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Coral Bay Nickel Corporation

Form 01 QC-2007 Rev.05

Reference No.: EMO-MNL-2022-E-010

DATE : October 26, 2022

FOR : **ENGR. WILLIAM P. CUÑADO**
Director
ENVIRONMENTAL MANAGEMENT BUREAU
DENR Compound, Visayas Ave.,
Diliman, Quezon City

Attention: **ENGR. ESPERANZA A. SAJUL**
Chief, Environmental Impact Assessment and Management Division

FROM : **JEB B. BADLON**
Pollution Control Officer

SUBJECT : **Report on the Geotechnical Engineering Design Review of Coral Bay Nickel Corporation Tailings Storage Facility No. 2**

Dear Director Cuñado:

We are submitting herewith to your office the "Geotechnical Engineering Design Review for the Tailings Storage Facility No. 2 of Coral Bay Nickel Corporation" which is a part of the recommended third party environmental audit that was stated in CBNC's ECC CO-1806-0014 (Environmental Planning Recommendations for the Proponent No. 13).

The CoVid-19 pandemic prevented the conduct of the Geotechnical Review and assessment together with the Environmental Audit which was submitted by CBNC to DENR-EMB last March 5, 2021. This Geotechnical Review was conducted from April 13 to September 22, 2022 by AMH Philippines Inc.

Very truly yours,

JEB B. BADLON
Pollution Control Officer

Noted by:

BENJAMIN A. TANSINGCO
VP Environmental Management

Copies Furnished:
1. **ATTY. WILFREDO G. MONCANO**
   MGB Central Office
2. **ENGR. GLENN MARCELO C. NOBLE**
   MGB Region IV-B-MIMAROPA

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TRISTAN G. BUENAFE
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To	**:**	Mr. Masahiro Kamiya	**Date**	**:**	15 September 2022
Project	**:**	CBNC TSF-2	**Ref. No.**	**:**	NP22.045.010

Quantity	Unit	Description
1	e-file	CBNC TSF-2 Geotechnical Engineering Design Review Final Report

Received By:		**Prepared By:**	GPDR/RTG/MPB/PAYS
Date and Time:		**Remarks:**	

Coral Bay Nickel Corporation

CORAL BAY NICKEL CORPORATION
TAILINGS STORAGE FACILITY TSF-2
Brgy. Rio Tuba, Bataraza, Palawan

Geotechnical Engineering Design Review
Final Report

amh PHILIPPINES, inc. ENGINEERS • CONSULTANTS

SEPTEMBER 2022

Ref. No. : NP22.045.010

15 September 2022

MR. MASAHIRO KAMIYA
President
CORAL BAY NICKEL CORPORATION
RTSEZ, Brgy. Rio Tuba, Bataraza, Palawan

Through : **MR. BEN TANSINGCO**
Vice President – Environmental Management
Sumitomo Metal Mining Philippine Holdings Corporation

Subject : **GEOTECHNICAL ENGINEERING DESIGN REVIEW (FINAL REPORT)**
CBNC Tailings Storage Facility TSF-2

Dear Mr. Kamiya,

We are pleased to submit herewith this Final Report for the Geotechnical Engineering Design Review of the Coral Bay Nickel Corporation Tailings Storage Facility TSF-2 in Brgy. Rio Ruba, Bataraza, Palawan. This document presents the results of the geotechnical engineering assessment, as well as the recommendations for the stability of the TSF-2 embankments, in particular the North and South Dams.

Should you have any questions, feel free to contact our office. We will be glad to discuss these with you.

Thank you very much.

Very truly yours,

ROY ANTHONY C. LUNA, MSCE
Principal Engineer/Project Team Leader

EXECUTIVE SUMMARY

Coral Bay Nickel Corporation (CBNC/Client) engaged AMH Philippines, Inc. (AMH/Geotechnical Consultant) to conduct a geotechnical engineering design review of the CBNC Tailings Storage Facility (TSF-2) as part of the 3rd-Party Environmental Audit requirements of EMB and DENR. The objective of the study is to evaluate potential risks and geohazards as well as assess the stability of the TSF.

Slope stability analysis was conducted for the Southern Dam and Northern Dam Embankments.

Based on the Geologic Map produced by Mines and Geosciences Bureau, the project site's regional geology consists of Recent Deposits, Oligocene-Miocene, Cretaceous-Paleogene, and Paleocene-Eocene: Recent Deposits consisting of alluvium, fluviatile, lacustrine, paludal, beach deposits, raised coral reefs and beach rocks; Oligocene-Miocene consisting of thick, extensive, transgressive mixed shelf marine deposits, largely wackes, shales, and reef limestone; Cretaceous-Paleogene consisting of undifferentiated ultramafic and mafic plutonic rocks, predominantly peridotite associated with late gabbro and/or diabase dikes; Paleocene-Eocene formation consisting of limited dacite and andesite flows and dikes.

AMH undertook the review and assessment of the results of the geotechnical investigations and laboratory tests and performed parallel slope stability analysis by Limit-Equilibrium Method in order to establish the stability of the embankments under static and pseudo-static (earthquake) conditions.

Seismic design inputs for slope stability analysis have also been reviewed and more details are discussed in the AMH Seismic Hazard Study Review (*ref: NP22.045.002 CBNC TSF 2 SHA Review R0 2022.05.26).* The current design accelerations used for the design of TSF-2 may be too conservative, which uses OBE and MCE accelerations directly from the guidelines of DENR Memorandum Order No. 99-32. New design accelerations were adopted in this study based on more recent literature on the Philippines' seismic hazard, i.e., PHIVOLCS Philippine Earthquake Model, Global Earthquake Model, etc.

From the results of the slope stability analyses, the TSF-2 Southern and Northern Embankment are found to be safe, having adequate factors of safety (FoS) for both static and earthquake conditions after operation (long term). Furthermore, the stability of the Northern Dam considering the addition of the random (unsuitable) material waste dump in front was assessed. Results show that the Northern Dam has adequate factors of safety and is stable.

Design review comments, findings and recommendations are summarized at the conclusion of the report.

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Brgy. Rio Tuba, Bataraza, Palawan

I. INTRODUCTION

Coral Bay Nickel Corporation (CBNC/Client) engaged AMH Philippines, Inc. (AMH/Geotechnical Consultant) to conduct a geotechnical engineering design review of the CBNC Tailings Storage Facility (TSF-2) as part of the 3rd-Party Environmental Audit requirements of EMB and DENR. The objective of the study is to evaluate potential risks and geohazards as well as assess the stability of the TSF, both the north and south sections, as it is built/constructed.

Figure 1. Project location (Source: Google Earth®)

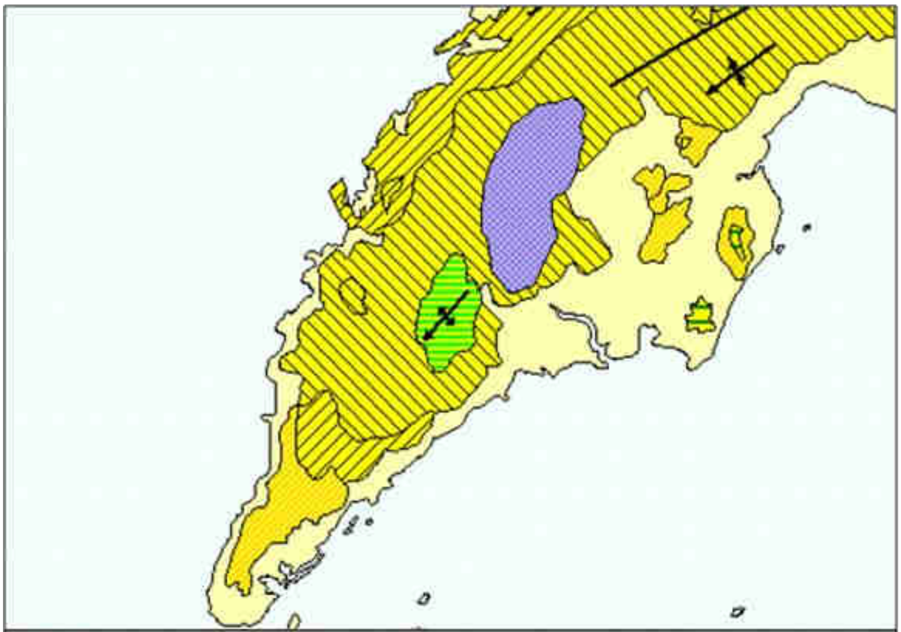
It is understood by the Consultant that the final design of TSF-2 North and South Dam Embankments were prepared by Sumitomo Mitsui Construction Co., Ltd. (SMCC/Designer), and is referenced from the preliminary engineering design and drawings carried out by Hatch Associates Pty Limited (HATCH). The following Client-issued documents were used as the main references for this design review study:

- *Rio Tuba FR Vol_I Main Report 090618*
- *Rio Tuba FR Vol_II-1 Drawings_090618*
- *Rio Tuba FR Vol_II-2 Drawings_090618*
- *Rio Tuba FR Vol_III Spec 090623*
- *Rio Tuba FR Vol_IV Design Calculation 090618*
- *Rio Tuba FR Vol_V Quantity Calculation 090624*
- *Additional Design Report (October 2011)*

II. REGIONAL GEOLOGY

1. Stratigraphy

The Regional Geology of the Project area consists of Recent Deposits, Oligocene-Miocene, Cretaceous-Paleogene, and Paleocene-Eocene: Recent Deposits consisting of alluvium, fluviatile, lacustrine, paludal, beach deposits, raised coral reefs and beach rocks; Oligocene-Miocene consisting of thick, extensive, transgressive mixed shelf marine deposits, largely wackes, shales, and reef limestone; Cretaceous-Paleogene consisting of undifferentiated ultramafic and mafic plutonic rocks, predominantly peridotite associated with late gabbro and/or diabase dikes; Paleocene-Eocene formation consisting of limited dacite and andesite flows and dikes, generally intercalated with and/or intrude Eocene clastic and, included with Eocene sedimentary rocks (Figure 2). The project site is underlain by Oligocene-Miocene which consist of thick, extensive, transgressive mixed shelf marine deposits, largely wackes, shales, and reef limestone.



	R	RECENT	Alluvium, fluviatile, lacustrine, paludal, and beach deposits; raised coral reefs, atolls, and beachrock.
	N1	OLIGOCENE-MIOCENE (e,?-f$_2$)	Thick, extensive, transgressive mixed shelf marine deposits, largely wackes, shales, and reef limestone. Underlain by conglomerate and/or associated with paralic coal measures in places. Sometimes associated with basic to intermediate flows and pyroclastics within Luzon, Visayas, and Mindanao. Largely arkosic and quartzitic clastics (miogeosynclinal type?) in southern Mindoro and Palawan. Generally well indurated. Folded and locally intruded by quartz diorite. The epidermal cover of many folded mountains. In some places probably includes Oligocene (c-d).
	UC	CRETACEOUS-PALEOGENE	Undifferentiated ultramafic and mafic plutonic rocks. Predominantly peridotite associated with late gabbro and/or diabase dikes. Complex layered type in Zambales. Generally thrusted or upfaulted into Tertiary and older rock formations. Most bodies probably late Mesozoic to early Tertiary.
	PG1	PALEOCENE (?)-EOCENE	Limited dacite and andesite flows and dikes, generally intercalated with and/or intrude Eocene clastics. Included with Eocene sedimentary rocks in this map.

Figure 2. Extracted from 1:500,000 scale of Geologic Map of the Philippine (Source: MGB)

2. Geomorphology

The project site is located across the Bulanjao Range. The 1:50,000 scale NAMRIA Topographic Map of Canipan Quadrangle (Figure 3) shows that the property is in the 106 -meter contour. The nearest spot height is 5.5 meters northwest of the property with 983 meters elevation.

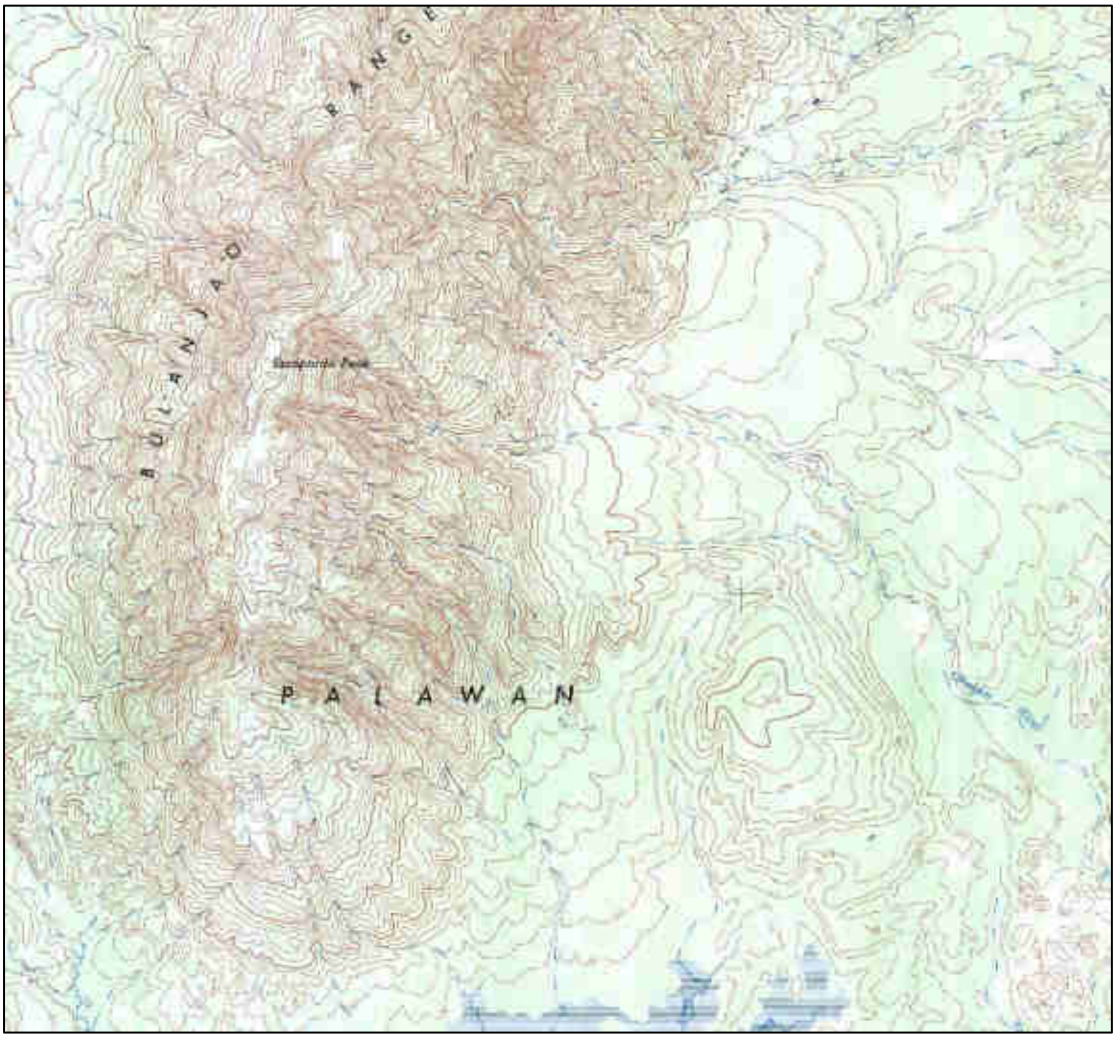


Figure 3. Extracted from 1:50,000 scale Topographic Map of Canipan City (Sheet 2445-I) (Source: NAMRIA)

III. GEOTECHNICAL ENGINEERING ASSESSMENT

The stability of the TSF-2 North and South Dam Embankments are established using Slope Stability Analysis (SSA) by Limit-Equilibrium Method (LEM).

Presented in the following sections are the methodology and results of the slope stability analysis, as well as findings and recommendations for each of the TSF-2 dams.

1. Design Criteria

1.1 Factor of Safety (FoS)

In reference to the *Rio Tuba FR Vol_I Main Report 090618 – Chapter 5,* the required minimum factors of safety are based on established threshold values of the following agencies:

- *Department of the Army, U.S. Army Corps of Engineer – Engineer Manual EM 1110-2-1902 Slope Stability, October 2003.*
- *Australian National Committee on Large Dams (ANCOLD) – Guidelines on Tailings Dam Design, Construction and Operation, October 1999.*
- *Japan National Committee on Large Dams (JCOLD) – Design Criteria for Dams, August 1978.*

These references provide the minimum recommended factors of safety for slope stability of embankments considering various loading conditions and different stages of construction/operation. As these are well-known and accepted references in the field of embankment stability analysis, similar FoS values were adopted in this 3rd-party review.

<u>Static Condition</u>

- Factor of Safety for maximum storage pool (steady seepage); Long term: 1.5
- Factor of Safety for high pore water pressure (extreme rainfall); Short term: 1.3

<u>Earthquake (Pseudo-static) Condition</u>

- Factor of Safety for Operating Basis Earthquake (OBE); Long term: 1.2
- Factor of Safety for Safety Evaluation Earthquake (SEE); Long term: 1.0

It is noted that the above-mentioned factors of safety also conform to the provision of the DENR DMO 1999-32, which states that dams made of earth and rock materials are to be designed and constructed with the following factors of safety:

- Factor of Safety for Static Conditions: 1.2
- Factor of Safety for Maximum Probable Earthquake: 0.98 – 1.2

1.2 Seismic Loading

Earthquake ground motions can induce considerable destabilizing inertial forces in slopes. Seismic analysis is therefore essential in evaluating the long-term stability of slopes and embankments. The pseudo-static method is the simplest and most common method in evaluating the stability of slopes during earthquakes. In this method, the earthquake's inertial forces are simulated by the inclusion of a static horizontal and vertical force in a limit equilibrium analysis. The seismic force induces a horizontal inertial force k_hW (where k_h is the horizontal seismic coefficient and W is the weight of the potential sliding mass), and k_vW (where k_v is the vertical seismic coefficient). In the limit equilibrium analysis, the horizontal inertial force is applied to act away from the face of the slope, and the vertical inertial force is applied to act upwards.

For the earthquake-resistant design of embankments, the objective is to come up with a design for the structure that can withstand a certain level of shaking without excessive damage or collapse. This level of shaking is described by a design ground motion. Specifying the design ground motion parameters is one of the most important problems in geotechnical earthquake engineering. In seismic slope stability analysis, this translates to the selection of an appropriate seismic coefficients k_h and k_v, and the value of an acceptable factor of safety (FOS). Table 1 presents a summary of typical seismic coefficients adopted as practice in the Philippines (Melo and Sharma 2004, Kavazanjian 1997).

