01 % <= 100.00 % OK

États limites : Insuffisante

Tous droits réservés

GRAITEC	Notes de calcul	No de projet :
	Nom de projet : Pont Kenamu_convoi special	62240-001
	Membrure : CordeInf05 Groupe : B1	Vérifiée par :
	Préparé par : Dieudonné YAPO, ing.jr.	Date :

[1] Combinaison :ÉLUL 1:max0



Capacité de la section WRS800.12x500/540.25 - CAN/CSA S6-06

Propriétés de la section : WRS800.12x500/540.25
I_x =4323.00 10e6mm4, I_y =588.57 10e6mm4, J = 5.85 10e6mm4, C_w =87194.76 10e9mm6
Aire = 35000.00 mm², Aire nette = 35000.00 mm², Longueur : 4050.00 mm
Aire (cis.x) =22091.50 mm², Aire (cis.y) =9088.77 mm²

Propriétés du matériau 350G/W/WT/AT
Module E = 200000.00 MPa, F_y =350.00 MPa, F_u =450.00 MPa

Efforts pondérés maximums contrôlant le design de la membrure

[1] Efforts combinés - Combinaison :ÉLUL 1:max0 : 1.09D+1.28Lm01

Dans le système d'axes orthogonal de base
M_{fx} = 578.40 kN.m, V_{fy} = 119.87 kN, M_{fy} = 8.22 kN.m, V_{fx} = 2.11 kN
N_{fz} = 7114.77 kN (traction), T_{fz} = 0.35 kN.m

[2] Cisaillement - Combinaison :ÉLUL 1:max0 : 1.09D+1.28Lm01

Dans le système d'axes orthogonal de base
V_{fy} = 131.76 kN, V_{fx} = 2.11 kN, T_{fz} = 0.35 kN.m

La membrure est en traction

La section est de classe 4

Valeur de KL/r (max) = 31.2 < 200 Ok

Valeurs de M_r avec et sans déversement latéral
$M_{rx}(L_u=0)$ =3496.71 kN.m, $M_{rx}(L_u>0)$ =3496.71 kN.m, L_{ux}=4050.00 mm, ω_1 =1.65
$M_{ry}(L_u=0)$ =728.11 kN.m, $M_{ry}(L_u>0)$ =728.11 kN.m, L_{uy}=0.00 mm, ω_y =1.00

Article 10.8.3 a)
$T_f/T_r + M_{fx}/M_{rx} + M_{fy}/M_{ry}$ <= 1.0 (sans déversement latéral)
7114.77/11637.50 kN + 578.4/3496.71 kN.m + 8.22/728.11 kN.m = 78.81 % <= 100.00 % OK

Article 10.8.3 b)
$M_{fx}/M_{rx} + M_{fy}/M_{ry} - (T_f{}^*S_x)/(M_{rx}{}^*A)$ (avec déversement latéral)
578.4/3496.71 kN.m + 8.22/728.11 kN.m - 61.14 % = -43.47 % <= 100.00 % OK

Vérification de l'interaction M_x - V_y
Article 10.10.5.2
0.727 M_{fx}/M_{rx} + 0.455 V_{fy}/V_{ry} (avec déversement latéral)
0.727*578.4/3496.71 kN.m + 0.455*119.87/1715.10 kN = 15.21 % <= 100.00 % OK

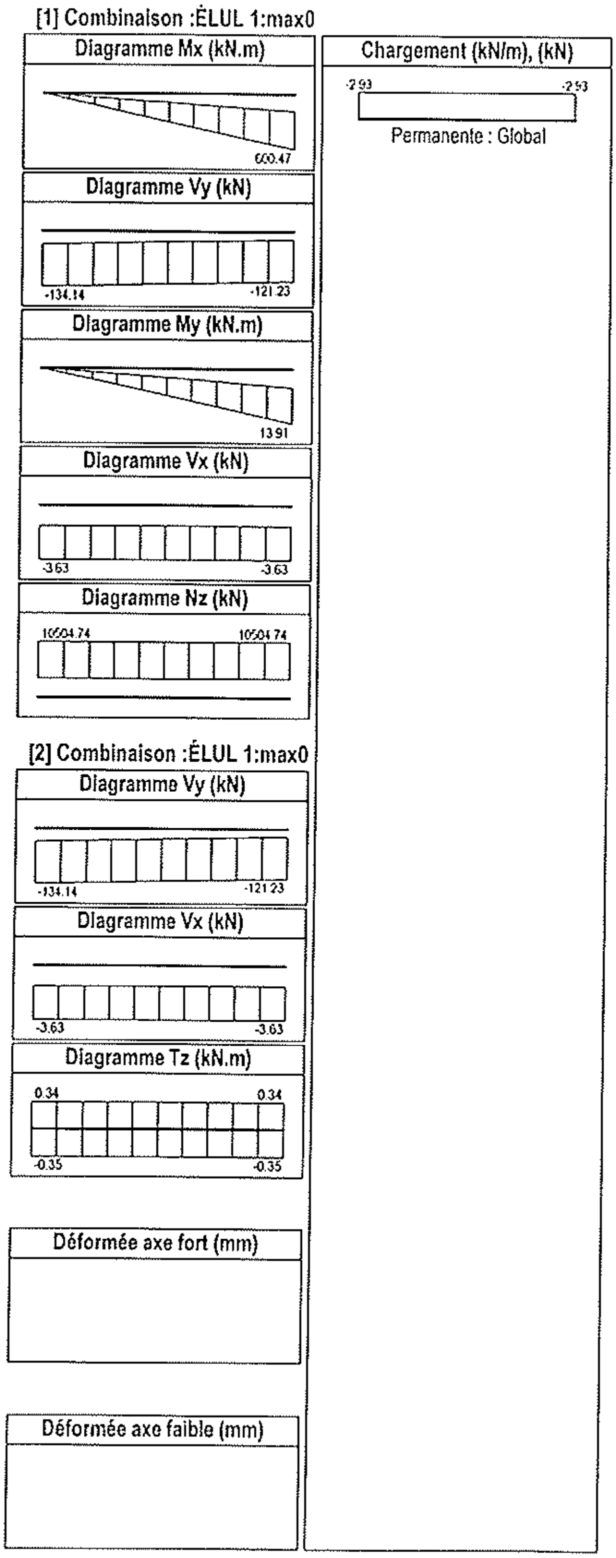
Article 10.10.5.1
$V_{fy}/V_{ry} + T_{fz}/T_{rz}$ (incluant l'effet de torsion)
131.76/1715.10 kN = 7.68 % <= 100.00 % OK

Article 10.10.5.1
$V_{fx}/V_{rx} + T_{fz}/T_{rz}$ (incluant l'effet de torsion)
2.11/3545.31 kN + 0.35/51.29 kN.m = 0.75 % <= 100.00 % OK

États limites : Suffisante

Tous droits réservés

GRAITEC	**Notes de calcul**	No de projet :
	Nom de projet : Pont Kenamu_convoi special	62240-001
	Membrure : Cordelnf31 Groupe : B2	Vérifiée par : CR
	Préparé par : Dieudonné YAPO, ing.jr.	Date :



Capacité de la section WRS800.16x500/540.25 - CAN/CSA S6-06

Propriétés de la section : WRS800.16x500/540.25
I_x =4463.97 10e6mm4, I_y =588.72 10e6mm4, J = 6.44 10e6mm4, C_w =87194.76 10e9mm6
Aire = 38000.00 mm², Aire nette = 38000.00 mm², Longueur : 4050.00 mm
Aire (cis.x) =22091.50 mm², Aire (cis.y) =11950.12 mm²

Propriétés du matériau 350G/W/WT/AT
Module E = 200000.00 MPa, F_y =350.00 MPa, F_u =450.00 MPa

Efforts pondérés maximums contrôlant le design de la membrure

[1] Efforts combinés - Combinaison :ÉLUL 1:max0 : 1.09D+1.28Lm01

Dans le système d'axes orthogonal de base
M_{fx} = 600.47 kN.m, V_{fy} = -121.23 kN, M_{fy} = 13.91 kN.m, V_{fx} = -3.63 kN
N_{fz} = 10504.74 kN (traction), T_{fz} = -0.35 kN.m

[2] Cisaillement - Combinaison :ÉLUL 1:max0 : 1.09D+1.28Lm01

Dans le système d'axes orthogonal de base
V_{fy} = -134.14 kN, V_{fx} = -3.63 kN, T_{fz} = -0.35 kN.m

La membrure est en traction

La section est de classe 4

Valeur de KL/r (max) = 32.5 < 200 Ok

Valeurs de M_r avec et sans déversement latéral
$M_{rx}(L_u=0)$ =3618.43 kN.m, $M_{rx}(L_u>0)$ =3618.42 kN.m, L_{ux}=4050.00 mm, ω_x =1.65
$M_{ry}(L_u=0)$ =728.29 kN.m, $M_{ry}(L_u>0)$ =728.29 kN.m, L_{uy}=0.00 mm, ω_y =1.00

Article 10.8.3 a)
$T_f/T_r + M_{fx}/M_{rx} + M_{fy}/M_{ry}$ <= 1.0 (sans déversement latéral)
10504.74/12635.00 kN + 600.47/3618.43 kN.m + 13.91/728.29 kN.m = 101.64 % > 100.00 % Pas (

Article 10.8.3 b)
$M_{fx}/M_{rx} + M_{fy}/M_{ry} - (T_f{*}S_x)/(M_{rx}{*}A)$ (avec déversement latéral)
600.47/3618.42 kN.m + 13.91/728.29 kN.m - 83.14 % = -64.64 % <= 100.00 % OK

Article 10.10.5.1
$V_{fy}/V_{ry} + T_{fz}/T_{rz}$ (incluant l'effet de torsion)
134.14/2302.23 kN = 5.83 % <= 100.00 % OK

Article 10.10.5.1
$V_{fx}/V_{rx} + T_{fz}/T_{rz}$ (incluant l'effet de torsion)
3.63/3547.56 kN + 0.35/56.48 kN.m = 0.71 % <= 100.00 % OK

États limites : Insuffisante

Tous droits réservés

GRAITEC	Notes de calcul	No de projet : 62240-001
	Nom de projet : Pont Kenamu_convoi special	
	Membrure : CordeInf13 Groupe : B3	Vérifiée par : CR
	Préparé par : Dieudonné YAPO, ing.jr.	Date :

[1] Combinaison :ÉLUL 1:max0

Diagramme Mx (kN.m)

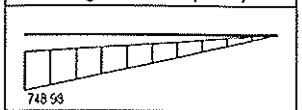


Diagramme Vy (kN)

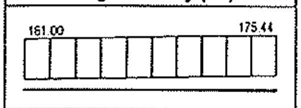


Diagramme My (kN.m)

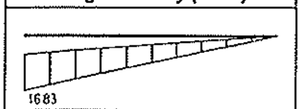


Diagramme Vx (kN)

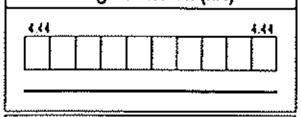
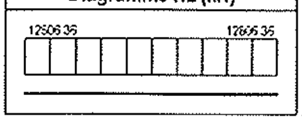


Diagramme Nz (kN)



[2] Combinaison :ÉLUL 1:max0

Diagramme Vy (kN)

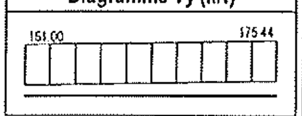


Diagramme Vx (kN)

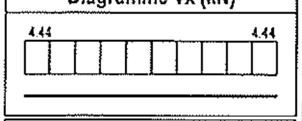
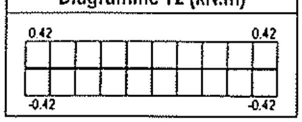


Diagramme Tz (kN.m)



Déformée axe fort (mm)

Déformée axe faible (mm)

Chargement (kN/m), (kN)

Permanente : Global

Capacité de la section WRS800.22x500/540.25 - CAN/CSA S6-06

Propriétés de la section : WRS800.22x500/540.25
I_x =4675.32 10e6mm4, I_y =589.13 10e6mm4, J = 8.08 10e6mm4, C_w =87194.76 10e9mm6
Aire = 42500.00 mm², Aire nette = 42500.00 mm², Longueur : 4050.00 mm
Aire (cis.x) =22091.51 mm², Aire (cis.y) =16137.24 mm²

Propriétés du matériau 350G/W/WT/AT
Module E = 200000.00 MPa, F_y =350.00 MPa, F_u =450.00 MPa

Efforts pondérés maximums contrôlant le design de la membrure

[1] Efforts combinés - Combinaison :ÉLUL 1:max0 : 1.09D+1.28Lm01

Dans le système d'axes orthogonal de base
M_{fx} = 748.98 kN.m, V_{fy} = 161.00 kN, M_{fy} = 16.83 kN.m, V_{fx} = 4.44 kN
N_{fz} = 12806.36 kN (traction), T_{fz} = -0.42 kN.m

[2] Cisaillement - Combinaison :ÉLUL 1:max0 : 1.09D+1.28Lm01

Dans le système d'axes orthogonal de base
V_{fy} = 175.44 kN, V_{fx} = 4.44 kN, T_{fz} = -0.42 kN.m

La membrure est en traction

La section est de classe 4

Valeur de KL/r (max) = 34.4 < 200 Ok

Valeurs de M_r avec et sans déversement latéral
$M_{rx}(L_u=0)$ =3799.75 kN.m, $M_{rx}(L_u>0)$ =3799.75 kN.m, L_{ux}=4050.00 mm, ω_2 =1.65
$M_{ry}(L_u=0)$ =728.80 kN.m, $M_{ry}(L_u>0)$ =728.80 kN.m, L_{uy}=0.00 mm, ω_2 =1.00

Article 10.8.3 a)
$T_f/T_r + M_{fx}/M_{rx} + M_{fy}/M_{ry}$ <= 1.0 (sans déversement latéral)
12806.36/14131.25 kN + 748.98/3799.75 kN.m + 16.83/728.80 kN.m = 112.64 % > 100.00 % Pas (

