Robert L. Cloud and Associates, Inc.

RLCA

Interim Technical Report

DIABLO CANYON UNIT 1
INDEPENDENT DESIGN VERIFICATION PROGRAM
SOILS REPORT - INTAKE STRUCTURE
SLIDING RESISTANCE
ITR # 40
REVISION 0

Docket No. 50-275
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Dr. R. McNeill
Technical Review

3/9/83
Project Engineer/Date
Technical Review

3/9/83
Project Manager/Date
Approved P 105-4-839-040

PROGRAM MANAGER'S PREFACE

DIABLO CANYON NUCLEAR POWER PLANT - UNIT 1
INDEPENDENT DESIGN VERIFICATION PROGRAM

INTERIM TECHNICAL REPORT

SOILS - INTAKE STRUCTURE SLIDING RESISTANCE

This is the fortieth of a series of Interim Technical Reports prepared by the DCNPP-IDVP for the purpose of providing a conclusion of the program.

This report provides the review results and conclusions of the IDVP with respect to the review of soils - intake structure sliding resistance. No EOI files were initiated as a result of this IDVP verification effort.

As IDVP Program Manager, Teledyne Engineering Services has approved this ITR-40, including the conclusions presented. The methodology followed by TES in performing this review and evaluation is described in Appendix B to this report.

ITR Reviewed and Approved
IDVP Program Manager
Teledyne Engineering Services

W. E. Gorgen for
R. Wray
Assistant Project Manager

SOILS REPORT-INTAKE STRUCTURE,

SLIDING RESISTANCE

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1.0 INTRODUCTION

Purpose and Scope

This interim technical report summarizes the review by the Independent Design Verification Program (IDVP) of the sliding resistance, which is included in the soils analyses for the intake structure at Diablo Canyon Nuclear Power Plant, Unit 1 (DCNPP-1).

The IDVP Phase I Plan specifies that Robert L. Cloud Associates review the soils analyses performed by PGandE's seismic service-related contractor, Harding Lawson Associates (HLA). For their soils analyses, HLA examined the following areas: intake structure, outdoor water storage tanks, buried diesel fuel oil tanks and connecting lines, and buried auxiliary saltwater piping.

For the intake structure, the HLA analyses included a lithology definition, backfill property definition, bearing capacity calculations, lateral earth pressure calculations and sliding forces calculations. All but the last of these subjects has been verified and described in previous reports.

This report presents the IDVP review of the HLA postulated sliding surface and resistive forces. This information was used in a subsequent structural review to determine the factor of safety against sliding. The IDVP will address this subject in a later report on the structural review of the intake structure.

ITR #13, Revision 0, describes the IDVP review of bedrock depth determination and backfill property definition for the intake structure (Reference 6). ITR #39, Revision 0, describes the IDVP review of bearing capacity and lateral earth pressure (Reference 13).

The balance of the IDVP soils review both for the intake structure and the other areas will be presented in separate ITRs. These will include a review of possible changes that may have occurred which affect either the surface or subsurface condition (e.g., additional roadways).

This report is one of several interim technical reports of the Independent Design Verification Program (IDVP). Interim technical reports include references, sample definitions and descriptions, methodology, a listing of Error and Open Items, an examination of trends and concerns, and a conclusion (Reference 1). This report presents the results of the IDVP intake building sliding resistance review and serves as a vehicle for NRC review. It will also be referenced in the Phase I Final Report.

Summary

The IDVP has completed the review of the Harding Lawson Associates' (HLA) soils work for the DCNPP-1 intake structure. The IDVP performed independent calculations, examined HLA reports, and compared results.

Both the HLA postulated sliding surface and resistive forces were found to either agree with IDVP results or to give conservative results. Therefore, the HLA intake sliding resistance conclusions were determined to be acceptable.

Background

On September 28, 1981 PGandE reported that a diagram error had been found in a portion of the seismic qualification of the Diablo Canyon Nuclear Power Plant Unit 1. This error resulted in an incorrect application of the seismic floor response spectra for sections of the annulus of the Unit 1 containment building. The error originated when PGandE transmitted a sketch of Unit 2 to a seismic service-related contractor. This sketch contained geometry incorrectly identified as Unit 1 geometry.

As a result of this error, a seismic reverification program was established to determine if the seismic qualification of the plant was adequate for the postulated Hosgri 7.5M earthquake. This program was presented orally to the NRC in a meeting in Bethesda, Maryland on October 9, 1981.

