APPENDIX ‘A’

GEOTECHNICAL REPORT

WSP Project No.: 20M-01243-00
June 21, 2023

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Subject: Additional Assessment – Keewatin Slope Stability Review, Winnipeg, MB

INTRODUCTION

As requested, WSP Canada Inc. (WSP) prepared this technical memo to provide an additional assessment in order to support the upcoming construction of the existing sidewalk widening along with the embankment at the west of the Keewatin Underpass. The scope of work for this additional assessment included the following,

- Review provided information, including soil logs, survey data and construction drawings
- Complete a technical memo summarizing the slope stability results and considerations

The purpose of this additional assessment was to review the existing embankment slope stability at the west side of the Keewatin Underpass and determine if the proposed sidewalk widening would have a negative impact on the existing embankment slope stability.

REVIEW OF EXISTING INFORMATION AND FINDINGS

The following information was reviewed in preparation for this report,

1 **Construction Drawings – Keewatin Street Underpass Construction of C.P.R. Grade Separation Structure and Related Underpass Roadworks, P.D. NO. 88-65, Winnipeg, MB, dated April 1987, prepared by Dillon Consulting Limited**

Based on the provided drawings, it was understood that the subsurface condition at the site generally consisted of fill material followed by native lacustrine clay underlain by glacial till to the auger refusal at a depth of +/- 16.0 m below grade. The fill material mostly consisted of silty clay with some gravel or concrete rubbles and have a total thickness of 0.5 m to 1.5 m. The native clay was mottled brown, highly plastic, stiff to firm and became grey at elevations between 227 m and 228 m. The glacial till was encountered at elevations between 221 m and 222 m and had an average thickness of 3.0 m prior to the auger refusal. Groundwater levels encountered at the site ranged between 4.5 m and 5.0 m below grade surface (i.e., Elevations 228.5 m and 228.0 m).

2 **Existing Site Survey**

Following the review of the existing site survey data, one cross-section (i.e.XS-01 near STA 1+70) near the bridge location was selected for the slope stability assessment. In general, the elevation at the top of the bank is approximately 233.0 m, then it slopes at an average inclination of 4H:1V (Horizontal to Vertical) to the road

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at the elevation of +/- 226.5 m. The existing sidewalk was approximately 1.7 m wide and situated near the lower bank at the elevation of +/- 228.9 m.

3 **Preliminary Construction Drawings – Keewatin Street Pathway, New Pathway, Tender No. 376-2023, Winnipeg, MB, Prepared by WSP Canada Inc.**

Based on the preliminary drawings, it was understood that the proposed cast-in-place (CIP) concrete sidewalk was generally 3.0 m wide with a shear key (typically 300 mm in depth). In addition, a short concrete retaining wall having a total height of 400 mm to 850 mm was also required to retain the soil materials at the upper slope.

SLOPE STABILITY ASSESSMENT

To evaluate the slope stability, limit-equilibrium slope stability models were completed using a computer program SLOPE/W with Morgenstern-Price method, developed by Geoslope International Ltd. This analysis method compared forces resisting instability against those driving instability and expressed this as a ratio referred to as Factor of Safety (FS). As mentioned above, one cross-section near the bridge location, XS-01, at STA 1+70 was selected for the slope stability assessment.

Methodology

Slope stability assessment was completed using Morgensten-Price circular slip surfaces to estimate the Factor of Safety (FS) values of Potential Slip Surfaces (PSSs). The steady-state analysis was conducted using the subsurface and groundwater conditions outlined in the soil logs (i.e., Item 1 from existing information) to determine the existing embankment slope stability, especially at the sidewalk location. The strategy was to determine the existing embankment stability as a starting point, which will be then used to compare the FS value after the proposed works and therefore, to determine if the proposed sidewalks would have a negative impact on the existing slope stability.