Article 10.8.3 b)
$M_{fx}/M_{rx} + M_{fy}/M_{ry} - (T_f{*}S_x)/(M_{rx}{*}A)$ (avec déversement latéral)
748.98/3799.75 kN.m + 16.83/728.80 kN.m - 90.62 % = -68.60 % <= 100.00 % OK

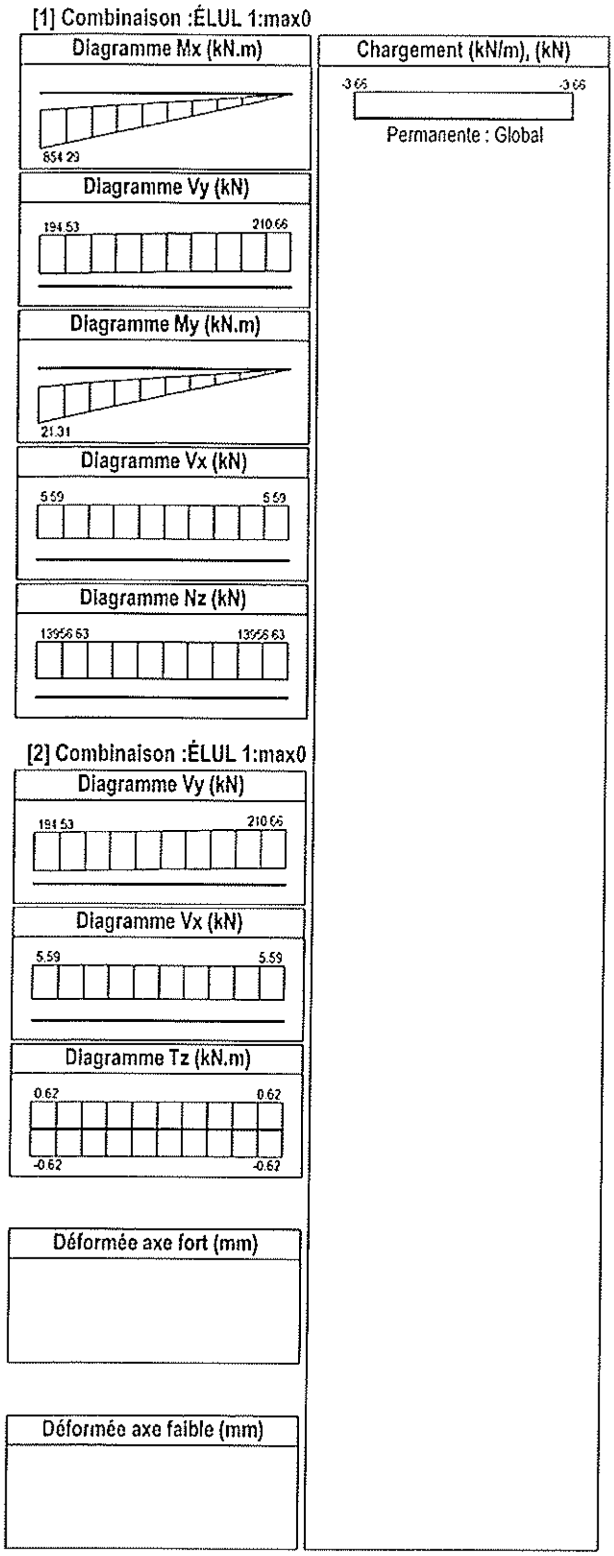
Article 10.10.5.1
$V_{fy}/V_{ry} + T_{fz}/T_{rz}$ (incluant l'effet de torsion)
175.44/3165.57 kN = 5.54 % <= 100.00 % OK

Article 10.10.5.1
$V_{fx}/V_{rx} + T_{fz}/T_{rz}$ (incluant l'effet de torsion)
4.44/3552.81 kN + 0.42/70.84 kN.m = 0.72 % <= 100.00 % OK

États limites : Insuffisante

Tous droits réservés

GRAITEC	**Notes de calcul**	No de projet :
	Nom de projet : Pont Kenamu_convoi special	62240-001
	Membrure : Cordelnf17 Groupe : B4	Vérifiée par : CR
	Préparé par : Dieudonné YAPO, ing.jr.	Date :



Capacité de la section WRS800.22x500/540.30 - CAN/CSA S6-06

Propriétés de la section : WRS800.22x500/540.30
I_x =5365.38 10e6mm4, I_y =706.82 10e6mm4, J = 11.99 10e6mm4, C_w =103287.95 10e9mm6
Aire = 47480.00 mm², Aire nette = 47480.00 mm², Longueur : 4050.00 mm
Aire (cis.x) =26509.81 mm², Aire (cis.y) =16234.96 mm²

Propriétés du matériau 350G/W/WT/AT
Module E = 200000.00 MPa, F_y =350.00 MPa, F_u =450.00 MPa

Efforts pondérés maximums contrôlant le design de la membrure

[1] Efforts combinés - Combinaison :ÉLUL 1:max0 : 1.09D+1.28Lm01

Dans le système d'axes orthogonal de base
M_{fx} = 854.29 kN.m, V_{fy} = 194.53 kN, M_{fy} = 21.31 kN.m, V_{fx} = 5.59 kN
N_{fz} = 13956.63 kN (traction), T_{fz} = -0.62 kN.m

[2] Cisaillement - Combinaison :ÉLUL 1:max0 : 1.09D+1.28Lm01

Dans le système d'axes orthogonal de base
V_{fy} = 210.66 kN, V_{fx} = 5.59 kN, T_{fz} = -0.62 kN.m

La membrure est en traction

La section est de classe 2

Valeur de KL/r (max) = 33.2 < 200 Ok

Valeurs de M_r avec et sans déversement latéral
$M_{rx}(L_u=0)$ =4989.97 kN.m, $M_{rx}(L_u>0)$ =4989.97 kN.m, L_{ux}=4050.00 mm, ω_1 =1.65
$M_{ry}(L_u=0)$ =1380.39 kN.m, $M_{ry}(L_u>0)$ =1380.39 kN.m, L_{uy}=0.00 mm, ω_1 =1.00

Article 10.8.3 a)
$T_f/T_r + M_{fx}/M_{rx} + M_{fy}/M_{ry}$ <= 1.0 (sans déversement latéral)
13956.63/15787.10 kN + 854.29/4989.97 kN.m + 21.31/1380.39 kN.m = 107.07 % > 100.00 % Pas

Article 10.8.3 b)
$M_{fx}/M_{rx} + M_{fy}/M_{ry} - (T_f{*}Z_x)/(M_{rx}{*}A)$ (avec déversement latéral)
854.29/4989.97 kN.m + 21.31/1380.39 kN.m - 88.41 % = -69.74 % <= 100.00 % OK

Article 10.10.5.1
$V_{fy}/V_{ry} + T_{fz}/T_{rz}$ (incluant l'effet de torsion)
210.66/3123.36 kN = 6.74 % <= 100.00 % OK

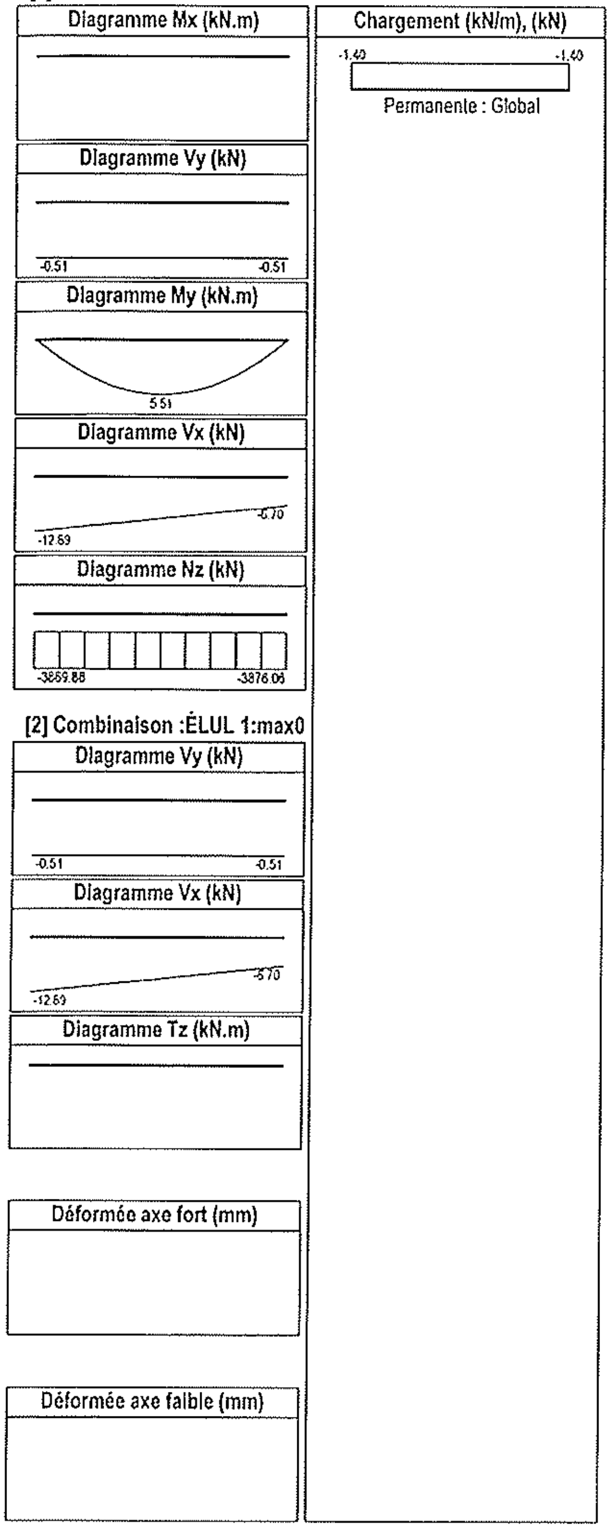
Article 10.10.5.1
$V_{fx}/V_{rx} + T_{fz}/T_{rz}$ (incluant l'effet de torsion)
5.59/4262.52 kN + 0.62/87.57 kN.m = 0.84 % <= 100.00 % OK

États limites : Insuffisante

Tous droits réservés

GRAITEC	Notes de calcul	No de projet : 62240-001
	Nom de projet : Pont Kenamu_convoi special	
	Membrure : Diag01 Groupe : Compression	Vérifiée par : CR
	Préparé par : Dieudonné YAPO, ing.jr.	Date :

[1] Combinaison :ÉLUL 1:max0



Capacité de la section W310x143 - CAN/CSA S6-06

Propriétés de la section : W310x143
I_x =348.00 10e6mm4, I_y =113.00 10e6mm4, J = 2.87 10e6mm4, C_w =2540.00 10e9mm6
Aire = 18200.00 mm², Aire nette = 18200.00 mm², Longueur : 5727.57 mm
Aire (cis.x) =12024.75 mm², Aire (cis.y) =4075.88 mm²

Propriétés du matériau 350G/W/WT/AT
Module E = 200000.00 MPa, F_y =350.00 MPa, F_u =450.00 MPa

Efforts pondérés maximums contrôlant le design de la membrure

[1] Efforts combinés - Combinaison :ÉLUL 1:max0 : 1.09D+1.28Lm01

Dans le système d'axes orthogonal de base
M_{fx} = 0.00 kN.m, V_{fy} = -0.51 kN, M_{fy} = 5.51 kN.m, V_{fx} = -9.79 kN
N_{fz} = -3872.97 kN (compression), T_{fz} = 0.00 kN.m

[2] Cisaillement - Combinaison :ÉLUL 1:max0 : 1.09D+1.28Lm01

Dans le système d'axes orthogonal de base
V_{fy} = -0.51 kN, V_{fx} = -12.89 kN, T_{fz} = 0.00 kN.m

La membrure est en compression

La section est de classe 1

Valeur de KL/r (max) = 72.7 < 200 Ok

Valeurs de M_r avec et sans déversement latéral
$M_{rx}(L_u=0)$ =804.65 kN.m, $M_{rx}(L_u>0)$ =787.66 kN.m, L_{ux}=5727.57 mm, ω_x =1.00
$M_{ry}(L_u=0)$ =369.07 kN.m, $M_{ry}(L_u>0)$ =369.07 kN.m, L_{uy}=0.00 mm, ω_y =1.00

Analyse incluant les effets non linéaires PΔ et Pδ($U1_x$ = $U1_y$ = 1.0)

Article 10.9.4.4 a)
C_f/C_{rx} + 0.85 M_{fx}/M_{rx} + 0.60 M_{fy}/M_{ry} <= 1.0
3872.97/4994.46 kN + 0.85 0/804.65 kN.m + 0.60 5.51/369.07 kN.m = 68.45 % <= 100.00 % OK

Article 10.9.4.4 b)
C_f/C_{rx} + 0.85 M_{fx}/M_{rx} + 0.60 M_{fy}/M_{ry} <= 1.0
3872.97/4994.46 kN + 0.85 0/804.65 kN.m + 0.60 5.51/369.07 kN.m = 78.44 % <= 100.00 % OK

Article 10.9.4.4 c)
C_f/C_r + 0.85 M_{fx}/M_{rx} + 0.60 M_{fy}/M_{ry} <= 1.0 (M_{ry} sans déversement latéral, C_r=C_{ry})
3872.97/3528.48 kN + 0.85 0/787.66 kN.m + 0.60 5.51/369.07 kN.m = 110.66 % > 100.00 % Pas C

Résistance à la compression seulement (10.9.3.1)
C_f/C_r <= 1.0 (avec KL/r max)
3872.97/3528.48 kN = 109.76 % > 100.00 % Pas Ok

Flexion bi-axiale (10.10.2, 10.10.3, 10.9.4.4)
M_{fx}/M_{rx} + M_{fy}/M_{ry} <= 1.0 (avec déversement latéral)
0/787.66 kN.m + 5.51/369.07 kN.m = 1.49 % <= 100.00 % OK

