Bridges on the Trans Labrador Highway

Gordon Jin, P.Eng., Bridge Design Engineer
Peter Lester, P.Eng., Chief Bridge Engineer
Terry McCarthy, P.Eng., Senior Coordinator (TLH)

Government of Newfoundland and Labrador
Department of Works, Services & Transportation
Highway Design & Construction Division

Paper prepared for presentation
at the ***Bridges - Engineering Impacting Society (B)*** Session

of the 2003 Annual Conference of the
Transportation Association of Canada
St. John's, Newfoundland and Labrador

ABSTRACT

In 1983, the Province of Newfoundland and Labrador started construction of the Trans Labrador Highway (TLH). Upgrading and new construction was undertaken in three phases starting in1997. Phase II (Red Bay to Cartwright), a 325 km all-weather gravel highway passing through uninhabited and undeveloped wilderness country, is intersected by 150 watercourses, ranging from small streams to large rivers (Alexis and St. Lewis).

These two large rivers created difficult challenges for the planning and design of the 110 m single span truss bridges, including site optimization, road travel minimization and maintenance through mountainous terrain and/or traversing deep tidal inlets.

Environmental considerations using survey data from 1823 hydrometric surveys (depth soundings) were employed along with a hydrological/hydraulic study (tidal effects), as well as river and ocean ice concerns.

Bridge structures over the Alexis and St. Lewis Rivers consisted of steel truss designs with steel grid deck and reinforced concrete abutments. Problems encountered included route layout and selection, geoscience considerations, hydrology, hydraulics, causeway construction, bridge launching and environmental issues. Weak clayey silts had to sustain a load of up to a 30 m high causeway at the abutments.

Part of Phase III is the forthcoming bridge over the Churchill River. Problems include the search for a good crossing point, hydraulic design and hydrological considerations, foundation concerns, ice forces and erection methods.

Completion of the TLH will facilitate new opportunities in tourism, forestry and mining; provide improved access to health and education; and reduce travel costs.

1. Setting and Background

Labrador is the mainland portion of the province of Newfoundland and Labrador. It covers almost 293 000 km^2 (larger than all of the Maritime provinces and the island of Newfoundland combined at 247 000 km^2), with a population of less than 27,000 people scattered throughout the region (See Figure 1). Labrador has in excess of 30 communities that are mainly serviced by air, however marine services still form a vital part of the infrastructure system along its coast.

DWST Minister Lloyd Matthews in his January 1998 speech to The Combined Councils of Labrador noted “that transportation is therefore a very significant issue for communities which rely on a dependable transportation infrastructure for both personal travel, and for the movement of goods to and from communities within Labrador, and the rest of Canada. Historically, many Labrador communities have been isolated and without access to a dependable mode of transportation. While isolation is still a factor today, there is a recognition that improvements are required in order to thrive and flourish into the next century.”(1)

High costs associated with air and marine transportation have limited economic development in southern Labrador. The companies that do business need an improved and reliable transportation network. Indeed, an effective transportation link goes hand in hand with the economic development opportunities, growth and prosperity throughout the region. This premise is the *"raison d'étre"* for the construction of the Trans Labrador Highway (TLH).

2. Status of Project

In the late 1960's, a new Tote Road coined the "Freedom Road" was built by CFLCo between Churchill Falls and Happy Valley-Goose Bay. In 1983, the province of Newfoundland and Labrador committed to constructing a new highway from Labrador City to Happy Valley-Goose Bay at a cost of approximately $60 million. This section of road (along with part of the existing Tote Road from Churchill Falls to Happy Valley-Goose Bay) was constructed from 1983 to 1991.

***New Bridges on Freedom Road (Labrador City to Churchill Falls)* - 231 km**

Ashuanipi River	40 m - 48 m - 40 m steel plate girder
Miron River	18 m steel plate girder
Ossokmanuan Reservoir	44 m - 57 m - 44 m steel box girder
Valley River	17 m steel plate girder
Raft River	15 m steel plate girder
Brinco	110 m steel truss

***New Bridges on Tote Road (Churchill Falls to Happy Valley-Goose Bay)* - 292 km**

Cache River	40 m steel plate girder
East Metchim	27 m steel plate girder
West Metchim	30 m steel plate girder
Main Wilson River	40 m steel plate girder
East Wilson River	40 m steel plate girder

Designed by Delcan

Edwards River	24 m AASHTO IV girder
Upper Brook	16 m AASHTO III girder
Lower Brook	27 m AASHTO IV girder
Pinus River	3 spans @ 29.5 m AASHTO IV girder

In 1997, the province initiated improvements and new road construction in Labrador. Phase I consisted of upgrading the existing Tote Road which ran between Churchill Falls to Happy Valley-Goose Bay. Upgrading this existing roadway was completed in 1999 at a cost of $60 million. Phase II comprised construction of an all-weather two-lane gravel highway on the southeast coast of Labrador running from Red Bay to Cartwright. Construction of this 325 km of new highway started in 1999 and was substantially completed by 2002 at a cost of $130 million (See Figure 2).

***New Bridges on Phase II (Red Bay to Cartwright)* - 325 km**

St Charles River	61 m steel truss (constructed in 1990)
St. Mary's River	20 m steel plate girder
St. Lewis River	*110 m steel truss*
Alexis River	*110 m steel truss*
South Feeder	30 m steel plate girder (under construction in 2003)

South West Tributary	21 m steel plate girder
Dykes River	21 m steel plate girder
Gilbert River	35 m steel plate girder (under construction in 2003)

This paper will concentrate mainly on the technical aspects of the design and construction of the Alexis and St. Lewis River Bridges in Phase II.

