

GEOCREs No. 41 40J-54DIST. 18 REGION W.P. No. 646-92-00CONT. No. W. O. No. STR. SITE No. 388-23HWY. No. 556LOCATION Missinagi River Bridge
Sault Ste. MarieNo of PAGES -

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. REMARKS:

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President

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 646-92-00 DIST 18
HWY 556 STR SITE 38S-23

Mississagi River Bridge

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FOUNDATION INVESTIGATION REPORT

For

Mississagi River Bridge

W.P. 646-92-00, Site: 38S-23

Hwy 556, District 18, Sault Ste. Marie

INTRODUCTION

Due to a traffic accident, the bailey bridge carrying Highway 556 over the Mississagi River collapsed resulting in a 300 km long detour. The Northwestern Region Structural Section requested an emergency Foundation Investigation on December 15, 1992, so that a new bailey bridge could be constructed with minimum delay.

It was proposed that the replacement structure would be launched from the east side of the river and therefore, the maximum foundation loading would be applied at that location. Based on visual observations at the site, it was understood that the soil at the site was predominantly bouldery and the drilling with an auger machine might not be possible. The Structural Section informed that there were no underground utilities at the site.

Due to the emergency situation, the Foundation Design Section deferred other projects to respond as soon as possible. A drilling contractor was hired to begin the investigation on Monday, December 21, 1992. A backhoe and truck were arranged to stand by to remove boulders and backfill pits so that the foundation investigation could proceed as quickly as possible.

Another contractor, 'And-son Contracting & Gravel Enterprises Incorporated', was already present at the site with cranes, bulldozers and a crew of at least 7 men and was removing the damaged bridge. With the assistance of the Northwestern Region Structural Section, arrangements were negotiated for the safe operation of the foundation investigation without undo delay, while not interfering with the removal of the bridge.

The water level in the river is controlled by an Ontario Hydro power station. Representatives from the Ontario Hydro were present at the site and advised that work near the river should be halted after 4:30 pm, as the water level would rise to a dangerous level.

The Foundation Investigation was completed on December 22, 1992. Preliminary recommendations were provided to the Structural Section Wednesday December 23, 1992.

SITE DESCRIPTION

The site is located on Hwy 556 near the Hwy 556 and Hwy 129 intersection. The intersection is about 120 km east of Sault Ste. Marie and 98 km north of Thessalon. The bridge was used to carry Hwy 556 over the Mississagi river.

The river channel is about 42m wide at the crossing and the river flows towards the south. The river banks are covered with boulders.

The boulders are angular on the east bank and rounded on the west bank. Bedrock is exposed at some location on the south side of the east approach embankment.

INVESTIGATION PROCEDURE

The field investigation started on the north side of the east approach fill. A track mounted auger machine equipped with 83mm ID hollow stem augers was used to advance the boreholes. However, due to the bouldery nature of the overburdens, boreholes could not be advanced. Attempts were made to conduct dynamic cone penetration tests, but the cones could not be advanced due to boulders. Therefore, it was necessary to dig test pits to obtain soil information. If the boulders were only present within the top few metres, then the excavation would be backfilled with sand and the boreholes would be advanced through the sandfill.

Due to restriction by the bridge removal activities at the site the first test pit was excavated on the south side of the east approach embankment.

Four test pits (TP1, TP2, TP4 and TP5) were dug on the north and south sides of the east and west abutments. A shallow test pit (TP3) was also dug within the east approach fill to investigate the material placed in the approach fill.

Locations of the test pits are shown on Drawing No. 6469200-A appended.

SUBSURFACE CONDITIONS

In general, the soil at the site consists of sandy gravel with boulders underlain by boulders mixed with gravel and sand. Bedrock was encountered only at the south side of the east approach embankment at a depth of 2.7m below ground surface.

The material in the approach fill consists of granular material underlain by sandy gravel with boulders.

Photographs of the test pits and the material obtained from the test pits are presented on Plates 1 through 9 appended.

Details of the soil stratigraphy in each test pits are as follows:

Test Pit No. 1 (South Side of the East Abutment)

(Ground Elevation 338.0m)

0.0 - 1.4m	Mixture of Silt, Sand & Gravel, Trace Clay, Occasional Boulders. Very Dense
1.4m - 1.8m	Clayey Silt with Organics, Very Stiff
1.8m - 2.7m	Sandy Gravel with Boulders, Very Dense
@ 2.7m	Bedrock

Test Pit No. 2 (North Side of the East Abutment)

(Ground Elevation 339.0m)

0.0 - 1.2m	Sandy Gravel with Boulders, Very Dense
1.2m - 5.3m	Boulders with sandy Gravel, Very Dense

Test Pit No. 3 (On the East Approach Fill)

(Ground Elevation 342.5m)

0.0 - 0.6m	Granular Material (Granular 'A'), Very Dense
0.6m - 1.8m	Sandy Gravel with Boulders, Very Dense

Test Pit No. 4 (South Side of the West Abutment)

(Ground Elevation 338.5m)

0.0 - 0.7m	Sandy Gravel with Boulders, Very Dense
0.7m - 1.6m	Silt with Boulders, Trace of Clay, Very Dense
1.6m - 4.9m	Boulders with Sandy Gravel, Very Dense

Test Pit No. 5 (North Side of the West Abutment)

(Ground Elevation 339.0m)

0.0 - 0.9m	Sandy Gravel with Boulders, Very Dense
0.9m - 1.8m	Silt with Boulders, Trace of Clay, Very Dense
1.8m - 4.9m	Boulders with Sandy Gravel, Very Dense

DISCUSSION AND RECOMMENDATIONS

The old bailey bridge was a 55m long single span structure. The bridge was supported on two bearings on each abutment.

It is understood that a new Acrow bridge (DDR2H) will be constructed at the old bridge site. The new bridge will be of the same length but will be wider than the old bridge, with overall width of 9.3m. Since the new bridge will be wider, new rock-filled timber cribs are proposed to be constructed at each abutment location. The proposed timber cribs would be about 12m wide and about 2.4m high. Each end of the bridge will be supported on two bearings. It is further understood that during bridge launching a counter weight will be added to the bridge to balance the overturning moment. Therefore, the pressure on the bearing plates will be evenly distributed. The maximum unfactored load on each bearing (including loads to counter balance) will be 700 kN and will be applied on an area of 3m by 1m. This will result in an evenly applied pressure of 233 kPa at each bearing locations. Total tolerable settlement would be 40mm and the differential settlement between adjacent bearings would be allowed up to 10mm.

