INTERIM REPORT

phase 1(a) preliminary investigation of
MACKENZIE HIGHWAY BRIDGES
MILE 461-550

dec. 1972

Stanley Associates
Engineering Ltd.
Consulting Engineers and Planners

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LETTER OF TRANSMITTAL

December 4, 1972
File: 650-7-1-1

Mr. J.A. Brown
Regional Director
Western Region
10th Floor, One Thornton Court
EDMONTON, Alberta

Dear Sir:

RE: PHASE 1 (A) ENGINEERING INVESTIGATION
BRIDGE STRUCTURES - MILE 461 to MILE 550
MACKENZIE HIGHWAY - NORTHWEST TERRITORIES

We are pleased to submit herewith our Interim Report on the Phase 1 (A) investigation of bridge requirements between Mile 461 and 550 on the Mackenzie Highway, with the exception of the Black Water River Bridge. This work has been carried out in accordance with the Terms of Reference outlined in your letter dated August 30, 1972, and subsequent discussions held with representatives of the Department of Public Works.

Once you and your Department have had an opportunity to review this Report, we would be pleased to meet with you to discuss any questions that may arise. We have enjoyed participating in this work and look forward to your authorization for us to proceed to complete the preliminary stage design and report.

Yours very truly,
Stanley Associates Engineering Ltd.

E.H. Kuechler, P. Eng.
Chief Structural Engineer

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LIST OF ATTACHMENTS

A number of drawings which are referred to in this Report have been forwarded as separate attachments to the Report. These are referenced below:

SITE	DRAWING NUMBER
Rainbow Creek - Mile 472	650-7-1-P1
Steep Creek - Mile 511	650-7-1-P2
Saline River - Mile 521	650-7-1-P3
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INTRODUCTION

Relative to the Federal Government's decision to rapidly pursue construction of the Mackenzie Highway, a tentative bridge needs evaluation was conducted by the Department of Public Works.

From the needs survey certain bridge requirements were defined and various bridge design packages were established, along with a proposed design-construct schedule.

In this respect, Stanley Associates Engineering Ltd. was selected to provide Consultant Investigation and Design for "Bridge Section Mile 461 - 550".

Although the overall assignment includes detailed design and construction supervision, the co-ordination and urgent timing of the project led to the identification of the first stage of the assignment as Phase 1(A) Preliminary Investigation and Report.

TERMS OF REFERENCE

The terms of reference for the Phase 1(A) assignment, as defined in Mr. Brown's letter of August 30, 1972, require that a preliminary engineering investigation be undertaken and a Report thereon prepared. Specifically, it is required that the study recommend the bridge type best suited to each site, taking into consideration hydrological and hydraulic conditions, cost, environmental concerns, aesthetics and fisheries considerations.

The following crossings were included in the Terms of Reference:

1. No Name (later called Rainbow Creek) - Mile 471.

2. No Name (later called Steep Creek) - Mile 511.

3. Saline River - Mile 521.

4. Little Smith Creek - Mile 533.

5. Big Smith Creek - Mile 546.

PROCEDURE

The following general procedure was used in carrying out the Phase 1(A) assignment. Initial meetings were held with DPW officials to determine availability of data such as survey information, aerial photographs, contour maps, etc. In addition, meetings were held with the hydrological and environmental consultants, in order to obtain as much preliminary data as possible prior to any site inspection.

A field inspection of the individual sites was made early in October, 1972 to obtain firsthand information on site conditions.

Subsequent to the field reconnaissance trip, and after receipt of the design data from the hydrological consultants, a number of alternative bridge types were developed for further evaluation and consideration. In the case of Big Smith Creek, an architectural consultant was retained to advise on matters of an aesthetic nature.

Unfortunately, soils information and foundation data is still unavailable for the bridge sites considered in this study, since the geotechnical consultants have not been able to move their equipment to these sites. In this regard, the hydrological consultant made an attempt to obtain preliminary foundation information with the use of a mobile drilling rig, however, this was abandoned because of difficulties encountered in maintaining circulation of the drilling fluid in the river gravel. Consequently the preliminary design and economic evaluations to date have been developed without benefit of proper soils information.

Nonetheless, cursory evaluation of some of the alternative bridge types postulated still allowed their rejection at this stage for obvious economic, engineering or environmental reasons.