Table 1. Typical seismic coefficients

k_h	Reference / Source	Remarks
0.10	US Corps of Engineers	Major Earthquakes, FOS > 1.0
0.15	US Corps of Engineers	Great Earthquake, FOS > 1.0
0.10 – 0.20 (for fill dams)	Japan	FOS > 1.2
0.05 – 0.15	State of California	
0.10	Terzaghi (1950)	"Violent and destructive" earthquakes
0.15	Seed (1979)	FOS > 1.15 and a 20% strength reduction
1/2 PHA_{rock}	**Hynes-Griffin and Franklin (1984)**	**FOS > 1.0 and a 20% strength reduction**
0.17 PHA_{soil} If response analysis is performed	Kavazanjian et al. (1997)	FOS > 1.0 and a 20% strength reduction
0.5 PHA_{soil} If response analysis is not performed	**Kavazanjian et al. (1997)**	**FOS > 1.0 and a 20% strength reduction**

PHA is the Peak Horizontal Acceleration, which is the maximum value of acceleration reached at any instant during the ground shaking. PHA is given in relation to the acceleration due to gravity (g) or in absolute values m/s^2 units. A very conservative assumption in selecting the seismic coefficient is to assume k_h = PHA, but this will result in an uneconomical design.

The criterion by Hynes-Griffin and Franklin (1984) is developed for earth dams and also reflect the results of deformation analyses, and is based on the peak horizontal bedrock acceleration and does not require site response analysis. On the other hand, the criterion developed by Kavazanjian et. al (1997) require site response analysis and is based on the peak horizontal soil acceleration. Melo and Sharma (2004) concluded from their parametric study of seismic coefficients for pseudo-static slope analysis that the method proposed by Hynes-Griffin and Franklin defines the upper bound choice of seismic coefficients for design.

From the above discussions, it is evident that using a seismic coefficient value, k_h, equal to half of the peak ground acceleration, PGA, would be the more conservative approach especially considering the limited seismic hazard study that was conducted for the project.

The current seismic coefficients used for the design of TSF-2 are found to be too conservative—directly adopting the recommended seismic coefficients for both OBE and MCE from DENR Memorandum Order No. 99-32. The seismic coefficients from the aforementioned document are oftentimes superseded by site-specific studies and/or updated references because the details in DENR Memorandum Order No. 99-32 are quite vague and the documentation is very lacking:

- Attenuation models for ground shaking estimation is probably not updated;
- OBE and MCE have no sense of return period/recurrence interval;
- Does not account for subsurface conditions/site class;
- Has no sense of location (does not consider how close or how far from the seismic source);
- Generalized for the whole Philippines (the Philippines is divided into 2 seismic zones); and
- Size, risk, and consequence of the dam/embankment are not accounted for.

Specifically for Palawan, where the seismic hazard is very low (Seismic Zone 2) and potential earthquake generators are nowhere near the island, accurate estimates of the seismic demand (i.e., PGA) is not necessarily needed. As long as reference values are available, it is believed that these can be adopted (as long as the appropriate subsurface conditions and return period/recurrence interval are matched). With the emergence and development of more recent publications such PHIVOLCS Philippine Earthquake Model (PEM), Global Earthquake Model (GEM), etc., more appropriate—albeit not really very accurate—design accelerations can be obtained for specific subsurface conditions. By adopting the recommended PGAs in the Seismic Hazard Study Review of AMH (*ref: NP22.045.002 CBNC TSF 2 SHA Review R0 2022.05.26)*, the following seismic coefficients are calculated for each hazard level:

Table 2. Seismic design parameters for slope stability analysis

Seismic Hazard Level	Peak Ground Acceleration (PGA)	Horizontal Seismic Coefficient (k_h)
Operating Basis Earthquake (OBE); 475-yr	0.10g	0.05g
Safety Evaluation Earthquake (SEE); 10,000-yr	0.35g	0.175g

2. Slope Stability Analysis by Limit Equilibrium Method

Slope stability is the potential or likelihood of a slope to fail due to a specific mechanism. It involves the interplay of two types of forces: a) driving forces which promote the downward movement of materials and b) resisting forces which defer the downward movement of materials. Typical causes of slope failures are erosion, rainfall, earthquakes, geologic features, and induced loads.

The analysis of slope stability is done by Limit-Equilibrium Method. The mass is divided into small slices along an assumed or known failure surface, as shown in Figure 4. Forces that are acting on each slice such as weight, normal and tangential reactions, and shear forces are determined; and by equilibrium conditions, the moment of the driving forces about the center of the failure surface should be equal to the moment of the resisting forces.

The Factor of Safety (FS) is expressed as the ratio of resisting forces to the driving or overturning forces:

$$FS = \frac{Resisting\ Forces}{Overturning\ Forces}$$

Where,

$FS < 1$ Indicates an unstable slope;
$FS = 1$ Indicates a critically stable slope;
$FS > 1$ Indicates a stable slope.

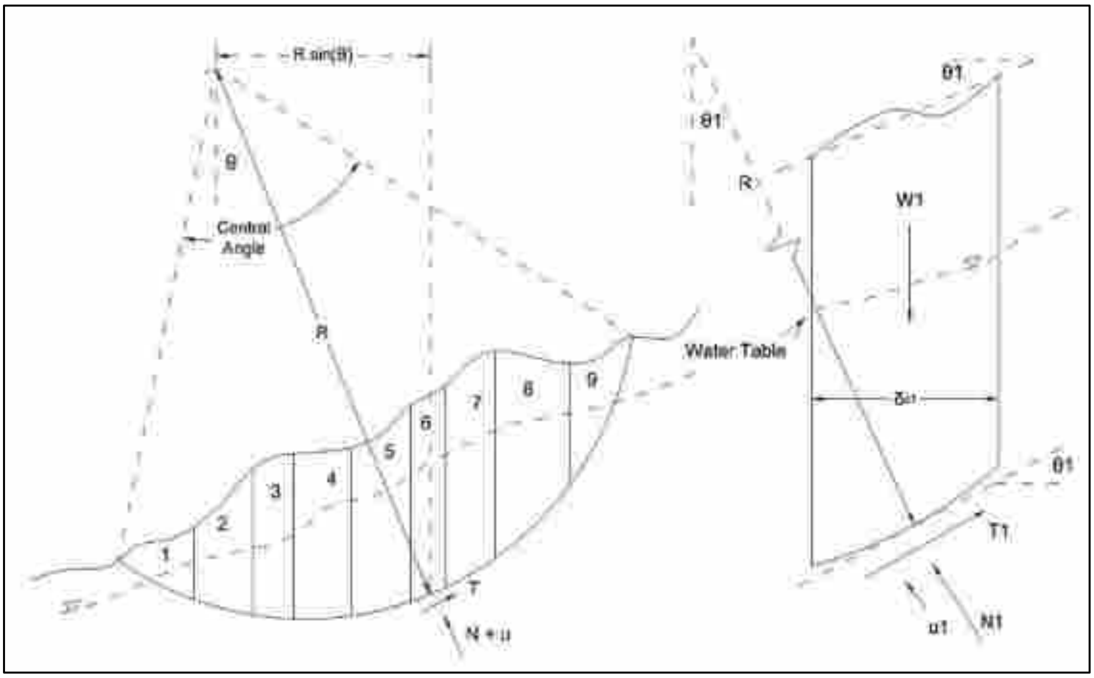


Figure 4. Stability Analysis by Limit-Equilibrium Methods

2.1 Methodology

Rocscience Slide 6.0®, a slope stability computer software, was utilized to facilitate calculations for determining the global stability of the dam embankments. This modeling software performs slope stability analysis procedure based on Limit Equilibrium Methods.

The stability analysis was analyzed in compliance with the references mentioned in Factor of Safety (FoS), which requires analysis in both static and pseudo-static (earthquake) conditions. Both the Bishop Method and Morgenstern-Price Methods were used in the analyses considering circular and non-circular failure planes.

2.2 Material Properties

Foundation

The material properties for the foundation materials that were used in the designer's stability assessment were based on the results of laboratory tests conducted by HATCH, as indicated in the *Rio Tuba Vol_I Main Report 090618 – Chapter 5*. Similar geotechnical parameters were adopted in this 3rd-party review.

Embankment

The material properties for the embankment materials were generally based on the field and laboratory tests conducted on each soil/rock layers, as presented in the *Additional Design Report – October 2011.* The engineering properties of the core zone and rock zone (final stage) layers, as well as the random materials, were based on the laboratory test results while material properties for filter zone and rock zone (first stage) layers were based on the required properties and characteristics of each embankment zone in consideration of stability, permeability, compaction and other requirements.

Tailings

Tailings materials were assigned to have zero shear strength properties, i.e., zero cohesion and friction angle, in the main design report of TSF-2. There were also no previous tests conducted in the tailings to determine its strength properties. However, during the site inspection, it was observed that even the relatively new tailings at the topmost ground surface would exhibit a very cohesive hard soil consistency. Similar observations were pointed by CNBC/SMCC engineers. As such, it would be appropriate to assign strength properties for the tailings material. However, due to the lack of available information and tests, these parameters were based on typical values of tailings material and established correlations for cohesive soils from the consultant's engineering experience. It is highly recommended to conduct tests to determine the actual shear strength of the tailings material.

Random Material Waste Dump

During the AMH site inspection around the perimeter of TSF-2, it was observed that the existing condition of Northern Embankment differs from its original design as a 24m high random material waste dump embankment was backfilled in front of the TSF. This is also described as dumping site for unsuitable materials. In order to model and analyze this scenario, parameters for the random materials were obtained from laboratory tests conducted at the said materials as presented in the *"Additional Design Report – October 2011."*

Reduced Shear Strength Properties during Earthquake (SEE)

In accordance with the aforementioned guidelines and well-established references in seismic design (Kavazanjian 1997, Makdisi and Seed 1978), there should be a 20% reduction in the strength properties of the embankment materials when using a minimum factor of safety of 1.0. During very strong ground shaking, as in the Safety Evaluation Earthquake level, significant pore water pressure builds-up within the soil matrix, thereby reducing the effective shear strength of the soil layers. Hence, all embankment materials below the phreatic surface/seepage line will have reduced parameters under SEE loading. It is noted that the 20% reduction is only applied to the saturated embankment and tailings materials (foundation not included). On the other hand, no strength reductions are necessary for OBE analysis since the minimum FoS considered is 1.2– greater than 1.0.

Table 3 and Table 4 present the summary of the material properties for both the TSF-2 Southern and Northern Dam Embankments.

Table 3. Material properties for TSF-2 Southern Dam

Area	Material Description	Dry Unit Weight, γ	Saturated Unit Weight, γ	Eff. Cohesion, c'	Eff. Friction Angle, ϕ'	Reduced Parameters during Earthquake	
						Eff. Cohesion, c	Eff. Friction Angle, ϕ'
[-]	[-]	[kN/m³]	[kN/m³]	[kPa]	[°]	[kPa]	[°]
Embankment	Core Zone	15.01	20.21	1.5	31	1.2	24.8
	Fine Filter Zone	12.54	20.60	0	35	0	28
	Coarse Filter Zone	12.41	20.60	0	35	0	28
	Rock Zone (First Stage)	15.70	18.64	5	36	4	28.8
	Rock Zone (Final Stage)	16.78	18.64	5	38	4	30.4
Foundation	Magas-Magas	17.66	17.66	5	35	-	-
	Lean Clay/Silt	14.72	14.72	5	25	-	-
	Clayey Sandy Silt	14.72	14.72	5	22	-	-
	Residual Claystone	15.70	15.70	10	25	-	-
	Coarse Drain Material	18.64	20.60	5	25	4	20
	Foundation Layer	29.43	29.43	50	45	-	-
Tailings	Slightly Consolidated	16.00	16.00	15	18	12	14.4
	Consolidated	18.00	18.00	50	25	40	20

Table 4. Material properties for TSF-2 Northern Dam

Area	Material Description	Dry Unit Weight, γ	Saturated Unit Weight, γ	Eff. Cohesion, c'	Eff. Friction Angle, ϕ'	Reduced Parameters during Earthquake	
						Eff Cohesion, c'	Eff. Friction Angle, ϕ'
[-]		[kN/m³]	[kN/m³]	[kPa]	[°]	[kPa]	[°]
Embankment	Core Zone	15.01	20.21	1.5	31	1.2	24.8
	Fine Filter Zone	12.54	20.60	0	35	0	28
	Coarse Filter Zone	12.41	20.60	0	35	0	28
	Rock Zone (Final Stage)	16.78	18.64	5	38	4	30.4
	Random Material	12.26	17.66	5	30	4	24
Foundation	Fine Drain Material	12.54	20.60	0	35	0	28
	Foundation Layer	14.72	14.72	5	35	-	-
Tailings	Slightly Consolidated	16.00	16.00	15	18	12	14.4
Waste Dump	Random Material	12.26	17.66	5	28	-	-

2.3 Slope Sections

The slope cross sections used for the modelling and analysis of both the Southern and Northern Dams were extracted from the two (2) client-issued as-built plans: *1) TSF2 60masl As-Built and 2) TSF2 80masl As-Built.* The TSF2 60masl plans reflect the first stage construction while the TSF2 80masl plans show the final stage of the construction. Furthermore, the subsurface idealizations of the residual soil layers as well as the foundation layers were interpolated from the slope stability analysis models of the designer, as presented in the *Rio Tuba FR Vol_IV Design Calculation 090618.*

Shown in the following figures are the extracted slope sections that were utilized in this study.

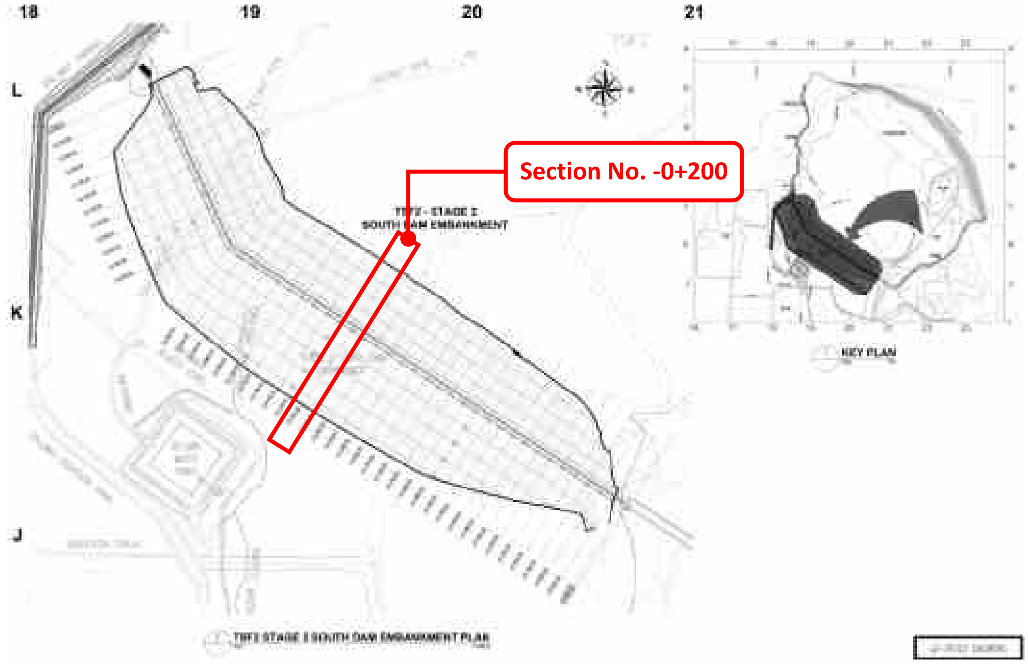
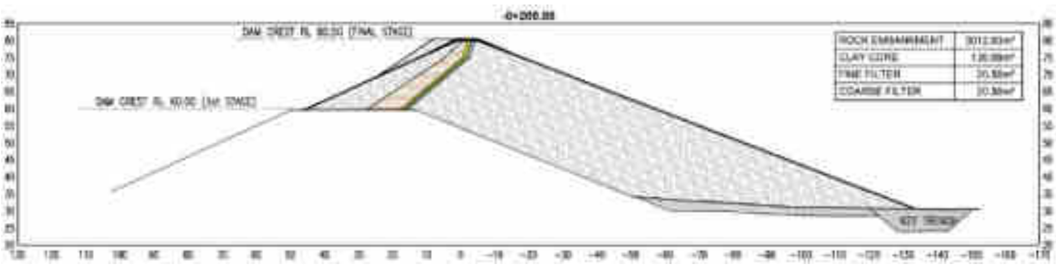
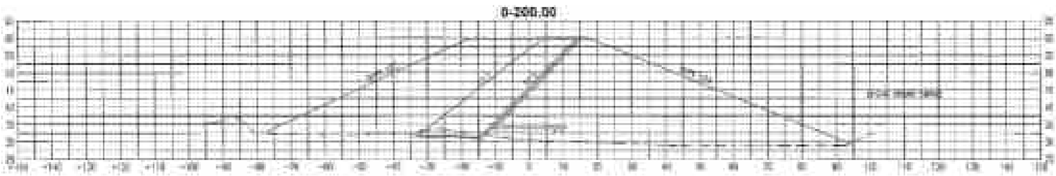


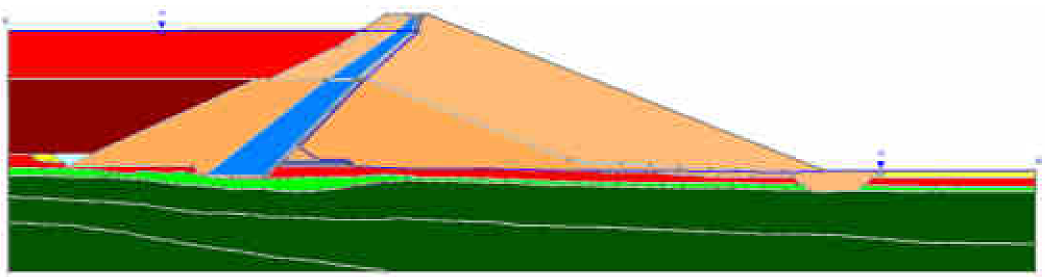
Figure 5. Southern Dam section line (Client-issued)



(a)



(b)



(c)

Figure 6. Southern Dam: (a) 80masl section, (b) 60masl section, (c) Combined slope section considered in the analysis

