DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 30L14-43

DIST. 4 REGION

W.P. No. 174-87-00

CONT. No.

W. O. No.

STR. SITE No. 34-232

HWY. No. 140

LOCATION HWY 140 / CNR & CPR STRUCTURES
EMBANKMENT FAILURE

No. of PAGES - ~

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

G.I.-30 SEPT. 1976

memorandum

Ontario

To: J. Marcolin
Assistant District Engineer, Maintenance
District 4, Burlington

Date: 1992 04 03

From: Foundation Design Section
Room 315, Central Building

Re: Slope Flattening of Approach Embankment
Highway 140, C.N.R. Overhead Structure
W.P. 174-87-00, Site 34-232
District 4, Burlington

Further to the meeting on April 1, 1992 at your Burlington District Office, the stability of flattened slopes without mid-height berms at the above site has been reviewed by this office.

It is understood that the District Office wants to eliminate the 5 m wide mid-height berm which was recommended in our previous recommendations (a memo dated November 14, 1991) and, instead, to flatten the embankment slope toward transverse direction. Figure 1 shows an existing cross section, previously proposed section with the mid-height berm, and a flattened slope with a 3:5H:1V geometry. As shown on Figure 1 if the 3.5H:1V slope superimposes on the previously proposed Section, the toe of two slopes will lie on one another. It is also understood that Granular 'A' or 'B' material will be used as an additional fill material with a minimum granular blanket thickness of about 0.6 m.

Based on the stability analyses, this Section provides the following recommendations:

1) For fills higher than 5 m, permanent slopes will be stable at 3.5H:1V side slopes.

2) For fills higher than 3.5 m and equal to or lower then 5 m, permanent slopes will be stable with side slopes of 3H:1V.

3) For fills equal to or lower than 3.5 m, permanent slopes will be stable provided side slopes of 2.5H:1V.

As discussed in our previous recommendations, all surficial softened material in the affected area should be removed and replaced with suitable granular material. The granular fill should be placed as per M.T.O. Standard.

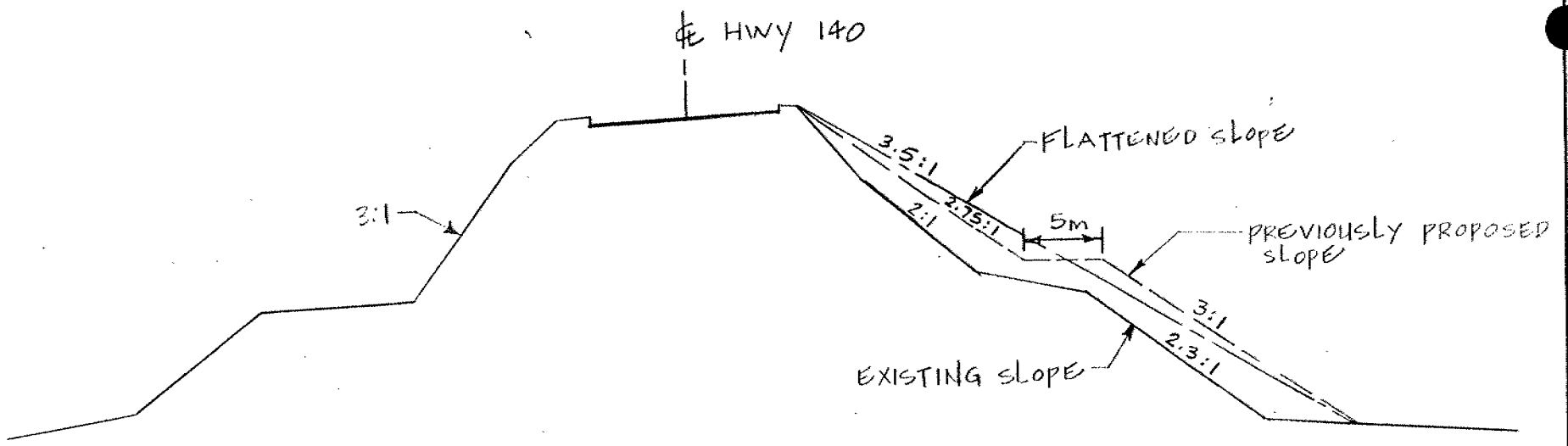
It is also recommended that the drainage trench be provided at the toe of the slope to depress the groundwater level as discussed in our previous recommendations. The drainage trenches should be lined with a suitable geotextile filter fabric, such as class 1 non-woven geotextile with EOS of 75 to 150 μm. The perforated pipes should be 150 mm minimum diameter and should be surrounded by a minimum of 150 mm of granular backfill. The drains should be connected to an approximate permanent drainage system.

Normal slope vegetation should be established as soon as possible after completion of fill slope in order to control surficial erosion as per M.T.O. Standard.

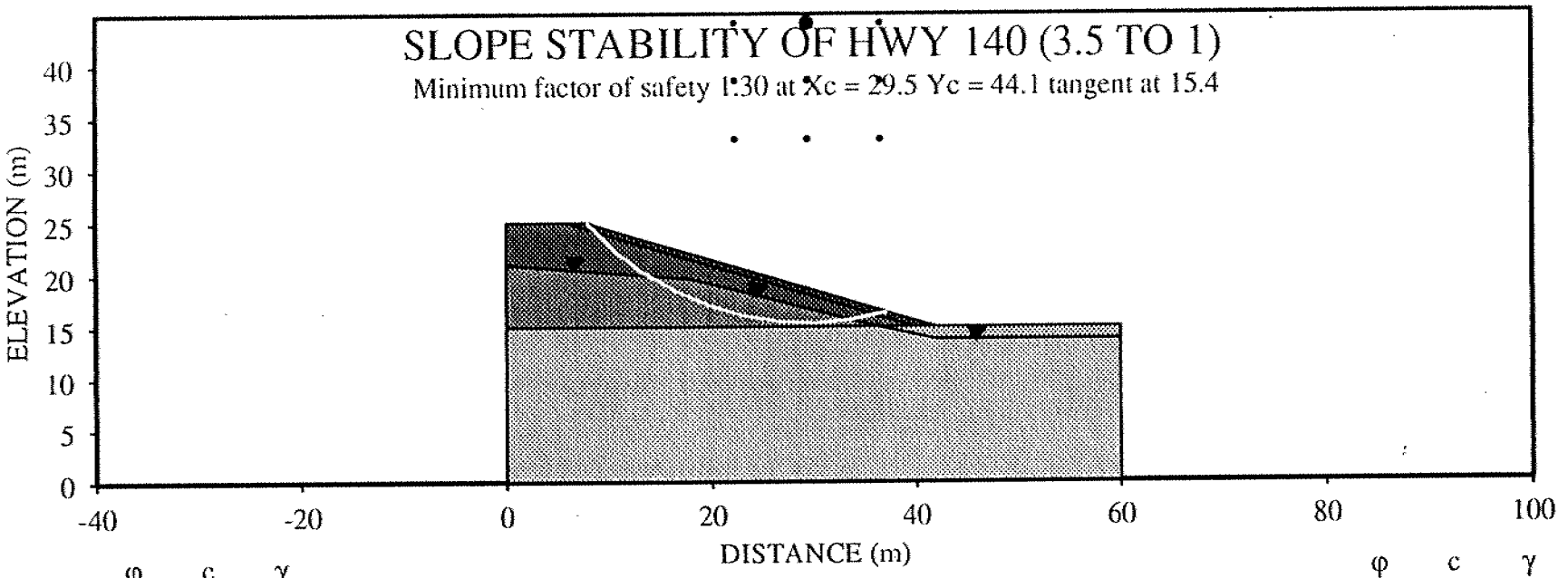
We have no further comments. If you have any further questions, please contact this office.

Taechul Kim

T.C. Kim, P. Eng.
Sr. Foundation Engineer
for
M. Devata, P. Eng.
Chief Foundation Engineer



Ministry of Transportation Ontario	CROSS SECTION @ STA 15+660 HWY 140 & CNR (NORTH APPROACH)	FIG No 1 WP 174-87-00

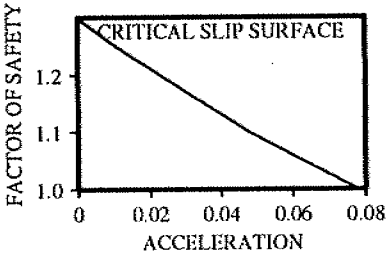


φ	c	γ	
35.0	0.1	22.0	GRANULAR SHEETING
23.0	0.1	18.5	CLAYEY FILL

	φ	c	γ
CLAYEY FILL	23.0	0.1	18.8
CLAY	25.0	13.0	19.6
CLAY	25.0	13.0	19.6

CRITICAL ACCELERATIONS

0.111	**0.078**	0.125
0.102	0.083	0.137
0.098	0.094	0.150



FACTORS OF SAFETY

1.499	**1.299**	1.479
1.426	1.317	1.522
1.379	1.358	1.571

FIG - 2
WP 174-87-00

Ontario Ministry of Transportation
Ministère des Transports

Tel: (416) 637-5625
Fax: (416) 637-4114

MINUTES OF MEETING
APPROACH EMBANKMENTS, HWY. 140
CNR OVERHEAD STRUCTURE (SITE 34-232)
HELD IN DISTRICT 4, BURLINGTON
ON APRIL 1, 1992

Foundation and Regional Geotechnical Office submitted recommendations with regards to remedial measures dealing with stabilizing approach embankments at the above location. Construction and District reviewed the field conditions and provided their comments to the recommendations.

A meeting was convened at the District Office boardroom to discuss the proposal, offer suggestions and seek clarification. The meeting was held April 1, 1992 at 10:30 a.m. In attendance:

P. Payer	Foundation Design
T.C. Kim	Foundation Design
M. Devata	Foundation Design
J. Marcolin	Assistant District Engineer, Maintenance
D. Aubin	Maintenance Supervisor
G. Scott	Construction Technician
H. Guise	Construction Supervisor
E. Dufresne	Secretary

The pros and cons of the recommendations were discussed at length. There is concern with the Welland clay used to construct the existing embankment, i.e. 2:1 slopes vs. the need for 3:1 slopes and the method or extent of the work required to flatten the slope with due regard to totally correcting the problem. The cost associated with the works is also foremost in any plan of action to be taken.

Several issues were put forth by Construction and of prime concern is drainage, work space limitations, the width of trenches, granular backfill and compaction. The work must be carried out June/July/August to insure maximum dry conditions. Trenching should be limited to 1.5 m maximum and backfilled with compacted Granular 'A'. A two (2') foot granular blanket on the slopes was discussed and the meeting agreed that this method of construction is preferred. No filter cloth will be used. The subdrain elevation will be raised to suit field conditions. It was concluded, following this forum, Foundation, Construction and District will meet at the site on April 7, 1992 at 2:00 p.m. and confirm requirements and identify by station references the work limitations for tender preparation purposes. Foundation will confirm by fax early next week the method of construction. There is cracking at some location(s) in the shoulder. Recommendations will include measures to correct this problem.

