CRWMS/M&O

Design Analysis Cover Sheet

Complete only applicable items.

(1.) QA: L

2. DESIGN ANALYSIS TITLE		
PERMANENT ROCKBOLT AND TEMPORARY CHANNEL INTERACTION ANALYSIS (SCPB: NA)		
3. DOCUMENT IDENTIFIER (Including Rev. No.) BABEAB000-01717-0200-00012 REV 00	4. REV. NO. 00	5. TOTAL PAGES 21
6. TOTAL ATTACHMENTS NONE	7. ATTACHMENT NUMBERS - NO. OF PAGES IN EACH NONE	8. SYSTEM ELEMENT MGDS

	Print Name	Signature	Date
9. Originator	J. Keifer/M. Taylor	Jerald W Keifer / M.E. Taylor, Jr.	3/14/95 / 3-14-95
10. Checker	M.Gomez/D. Tang	[signature] / David Tang	03/14/95 / 3-14-95
11. Lead Design Engineer	M.E.Taylor	M.E. Taylor, Jr.	3-14-95
12.QA Manager	JW Willis	JW Willis	3-14-95
13. Department Manager	DANA J. ROGERS	Dana J. Rogers	3/14/95

14. REMARKS

The Structural Evaluation (section 7.4) was originated by M. Taylor,and checked by M. Gomez. The Linings and Ground Support Evaluation (Section 7.5) was originated by J. Keifer and Checked by D. Tang. The other sections of the analysis which were common to both disciplines were prepared by collaboration of the originators and checked by M. Gomez.

CRWMS/M&O

Design Analysis Revision Record

Complete only applicable items.

(1.) QA: L

2. DESIGN ANALYSIS TITLE

PERMANENT ROCKBOLT AND TEMPORARY CHANNEL INTERACTION ANALYSIS

3. DOCUMENT IDENTIFIER (Including Rev. No.)	4. REVISION NO.
BABEAB000-01717-0200-00012 REV 00	00

5. Revision No.	6. Total Pages	7. Description of Revision
00	21	Initial Issue

1. PURPOSE

The purpose of this analysis is to evaluate the interaction of a quality assurance (QA) classified item (QA-1 and QA-5) with an item of temporary function (QA: NONE), in accordance with Requirement 8 of the Determination of Importance Evaluation (DIE) (Reference Section 5.1). This interaction analysis will be done by determining the forces on "Williams" rockbolts transferred from temporary function channels under maximum capacity loads, and ensuring that these loads do not compromise the critical characteristics of these rockbolts.

2. QUALITY ASSURANCE

The QA classification and control for the North Ramp linings and ground support are presented as part of the DIE for the Exploratory Studies Facility (ESF) Package 2C (Reference Section 5.1). Sections 11.1 and 11.3 of the DIE provide the basis for classifying the permanent rockbolts QA-1 and QA-5, and for establishing Q-controls on temporary items that connect to permanent items.

3. METHOD

The analytical method and hand calculations are used in this analysis. The analysis will determine the forces on "Williams" rockbolts transferred from temporary function channels, and compare those forces to capacity of the rockbolts to ensure that these loads do not compromise the critical characteristic of the rockbolts.

4. DESIGN INPUTS

4.1 DESIGN PARAMETERS

4.1.1 Rockbolts layout, pattern design, and dimensions: Reference Sections 5.3, 5.4, and 5.5.

4.1.2 Rockbolt critical characteristic (Reference Section 5.7):

A. Tensile strength of rockbolt
B. Effective installation
C. Strength of the nut
D. Rigidity of the bearing plate.

4.1.3 Structural properties of B7X William hollow continuous threaded steel bars: maximum O.D. = 1 3/16 in., I.D. = 0.325 in., net area = 0.68 square inch, and "spin slock" head assembly of B7X = 7NC (overall assembly length = 9 7/8 in.). Reference Section 5.2.

4.1.4 Minimum strength rockbolt as identified in design: American Society for Testing and Materials, ASTM A615, Grade 60, #8 barsize (Reference Section 5.7).

4.2 CRITERIA

4.2.1 Ground support:

Any means used to reinforce rock and/or control the movement of rock except for items of support which may be removed or replaced if the ESF is incorporated into the potential repository. [Exploratory Studies Facility Design Requirements (ESFDR) 3.2.1 H.1.C.]

4.2.2 The following potential repository design criteria, to the extent known at the time of ESF design, shall be considered for the ESF permanent systems, structures, and components (SSC) important to safety (ITS). These criteria will apply only during the period of the potential repository operations and shall not interfere with ESF operations. [ESFDR 3.2.1.H.2]

4.2.3 The SSC ITS shall be designed so that natural phenomena and environmental conditions anticipated at the geologic repository operations area will not interfere with necessary safety functions. [ESFDR 3.2.1.H.2.a,]

4.2.4 Design and construction shall consider the Federal Mine Safety and Health Act of 1977. The design shall include provisions for worker protection necessary to provide reasonable assurance that all SSC ITS can perform their intended functions. Any deviation from relevant design requirements in 30 CFR, Chapter I, Subchapters D, E (subchapters D and E are no longer used; they are now covered in parts 18-36) and N will give rise to rebuttable presumption that this requirement has not been met. [ESFDR 3.2.1.H.2.e]