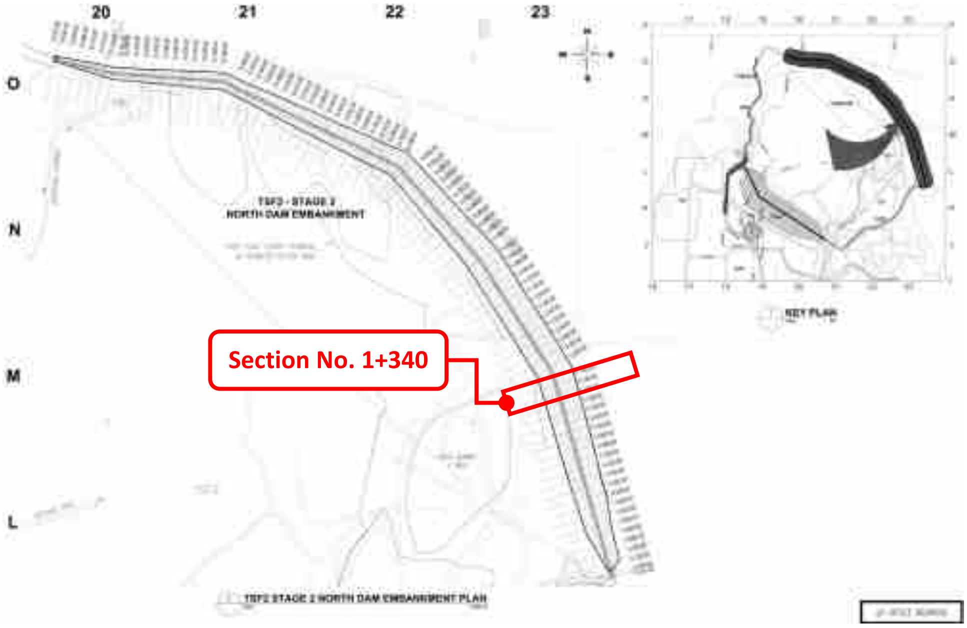
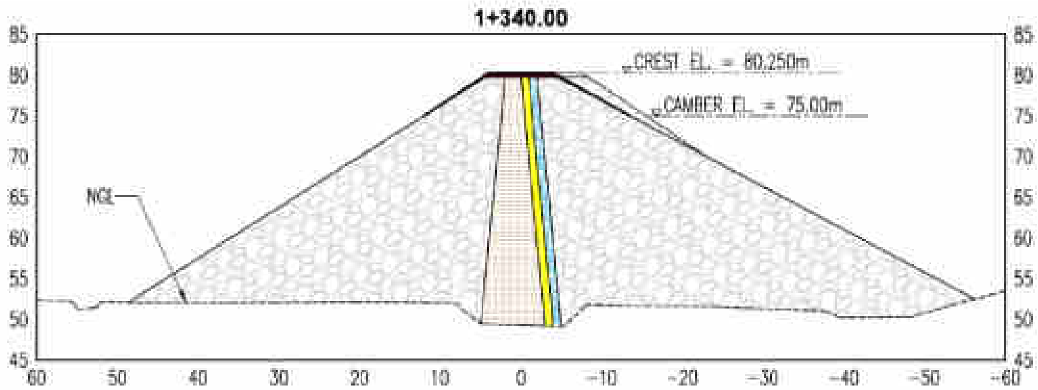
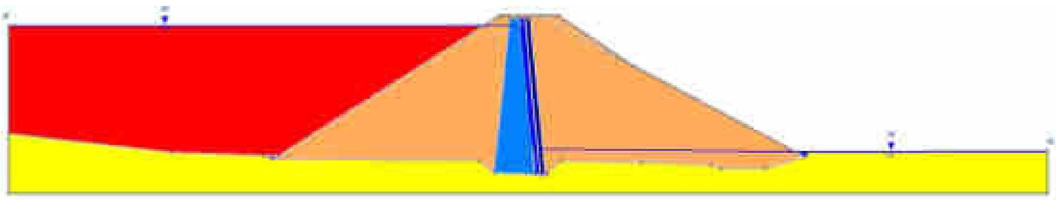


Figure 7. Northern Dam section line (Client-issued)

For the Northern Dam, it was observed during AMH's site inspection on July 20, 2022 that a huge volume of random (unsuitable) material waste dump was backfilled in front of the TSF. It is estimated to be about 24m high and 25m wide. For this study, stability of the TSF is checked with and without the said waste dump.



(a)



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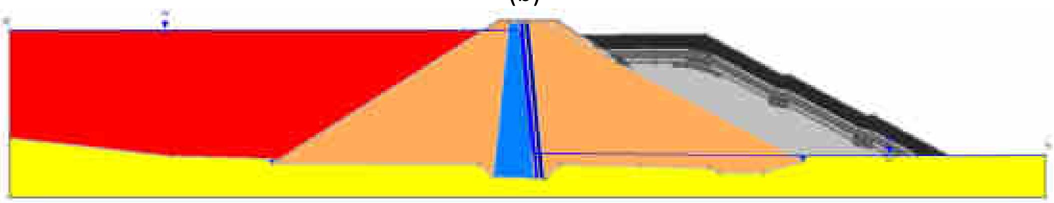


(c)

Figure 8. Northern Dam: (a) 80masl section, (b) Slope Section for After Operation, (c) Slope Section for Existing Condition (w/ Random material waste dump).

2.4 Load Cases

The following tables present the various load cases that are considered in the dam stability analysis, as well as the corresponding minimum factors of safety.

Table 5. Original design load cases

No.	Type of Analysis	Description	Min. FoS
1	Static	After operation – upstream; seepage line	1.5
2		After operation – downstream; seepage line	1.5
3	Pseudo-static	After operation – upstream with OBE; seepage line	1.2
4		After operation – downstream with SEE; seepage line	1.0

Table 6. Additional load cases for Southern Dam

No.	Type of Analysis	Description	Min. FoS
1	Static	After operation – upstream; extreme rainfall event (ru)	1.3
2		After operation – downstream; extreme rainfall event (ru)	1.3

Table 7. Additional load cases for Northern Dam

No.	Type of Analysis	Description	Min. FoS
1	Static	TSF w/ waste dump – upstream; seepage line	1.5
2		TSF w/ waste dump – downstream; seepage line	1.5
3	Pseudo-static	TSF w/ waste dump – upstream with OBE; seepage line	1.2
4		TSF w/ waste dump – downstream with OBE; seepage line	1.2
5		TSF w/ waste dump – upstream with SEE; seepage line	1.0
6		TSF w/ waste dump – downstream with SEE; seepage line	1.0

Table 6 and Table 7 present the additional load cases that are considered on top of the original load cases. These cases are included to account for 1) the effects extreme rainfall events and 2) the presence of the existing random material waste dump in front of the Northern Dam.

Effects of a Strong Rainfall Event

To account for the build-up of pore water pressure in the soil/rock layers during a strong rainfall event, pore water pressure ratio, r_u, is assigned to the upper layers of the embankments. The pore water pressure ratio, r_u, is defined as the fraction of pore water pressure to the total vertical pressure exerted by soil. This ratio represents the saturation level of the soil mass in case of a rainfall event. Strong rainfall is typically represented by an r_u value equal to 0.4, while low to moderate rainfalls have r_u equal to 0.2 (Mesri and Shahien 2003). For this study, a maximum r_u value of 0.4 is used for static conditions while maximum r_u of 0.2 is considered for pseudo-static conditions.

2.5 Results of Slope Stability Analysis of Embankment Dams

In order to obtain the global minimum FoS, the "Auto Refine Search" in the Rocscience Slide 6.0® software was used wherein a total of about 38,000 slip surfaces were considered in the analyses for both circular and non-circular planes. Results show that most of the minimum FoS correspond to non-circular failure planes from of Morgenstern-Price Method.

Table 8 presents the summary of the results of the stability analyses that are carried out for both the Southern Dam and Northern Dam Embankments considering the original design load cases. Results show that factors of safety (FoS) for both static conditions and earthquake conditions yield adequate values.

On the other hand, Table 9 presents the summary of the results considering the additional load cases for both the Southern Dam and Northern Dam. Results also show that the factors of safety (FoS) are adequate for all cases under static and earthquake conditions. For the Northern Dam sections, the extent/thickness of the foundation layer was extended downward to evaluate much deeper failure planes and results show similar FoS values.

Presented in the Annexes are the mathematical models and results of the slope stability analysis.

Table 8. Summary of embankment stability analysis results

Dam	Condition	Cases	Water Prop.	kh	Factor of Safety (FoS)		Failure Type	Acceptable?
					Req'd	AMH		
Southern Dam	Static Condition	After Operation – Upstream	Water table	-	1.5	1.99	Circular	Y
		After Operation – Downstream	Water table	-	1.5	1.77	Non-Circular	Y
	Earthquake Condition	After Operation – Upstream with OBE	Water table	0.050g	1.2	1.79	Non-Circular	Y
		After Operation – Downstream with OBE	Water table	0.050g	1.2	1.45	Non-Circular	Y
		After Operation – Upstream with SEE	Water table	0.175g	1.0	1.00	Non-Circular	Y
		After Operation – Downstream with SEE	Water table	0.175g	1.0	1.02	Non-Circular	Y
Northern Dam	Static Condition	After Operation – Upstream	Water table	-	1.5	2.80	Non-Circular	Y
		After Operation – Downstream	Water table	-	1.5	1.67	Non-Circular	Y
	Earthquake Condition	After Operation – Upstream with OBE	Water table	0.050g	1.2	2.54	Non-Circular	Y
		After Operation – Downstream with OBE	Water table	0.050g	1.2	1.47	Non-Circular	Y
		After Operation – Upstream with SEE	Water table	0.175g	1.0	1.11	Non-Circular	Y
		After Operation – Downstream with SEE	Water table	0.175g	1.0	1.01	Non-Circular	Y

Table 9. Summary of embankment stability analysis results for additional cases

Dam	Condition	Cases	Water Prop.	kh	Factor of Safety (FoS)		Failure Type	Acceptable?
					Req'd	AMH		
Southern Dam	Static Condition	After Operation – Upstream; with pore water pressure*	Water table + ru=0.1-0.2	-	1.3	1.93	Non-Circular	Y
		After Operation – Downstream; with pore water pressure*	Water table + ru=0.1-0.2	-	1.3	1.64	Non-Circular	Y
Northern Dam	Static Condition	TSF w/ Waste Dump – Upstream	Water table	-	1.5	2.79	Non-Circular	Y
		TSF w/ Waste Dump – Downstream	Water table	-	1.5	2.31	Non-Circular	Y
	Earthquake Condition	TSF w/ Waste Dump – Upstream with OBE	Water table	0.050g	1.2	2.54	Non-Circular	Y
		TSF w/ Waste Dump – Downstream with OBE	Water table	0.050g	1.2	1.93	Non-Circular	Y
		TSF w/ Waste Dump – Upstream with SEE	Water table	0.175g	1.0	1.11	Non-Circular	Y
		TSF w/ Waste Dump – Downstream with SEE	Water table	0.175g	1.0	1.40	Non-Circular	Y

*Additional load cases with pore water pressure ru applied at the upper surfaces of the exposed slopes

IV. DESIGN REVIEW COMMENTS, FINDINGS AND RECOMMENDATIONS

1. Slope Stability Analysis of TSF-2 Dams

The results of the slope stability analysis indicate that both the Southern and Northern Dams are safe and stable under static and earthquake conditions, with calculated factors of safety greater than the requirement of the codes and guidelines.

2. Pore Water Pressure Ratio (ru) Considerations

For the Southern Dam, the additional load case of applying pore water pressure ratio, r_u, at the upper layers of the rock zone was considered in this study to evaluate the TSF's sensitivity to short term saturation during rainfall events. It is acknowledged by the Consultant that this can be quite a conservative approach considering that most of the TSF's material is rockfill which has very high permeability, hence, allowing water to seep through without allowing pressure build-up. Nonetheless, results of the analyses show that high factors of safety ranging from 1.64 to 1.93 (>1.3) are still achieved and that it does not affect the overall stability of the slope.

For the Northern Dam, no pore water pressure ratio (r_u) is applied at the TSF rockfill surface since its slope face is covered by the waste dump embankment, thus, preventing rainfall to seep and build-up saturation within the TSF embankment materials.

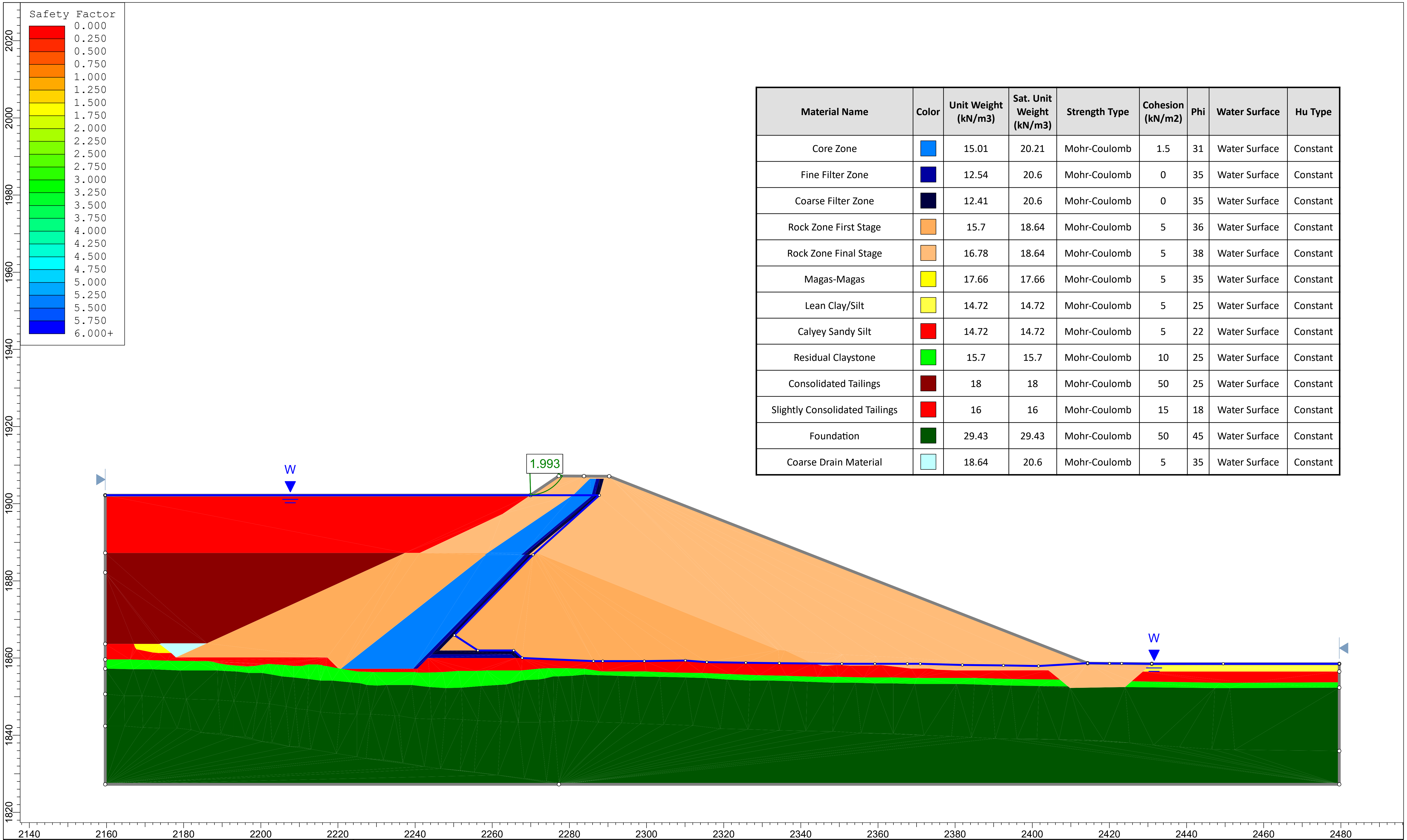
3. **Undrained Shear Strength Considerations for Cohesive Materials (e.g., Clay core) during Earthquake Events**

   During short-term load application scenarios such as an earthquake, cohesive materials tend to exhibit undrained behavior due to the build-up of excess pore water pressure within its voids. Since these materials have very low permeability, the excess pore water pressure that developed in the soil mass during ground shaking could not dissipate instantaneously via expulsion of water through the voids, thus, resulting to undrained conditions. As such, it is recommended to also consider undrained shear strength parameters for the cohesive materials that are below the water table, i.e., clay core zone, when performing pseudo-static (earthquake) conditions. Such assessment is not included in this study and is only a recommendation to the Designer for their consideration/verification.

V. EXCLUSIONS

This geotechnical design review report presents the results of the embankment stability assessment for the Tailings Storage Facility No. 2 (TSF-2) conducted solely for the purpose of evaluating the safety and stability of the Southern and Northern Dam embankment structures. Assessment of other adjacent structures such as the random material waste dump embankment is excluded from the scope of this study.

ANNEX A. SLOPE STABILITY ANALYSIS RESULTS FOR SOUTHERN DAM EMBANKMENT - ORIGINAL DESIGN LOAD CASES



Material Name	Color	Unit Weight (kN/m3)	Sat. Unit Weight (kN/m3)	Strength Type	Cohesion (kN/m2)	Phi	Water Surface	Hu Type
Core Zone		15.01	20.21	Mohr-Coulomb	1.5	31	Water Surface	Constant
Fine Filter Zone		12.54	20.6	Mohr-Coulomb	0	35	Water Surface	Constant
Coarse Filter Zone		12.41	20.6	Mohr-Coulomb	0	35	Water Surface	Constant
Rock Zone First Stage		15.7	18.64	Mohr-Coulomb	5	36	Water Surface	Constant
Rock Zone Final Stage		16.78	18.64	Mohr-Coulomb	5	38	Water Surface	Constant
Magas-Magas		17.66	17.66	Mohr-Coulomb	5	35	Water Surface	Constant
Lean Clay/Silt		14.72	14.72	Mohr-Coulomb	5	25	Water Surface	Constant
Calyey Sandy Silt		14.72	14.72	Mohr-Coulomb	5	22	Water Surface	Constant
Residual Claystone		15.7	15.7	Mohr-Coulomb	10	25	Water Surface	Constant
Consolidated Tailings		18	18	Mohr-Coulomb	50	25	Water Surface	Constant
Slightly Consolidated Tailings		16	16	Mohr-Coulomb	15	18	Water Surface	Constant
Foundation		29.43	29.43	Mohr-Coulomb	50	45	Water Surface	Constant
Coarse Drain Material		18.64	20.6	Mohr-Coulomb	5	35	Water Surface	Constant