Article 10.10.5.1
V_{fy}/V_{ry} + T_{fz}/T_{rz} (incluant l'effet de torsion)
0.51/867.56 kN = 0.06 % <= 100.00 % OK

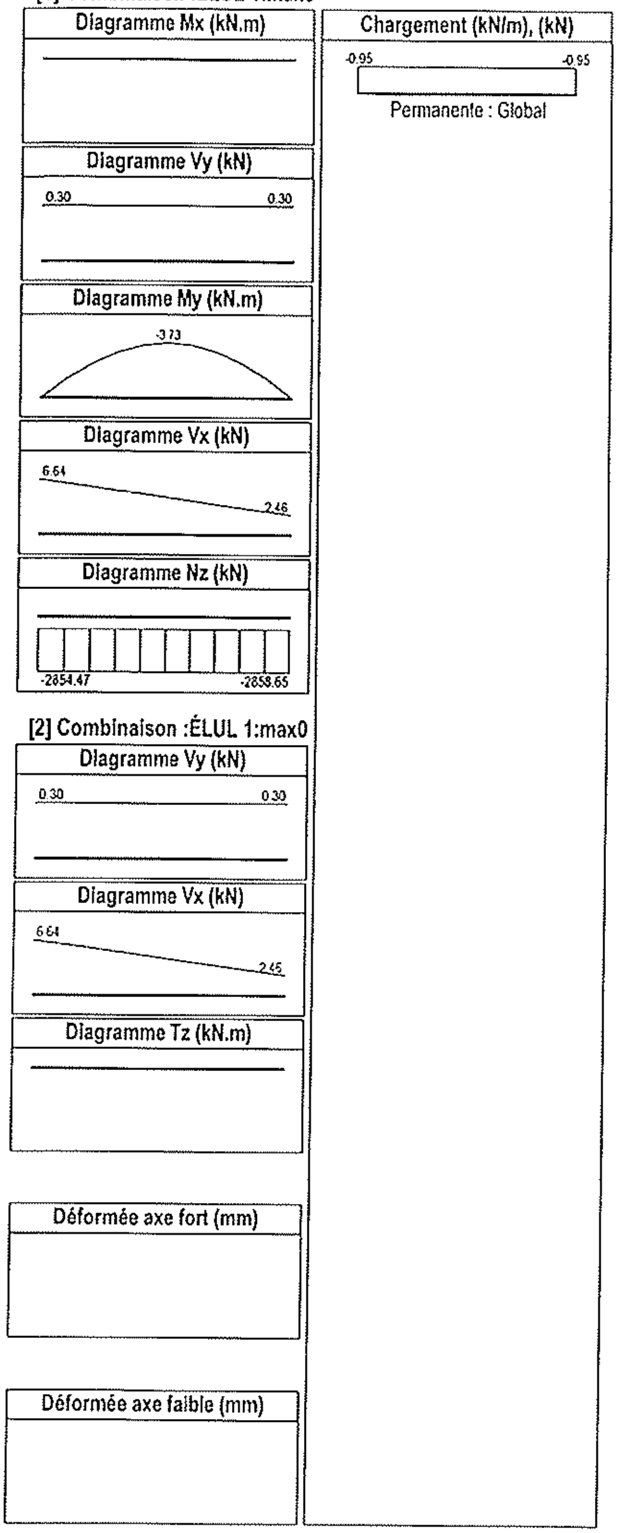
Article 10.10.5.1
V_{fx}/V_{rx} + T_{fz}/T_{rz} (incluant l'effet de torsion)
12.89/2081.99 kN + 0/27.47 kN.m = 0.62 % <= 100.00 % OK

États limites : Insuffisante

Tous droits réservés

GRAITEC	**Notes de calcul**	No de projet : 62240-001
	Nom de projet : Pont Kenamu_convoi special	
	Membrure : Diag32 Groupe : Compression	Vérifiée par : CR
	Préparé par : Dieudonné YAPO, ing.jr.	Date :

[1] Combinaison :ÉLUL 1:max0



Capacité de la section W310x97 - CAN/CSA S6-06

Propriétés de la section : W310x97
I_x =222.00 10e6mm4, I_y =72.90 10e6mm4, J = 0.91 10e6mm4, C_w =1560.00 10e9mm6
Aire = 12300.00 mm², Aire nette = 12300.00 mm², Longueur : 5727.56 mm
Aire (cis.x) =7981.83 mm², Aire (cis.y) =2768.47 mm²

Propriétés du matériau 350G/W/WT/AT
Module E = 200000.00 MPa, F_y =350.00 MPa, F_u =450.00 MPa

Efforts pondérés maximums contrôlant le design de la membrure

[1] Efforts combinés - Combinaison :ÉLUL 1:max0 : 1.09D+1.28Lm01

Dans le système d'axes orthogonal de base
M_{fx} = 0.00 kN.m, V_{fy} = 0.30 kN, M_{fy} = -3.73 kN.m, V_{fx} = 4.55 kN
N_{fz} = -2856.56 kN (compression), T_{fz} = 0.00 kN.m

[2] Cisaillement - Combinaison :ÉLUL 1:max0 : 1.09D+1.28Lm01

Dans le système d'axes orthogonal de base
V_{fy} = 0.30 kN, V_{fx} = 6.64 kN, T_{fz} = 0.00 kN.m

La membrure est en compression

La section est de classe 3

Valeur de KL/r (max) = 74.4 < 200 Ok

Valeurs de M_r avec et sans déversement latéral
$M_{rx}(L_u=0)$ =479.32 kN.m, $M_{rx}(L_u>0)$ =459.41 kN.m, L_{ux}=5727.56 mm, ω_x =1.00
$M_{ry}(L_u=0)$ =158.95 kN.m, $M_{ry}(L_u>0)$ =158.95 kN.m, L_{uy}=0.00 mm, ω_y =1.00

Analyse incluant les effets non linéaires PΔ et Pδ($U1_x = U1_y$ = 1.0)

Article 10.9.4.1 a)
$C_f/C_r + M_{fx}/M_{rx} + M_{fy}/M_{ry}$ <= 1.0 (sans déversement latéral)
2856.56/3874.50 kN + 0/479.32 kN.m + 3.73/158.95 kN.m = 76.07 % <= 100.00 % OK

Article 10.9.4.1 b)
$C_f/C_r + M_{fx}/M_{rx} + M_{fy}/M_{ry}$ <= 1.0 (sans déversement latéral)
2856.56/3341.61 kN + 0/479.32 kN.m + 3.73/158.95 kN.m = 87.83 % <= 100.00 % OK

Article 10.9.4.1 c)
$C_f/C_r + M_{fx}/M_{rx} + M_{fy}/M_{ry}$ <= 1.0 (M_{ry} sans déversement latéral, $C_r=C_{ry}$)
2856.56/2331.38 kN + 0/459.41 kN.m + 3.73/158.95 kN.m = 124.87 % > 100.00 % Pas Ok

Résistance à la compression seulement (10.9.3.1)
C_f/C_r <= 1.0 (avec KL/r max)
2856.56/2331.38 kN = 122.53 % > 100.00 % Pas Ok

Flexion bi-axiale (10.10.2, 10.10.3, 10.9.4.4)
$M_{fx}/M_{rx} + M_{fy}/M_{ry}$ <= 1.0 (avec déversement latéral)
0/459.41 kN.m + 3.73/158.95 kN.m = 2.34 % <= 100.00 % OK

Article 10.10.5.1
$V_{fy}/V_{ry} + T_{fz}/T_{rz}$ (incluant l'effet de torsion)
0.3/585.00 kN = 0.05 % <= 100.00 % OK

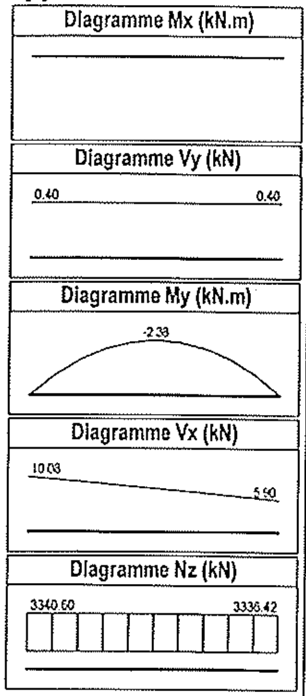
Article 10.10.5.1
$V_{fx}/V_{rx} + T_{fz}/T_{rz}$ (incluant l'effet de torsion)
6.64/1377.25 kN + 0/12.98 kN.m = 0.48 % <= 100.00 % OK

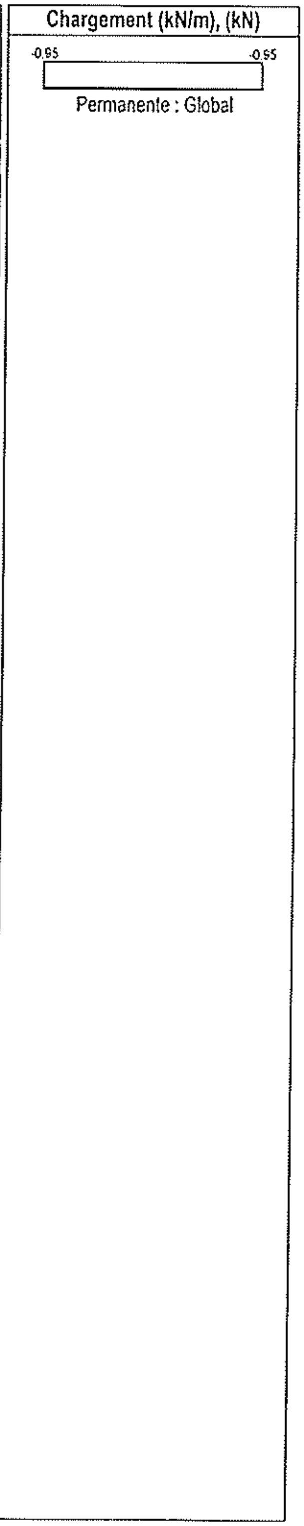
États limites : Insuffisante

Tous droits réservés

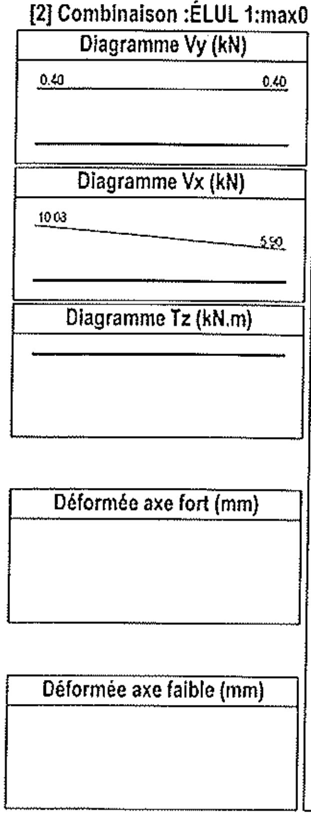
GRAITEC	**Notes de calcul**	No de projet : 62240-001
	Nom de projet : Pont Kenamu_convoi special	
	Membrure : Diag02 Groupe : Traction	Vérifiée par : CL
	Préparé par : Dieudonné YAPO, ing.jr.	Date :

[1] Combinaison :ÉLUL 1:max0





[2] Combinaison :ÉLUL 1:max0



Capacité de la section W310x97 - CAN/CSA S6-06

Propriétés de la section : W310x97
I_x =222.00 10e6mm4, I_y =72.90 10e6mm4, J = 0.91 10e6mm4, C_w =1560.00 10e9mm6
Aire = 12300.00 mm², Aire nette = 12300.00 mm², Longueur : 5727.57 mm
Aire (cis.x) =7981.83 mm², Aire (cis.y) =2768.47 mm²

Propriétés du matériau 350G/W/WT/AT
Module E = 200000.00 MPa, F_y =350.00 MPa, F_u =450.00 MPa

Efforts pondérés maximums contrôlant le design de la membrure

[1] Efforts combinés - Combinaison :ÉLUL 1:max0 : 1.09D+1.28Lm01

Dans le système d'axes orthogonal de base
M_{fx} = 0.00 kN.m, V_{fy} = 0.40 kN, M_{fy} = -2.38 kN.m, V_{fx} = 7.99 kN
N_{fz} = 3338.51 kN (traction), T_{fz} = 0.00 kN.m

[2] Cisaillement - Combinaison :ÉLUL 1:max0 : 1.09D+1.28Lm01

Dans le système d'axes orthogonal de base
V_{fy} = 0.40 kN, V_{fx} = 10.08 kN, T_{fz} = 0.00 kN.m

La membrure est en traction

La section est de classe 3

Valeur de KL/r (max) = 74.4 < 200 Ok

Valeurs de M_r avec et sans déversement latéral
$M_{rx}(L_u=0)$ =479.32 kN.m, $M_{rx}(L_u>0)$ =459.41 kN.m, L_{ux}=5727.57 mm, ω_x =1.00
$M_{ry}(L_u=0)$ =158.95 kN.m, $M_{ry}(L_u>0)$ =158.95 kN.m, L_{uy}=0.00 mm, ω_y =1.00

Article 10.8.3 a)
$T_f/T_r + M_{fx}/M_{rx} + M_{fy}/M_{ry}$ <= 1.0 (sans déversement latéral)
3338.51/4089.75 kN + 0/479.32 kN.m + 2.38/158.95 kN.m = 83.13 % <= 100.00 % OK

Article 10.8.3 b)
$M_{fx}/M_{rx} + M_{fy}/M_{ry} - (T_f{*}S_x)/(M_{rx}{*}A)$ (avec déversement latéral)
0/459.41 kN.m + 2.38/158.95 kN.m - 85.17 % = -83.67 % <= 100.00 % OK

Article 10.10.5.1
$V_{fy}/V_{ry} + T_{fz}/T_{rz}$ (incluant l'effet de torsion)
0.4/585.00 kN = 0.07 % <= 100.00 % OK