The province is committed to completing Phase III which is scheduled to be completed by 2006. This comprises "The Great Circle Route" with a 250 km link from Happy Valley-Goose Bay to Cartwright Junction (87 km south of Cartwright) at an estimated cost of $120 million. Phase III is currently undergoing an environmental review.

New Bridges on Phase III (Happy Valley-Goose Bay to Cartwright Junction)

Churchill River	3@120 m steel truss + 500 m causeway (design in 2003)
Traverspine River	in planning stage
Kenamu River	in planning stage
Eagle River	in planning stage
Otter River	in planning stage
Paradise River	in planning stage

3. Purpose

The purpose of Phase II was to provide a safe, reliable and cost-effective all-weather gravel highway between communities in southern Labrador and communities in the Labrador Straits. Prior to now, the only inter-community connection in southern Labrador was a 10 km road linking the communities of Mary's Harbour and Lodge Bay. Southern Labrador residents rely mainly on marine coastal transportation from June to November, snowmobile in the winter months and air service year-round for travel to other communities.

Phase II provides a direct link between the communities of Red Bay, Lodge Bay, Mary's Harbour, Port Hope Simpson, Paradise River and Cartwright. Access roads connect the coastal communities of St. Lewis, Charlottetown and Pinsent's Arm to the main highway.

4. Construction Funding - Labrador Transportation Initiative

In April 1997, the province of Newfoundland and Labrador entered into an agreement with the federal government to assume all responsibility for federally-operated marine services in Labrador, with the province receiving $340 million in cash settlement and all related infrastructure, including two vessels valued at $25 million to provide transportation services. Arising out of this agreement, the province approved the *Labrador Transportation Initiative*, a $340 million fund earmarked exclusively for improving the transportation network to and within Labrador. There are essentially two components to the *Labrador Transportation Initiative*: the development and construction of the Trans Labrador Highway (Phases I and II) and the provision of marine and ferry services to Labrador.

5. Public Information and Stakeholder Input

Held in June 1998, the public consultation and stakeholder input program involved seven public information sessions in surrounding communities bordering along the TLH. The purpose of these sessions was to inform area residents about the highway/bridge development and to identify issues and concerns. The sessions were open to all members of the public interested in the project. Comments provided were reviewed and incorporated into the project as necessary.

6. Design Standards (Phase II TLH)

Design standards for Phase II (TLH) including access roads are similar to those used for the recently constructed highway between Labrador City & Churchill Falls. The highway was designed to RLU 60 Modified (RLU 80) for horizontal alignment and was designed to a 70 km/h posted speed limit standard, while access roads were designed to a 60 km/h posted speed limit standard.

7. Environmental Constraints

i. Navigable Waters Protection Act

The Navigable Waters Protection Act (NWPA) was originally intended to protect marine navigation routes by controlling the logging industry and the construction of bridges and dams. Although its application has evolved, the prime purpose of the Act is still the protection of the public right of navigation on all navigable Canadian waterways.

This is accomplished through federal legislation of the construction of works built or placed in, over, through or across navigable waterways through a legal framework to deal with obstacles and obstructions to navigation. It ensures that construction works in waterways are approved and regulated so that the impact on navigation is minimized and also includes provisions for the removal of unauthorized works or obstructions to navigation.[(2)] The NWPA is administered by the Canadian Coast Guard of the Department of Fisheries & Oceans (DFO). The navigation opening provided for both Alexis and St. Lewis structures was 6 m high (above high water mark) by 80 m wide. Both bridge structures and causeways were considered an impact to navigation and underwent a formal approvals process under the NWPA before construction could be initiated.

ii. Habitat and Fisheries

Labrador is recognized for its wild waters and rugged wilderness, which harbour a multitude of wildlife. Although there was strong public support for the TLH, there existed a counterbalancing concern for the environmental effect its construction and subsequent operation would have. Every effort was made to protect the pristine Labrador environment and the transportation infrastructure that meets the needs of people and businesses throughout Labrador, without compromising the environmental standards expected.

8. Significant Issues and Constraints

i. Route Selection

Phase II of the TLH crosses more than 150 watercourses between Red Bay and Cartwright, ranging from small streams to large rivers.[(3)] Nine of these watercourses required bridges and six required structural pipe arches. The TLH also incorporated the existing road between Lodge Bay and Mary's Harbour and an existing bridge structure over the St. Charles River at Lodge Bay. The St. Charles River Bridge is a 61 m Callender-Hamilton structure built in 1990. The balance of the watercourse crossings on Phase II are small and only require culverts. Watercourse crossings will be designed and constructed in accordance with DFO regulations to ensure minimal disturbance to fish and fish habitat. Detailed design work, watercourse and watershed characteristics and existing environmental conditions will determine the type of structure placed at each crossing point.

ii Layout of Bridge Sites

Alternative route segments for the bridge structures at the Alexis and St. Lewis Rivers were identified for technical reasons and as a means to avoid areas of special interest to area residents and/or to enhance tourism potential (See Figure 3). The alignment over these two river crossings was based on efficiency of road versus total overall capital and maintenance costs over the long term. The *"original"* longer route may have avoided deeper crossings, have better foundations and a less costly bridge, but up-front capital (longer road) and annual maintenance costs (ie, road grading and snow clearing) precluded this option. In both river crossings, the *"preferred"* routes chosen optimized on a shorter route which translated to indirect cost savings thru decrease travel time in summer and reduction in winter maintenance during the winter (See Figure 8).