Preliminary cost estimates of the remaining alternatives were prepared in order to determine the relative cost differences between respective, alternative bridge types. These estimates were prepared on the basis of unit costs developed through preliminary consultations with contractors familiar with costs and working conditions in the North. Cost figures for structural steel were obtained locally and without great difficulty. Sources of concrete aggregate are as yet unconfirmed. Although there are indications that gravel will be available in the general area, it has been difficult to establish a firm basis for cost calculations. In addition, our sources for cost information reported large variations in concrete costs.

While these circumstances did not significantly affect the selection of the bridge types, absolute cost estimate budget figures for individual bridges would be affected, and much further detail investigation will need to be undertaken in the Phase 1(B) and design stages, to more accurately estimate the probable construction costs. Since the costs developed were used for comparative purposes only, the quantification and costing of the approach fills were not estimated at this time. The alternatives were then evaluated taking into consideration costs, environmental and fisheries concerns, and aesthetics. From this evaluation bridge types were selected and recommendations prepared.

DESIGN CRITERIA

In the preparation of preliminary alternative bridge types and cost estimates, the following design criteria were used:

(a) Loading:

Live Load - CSA H25-S20 - with impact.

- CSA H40-S32 loading with no impact and allowing 25% overstress.

Dead Load - actual load plus provision for 30 lbs. per sq. ft. of deck for future wearing surface.

(b) Design Specifications & Codes:

CSA Specification S-6 and AASHO latest editions.

(c) Roadway Clearances:

(i) Horizontal: 28 ft. for bridge lengths over 200 ft. overall.
32 ft. for bridge lengths under 200 ft. overall.

(ii) Vertical: 20 ft. above roadway.

ASSUMPTIONS & SOURCES OF COST INFORMATION

Due to difficulties with regard to transportation of drilling equipment, and the short time available to the consultants after receipt of the design data from the hydrological consultants, certain assumptions were necessary, in order to prepare this Interim Report.

Since foundation information was not available, it was assumed that all pier and abutment structures would require pile foundations. In general, soil penetrations in the order of 35 feet were assumed under piers, and all abutment piles were assumed to be up to 60 feet long depending on the depth of fill.

In developing the unit cost estimates for cast-in-place concrete, it was assumed that aggregates would have to be supplied by the Contractor, screened and used in an uncrushed form. Costs are based on the Contractor supplying his own camp and facilities. Similarly, the structural steel prices include an allowance for camp costs.

Since preliminary design of the structures was based on very preliminary data and broad assumptions, the cost information was not developed in detail. However, the same cost bases were used in all alternatives and, therefore, comparisons are indicative of the relative economics of one bridge type versus another.

As discussed in Item 2, "Procedure", concrete costs require more research work for more accurate estimating. At this stage it was not possible to evaluate the economics of cast-in-place concrete superstructures as alternative bridge types to those reported. For similar reasons, we are uncertain at this time if steel deck grating will be more or less expensive in comparison with concrete decks. Concrete cost estimates varied from $125 to $250 per cu. yd., a variation of 100% between different sources of information. The following price information received from Poole Construction Ltd., was used for our estimates.

Concrete, assuming aggregate available @ $20.00/cu. yd.:

Mixed and Placed	$188 cu. yd.
Forming and shoring of Straight Surfaces	$ 5.10 sq. ft.
Reinforcing Steel in-place	$ .44 per lb.
8" to 12" H-piles in-place	$25.00 to $30.00 per l.f.

Based on information provided by Great West Steel Ltd., in Edmonton, structural steel was estimated at a unit cost of $1,250 per ton erected-in-place. If trusses are to be used, this estimate would increase to $1,500 per ton erected-in-place.

Con Force Ltd., a Calgary precast concrete Firm, indicated that their Deck-Girder type superstructures, up to 105 ft. span, would be about $25 per sq. ft. of bridge, which appears to be very competitive with steel, suggesting calling for precast alternates in the bidding stage.

INDIVIDUAL SITES

Rainbow Creek - Mile 471

As shown on the attached Drawing No. 650-7-1-P1.

Site Location and Conditions

The location of this bridge is 400 feet above the confluence of Rainbow Creek and Mackenzie River. The Creek valley is approximately 400 feet wide and the site is affected by high water, driftwood and ice from the Mackenzie. Site location and crossing type is not yet finalized and presently this matter is under study by other consultants.

Foundations

In the absence of any soils exploration data, substructures were assumed to be piers and abutments of concrete on steel H-piles.

Approaches

A considerable amount of fill is required, reducing the length of the bridge to a minimum. Grade lines allow adequate highway standards with flat grades.