Based on our findings, the soil condition is extremely competent. In our opinion, it will be appropriate to salvage the existing timber crib foundations and use them to support the new structure. This would permit high foundation loadings because of our high confidence level in the competent nature of the existing foundation. If required, the foundation base may be widened by adding cribs beside existing cribs and backfill them with granular material or rockfill.

The recommended bearing capacities for the footings, on the existing timber crib foundations, as per the O.H.B.D.C. are as follows:

Factored Bearing Capacity at U.L.S.	= 1000 kPa
Bearing Capacity at S.L.S. Type II	= 500 kPa

It is our understanding that it may be necessary to remove the existing cribs and construct new cribs filled with rockfill. Since the new rockfill foundation will not be as competent as the existing foundation, bearing capacities are reduced.

The recommended bearing capacities for the footings, on the rock-filled timber crib, as per the O.H.B.D.C. are as follows:

$$\begin{aligned}\text{Factored Bearing Capacity at U.L.S.} &= 750 \text{ kPa} \\ \text{Bearing Capacity at S.L.S. Type II} &= 250 \text{ kPa}\end{aligned}$$

It is our understanding that these capacities are adequate for design of the new structure.

Frost Protection

Frost protection is not a concern for foundation constructed on free draining material. Also the foundation will be situated above water table.

Dewatering

No dewatering will be required at this project. The construction will be above prevailing water table. At the time our investigation the groundwater table was at the same level as the water level in the river. However, the groundwater level will fluctuate with the river water.

Lateral Earth Pressure

A new timber crib may be constructed and filled with rockfill. The timber crib can be designed using following parameter;

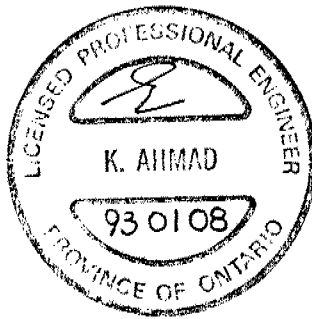
Granular 'A'	$\gamma = 22.8 \text{ kN/m}^3$, $\phi = 35^\circ$, $K_a = 0.27$
Granular 'B'	$\gamma = 21.2 \text{ kN/m}^3$, $\phi = 30^\circ$, $K_a = 0.33$
Rockfill	$\gamma = 18.0 \text{ kN/m}^3$, $\phi = 35^\circ$, $K_a = 0.27$

Lateral earth pressures should be computed in accordance with Section 6.6.1.2 of the O.H.B.D.C. Active condition should be assumed to apply in calculating the lateral earth pressure.

MISCELLANEOUS

The fieldwork for this project was carried out under the supervision of K. Ahmad. The drilling equipment used was owned and operated by Master Soil Investigation Ltd. The excavation equipment was owned and operated by Leroy Construction of Sault St. Marie.

The report was written by K. Ahmad, Foundation Engineer, reviewed by D. Dundas, Senior Foundation Engineer and approved by M. Devata, Chief Foundation Engineer



A handwritten signature in cursive script, reading 'K.S.Q. Ahmad'.

K.S.Q. Ahmad, P. Eng.
Foundation Engineer

A handwritten signature in cursive script, reading 'M.S. Devata'.

M.S. Devata, P. Eng.
Chief Foundation Engineer

APPENDIX

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S SPLIT SPOON	T P THINWALL PISTON
W S WASH SAMPLE	O S OSTERBERG SAMPLE
S T SLOTTED TUBE SAMPLE	R C ROCK CORE
B S BLOCK SAMPLE	P H T W ADVANCED HYDRAULICALLY
C S CHUNK SAMPLE	P M T W ADVANCED MANUALLY
T W THINWALL OPEN	F S FOIL SAMPLE

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

PHYSICAL PROPERTIES OF SOIL

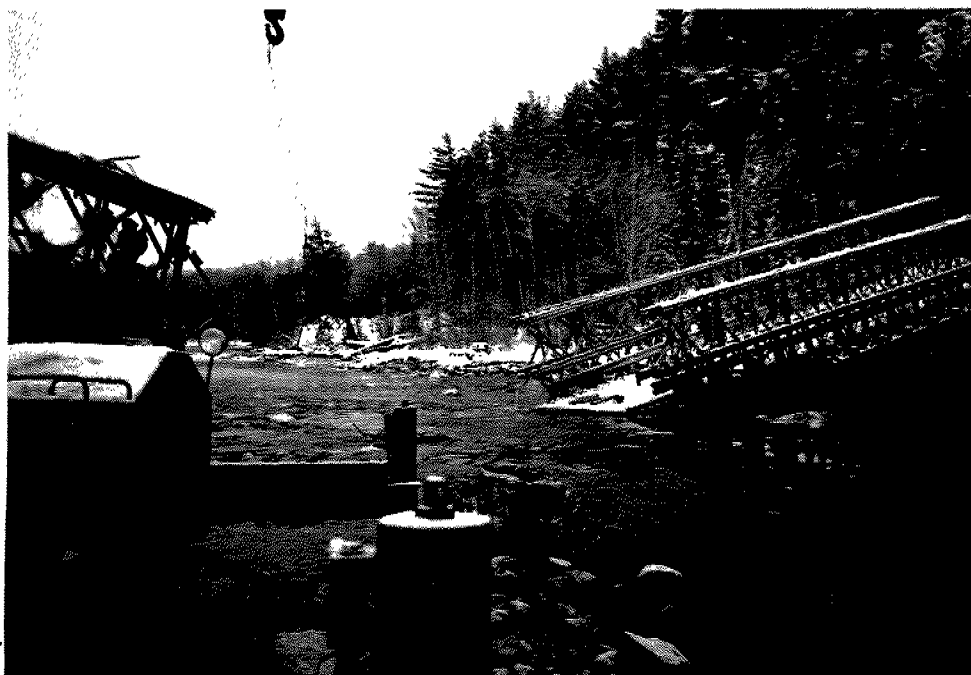
ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{\min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m^3	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_l	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m^3	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_l - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_l - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m^2	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						