Alexis River

The original location and routing for the Alexis River Bridge was changed. The *"preferred"* route crosses the Alexis River near Port Hope Simpson and connects with the Charlottetown Access Road near Shinney's River. This *"preferred"* route would shorten the travel distance between the communities of Charlottetown and Port Hope Simpson. Proximity to rivers and popular fishing areas was again of primary concern. This alternative route, closer to Port Hope Simpson, was suggested in order to avoid good fishing areas on the Alexis River.

The *"preferred"* route crosses the Alexis River fjord, approximately 1.0 km upstream and northwest of Port Hope Simpson, at a site locally known as "the Tickle". Port Hope Simpson itself is located on the same fjord approximately 40 km from the open sea. The fjord continues for a further 6.5 km beyond "the Tickle" ending at the outlet of Alexis River, an area characterized by gravel fan type alluvial deposits - typical of a river outlet. This area is subject to tides having ranges of 0.98 m to 1.6 m, for average and large tides respectively. This "preferred" route shortens the access road into Charlottetown, eliminates a bridge crossing at Bobby's Brook, and decreases construction costs by about $3 million dollars.(3)

St. Lewis

The original route for the St. Lewis River Bridge was at the river mouth, approximately 7 km west of the current location. It was situated to the west of the current *"preferred"* route segment, which crosses Wood Island in the St. Lewis Inlet. Concerns about habitat at the river mouth and its effects on fish populations, as well as issues and concerns raised by representatives of the provincial government's Department of Tourism, Culture and Recreation and local residents (thru public consultations) led to further study of this crossing.

Further field studies assessing the technical feasibility raised concerns about placing a bridge near the river mouth. Preliminary evaluation by DWST identified an alternative crossing point over Wood Island in St. Lewis Inlet, which later became the *"preferred"* route. The proposed St. Lewis Inlet crossing comprises a causeway across the South Channel to Wood Island, an overland portion crossing Wood Island and another causeway across the North Channel. A bridge structure was built in the North Channel causeway to handle combined flood flows from St. Lewis River and tidal flows, and to facilitate the passage of fishing vessels travelling through St. Lewis Inlet. Three (3) aluminum structural plate culverts were built in the South Channel causeway to maintain the exchange of flows through the South Channel.

The distance from the open sea (near Mary's Harbour), to the crossing location at Wood Island is about 23 km. The inlet continues a further 7 km to the head of the bay and mouth of the St. Lewis River and is subjected to tidal flow.(3) Although the inlet crossing has a much deeper channel, it shortens the St. Lewis access road (accrued savings in annual road maintenance) and avoids salmon fishing areas at the mouth of the St. Lewis River.

iii Hydrology and Hydraulics (Tidal Flows)

Due to " inadequacies in hydrometric and climatic networks ", flood flow estimates in Labrador are difficult. This is according to *"The Hydrology of Labrador"*, a publication of the provincial government's Department of Environment's Water Resources Division. It concludes that "the physiographic, climatic and hydrometric databases are not adequate to meet the modelling requirements for water resources management " and "data for hydrological design in Labrador is desperately lacking".

Those stations in the database tend to be large, controlled watersheds associated with hydro development. They are scarce and for short time periods. On top of this, anecdotal evidence is scarce due to the country being remote and little traveled during periods of high flood.

A lot of information has been gained from less than adequate performance of some of the original bridge structures on the previous Tote Road from Churchill Falls to Happy Valley-Goose Bay. This was built as a short period access road. The bridges were not intended to be permanent structures. Water Resources Division has developed a Regional Flood Formula from flood frequency analysis of the limited available data augmented by using gauges located in Quebec and on the island of Newfoundland.(4)

$$Q_t = C \; ((\text{Drainage Area})^{a1} \, ((\text{Lake Attenuation Factor})^{a2}$$

where Q_t = flood of return period T
C, a1, a2 = constants

Ice, particularly, and debris play a big part in sizing a bridge and much is achieved through adequate site investigation, looking for ice scars and other indicators of past high water. However many bridges have been built in Labrador, which seem to be sensible from a hydraulic perspective.

Alexis and St. Lewis bridges were initially considered as three-span continuous structures. There was confidence that steel girder of spans approximately 35m-45m-35m on a bedrock foundation would be appropriate. Relocating the bridge sites, for economic and sociological reasons as described in (ii), meant greater difficulties both from hydraulic and soils perspectives.

Crossing the Alexis and St. Lewis Rivers entailed significant causeways, deep water, tidal currents and weak soils. Constriction of the tidal inlets raised the following design concerns:

- water velocity was to be kept to a practical minimum for fish passage
- boats could proceed against the current
- there should be no excessive backwater increase
- there was adequate protection against scour
- there should be adequate protection against erosion for the causeway

In particular, it was felt that if the crossing could be effected with a single span, several problems associated with pier construction could be eliminated. Dewatering, deep cofferdams and much piling would be difficult, costly and time-consuming in this environment. Discussions with some bridge manufacturers indicated a span of 110 m would be fairly practical and economical.

Some general guidance is given in TAC's *"Guide to Bridge Hydraulics"*, but it was felt specialist advice should be sought. The Guide notes "the large body of literature on tidal hydraulics and coastal processes contains comparatively little discussion of the particular problems of bridge crossings." It was decided to seek specialist advice and AMEC was retained. They were asked to investigate the feasibility of an installation of a clear span of 110 metres and outline the environmental consequences.

The following were the main conclusions of the AMEC report for Alexis River:[(4)]

- A bridge span of ~110 metres is recommended centred over deepest part of the channel.
- A minimum flow area through the bridge opening of 700 m^2 below water level 97.6 m should be provided.