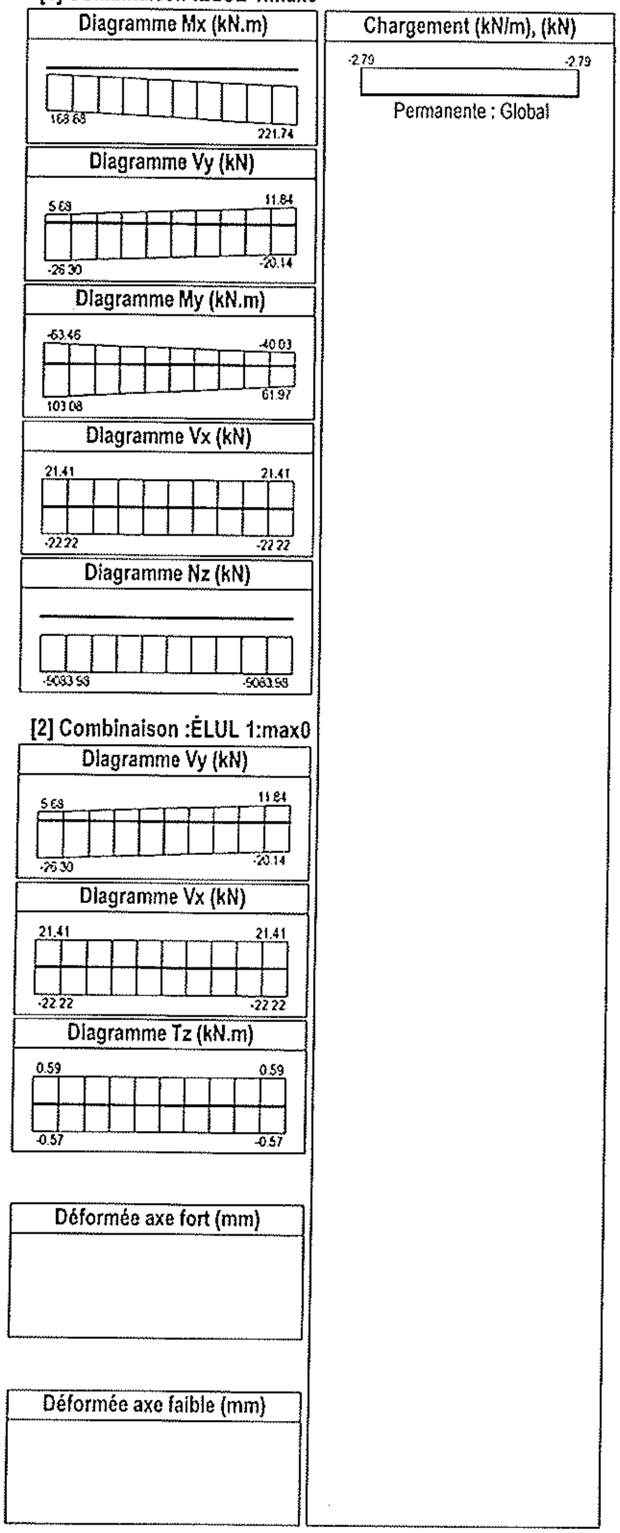
Article 10.10.5.1
$V_{fx}/V_{rx} + T_{fz}/T_{rz}$ (incluant l'effet de torsion)
10.08/1377.25 kN + 0/12.98 kN.m = 0.73 % <= 100.00 % OK

États limites : Suffisante

Tous droits réservés

GRAITEC	**Notes de calcul**	No de projet :
	Nom de projet : Pont Kenamu_convoi special	62240-001
	Membrure : CordeSup03 Groupe : T1	Vérifiée par : OR
	Préparé par : Dieudonné YAPO, ing.jr.	Date :

[1] Combinaison :ÉLUL 1:max0



Capacité de la section WS500.25x500.25 - CAN/CSA S6-06

Propriétés de la section : WS500.25x500.25
I_x =1601.30 10e6mm4, I_y =521.42 10e6mm4, J = 7.55 10e6mm4, C_w =29411.31 10e9mm6
Aire = 36250.00 mm², Aire nette = 36250.00 mm², Longueur : 2025.00 mm
Aire (cis.x) =21241.83 mm², Aire (cis.y) =10715.69 mm²

Propriétés du matériau 350G/W/WT/AT
Module E = 200000.00 MPa, F_y =350.00 MPa, F_u =450.00 MPa

Efforts pondérés maximums contrôlant le design de la membrure

[1] Efforts combinés - Combinaison :ÉLUL 1:max0 : 1.09D+1.28Lm01

Dans le système d'axes orthogonal de base
M_{fx} = 168.88 kN.m, V_{fy} = -26.30 kN, M_{fy} = 103.08 kN.m, V_{fx} = -22.22 kN
N_{fz} = -9083.98 kN (compression), T_{fz} = 0.59 kN.m

[2] Cisaillement - Combinaison :ÉLUL 1:max0 : 1.09D+1.28Lm01

Dans le système d'axes orthogonal de base
V_{fy} = -26.30 kN, V_{fx} = -22.22 kN, T_{fz} = 0.59 kN.m

La membrure est en compression

La section est de classe 3

Valeur de KL/r (max) = 67.5 < 120 Ok

Valeurs de M_r avec et sans déversement latéral
$M_{rx}(L_u=0)$ =2129.73 kN.m, $M_{rx}(L_u>0)$ =2129.73 kN.m, L_{ux}=8100.00 mm, ω_x =1.21
$M_{ry}(L_u=0)$ =693.49 kN.m, $M_{ry}(L_u>0)$ =693.49 kN.m, L_{uy}=0.00 mm, ω_y =1.00

Analyse incluant les effets non linéaires PΔ et Pδ($U1_x$ = $U1_y$ = 1.0)

Article 10.9.4.1 a)
$C_f/C_r + M_{fx}/M_{rx} + M_{fy}/M_{ry}$ <= 1.0 (sans déversement latéral)
9083.98/11418.75 kN + 168.88/2129.73 kN.m + 103.08/693.49 kN.m = 102.35 % > 100.00 % Pas (

Article 10.9.4.1 b)
$C_f/C_r + M_{fx}/M_{rx} + M_{fy}/M_{ry}$ <= 1.0 (sans déversement latéral)
9083.98/11171.05 kN + 168.88/2129.73 kN.m + 103.08/693.49 kN.m = 104.11 % > 100.00 % Pas (

Article 10.9.4.1 c)
$C_f/C_r + M_{fx}/M_{rx} + M_{fy}/M_{ry}$ <= 1.0 (M_y sans déversement latéral, C_r=C_{ry})
9083.98/9202.15 kN + 168.88/2129.73 kN.m + 103.08/693.49 kN.m = 121.51 % > 100.00 % Pas O

Résistance à la compression seulement (10.9.3.1)
C_f/C_r <= 1.0 (avec KL/r max)
9083.98/9202.15 kN = 98.72 % <= 100.00 % OK

Flexion bi-axiale (10.10.2, 10.10.3, 10.9.4.4)
$M_{fx}/M_{rx} + M_{fy}/M_{ry}$ <= 1.0 (avec déversement latéral)
168.88/2129.73 kN.m + 103.08/693.49 kN.m = 22.79 % <= 100.00 % OK

Article 10.10.5.1
$V_{fy}/V_{ry} + T_{fz}/T_{rz}$ (incluant l'effet de torsion)
26.3/2158.34 kN = 1.22 % <= 100.00 % OK

Article 10.10.5.1
$V_{fx}/V_{rx} + T_{fz}/T_{rz}$ (incluant l'effet de torsion)
22.22/3670.79 kN + 0.59/66.21 kN.m = 1.50 % <= 100.00 % OK

États limites : Insuffisante

Tous droits réservés

GRAITEC	**Notes de calcul**	No de projet :
	Nom de projet : Pont Kenamu_convoi special	62240-001
	Membrure : CordeSup07 Groupe : T2	Vérifiée par : CR
	Préparé par : Dieudonné YAPO, ing.jr.	Date :

[1] Combinaison :ÉLUL 1:max0

Diagramme Mx (kN.m)

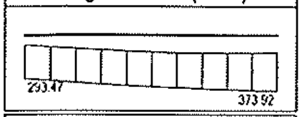


Diagramme Vy (kN)

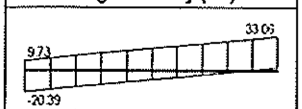


Diagramme My (kN.m)

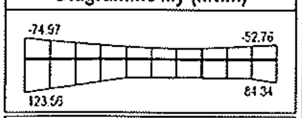


Diagramme Vx (kN)

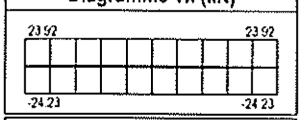
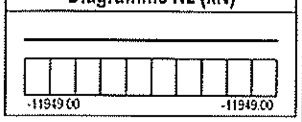
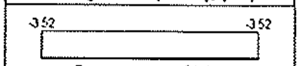


Diagramme Nz (kN)



Chargement (kN/m), (kN)



Permanente : Global

[2] Combinaison :ÉLUL 1:max0

Diagramme Vy (kN)

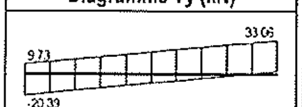


Diagramme Vx (kN)

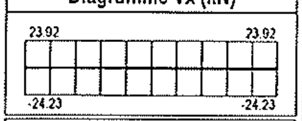
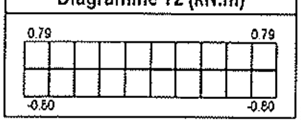


Diagramme Tz (kN.m)



Déformée axe fort (mm)

Déformée axe faible (mm)

Capacité de la section WS500.25x500.35 - CAN/CSA S6-06

Propriétés de la section : WS500.25x500.35
I_x =2061.18 10e6mm4, I_y =729.73 10e6mm4, J = 16.53 10e6mm4, C_w =39446.28 10e9mm6
Aire = 45750.00 mm², Aire nette = 45750.00 mm², Longueur : 6075.00 mm
Aire (cis.x) =29738.56 mm², Aire (cis.y) =10964.61 mm²

Propriétés du matériau 350G/W/WT/AT
Module E = 200000.00 MPa, F_y =350.00 MPa, F_u =450.00 MPa

Efforts pondérés maximums contrôlant le design de la membrure

[1] Efforts combinés - Combinaison :ÉLUL 1:max0 : 1.09D+1.28Lm01

Dans le système d'axes orthogonal de base
M_{fx} = 373.92 kN.m, V_{fy} = 33.06 kN, M_{fy} = 84.34 kN.m, V_{fx} = -24.23 kN
N_{fz} = -11949.00 kN (compression), T_{fz} = -0.80 kN.m

[2] Cisaillement - Combinaison :ÉLUL 1:max0 : 1.09D+1.28Lm01

Dans le système d'axes orthogonal de base
V_{fy} = 33.06 kN, V_{fx} = -24.23 kN, T_{fz} = -0.80 kN.m

La membrure est en compression

La section est de classe 1

Valeur de KL/r (max) = 64.1 < 120 Ok

Valeurs de M_r avec et sans déversement latéral
$M_{rx}(L_u=0)$ =3089.96 kN.m, $M_{rx}(L_u>0)$ =3089.96 kN.m, L_{ux}=8100.00 mm, ω_x =1.05
$M_{ry}(L_u=0)$ =1477.03 kN.m, $M_{ry}(L_u>0)$ =1477.03 kN.m, L_{uy}=0.00 mm, ω_y =1.00

Analyse incluant les effets non linéaires PΔ et Pδ($U1_x$ = $U1_y$ = 1.0)

Article 10.9.4.4 a)
C_f/C_{rx} + 0.85 M_{fx}/M_{rx} + 0.60 M_{fy}/M_{ry} <= 1.0
11949/14111.69 kN + 0.85 373.92/3089.96 kN.m + 0.60 84.34/1477.03 kN.m = 96.63 % <= 100.00

Article 10.9.4.4 b)
C_f/C_{rx} + 0.85 M_{fx}/M_{rx} + 0.60 M_{fy}/M_{ry} <= 1.0
11949/14111.69 kN + 0.85 373.92/3089.96 kN.m + 0.60 84.34/1477.03 kN.m = 98.39 % <= 100.00

Article 10.9.4.4 c)
C_f/C_r + 0.85 M_{fx}/M_{rx} + 0.60 M_{fy}/M_{ry} <= 1.0 (M_{ry} sans déversement latéral, C_r=C_{ry})
11949/12049.70 kN + 0.85 373.92/3089.96 kN.m + 0.60 84.34/1477.03 kN.m = 112.88 % > 100.00

Résistance à la compression seulement (10.9.3.1)
C_f/C_r <= 1.0 (avec KL/r max)
11949/12049.70 kN = 99.16 % <= 100.00 % OK

Flexion bi-axiale (10.10.2, 10.10.3, 10.9.4.4)
M_{fx}/M_{rx} + M_{fy}/M_{ry} <= 1.0 (avec déversement latéral)
373.92/3089.96 kN.m + 84.34/1477.03 kN.m = 17.81 % <= 100.00 % OK

Article 10.10.5.1
V_{fy}/V_{ry} + T_{fz}/T_{rz} (incluant l'effet de torsion)
33.06/2062.41 kN = 1.60 % <= 100.00 % OK

Article 10.10.5.1
V_{fx}/V_{rx} + T_{fz}/T_{rz} (incluant l'effet de torsion)
24.23/5137.28 kN + 0.8/103.51 kN.m = 1.24 % <= 100.00 % OK

États limites : Insuffisante

Tous droits réservés

GRAITEC	**Notes de calcul**	No de projet :
	Nom de projet : Pont Kenamu_convoi special	62240-001
	Membrure : CordeSup11 Groupe : T3	Vérifiée par : CR
	Préparé par : Dieudonné YAPO, ing.jr.	Date :

[1] Combinaison :ÉLUL 1:max0

Diagramme Mx (kN.m)

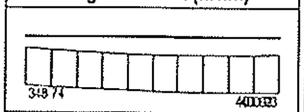


Diagramme Vy (kN)

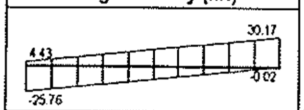


Diagramme My (kN.m)