Robert L. Cloud and Associates (RLCA) presented a preliminary report on the seismic reverification program to the NRC on November 12, 1981 (Reference 2). This report dealt with an examination of the interface between URS/Blume and PGandE.

The NRC commissioners met during the week of November 16, 1981 to review the preliminary report and the overall situation. On November 19, 1981 an Order Suspending License CLI-81-30 was issued which suspended PGandE's license to load fuel and conduct low power tests up to 5% of rated power at DCNPP-1. This suspending order also specified that an independent design verification program be conducted to ensure that the plant met the licensing criteria.

PGandE retained Robert L. Cloud and Associates as program manager to develop and implement a program that would address the concerns cited in the order suspending license CLI-81-30. The Phase I Plan for this program was transmitted to the NRC staff in December 1981 and discussed on February 3, 1982. Phase I deals with PGandE internal activities and seismic service-related contracts prior to June 1978.

On March 19, 1982 the NRC approved Teledyne Engineering Services (TES) as program manager to replace Robert L. Cloud and Associates (RLCA). However, RLCA continued to perform the independent review of seismic, structural, mechanical and geotechnical aspects of Phase I.

The NRC approved the Independent Design Verification Program Phase I Engineering Program Plan on April 27, 1982 (Reference 3). This plan dictates that a sample of piping, equipment, structures and components be selected for independent analysis. The results of these analyses are to be compared to the design analyses results. If the acceptance criteria is exceeded, an Open Item Report is to be filed. Interim technical reports are to be issued to explain the progress of different segments of the technical work.

As part of Phase I Program, Roger F. Reedy, Inc. (RFR) performed a quality assurance (QA) review of PGandE and seismic service-related contractors prior to June 1978 which included the firm of Harding Lawson Associates (HLA). The results of these QA reviews showed that Harding Lawson Associates did not implement a quality assurance program for the DCNPP-1 soils work. As a result, RLCA and Dr. Robert McNeill formulated a review program to verify the HLA soils work (Reference 4).

In addition to the intake structure, the balance of the review program included the outdoor water storage tanks, auxiliary saltwater piping and diesel fuel oil tanks. For the outdoor water storage tanks, the HLA analysis included a lithology definition, material property definition and bearing capacity calculations. The IDVP review of this HLA work is presented in ITR #16, Revision 0 (Reference 5). For the auxiliary saltwater piping and diesel fuel oil tanks, the HLA analyses included a lithology definition, material property definition and finite element analysis.

For intake structure, the HLA analyses included a lithology definition, backfill property definition, lateral earth pressure calculations, sliding force calculations and bearing capacity calculations.

ITR #13, Revision 0 presents the IDVP review of the bedrock depth and backfill property definition for the HLA intake structure analyses (Reference 6). ITR #39, Revision 0 presents the IDVP review of the HLA lithology definition, bearing capacity and lateral earth pressure calculations for the intake structure (Reference 13).

2.0 IDVP REVIEW METHOD AND RESULTS

Robert L. Cloud and Associates, together with Dr. Robert McNeill, reviewed HLA work, which consisted of postulating the sliding surface and determining resistive forces. RLCA engineers and Dr. Robert McNeill also toured the DCNPP site to examine exposed rock and in-situ backfill.

The intake structure is a reinforced concrete building 240 feet by 100 feet by 50 feet. It is founded on a grout mudmat poured neat to bedrock. Three sides have been backfilled to grade. Figure 1 shows a plan view of the intake structure and control building. Figure 2 shows the section view of the intake structure. These figures include approximate dimensions and elevations.