Further comments were:[(5)]

a) Under average flow conditions, there will be no discernable changes except for localized velocity increases.
b) Additional flood would be 0.25 m during 1 in 100 year flood.
c) Upstream saline regime would be unaffected.
d) Flow velocities high enough to adversely affect upstream salmon (in excess of 1.5m/s) will be very rare and of short duration, occurring during major floods.
e) Flows should remain regular even for the design flood.

The combination of Q_{100} instantaneous, coincident with an average tide was a more severe condition than a large tide with an average flood. Ice problems were probably less at the new site locations. Ice in the "preferred" locations tends to melt in place whereas at the original sites prior to rerouting, ice jamming would probably have been anticipated.

iv. Geoscience Considerations

The geotechnical investigation for the Alexis and St. Lewis River sites was undertaken by Newfoundland Geosciences Ltd. When originally hired, a piled structure was contemplated but during the investigation, it was decided to hone in on to a single-span structure plus causeway and spread footings. The geotechnical investigation consisted of drilling marine boreholes and Dynamic Cone Penetration Tests (DCPT) in the proposed abutment areas. Both structures were built on soft silty soils. Causeway construction was built in stages to permit consolidation of materials due to nature of soil in the river bed. Consolidation settlement was allowed for a year prior to construction of abutments and superstructure. Construction of causeway was undertaken by end-dumping with quarried rock.

Riverbed slopes at Alexis River were approximately 8.6H:1V at north abutment (~15 m fill height) and 20H:1V at south abutment (~14 m fill height). Concerns for slope stability with submerged slopes of 2H:1V during the construction phase for both north and south approach embankments led to the fill being placed in 2 stages. Embankments were built to +0.5 m (LNT), monitored for settlement and then completed to grade +2.0 m (LNT). Embankment slope stability was governed by strength and dip of the underlying clay layer. One controlled blast was undertaken to densify and displace the near surface materials in the vicinity of the north abutment during Stage I construction. Estimated settlements for 7.0 to 9.0 m high fill embankments as a result of Stage I loading in the clay and sand/silt layers as well as rockfill due to self-weight, did occur as the load was applied, with cumulative settlement from clay, sand/silt and rockfill (due to self-weight) ranging from 500 to 1400 mm.(5)

Riverbed slopes at St. Lewis River was approx. 20H:1V at north abutment (~29 m fill height) and 11H:1V at south abutment (~27 m fill height). Concerns for slope stability with submerged slopes of 1.5H:1V during the construction phase for both north and south approach embankments led to the fill being placed in 2 stages. Embankments were built to +0.5 m (LNT), monitored for settlement and then completed to grade +2.0 m (LNT). Embankment slope stability was governed by slope angle of submerged fill. No controlled blasting took place at St. Lewis. Estimated settlements for 20 to 22 m high fill embankments as a result of Stage I loading in sand/silt layers as well as rockfill due to self-weight, did occur as the load was applied, with cumulative settlement from sand/silt and rockfill (due to self-weight) ranging from 1100 to 2000 mm.(6)

Stage II construction, up to +8.6 m (LNT) to road grade, was undertaken. The north approach embankment at Alexis was the more critical of the two, based on subsurface conditions. Estimated settlements for fill heights to elevation +8.6 m as a result of Stage II loading in sand/silt layers as well as rockfill due to self-weight, did occur as the load was applied, with cumulative settlement from clay, sand/silt and rockfill (due to self-weight) ranging from 200 to 775 mm (Alexis) and 250 to 450 mm (St. Lewis).

Recommended shallow foundations for both sites with 300 kPa allowable bearing pressure. Foundation settlements anticipated to be 75 to 125 mm (Alexis) and 50 to 100 mm (St. Lewis) over a period of 5 years.(5) (6)

v. Causeway Construction

Blasted rock fill was employed for construction of both causeways. To minimize bridge spans, shallow concrete foundations perched atop blasted rockfill embankments were built at both ends of the bridge. The embankments were built up to the high water mark and left for next construction season. This was required as per geotechnical recommendations for preconsolidation and settlement of the approach fills on the causeway, due to the nature of the soil in the riverbed. Sounding surveys were undertaken to determine slope of protection required. There were concerns with scour at the St. Lewis site and the toes of the newly-constructed causeway met at this point to provide for scour protection. The Alexis River Channel was lined with rip-rap rock mattress to protect the toes of each causeway.

Anticipated settlement was to be 100 mm, however actual settlement was more in the order of 200 mm. Settlement plates were employed to monitor actual settlement. It comprised a 1 metre square steel plate 25 mm thick. The riser pipe was 42 mm O.D. Schedule 40 pipe with threaded couplings to accommodate extensions. The riser and plate were welded together at the base connection. An outside pipe sleeve was required to prevent friction and down drag forces from the embankment fill from damaging the riser pipe or base connection.

Settlement plates were installed in zones on both north and south abutments. The plates were to be in two staggered rows at various intervals. The instrumented zones were to extend approximately 110 m in each direction from the centerline of bearing from each abutment. Each row of plates was located at a 3 m offset and staggered from the embankment centerline in order to avoid interference with, and damage from, construction equipment.

vi. Causeway Protection

Causeway embankments will be exposed to both wave and current action.

Current action due to freshwater and tidal flow will be confined to the bridge channel:(7) (8)

- Current induced erosions and riprap design to protect the causeway slopes against current induced erosion was based on California Highways formula and confirmed using Pilarczyk Formula. The design assumed a max. flow velocity of 2.3 m/s and side slopes of 1.5H:1V. Recommended riprap was 600 mm thick where placement can be controlled and 900 mm thick where placement is by dumping.
- Toe protection is a concern since the weak in-situ soils were very soft and localised “toe” scour could undermine the causeway side slopes. Furthermore, whether the causeway fill will come to rest on the compact underlayer or perched soft material is uncertain, therefore a conservative treatment using riprap launching aprons was proposed, comprising a 900 mm riprap layer placed by dumping.