4.2.5 Activities associated with installation, operation, maintenance, and removal of furnishings shall be conducted in a manner that limits, to the extent practical, adverse effects on the long-term performance of the potential geologic repository and on-site characterization testing. [ESFDR 3.2.1.4.F]

4.2.6 Procedures shall provide for routine inspection, maintenance, monitoring, and repair (as required) of components of the ground support system in both the Topopah Spring North Ramp and in associated alcoves and refuge chambers. The in-place testing and surveillance frequencies and repair criteria for these procedures should be based on review and evaluation of manufacturers' recommendations and standard mining practices. Maintenance or the addition of appurtenances shall not compromise the critical characteristics of the permanent function ground support in the Topopah Spring North Ramp or associated excavations. Post-installation welding on ground support components must consider the applicable sections of QARD Section 9.0. The inspection, maintenance, and repair procedures shall document work processes in conformance with 10 CFR 60.72 and shall be maintained as QA records. [ESFDR 3.2.1.4.B.1(a), 3.2.9.4.A, 3.2.1.M, 3.2.1.M.1, 3.2.2.4.D]

4.3 ASSUMPTIONS

Not Used.

4.4 CODES AND STANDARDS

4.4.1 American Institute of Steel Construction (AISC):

AISC M016-89 — Manual of Steel Construction, Allowable Stress Design, Ninth Edition.

4.4.2 American Society for Testing and Materials (ASTM):

ASTM A615-92 — Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement

5. REFERENCES

5.1 DIE for ESF Package 2C, Document Identifier (DI) BAB000000-01717-2200-00005 REV 04.

5.2 Rock Anchor Systems Catalog, No. 392, Williams Form Engineering Corp. Main Office & International Division, Grand Rapids, Michigan 49510 (Copyright 1992).

5.3 Topopah Spring North Ramp Ground Support Category 1, Elevation and Section, DI BABEAB000-01717-2100-40152 REV 01. BCP-02-95-0016.

5.4 Topopah Spring North Ramp Ground Support Category 2, Elevation and Section, DI BABEAB000-01717-2100-40153 REV 01. BCP-02-95-0017.

5.5 Topopah Spring North Ramp Ground Support Category 3, Elevation and Section, DI BABEAB000-01717-2100-40154 REV 01.

5.6 Rockbolts and Accessories, DI BABEAB000-01717-6300-02165 REV 04.

5.7 Material Dedication Analysis: Rockbolts, Shotcrete, and Accessories Procured as Commercial Grade Items, DI BABEAB000-01717-0200-00009 REV 01.

5.8 YMP/CM-0019 Revision 1, ICN-1, ESFDR, January 19, 1995.

5.9 Temporary Function Ground Support Plan, BABEAB000-01717-6300-02165-CD-10-0.

5.10 Roark, Raymond J. and Warren C. Young, Formulas for Stress and Strain. Fifth Edition.

5.11 Drift Design Methodology and Preliminary Application for the Yucca Mountain Site Characterization Project-Sandia National Laboratory (SNL) Report-SAND89-0837·UC-814 Printed December 1991.

6. COMPUTER PROGRAMS

Not Used.

7. DESIGN ANALYSIS

7.1 The constructor-approved Temporary Function Ground Support Plan (Reference Section 5.9) includes the installation of a channel that attaches to temporary function and permanent function rockbolts. The constructor will install the channel as a ringbeam element in conjunction with the welded wire fabric that spans the gap between temporary function and/or permanent function rockbolts that will prevent rock spalling and distribute the load while preventing loosened rock from falling. The ESF permanent function rockbolts are part of the Topopah Spring North Ramp ground support design.

The permanent function rockbolts have been classified as QA-1 and QA-5 (Reference Section 5.1). The channel, a temporary function item (QA: None), has been selected by the constructor. The DIE requires that interfaces between QA items and QA: None items be controlled (Reference Section 5.1, Section 11.3, Requirement 8).

This analysis addresses the potential interaction of the channel with the Q rockbolt to ensure that the ability of the permanent function rockbolt to perform its intended function is not compromised by the channel. The scope of this analysis does not cover the design of either the rockbolts or the channel.

7.2 The configuration of the channel is based on the excavated shape of the tunnel and the layout of the Q rockbolts (Reference Sections 5.3, 5.4, and 5.5).

The C10 x 15.3 channel has been proposed by the constructor as a part of the temporary function ground support to address personnel safety concerns in the area between the tunnel boring machine (TBM) and the trailing floor until the balance of the permanent function rockbolts are installed at the supplemental bolting platform. The C10 channel may be erected during the installation process of rockbolts and welded wire fabric. The installation of C10 channel shall be in compliance with the constructor's safety and construction procedures and in accordance with the design document (Reference Section 5.6, 5.7, and 5.9).

7.3 The calculations supporting the evaluation that the ability of the Q rockbolts perform their intended function is not compromised by the C10 channel are presented in detail in Section 7.4, Structural Evaluation Process, and Section 7.5, Lining and Ground Support Evaluation Process.