The steps of this slope stability assessment are outlined below,

- Determine the critical FS value of the PSS near the sidewalk location (pre-construction) based on the existing site survey data
- Determine the critical FS value of the same PSS after the construction of the sidewalk
- Examine any changes in FS values pre- and post-construction of the proposed sidewalk

It should be noted that this additional assessment mainly focuses on if the proposed works would have an impact on the existing embankment stability. As such, the changes in FS values before and after the proposed construction are the key factor rather than the critical FS values obtained under the existing conditions (i.e., existing embankment slope stability). Since no site investigation or groundwater monitoring was conducted at the site during the design, the provided subsurface and groundwater conditions outlined in the construction drawings prepared by Dillon Consulting Limited were used to determine the existing embankment slope stability.

Soil Parameters

Since there are no embankment failures or tension cracks observed/reported during site survey, the post-peak clay strength parameters were used in the analysis. Table 1 outlines the soil parameters and groundwater level used in the model.

Table 1 Soil Strength Parameters and Groundwater Levels

Soil Layers	Depth (m)	Unit Weight (kN/m^3)	Effective Shear Strength Parameters		Groundwater Level (m)
			Cohesion (kPa)	Friction Angle (deg.)	
Native Clay	233 to 220	18	5	15	228.5
Glacial Till	Below 220	Impenetrable			

Slope Stability Results

Based on the above, the slope stability results near the bridge location are outlined in Table 2 below. The slope stability output is summarized in Appendix A.

Table 2 Pre- and Post- New Sidewalk Construction Results

PSSs		Factor of Safety (FS)	
		Pre-Construction	Post-Construction
XS-01 near STA 1+70	Critical, PSS1	1.44	1.44
	PSS2	1.90	1.97 (+3.6%)*

*Values in bracket represent the percentage increase between pre-and post-construction

From the FS values outlined in Table 2, it is clear to conclude that the proposed sidewalk widening will not have a negative impact on the critical FS at PSS1. Instead, it has slightly improved the FS values at the upper bank (i.e. PSS2) since the clayey soils near the sidewalk were replaced with stronger concrete material.

It should be noted that the FS values obtained under the existing condition were not truly representative of the existing embankment slope stability since no geotechnical site investigation and/or groundwater monitoring program was conducted by WSP during the design. The changes in FS values between Pre-and Post-construction are the purpose of this assessment, which indicated that the proposed works will not have a negative impact on the existing embankment slope stability.

Stability of Proposed Sidewalk

Based on the typical section view of the sidewalk, the FS against overturning, sliding and bearing capacity are well above 2.0. As such, the stability of the proposed sidewalk is not a concern.

CONSIDERATIONS

Some key factors should be considered during construction as described below,

- All the excavated material or additional surcharge from heavy equipment cannot be stored at the top of the embankment.
- It is assumed that the contractor will be responsible for slope protection and/or temporary shoring (if required) during construction.

CONCLUSION

Based on the above, WSP concludes that the proposed sidewalk widening near the lower bank will not have a negative impact on the existing embankment slope stability. The proposed new sidewalk construction will slightly improve the upper bank stability as soft clay material near the sidewalk is replaced with stronger concrete material. As Such, WSP is in support of the proposed sidewalk construction at the subject site.

CLOSURE

WSP trusts that the information contained in this technical memo meets your present requirements. Should you require any review services or further information regarding the technical aspects of this project, please contact the undersigned.

Respectfully submitted,

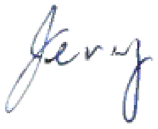
WSP Canada Inc.

Written By:

Wei Gao, P.Eng.

Geotechnical Engineer, Earth & Environment

Reviewed By:



Jerry Leung, P.Eng.