MISSISSAGI RIVER BRIDGE (HWY 556)
PRIOR TO COLLAPSE



MISSISSAGI RIVER BRIDGE (HWY 556)
AFTER COLLAPSE



REMOVAL OF DAMAGED BRIDGE



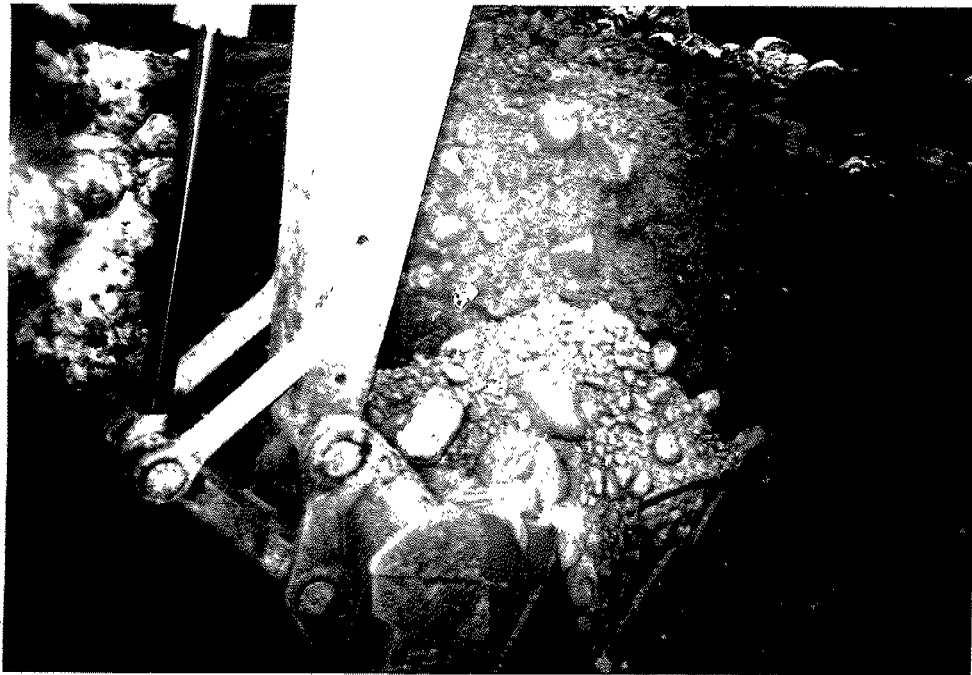
REMOVAL OF DAMAGED BRIDGE



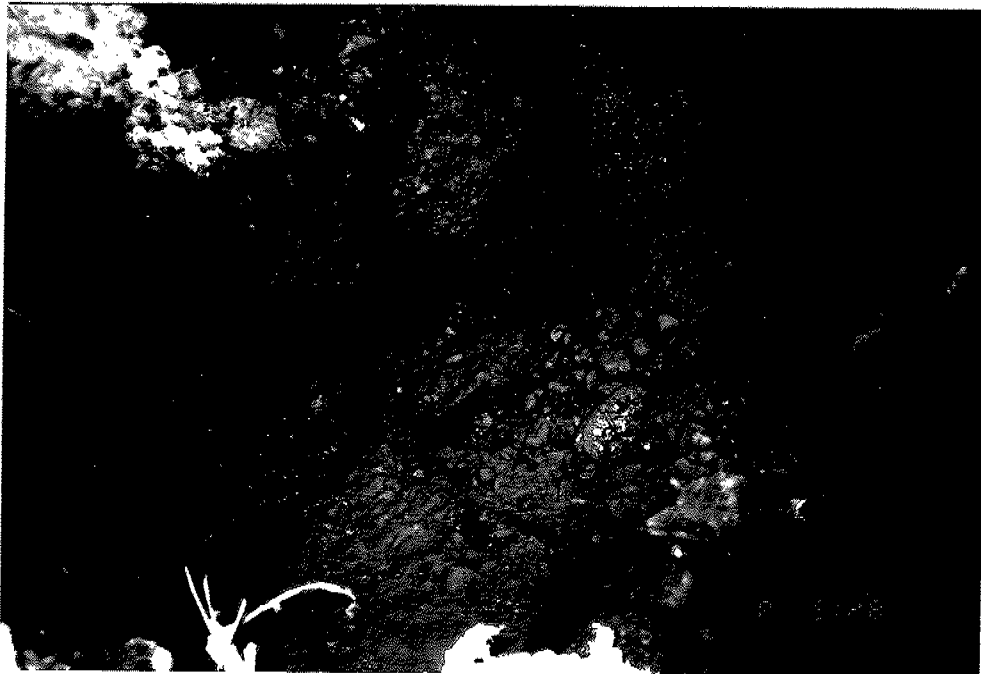
TP 1 - SOUTH SIDE, EAST APPROACH FILL
(EXPOSED BEDROCK)