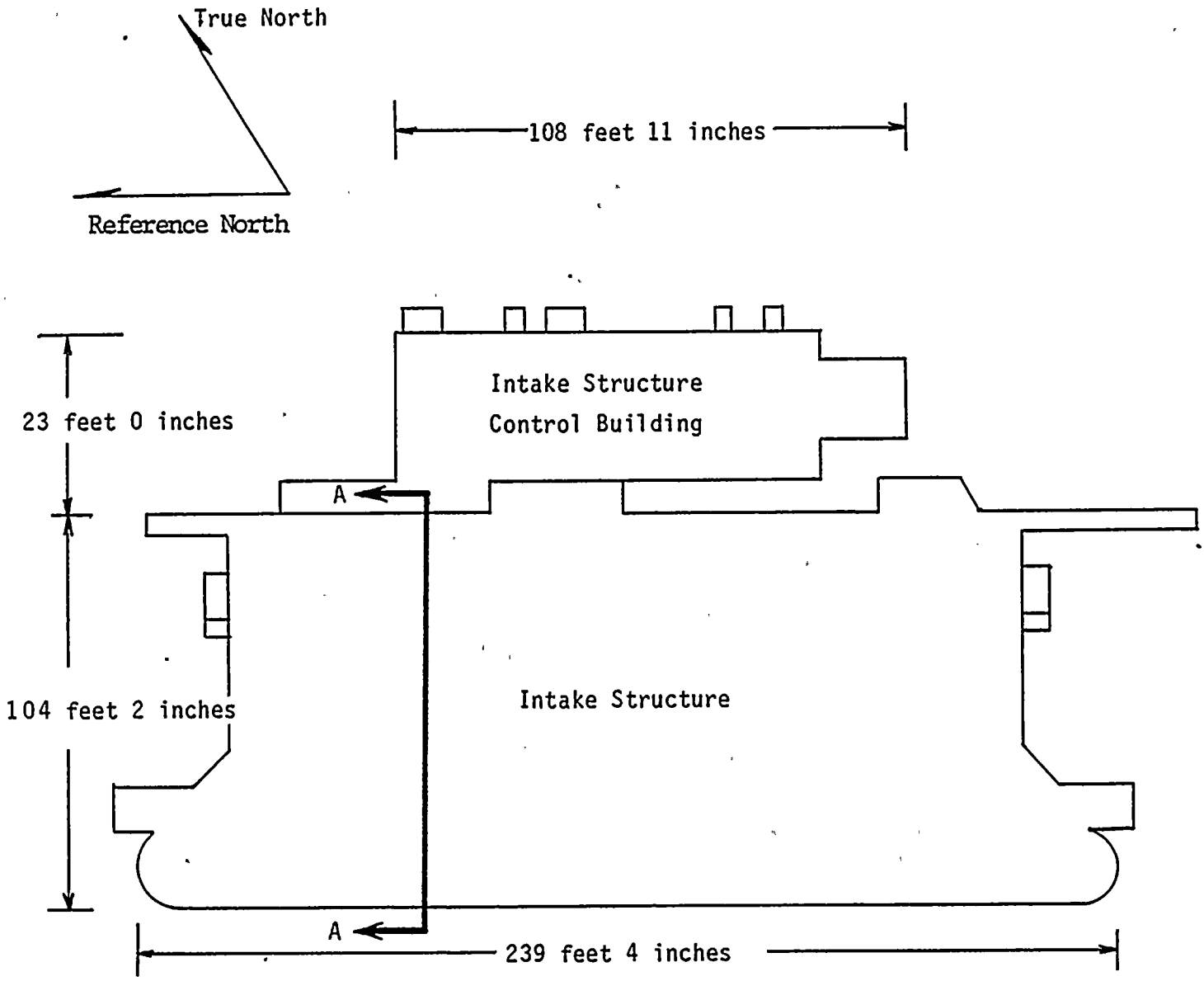


Figure 1

Intake Structure and Control Building

Plan View

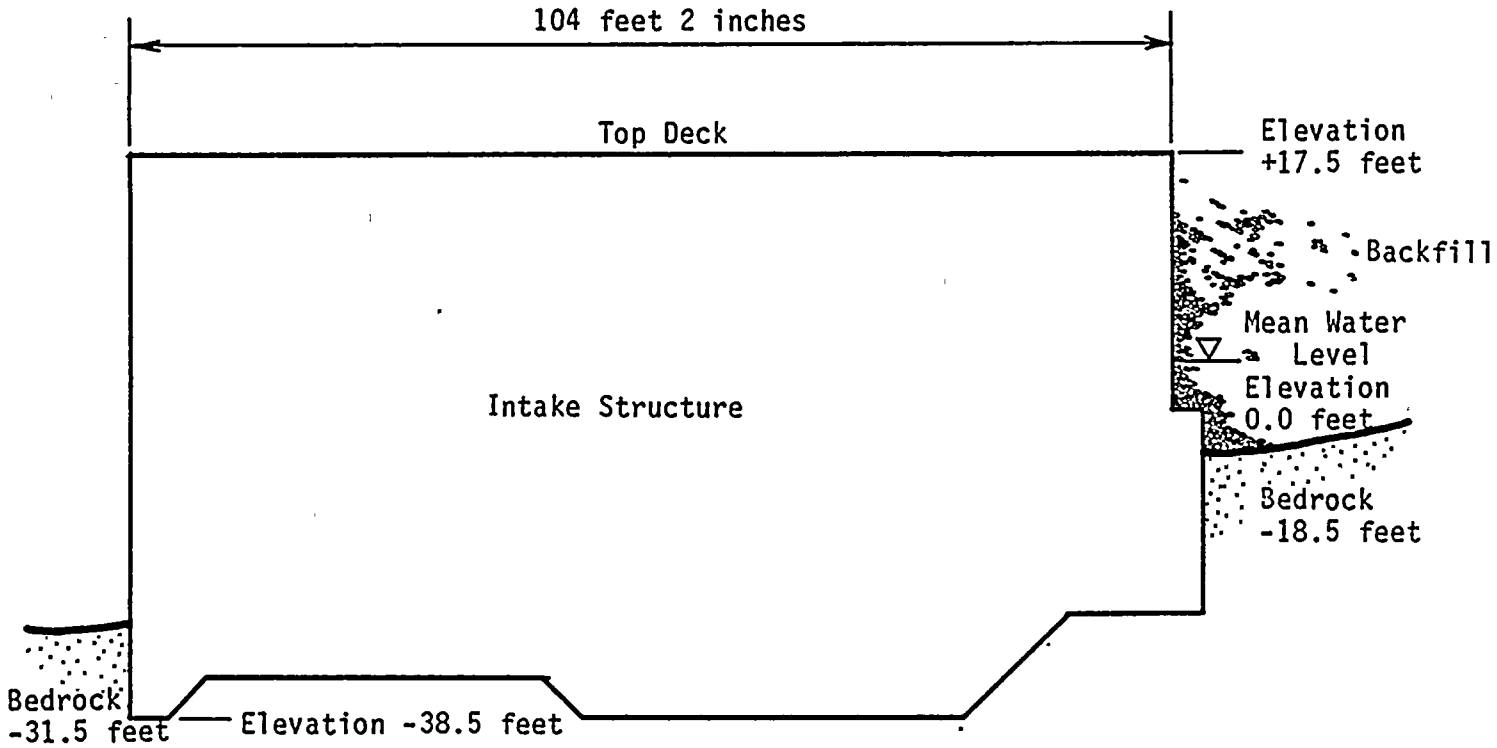


Figure 2

Intake Structure - Section View A-A
Outline Only

2.1 HLA Specifications

In 1978, Harding Lawson Associates (HLA) determined the postulated sliding surface and resistance factors for the intake building (References 8 and 9). Postulated sliding surface was defined as shearing action through the bedrock between the two shear keys (see Figures 3 and 4). Resistance factors included:

- o Resistance to shear between the two shear keys.
- o Resistance to sliding along the remaining length of the base as (weight reduced by the effect of vertical acceleration) times (tangent of the angle of internal friction).
- o Resistance to sliding due to passive pressure on the western shear key as (2) times (cohesion).