Protection against wave action:(7) (8)

The causeways will be exposed to wind generated waves. The techniques used to assess wave climate and determine riprap sizes followed general procedures from recent guidelines prepared by the Société d’ énergie de la Baie James.

vii. Structural Design

The tendency in Labrador had been to use structural steel plate or box girders in contrast to the island of Newfoundland where as a rule, concrete was used. There were two precast concrete plants (ie, St. John’s and Corner Brook) located on the island and cement was also manufactured in Corner Brook. Proximity to these major centres resulted in better quality control being maintained. However that being said, there were several structural steel bridges built in the 1960's on the island of Newfoundland.

The lack of precast concrete plants in Labrador and the short construction season (mid-May to late-November) led to greater use of structural steel in earlier stages of the TLH, between Labrador City and Happy Valley-Goose Bay. This practice has been followed in southern Labrador where four steel truss bridges have been used to date. For this location, this type of construction has been very cost competitive.

In general, these steel bridges have required very little maintenance. Despite the cost, they sometimes are well travelled and located close to salt water, eg, St. Paul’s on the northern peninsula of Newfoundland, where the structure has been in-service for 40 years. Only minor sandblasting of girders has been required, and the structure is still in good condition (See Figure 9).

Originally conceived as a three-span continuous structure, the design proposal for the Alexis and St. Lewis River structures were changed to a single-span after further consultation and review by the designers. The deep channel depth, windy conditions, fast-running currents, short construction season and cost of cofferdams for pier construction at both sites made the construction of a three-span structure more difficult. Geotechnical investigations at the sites revealed weak in-situ soils, and would involve difficult construction employing fairly lengthy piles. After further hydraulic studies, it was noted that a 110 m single span steel truss bridge could be employed.

The TLH Phase II bridge structures were designed using the CS-600 truck load as per CSA S6-88. Earlier structures on TLH Phase I (Freedom and Tote Roads) were designed to MS-250 truck loads as per CSA S6-M77. Special provision for extraordinary heavy loadings (CFL Co. Transporter) was required on bridges of the TLH from Labrador City to Churchill Falls to accommodate the special vehicle needed to transport a 250 metric tonne transformer to the Churchill Falls hydroelectric plant (see Figure 4).

Structural steel trusses were employed as the preferred choice for both Alexis and St. Lewis Rivers for several reasons - low initial cost, low maintenance (galvanized steel), simple field erection, ease of transportation and load carrying capacity. The truss bridge behaves much like a closed box where it has four planes capable of resisting shear and end portals to transmit shear back into vertical loads at the bearings. Experience has been good employing these structures on the island of Newfoundland. Originally built with a wood decking system, these have been changed lately to steel deck grating for durability and maintenance reasons.

The steel truss bridge is characterized by an array of bracing in addition to those members typically seen in elevation views. Lateral members in the plane of the top and bottom chords resist wind loads and brace the compression chords. Sway frames square the truss to increase its torsional rigidity. The end portals carry these torsional loads resulting from uneven vertical loads and wind loads into the bearings.

The visual impact of these various members, especially the bracing members, contributes to often displeasing aesthetics in many truss bridges. However, if unforseen events cause damage to a main truss member, these bracing members serve as additional load paths to carry the member load around the damaged area.

The bridge structure chosen was of a Callendar-Hamilton design supplied by Balfour Beatty in the United Kingdom, although DWST specifications specified a Mabey Johnson or approved equal as an acceptable product. The General Contractor was McNamara Construction. The parts for the structure were shipped from the United Kingdom to Halifax and then to Port Hope Simpson.

Each bridge structure supplied consisted of 14 panel bays, of which 12 panel bays @ 8 m and 2 panel bays @ 7 m. The 7 m panel bays are located at the centre of the structure. The height of the steel trusses from centre-of-gravity of bottom chord to centre-of-gravity of top chord was 9000 mm. The clearance between steel trusses is 7675 mm and the roadway width between steel guiderails (on the bridge) is 7350 mm. An approximate maximum headroom of 6850 mm is provided between top of steel grating and underside of upper chord. The total weight of the bridge equated to 368,325 kg.[9]

All steelwork is hot-dipped galvanized to B.S. EN ISO 1461 after fabrication. The steel was tested to Charpy V-Notch for cold temperature application (Labrador environment). The concrete abutment design was according to forces provided by the manufacturer. Abutment construction was undertaken during same construction season as truss erection.

viii. Construction Issues

Geographical location, altitude, and coastal exposure all influence the climate of southeastern Labrador. This climate dictates to some degree the length of the actual construction season and subsequent delays. The more common construction methods employed for truss bridges include cantilever construction, falsework and float-ins. Although no method was specified by the Owner, the actual method selected to erect a truss bridge depends on several factors, including type of bridge, length and height, type and amount of river traffic, water depth, adjacent geographic conditions, cost and weight, availability, and cost of erection equipment.

Launching of both bridges was considered to be by a floating pontoon system, however due to strong currents and deep water at both sites, the structures were built using an innovative method never before employed in the province. Known as the “static cantilevered method”, the counterweight employed was another truss bridge structure erected and attached to the abutment end of the proposed structure. Two individual bridges were to be assembled at the site, but this “counterweight” was only sufficient up to cantilevered four bays of the truss bridge out over water. Additional steel grid decking and sandbags filled with OM (ballast) were then required to be placed on the “counterweight” assembly (See Figure 5).