Conclusions

Foundation will revisit recommendations for remedial work. Construction will provide items, tender quantities and non-standard specials for tendering purposes. District will produce a justification report for funding and a tender package for a local call contract. Construction will supervise the work and call in Foundation during construction to insure recommendations are appropriate given other sites need similar repairs. District will look for a topsoil disposal site (patrol yard?). J.P. Marcolin will arrange for a temporary charge number. Foundation will distribute minutes of their site meeting of April 7, 1992.

E. Dufresne
Secretary

cc: All attending
P. Kinnear

memorandum

Ontario

To: Mr. G. Cautillo
Head, Geotechnical Section
2nd Floor, Atrium Tower

Date: 1992 01 30

From: Foundation Design Section
Room 315, Central Building

Re: Instability of Approach Embankment
Highway 140, CNR Overhead Structure
W.P. 174-87-00, Site 34-232
District 4, Burlington

Further to our telephone conversation, we have reviewed the comments in your draft memo dated January 9, 1992.

Based on our review, I would like to express our concern as follows:

1. Foundation Design Section is responsible for slope stability.

2. Contrary to your comments, for the slope stability of high embankments, Districts normally deal directly with the Foundation Design Section as we do not have a Regional counterpart. The Geotechnical Section acting as an intermediary is ineffective and inefficient.

3. There was some communication problem between your Section and our Section during the site visit. I agree that we had some discussions concerning the remedial works. However, as far as I remember, we did not reach any consensus at that time. We expected you to call a meeting to discuss this matter in detail. Much to our surprise, a brief recommendation letter was sent to the Burlington District Maintenance Office from your section on December 11, 1991 which did not include our original observations of the problem and our recommendations.

4. Although a policy is to be open to comments, we reserve the right to have the final word in recommendations for which we are responsible. Further, we have a serious problem with the courtesy and ethics of alteration of a professional engineers recommendations (APEO philosophy).

5. It should be noted that writing of any discussion or agreement is our policy so that your proposals are not accepted unless they are enforced in writing from our office.

6. Also, from a technical point of view, we are not in agreement with the recommendations as stated in your memo, since the problem is more serious than you thought. It is our responsibility to clarify this concern before we accept your proposal.

7. A joint project is not flexible, and we recommend that we do the project independently in the future to avoid any conflict between our Section.

I would be pleased to discuss this matter with you. If you have any questions, please contact this office.

M. Devata, P. Eng.
Chief Foundation Engineer

MD/jb

M E M O R A N D U M

GEOTECHNICAL SECTION, CENTRAL REGION, TELEPHONE: 235-5431

TO: Mr. M. Devata
Chief Foundation Engineer
Foundation Design Section
3rd Floor, Central Building

DATE: 92-01-09

RE: APPROACH EMBANKMENTS, HWY. 140
CNR OVERHEAD STRUCTURE (SITE NO. 34-232)
DISTRICT 4, BURLINGTON

This is further to a letter from your office dated 91/12/16 to the Burlington District Office regarding remedial measures for approach embankments at the above location.

On January 3, 1990, the Central Region Geotechnical Section requested the Foundation Design Section to investigate a surficial slope problem on the approach embankment to the Hwy. 140 CNR Overhead Structure. Site visits were made by several members of the Foundation Design Section during December, 1990 as well as June and October, 1991.

A letter was subsequently forwarded from your office to the Geotechnical Section on 91/11/14 containing recommendations for substantial remedial slope treatments throughout the entire site. After a review of these recommendations, the Geotechnical Section believed that portions of the work may be in excess of what is currently necessary to address the situation in a manner which balances present fiscal circumstances with long term maintenance requirements.

Further to this, a site meeting was held on 91/12/04 with staff from both the Foundation Design and Geotechnical Section in an attempt to resolve the discrepancies that existed on what work was required. At that time, a consensus was reached that a portion of the work recommended, consisting of all corners at forward slopes, should be carried out now to address present needs while the remaining side slope work could be done at a later date to address long term needs.

...../2

On 91/12/11, a letter was sent to the Burlington District Maintenance Office from the Geotechnical Section incorporating the recommendations from your original letter in conjunction with the decisions agreed to at the site meeting. A copy of this letter was forwarded to the Foundation Design Section for your records. Specifically, the letter indicated what work should be carried out now and what work could be done at a later date.

Subsequent to this, and much to our surprise, a letter dated 91/12/16 was forwarded to the Burlington District Office from your section along with a copy of your original recommendations instructing that the remedial measures as outlined be fully implemented. We find this somewhat perplexing considering the understanding our sections reached in the field in how the matter should be dealt with. Moreover, a mixed message has been conveyed to the District on exactly what course of action to take. Normally, the District will liaise at a Regional level for assistance in these types of situations and the Region will in turn liaise with Head Office if necessary.

I would be pleased to discuss the details of this matter with you, including your letter to the District so that this type of confusion can be avoided in the future.

G. Cautillo, P. Eng.
Head, Geotechnical Section

GC/RK/rb

c.c. D. Garner
R. Northwood

Disk File: c:\highway\hwy140.emb

memorandum

Ontario

To: Mr. J. Marcolin
Maintenance Engineer
District 4, Burlington

Date: 1991 12 16

From: Foundation Design Section
Room 315, Central Building

Re: Instability of Approach Embankment
Highway 140, CNR Overhead Structure
W.P. 174-87-00, Site 34-232
District 4, Burlington

Attached please find the original memo which summarizes our observations and recommendations pertaining to the remedial measures for the instability of approach embankments at Highway 140 in the vicinity of CNR overhead structure.

We believe that the recommendations from the Foundation Design Section should be fully implemented.

If you have any further questions, please contact this office.

Tae C. Kim, P. Eng.
Sr. Foundation Engineer

for

M. Devata, P. Eng.
Chief Foundation Engineer

MD/TCK/jb

c.c. G. Cautillo (memo only)

M E M O R A N D U M

GEOTECHNICAL SECTION, CENTRAL REGION, TELEPHONE: 235-5431

TO: Mr. J. Marcolin
Maintenance Engineer
District 4, Burlington

DATE: 91-12-11

RE: APPROACH EMBANKMENTS, HWY. 140
CNR OVERHEAD STRUCTURE (SITE NO. 34-232)
DISTRICT 4, BURLINGTON

This is further to a letter dated 91/11/14 from the Foundation Design Section containing recommendations for remedial action pertaining to approach embankments at the above site.

The recommendations were provided in response to a request from the Geotechnical Section after District staff raised concerns about local surficial failures on the approach embankments of the Hwy. 140 structure. Tension cracks and surficial sloughing are present at various locations throughout the site, however, the most pronounced distresses are located at the corners of the forward slopes.

Based on visual observations, the Foundation Design Section has attributed the surficial sloughing to weakness of the fill material and seepage through the slopes which results in a softening of the silty clay fill.

The recommendations that were provided address both short term and long term slope stability. Of greatest present concern are the corner sections on the forward slopes at both the north and south approaches. It is recommended that these areas be treated with a 2 m thick Granular "A" blanket drained by a toe drain (granular trench with pipe) where possible. Excavation of the fill material on the forward slopes should be carried out in narrow strips, then immediately backfilled with Granular "A".

In order to address long term surficial stability concerns, a significant amount of additional work has been recommended for the side slopes. The work includes the following slope flattening:

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	Height of Fill	Maximum Slope
Upper Slope (above berm)	< 2.8 m	2:1
	2.8 - 4.0 m	2.5:1
	4.0 - 5.0 m	2.75:1
Lower Slope (below berm)	< 2.8 m	2:1
	2.8 - 3.8 m	2.5:1
	3.8 - 5.0 m	3:1

Slope flattening should be carried out by removing all topsoil and wet surface material from the existing embankment and benching as per OPSD 208.01.

In addition to the slope flattening, diagonal counterfort drains are recommended for the side slopes. The drains should be 0.6 m wide by 1.5 m deep spaced 10 m apart from edge to edge, backfilled with Granular "A", and constructed from the shoulder of the road to the toe of slope. Toe drains (granular trench and pipe) should be provided on both the upper and lower slopes where possible to drain the counterfort system.

It is recommended that the granular blanket work at the corners of the forward slopes be carried out reasonably soon to address present needs. The side slopes flattenings and counterfort drains which address long term stability may be incorporated at a future date.

In an associated issue to this matter, the Geotechnical Section in conjunction with the Foundation Design Section is proposing to carry out a study of embankments in eastern Niagara Region which were constructed with "Welland clay". The study, which is proposed for next summer and is subject to the approval of appropriate funding, would include site visits and some associated field work at various locations where fill embankments are exhibiting failures.

I trust the above information addresses the concerns raised pertaining to the Hwy. 140 approach embankments at the CNR structure. Should you have any questions regarding these recommendations, please contact this office.

R. Kohlberger
Soils Unit Supervisor
for:
G. Cautillo
Head, Geotechnical Section

RK/GC/rb

c.c. M. Devata

Disk File: c:\highway\hwy140.cnr

memorandum

Ontario

235-3731

To: Mr. G. Cautillo
Head, Geotechnical Section
Central Region

Date: 1991 11 14

Attn: J. Vanbiesbrouck
P.D.E.O.

From: Foundation Design Section
Room 315, Central Building

Subject: Instability of Approach Embankments
Highway 140, CNR Overhead Structure
W.P. 174-87-00, Site No. 34-232
District 4, Burlington

Further to the official request from the Regional Geotechnical Section (memo January 3, 1990), site visits have been made by the members of the Foundation Design Section during December 1990, June and October 1991, at the above-mentioned site. This memo will summarize our observations made during the site visits and recommendations pertaining to the remedial measures.

OBSERVATIONS

The following visual observations were made on December 4, 1990 by Messrs. P. Payer and T. Kim.

1. The void between the concrete abutment and the earth fill at the north abutment had been backfilled with cohesive soil by MTO maintenance crew when we visited the site (see photo #1).

2. Localized surficial sloughing was noted on the portion of the upper slope (2:1) above the berm, particularly the east and west side of the north approach fill (see photos #2 and #3). However, it would appear that these conditions are confined to an area where the Granular 'A' blanket was placed.

3. The 2:1 slope, below the berm appears to be reasonably stable.

Subsequent site visit made on June 21, 1991 by T. Kim further confirmed the forementioned comments.

The additional observations are as follows:

.../2

1. Tension cracks, running parallel to the roadway, were noticed at both sides on the upper slopes. These cracks generally are present along the shoulder, outside of guide rail, and extended to about 200 m north from the end of concrete slab. The District Construction personnel have indicated that these cracks were originally minor (0.3 cm); however, they were as wide as 5 cm near the bridge abutment during the time of this site visit (see photos #4, #5 and #6).

2. It was found that localized surficial sloughing was further extended to the north (about 30 m long) on the upper slope above the mid-height berm, particularly the east side of the north approach fill (see photo #7).

3. Tension cracks was also detected on the east side of the lower slopes along the edge of the mid-height berm. These cracks are about 60 m long and as wide as 20 cm during the time of this site visit (see photo #8).