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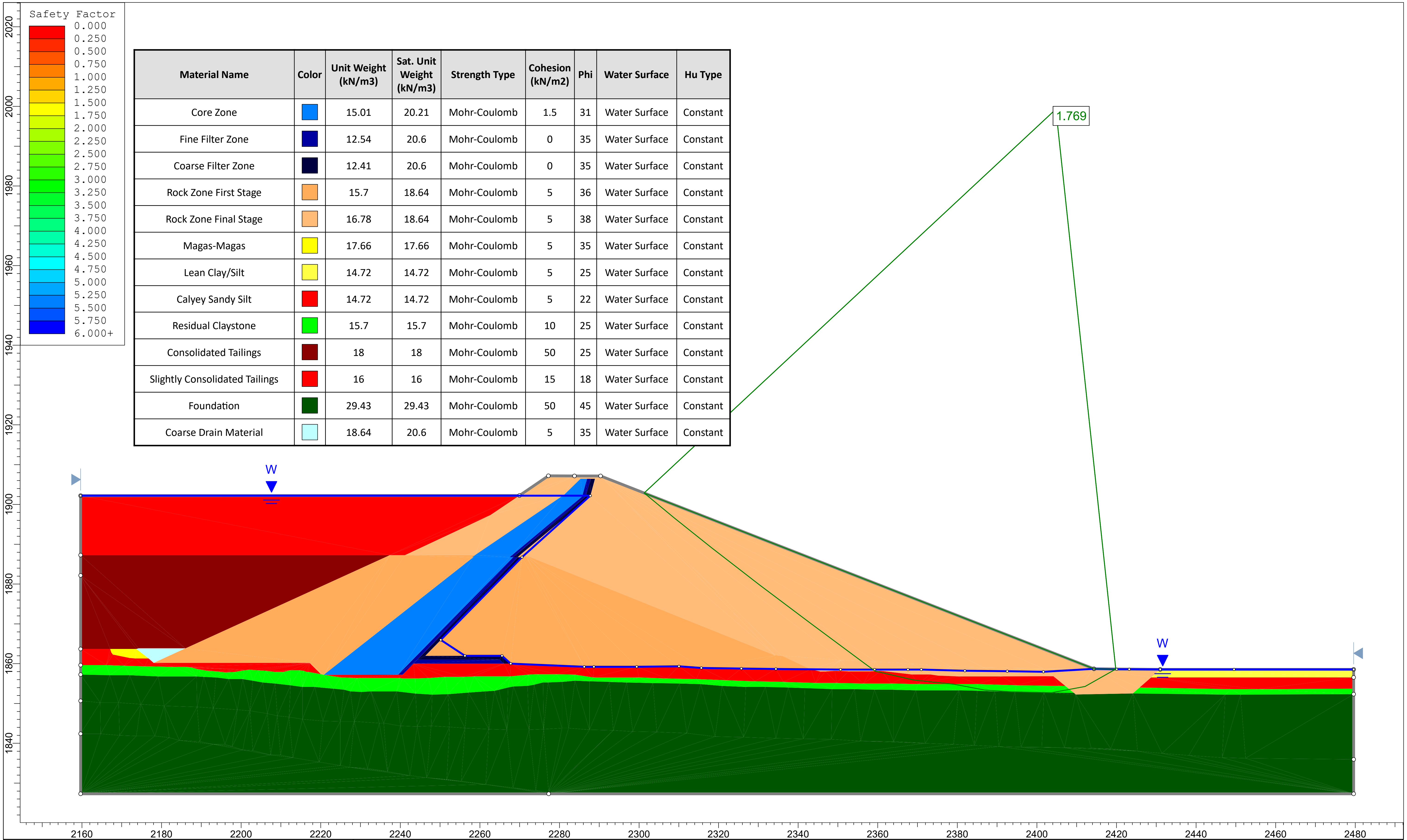
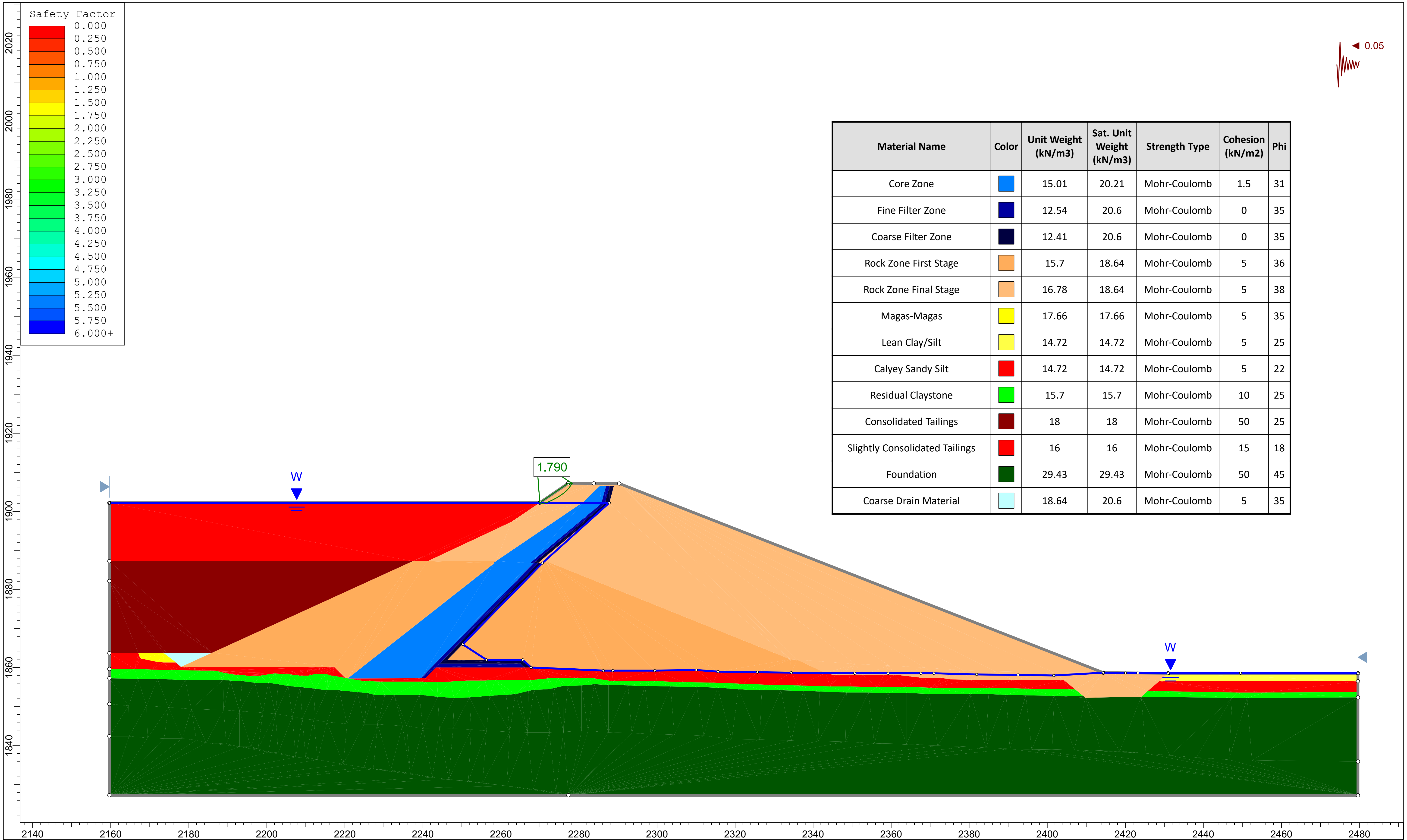
Project	CBNC - TSF 2 R1		
Analysis Description	Southern Dam After Operation Static - Upstream; Morgenstern-Price Method (Non Circular)		
Drawn By	RTG	*Company*	AMH
Date	06/13/2022, 8:49:57 AM	*File Name*	Southern Dam After Operation - Upstream; Non-Circular.slim



Material Name	Color	Unit Weight (kN/m3)	Sat. Unit Weight (kN/m3)	Strength Type	Cohesion (kN/m2)	Phi	Water Surface	Hu Type
Core Zone		15.01	20.21	Mohr-Coulomb	1.5	31	Water Surface	Constant
Fine Filter Zone		12.54	20.6	Mohr-Coulomb	0	35	Water Surface	Constant
Coarse Filter Zone		12.41	20.6	Mohr-Coulomb	0	35	Water Surface	Constant
Rock Zone First Stage		15.7	18.64	Mohr-Coulomb	5	36	Water Surface	Constant
Rock Zone Final Stage		16.78	18.64	Mohr-Coulomb	5	38	Water Surface	Constant
Magas-Magas		17.66	17.66	Mohr-Coulomb	5	35	Water Surface	Constant
Lean Clay/Silt		14.72	14.72	Mohr-Coulomb	5	25	Water Surface	Constant
Calyey Sandy Silt		14.72	14.72	Mohr-Coulomb	5	22	Water Surface	Constant
Residual Claystone		15.7	15.7	Mohr-Coulomb	10	25	Water Surface	Constant
Consolidated Tailings		18	18	Mohr-Coulomb	50	25	Water Surface	Constant
Slightly Consolidated Tailings		16	16	Mohr-Coulomb	15	18	Water Surface	Constant
Foundation		29.43	29.43	Mohr-Coulomb	50	45	Water Surface	Constant
Coarse Drain Material		18.64	20.6	Mohr-Coulomb	5	35	Water Surface	Constant

SLIDEINTERPRET 6.008

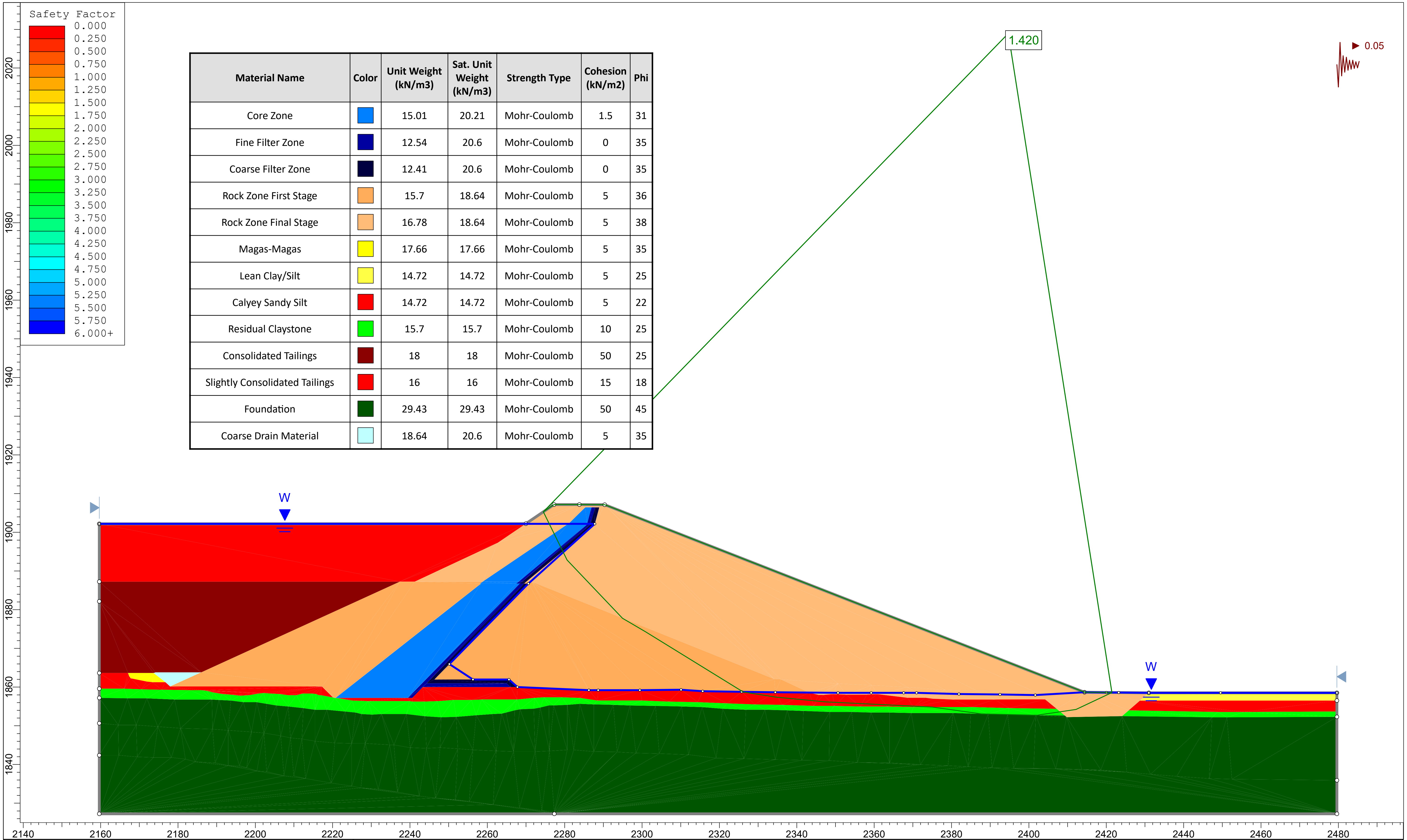
Project	CBNC - TSF 2 R1
Analysis Description	Southern Dam After Operation Static - Downstream; Morgenstern-Price Method (Non Circular)
Drawn By	RTG
Company	AMH
Date	06/13/2022, 8:49:57 AM
File Name	Southern Dam After Operation - Downstream; Non-Circular.slim



Material Name	Color	Unit Weight (kN/m3)	Sat. Unit Weight (kN/m3)	Strength Type	Cohesion (kN/m2)	Phi
Core Zone		15.01	20.21	Mohr-Coulomb	1.5	31
Fine Filter Zone		12.54	20.6	Mohr-Coulomb	0	35
Coarse Filter Zone		12.41	20.6	Mohr-Coulomb	0	35
Rock Zone First Stage		15.7	18.64	Mohr-Coulomb	5	36
Rock Zone Final Stage		16.78	18.64	Mohr-Coulomb	5	38
Magas-Magas		17.66	17.66	Mohr-Coulomb	5	35
Lean Clay/Silt		14.72	14.72	Mohr-Coulomb	5	25
Calyey Sandy Silt		14.72	14.72	Mohr-Coulomb	5	22
Residual Claystone		15.7	15.7	Mohr-Coulomb	10	25
Consolidated Tailings		18	18	Mohr-Coulomb	50	25
Slightly Consolidated Tailings		16	16	Mohr-Coulomb	15	18
Foundation		29.43	29.43	Mohr-Coulomb	50	45
Coarse Drain Material		18.64	20.6	Mohr-Coulomb	5	35

SLIDEINTERPRET 6.008

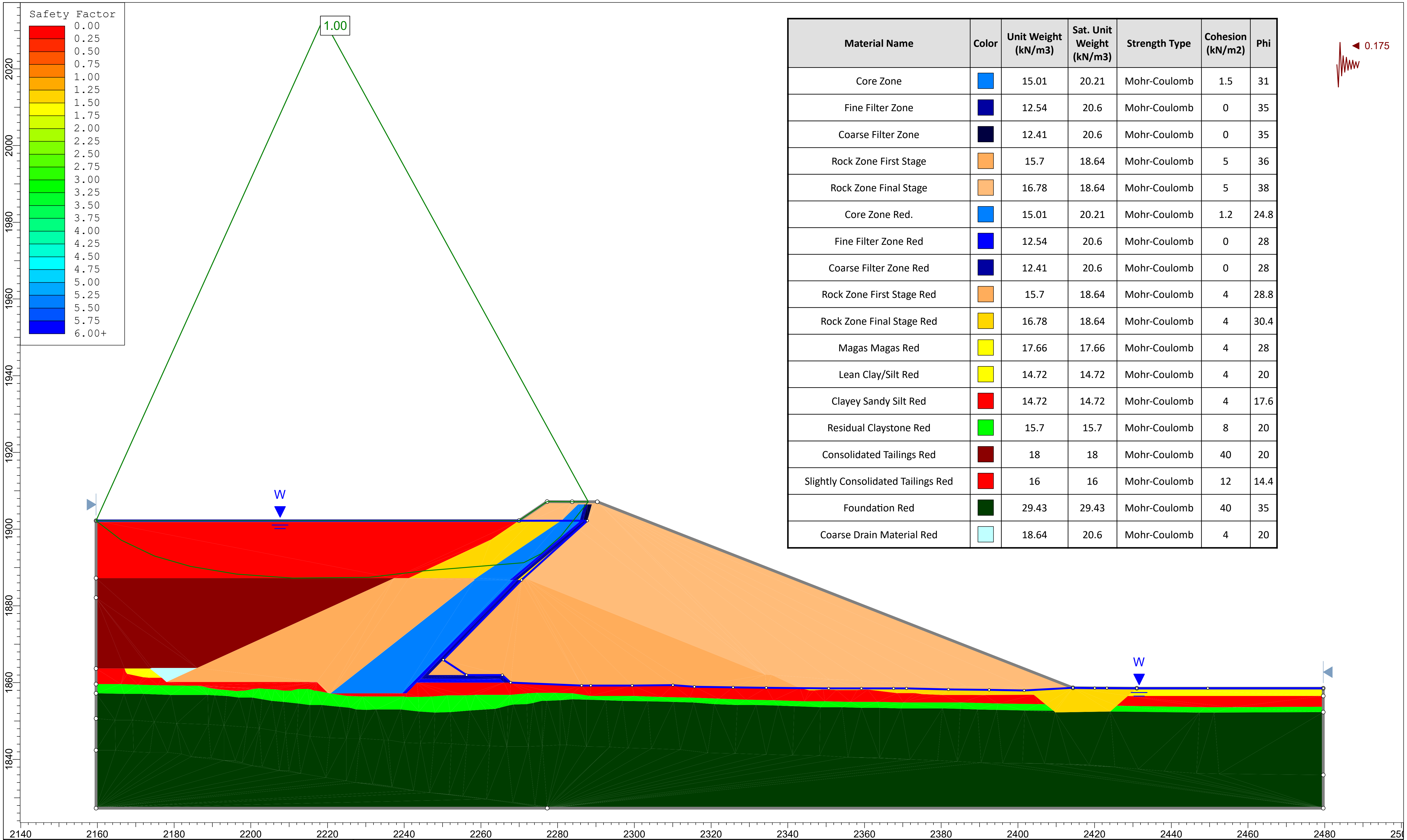
Project	CBNC - TSF 2 R1		
Analysis Description	Southern Dam After Operation EQ - Upstream 0.5OBE; Morgenstern-Price Method (Non Circular)		
Drawn By	RTG	*Company*	AMH
Date	06/13/2022, 8:49:57 AM	*File Name*	Southern Dam After Operation - Upstream with 0.5OBE (kh = 0.05); Non-Circular.slim



Material Name	Color	Unit Weight (kN/m3)	Sat. Unit Weight (kN/m3)	Strength Type	Cohesion (kN/m2)	Phi
Core Zone		15.01	20.21	Mohr-Coulomb	1.5	31
Fine Filter Zone		12.54	20.6	Mohr-Coulomb	0	35
Coarse Filter Zone		12.41	20.6	Mohr-Coulomb	0	35
Rock Zone First Stage		15.7	18.64	Mohr-Coulomb	5	36
Rock Zone Final Stage		16.78	18.64	Mohr-Coulomb	5	38
Magas-Magas		17.66	17.66	Mohr-Coulomb	5	35
Lean Clay/Silt		14.72	14.72	Mohr-Coulomb	5	25
Calyey Sandy Silt		14.72	14.72	Mohr-Coulomb	5	22
Residual Claystone		15.7	15.7	Mohr-Coulomb	10	25
Consolidated Tailings		18	18	Mohr-Coulomb	50	25
Slightly Consolidated Tailings		16	16	Mohr-Coulomb	15	18
Foundation		29.43	29.43	Mohr-Coulomb	50	45
Coarse Drain Material		18.64	20.6	Mohr-Coulomb	5	35

SLIDEINTERPRET 6.008

Project	CBNC - TSF 2 R1
Analysis Description	Southern Dam After Operation EQ - Downstream with 0.5OBE; Morgenstern-Price Method (Non Circular)
Drawn By	RTG
Company	AMH
Date	06/13/2022, 8:49:57 AM
File Name	Southern Dam After Operation - Downstream with 0.5OBE (kh = 0.05); Non-Circular.slim