7.4 STRUCTURAL EVALUATION PROCESS

This calculation is performed to evaluate that the Q-rockbolts ability to perform their intended function is not hampered by the limited structural capacity of the C10 x 15.3 channel under the following rock loads:

A. Uniform ravilling rocks at tunnel crown applied as uniform radial load on the channel. (Case-I)

B. Concentrated ravilling rocks at tunnel crown--applied as point load at the channel mid-span (Case-II).

The C10 channel arrangement and length, and location of interaction points to Q-rockbolts is based on Reference Section 5.3, 5.4, 5.5, and 5.9.

The combined bending and axial stresses that can be induced to the channel is considered equal to $F_u = 58^{ksi}$ (ASTM A-36 minimum tensile strength) to ensure that the reaction obtained is maximum.

The following parameters are used in this calculation:

A. Hole in rock for rockbolt: 2 1/4 inch diameter (nominal) (Reference Section 5.6, Paragraph 2.01.C.3a).

B. Q-rockbolts: 1 1/8 inch diameter and 10 foot long (nominal) (Reference Section 5.3, 5.4, 5.5, and 5.6 Paragraph 2.01.C.2).

C. Rockbolts pullout working capacity: 37,500 pounds (Reference Sections 5.1, 5.7 and 10.4.1). For this analysis a rockbolt pullout capacity equal to 47,400 pounds is used (Reference Sections 7.5.2 and 7.5.3).

D. The allowable shear stress of $F_v = 0.40F_y = 18.90^{ksi}$ (AISC eq. F4-1) is used for this analysis.

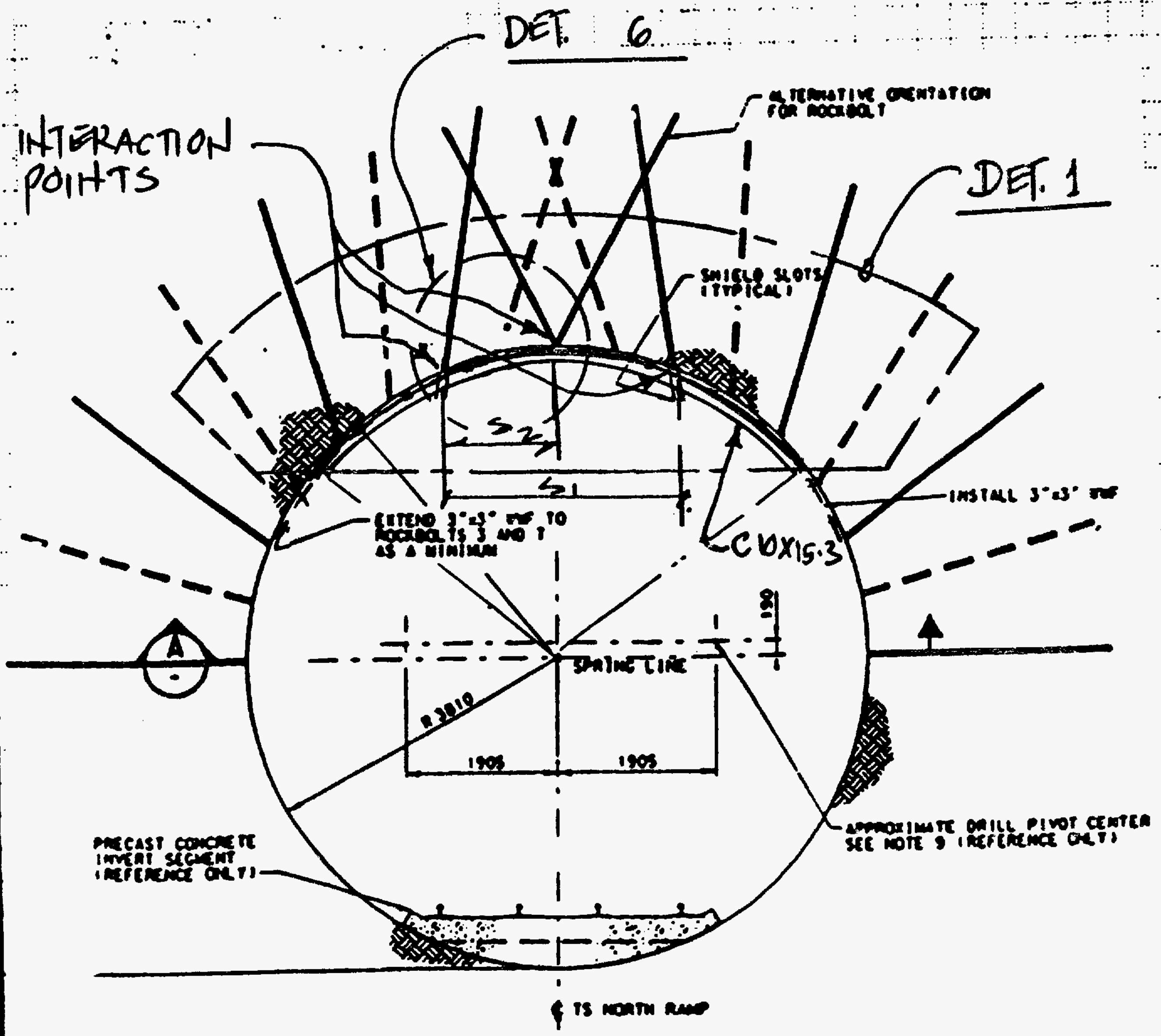
E. The interaction point location and the channel geometry that are shown on typical tunnel cross section, Det. 1 and Section B are based on Reference Sections 5.3, 5.4, 5.5, and 5.9.