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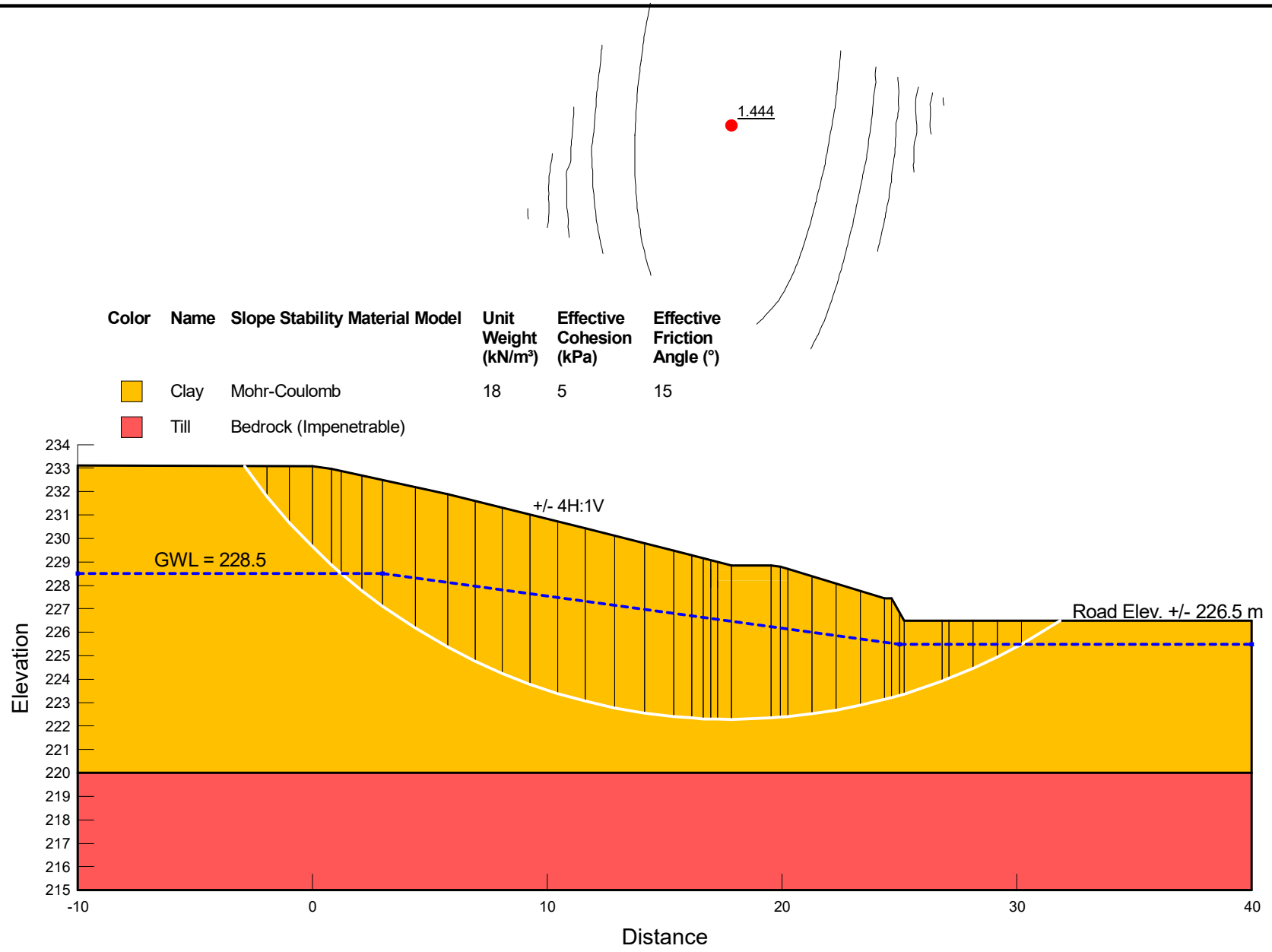
Attachments: Appendix A – Slope Stability Output