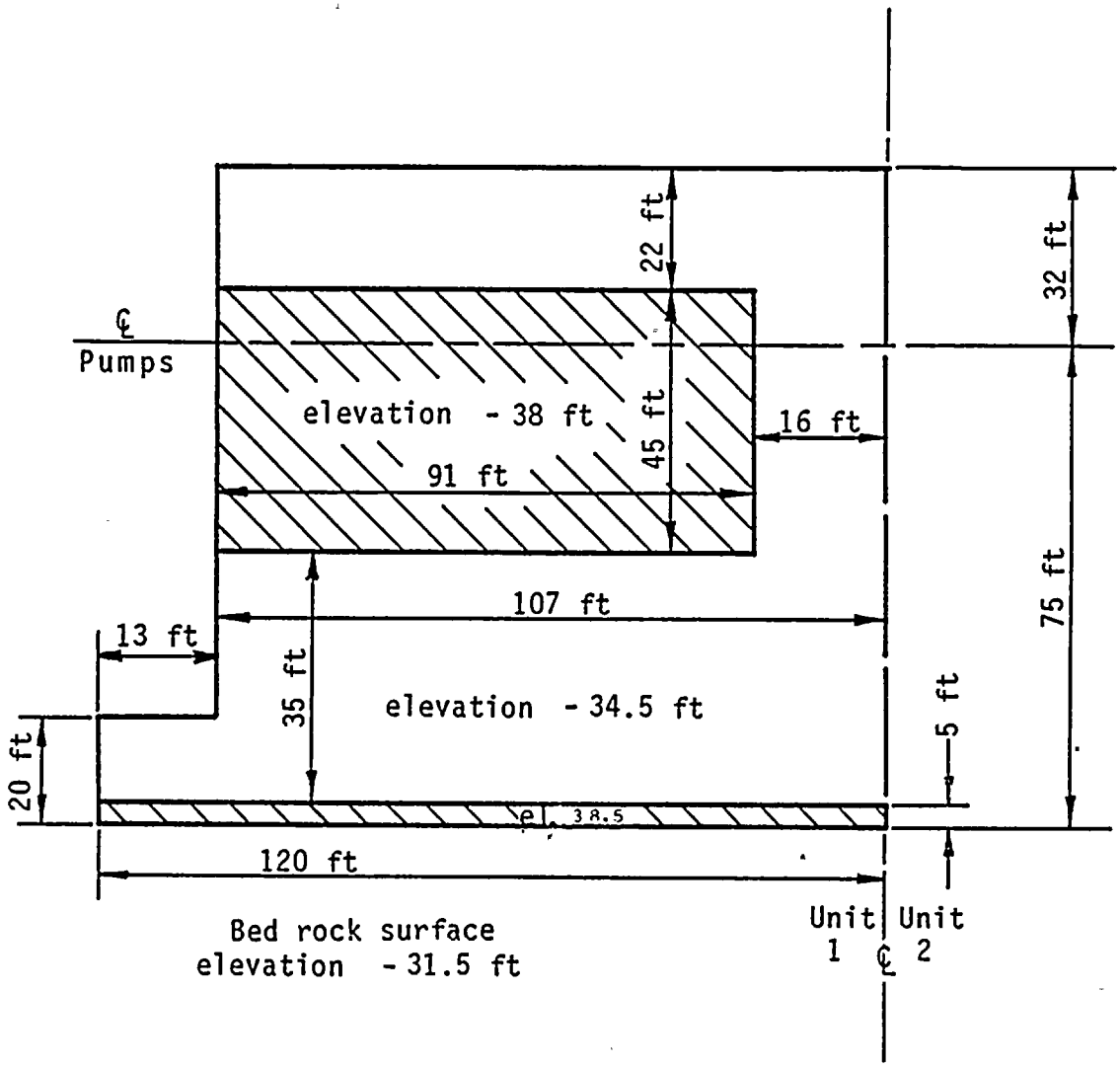
2.2 IDVP Review and Calculations

To verify the HLA work, the IDVP postulated the sliding surface and determined the resistance factors for the intake structure (Reference 10).

Figure 3 shows the interface between the intake structure and the bedrock which the IDVP determined by reviewing the concrete lift-pour drawings. The IDVP postulated the sliding surface shown in Figure 4.

The IDVP determined three resistance factors:

- o Resistance to shear between the two shear keys.
- o Resistance to sliding along the remaining length of the base as (buoyant weight reduced by the effect of vertical acceleration) times (coefficient of friction = .6).
- o Passive pressure west of the outboard resistance along a 2 to 1 horizontal to vertical slope.