4. A typical local failure has been developed on the east side of the south abutment forward slope where a subdrain pipe (8" diameter perforated C.I.P.) was installed (see photo #9). As shown on photo, a small circular failure accured on the forward slope with an approximate width of 16 m.

5. A similar circular failure was occured on the west side of the south abutment forward slope above the concrete culvert as shown on photo #10. The size of this circular failure block is about the same as that of east side one (approximately 17 m wide).

6. In addition to the Highway No. 140 site visit, a number of St. Lawrence Seaway Authority structure sites along the Welland Canal were visited where the similar silty clay has been used as fill. It was interesting to note that where 3H:1V slopes were employed, the embankments appeared reasonably stable. However, where 2:1 slopes are present, the same type of surficial instability has been noticed.

Subsequent site visit made on October 17, 1991 by Messrs T. Kim and A. Drevininkas brought forth the following observations (see Figure 1)

1. Tension cracks, running parallel to the roadway, were noticed on the upper slopes of the north approach fill and the east side of the south approach fill. These cracks are generally present along the shoulder, outside of the guiderail,

.../3

extending to about 260 m north of the north abutment and extending 250 m south of the south abutment. The size of these tension cracks are 5-6 cm in width, with those on the north approach fill being more prominant.

2. Tension cracks, running parallel to the those on the upper slopes, were also detected on all of the lower slopes along the edge of the mid-height berm. These cracks are between 140 m and 190 m in length, running the whole length of the mid-height berm (185 m) on the north approach fill.

3. Localized surficial sloughing was found to the north (about 100 m long) and to the south (about 25 m long) on the upper slope above the mid-height berm. The amount of settlement along the upper slope of the south approach fill was as much as 80 cm.

4. A typical local failure, circular in nature, has developed on the east side of the south abutment forward slope, 16 m east-west, 13 m north-south.

5. A similar typical failure has occured on the west side of the south abutment forward slope (17 m x 14 m).

6. Typical local failures have also occured on the east and west side of the north abutment forward slopes. The maximum width of these circular failures are 12 m (east side) and 9 m (west side).

7. A typical local slope failure has also occured on the lower slope of the east side of the north approach fill. The failure has occured 30 m north of the base of the north abutment and is 17 m in width. The failure has displaced the top of the lower slope, 35 cm in height and 30 cm in width, causing the toe of the slope to bulge.

DISCUSSION AND RECOMMENDATIONS

Based on our visual observations at the site, the slope instability of the approach embankments of C.N.R. overhead structure at Highway No. 140 appears to be a surficial nature. The primary cause of these surficial sloughing (localized failures) is probably due to the weakness of the fill material and the action of water seeping through the slopes which resulted in softening of the silty clay fill material.

Stability analyses were carried out to evaluate the existing approach fills in transverse direction and the internal stability of fills. An effective stress analysis was applied for

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calculations of slope stability of the approach fills using the limit equilibrium method of stability developed by Sarma (1973) [Sarma, S.K., 1973 Stability Analysis of Embankments and Slopes, Geotechnique, Vol. 23, No. 3]. Since the approach fill is permanent for the bridge structure, a minimum factor of safety of 1.3 was incorporated for the analyses.

Upper Slope

Stability analyses were carried out for different height of fill in upper silty clay slope with different side slope as shown on Figure 2. Based on the analyses as shown on Figure 3, the following conclusion have been derived for the upper slope.

Approach fills up to 2.8 m in height will be stable provided they are constructed with standard 2H:1V slopes. A flatter side slope will be required for the higher fill exceeding 2.8 m in height to ensure the stability of approach fill. The existing 5 m high fill above the mid-height berm will require a flatter slope of 2.75H:1V as shown in Figure 3.

Lower Slope

Figure 4 shows a typical section of the lower slope. Stability analyses were also carried out for different height of fill with different side slope as shown on Figure 5. It should be noted that for the existing 5 m high lower slope, a flatter side slope of 3H:1V will be required to ensure the stability as shown on Figure 5.

In view of this, it is recommended that the following remedial measures be carried out as soon as possible in order to control the seepage within the fill and to stabilize the sloughed part of the slopes.

1. All the surficial softened material in the affected area should be removed, and replaced with suitable earth material.

2. The fill should be placed in thin layers and compacted as per MTO standards. The fill should be keyed into the existing slope in accordance with current MTO Standards and practice. The slope should then be constructed to no steeper than 2.75H:1V for the upper slope and 3.0H:1V for the lower slope.

3. Diagonal counterfort drains, at least 1.5 m deep (for frost protection) and having a minimum base width of 0.6 m should be constructed from the shoulder of the road to the toe of the slope on the upper and lower slope. The spacing of these

.../5

drains should be about 10 m from edge to edge at their upper surface as shown on Figure 6. The material used for the drains should consist of free-draining granular material, such as Granular 'A'. Positive drainage measures should be adopted to relieve the water from the blanket. This can be achieved by placing a subdrain (20 cm diameter perforated C.I.P.) at the toe of the upper and lower slopes as shown on on Figure 6. This system should drain into the existing ditches at the toes of the approach fills.

4. Both the corner areas of the approach embankments toward forward slope can be remedied by placing a thick granular blanket as shown on Figure 7. The details of the placement of the the granular blanket will be discussed later. In any case, all softened fill material should be removed from the affected areas and replaced with suitable granular material.

   At least 1.5 m deep (for frost protection) and having a minimum base width of 0.6 m should be constructed at the toe of the slope as shown on Figure 7. The material used for the drains should consist of free-draining granular material, such as Granular 'A'. Any water collected by these drains should be intercepted by the cutoff drain with 20 cm diameter perforated C.I.P. discussed in Item 3.

Construction Considerations

It is possible that the existing fill material may be reused, providing all topsoil is removed and the moisture content of the material can be controlled at or near its optimum moisture content. It should be noted, however, that significant air-drying of this material may be necessary. Alternatively, any locally acceptable cohesive and non-cohesive earth material may be used.

During excavation of the failed material along the forward slopes, the area should be excavated with small strips in order to achieve the safety standard for the bridge abutments and backfilled with appropriate granular material as shown on Figure 7.

After completion of the rehabilitation, the slope should be sodded in accordance with OPSD 218.01, to protect the earthfill from gullying.

We believe that this memo meets with your present requirements. If you have any questions, please contact us.

Taechul Kim

Tae C. Kim, P.Eng.
Senior Foundation Engineer

for

M. Devata, P.Eng.
Chief Foundation Engineer

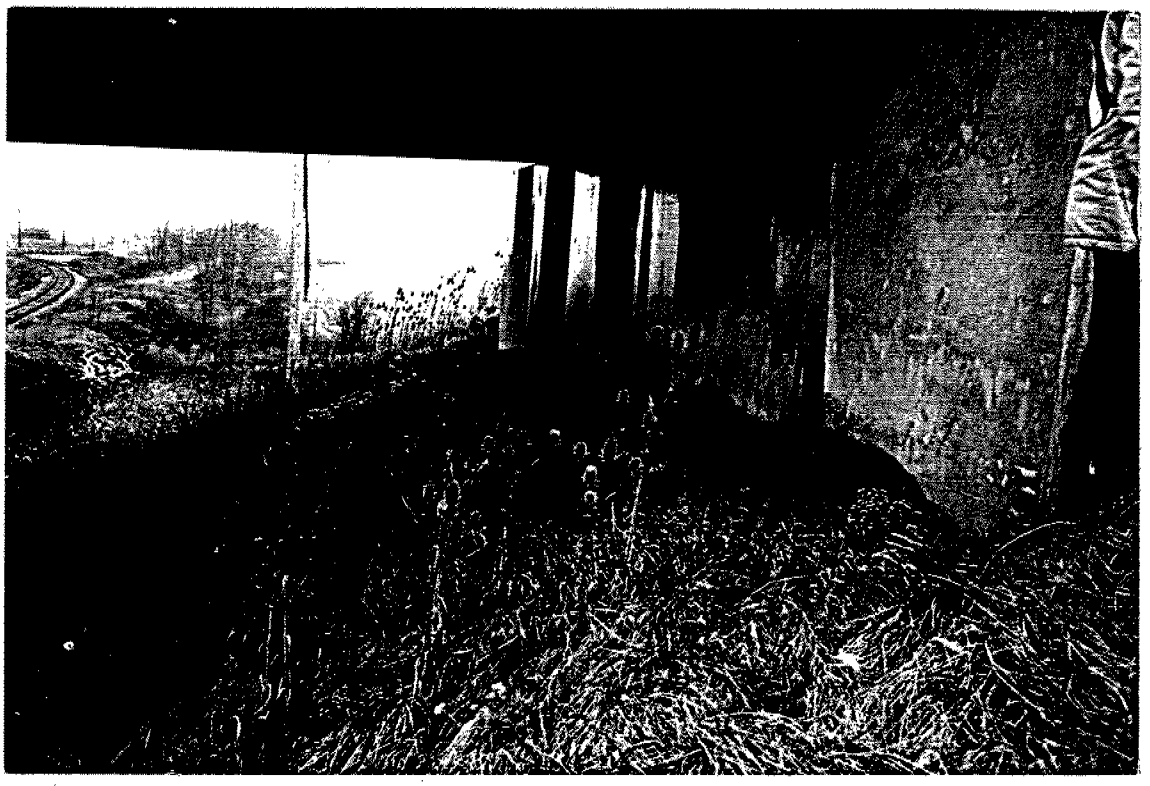


PHOTO #1. NORTH ABUTMENT (LOOKING WEST)

PHOTO #2. NORTH APPROACH FILL, UPPER SLOPE
(EAST SIDE, LOOKING NORTH)