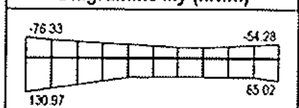


Diagramme Vx (kN)

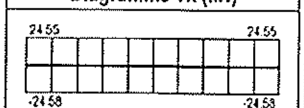
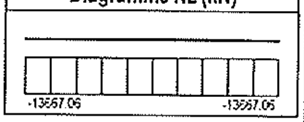
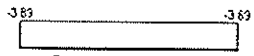


Diagramme Nz (kN)



Chargement (kN/m), (kN)



Permanente : Global

[2] Combinaison :ÉLUL 1:max0

Diagramme Vy (kN)

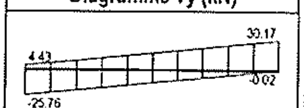


Diagramme Vx (kN)

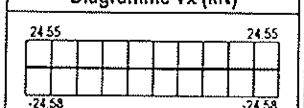
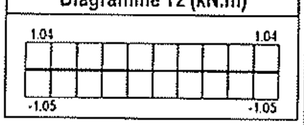


Diagramme Tz (kN.m)



Déformée axe fort (mm)

Déformée axe faible (mm)

Capacité de la section WS500.25x500.40 - CAN/CSA S6-06

Propriétés de la section : WS500.25x500.40
I_x =2275.68 10e6mm4, I_y =833.88 10e6mm4, J = 23.52 10e6mm4, C_w =44112.27 10e9mm6
Aire = 50500.00 mm², Aire nette = 50500.00 mm², Longueur : 6075.00 mm
Aire (cis.x) =33986.93 mm², Aire (cis.y) =11053.36 mm²

Propriétés du matériau 350G/W/WT/AT
Module E = 200000.00 MPa, F_y =350.00 MPa, F_u =450.00 MPa

Efforts pondérés maximums contrôlant le design de la membrure

[1] Efforts combinés - Combinaison :ÉLUL 1:max0 : 1.09D+1.28Lm01

Dans le système d'axes orthogonal de base
M_{fx} = 348.74 kN.m, V_{fy} = -25.76 kN, M_{fy} = 130.97 kN.m, V_{fx} = -24.58 kN
N_{fz} = -13667.06 kN (compression), T_{fz} = -1.05 kN.m

[2] Cisaillement - Combinaison :ÉLUL 1:max0 : 1.09D+1.28Lm01

Dans le système d'axes orthogonal de base
V_{fy} = 30.17 kN, V_{fx} = -24.58 kN, T_{fz} = -1.05 kN.m

La membrure est en compression

La section est de classe 1

Valeur de KL/r (max) = 63.0 < 120 Ok

Valeurs de M_r avec et sans déversement latéral
$M_{rx}(L_u=0)$ =3425.58 kN.m, $M_{rx}(L_u>0)$ =3425.58 kN.m, L_{ux}=8100.00 mm, ω_x =1.02
$M_{ry}(L_u=0)$ =1684.32 kN.m, $M_{ry}(L_u>0)$ =1684.32 kN.m, L_{uy}=0.00 mm, ω_y =1.00

Analyse incluant les effets non linéaires PΔ et Pδ($U1_x$ = $U1_y$ = 1.0)

Article 10.9.4.4 a)
$C_f/C_{rx} + 0.85\ M_{fx}/M_{rx} + 0.60\ M_{fy}/M_{ry} <= 1.0$
13667.06/15576.99 kN + 0.85 348.74/3425.58 kN.m + 0.60 130.97/1684.32 kN.m = 99.23 % <= 10

Article 10.9.4.4 b)
$C_f/C_{rx} + 0.85\ M_{fx}/M_{rx} + 0.60\ M_{fy}/M_{ry} <= 1.0$
13667.06/15576.99 kN + 0.85 348.74/3425.58 kN.m + 0.60 130.97/1684.32 kN.m = 101.06 % > 10

Article 10.9.4.4 c)
$C_f/C_r + 0.85\ M_{fx}/M_{rx} + 0.60\ M_{fy}/M_{ry} <= 1.0$ (M_{ry} sans déversement latéral, C_r=C_{ry})
13667.06/13449.84 kN + 0.85 348.74/3425.58 kN.m + 0.60 130.97/1684.32 kN.m = 114.93 % > 10

Résistance à la compression seulement (10.9.3.1)
$C_f/C_r <= 1.0$ (avec KL/r max)
13667.06/13449.84 kN = 101.62 % > 100.00 % Pas Ok

Flexion bi-axiale (10.10.2, 10.10.3, 10.9.4.4)
$M_{fx}/M_{rx} + M_{fy}/M_{ry} <= 1.0$ (avec déversement latéral)
348.74/3425.58 kN.m + 130.97/1684.32 kN.m = 17.96 % <= 100.00 % OK

Article 10.10.5.1
$V_{fy}/V_{ry} + T_{fz}/T_{rz}$ (incluant l'effet de torsion)
30.17/2014.45 kN = 1.50 % <= 100.00 % OK

Article 10.10.5.1
$V_{fx}/V_{rx} + T_{fz}/T_{rz}$ (incluant l'effet de torsion)
24.58/5870.52 kN + 1.05/128.88 kN.m = 1.23 % <= 100.00 % OK

États limites : Insuffisante

Tous droits réservés

GRAITEC	**Notes de calcul**	No de projet :
	Nom de projet : Pont Kenamu_convoi special	62240-001
	Membrure : CordeSup15 Groupe : T4	Vérifiée par : CR
	Préparé par : Dieudonné YAPO, ing.jr.	Date :

[1] Combinaison :ÉLUL 1:max0

Diagramme Mx (kN.m)

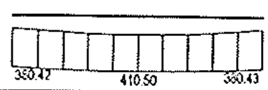


Diagramme Vy (kN)

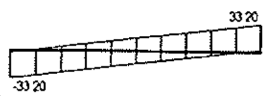


Diagramme My (kN.m)

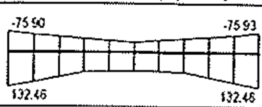


Diagramme Vx (kN)

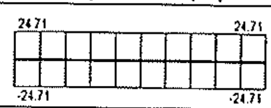
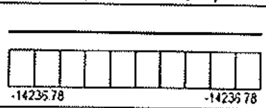


Diagramme Nz (kN)



[2] Combinaison :ÉLUL 1:max0

Diagramme Vy (kN)

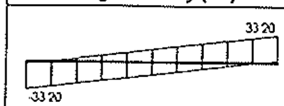


Diagramme Vx (kN)

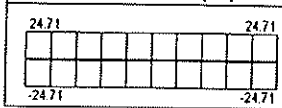
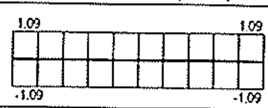


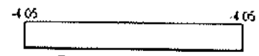
Diagramme Tz (kN.m)



Déformée axe fort (mm)

Déformée axe faible (mm)

Chargement (kN/m), (kN)



Permanente : Global

Capacité de la section WS500.30x500.40 - CAN/CSA S6-06

Propriétés de la section : WS500.30x500.40
I_x =2306.55 10e6mm4, I_y =834.28 10e6mm4, J = 25.11 10e6mm4, C_w =44133.33 10e9mm6
Aire = 52600.00 mm², Aire nette = 52600.00 mm², Longueur : 8100.00 mm
Aire (cis.x) =33986.93 mm², Aire (cis.y) =13017.82 mm²

Propriétés du matériau 350G/W/WT/AT
Module E = 200000.00 MPa, F_y =350.00 MPa, F_u =450.00 MPa

Efforts pondérés maximums contrôlant le design de la membrure

[1] Efforts combinés - Combinaison :ÉLUL 1:max0 : 1.09D+1.28Lm01

Dans le système d'axes orthogonal de base
M_{fx} = 380.43 kN.m, V_{fy} = 33.20 kN, M_{fy} = 132.46 kN.m, V_{fx} = -24.71 kN
N_{fz} = -14236.78 kN (compression), T_{fz} = -1.09 kN.m

[2] Cisaillement - Combinaison :ÉLUL 1:max0 : 1.09D+1.28Lm01

Dans le système d'axes orthogonal de base
V_{fy} = -33.20 kN, V_{fx} = -24.71 kN, T_{fz} = -1.09 kN.m

La membrure est en compression

La section est de classe 1

Valeur de KL/r (max) = 64.3 < 120 Ok

Valeurs de M_r avec et sans déversement latéral
$M_{rx}(L_u=0)$ =3498.90 kN.m, $M_{rx}(L_u>0)$ =3498.90 kN.m, L_{ux}=8100.00 mm, ω_x =1.01
$M_{ry}(L_u=0)$ =1693.92 kN.m, $M_{ry}(L_u>0)$ =1693.92 kN.m, L_{uy}=0.00 mm, ω_y =1.00

Analyse incluant les effets non linéaires PΔ et Pδ(U1$_x$ = U1$_y$ = 1.0)

Article 10.9.4.4 a)
$C_f/C_{rx} + 0.85\ M_{fx}/M_{rx} + 0.60\ M_{fy}/M_{ry} <= 1.0$
14236.78/16203.83 kN + 0.85 380.43/3498.90 kN.m + 0.60 132.46/1693.92 kN.m = 99.86 % <= 10

Article 10.9.4.4 b)
$C_f/C_{rx} + 0.85\ M_{fx}/M_{rx} + 0.60\ M_{fy}/M_{ry} <= 1.0$
14236.78/16203.83 kN + 0.85 380.43/3498.90 kN.m + 0.60 132.46/1693.92 kN.m = 101.79 % > 10

Article 10.9.4.4 c)
$C_f/C_r + 0.85\ M_{fx}/M_{rx} + 0.60\ M_{fy}/M_{ry} <= 1.0$ (M_{ry} sans déversement latéral, C_r=C_{ry})
14236.78/13828.03 kN + 0.85 380.43/3498.90 kN.m + 0.60 132.46/1693.92 kN.m = 116.89 % > 10

Résistance à la compression seulement (10.9.3.1)
$C_f/C_r <= 1.0$ (avec KL/r max)
14236.78/13828.03 kN = 102.96 % > 100.00 % Pas Ok

Flexion bi-axiale (10.10.2, 10.10.3, 10.9.4.4)
$M_{fx}/M_{rx} + M_{fy}/M_{ry} <= 1.0$ (avec déversement latéral)
380.43/3498.90 kN.m + 132.46/1693.92 kN.m = 18.69 % <= 100.00 % OK

Article 10.10.5.1
$V_{fy}/V_{ry} + T_{fz}/T_{rz}$ (incluant l'effet de torsion)
33.2/2417.34 kN = 1.37 % <= 100.00 % OK

Article 10.10.5.1
$V_{fx}/V_{rx} + T_{fz}/T_{rz}$ (incluant l'effet de torsion)
24.71/5879.80 kN + 1.09/137.61 kN.m = 1.21 % <= 100.00 % OK

États limites : Insuffisante

Tous droits réservés

62 240. 001.