The following are considered in this analysis.

A. Permanent function rockbolts are installed in the TBM tail shield area at nominal spacing of S_1 (Condition-I).

B. Additional temporary function rockbolts may be installed as needed for safety in the TBM tail shield area at nominal distance S_2 from permanent function rockbolts (Condition-II).

ROCKBOLTS PATTERN (REF. 5.3, 5.4 AND 5.5)



TYPICAL TUNNEL CROSS SECTION

S_1 = DISTANCE BETWEEN INTERACTION POINT (CONDITION-1)

S_2 = DISTANCE BETWEEN INTERACTION POINT (CONDITION-II)

CALCULATION (CASE-1 AND CONDITION 1)

CHANNEL GEOMETRY - SHOWN ON DET 1 & SECT. B. (REF. 6.9)

C10X15.3 CHANNEL PROPERTIES (AISC 1-40 & 1-41)

$A = 4.49\ in^2$ $\bar{X} = 0.634\ in$

$S_x = 13.5\ in^3$ $d = 10\ in$

$S_y = 1.16\ in^3$

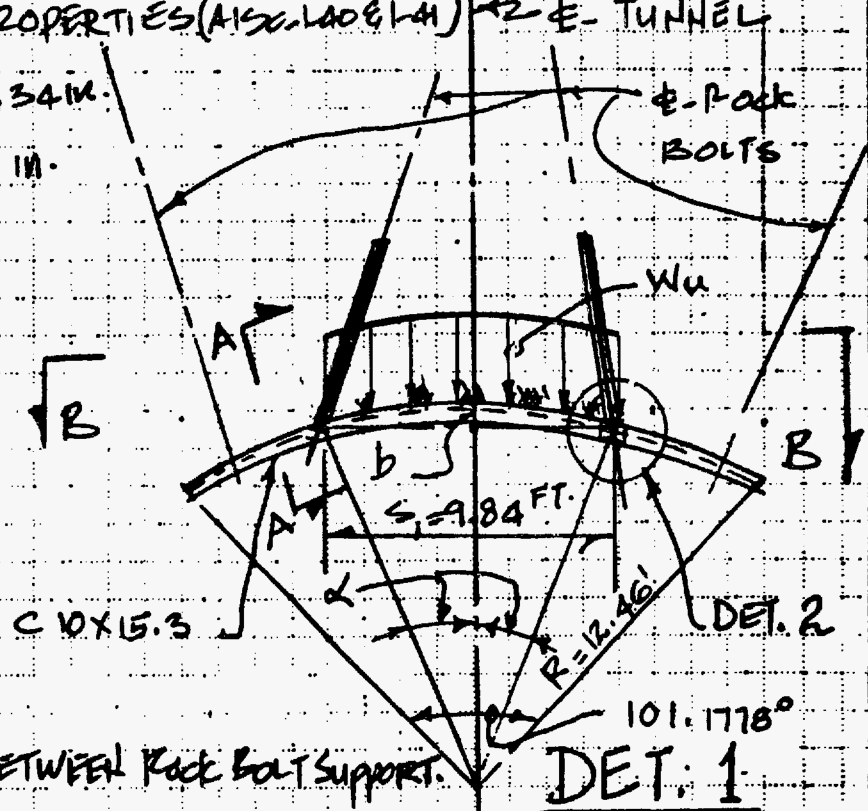
$t_w = 0.24\ in$

$I_y = 2.28\ in^4$

$I_x = 67.4\ in^4$

$r_x = 3.87\ in$

$r_y = 0.713\ in$



DET. 1

LEGEND

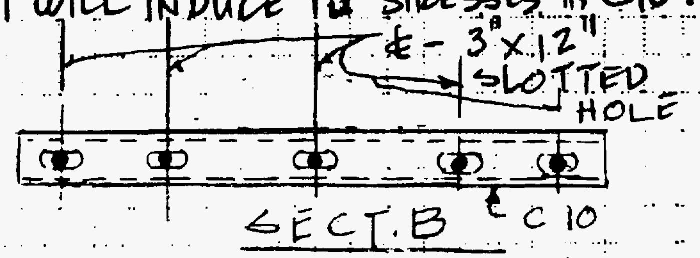
b = RISE IN CHORD BETWEEN ROCK BOLT SUPPORT.

f_c = COMBINED AXIAL & BENDING STRESSES IN THE CHANNEL (MAX.)