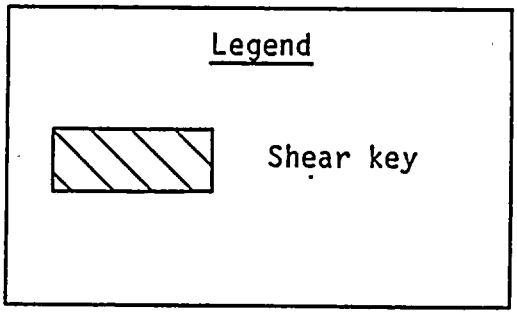
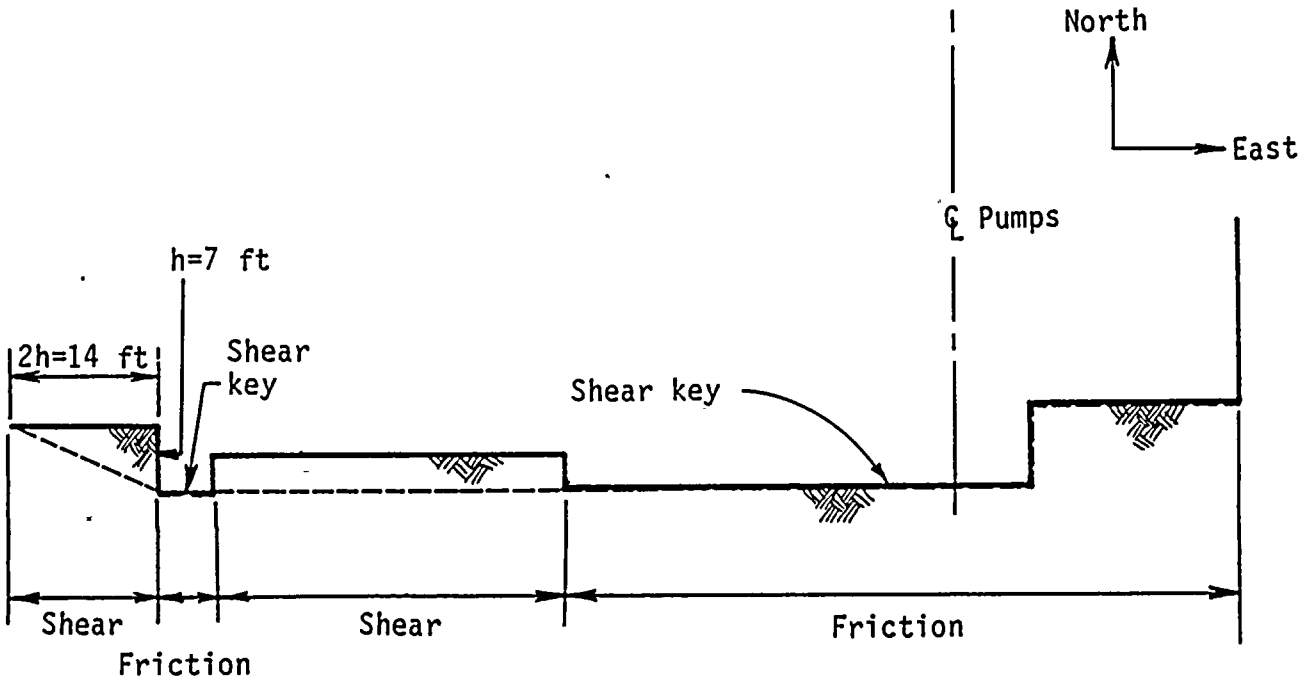


Figure 3

Intake Structure Foundation
Plan View



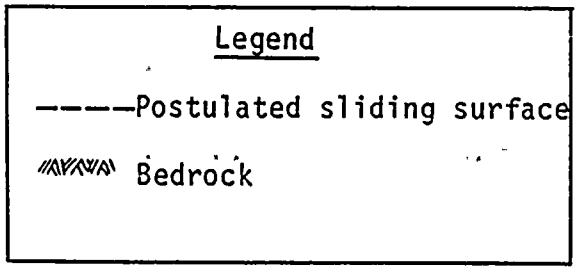


Figure 4

Intake Structure
Foundation Profile A-A

2.3 IDVP/HLA Comparison

A comparison of the IDVP and HLA methods for postulating sliding surface and determining resistive forces showed that the two analyses were similiar with the following three exceptions:

1. The IDVP accounted for the resistive action west of the outboard key as shear along a 2 to 1 horizontal to vertical slope. HLA accounted for this action by calculating (2) times cohesion (c).

   Shearing Resistance to Sliding in Western Shear Key

HLA	IDVP
2 (c) h	$c\sqrt{h^2 + (2h)^2}$
2 (3ksf) 7 ft	3 ksf (15.7 ft)
= 42 k/ft	= 47 k/ft

   where

   c = 3 ksf
   h = 7 ft (see Figure 4)

2. The IDVP used a 0.6 frictional coefficient. This frictional coefficient corresponds to concrete on gravel or coarse sand (Reference 11) and will yield conservative values. HLA used a tangent of the angle of friction of the rock material. This angle (30 degrees) is discussed in ITR #39 (Reference 13).

   Frictional Resistance to Sliding Along Remaining Length of Base

HLA	IDVP
Tan (ø)	0.6 (Reference 11)
Tan 30 degrees = .58	

3. The IDVP explicitly defined the structure's buoyant weight. Although HLA did not specifically address buoyant weight, subsequent design calculations for factor of safety against sliding considered buoyant weight effects (Reference 12).

The differences in the HLA and IDVP results have been examined. As shown previously, the HLA results for cases 1 and 2 produce smaller (conservative) resistive forces. While the HLA results did not explicitly specify a bouyant structural weight, the IDVP determined that it was considered in a subsequent design analysis. Therefore, this difference had no impact.