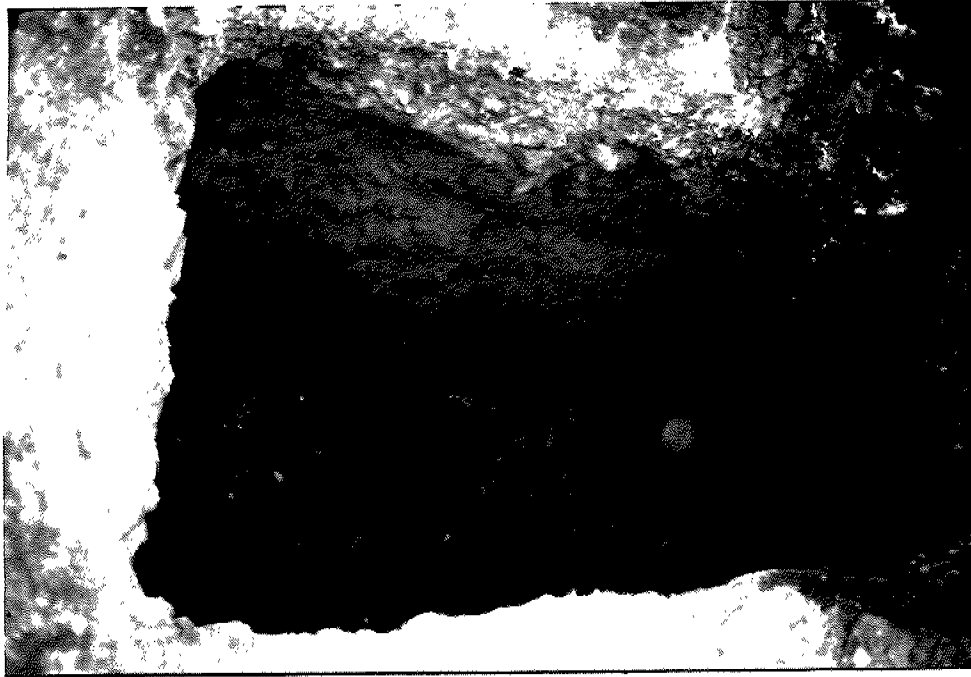
TP 2 - NORTH SIDE, EAST APPROACH FILL



TP 2 - BOULDERS AND GRAVEL



TP 2 - BOULDERS AND GRAVEL



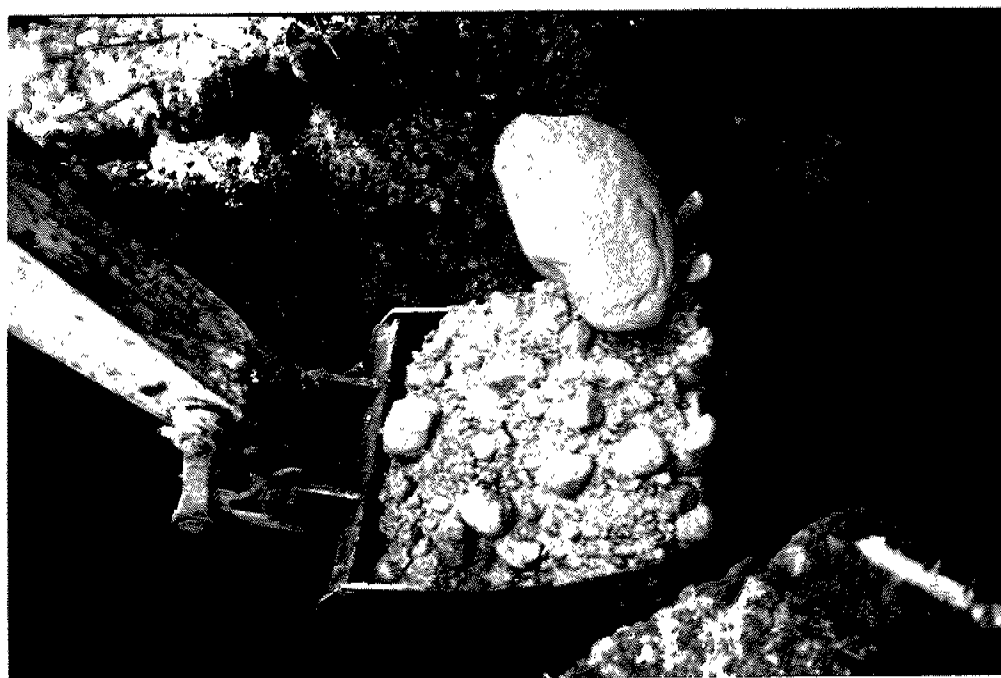
TP 3 - ON THE EAST APPROACH FILL
(WELL COMPACTED MATERIAL)