T_A = MAXIMUM RING / CHANNEL THRUST WHICH WILL INDUCE F_u

T_{cb} = MAXIMUM CHANNEL THRUST DUE TO CRITICAL BUCKLING

W_u = UNIFORM LOAD THAT WILL INDUCE F_u STRESSES IN C10. (CASE-1)



$\sin\alpha = \frac{4.92'}{12.46}$, $\alpha = 23.26°$

$b = R(1 - \cos\alpha)$

$b = 12.46(1 - \cos 23.26) = 1.01$ FT

CALCULATION (CASE-1 AND CONDITION-I)

INTERACTION POINT - SHOWN ON DET-2 & SECT. A

$b_1 = b - \bar{x}$

$b_1 = 1.01 - \dfrac{0.634''}{12''/FT}$

$b_1 = 0.957 FT = 11.49 in$

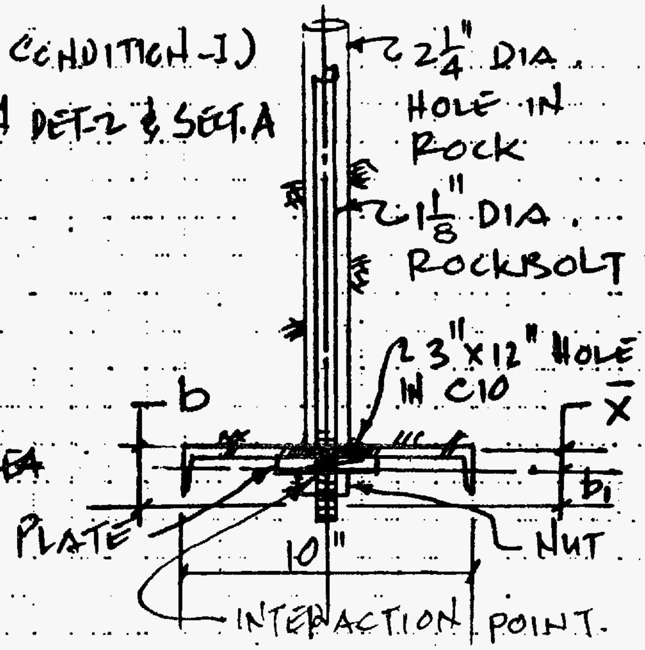
A_N = CHANNEL SECTION NET AREA

$A_N = A - 3''(t_w)$

$A_N = 4.49 - 3''(0.24'')$

$A_N = 3.77 \, in^2$

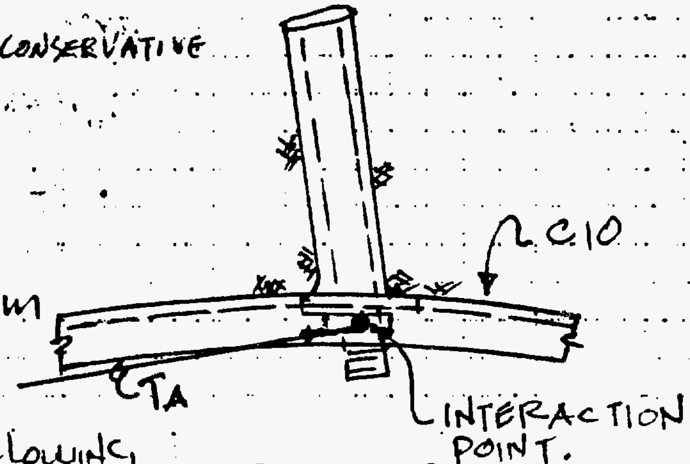
$S_Y = 1.16 \, in^3$ (A REDUCTION IN S_Y WILL INCREASE T_A ∴ USE NO REDUCTION FOR S_Y IS CONSERVATIVE FOR ROCK BOLT LOAD).



SECTION A

(ROCKBOLT & CHANNEL CONNECTION)

TO SOLVE FOR MAXIMUM AXIAL LOAD T_A IN C10 CHANNEL THE FOLLOWING EQUATIONS ARE USED EQ. 1 & 2 ON NEXT PAGE.



DET. 2

(INTERACTION POINT)

$$F_U = \frac{T_A}{A_N} + \frac{M}{S_Y}$$ ——— EQUATION 1 - (COMBINED AXIAL AND BENDING STRESSES)

$$M = (b - \frac{t_w}{2})T_A = 12\,T_A$$ ——— EQ. 2 (BENDING MOMENT ON C10 CHANNEL)

SUBSTITUTE EQUATION 2 TO EQ. 1 AND SOLVE FOR T_A

$$F_U = \frac{T_A}{A_N} + \frac{12T_A}{S_Y}$$

$$F_U = \frac{T_A S_Y + 12\,T_A A_N}{A_N S_Y}$$

$$T_A S_Y + 12 T_A A_N = F_U A_N S_Y$$

$$T_A = \frac{F_U A_N S_Y}{S_Y + 12 A_N}$$

$$T_A = \frac{58\,(3.77)\,(1.16)}{1.16 + 12 * (3.77)}$$

$$T_A = \frac{253.65}{46.4}$$

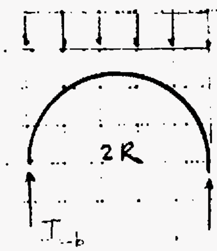
$$T_A = 6.47^k = 5{,}470 \text{ lb}$$

CALCULATION (CASE-I AND COND-I)

$$P \simeq \frac{3EI_y}{R^3}$$ — C10 CHANNEL LOAD FROM EQUATION FOR CRITICAL BUCKLING REF. 5.10 PAGE- 343. THIS IS AN APPROXIMATE MODEL.