Material Name	Color	Unit Weight (kN/m3)	Sat. Unit Weight (kN/m3)	Strength Type	Cohesion (kN/m2)	Phi
Core Zone		15.01	20.21	Mohr-Coulomb	1.5	31
Fine Filter Zone		12.54	20.6	Mohr-Coulomb	0	35
Coarse Filter Zone		12.41	20.6	Mohr-Coulomb	0	35
Rock Zone First Stage		15.7	18.64	Mohr-Coulomb	5	36
Rock Zone Final Stage		16.78	18.64	Mohr-Coulomb	5	38
Core Zone Red.		15.01	20.21	Mohr-Coulomb	1.2	24.8
Fine Filter Zone Red		12.54	20.6	Mohr-Coulomb	0	28
Coarse Filter Zone Red		12.41	20.6	Mohr-Coulomb	0	28
Rock Zone First Stage Red		15.7	18.64	Mohr-Coulomb	4	28.8
Rock Zone Final Stage Red		16.78	18.64	Mohr-Coulomb	4	30.4
Magas Magas Red		17.66	17.66	Mohr-Coulomb	4	28
Lean Clay/Silt Red		14.72	14.72	Mohr-Coulomb	4	20
Clayey Sandy Silt Red		14.72	14.72	Mohr-Coulomb	4	17.6
Residual Claystone Red		15.7	15.7	Mohr-Coulomb	8	20
Consolidated Tailings Red		18	18	Mohr-Coulomb	40	20
Slightly Consolidated Tailings Red		16	16	Mohr-Coulomb	12	14.4
Foundation Red		29.43	29.43	Mohr-Coulomb	40	35
Coarse Drain Material Red		18.64	20.6	Mohr-Coulomb	4	20

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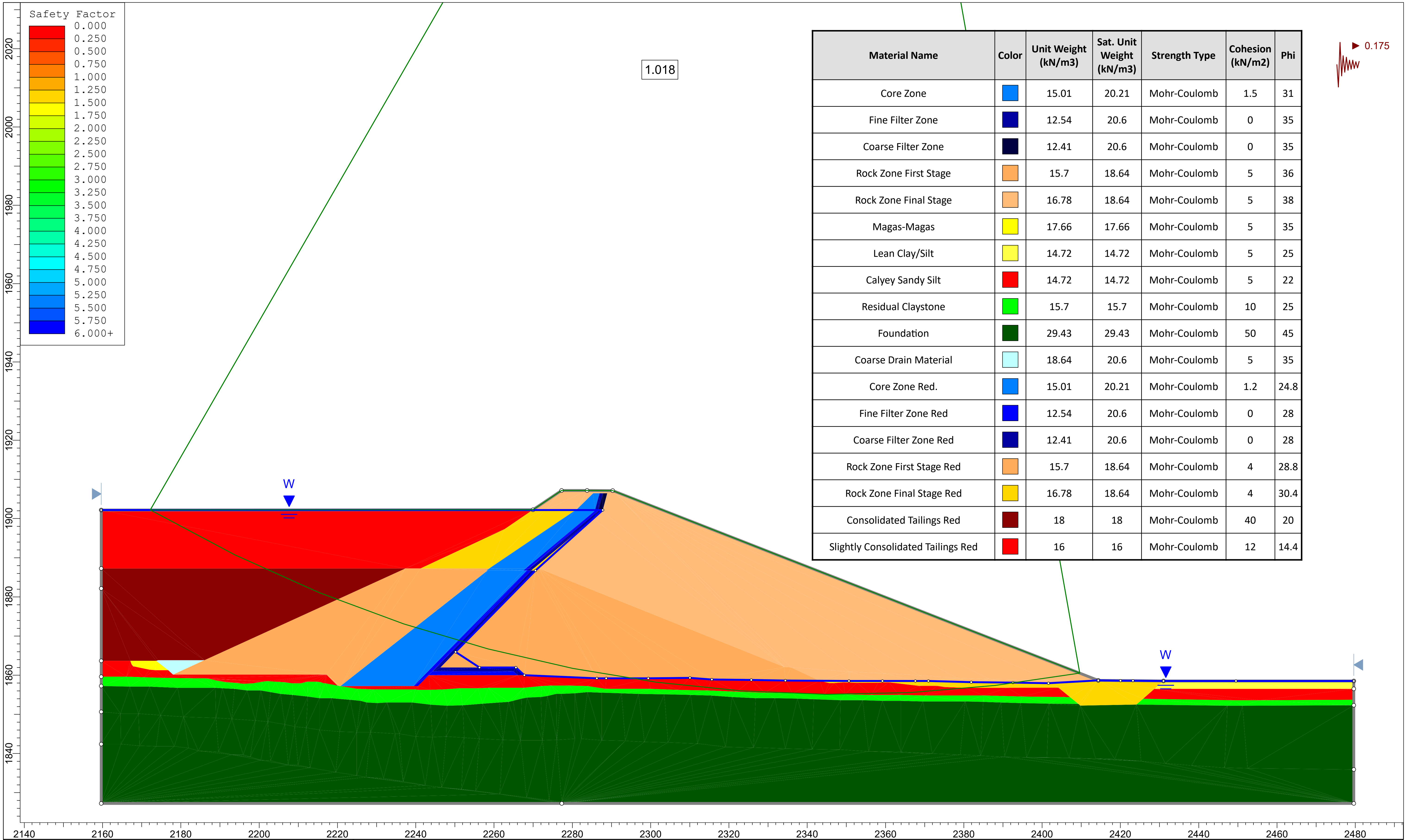
Project	CBNC - TSF 2 R1		
Analysis Description	Southern Dam After Operation EQ - Upstream with 0.5SEE; Morgenstern-Price Method (Non Circular)		
Drawn By	RTG	*Company*	AMH
Date	06/13/2022, 8:49:57 AM	*File Name*	Southern Dam After Operation - Upstream with 0.5OSEE (kh = 0.175); Non-Circular.slim



Material Name	Color	Unit Weight (kN/m3)	Sat. Unit Weight (kN/m3)	Strength Type	Cohesion (kN/m2)	Phi
Core Zone		15.01	20.21	Mohr-Coulomb	1.5	31
Fine Filter Zone		12.54	20.6	Mohr-Coulomb	0	35
Coarse Filter Zone		12.41	20.6	Mohr-Coulomb	0	35
Rock Zone First Stage		15.7	18.64	Mohr-Coulomb	5	36
Rock Zone Final Stage		16.78	18.64	Mohr-Coulomb	5	38
Magas-Magas		17.66	17.66	Mohr-Coulomb	5	35
Lean Clay/Silt		14.72	14.72	Mohr-Coulomb	5	25
Calyey Sandy Silt		14.72	14.72	Mohr-Coulomb	5	22
Residual Claystone		15.7	15.7	Mohr-Coulomb	10	25
Foundation		29.43	29.43	Mohr-Coulomb	50	45
Coarse Drain Material		18.64	20.6	Mohr-Coulomb	5	35
Core Zone Red.		15.01	20.21	Mohr-Coulomb	1.2	24.8
Fine Filter Zone Red		12.54	20.6	Mohr-Coulomb	0	28
Coarse Filter Zone Red		12.41	20.6	Mohr-Coulomb	0	28
Rock Zone First Stage Red		15.7	18.64	Mohr-Coulomb	4	28.8
Rock Zone Final Stage Red		16.78	18.64	Mohr-Coulomb	4	30.4
Consolidated Tailings Red		18	18	Mohr-Coulomb	40	20
Slightly Consolidated Tailings Red		16	16	Mohr-Coulomb	12	14.4

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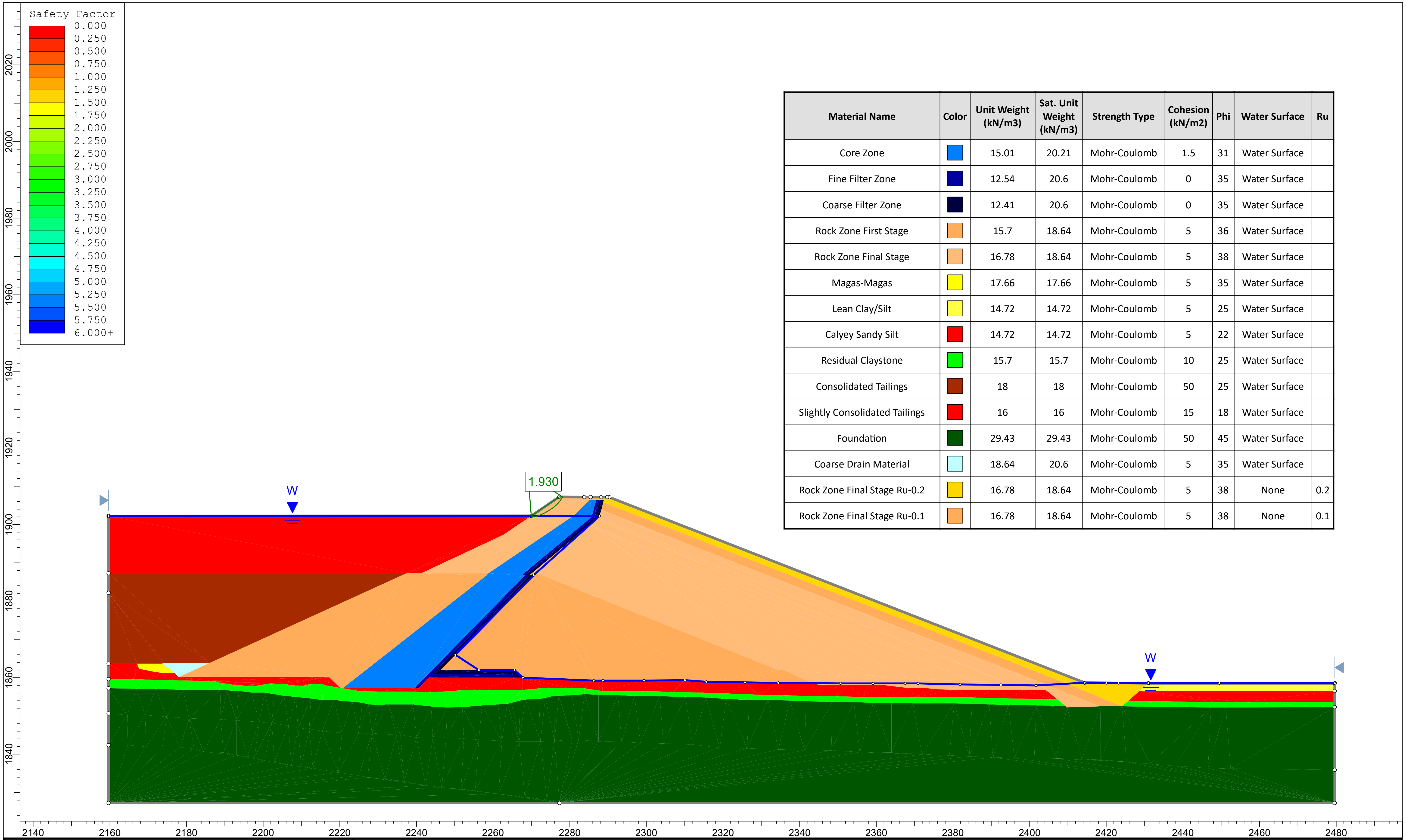
Project	CBNC - TSF 2 R1		
Analysis Description	Southern Dam After Operation EQ - Downstream with 0.5SEE; Morgenstern-Price Method (Non Circular)		
Drawn By	RTG	*Company*	AMH
Date	06/13/2022, 8:49:57 AM	*File Name*	Southern Dam After Operation - Downstream with 0.5OSEE (kh = 0.175); Non-Circular.slim

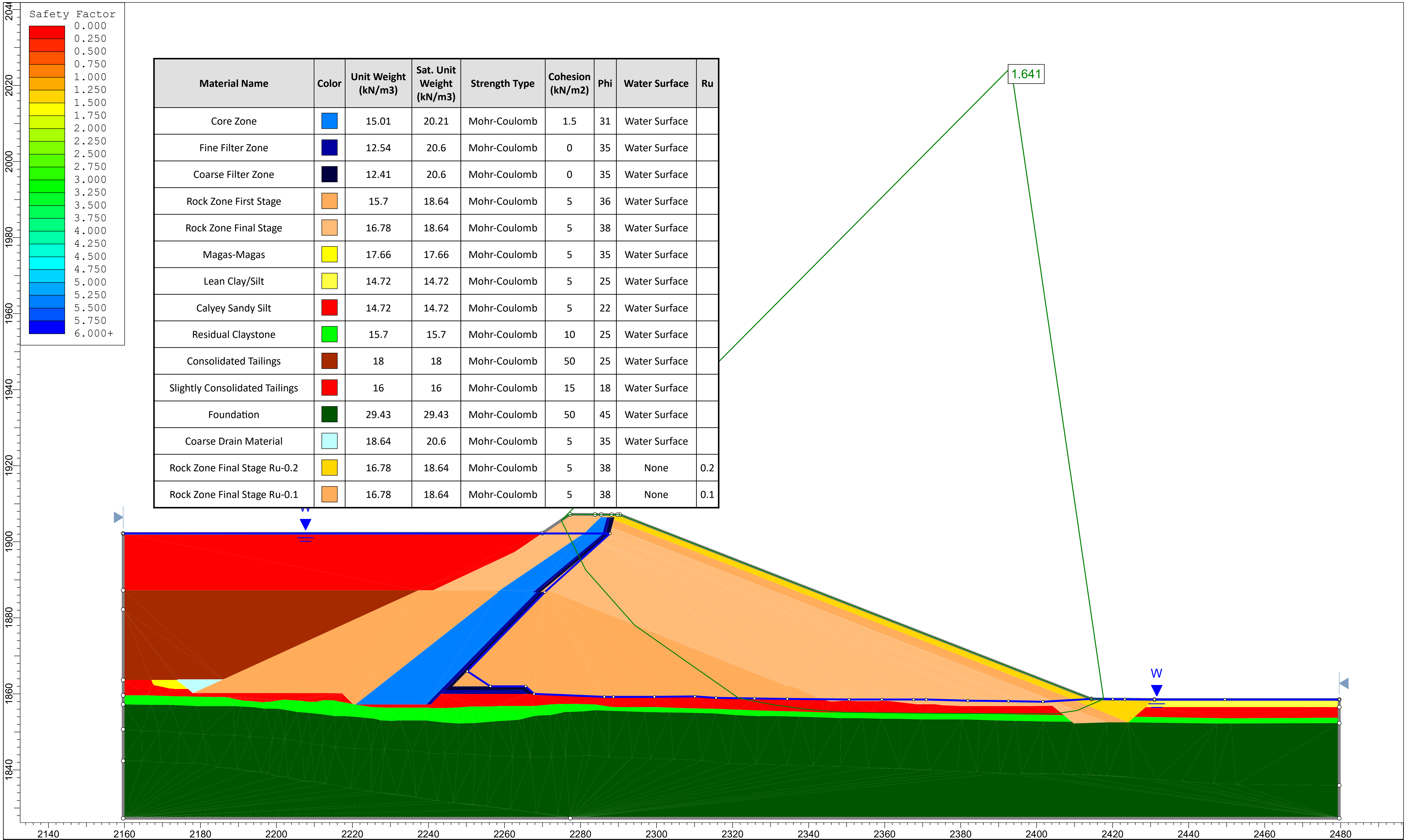
ANNEX B. SLOPE STABILITY ANALYSIS RESULTS FOR SOUTHERN DAM EMBANKMENT - ADDITIONAL DESIGN LOAD CASES



Material Name	Color	Unit Weight (kN/m3)	Sat. Unit Weight (kN/m3)	Strength Type	Cohesion (kN/m2)	Phi	Water Surface	Ru
Core Zone		15.01	20.21	Mohr-Coulomb	1.5	31	Water Surface	
Fine Filter Zone		12.54	20.6	Mohr-Coulomb	0	35	Water Surface	
Coarse Filter Zone		12.41	20.6	Mohr-Coulomb	0	35	Water Surface	
Rock Zone First Stage		15.7	18.64	Mohr-Coulomb	5	36	Water Surface	
Rock Zone Final Stage		16.78	18.64	Mohr-Coulomb	5	38	Water Surface	
Magas-Magas		17.66	17.66	Mohr-Coulomb	5	35	Water Surface	
Lean Clay/Silt		14.72	14.72	Mohr-Coulomb	5	25	Water Surface	
Calyey Sandy Silt		14.72	14.72	Mohr-Coulomb	5	22	Water Surface	
Residual Claystone		15.7	15.7	Mohr-Coulomb	10	25	Water Surface	
Consolidated Tailings		18	18	Mohr-Coulomb	50	25	Water Surface	
Slightly Consolidated Tailings		16	16	Mohr-Coulomb	15	18	Water Surface	
Foundation		29.43	29.43	Mohr-Coulomb	50	45	Water Surface	
Coarse Drain Material		18.64	20.6	Mohr-Coulomb	5	35	Water Surface	
Rock Zone Final Stage Ru-0.2		16.78	18.64	Mohr-Coulomb	5	38	None	0.2
Rock Zone Final Stage Ru-0.1		16.78	18.64	Mohr-Coulomb	5	38	None	0.1

SLIDEINTERPRET 6.008

Project	CBNC - TSF 2		
Analysis Description	Southern Dam After Operation - Upstream; Morgenstern Proce Method (Non Circular)		
Drawn By	RTG	Company	AMH
Date	06/13/2022, 8:49:57 AM	File Name	Southern Dam After Operation with RU - Upstream; Non-Circular.slim