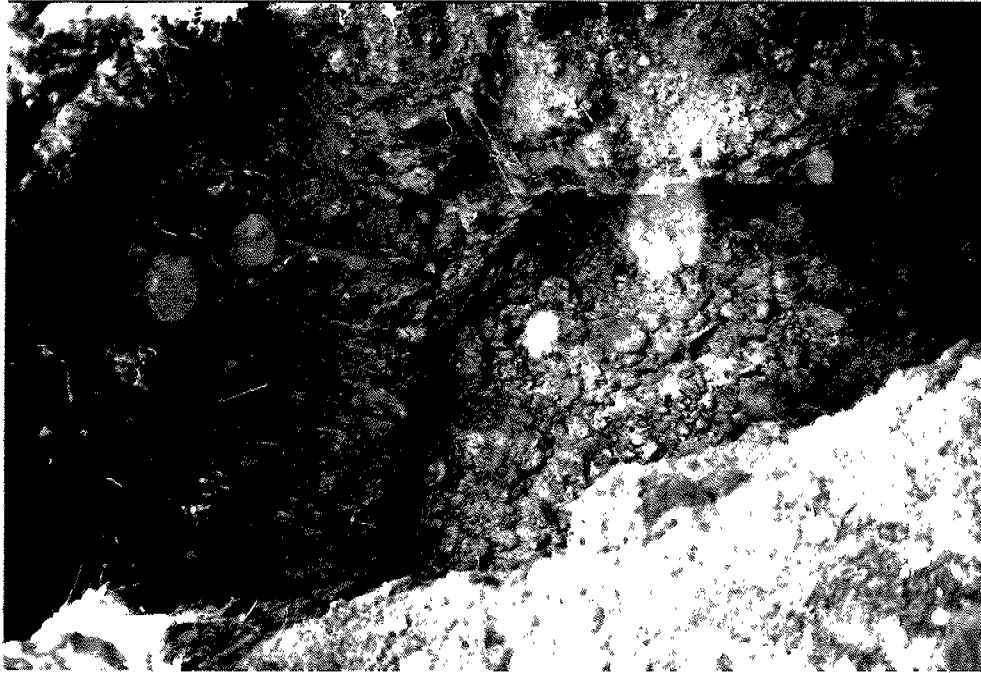
TP 3 - MATERIAL FROM THE PIT



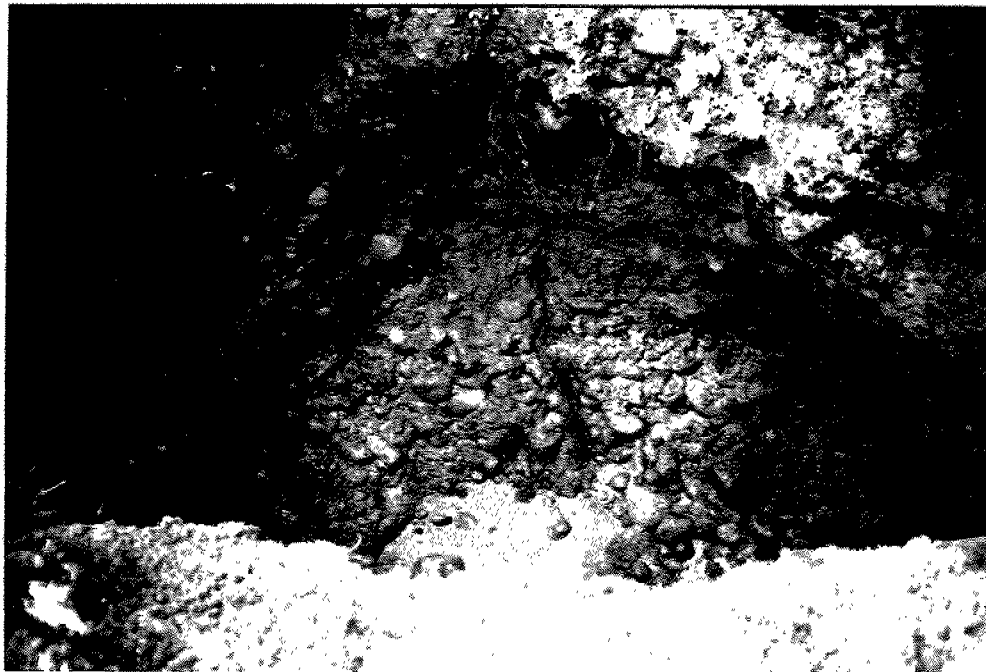
TP 5 - NORTH SIDE, WEST APPROACH FILL
(BOULDERS AND GRAVEL)



TP 5 - BOULDERS AND GRAVEL



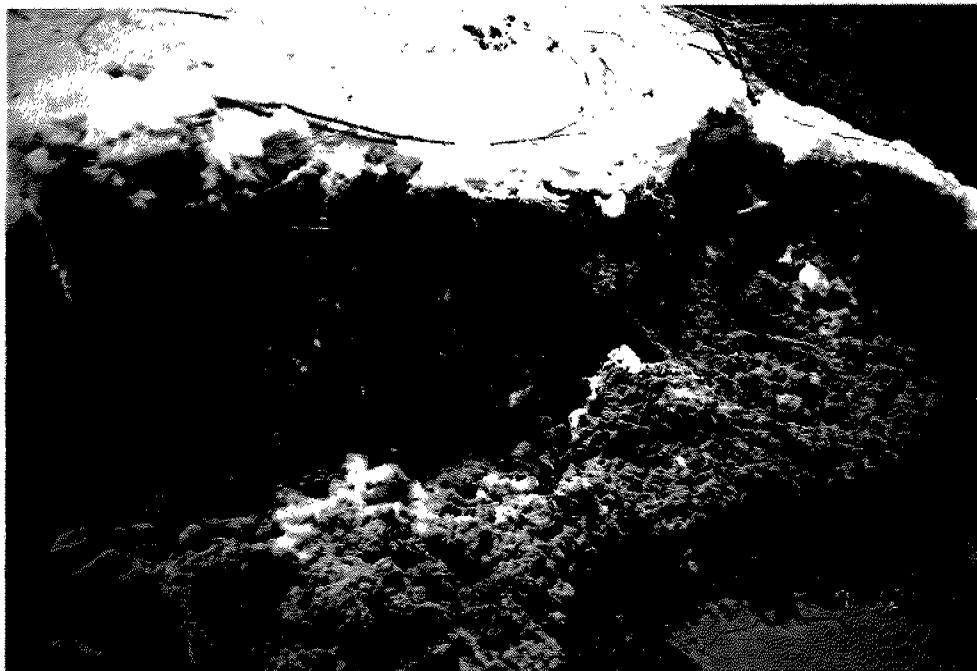
TP 5 - BOULDERS AND GRAVEL



TP 5 - BOULDERS AND GRAVEL
(PIT CAVING IN)