E = MODULUS OF ELASTICITY OF STEEL = 29×10^3 KSI

$R = 12.46^{FT} = 149.52$ IN.



lb PER LINEAR INCH

$$\therefore P' = \frac{3(29\times10^3)(2.28)}{(149.52)^3} \times 12''$$

$P' = 0.712^{K/FT}$ /CHANNEL

$$T_{cb} = \frac{0.712 \times (2 \times 12.46)}{2} = 8.87^K > T_A$$ THE C10 WILL FAIL THEREFORE USE T_A.

$$\therefore W_u = \frac{T_A}{d},$$ d = 4 FT MAX. CHANNEL SPACING IN LONGITUDINAL DIRECTION OF THE TUNNEL (REF 5.3, 5.4 & 5.5)

USE 5 FT TO INCLUDE MAX. TOLERANCE.

$$W_u = \frac{5.47 \times 1000}{5^{FT} \times (12.46^{FT})}$$

$W_u = \underline{\underline{87.8}}$ lb/FT^2

$T_A = 5.47^K$ MAXIMUM AXIAL LOAD ON THE C10 CHANNEL

CALCULATION (CASE-1 AND COND. 1)

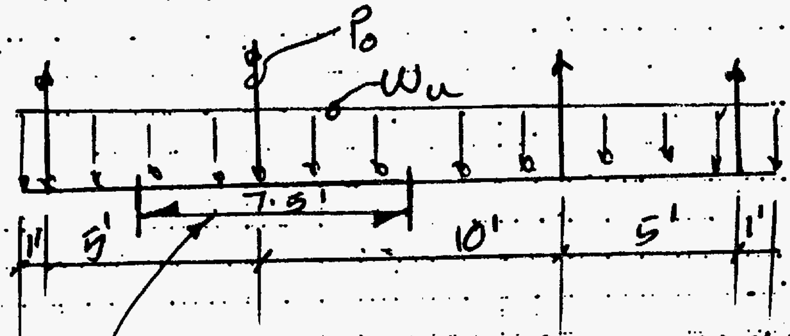
CALCULATION FOR PULLOUT REACTION FROM W_u

$W_u = 87.8$ lb/FT²

OR

$W_u = 87.8$ (5) PLF

$= 440$



C10 CHANNEL DEVELOPED VIEW (REF. 5.9)

TRIBUTARY AREA FOR MAXIMUM PULLOUT FORCE

P_o = Maximum Pullout Force

$P_o = W_u (7.5)$

$P_o = 440 \times (7.5)$

$P_o = 3,300$ lb

CALCULATION (CASE-1 AND COND-II)

CALCULATION FOR W_u

$$\sin \alpha = \frac{2.46}{12.46}$$

$$\alpha = 11.39^\circ$$

$$b = R(1 - \cos\alpha)$$

$$b = 12.46(1 - \cos 11.39^\circ)$$

$$b = 0.25^{FT} = 3.0 \text{ IN.}$$

$$b_1 = 0.25 - \frac{0.634}{12}$$

$$b_1 = 0.20 \text{ FT} = 2.4 \text{in.}$$

$$T_A = \frac{F_b (A_N)(S_y)}{S_y + (b_1 - \frac{t_w}{2})A_N} \quad \text{— EQ.-3}$$

$$T_A = \frac{58(3.77)(1.16)}{1.16 + 12 \times (3.77)}$$

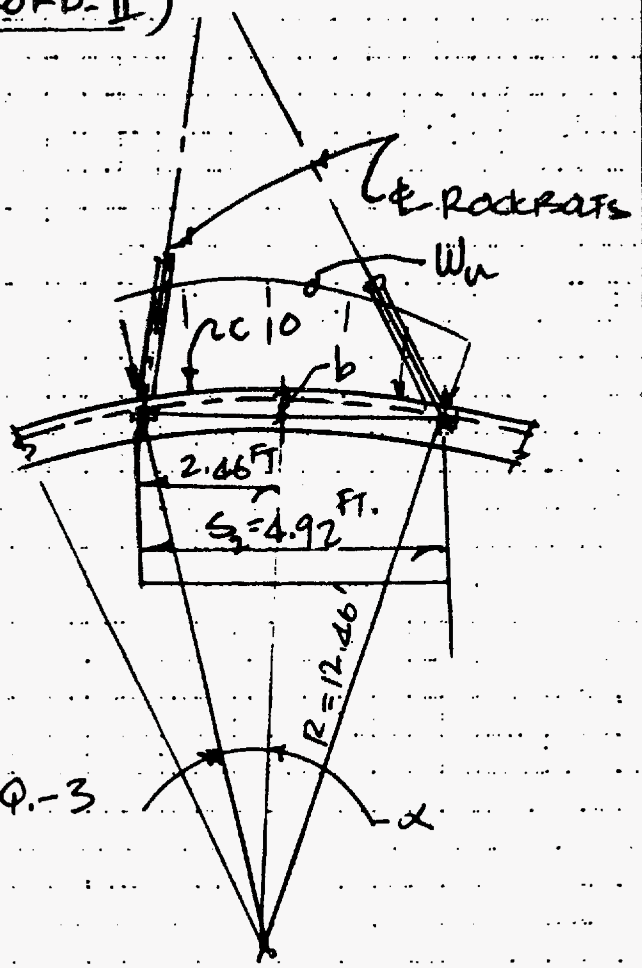
$$T_A = \frac{253.65}{46.4}$$

$$T_A = 5.47^k$$

$T_A < T_{cb} = 8.87^k$ — C10 CHANNEL WILL FAIL FOR T_A.
(THEREFORE USE T_A)