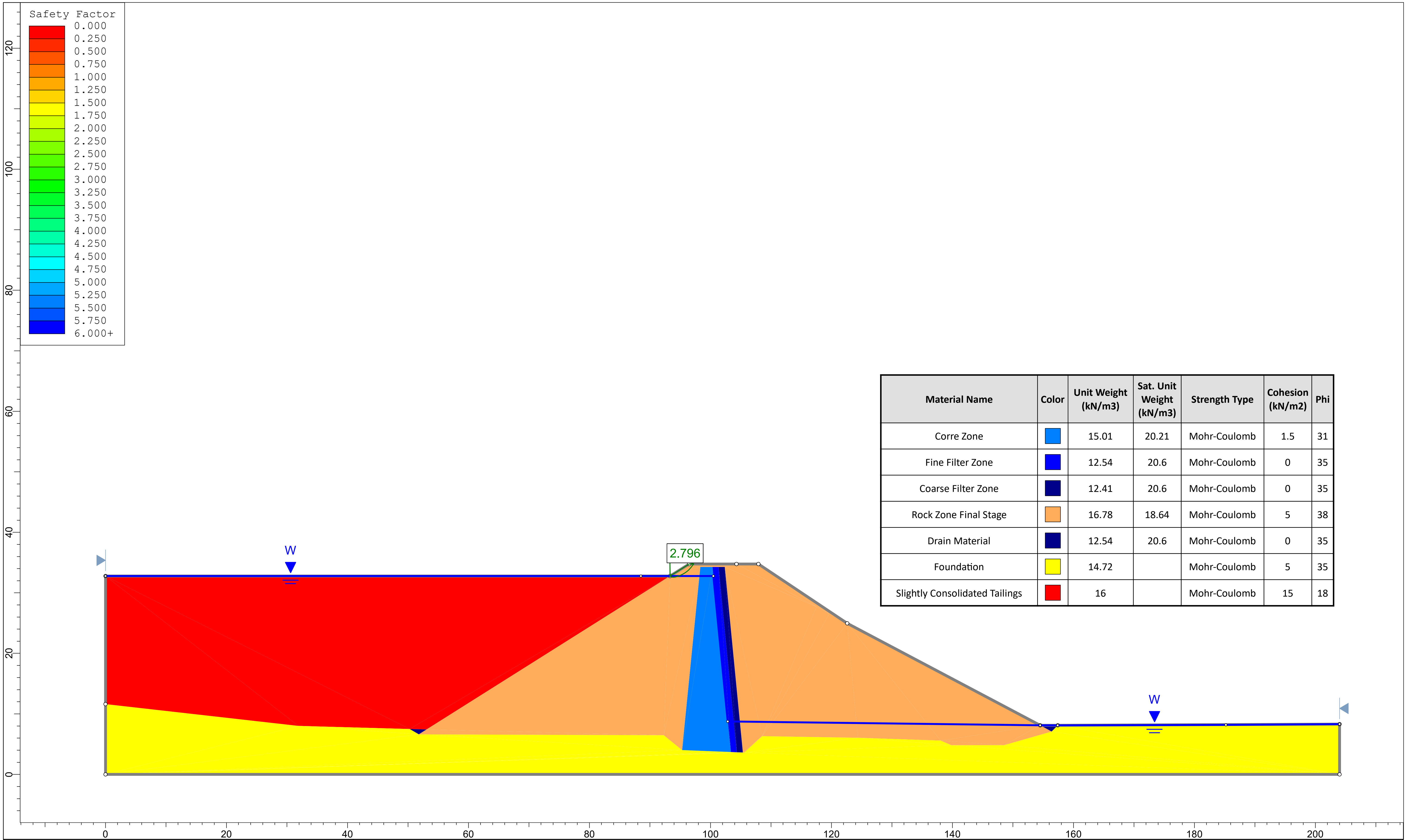


Material Name	Color	Unit Weight (kN/m3)	Sat. Unit Weight (kN/m3)	Strength Type	Cohesion (kN/m2)	Phi	Water Surface	Ru
Core Zone		15.01	20.21	Mohr-Coulomb	1.5	31	Water Surface	
Fine Filter Zone		12.54	20.6	Mohr-Coulomb	0	35	Water Surface	
Coarse Filter Zone		12.41	20.6	Mohr-Coulomb	0	35	Water Surface	
Rock Zone First Stage		15.7	18.64	Mohr-Coulomb	5	36	Water Surface	
Rock Zone Final Stage		16.78	18.64	Mohr-Coulomb	5	38	Water Surface	
Magas-Magas		17.66	17.66	Mohr-Coulomb	5	35	Water Surface	
Lean Clay/Silt		14.72	14.72	Mohr-Coulomb	5	25	Water Surface	
Calyey Sandy Silt		14.72	14.72	Mohr-Coulomb	5	22	Water Surface	
Residual Claystone		15.7	15.7	Mohr-Coulomb	10	25	Water Surface	
Consolidated Tailings		18	18	Mohr-Coulomb	50	25	Water Surface	
Slightly Consolidated Tailings		16	16	Mohr-Coulomb	15	18	Water Surface	
Foundation		29.43	29.43	Mohr-Coulomb	50	45	Water Surface	
Coarse Drain Material		18.64	20.6	Mohr-Coulomb	5	35	Water Surface	
Rock Zone Final Stage Ru-0.2		16.78	18.64	Mohr-Coulomb	5	38	None	0.2
Rock Zone Final Stage Ru-0.1		16.78	18.64	Mohr-Coulomb	5	38	None	0.1

SLIDEINTERPRET 6.008

Project	CBNC - TSF 2
Analysis Description	Southern Dam After Operation - Downstream; Morgenstern Proce Method (Non Circular)
Drawn By	RTG
Company	AMH
Date	06/13/2022, 8:49:57 AM
File Name	Southern Dam After Operation with RU - Downstream; Non-Circular.slim

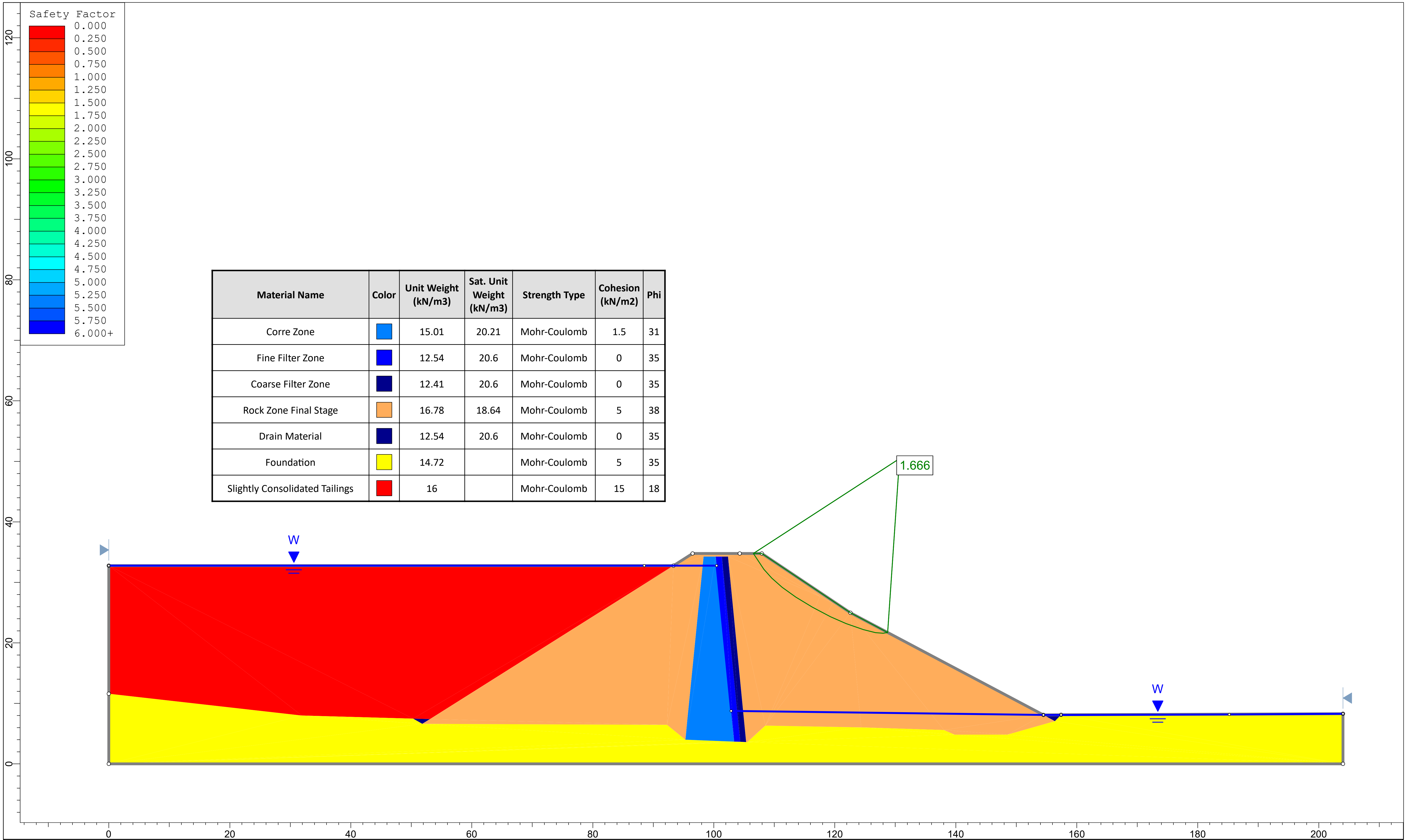
ANNEX C. SLOPE STABILITY ANALYSIS RESULTS FOR NORTHERN DAM EMBANKMENT - ORIGINAL DESIGN LOAD CASES



Material Name	Color	Unit Weight (kN/m3)	Sat. Unit Weight (kN/m3)	Strength Type	Cohesion (kN/m2)	Phi
Corre Zone		15.01	20.21	Mohr-Coulomb	1.5	31
Fine Filter Zone		12.54	20.6	Mohr-Coulomb	0	35
Coarse Filter Zone		12.41	20.6	Mohr-Coulomb	0	35
Rock Zone Final Stage		16.78	18.64	Mohr-Coulomb	5	38
Drain Material		12.54	20.6	Mohr-Coulomb	0	35
Foundation		14.72		Mohr-Coulomb	5	35
Slightly Consolidated Tailings		16		Mohr-Coulomb	15	18

SLIDEINTERPRET 6.008

Project	CBNC - TSF 2 R1
Analysis Description	Northern Dam After Operation Static - Upstream; Morgenstern-Price Method; Non Circular
Drawn By	RTG
Company	AMH Philippines, Inc.
Date	07/29/2022, 10:51:39 am
File Name	Northern Dam After Operation Static - Upstream; Non Circular.slim

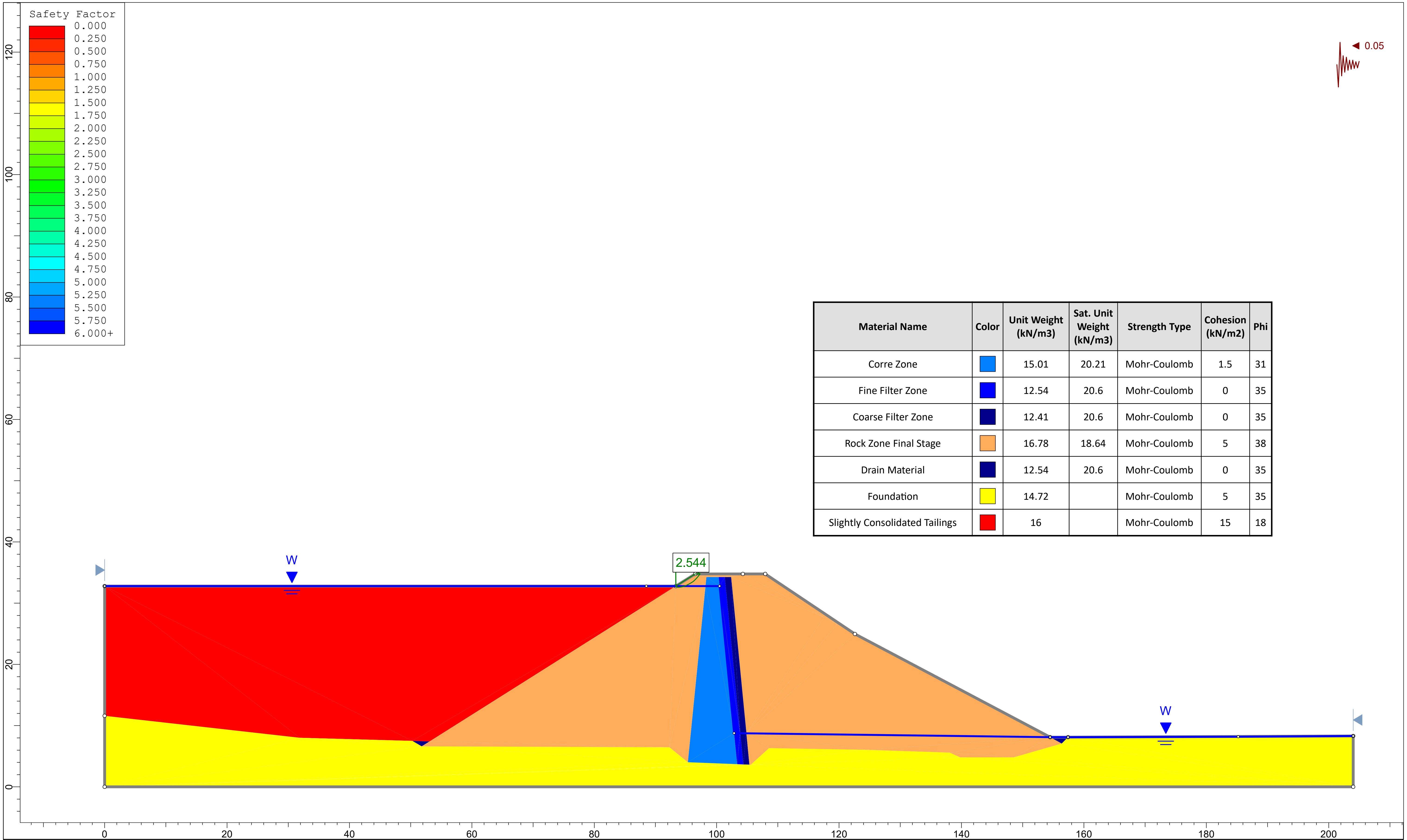


Material Name	Color	Unit Weight (kN/m3)	Sat. Unit Weight (kN/m3)	Strength Type	Cohesion (kN/m2)	Phi
Corre Zone		15.01	20.21	Mohr-Coulomb	1.5	31
Fine Filter Zone		12.54	20.6	Mohr-Coulomb	0	35
Coarse Filter Zone		12.41	20.6	Mohr-Coulomb	0	35
Rock Zone Final Stage		16.78	18.64	Mohr-Coulomb	5	38
Drain Material		12.54	20.6	Mohr-Coulomb	0	35
Foundation		14.72		Mohr-Coulomb	5	35
Slightly Consolidated Tailings		16		Mohr-Coulomb	15	18

rocscience

SLIDEINTERPRET 6.008

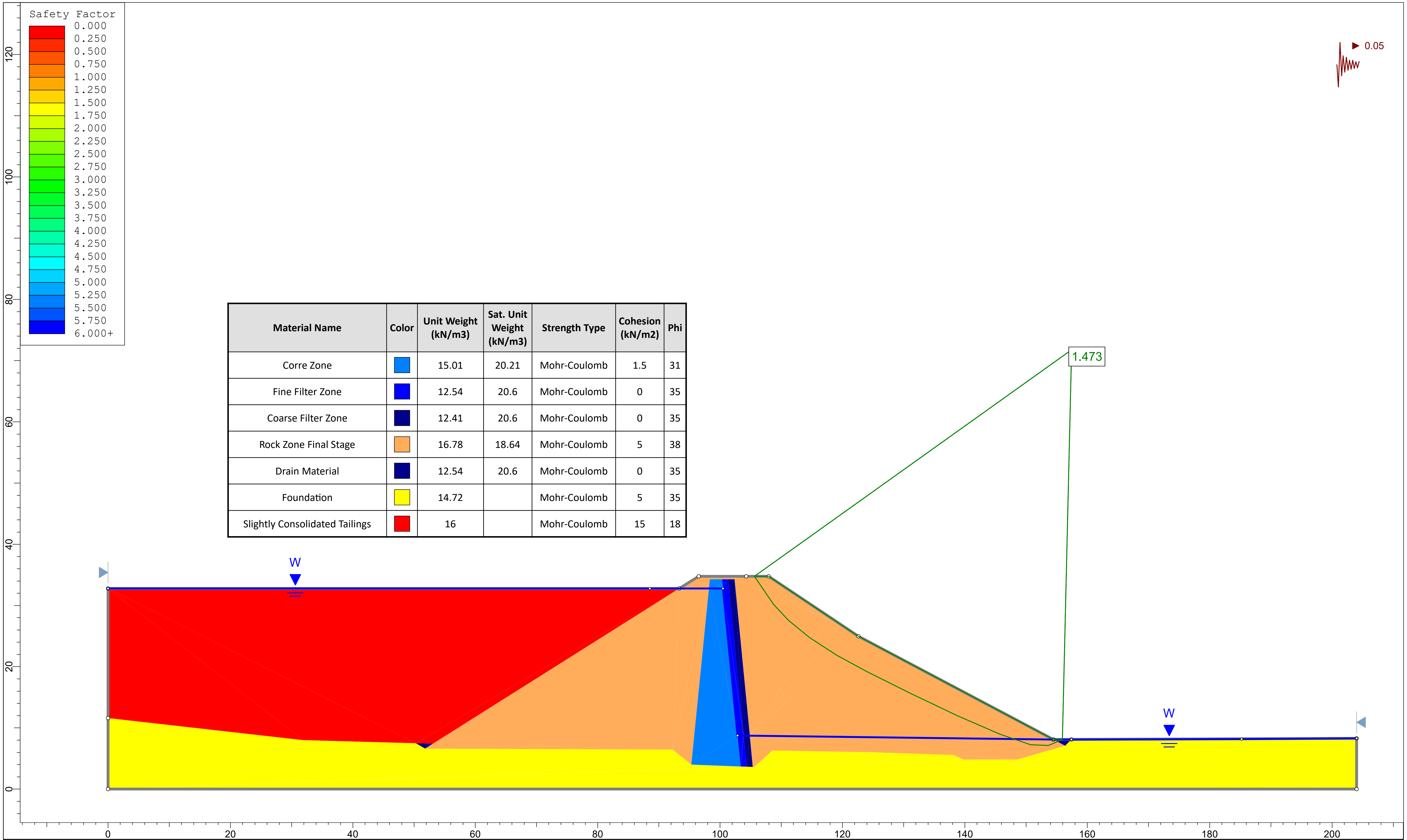
Project	CBNC - TSF 2 R1
Analysis Description	Northern Dam After Operation Static - Downstream; Morgenstern-Price Method; Non-Circular
Drawn By	RTG
Company	AMH Philippines, Inc.
Date	07/29/2022, 10:51:39 am
File Name	Northern Dam After Operation Static - Downstream; Non Circular.slim



Material Name	Color	Unit Weight (kN/m3)	Sat. Unit Weight (kN/m3)	Strength Type	Cohesion (kN/m2)	Phi
Corre Zone		15.01	20.21	Mohr-Coulomb	1.5	31
Fine Filter Zone		12.54	20.6	Mohr-Coulomb	0	35
Coarse Filter Zone		12.41	20.6	Mohr-Coulomb	0	35
Rock Zone Final Stage		16.78	18.64	Mohr-Coulomb	5	38
Drain Material		12.54	20.6	Mohr-Coulomb	0	35
Foundation		14.72		Mohr-Coulomb	5	35
Slightly Consolidated Tailings		16		Mohr-Coulomb	15	18

Project	CBNC - TSF 2 R1		
Analysis Description	Northern Dam After Operation Seismic - Upstream with 0.5OBE; Morgenstern-Price Method; Non Circular		
Drawn By	RTG	*Company*	AMH Philippines, Inc.
Date	07/29/2022, 10:51:39 am	*File Name*	Northern Dam After Operation Seismic - Upstream with 0.5OBE; Non Circular.slim