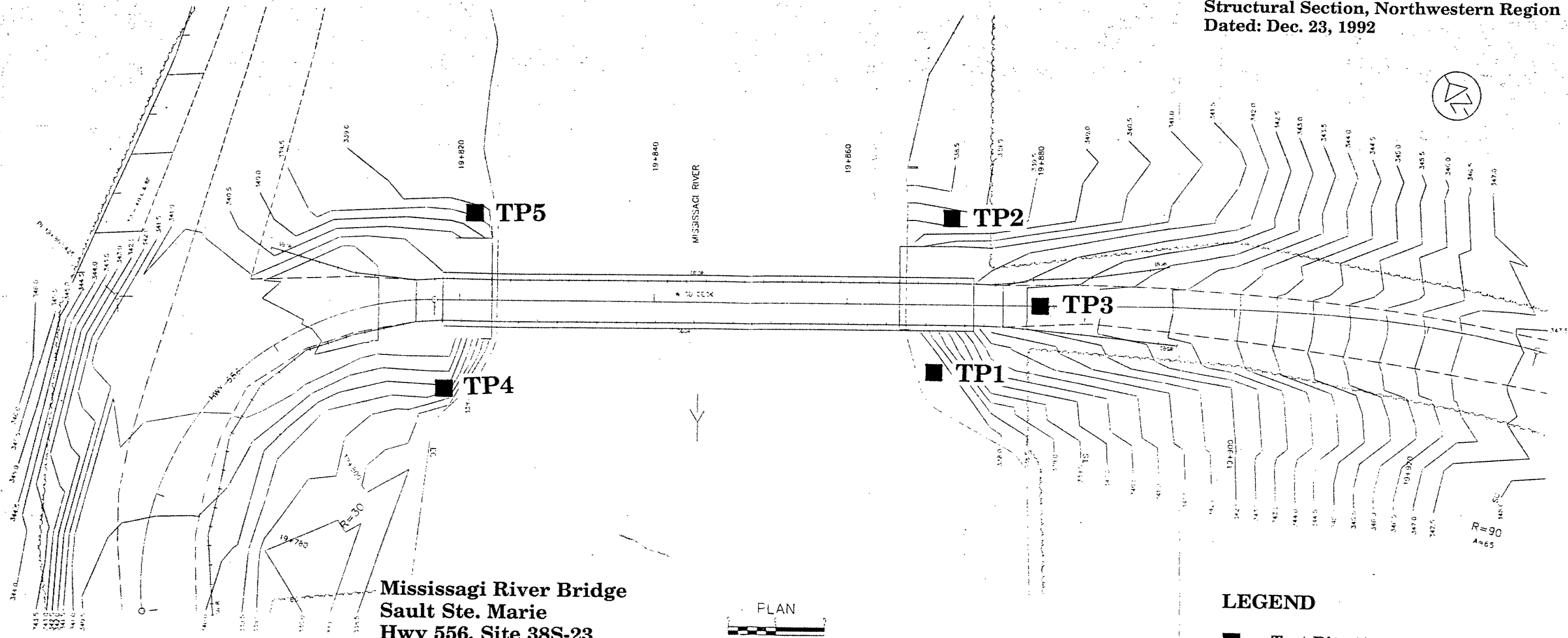
TIMBER CRIB, EAST APPROACH FILL



**EROSION IN THE EAST APPROACH EMBANKMENT
NORTH SIDE**

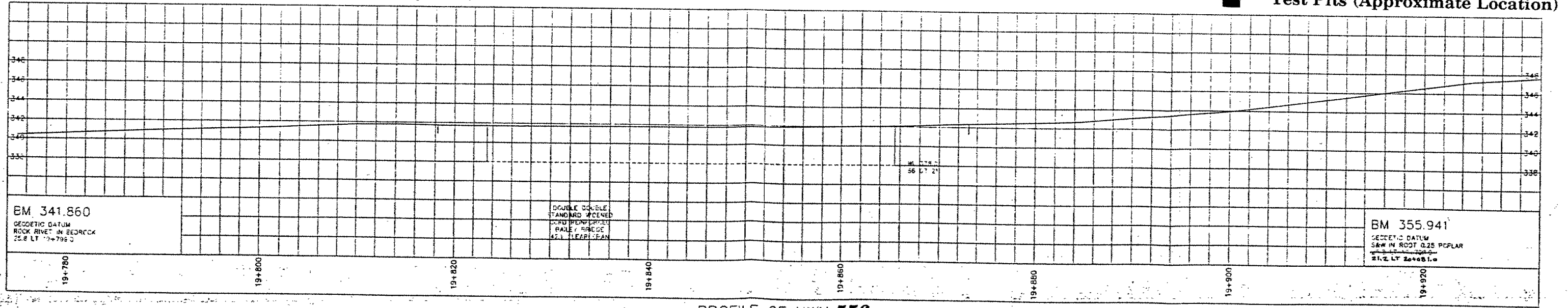


STEEL BEAM SUPPORTING BRIDGE BEARINGS



LEGEND

■ Test Pits (Approximate Location)



MEMORANDUM

(416)235-3731

To: Ray Krisciunas
Head, Structural Office
Northwestern Region
1992 12 23
Attn.: W.C. Prystanski

From: Foundation Design Section
Room 315, Central Building
Downsview, Ontario

Re: Preliminary Foundation Recommendations
Mississagi River Bridge
W.P. 646-92-00, Site: 38S-23
Hwy 556, District 18, Sault Ste. Marie

Further to your faxgram dated December 16, 1992 requesting foundation investigation on an emergency basis due to the collapse of the bridge, this memo presents our findings and preliminary recommendations for the new bridge foundations.

The Foundation Investigation was carried out on December 21 and 22, 1992 using a track mounted drilling machine and a backhoe. Several attempts were made to drill boreholes but due to bouldery type of soil boreholes could not be advanced.

It was therefore, decided to excavate the boulders with a backhoe and then advance the boreholes if possible.

Four test pits (TP1, TP2, TP4 and TP5) were dug on the north and south side of the east and west abutments. A shallow test pit (TP3) was also dug on the east approach to investigate the material placed in the approach fill.

In general, the soil at the site consists of sandy gravel with boulders underlain by boulders with gravel and sand. Bedrock was encountered only on the south side of the east approach embankment at a depth of 2.7m below ground surface.

The material in the approach fill consists of granular material underlain by sandy gravel with boulders.

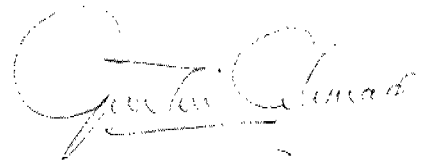
Based on these finding, in our opinion the subsurface material is extremely competent.

It is understood that there would be two bearings on each abutment. The unfactored load on each bearing will be 700 kN and will be applied on an area of 3m by 1m. This will result in an applied pressure of 233 kPa at each bearing location. Total tolerable settlement would be 40mm and the deferential settlement between adjacent bearings would be allowed up to 10mm. The new bridge will be a single span and will be constructed at the same location where the old bridge stood.

As a preliminary recommendation the existing foundation is suitable to support the proposed loads and the total and differential settlement would be within the tolerable limit.

We are proceeding with further analyses. After having further discussion with you on this project, we expect to provide you detailed recommendations in a final report format in early January, 1993.

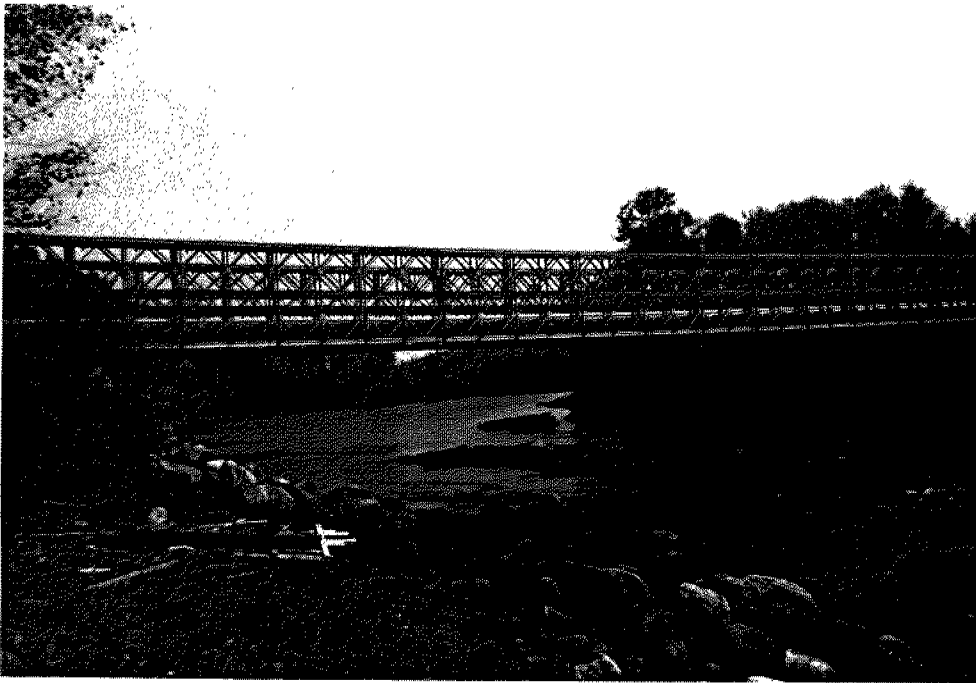
We hope that this will allow you to proceed with your design. However, should you have any further questions please advise.