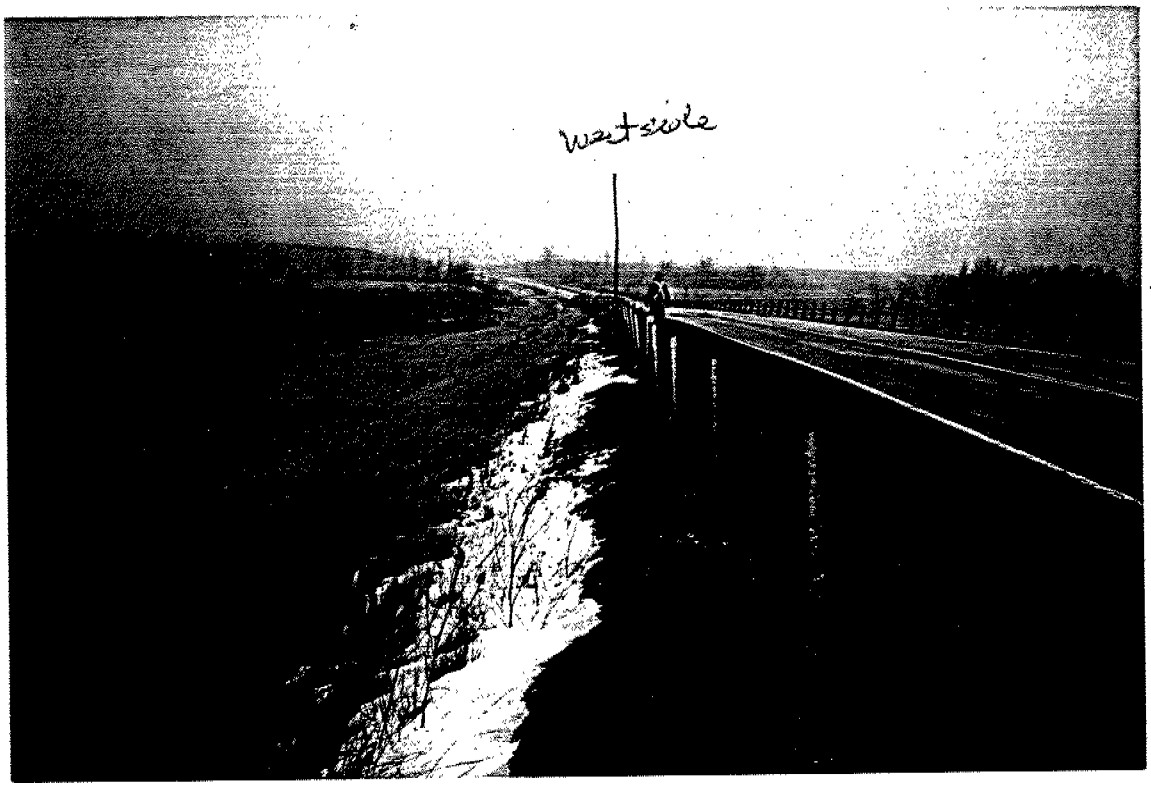


PHOTO #3. NORTH APPROACH FILL, UPPER SLOPE (WEST SIDE, LOOKING NORTH)

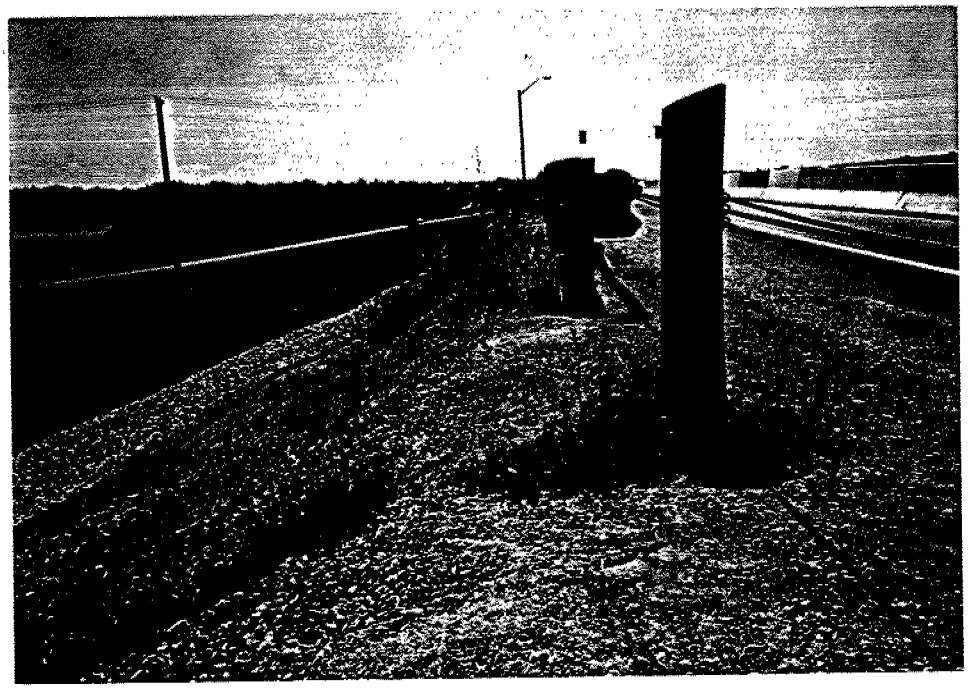


PHOTO #4. LONGITUDINAL CRACKS ON NORTH APPROACH (EAST SIDE, LOOKING SOUTH)

PHOTO # 5. CLOSEUP OF LONGITUDINAL CRACKS ON NORTH APPROACH

PHOTO # 6. CLOSEUP OF LONGITUDIAL CRACKS ON NORTH APPROACH

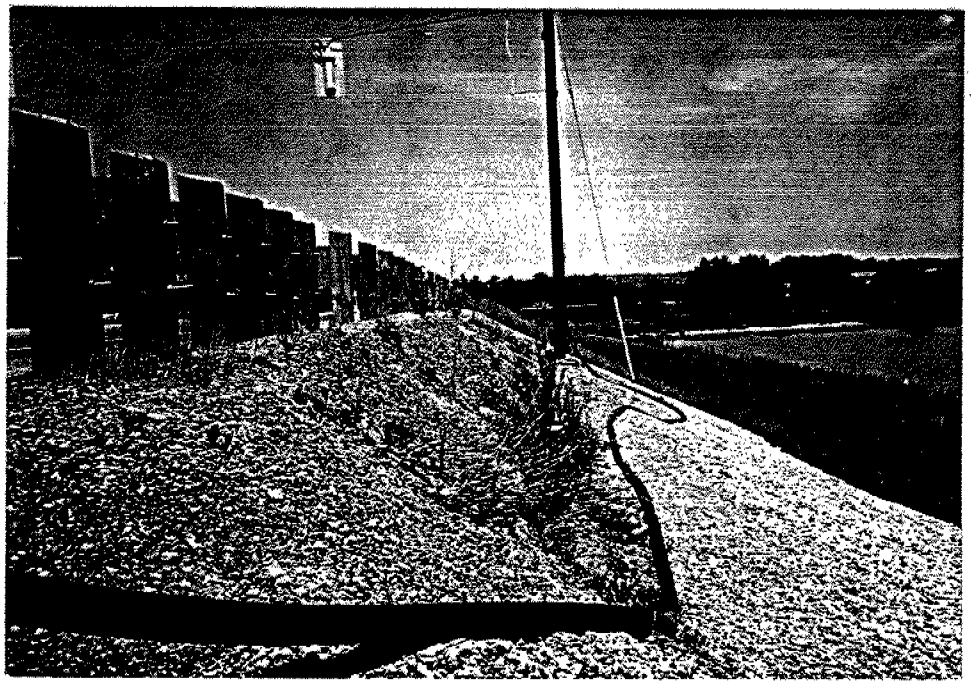


PHOTO # 7. SURFICIAL SLOUGHING AT NORTH APPROACH FILL (EAST SIDE, LOOKING NORTH)

PHOTO # 8. LOCAL FAILURE ON LOWER SLOPE AT NORTH APPROACH (EAST SIDE SLOPE)

PHOTO #9. FORWARD SLOPE FAILURE AT EAST SIDE OF SOUTH ABUTMENT (LOOKING SOUTH)

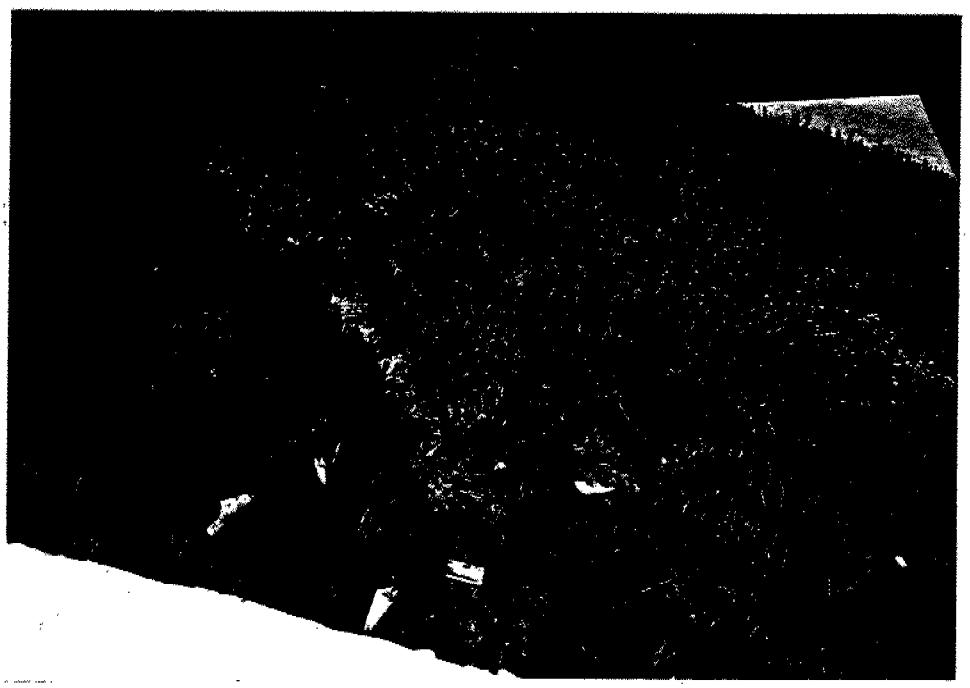
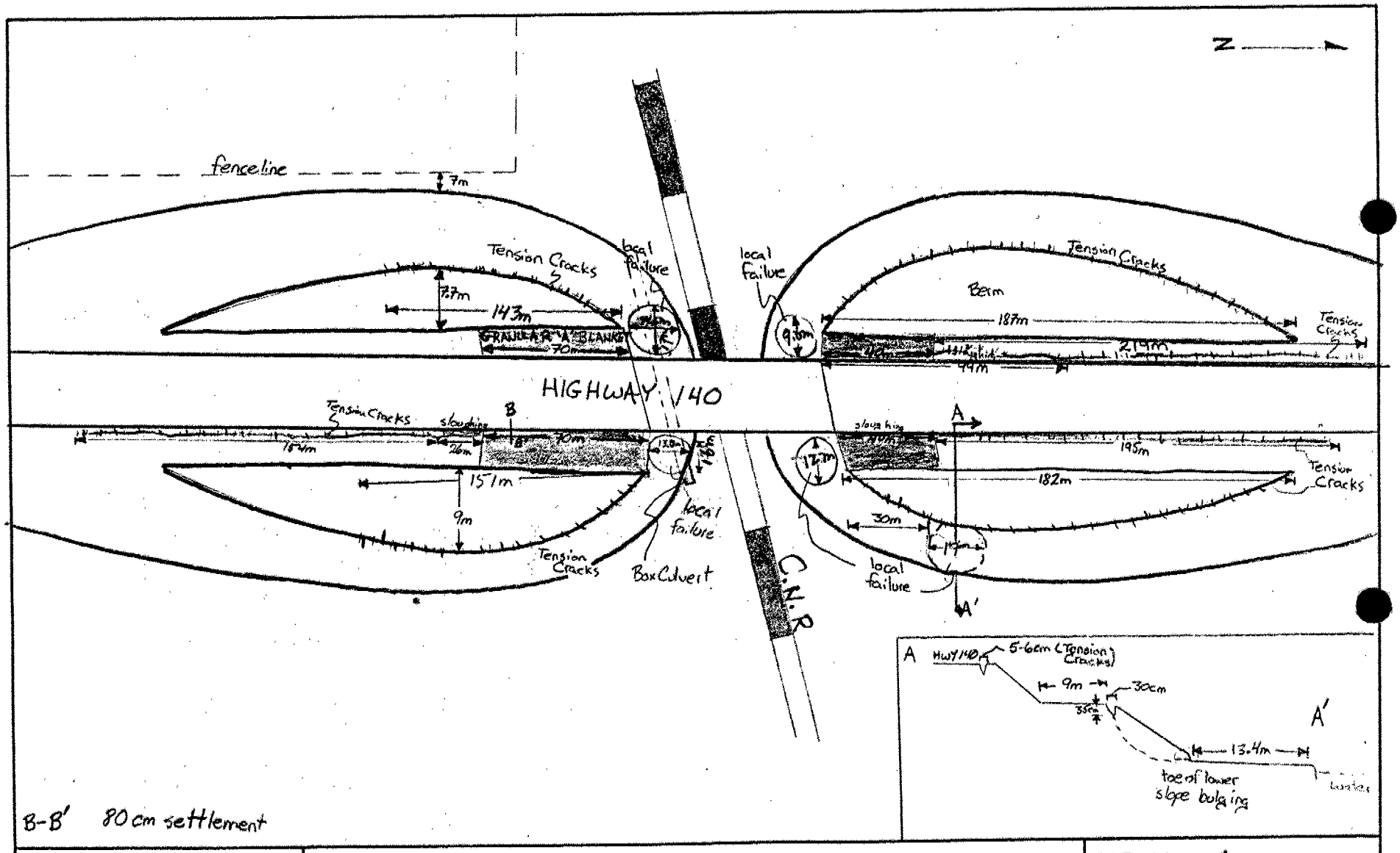