3.0 EOI REPORTS

No EOI reports were issued as a result of the IDVP verification of the intake structure sliding resistance.

4.0 EVALUATION

The IDVP examined the HLA soils work for the intake structure related to the sliding resistance. A review of the HLA specifications for postulated sliding surface and resistive forces was conducted and independent calculations were performed. A comparison of IDVP and HLA results shows the HLA sliding resistance work to be acceptable.

5.0 CONCLUSION

The HLA soils work related to sliding resistance of the intake structure has been found acceptable by the IDVP.

6.0 REFERENCES

References	Title	RLCA File No.
1	DCNPP-1 Phase I Program Management Plan, Independent Design Verification Program, Revision 1, July 6, 1982 (Revision 0, March 29, 1982).	
2	"Preliminary Report, Seismic Reverification Program," Robert L. Cloud Associates, Inc., November 12, 1981.	P105-4-820-005
3	DCNPP-1 Phase I Engineering Program Plan, Independent Design Verification Program, Revision 0, DCNPP-IDVP-PP-001, March 31, 1982.	
4	Program for Design Work Done by Harding Lawson Associates, Robert L. Cloud Associates, Revision 0, May 28, 1982.	
5	"Interim Technical Report, #16, Diablo Canyon Unit 1, Independent Design Verification Program, Soils-Outdoor Water Storage Tanks," Robert L. Cloud Associates, Inc., Revision 0.	P105-4-839-016
6	"Interim Technical Report, #13, Diablo Canyon Unit 1, Independent Design Verification Program, Soils-Intake Structure," Robert L. Cloud Associates, Inc., Revision 0.	P105-4-839-013
7	DCNPP-IDVP-PP-003 Preparation of Open Item Reports, Program Resolution Reports, and IDV Completion Reports, Revision 1, June 18, 1982.	

References	Title	RLCA File No.
8	"Geotechnical Studies, Intake Structure, Water Storage Tanks, Diesel Fuel Oil Storage Tanks, Diablo Canyon Nuclear Power Plant, San Luis Obispo County, California," Harding Lawson Associates, April 12, 1978.	P105-4-449-001
9	Letter of Transmittal, Harding-Lawson Associates, to URS/Blume, Intake Structure Sliding and Overturning Resistance, March 30, 1978.	P105-4-449-049 (26,27 and 28)
10	RLCA Calculation "Intake Structure-Sliding Resistance" Revision 0.	P105-4-515-014
11	"Soils Mechanics, Its Principles and Structural Applications", Krynine, McGraw-Hill, Second Edition.	
12	"Diablo Canyon Intake Structure, Factor of Safety Against Overturning, Foundation Bearing Pressures," URS/Blume, November 13, 1978.	Log 2.2.2
13	"Interim Technical Report, #39, Diablo Canyon Unit 1, Independent Design Verification Program, Soils - Intake Structure-Bearing Capacity and Lateral Earth Pressure," Robert L. Cloud Associates, Inc., Revision 0.	P105-4-839-039

Appendix A

Key Term Definitions

(6 pages)

KEY TERMS AND DEFINITIONS

(The definitions in this glossary establish the meanings of words in the context of their use in this document. These meanings in no way replace the specific legal and licensing definitions.)

Closed Item

- A form of program resolution of an Open Item which indicates that the reported aspect is neither an Error nor a Deviation. No further IDVP action is required (from Reference 7).

Completion Report

- Used to indicate that the IDVP effort related to the Open Item identified by the File Number is complete. It references either a Program Resolution Report which recategorized the item as a Closed Item or a PGandE document which states that no physical modification is to be applied in the case of a Deviation or a Class D Error (from Reference 7).

DCNPP-1

- Diablo Canyon Nuclear Power Plant Unit 1

Design Codes

- Accepted industry standards for design (ex. AISC, AISI, ANSI, ASME, AWWA, IEEE).

EOI

- Error and Open Item Report

Error Report

- An Error is a form of program resolution of an Open Item indicating an incorrect result that has been verified as such. It may be due to a mathematical mistake, use of wrong analytical method, omission of data or use of inapplicable data.

  Each Error shall be classified as one of the following:

- o Class A: An Error is considered Class A if design criteria or operating limits of safety related equipment are exceeded and, as a result, physical modifications or changes in operating procedures are required. Any PGandE corrective action is subject to verification by the IDVP.