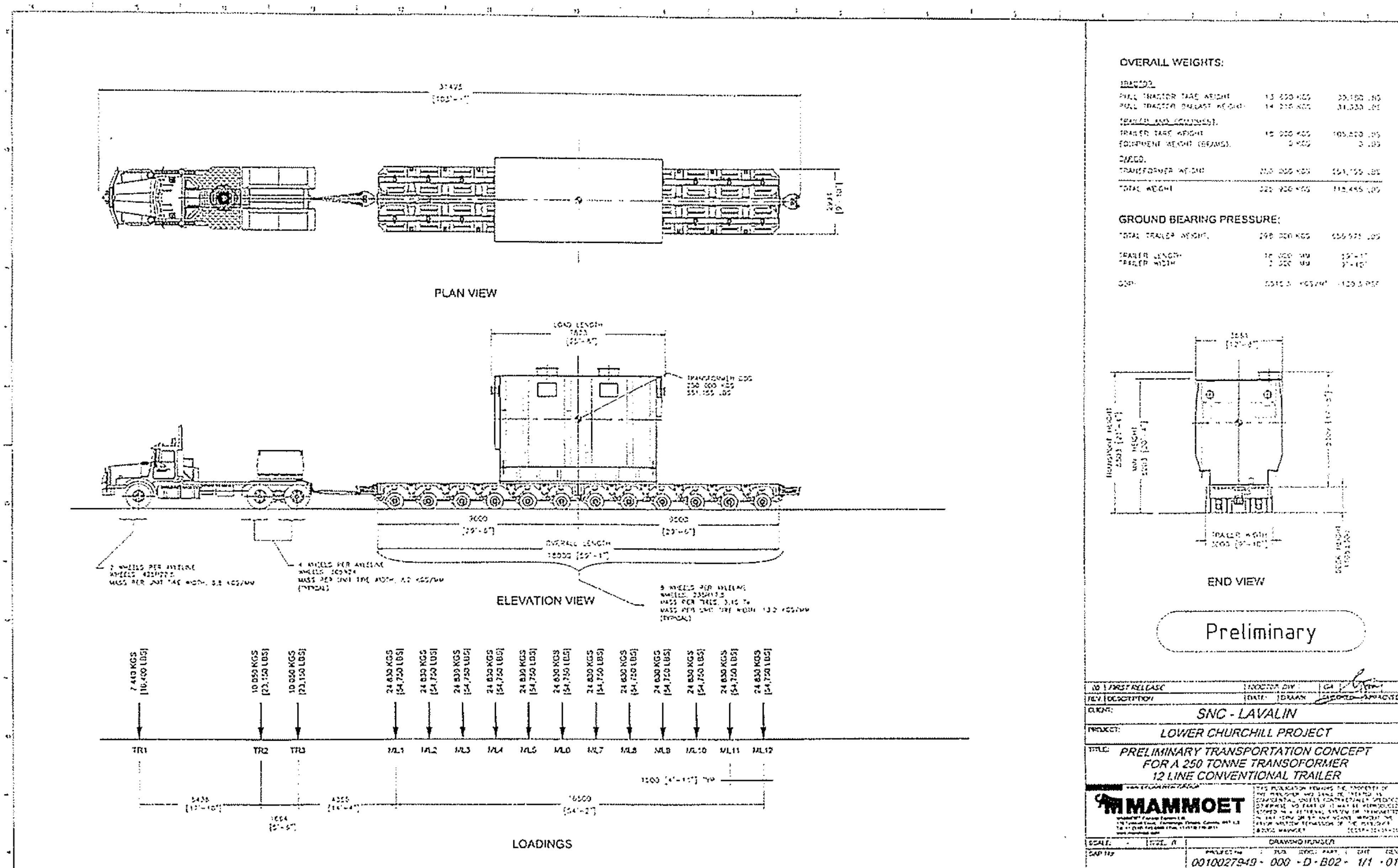
TABLEAU RÉCAPITULATIF DES TAUX DE SOLLICITATION DES MEMBRURES DU TREILLIS

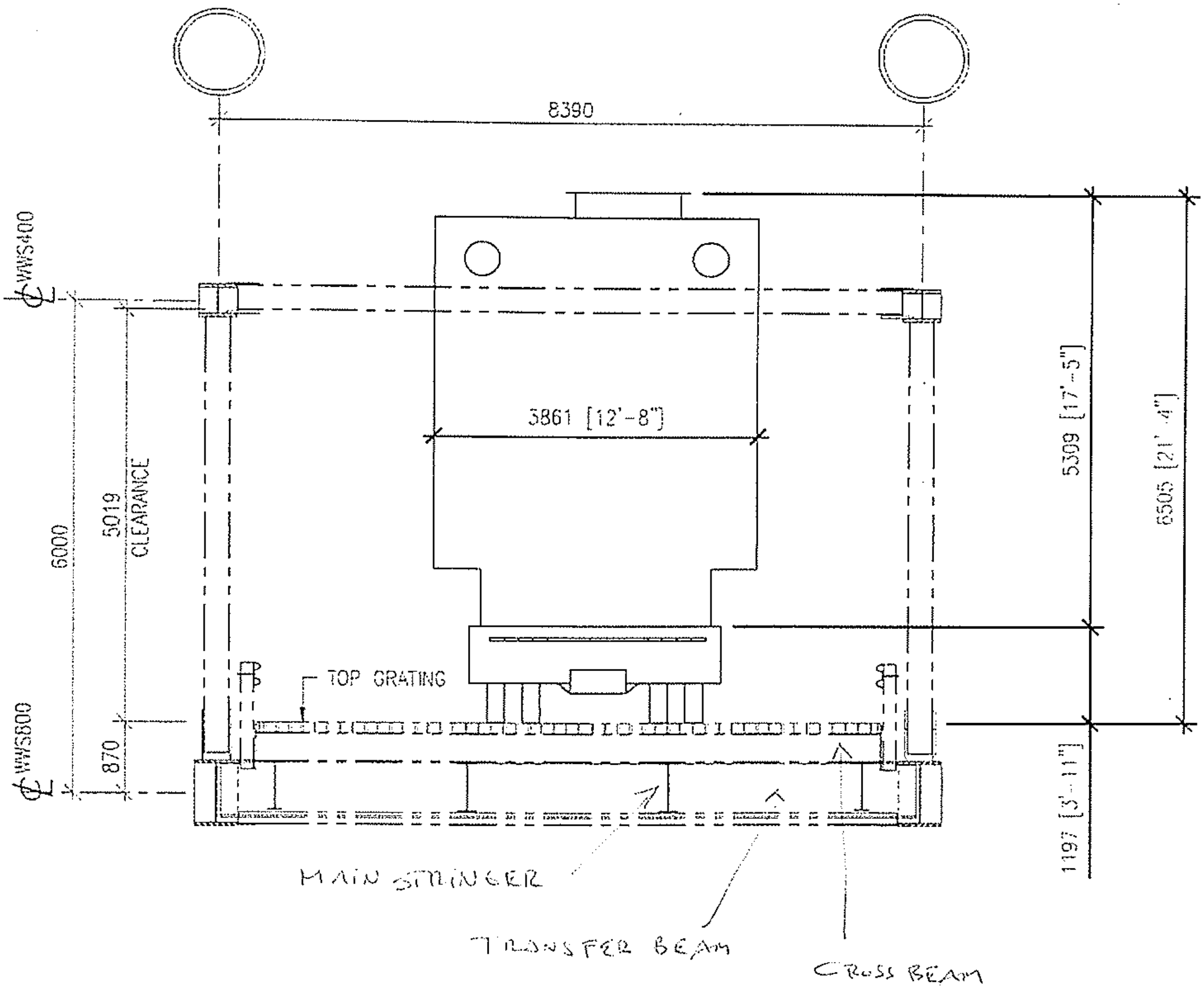
Désignation	Sollicitation Mf-Nf	Sollicitation Cisaillement
	%	%
CordeInf01	24.95	1.35
CordeInf02	24.95	1.35
CordeInf03	40.01	8.82
CordeInf04	40.00	8.82
CordeInf05	78.81	7.68
CordeInf06	78.80	7.68
CordeInf07	74.29	7.15
CordeInf08	74.28	7.15
CordeInf09	101.65	5.83
CordeInf10	101.64	5.83
CordeInf11	96.00	6.46
CordeInf12	96.00	6.46
CordeInf13	112.65	5.54
CordeInf14	112.64	5.54
CordeInf15	99.61	7.28
CordeInf16	99.61	7.28
CordeInf17	107.07	6.74
CordeInf18	107.06	6.74
CordeInf19	106.95	7.01
CordeInf20	106.95	7.01
CordeInf21	106.95	7.01
CordeInf22	106.94	7.01
CordeInf23	107.06	6.74
CordeInf24	107.06	6.74
CordeInf25	99.61	7.28
CordeInf26	99.60	7.28
CordeInf27	112.64	5.54
CordeInf28	112.64	5.54
CordeInf29	96.00	6.46
CordeInf30	96.00	6.46
CordeInf31	101.64	5.83
CordeInf32	101.64	5.83
CordeInf33	74.29	7.15
CordeInf34	74.28	7.15
CordeInf35	78.80	7.68
CordeInf36	78.80	7.68
CordeInf37	40.01	8.82
CordeInf38	40.00	8.82
CordeInf39	24.95	1.35
CordeInf40	24.95	1.35

Désignation	Sollicitation Mf-Nf	Sollicitation Cisaillement
	%	%
CordeSup01	80.21	1.59
CordeSup02	80.21	1.59
CordeSup03	121.51	1.50
CordeSup04	121.50	1.50
CordeSup05	89.84	1.70
CordeSup06	89.83	1.70
CordeSup07	112.88	1.60
CordeSup08	112.87	1.60
CordeSup09	102.86	2.06
CordeSup10	102.86	2.06
CordeSup11	114.93	1.50
CordeSup12	114.93	1.50
CordeSup13	112.98	1.61
CordeSup14	112.98	1.61
CordeSup15	116.89	1.37
CordeSup16	116.88	1.37
CordeSup17	112.98	1.61
CordeSup18	112.97	1.61
CordeSup19	114.93	1.50
CordeSup20	114.92	1.50
CordeSup21	102.86	2.06
CordeSup22	102.85	2.06
CordeSup23	112.87	1.60
CordeSup24	112.87	1.60
CordeSup25	89.83	1.70
CordeSup26	89.83	1.70
CordeSup27	121.51	1.50
CordeSup28	121.50	1.50
CordeSup29	80.21	1.59
CordeSup30	80.21	1.59

Désignation	Sollicitation Mf-Nf
	%
Diag01	110.66
Diag02	83.13
Diag03	110.65
Diag04	83.12
Diag05	98.47
Diag06	69.21
Diag07	98.46
Diag08	69.20
Diag09	124.88
Diag10	54.15
Diag11	124.88
Diag12	54.14
Diag13	101.92
Diag14	39.14
Diag15	101.92
Diag16	39.14
Diag17	77.52
Diag18	51.51
Diag19	77.52
Diag20	51.51
Diag21	51.52
Diag22	77.52
Diag23	51.51
Diag24	77.51
Diag25	39.14
Diag26	101.92
Diag27	39.14
Diag28	101.91
Diag29	54.14
Diag30	124.88
Diag31	54.14
Diag32	124.87
Diag33	69.20
Diag34	98.46
Diag35	69.20
Diag36	98.46
Diag37	83.12
Diag38	110.66
Diag39	83.12
Diag40	110.65

TRUCK CONFIGURATION

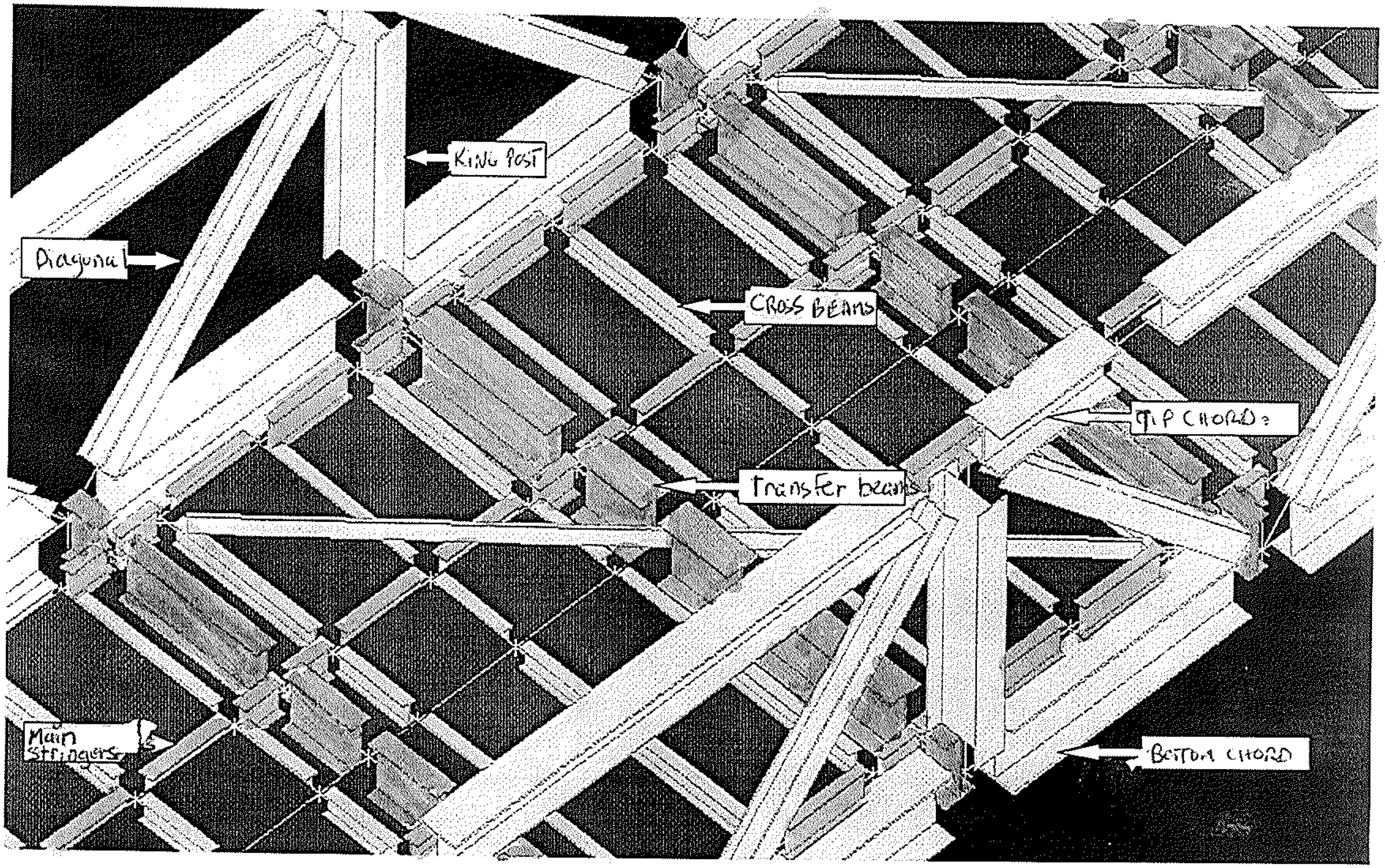

OVERALL WEIGHTS:
GROUND BEARING PRESSURE:
PLAN VIEW
ELEVATION VIEW
END VIEW
LOADINGS
Preliminary
TR1
TR2
TR3
7 440 KGS [16,400 LBS]
10 050 KGS [22,150 LBS]
10 050 KGS [22,150 LBS]
24 830 KGS [54,750 LBS]
SNC - LAVALIN
LOWER CHURCHILL PROJECT
PRELIMINARY TRANSPORTATION CONCEPT FOR A 250 TONNE TRANSOFORMER 12 LINE CONVENTIONAL TRAILER
MAMMOET
0010027949 - 000 - D - B02 - 1/1 - 01



TYPICAL SECTION

1:75

SUPERSTRUCTURE ELEMENT IDENTIFICATION



Vue 3D DES MEMBRURES SUR VISUAL DESIGN.