PHOTO #10. FORWARD SLOPE FAILURE AT ST SIDE OF SOUTH ABUTMENT (LOOKING SOUTHWEST)



Ministry of Transportation
Ontario

EXISTING CONDITION OF EMBANKMENT

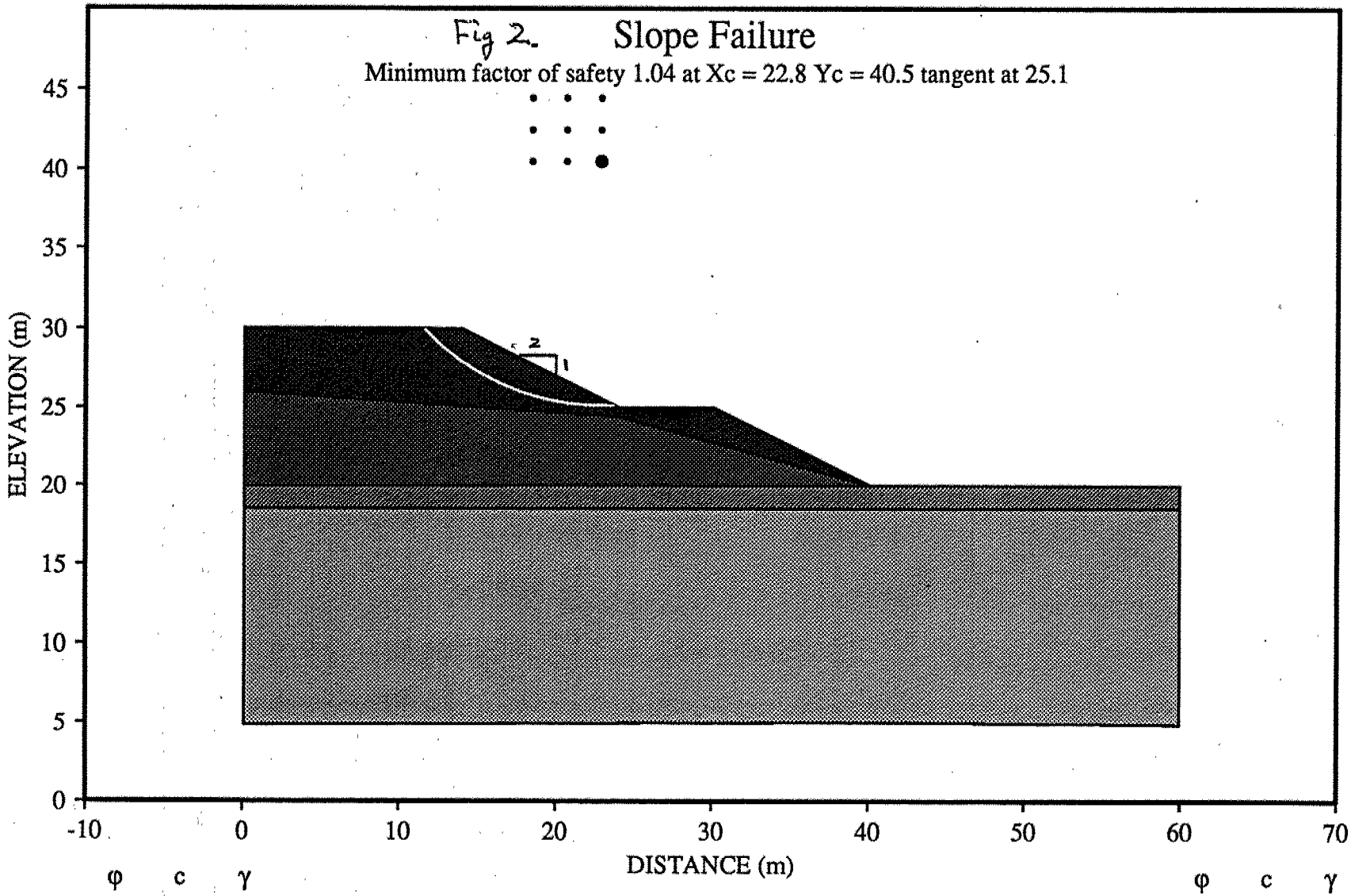
FIG No 1

WP 174-87-00

Fig 2.

Slope Failure

Minimum factor of safety 1.04 at Xc = 22.8 Yc = 40.5 tangent at 25.1

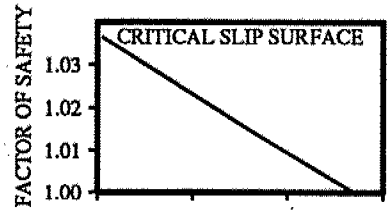


φ	c	γ	
23.0	0.0	18.5	Clayey Fill
23.0	0.0	18.8	Clayey Fill

φ	c	γ	
23.0	0.0	18.0	Clay (Softened)
23.0	0.0	19.6	Clay

CRITICAL ACCELERATIONS

0.175	0.118	0.056
0.165	0.102	0.036
0.153	0.085	0.013



FACTORS OF SAFETY

1.766	1.429	1.172
1.683	1.355	1.105
1.606	1.279	1.036

Figure 3, MINIMUM FACTOR OF SAFETY
Vs.
HEIGHT OF FILL
(UPPER SLOPE)

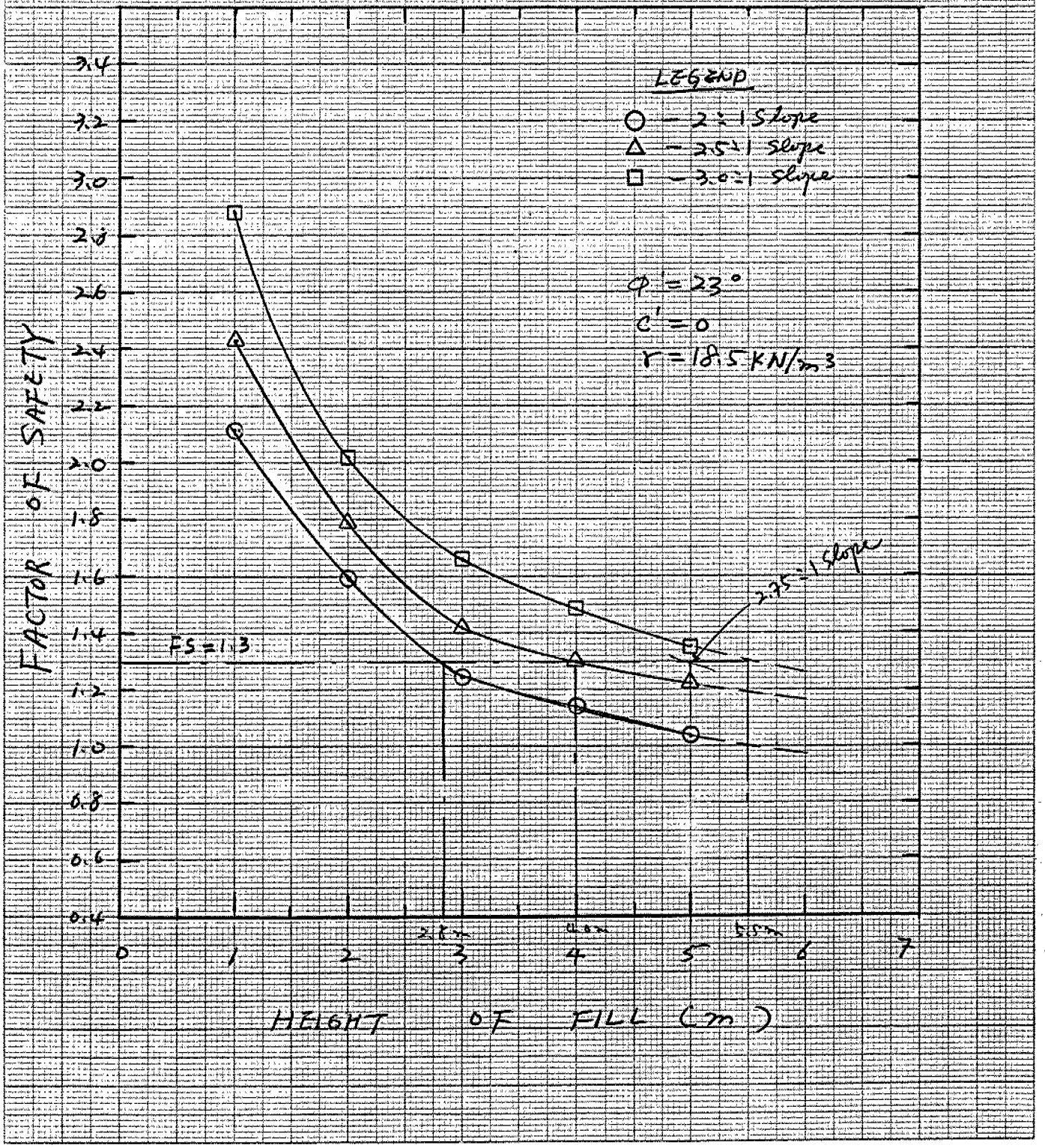
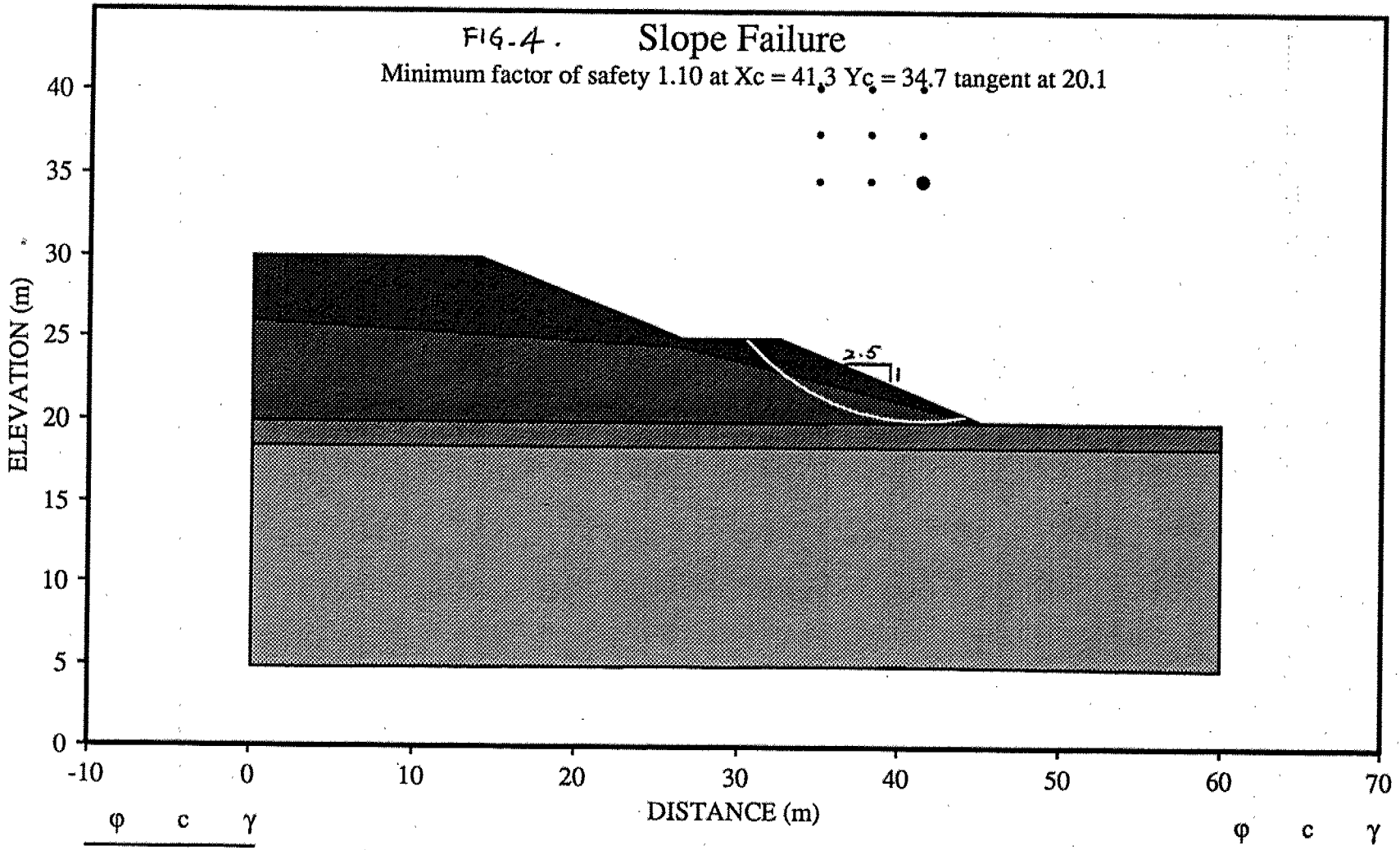