Alternative Types

Alternatives considered include a three span girder type bridge, a two span girder type bridge and a one span through truss.

The truss alternative was eliminated when early estimates indicated that the high quantity of steel required, and the high cost of fabrication and erection for trusses would make this alternative economically less attractive than a girder type of bridge.

Recommendations

Recommended for design and construction is the deck-girder type of bridge. It is expected that a three span type of deck-girder arrangement will be the most economical and the most suitable from all points of view. Further, we recommend that the deck girders be designed in structural steel and that an alternative design and price bid be obtained for precast girders when tenders are called.

The two span arrangement shown on the drawings is expected to be very little higher in cost but the pier location is not as satisfactory as the three span alternative.

Steep Creek - Mile 511

As shown on Drawing No. 650-7-1-P2.

Site Location and Conditions

The crossing is located approximately 1,200 feet above the confluence with the Mackenzie River on the first river terrace. The site is affected by back-up water from the Mackenzie River with possible ice and driftwood reaching the bridge. At the

crossing, the creek has formed a wide gravel bed which in fan like fashion slopes steeply towards the Mackenzie River. The creek's erosion effects appear to be a significant feature, requiring protective measures in the form of spur dikes.

Foundation

At present, foundation is assumed to be concrete piers and abutments on steel H-piles. Soils conditions are as yet unknown.

Approaches

The 400 ft. wide eroded bed will be filled in on both sides of the Creek channel. Grades will be flat, rising to slightly above the first terrace level.

Alternative Bridge Types

With similar conditions and length, the alternatives studied were the same as on Rainbow Creek.

- Three span girder type.
- Two span girder type.
- One span truss type.

The girder type bridges appeared to be most economical and the three span arrangement most suitable, as on Rainbow Creek.

Recommendations

Recommended for construction is the three span deck girder arrangement with either steel or precast concrete girders.

Saline River - Mile 521

As shown on Drawing No. 650-7-1-P3.

Site Location and Conditions

The crossing is located approximately 3/4 of a mile above the confluence with the Mackenzie River. The Saline River flows in a 180 ft. deep valley with steep valley banks on both sides.

Foundation

Soil conditions are not known. The foundation is anticipated to be concrete piers and abutments on steel H-piles. Piers of 45 ft. height are required. Foundation for abutments may require special consideration due to the height of fill involved.

Approaches

Steep approach grades descending down to bridge level are required. The bridge deck at 56 ft. above the river is the highest of all bridges under consideration.

Alternative Bridge Types

The following bridge types were investigated:

- Three span girder.
- Two span girder.
- Two span deck truss.
- Two span through truss.

The through truss was dropped from consideration due to high cost of fabrication and erection in comparison to a plate girder. There is little cost difference between the two span and three span arrangement. The three span arrangement may prove challenging to precast concrete Contractors with possible improved economy.

Recommendations

The three span girder bridge is preferred and recommended for construction as it may prove to be slightly lower in cost as compared to the two span arrangement. A temporary diversion of the channel appears to be necessary during pier construction.

The shorter length of girders may be appreciated in this remote location and allow competitive bidding by precast concrete Contractors.

Little Smith Creek - Mile 533

As shown on Drawing No. 650-7-1-P4.

Site Location and Conditions

This site is located approximately one mile from the Mackenzie River. The crossing is located at a point where flow has formed two channels in the streambed. The flow channel is near the north bank. The south bank is approximately 20 feet high and eroded. A spur dike extending about 300 feet upstream from the south approach fill is proposed to protect the eroded south bank. No skew angle is required for the bridge piers.

Although backwater of the Mackenzie could reach this site, it will have little effect on the bridge itself. Approach grade requirements govern the bridge deck elevation.

Foundations

As with the other sites, no foundation information is available. We have assumed concrete piers and abutments on H-pile foundations.

Approaches

The approach fill at the north abutment will reach a maximum height of approximately thirty feet. Sand material was found at the north bank. A steep grade of 7% will bring the highway back to the second river terrace south of the creek.

Alternative Bridge Types

Bridge types considered initially were:

1. Two span steel girder type.

2. Three span steel girder type.

3. Single span deck truss with short approach spans.

4. Single span through truss with approach spans.

The cost of the truss alternatives appeared to be roughly the same as those for the two span girder alternative. The deck truss arrangement would require a grade line about five feet higher than that of the other alternatives and hence the cost for fill and steel piles make this alternative less attractive. The three span type is slightly higher in cost than the two span arrangement.