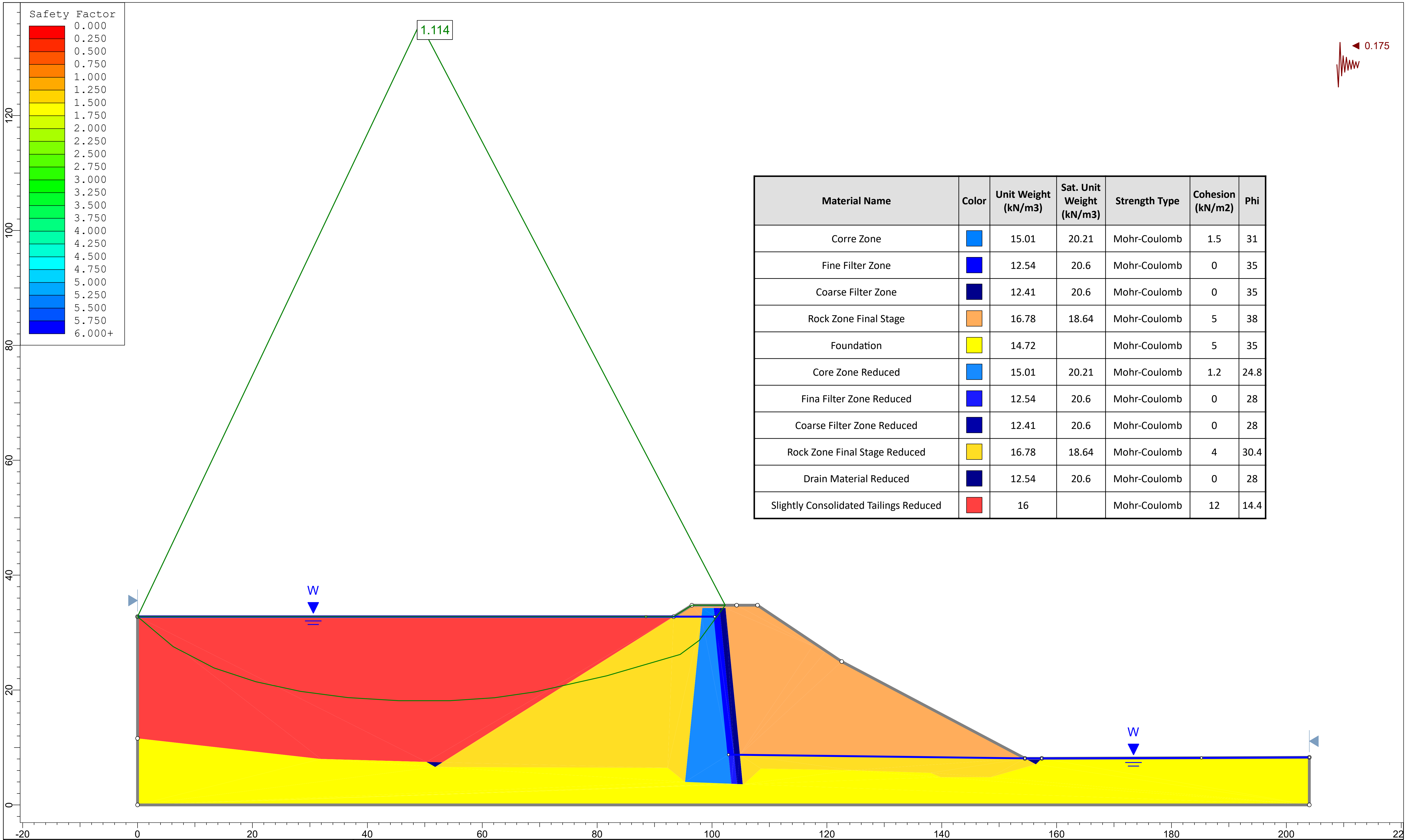
SLIDEINTERPRET 6.008



Material Name	Color	Unit Weight (kN/m3)	Sat. Unit Weight (kN/m3)	Strength Type	Cohesion (kN/m2)	Phi
Corre Zone		15.01	20.21	Mohr-Coulomb	1.5	31
Fine Filter Zone		12.54	20.6	Mohr-Coulomb	0	35
Coarse Filter Zone		12.41	20.6	Mohr-Coulomb	0	35
Rock Zone Final Stage		16.78	18.64	Mohr-Coulomb	5	38
Drain Material		12.54	20.6	Mohr-Coulomb	0	35
Foundation		14.72		Mohr-Coulomb	5	35
Slightly Consolidated Tailings		16		Mohr-Coulomb	15	18

SLIDEINTERPRET 6.008

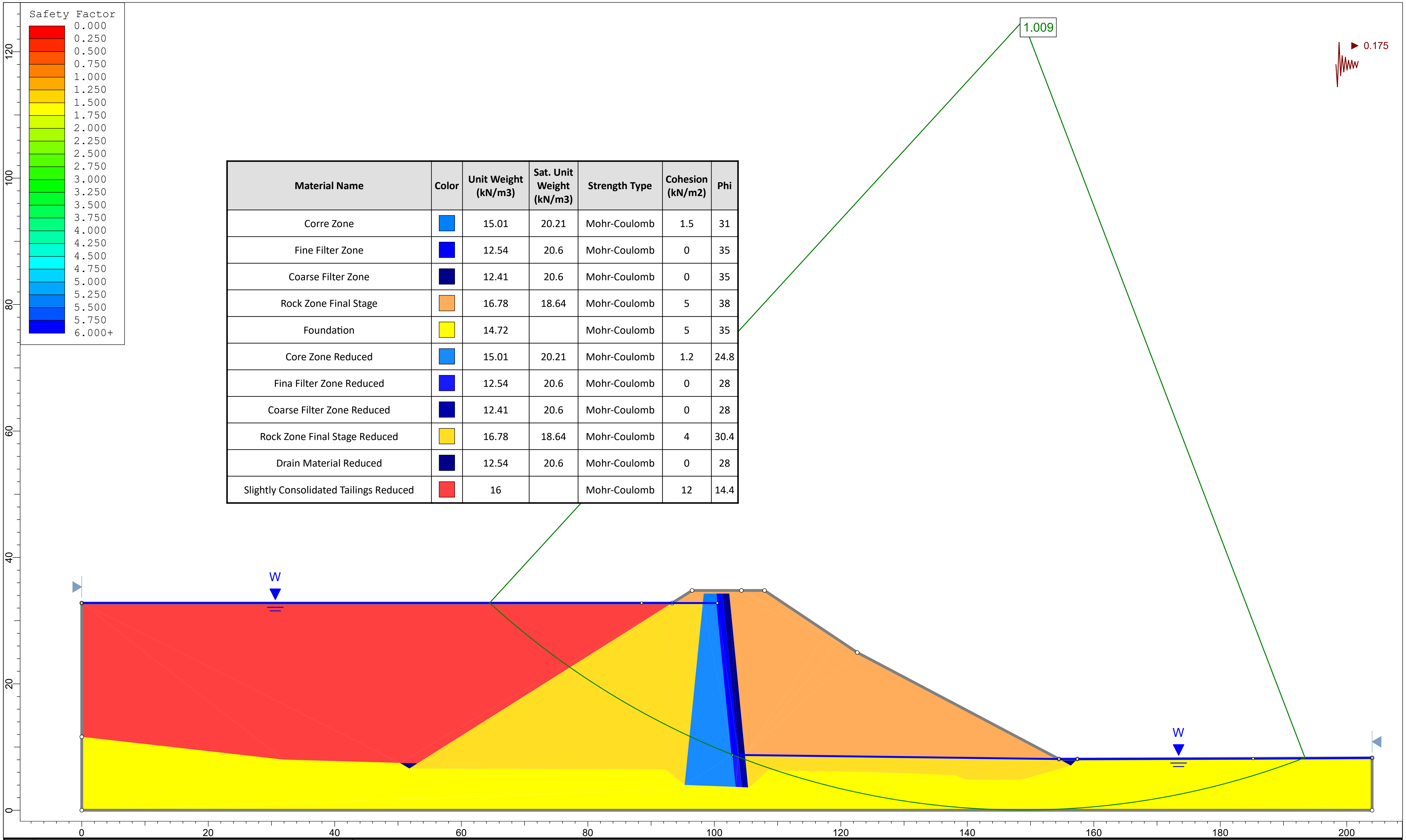
Project	CBNC - TSF 2 R1
Analysis Description	Northern Dam After Operation Seismic - Downstream with 0.5OBE; Morgenstern-Price Method; Non Circular
Drawn By	RTG
Company	AMH Philippines, Inc.
Date	07/29/2022, 10:51:39 am
File Name	Northern Dam After Operation Seismic - Downstream with 0.5OBE; Non Circular.slim



Material Name	Color	Unit Weight (kN/m3)	Sat. Unit Weight (kN/m3)	Strength Type	Cohesion (kN/m2)	Phi
Corre Zone		15.01	20.21	Mohr-Coulomb	1.5	31
Fine Filter Zone		12.54	20.6	Mohr-Coulomb	0	35
Coarse Filter Zone		12.41	20.6	Mohr-Coulomb	0	35
Rock Zone Final Stage		16.78	18.64	Mohr-Coulomb	5	38
Foundation		14.72		Mohr-Coulomb	5	35
Core Zone Reduced		15.01	20.21	Mohr-Coulomb	1.2	24.8
Fina Filter Zone Reduced		12.54	20.6	Mohr-Coulomb	0	28
Coarse Filter Zone Reduced		12.41	20.6	Mohr-Coulomb	0	28
Rock Zone Final Stage Reduced		16.78	18.64	Mohr-Coulomb	4	30.4
Drain Material Reduced		12.54	20.6	Mohr-Coulomb	0	28
Slightly Consolidated Tailings Reduced		16		Mohr-Coulomb	12	14.4

Project	CBNC - TSF 2 R1
Analysis Description	Northern Dam After Operation Seismic - Upstream with 0.5SEE; Morgenstern-Price Method; Non Circular
Drawn By	RTG
Company	AMH Philippines, Inc.
Date	07/29/2022, 10:51:39 am
File Name	Northern Dam After Operation Seismic - Upstream with 0.5SEE; Non Circular.slim

SLIDEINTERPRET 6.008



Material Name	Color	Unit Weight (kN/m3)	Sat. Unit Weight (kN/m3)	Strength Type	Cohesion (kN/m2)	Phi
Corre Zone		15.01	20.21	Mohr-Coulomb	1.5	31
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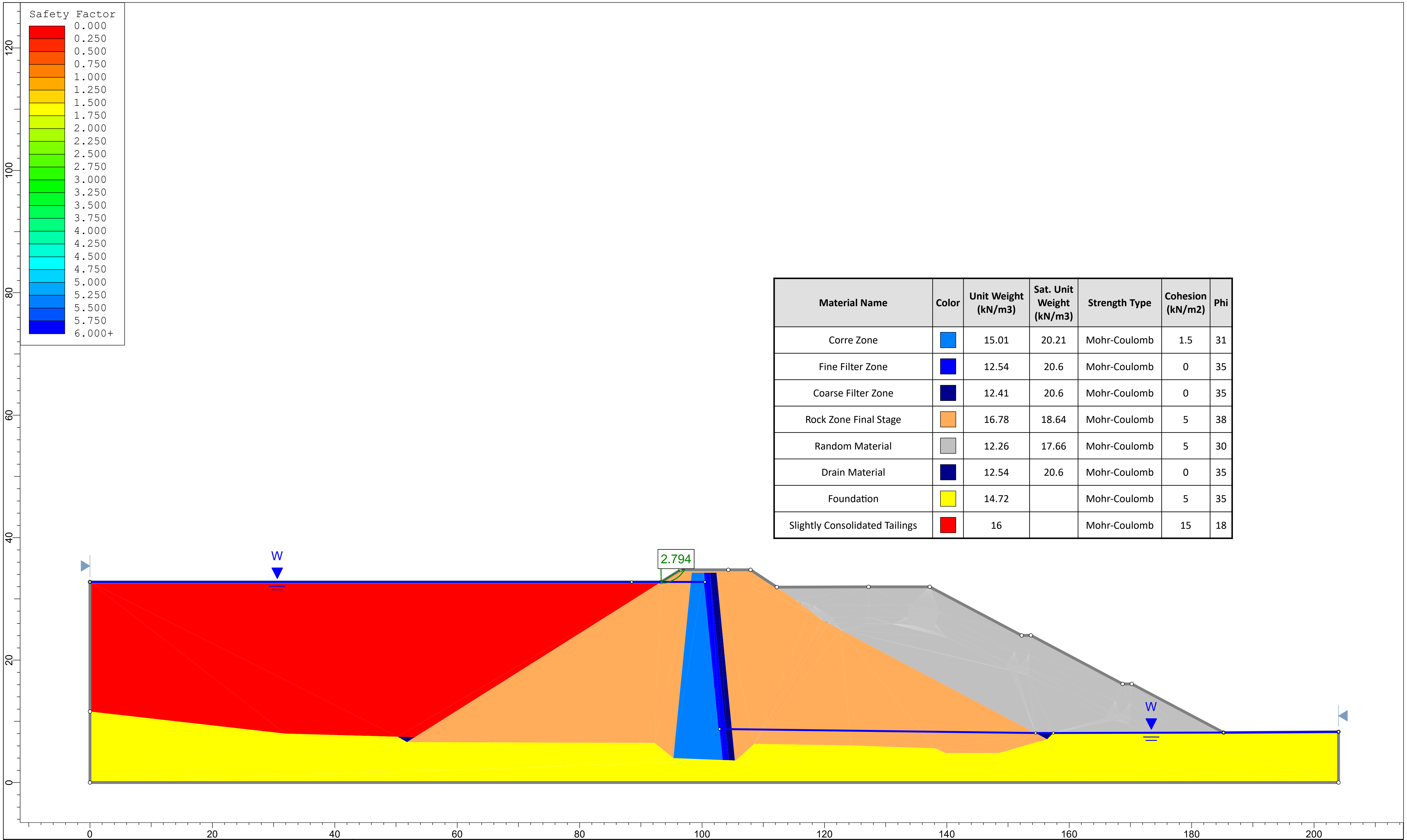
Rock Zone Final Stage		16.78	18.64	Mohr-Coulomb	5	38
Foundation		14.72		Mohr-Coulomb	5	35
Core Zone Reduced		15.01	20.21	Mohr-Coulomb	1.2	24.8
Fina Filter Zone Reduced		12.54	20.6	Mohr-Coulomb	0	28
Coarse Filter Zone Reduced		12.41	20.6	Mohr-Coulomb	0	28
Rock Zone Final Stage Reduced		16.78	18.64	Mohr-Coulomb	4	30.4
Drain Material Reduced		12.54	20.6	Mohr-Coulomb	0	28
Slightly Consolidated Tailings Reduced		16		Mohr-Coulomb	12	14.4

SLIDEINTERPRET 6.008

Project	CBNC - TSF 2 R1		
Analysis Description	Northern Dam After Operation Seismic - Upstream with 0.5 SEE; Simplified Bishop Method; Circular		
Drawn By	RTG	*Company*	AMH Philippines, Inc.
Date	07/29/2022, 10:51:39 am	*File Name*	Northern Dam After Operation Seismic - Downstream with 0.5SEE; Circular.slim

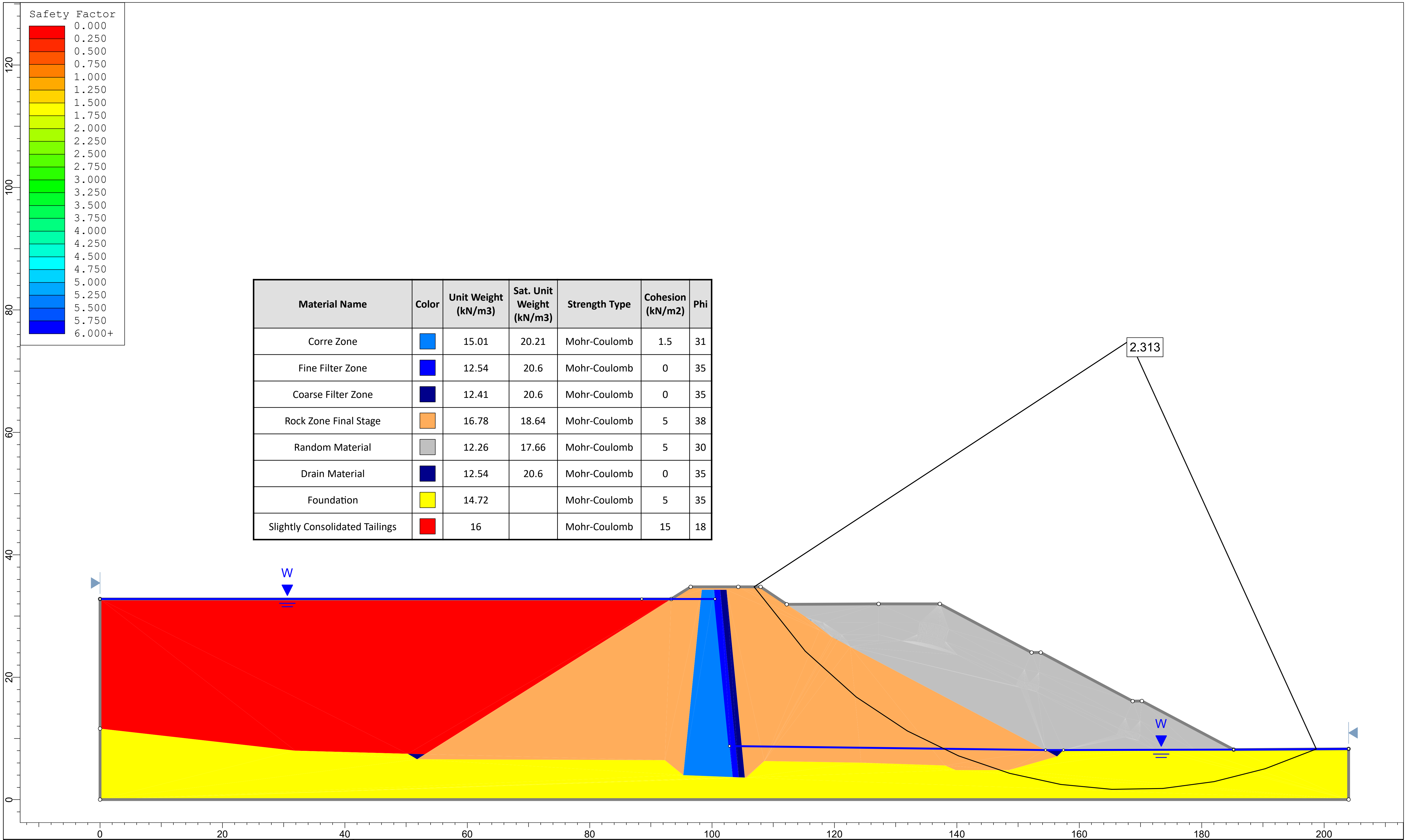
ANNEX D. SLOPE STABILITY ANALYSIS RESULTS FOR NORTHERN DAM EMBANKMENT - ADDITIONAL DESIGN LOAD CASES