Ken S.Q. Ahmad, P. Eng.
Foundation Engineer

For

D.H. Dundas, P. Eng.
Sr. Foundation Engineer



MISSISSAGI RIVER BRIDGE (HWY 556)
PRIOR TO COLLAPSE



MISSISSAGI RIVER BRIDGE (HWY 556)
AFTER COLLAPSE



REMOVAL OF DAMAGED BRIDGE



REMOVAL OF DAMAGED BRIDGE



TP 1 - SOUTH SIDE, EAST APPROACH FILL
(EXPOSED BEDROCK)



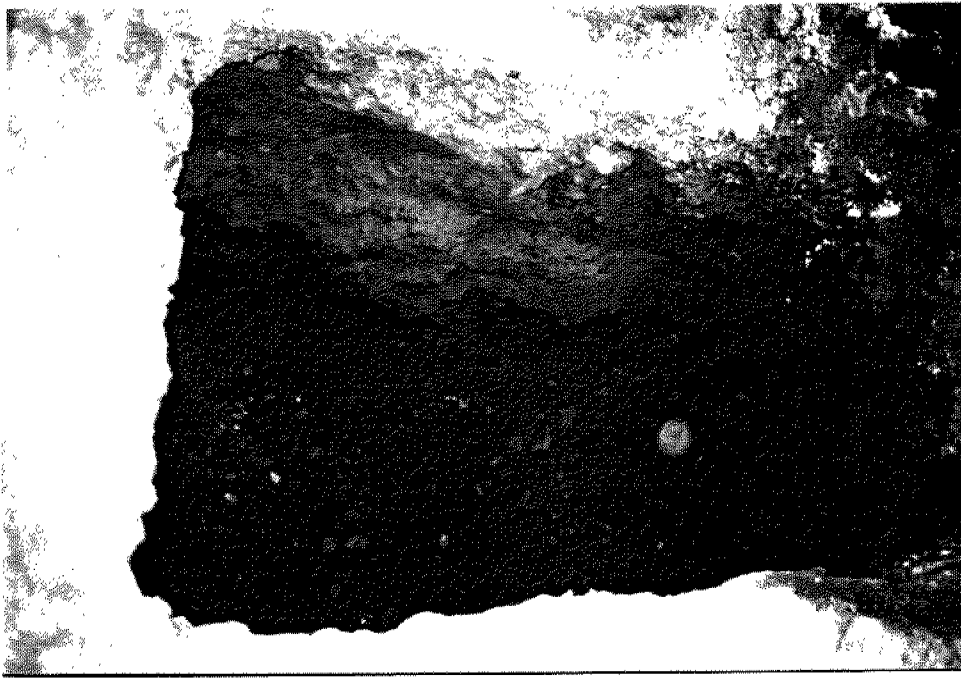
TP 2 - NORTH SIDE, EAST APPROACH FILL



TP 2 - BOULDERS AND GRAVEL



TP 2 - BOULDERS AND GRAVEL



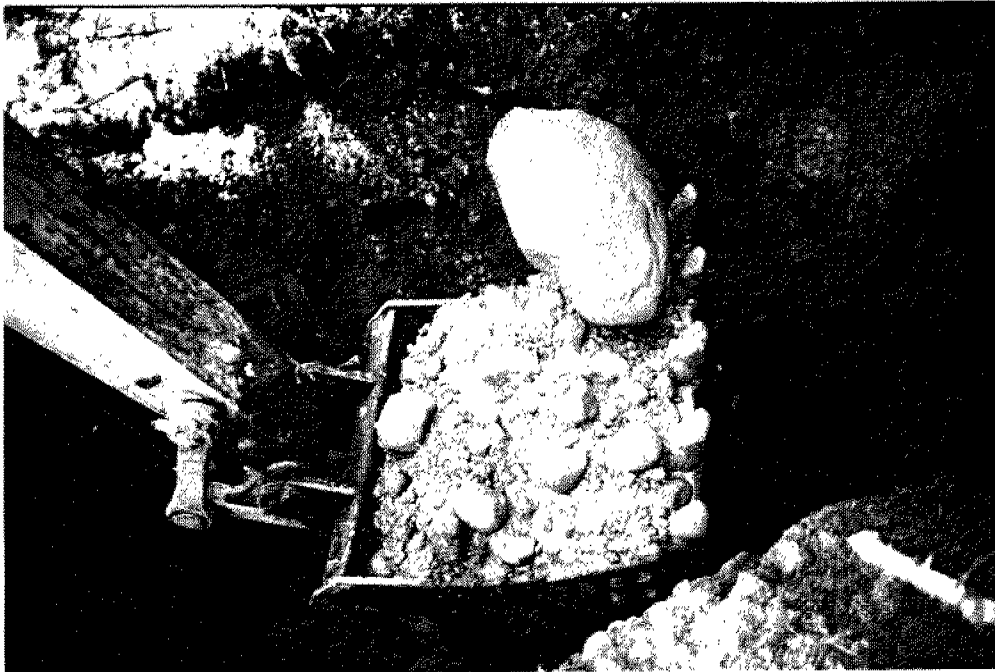
TP 3 - ON THE EAST APPROACH FILL
(WELL COMPACTED MATERIAL)