Recommendations

The two span girder type bridge is recommended. This type is

expected to be most economical, as we anticipate a more satisfactory competition for steel and precast alternatives which in turn may result in better economy.

The two span arrangement would mean a pier on the Island between the two water channels, which we believe is satisfactory.

Big Smith Creek- Mile 546

As shown on Drawing No. 650-7-1-P5, and as illustrated on the attached Artist's sketches Drawing Nos. 1, 2, and 3.

Site Location and Conditions

This site is approximately one mile from the Mackenzie River. The crossing is located 500 feet upstream of a limestone rock outcrop, below which a series of rapids and falls lower the creek to join the the Mackenzie River. This canyon area downstream is considered of special interest because of its pleasant scenic appeal, and we were instructed to give special consideration to aesthetic aspects in the design of the nearby bridge. D.S. Stevens and Partners, Architects, were retained as architectural consultants for this crossing and their recommendations are incorporated in our report.

The abrupt change in direction of the stream at the first rock exposure may increase the possibility of ice jams; however, a wide flood plain north of the bridge site and the presence of the rock barrier will keep the flow at a low velocity and relatively low high water levels. This allows the use of a relatively low approach fill and flat grades.

Foundations

No information was available on foundation conditions. It is

possible that bedrock will be encountered at the site; however, since the depth to rock is unknown, piling lengths and loads were assumed similar to those for other sites and as shown on the drawing. Banks are relatively low and wet and it is possible that permafrost will be encountered.

Approaches

Low approaches with moderate grades will be encountered. The winter water channel will not have to be filled in as recommended in other bridges, hence the natural environment will not be significantly altered or disturbed.

Alternative Bridge Types

The following types of bridges were studied:

1. Two span steel plate girder type.

2. Three span girder type.

3. One span through arch with approach spans.

4. Three span cantilever type, steel plate girder.

Normally, we would have eliminated the single span bridge types, when investigations revealed that the cost of these two proposals (Arch and Cantilever - Drawings No. 2 and 3, respectively) will cost in the order of 30% more than the recommended type. In this case, however, it was suggested by D.S. Stevens and Partners that a particularly pleasing visual effect could be achieved with the single arch type. Consequently, if the Department wishes, we could further examine this alternative if it is felt that the aesthetic prominence of this site justifies a somewhat higher cost expenditure for the arch

alternative (Drawing No. 3) which was preferred by the Architect. The absence of piers in the water may be of special appeal to the Architect, as well as to the environmental consultants. All bridges considered by the Architect were studied by means of photographs taken at the reconnaisance site visit. The sketched background provided by the Artist is, therefore, reasonably realistic.

Recommendations

A two span girder type bridge with parabolic haunches over a single pier, as shown on the Architect's Drawing No. 1, was considered. This type of bridge, when investigated with regard to cost, turned out to be the most economically attractive of all alternatives considered, and is therefore recommended. We believe that the aesthetic treatment of this bridge can be achieved at moderate additional expense.

A copy of the Architect's Report is appended.

COST ESTIMATES

The following schedule lists our estimated cost for the recommended bridge types, exclusive of approach fill or river protection work.

These estimates are based on information received to date, and for the reasons outlined earlier in this Report, more detail work is required to confirm the estimates. Engineering and contingency allowances are not included.

Rainbow Creek - Mile 471 (56' - 68' - 56' spans)

Three span deck girder type bridge - total length 200 ft.

Estimated Construction Cost - $505,000

Steep Creek - Mile 511 (57' - 68' - 57' spans)

Three span deck girder type bridge, total length 198 ft.

Estimated Construction Cost - $480,000

Saline River - Mile 521 (124' - 124' - 124' spans)

Three span deck girder type bridge, total length 400 ft.

Estimated Construction Cost - $990,000

Little Smith Creek - Mile 533 (108' - 108' spans)

Two span deck girder type bridge, total length 244 ft.

Estimated Construction Cost - $470,000

Big Smith Creek - Mile 546 (116' - 116' spans)

Two span deck girder type bridge, total length 270 ft.

Estimated Construction Cost - $555,000

APPENDIX

ARCHITECT'S REPORT - BIG SMITH CREEK BRIDGE

REPORT

McKENZIE HIGHWAY

BIG SMITH CREEK BRIDGE

D.S. STEVENS AND PARTNERS

D. S. STEVENS
AND PARTNERS
ARCHITECTURE
AND PLANNING

Alternative bridge forms have been studied, three of which are included. Analysis of the problem from an aesthetic and environmental point of view have led us to the following conclusions.

a. A single span as long as possible is preferable to create as little imposition on the river as possible.

b. Economy of visual form is essential to ensure the structures role is subordinate to its setting.

c. Structural integrity is highly desirable to create visual logic to the design.

d. Dark earth tones should be used for the spanning members to enable the bridge to blend into the natural background. Possibly natural rusting steel could be considered because of its ideal colour.