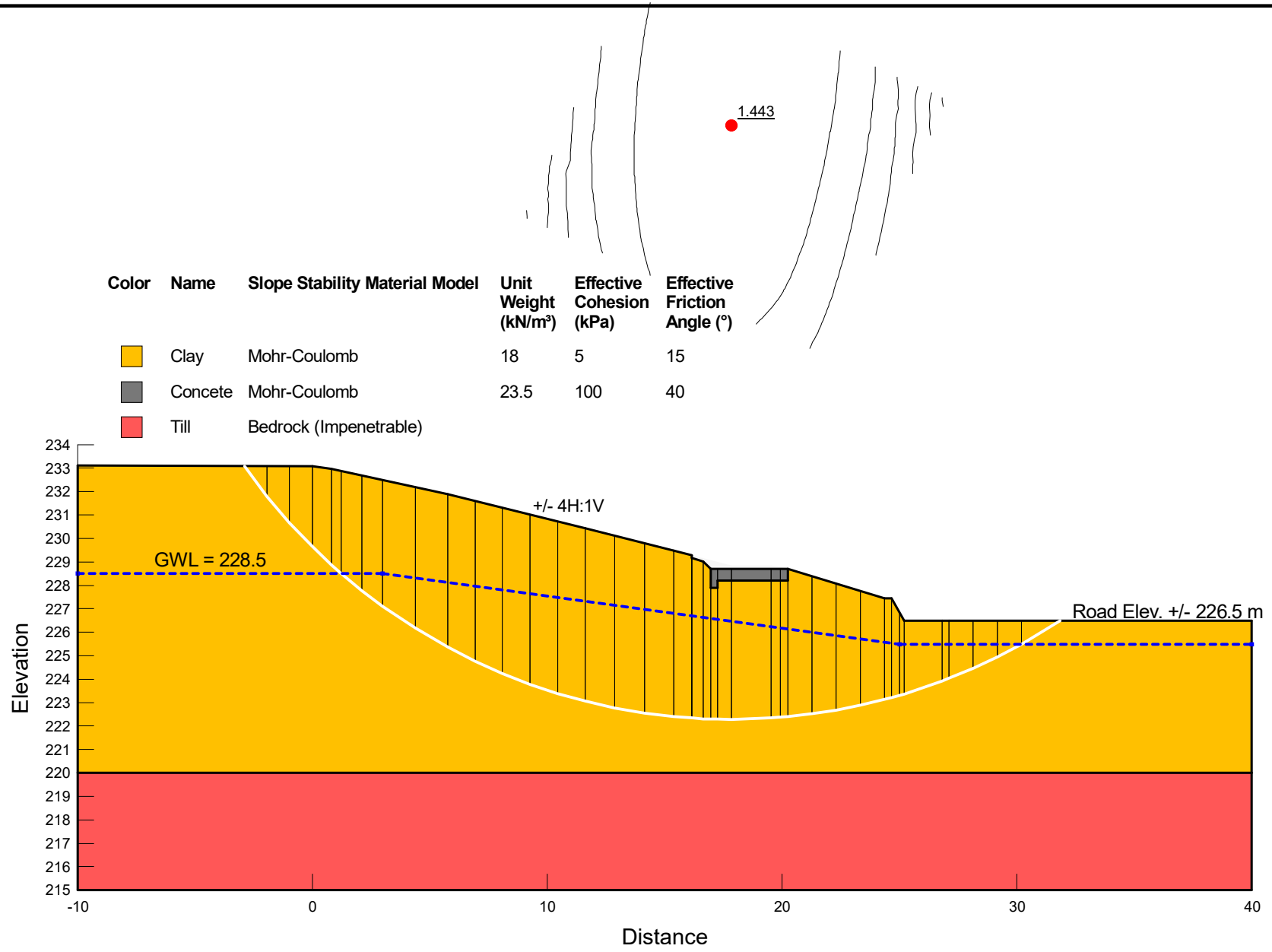
ENGINEERS GEOSCIENTISTS MANITOBA
Certificate of Authorization
WSP Canada Inc.
No. 5750 Date: June 21, 2023