- o Class B: An Error is considered Class B if design criteria or operating limits of safety related equipment are exceeded, but are resolvable by means of more realistic calculations or retesting. Any PGandE corrective action is subject to verification by the IDVP.

- o Class C: An Error is considered Class C if incorrect engineering or installation of safety related equipment is found, but no design criteria or operating limits are exceeded. No physical modifications are required, but if any are applied they are subject to verification by the IDVP.

- o Class D: An Error is considered Class D if safety related equipment is not affected. No physical modifications are required, but if any are applied, they are subject to verification by the IDVP (From Reference 7).

FSAR

- PGandE's Final Safety Analysis Report

Hosgri Criteria

- Licensing criteria referring specifically to the postulated 7.5M Hosgri earthquake.

Hosgri Report

- A report issued by PGandE that summarizes their evaluation of the DCNPP-1 for the postulated Hosgri 7.5M earthquake. Includes seismic licensing criteria.

Hosgri 7.5M Earthquake

- Maximum earthquake for which the plant is designed to remain functional. Same as Safe Shutdown Earthquake (SSE).

Interim Technical Report

- Interim technical reports are prepared when a program participant has completed an aspect of their assigned effort in order to provide the completed analysis and conclusions. These may be in support of an Error, Open Item or Program

Interim Technical Report (cont.)

Resolution Report or in support of a portion of the work which verifies acceptability. Since such a report is a conclusion of the program, it is subject to the review of the Program Manager. The report will be transmitted simultaneously to PGandE and to the NRC (from Reference 1).

NRC

- Nuclear Regulatory Commission

NRC Order Suspending License CLI-81-30

- The order dated November 19, 1981 that suspended the license to load fuel and operate DCNPP-1 at power levels up to 5% of full power and specified the programs that must be completed prior to lifting of the suspension.

Open Item

- A concern that has not been verified, fully understood and its significance assessed. The forms of program resolution of an Open Item are recategorization as an Error, as a Deviation, or as a Closed Item (from Reference 7).

PGandE

- Pacific Gas and Electric Company

Phase I Program

- Review performed by RLCA, RFR, and TES restricted to verifying work performed prior to June 1978 related to the Hosgri re-evaluation design activities of PGandE and their seismic service-related contractors.

Potential Program Resolution Report
and Potential Error Report

- Forms used for communication within IDVP.

Program Resolution Report

- Used to indicate that the specific item is no longer active in the IDVP. It indicates whether the resolution is a Closed Item, a Deviation, or that responsibility for an Open Item has been transferred to the PGandE Technical Program. Further IDVP action is required upon completion of the associated PGandE Technical Program Task if the IDVP transfers an Open Item to PGandE or if physical modifications are applied with respect to a deviation (Reference 7).

RLCA

- Robert L. Cloud and Associates, Inc.

Sample

- Initial Sample stipulated in Phase I Program of equipment, components, and buildings to be design verified by independent analysis.

Sampling Approach

- Method used by the IDVP to determine the initial sample (buildings, piping, equipment and components) for analysis and to provide for sample expansion when required.

SSE

- Safe Shutdown Earthquake: Maximum earthquake for which the plant is designed to remain functional (Hosgri 7.5M).

Seismic

- Refers to earthquake data.

Shear

- Slicing motion parallel to plane of reference.

Shear keys

- Structural member set in a slot or groove to resist planar forces.

Sliding resistance

- Resistance of base to sliding of a structure.

TES

- Teledyne Engineering Services

Verification Program

- Undertaken by the IDVP to evaluate Diablo Canyon Nuclear Power Plant for compliance with the licensing criteria.

Appendix B

Program Manager's Assessment

(1 page)

PROGRAM MANAGER'S ASSESSMENT

As program manager of the Independent Design Verification Program, TES has reviewed the work of RLCA personnel and Dr. Robert McNeill in developing this Interim Technical Report. The review activities of TES conform to the requirements of the Phase I Program Management Plan DCNPP-1 and the TES Engineering Procedure EP-1-014.

TES conducted the following tasks, in order to verify the review methodologies employed, and final content of this ITR:

1) A complete review and editorial comments were provided to RLCA on drafts of this ITR.

2) A general review of selected literature and background documents was conducted.

The items presented in this Interim Technical Report are considered complete and this ITR is therefore approved.

TES will continue to review the progress of the RLCA and McNeill work related to the soils review program.