The additional sandbags were placed on the counterweight (bridge structure) as per stipulated procedures while a 23 tonne crane and 20 men (work crew) were deployed in assembling sections of the bridge structure at the overhanging end. Structural members were lifted into place by the crane from a barge located below in the river channel. The truss bridge was constructed by assembling sections at the overhanging end using this crane and employing manual labour. This launching method was approved by the manufacturer in consultation with the Contractor.

This method of construction and launching placed an additional temporary live load of more than 9800 kN (sandbag counterweights + crane + labourers) at the bridge abutments which were not previously anticipated in the design, however a DWST design check of the foundations indicated that this temporary load did not cause any distress in the footings and/or surrounding soils.

The St. Lewis bridge structure was built first while employing the structural steel sections of the Alexis Bridge structure as the counterweight in construction. A separate non-galvanized steel structure was subsequently used as a counterweight platform for the Alexis River Bridge. The learning curve criteria was very much evident as construction time for the St. Lewis River Bridge was about 3 months whereas it took about 1 month for the Alexis River Bridge.

Overloading of the sandbags onto the main counterweight truss assembly also caused some construction problems. Unfortunately, as the Contractor stacked some of the sandbags on one side of the counterweight without regard to stipulated procedures, this resulted in some diagonal members at the end of the counterweight truss assembly undergoing a stress-reversal, ie, members shifted from tension to compression, resulting in buckling and yielding of these members. The Contractor replaced the damaged members with new members as this section was part of the Alexis Bridge.

Regardless of erection methods used on any project, an erection schedule was prepared by the manufacturer. Bridge geometry, member stress and stability at all stages of erection are checked. Bridges under construction often work completely differently than they do in their finished condition, and their stress characteristics change (ie, tension to compression or vice-versa). As a result, triangular members were initially placed in adjacent bays during construction and then relocated in alternate bays after erection was completed. Stresses induced by erection equipment are checked for wind stresses and wind-induced vibrations. Portions of the ARMCO steel grid decking were left off during the construction process to minimize on dead weight during erection. This was installed when launching was completed and main span lowered onto bridge abutment beam seat on the other side of the river.

9. Significant Features of the Alexis and St. Lewis River Bridges

1. The largest bridge structures on Phase II of the TLH (See Figures 6 and 7)
2. The largest static-cantilevered-launched structures in Labrador
3. Built and designed to CSA S6-88, although CSA S6-00 (CHBDC) was available, but not employed to ensure all structures on TLH (Phase II) designed to same code.

10. Churchill River Bridge

It is vitally important that the final link (Phase III) be constructed as it will permit a complete circular route for tourism that takes in the entire Eastern part of the country: Quebec, Labrador, the island of Newfoundland, Nova Scotia and New Brunswick. This first bridge structure proposed for Phase lll is located between Happy Valley-Goose Bay and Cartwright Junction, approximately 10 km west of Happy Valley-Goose Bay at a site referred to as the Blackrock Bridge. The 500 m long causeway from the north bank will be constructed using blasted rock fill. The causeway will have a top width of approximately 10.5 m, with side slopes of 1V:1.5H.

The proposed bridge structure will consist of three (3) - 120 m spans and will be a steel truss construction with steel grid deck. The substructure will consist of two concrete piers and two concrete abutments. The north abutment will have a deep foundation with a pile cap located 4 to 5 metres deep in the causeway fill. The north pier will have a deep foundation with a pile cap located at approximately river bed elevation.

The south pier will have a shallow foundation founded on bedrock and the south abutment will have a shallow foundation founded on bedrock in the hill on the south side of the Churchill River.

Construction of the bridge and causeway across the Churchill River will be carried out over one construction season. This is expected to commence in 2004, once the environmental assessment is completed.

11. Conclusions

The usage of 110 m structural steel trusses for bridge structures on the Alexis and St. Lewis Rivers has been a cost-effective and efficient solution for these water crossings on Phase II. The construction of the TLH is viewed as being a positive project for Labrador. As the community of Cartwright has now been identified as a transshipment centre for handling freight to and from the Labrador North Coast, the completion of the TLH (Phase II) from Red Bay to Cartwright will have a tremendous social and economic impact on the entire region. It will facilitate new opportunities in tourism, forestry and mining, and provide improve access to health, education and reduction in travel costs.

General Economic Benefits (Phase II)[10]

- New highway construction in each of the four construction seasons
- New highway construction jobs (over 8600 seasonal jobs were created)
- Improved road transportation system
- Improved year-round distribution of goods for all of Labrador
- Improved and expanded tourism opportunities (ie, Alaska)
- Improved access to existing/potential resource developments in mining, forestry

Employment and Investment Benefits (Phase II)[10]

- Upgrade of road from Churchill Falls to Happy Valley-Goose Bay:
  - seasonal employment for 3,000 people.
  - investment of $60 million
- New highway from Red Bay to Cartwright
  - seasonal employment for 5,600 people.
  - investment of $130 million

General Social Benefits (Phase II)[10]

- Greater interaction among Labrador residents in communities previously considered remote or isolated
- Greater access to health, education and recreation facilities in Labrador
- Eliminating the sense of isolation within Labrador, between Labrador and Newfoundland, and with other parts of Canada
- Reduced personal and business travel costs

REFERENCES

14. Minister of Works, Services and Transportation, Lloyd Matthews; Address to The Combined Councils of Labrador, January 30, 1998.

2. Navigable Waters Protection Act - Application Guide, Canadian Coast Guard

3. Trans Labrador Highway (Red Bay to Cartwright), Environmental Impact Statement, Project No. 1152, Jacques Whitford Limited, St. John’s, NL, September 1998.