FIG.4. Slope Failure

Minimum factor of safety 1.10 at Xc = 41.3 Yc = 34.7 tangent at 20.1

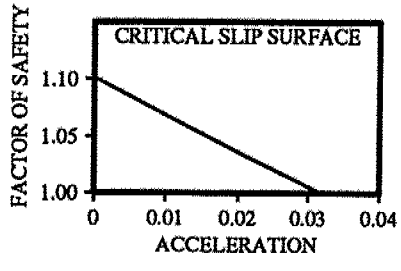


φ	c	γ	
23.0	0.0	18.5	Clayey Fill
23.0	0.0	18.8	Clayey Fill

φ	c	γ	
23.0	0.0	18.0	Clay (Softened)
23.0	0.0	19.6	Clay

CRITICAL ACCELERATIONS

0.124	0.114	0.067
0.137	0.111	0.050
0.151	0.100	0.032



FACTORS OF SAFETY

1.553	1.502	1.239
1.636	1.477	1.171
1.735	1.404	1.102

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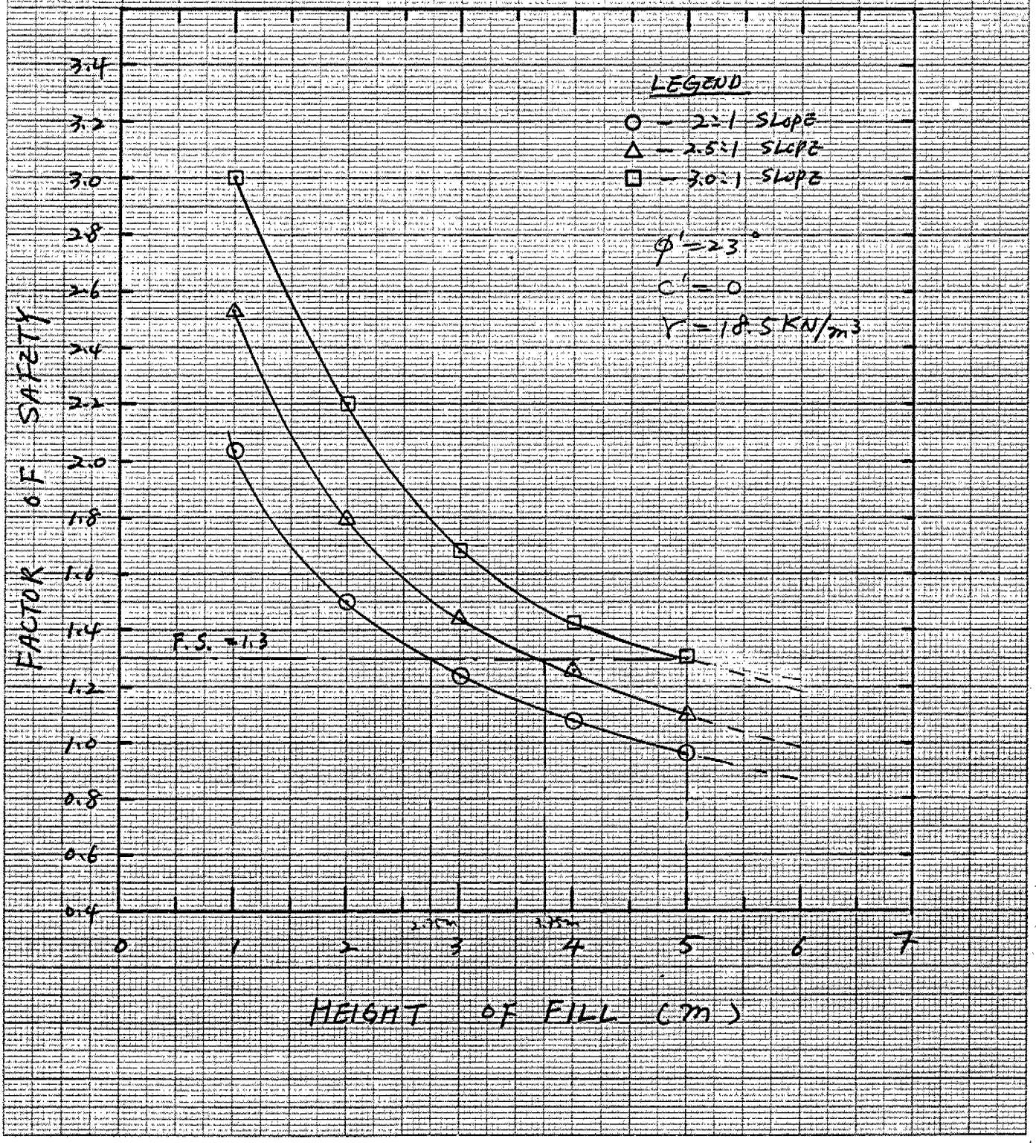
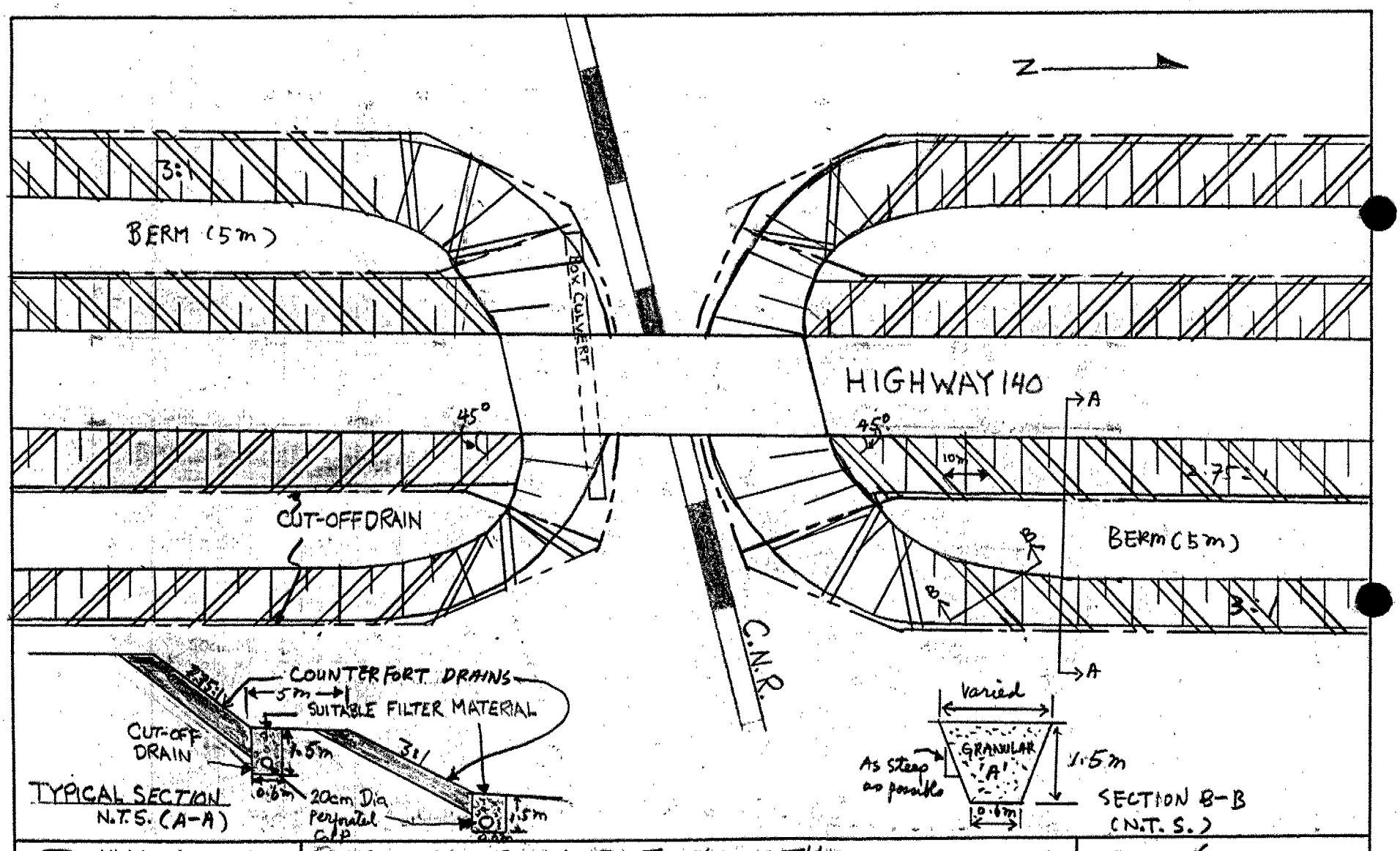
Figure 5. MINIMUM FACTOR OF SAFETY
Vs.
HEIGHT OF FILL
(LOWER SLOPE)