We are convinced that the most aesthetically and environmentally pleasing of the three alternatives is the single arched span (Sketch 2), with the abutments located some distance back from the main piers on each bank of the stream.

The girder ends are accentuated to emphasize the tie downs at the abutments and will assist in identifying the approaching bridge to the passing drivers.

The arched form gives the least visual obstruction up and down stream and the graceful curves complement the beauty of the site. The piers are a simple rounded form as visually conservative as possible and interupt the creek bank very little. Open railings are suggested above the curb lines to minimize the depth of the spanning members and to enable freer sight of the stream to passing motorists. The facing on the embankments around the abutments could be of a rip rap of the local limestone which may be available from the road bed and assist in blending the roadway into its surroundings.

Stanley Associates Engineering Ltd.

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December 21, 1972

LETTER OF TRANSMITTAL

Mr. J. A. Brown
Regional Director
Western Region
Canada Department of Public Works
10th Floor - One Thornton Court
Edmonton, Alberta

Dear Sir:

Re: Phase 1 (A) Engineering Investigation
Bridge Structure - Mile 498.5
MacKenzie Highway

We submit herewith our Addendum covering preliminary engineering investigation of the proposed bridge structure at Mile 498.5 on the Mac-Kenzie Highway.

This crossing was not included in our report of December 4, 1972 since it was an addition to our original assignment, and design data was not available till December 5, 1972. Verbal authorization to proceed with the additional work was given by Mr. S.C. Peng.

Our work on this structure has been carried out as outlined in our Interim Report dated December 4, and this Addendum should be read in conjunction with the above report.

Yours very truly,
Stanley Associates Engineering Ltd.

K. Nyhus, P. Eng.
Project Manager

KN/bn

ADDENDUM TO:

PHASE 1 (A) ENGINEERING INVESTIGATION
BRIDGE STRUCTURES
MILE 461 TO 550 MACKENZIE HIGHWAY
NORTHWEST TERRITORIES

Creek (No Name) - Mile 498.5

As shown on Drawing No. 650-7-1-1-P6

Site Location and Conditions

This crossing is located about three miles from the Mackenzie River. This bridge location was not identified at the time of our site reconnaissance in early October, consequently, our assessment of the site is based on aerial photographs and discussion with the hydrologic consultants.

The Creek occupies a wide shallow valley and consists basically of a series of ponds or sloughs. It is anticipated that velocity and amount of flow will be less than at most of the other crossings.

The location plan was drawn using an aerial photo enlargement and the crossing was located from DPW uncontrolled mosaic Drawing Mo. 85014-3. The plan is, therefore, intended to show general rather than exact location of the crossing.

Foundations

No foundation information is available for this site, consequently, for purposes of this analysis we have assumed that steel piling foundations will be required.

Approaches

Approach fills are expected to be approximately 14 feet in height extending into the existing valley resulting in an overall bridge length of about 110 feet. Although the waterway opening provided is considerably less than the natural waterway, this opening is considered adequate by the hydrologic consultant.

Because the fill height is governed by anticipated high water conditions, rather than maximum highway grades, the approach grades are relatively flat.

Alternative Bridge Types

Alternatives considered included single span, two span and three span deck girder type bridges. Pile bent type piers were considered suitable for this location because the bridge is relatively low.

It appears likely that cast-in-place concrete could be eliminated entirely at this site, particularly, if a single span is used. However, the various possibilities regarding material choices are considered to fall within the scope of the next phase of preliminary investigation.

Alternative span arrangements were, therefore, compared on the same basis as outlined for the other sites studied.

Recommendations

The two span deck girder arrangement is recommended since it is expected to be the most economical, and also suitable to accommodate flow through the bridge opening.

Cost Estimate

Two Span deck girder type bridge.

Total length 108 feet (47' - 47' spans)

Estimated Construction Cost	$ 220,000.

Stanley Associates Engineering Ltd.