Material Name	Color	Unit Weight (kN/m3)	Sat. Unit Weight (kN/m3)	Strength Type	Cohesion (kN/m2)	Phi
Corre Zone		15.01	20.21	Mohr-Coulomb	1.5	31
Fine Filter Zone		12.54	20.6	Mohr-Coulomb	0	35
Coarse Filter Zone		12.41	20.6	Mohr-Coulomb	0	35
Rock Zone Final Stage		16.78	18.64	Mohr-Coulomb	5	38
Random Material		12.26	17.66	Mohr-Coulomb	5	30
Drain Material		12.54	20.6	Mohr-Coulomb	0	35
Foundation		14.72		Mohr-Coulomb	5	35
Slightly Consolidated Tailings		16		Mohr-Coulomb	15	18

SLIDEINTERPRET 6.008

Project	CBNC - TSF 2 R1		
Analysis Description	Northern Dam Existing Condition Static - Upstream; Non Circular		
Drawn By	RTG	*Company*	AMH Philippines, Inc.
Date	07/29/2022, 10:51:39 am	*File Name*	Northern Dam Existing Condition Static - Upstream; Non Circular.slim



Material Name	Color	Unit Weight (kN/m3)	Sat. Unit Weight (kN/m3)	Strength Type	Cohesion (kN/m2)	Phi
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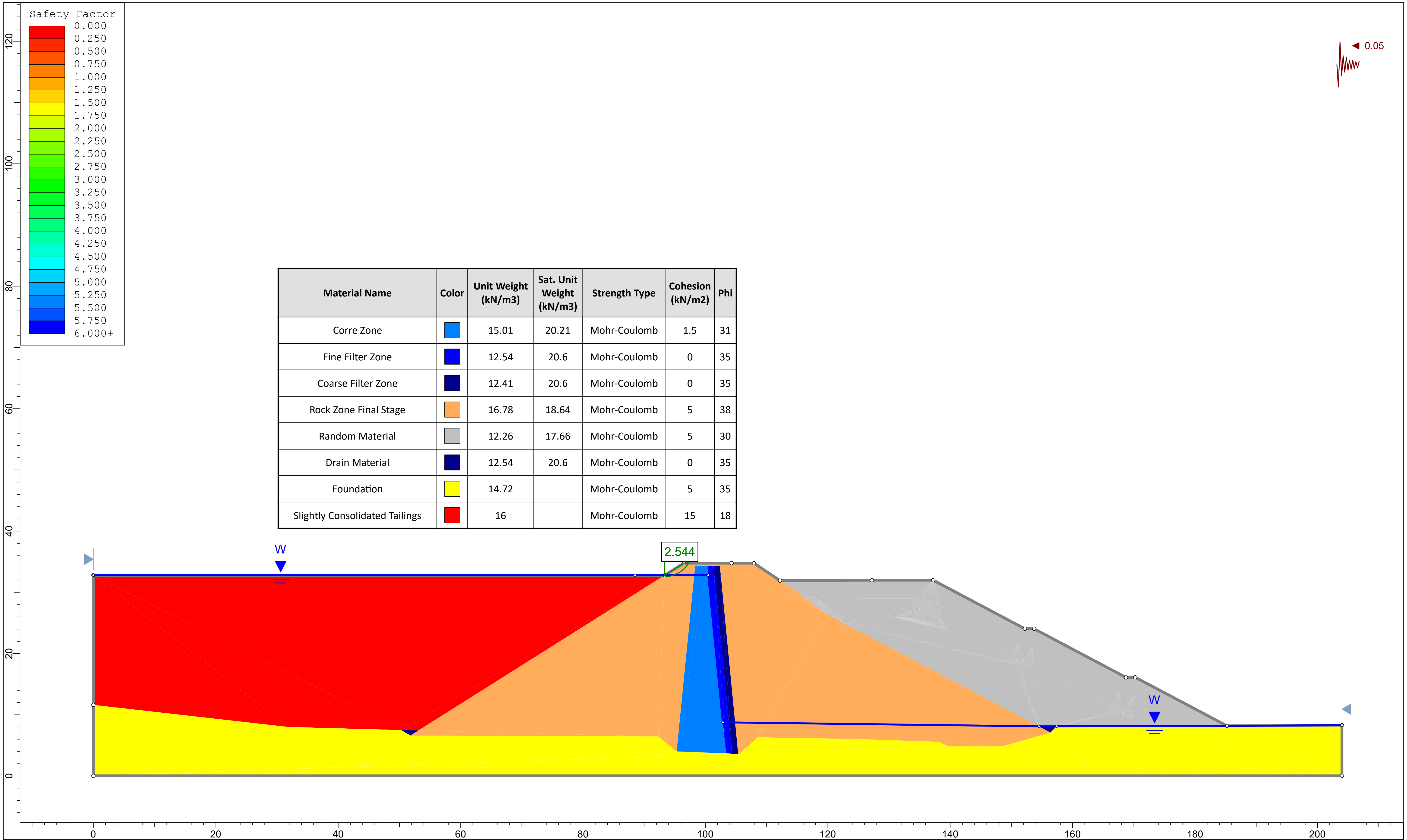
Random Material		12.26	17.66	Mohr-Coulomb	5	30
Drain Material		12.54	20.6	Mohr-Coulomb	0	35
Foundation		14.72		Mohr-Coulomb	5	35
Slightly Consolidated Tailings		16		Mohr-Coulomb	15	18

SLIDEINTERPRET 6.008

Project	CBNC - TSF 2 R1		
Analysis Description	Northern Dam Existing Condition Static - Downstream; Non Circular		
Drawn By	RTG	*Company*	AMH Philippines, Inc.
Date	07/29/2022, 10:51:39 am	*File Name*	Northern Dam Existing Condition Static - Downstream; Non Circular.slim



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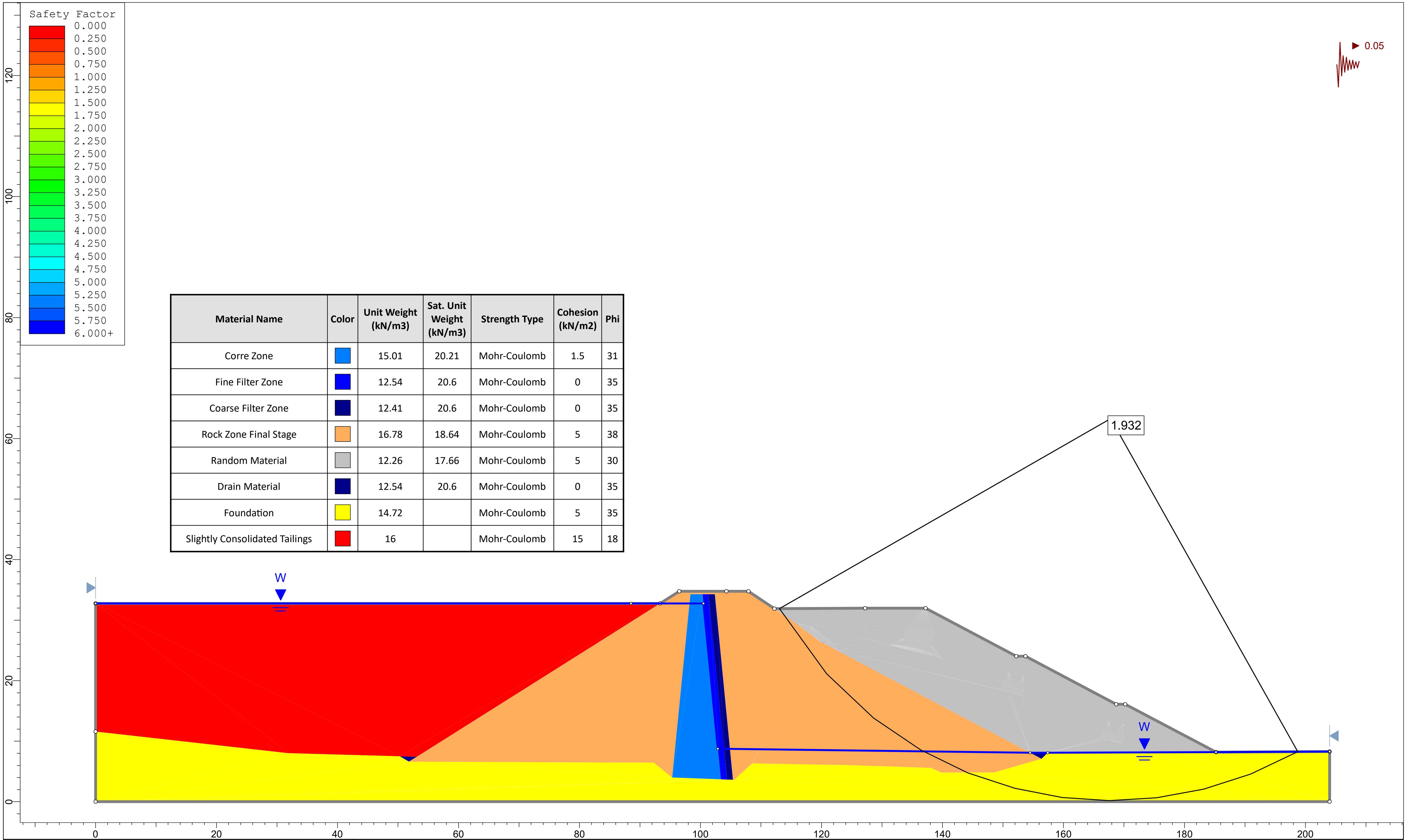
Random Material		12.26	17.66	Mohr-Coulomb	5	30
Drain Material		12.54	20.6	Mohr-Coulomb	0	35
Foundation		14.72		Mohr-Coulomb	5	35
Slightly Consolidated Tailings		16		Mohr-Coulomb	15	18

SLIDEINTERPRET 6.008

Project	CBNC - TSF 2 R1		
Analysis Description	Northern Dam Existing Condition Seismic - Upstream with 0.5OBE; Non Circular		
Drawn By	RTG	*Company*	AMH Philippines, Inc.
Date	07/29/2022, 10:51:39 am	*File Name*	Northern Dam Existing Condition Seismic - Upstream with 0.5OBE; Non Circular.slim



Material Name	Color	Unit Weight (kN/m3)	Sat. Unit Weight (kN/m3)	Strength Type	Cohesion (kN/m2)	Phi
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Random Material		12.26	17.66	Mohr-Coulomb	5	30
Drain Material		12.54	20.6	Mohr-Coulomb	0	35
Foundation		14.72		Mohr-Coulomb	5	35
Slightly Consolidated Tailings		16		Mohr-Coulomb	15	18

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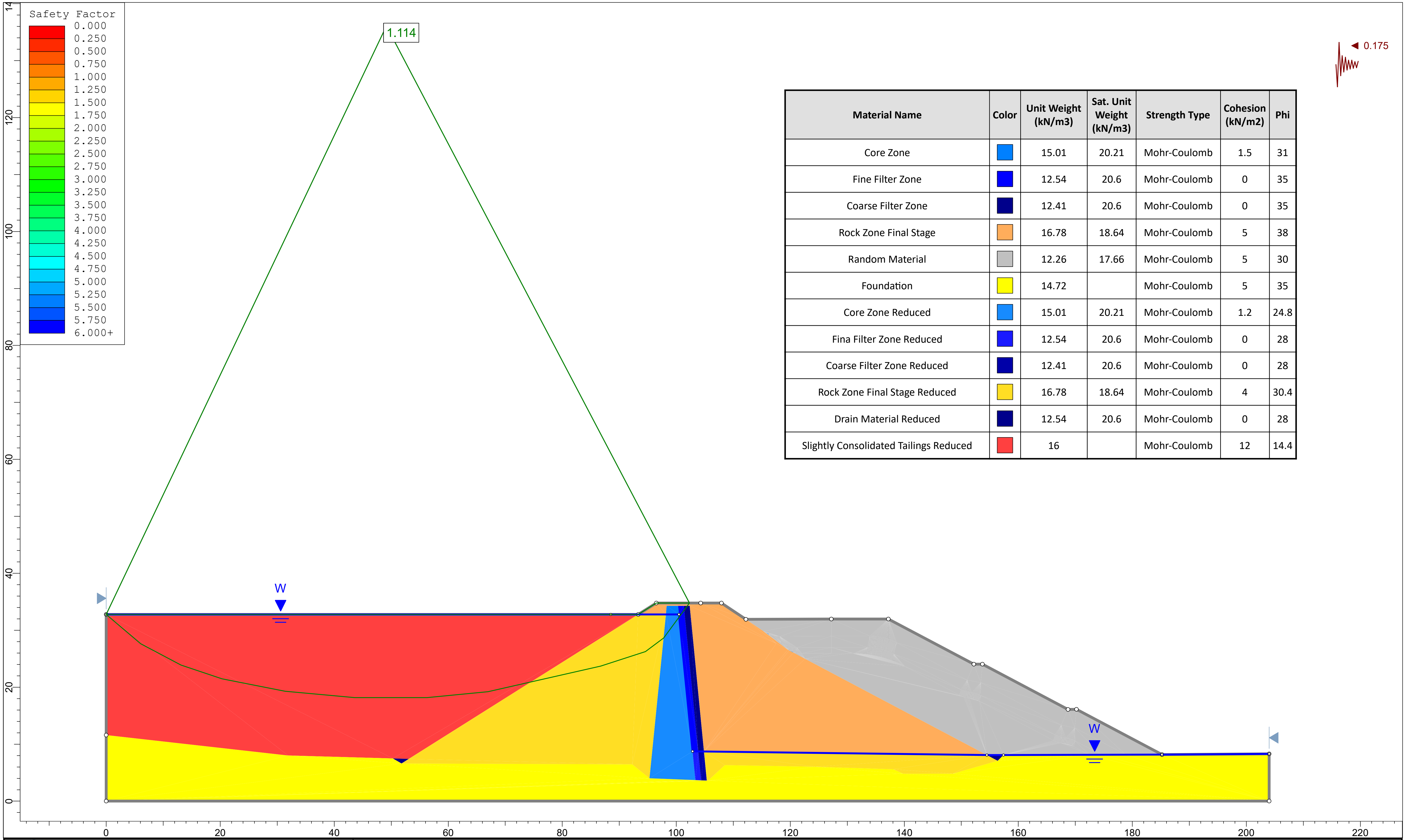
SLIDEINTERPRET 6.008

Project	CBNC - TSF 2 R1
Analysis Description	Northern Dam Existing Condition Seismic - Downstream with 0.5OBE; Non Circular
Drawn By	RTG
Company	AMH Philippines, Inc.
Date	07/29/2022, 10:51:39 am
File Name	Northern Dam Existing Condition Seismic - Downstream with 0.5OBE; Non Circular.slim



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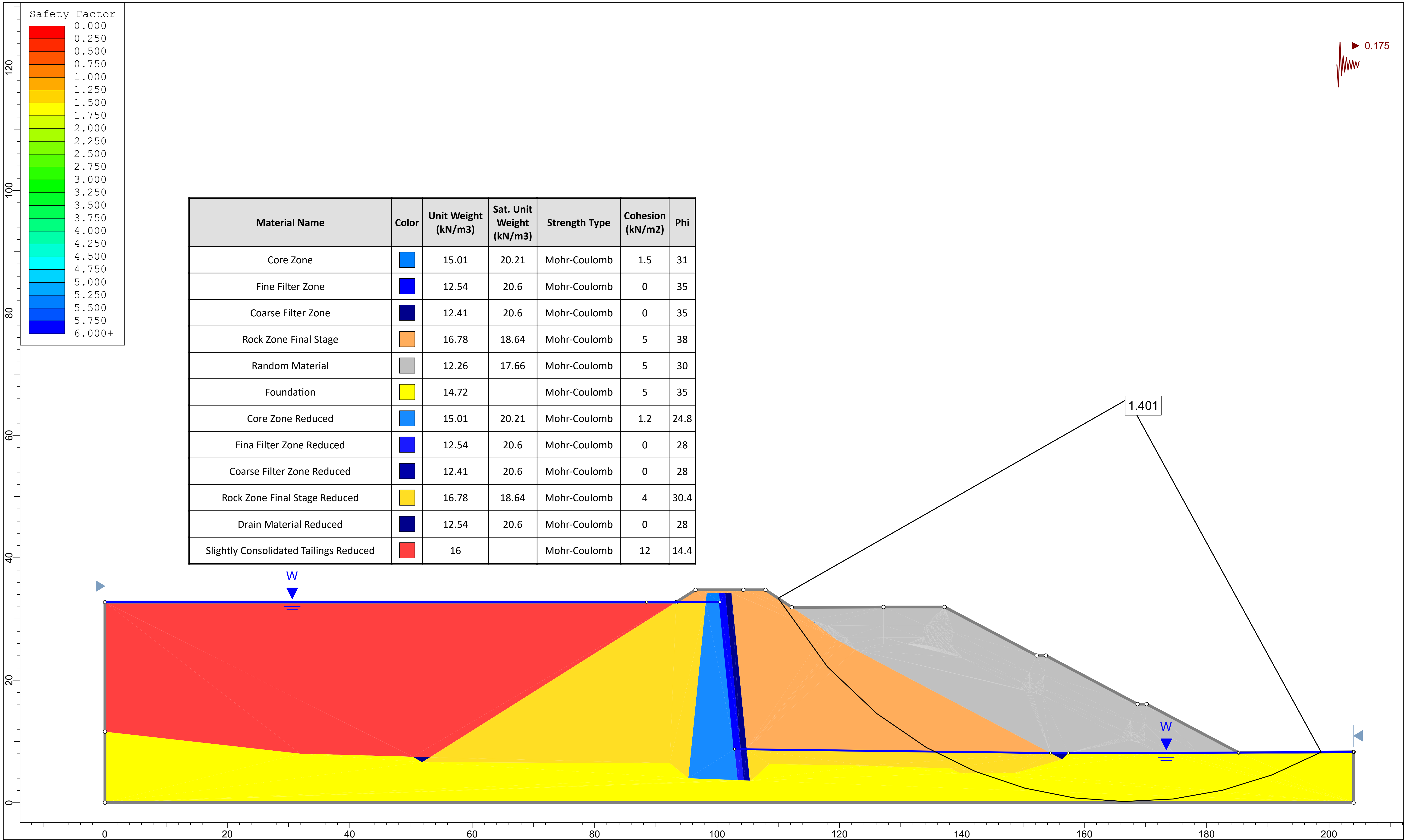
SLIDEINTERPRET 6.008

Project	CBNC - TSF 2 R1
Analysis Description	Northern Dam Existing Condition Seismic - Upstream with 0.5SEE; Non Circular
Drawn By	RTG
Company	AMH Philippines, Inc.
Date	07/29/2022, 10:51:39 am
File Name	Northern Dam Existing Condition Seismic - Upstream with 0.5SEE; Non Circular.slim



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SLIDEINTERPRET 6.008

Project	CBNC - TSF 2 R1
Analysis Description	Northern Dam Existing Condition Seismic - Downstream with 0.5SEE; Non Circular
Drawn By	RTG
Company	AMH Philippines, Inc.
Date	07/29/2022, 10:51:39 am
File Name	Northern Dam Existing Condition Seismic - Downstream with 0.5SEE; Non Circular.slim

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