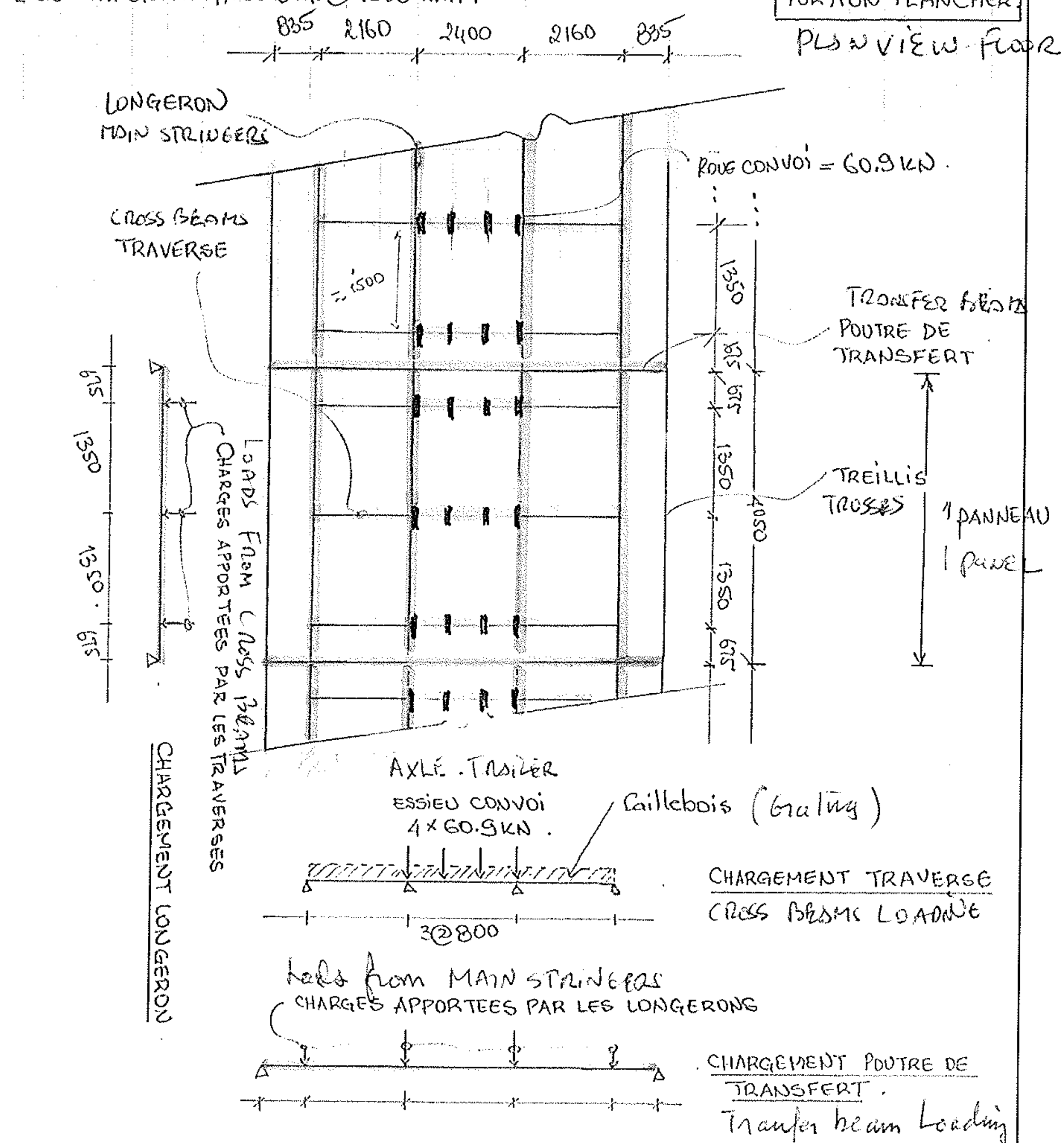
3D MEMBERS ID FROM ADA

ROCHE
INGÉNIEURS-CONSEILS

NOTES DE CALCUL

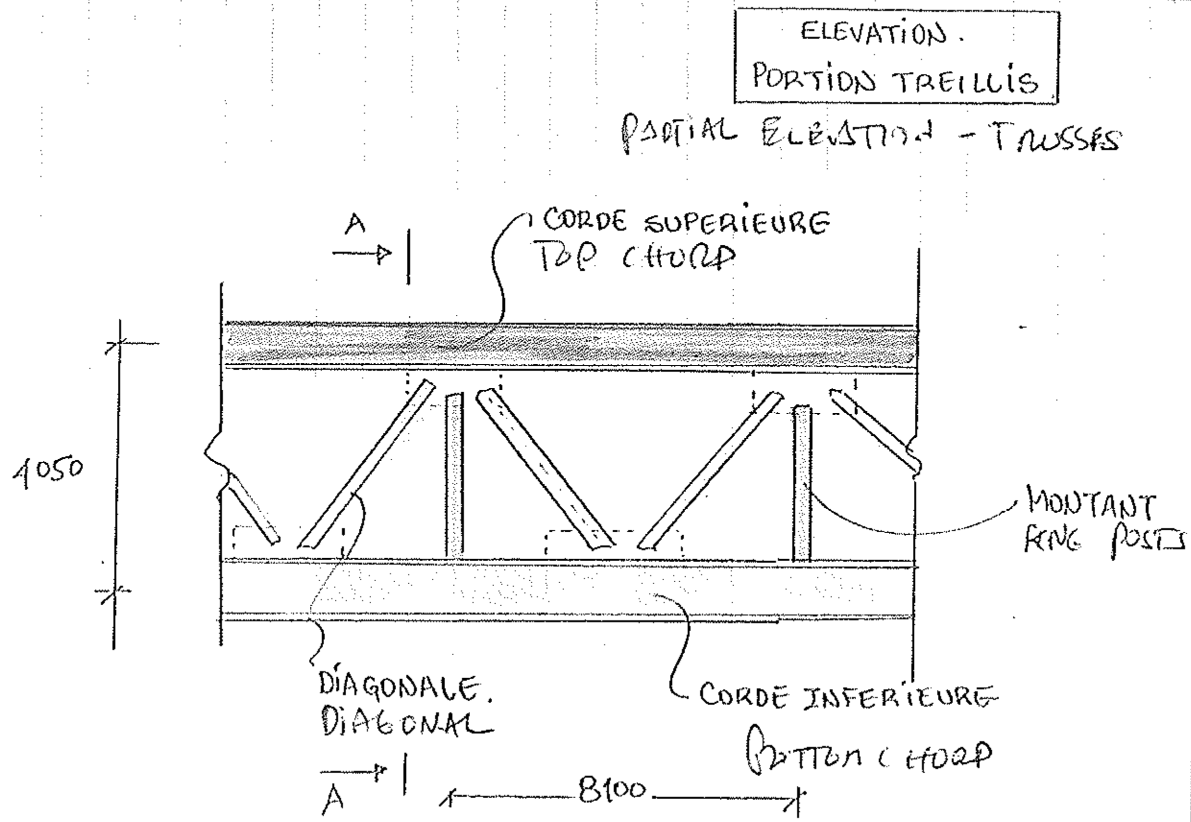
Projet nº	62 240.001
PROJET	MEMBERS IP
SUJET	DESCRIPTION DES MEMBRURES
Page	de
Par	
Date	
Vérifié	

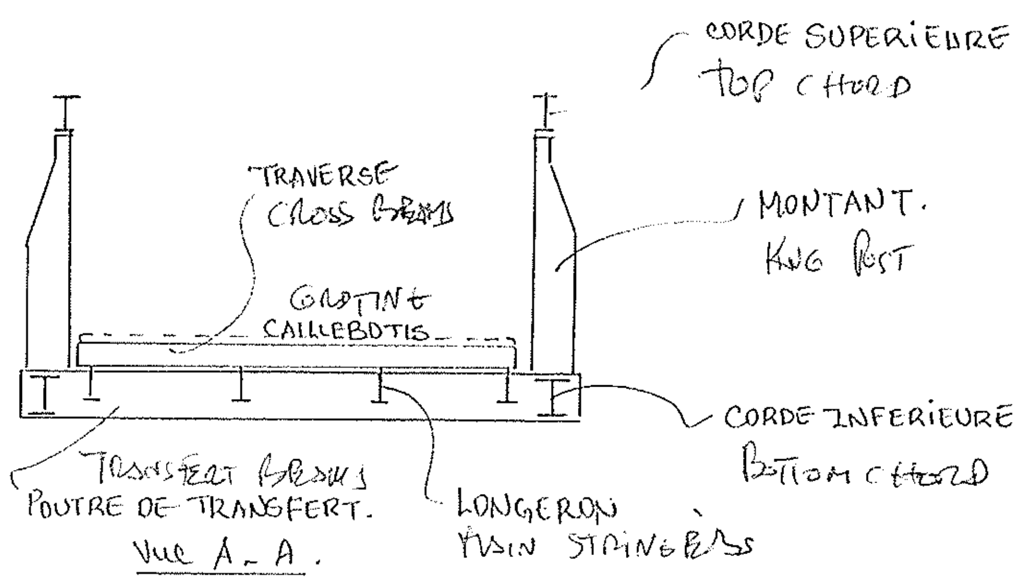
AXLE FROM TRAILER
ESSIEU FARDIER = 4x60.9kN @ 1500 mm.



CR

ROCHE INGÉNIEURS-CONSEILS	NOTES DE CALCUL	Projet nº 62 240-001
	PROJET MEMBRES ID	Page ___ de ___
	SUJET DESCRIPTION DE MEMBRURES	Par
		Date
		Vérifié





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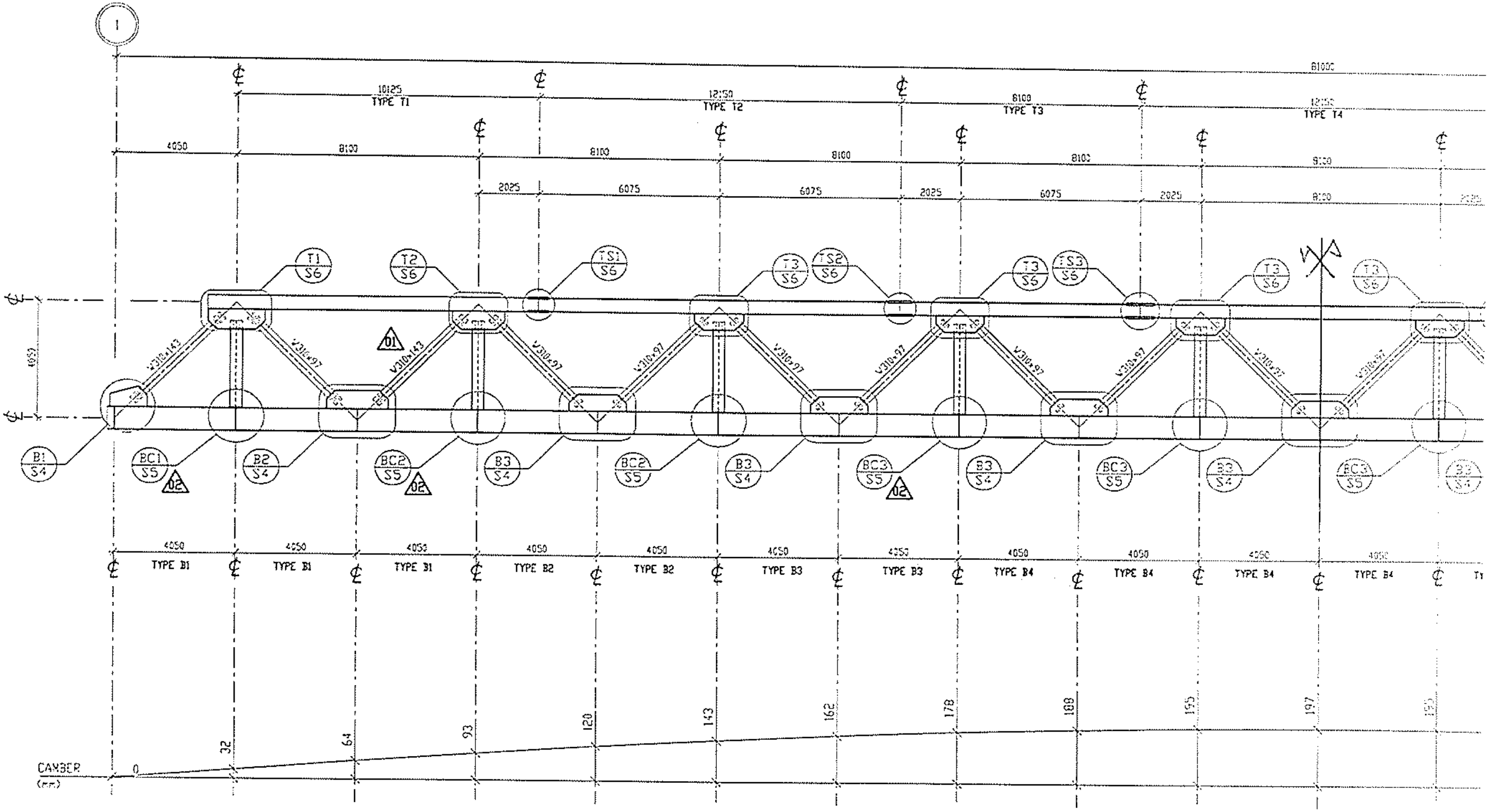
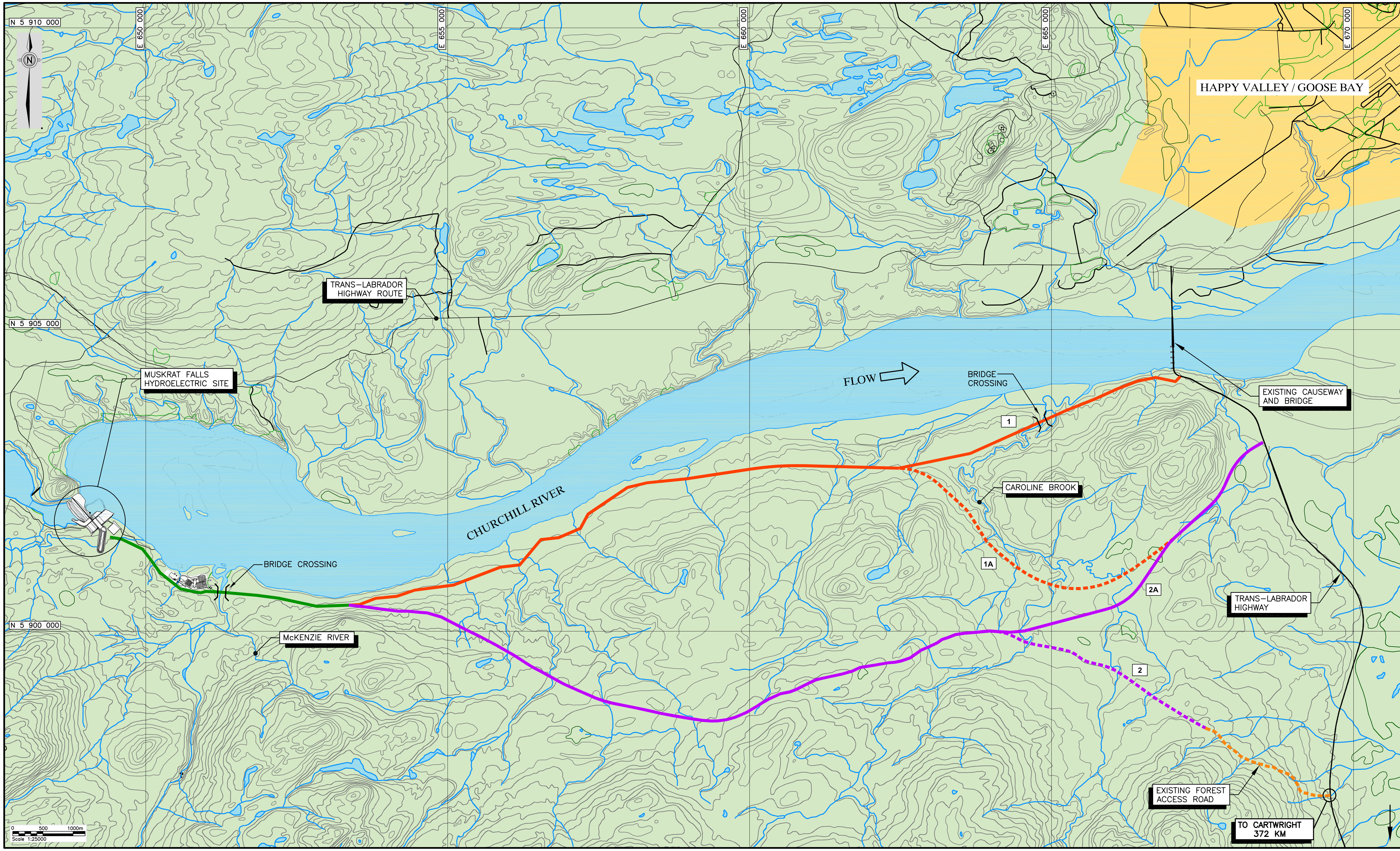