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January 16, 1973

Mr. J.A. Brown
Regional Director
Western Region
Canada Department of Public Works
10th Floor, One Thornton Court
EDMONTON, Alberta

Dear Sir:

Re: Phase 1(A) Engineering Investigation
All-Steel Alternative
Saline River Bridge - Mile 521
Mackenzie Highway

We submit herewith our preliminary cost estimate for an all steel structure at the above site, as an Addendum to the original report of December 4, 1972.

This additional work was authorized verbally, at the meeting of December 19, 1972.

Yours very truly,

Stanley Associates Engineering Ltd.

K. Nyhus, P. Eng.
Project Manager

KN:las

ADDENDUM

PHASE 1(A) ENGINEERING INVESTIGATION

BRIDGE STRUCTURES - MILE 461 to 550

MACKENZIE HIGHWAY

Preliminary Cost Estimate for All Steel Structure Saline River Bridge - Mile 521

General:

At the meeting of December 19, 1972, our Firm was instructed to prepare a preliminary cost estimate for this structure utilizing no cast-in-place concrete.

This was required to assist the Department in evaluating the most effective course of action with regard to supply of concrete aggregates.

This preliminary estimate is based on the same data as used in the original report and should be read in conjunction therewith.

No foundation information is available at this time.

Configuration of Structure:

Superstructure consists of welded steel deck grating supported on a system of steel stringers, floorbeams and plate girders.

Substructure is as shown on Drawing No. 650-7-1-1-P7.

Although precast concrete or timber components could perhaps be utilized in some portions of the structure, it was considered that detailed choice of materials would be studied further in the next phase of preliminary design. It was, therefore, considered satisfactory to base this estimate on the use of steel throughout.

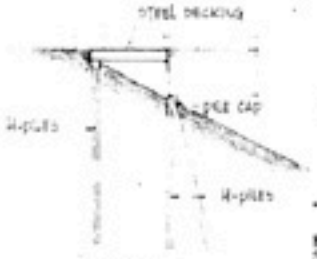
Cost Estimates:

Cost figures given are in comparison with the original estimate for this structure, based on the same design criteria. Our estimates indicate a cost of approximately $30,000 additional for the all steel alternative.

Cost Estimates (Cont'd)

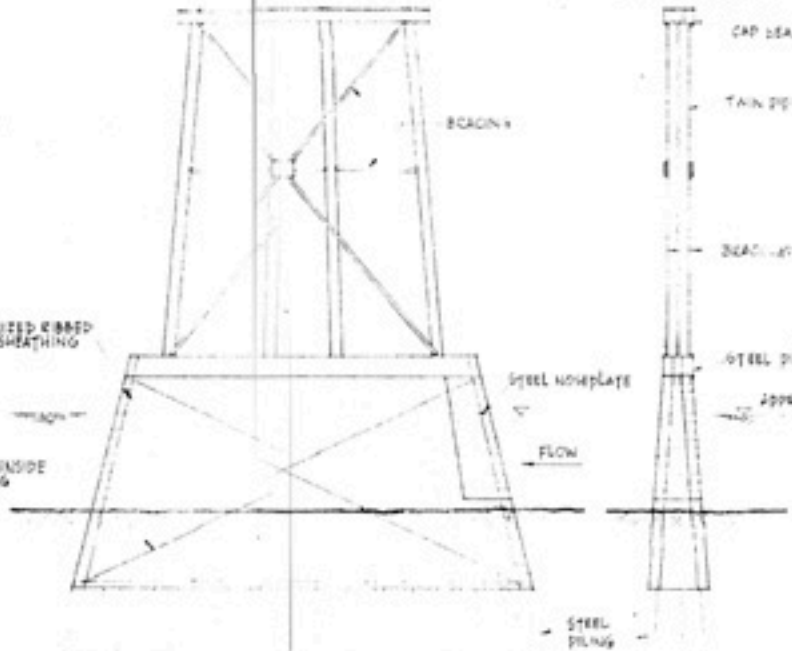
Although this differential is perhaps not significant in the total cost of the structure, it does indicate that cast in place concrete will be competitive. It appears that this would hold true for a cost of aggregate on site of up to about $40 to $50 per cubic yard.

PLAN



ELEVATION

ABUTMENT



FRONT ELEVATION

SIDE ELEVATION

PIER

PRELIMINARY ONL
NOT FOR CONSTRUCTION PURPOSES
Stanley Associates Engineering L

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GENERAL ARRANGEMENT — STEEL SUBSTRUCTURE
MACKENZIE HIGHWAY

SALINE RIVER CROSSING — MILE 521

DWG. NO. 650-01-01-P7