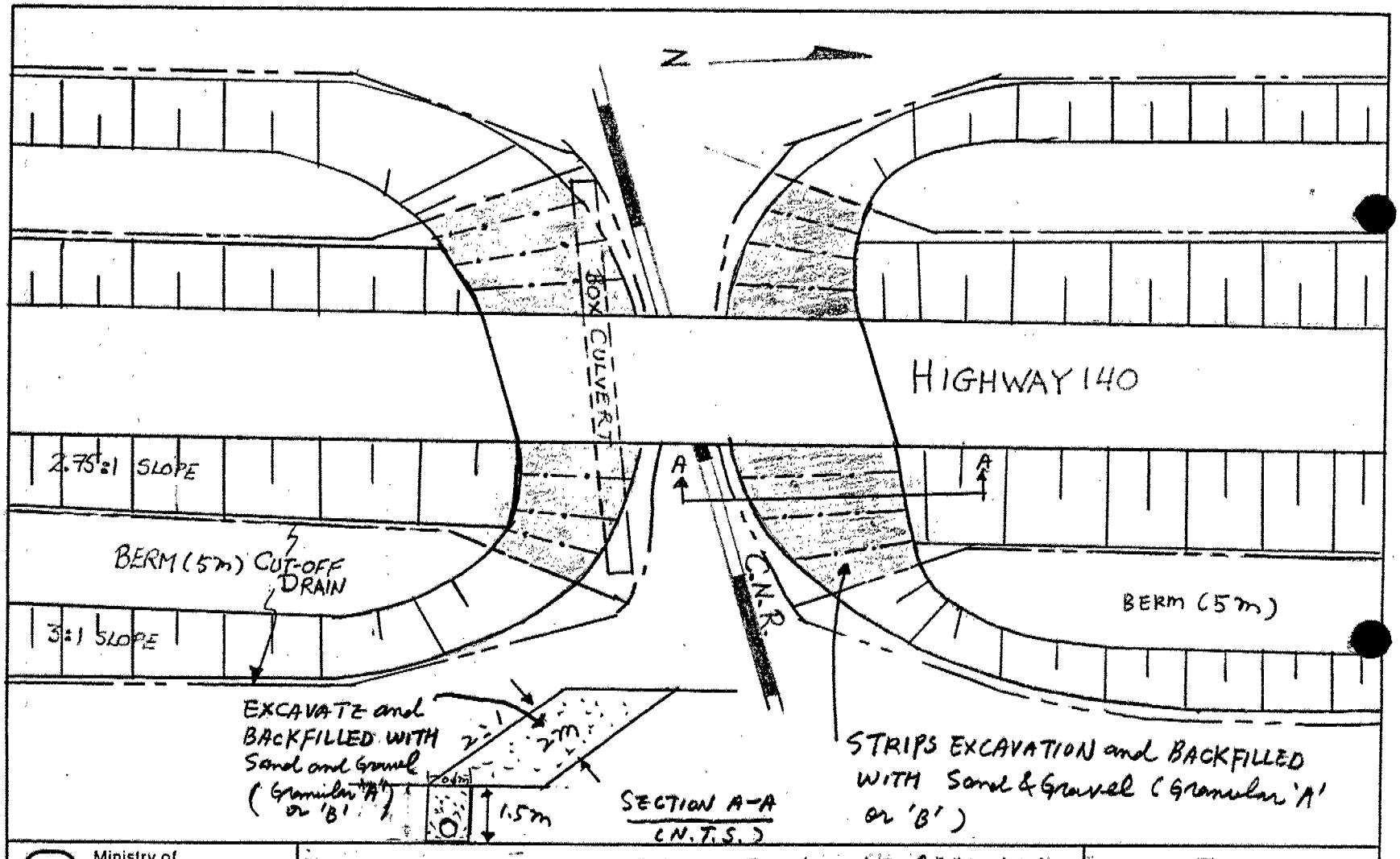


Ministry of Transportation
Ontario

SLOPE STABILIZATION WITH COUNTERFORT DRAINS

FIG No 6

WP 74-87-00



Ministry of Transportation
Ontario

FORWARD SLOPE EXCAVATION AND GRANULAR THICK BLANKET SCHEME

FIG No 7

WP 174-87-00

Memorandum

Ontario

To: E.C. Lane
Head, Structural Section
Kingston

Date: 1989 03 13

Atten: A. Van Dalen

From: Foundation Design Section
Room 315, Central Building

RE: Stability of Detours at Richmond Rd./Baseline Rd./CNR
W.P. 126/127-87-00
Hwy. 416, District 9, Ottawa

We received a memo from Mr. B. Ruck of Planning and Design on February 2, 1989, with regard to the stability of cut for the temporary detours at the above three structures. Further, as requested in your letter dated February 8, 1989, this Section has reviewed the slope stability of the temporary cuts at the aforementioned structures and provides the following comments.

Stability Conditions

Stability analyses were carried out to evaluate the effect of the excavation cut to the temporary detours at the above three structure locations.

An effective stress analysis was applied for calculations of slope stabilities of the excavation cut. Since the proposed cut is only temporary during the construction of bridge structures, a minimum factor of safety of 1.2 was incorporated for the analyses. It should be noted that since the depth to bedrock is somewhat variable at the site, analyses were carried out for different depths of cut in sensitive silty clay with different side slopes as shown on Figure 1. Based on the analyses, the following conclusions have been derived:

> Excavations down to 4.0 metres in depth will be stable provided they are maintained with 1½H:1V slopes, while deeper cuts between 5.5 and 7.0 metres will require 2H:1V slopes and 2½H:1V slopes, respectively, as shown in Figure 2. For excavations exceeding the above-mentioned depths, nominal mid-height stabilizing benches will be required.

Richmond Road Underpass

The excavations at this location will penetrate approximately 3.0 metres into the sensitive silty clay then to bedrock, provided the bedrock is at about elevation 72.0 metres. In this case, the cut will be stable with 1½H:1V slopes. However, if the bedrock elevation is found to be deeper, say for example, at about elevation 69.0 metres, flatter side slopes with 2H:1V or 2½H:1V would be required depending on the depth of the sensitive clay.

.....2

Baseline Road Underpass

The cuts at this location will penetrate only 3.0 metres into the sensitive clay. In our opinion, the excavation will be stable with 1½H:1V slopes.

C.N.R. Track Diversion

The excavations for the C.N.R. track diversion will penetrate approximately 12.0 metres into the sensitive silty clay, slope stability problems can be anticipated at this location. Based on the stability analyses, it should be noted that a 5 metre wide bench to the midheight of the slope and 2.5H:1V side slopes are required in all directions to ensure the stability of the proposed cut. In addition, a 2 m high embankment for the C.N.R. track diversion will be constructed. In order to ensure the overall stability, the embankment should be located at least 10.0 metres away from the top of the cut with 1½H:1V slopes as shown on Figure 3.

Dewatering

Since the water level is close to the ground surface, and also due to the presence of random layers of non-cohesive material, some dewatering measures will be required during the bridge construction.

One method of achieving this is by carrying out the excavation and pumping from the sumps.

We believe that this letter meets with your present requirements. If you have any questions, please contact us.