4. Regional Flood Frequency Analysis for the Island of Newfoundland, Users’ Guide and Electronic Spreadsheet, Department of Environment and Labour, January 2000.

5. Hydrotechnical Study, Alexis River Crossing, AGRA Monenco Inc., AMI Ref. No. 111806, St. John's, NL, October 1999.

6. Hydrotechnical Study, St. Lewis Inlet, AGRA Monenco Inc., AMI Ref. No. 112121, St. John's, NL, February 2000.

7. Geotechnical Investigation, TLH Proposed Bridge Crossing, Alexis River, Project No. 6338. Labrador, Newfoundland Geosciences Limited, St. John's, NL, February 2000.

8. Geotechnical Investigation, TLH Proposed Bridge Crossing, St. Lewis Inlet, Project No. 6338, Labrador, Newfoundland Geosciences Limited, St. John's, NL, February 2000.

9. Balfour Beatty structural shop drawings for Alexis River and St. Lewis River Bridges, 2000.

10. Government of Newfoundland - Executive Council News Release, April 26, 1999.

FIGURE 1 Map of Newfoundland & Labrador

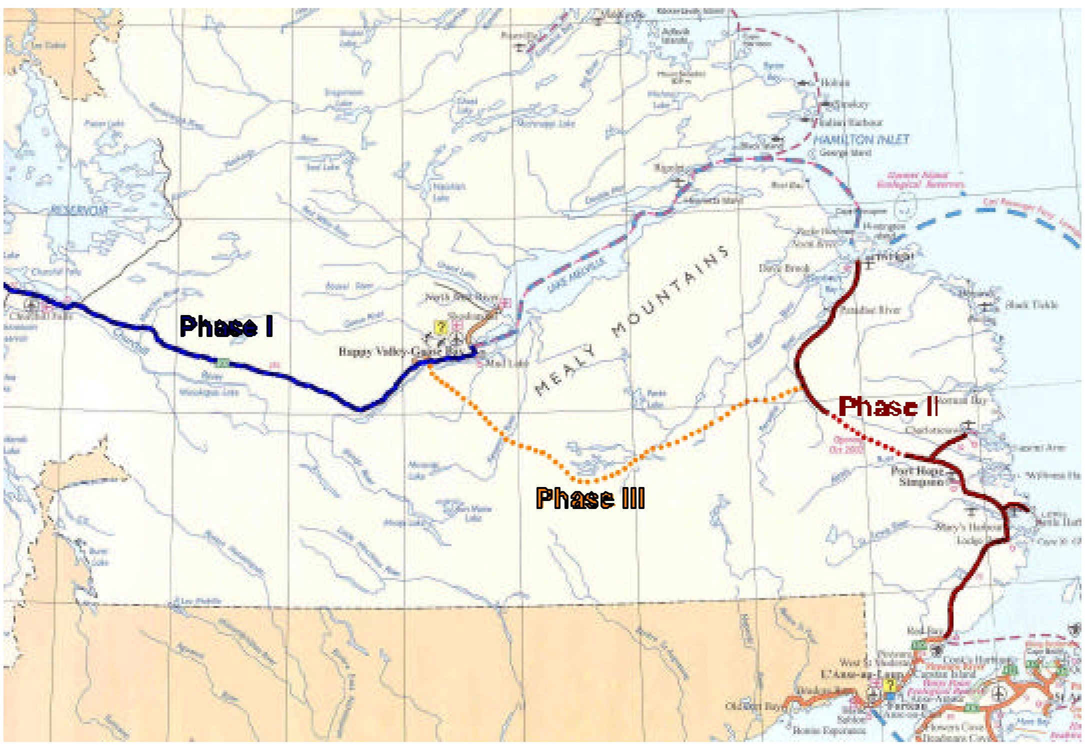


FIGURE 2 Trans Labrador Highway

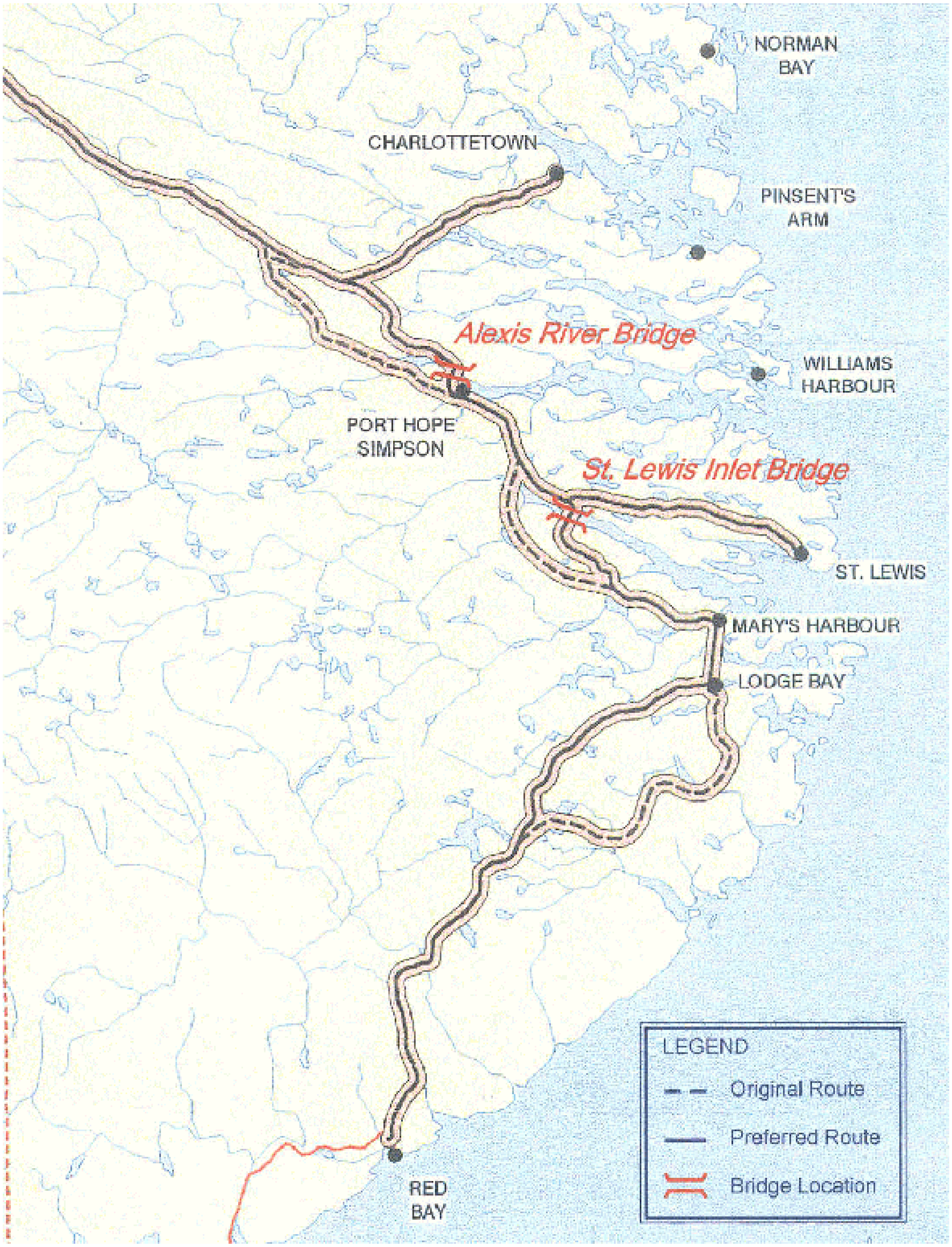
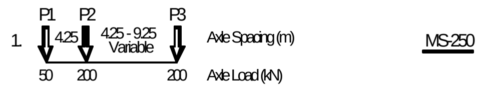
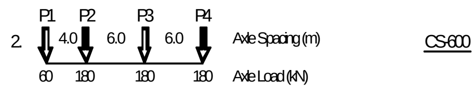
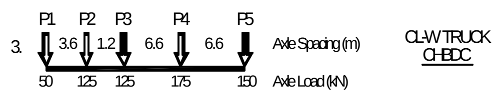


FIGURE 3 Original versus Preferred Routes

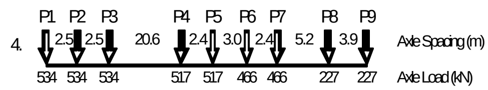
REFERENCE LOADS (CODE)

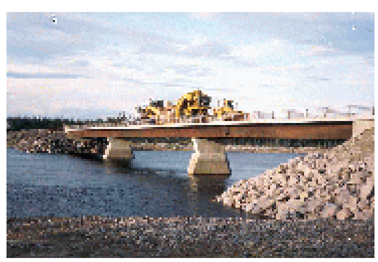






TRANSPORTER (SPECIAL LOAD)





CFL Co. Transporter (Special Load)

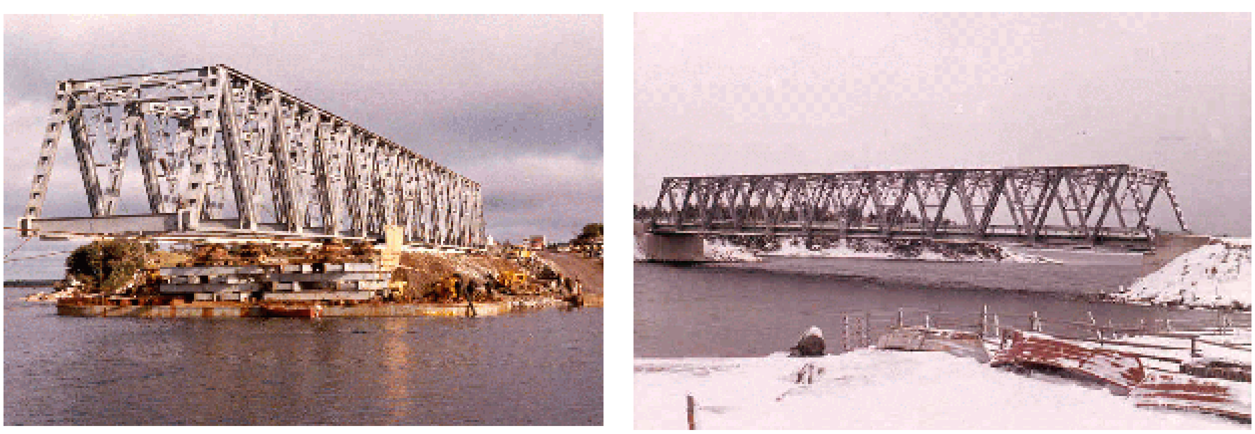
FIGURE 4 Design Loads

FIGURE 5 Erecting the St. Lewis River Bridge

FIGURE 6 Aerial View of Alexis Bridge and Causeway

FIGURE 7 Aerial View of St. Lewis River Bridge and Causeway

FIGURE 8 Winter Maintenance on Trans Labrador Highway



95 m Callender-Hamilton steel truss bridge

FIGURE 9 St. Paul's Bridge (Route 430), NL