$$W_u = \frac{T_{cb}}{d(R)} = \frac{5.47^k (1000^{lb/k})}{{}^{-FT}(12.46^{FT})}$$

$$W_u = 37.8 \text{ lb/FT}^2$$



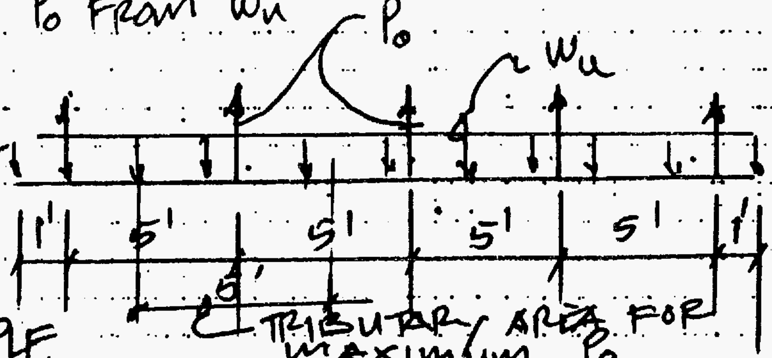
DET. 6 (REF. 5.9)

CALCULATION (CASE-1 AND COND-II)

CALCULATION FOR P_o FROM W_u

$W_u = 87.8$ lb/FT^2

P_o = MAXIMUM PULLOUT FORCE



C-10 CHANNEL DEVELOPED VIEW
(REF. 5.9)

$W_u = 87.8\ (5) = 439.0$ PLF

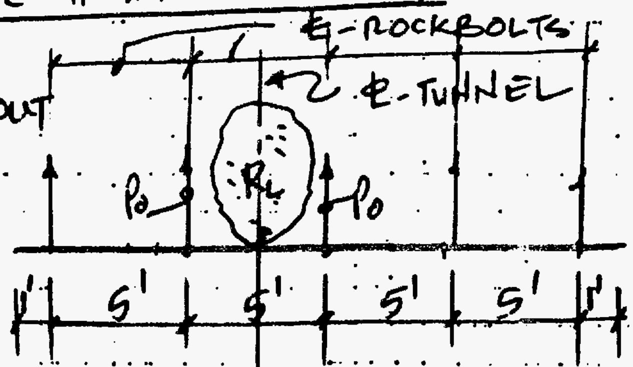
$P_o = W_u (5)$

$P_o = 439.0\ (5)$

$= 2,195.0$ lb

CALCULATION (CASE-II AND COND-II)

CALCULATION FOR FULL OUT REACTION FROM ROCK LOAD.



C-10 CHANNEL DEVELOPED VIEW (REF. 5.9)

R_L = ROCK CONCENTRATED AT CHANNEL MIDSPAN

$f_b = \frac{M}{S_y}$, $F_b = 58^{ksi}$

$M = \frac{R_L (5)(12)}{4} = 15.5\ R_L$ in-k

$\therefore\ 58 = \frac{15.50\ R_L}{1.16}$

$R_L = 4.485^{k} = 4{,}485^{lb}$

$P_0 = \frac{R_L}{2}$

$P_0 = \frac{4{,}485^{lb}}{2}$

$P_0 = 2{,}243^{lb}$

CALCULATION (CASE-II COND-I)

CALCULATION FOR PULL OUT REACTION FROM ROCK LOAD.

R_L = ROCK CONCENTRATED AT CHANNEL MID-SPAN

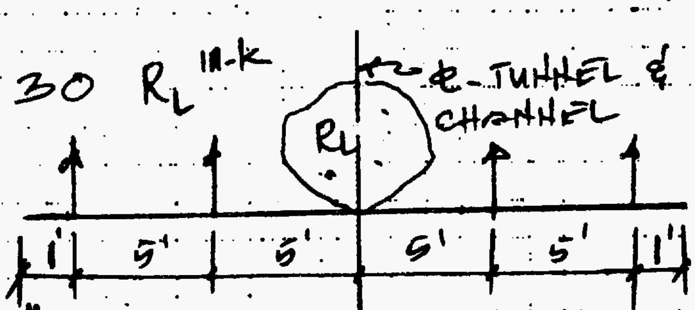
$f_b = \frac{M}{S_y}$, $F_u = 58^{ksi}$

$M = \frac{R_L(10)(12)}{4} = 30\ R_L^{\ in\text{-}k}$

$\therefore 58 = \frac{(30)R_L}{1.16}$

$R_L = 2.24^{\,k} = 2240^{lb}$

$P_0 = \frac{2240}{2} = \underline{1120\ lb}$



C10 CHANNEL DEVELOPED VIEW
(REF. 5.9)