ELEVATION
1:100

1001-0762

APPENDIX D

MUSKRAT FALLS ACCESS ROAD
DRAWINGS



LEGEND

PROPOSED

COMMON — ROUTE 2A — 2 ROUTE ALTERNATIVE

ALTERNATE

COMMON — ROUTE 1 — 1A ROUTE ALTERNATIVE

EXISTING FOREST ACCESS ROAD

SNC•LAVALIN BAE-Newplan

BAE-Newplan Group Limited
1133 Topsail Road
MOUNT PEARL NL A1N 5G2
CANADA

NOTICE:
This Drawing contains intellectual property of Newfoundland and Labrador Hydro (HYDRO) and shall not be copied or distributed in whole or in part without prior written consent from HYDRO. Use of the drawing shall be restricted to purposes of prosecution of a contract with HYDRO.

NALCOR ENERGY

ELECT.	SCALE:	AS NOTED
CIVIL	DESIGNED:	S.W.
TRANS.	DRAWN:	P.W.
MECH.	DATE:	2010/12/13
P&C	CHECKED:	T.M.
TELC.	APPROVED:	

LOWER CHURCHILL PROJECT
PROPOSED MUSKRAT FALLS SOUTHSIDE ACCESS ROAD
ALTERNATIVE ROUTES

W.O. NO.

DWG. NO. 723469-MF1310-41DD-0001

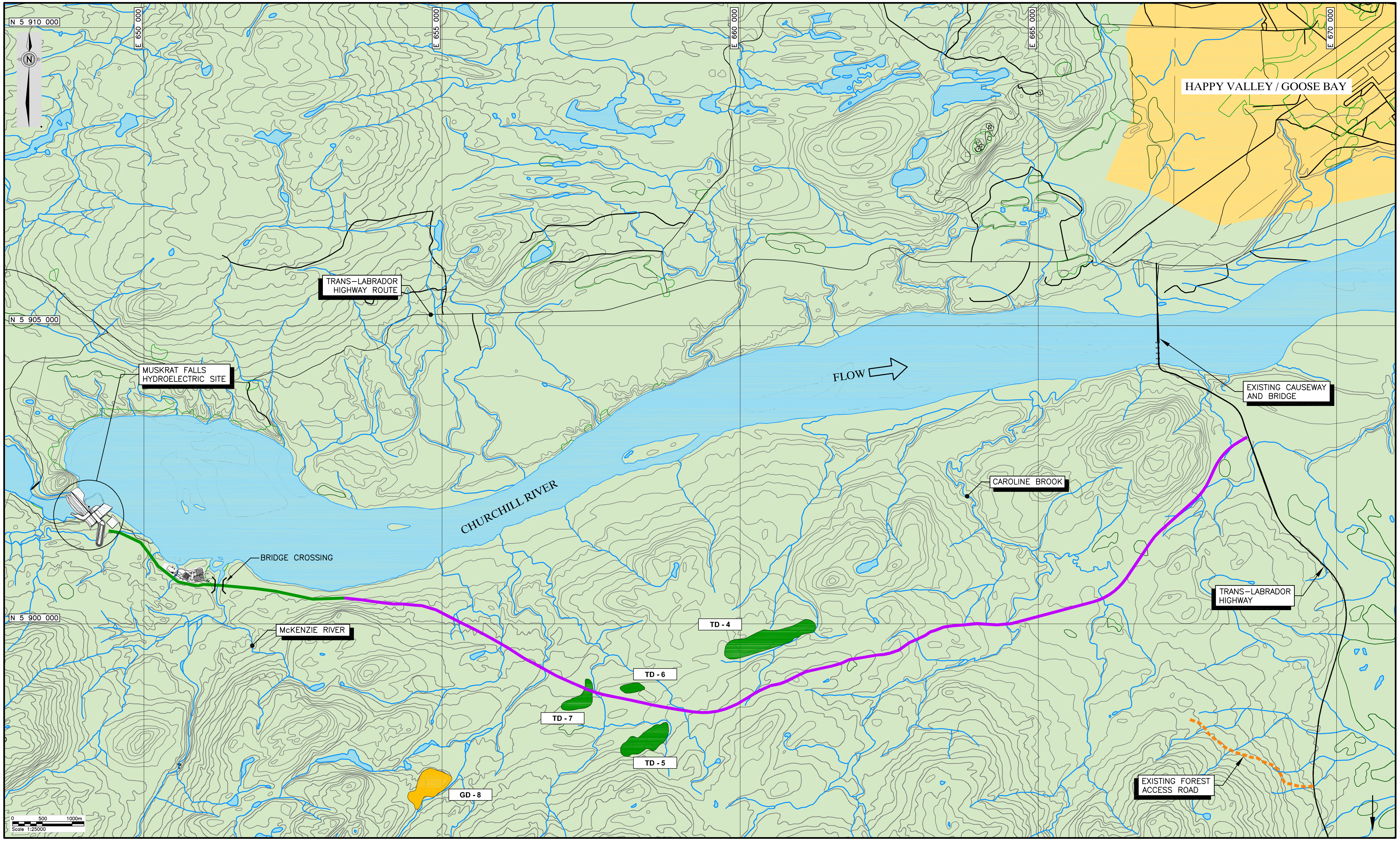
REV. 1

C.A.D.

DWG.NO.	TITLE	NO.	DATE	DESCRIPTION	DWN.	DESIGN.	CHK.	APP'D

REFERENCE DRAWINGS — REVISIONS

Jan 31, 2011 – 4:24pm



LEGEND

PROPOSED

COMMON — ROUTE 2A

EXISTING FOREST ACCESS ROAD

TILL DEPOSIT

GRANULAR DEPOSIT

SNC•LAVALIN BAE-Newplan

BAE-Newplan Group Limited
1133 Topsail Road
MOUNT PEARL NL A1N 5G2
CANADA

NOTICE:
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NALCOR ENERGY

DWG.NO.	TITLE	NO.	DATE	DESCRIPTION	DWN.	DESIGN.	CHK.	APP'D
REFERENCE DRAWINGS		REVISIONS						

ELECT.	SCALE:	AS NOTED
CIVIL	DESIGNED:	S.W.
TRANS.	DRAWN:	P.W.
MECH.	DATE:	2010/12/13
P&C	CHECKED:	T.M.
TELC.	APPROVED:	

LOWER CHURCHILL PROJECT
PROPOSED MUSKRAT FALLS SOUTHSIDE ACCESS ROAD
RECOMMENDED ROUTE

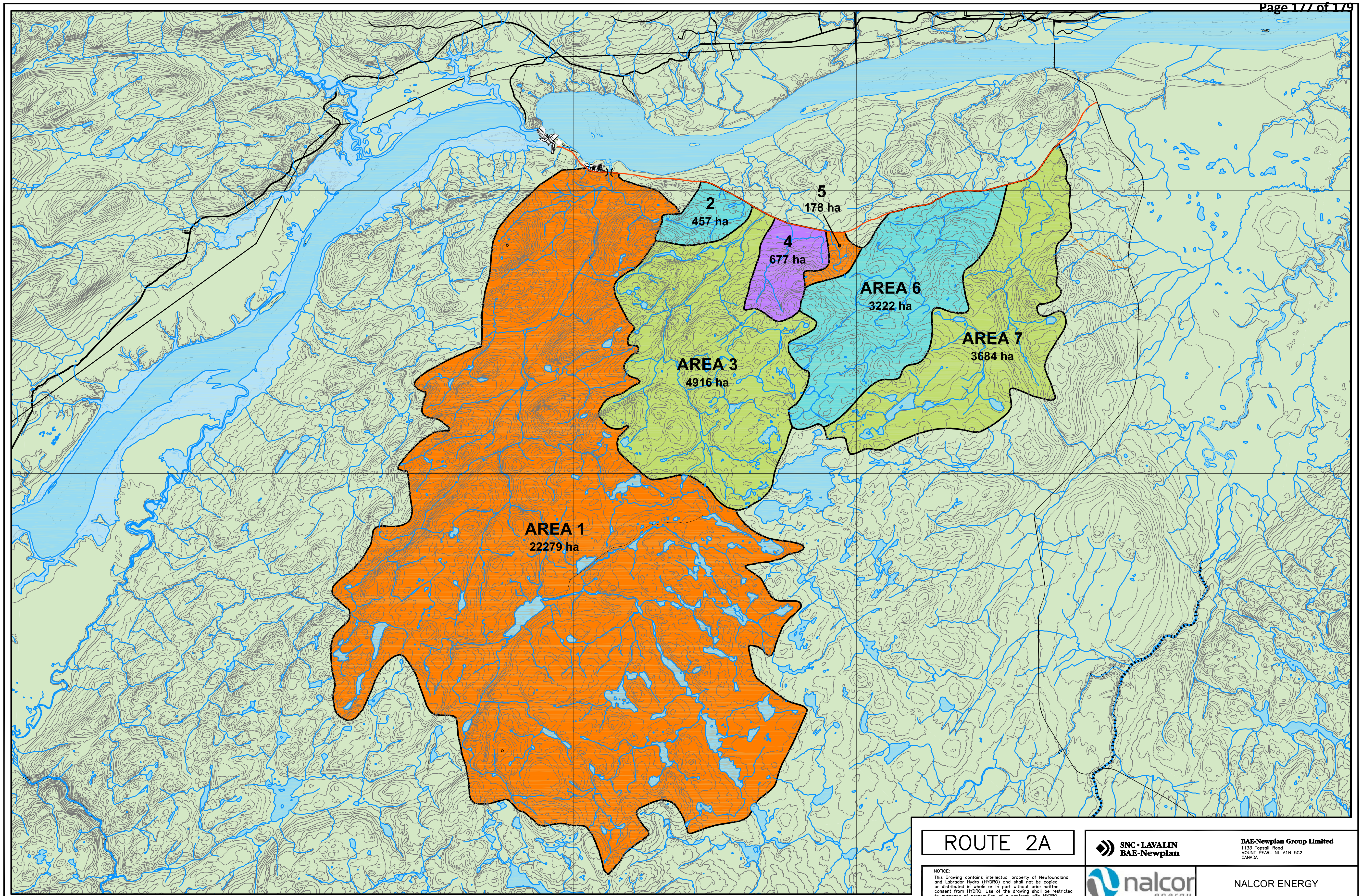
W.O. NO.

DWG. NO. 723469-MF1310-41DD-0002

REV. 1

C.A.D.

Jan 31, 2011 – 4:19pm



0 500 1500 2500m
SCALE 1:50,000

LEGEND

PROPOSED ROUTE 2A
EXISTING FOREST ACCESS ROAD

DWG.NO.	TITLE
REFERENCE DRAWINGS	

NO.	DATE	DESCRIPTION	DWN.	DESIGN.	CHK.	APP'D
REVISIONS						

ROUTE 2A

SNC•LAVALIN BAE-Newplan

BAE-Newplan Group Limited
1133 Topsail Road
MOUNT PEARL NL A1N 5G2
CANADA

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NALCOR ENERGY

ELECT.	SCALE:	AS NOTED
CIVIL	DESIGNED:	S.W.
TRANS.	DRAWN:	P.W.
MECH.	DATE:	2010/09/30
P&C	CHECKED:	T.M.
TELC.	APPROVED:	

LOWER CHURCHILL PROJECT
PROPOSED MUSKRAT FALLS SOUTHSIDE ACCESS ROAD
DRAINAGE AREAS FOR RECOMMENDED ROUTE 2A

W.O. NO.

DWG. NO. 723469-MF1310-41DD-0003

REV. 0

C.A.D.

Nov 17, 2010 – 3:30pm

APPENDIX E

MUSKRAT FALLS ACCESS ROAD

ROUTE QUANTITIES AND ESTIMATES

not filed with Public version