APPENDIX

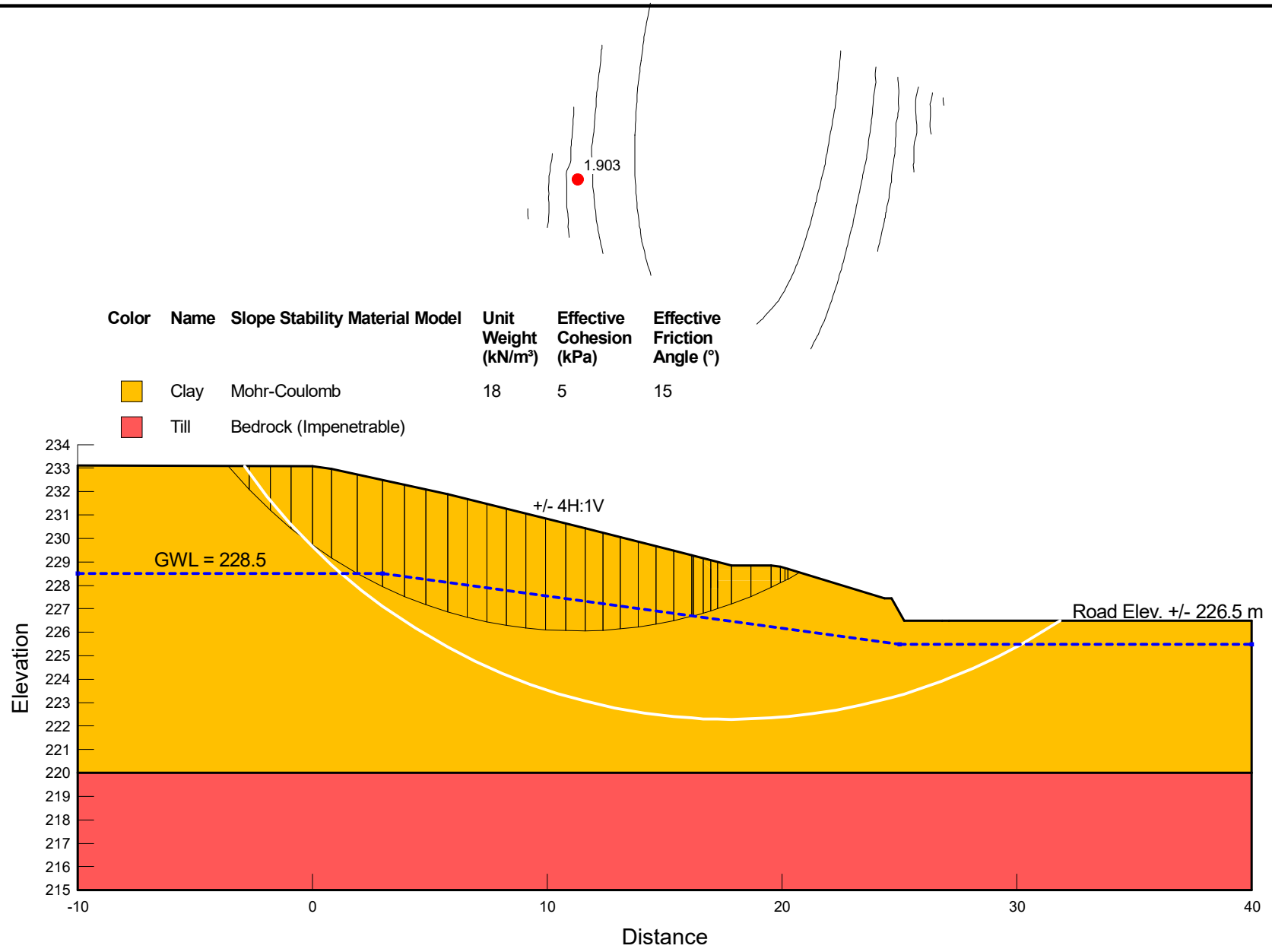
A SLOPE STABILITY OUTPUT



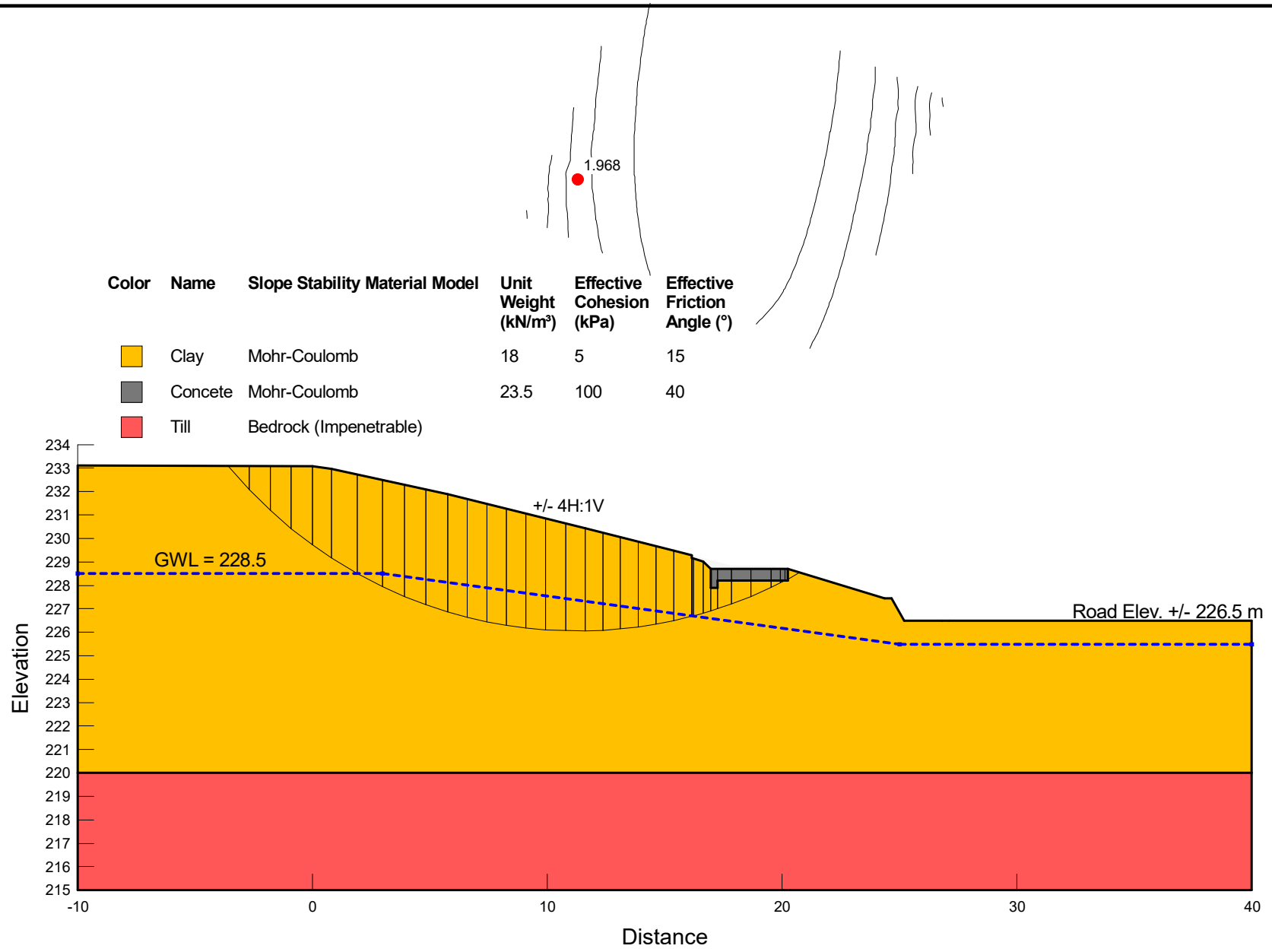
Pre-construction	
XS near 1+70	
Critical Slip Surface PSS1	FS= 1.44



Post-construction	
XS near 1+70	
Critical Slip Surface PSS1	FS= 1.44



Pre-construction	
XS near 1+70	
PSS2	FS= 1.90



Post-construction	
XS near 1+70	
PSS2	FS= 1.97