STRUCTURAL EVALUATION SUMMARY-(REF. PAGE 7 - 17)

LOADING CASE AND CONDITION	ROCK LOAD	Φ ROCKBOLT LOADS IMPACTED BY THE C10 REACTIONS	
		○ SHEAR	○ AXIAL LOADING
CASE-I AND CONDITION I	87.8 lb/FT²	Δ 5,470 lb	Δ 3,300 lb
CASE-I AND CONDITION II	178.0 lb/FT²	Δ 5,470 lb	Δ 2,195 lb
CASE-II AND CONDITION II	2,740 lb		Δ 1,120 lb
CASE-II AND CONDITION I	4,485 lb		Δ 2,243 lb

Δ = C10-CHANNEL REACTIONS

○ = Φ-ROCKBOLT CRITICAL CHARACTERISTIC.

7.5 LINING AND GROUND SUPPORT EVALUATION

7.5.1 ESF Ground Support Design Bases

The design of the lining and ground support in the ESF follows the "Drift Design Methodology" (Reference Section 5.11) which was developed by SNL for the Mined Geologic Disposal System repository design. This approach designs the lining and ground support components and systems with identified rock mass thermal mechanical units as interactive structures.

The design method selects a ground support system based upon empirical methods for identified ranges of rock mass parameters. In the case of rockbolts, the empirical method recommended the rockbolts system (i.e., size, type and length of rockbolts, and pattern spacing between rockbolts). These rockbolt system parameters and the rock mass parameter are then used to model the reinforced rock structure under static and dynamic (seismic) loading conditions to ensure the stability of the structure. The method does not solve for the magnitude of stress applied to any of the rockbolts in the system. However, the loading condition is bounded from zero loading (ground where rockbolts are not needed to provide stability) to a maximum usage of allowable loading as defined by the input parameter of the rockbolt.

7.5.2 Evaluation Criteria

The DIE requirement 8 states ". . .the addition of appurtenances shall not compromise the critical characteristics of the permanent function ground support in the Topopah Spring North Ramp. . . ." (Reference Section 4.2.6). The Material Dedication Analysis (Reference Section 5.7) states ". . .tensile strength is a critical characteristic for all rockbolts. The tensile strength is also important to resist shearing movements, which is a potential failure mode. . ." and "ASTM A615 grade 60, #8 bar size is the minimum strength bolt that will satisfy the force requirements." Therefore, the axial loading and the cross sectional area shear of the #8 grade 60 bar are the critical characteristic criteria that must not be compromised.

In case of axial loading, the maximum loading is combined loading of the ground support loading with the axial loading from the channel. Therefore, strength capacity equal to or greater than the minimum criteria must remain after deducting the maximum possible channel loads from the actual capacity of the Williams Rockbolt. In the case of shear, the channel is attached at the rock surface, where shear from differential rock movement is not possible, so that shear loading is not a combined load. Therefore, only capacity of the bolt to resist shear is necessary to prevent damage.

7.5.3 Summary of Evaluation

Yield Strength (William B7X) = 60,000 lbs
Area = .68 $inch^2$
ASTM A 615 #8 Bar - Grade 60 (Reference Section 4.4.2)
Area = .79 $inch^2$
F_y = 60 ksi

Yield Strength (#8 - Grade 60) = F_y x Area = 47,400 lbs

Axial loading calculations

Case I, Condition I
60,000 lbs - 3,300 lbs = 56,700 lbs
Case I, Condition II
60,000 lbs - 2,195 lbs = 57,805 lbs
Case II, Condition I
60,000 lbs - 1,120 lbs = 58,880 lbs
Case II, Condition II
60,000 lbs - 2,243 lbs = 57,757 lbs

Axial loading calculated in the preceding "Structural Evaluation Summary" for all cases and conditions in the remaining axial loading capacity is greater than the 47,400 pounds. Therefore, the critical characteristics of the permanent rockbolts are not compromised.

Shear calculations

Maximum Shear F_v = 18.90 ksi . (Reference Section 7.4)

Case I, Condition I
5,470 lbs/.68 $inch^2$ = 8.0 ksi
Case I, Condition II
5,470 lbs/.68 $inch^2$ = 8.0 ksi

Therefore, the shear loading is less than allowable shear stress and critical characteristics are not compromised.

8. CONCLUSIONS

The information in Sections 7.4 and 7.5 indicate that a C10 x 15.3 channel can be loaded to failure, and that the resulting reactions (forces) at the interface to the specified 1 1/8-inch-diameter B7X Williams rockbolt will not create an adverse impact to the critical characteristics of the permanent rockbolts.

8.1 QA CONTROL

Under no circumstance shall the installed position of the temporary supports interfere in a manner that precludes installation of the permanent function rockbolts as shown on the drawings (Reference Sections 5.3, 5.4, and 5.5).

8.2 QA CONTROL

Any temporary function ground support materials that are not removed shall be recorded and reported in accordance with the Tracers, Fluids, and Materials Management Plan.

9. ATTACHMENTS

Not Used.