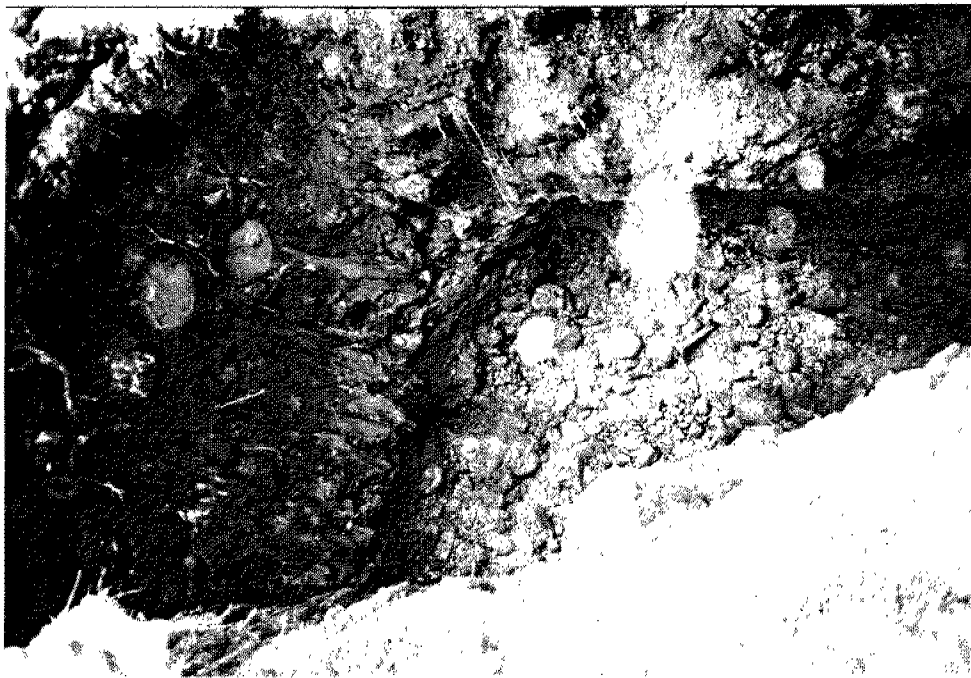
TP 3 - MATERIAL FROM THE PIT



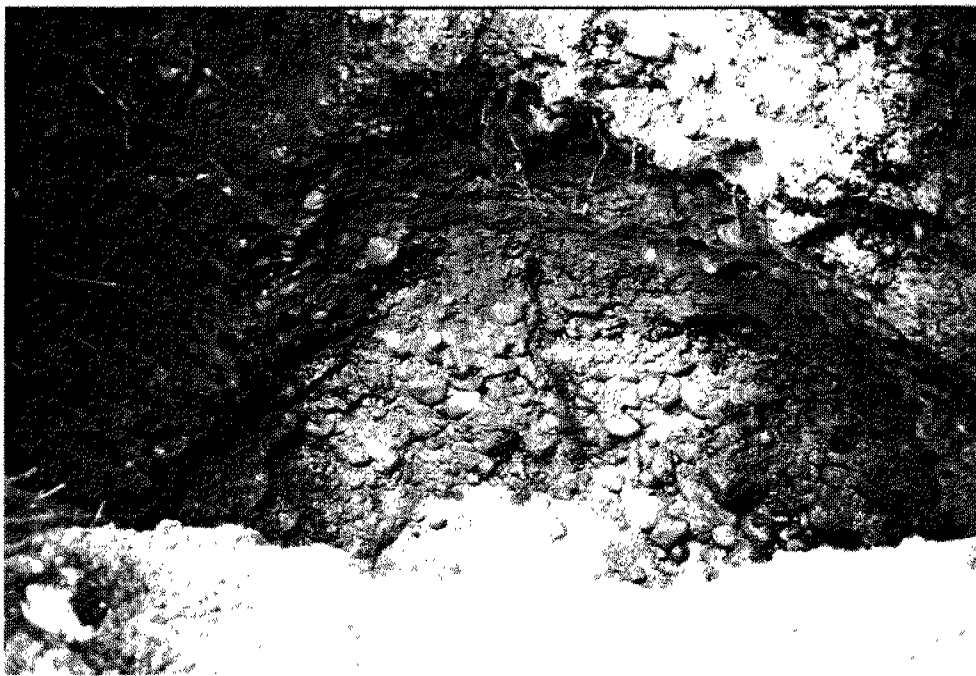
TP 5 - NORTH SIDE, WEST APPROACH FILL
(BOULDERS AND GRAVEL)



TP 5 - BOULDERS AND GRAVEL



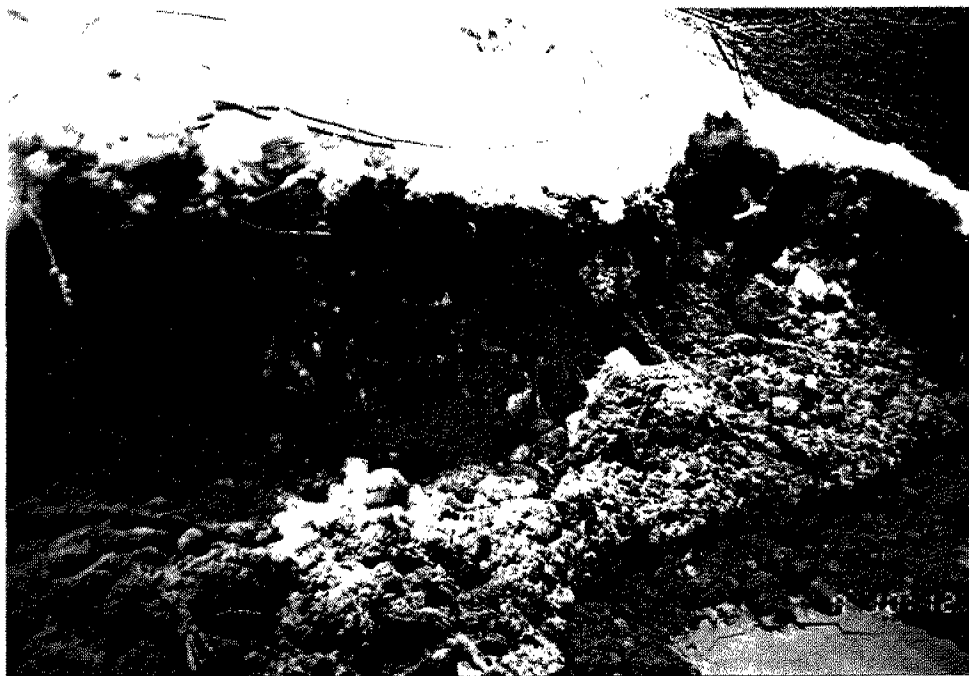
TP 5 - BOULDERS AND GRAVEL



TP 5 - BOULDERS AND GRAVEL
(PIT CAVING IN)



TIMBER CRIB, EAST APPROACH FILL



EROSION IN THE EAST APPROACH EMBANKMENT
NORTH SIDE



STEEL BEAM SUPPORTING BRIDGE BEARINGS