Taechul Kim

T.C. Kim, P. Eng.
Foundation Design Engineer

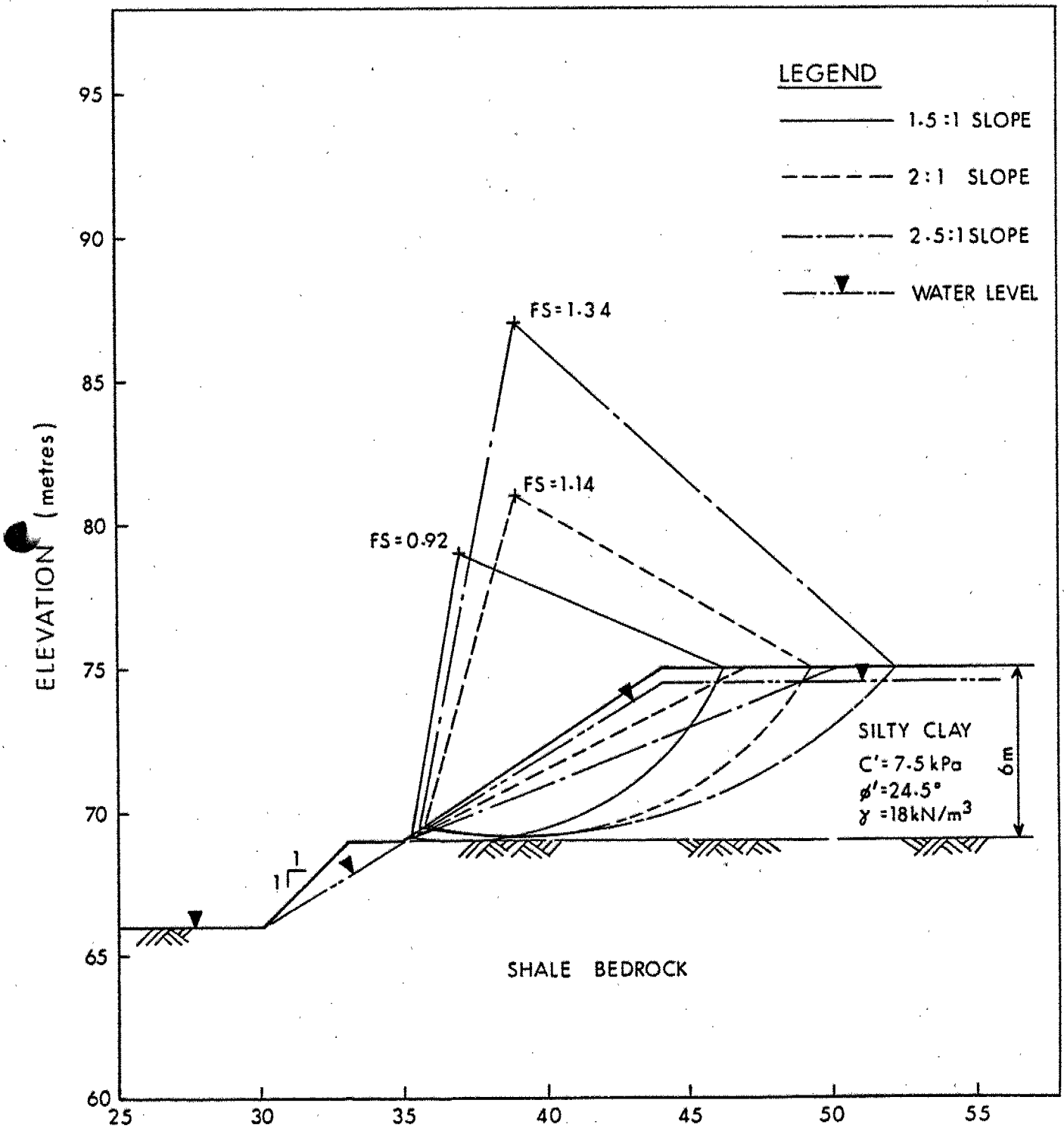
for

M. Devata, P. Eng.
Chief Foundation Engineer

TCK/mmj

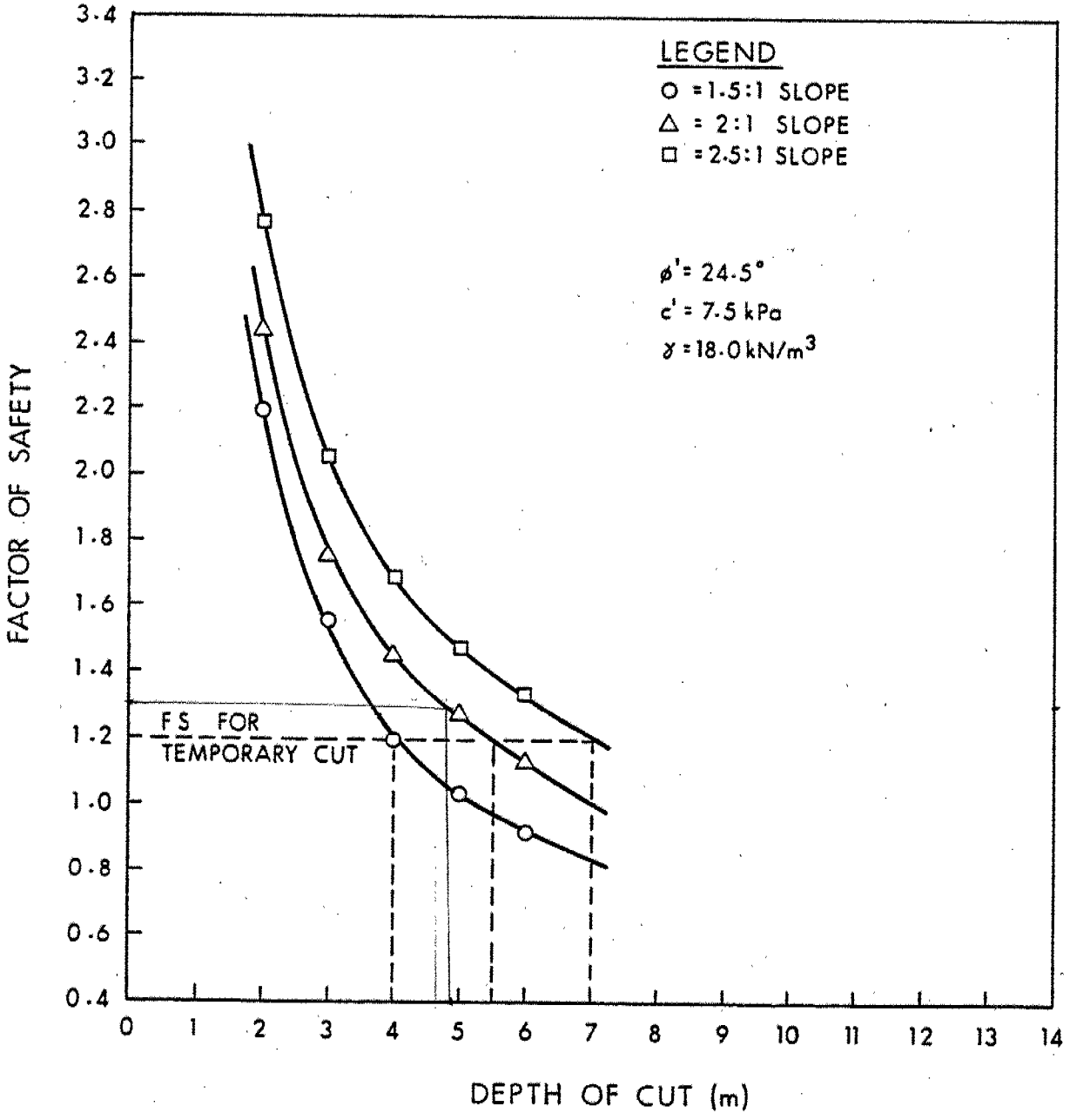
c.c. - K. Bassi
B.E. Ruck
B.J. Maloney
T.W. Murphy

STABILITY ANALYSES WITH DIFFERENT SLOPE ANGLES (MINIMUM FACTOR OF SAFETY)



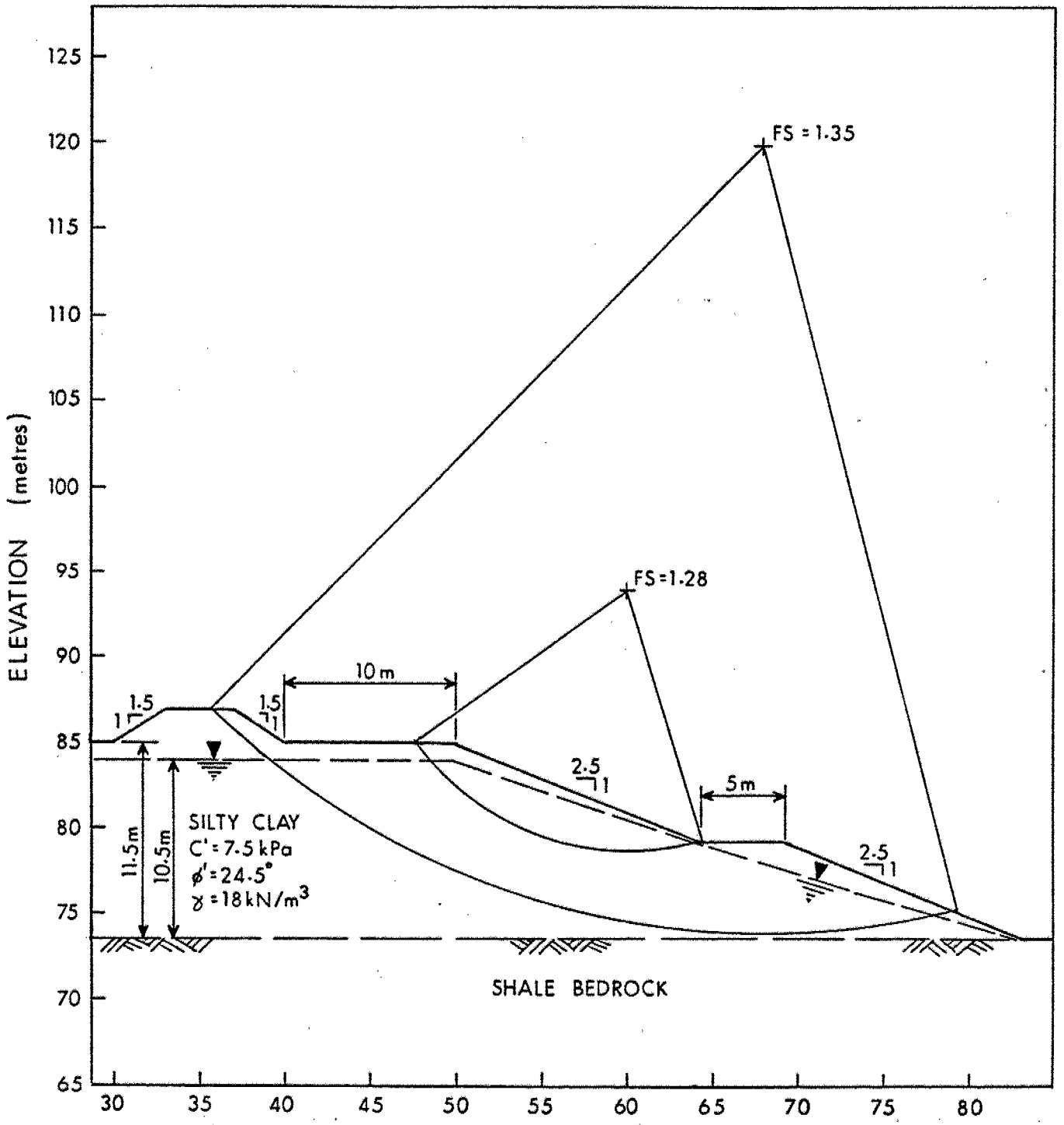
WP 127-87-00
Fig No 1

MINIMUM FACTOR OF SAFETY VS DEPTH OF CUT



WP 127-87-00
FIG No 2

STABILITY ANALYSES OF DEEP CUT FOR CN RAILWAY TRACK WITH 2·5:1 SLOPE (LOWER BENCH WIDTH 5m) (UPPER BENCH WIDTH 10m)



WP 126-87-00
FIG No 3

M E M O R A N D U M

Fax.

Geotechnical Section, Central Region **Telephone: 235-5432**

To: Mr. M.S. Devata
Chief Foundation Eng.
Foundation Design Section
3rd Floor, Central Bldg.
Downsview

Date: 90-01-03

Re: Embankment Failure Highway. 140
W.P. 174-87-00, CNR & PCR O'Head Structure
Site No. 34-232

It has been brought to our attention that the south earth fill for the above structure has settled. This settlement has reached a point where the abutment piles are visible in the void between the concrete abutment and the earth fill. This fill embankment was identified as a problem area when constructed under Contract 70-212.

Would you please have someone investigate and forward recommendations for treatment. This structure is to be rehabilitated in 1990 and is presently in the design stage.

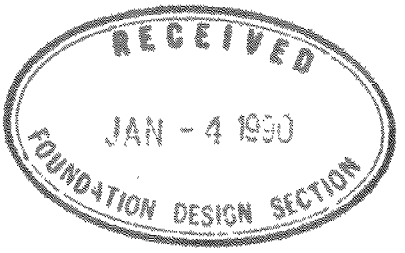
If you have any questions, please contact this section.

Jim
J. Vanbiesbrouck

JV/GC/rb

J. Vanbiesbrouck
P.D.E.O.
for:
G. Cautillo
Head, Geotechnical Section

c.c. B. Barsalou



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