| ENERCON SERVICES, INC. | CALCULATION COVER SHEET | CALC. NO. : TXUT-001-FSAR-2.5-CALC-041 | | | |
|---|---|---|---|---|---|
| | | REV. | 0 | | |
| | | PAGE NO. | 1 | Of | 8 |

| Title: | Coefficients of Sliding and Sidewall Friction | Client: MNES |
|---|---|---|
| | | Project: MITS194 |

| Item | Cover Sheet Items | Yes | No |
|---|---|---|---|
| 1 | Does this calculation contain any assumptions that require confirmation? (If **YES**, Identify the assumptions) _____ | | X |
| 2 | Does this calculation serve as an "Alternate Calculation"? (If **YES**, Identify the design verified calculation.) **Design Verified Calculation No.**_____ | | X |
| 3 | Does this calculation Supersede an existing Calculation? (If **YES**, identify the superseded calculation.) **Superseded Calculation No.**_____ | | X |

**Scope of Revision:**

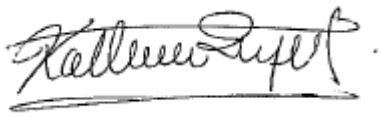
N/A – Initial Issue

**Revision Impact on Results:**

N/A – Initial Issue

| | | | |
|---|---|---|---|
| **Preliminary Calculation** | ☐ | **Final Calculation** | X |
| **Safety-Related** | X | **Non-Safety Related** | ☐ |

***(Print Name and Sign)***

| | |
|---|---|
| **Originator: Kathy Reyes**  | **Date: 05-07-13** |
| **Design Verifier: Osman El Menchawi**  | **Date: 05-07-13** |
| **Approver: Joseph Mancinelli, Project Manager**  | **Date: 05-10-13** |

## CALCULATION REVISION STATUS

| REVISION | DATE | DESCRIPTION |
|---|---|---|
| 0 | 05-07-13 | Initial Issuance of Calculation Package. |

## PAGE REVISION STATUS

| PAGE NO. | REVISION | PAGE NO. | REVISION |
|---|---|---|---|
| 1-8 | 0 | | |

## APPENDIX REVISION STATUS

| APPENDIX NO. | PAGE NO. | REVISION NO. | APPENDIX NO. | PAGE NO. | REVISION NO. |
|---|---|---|---|---|---|
| N/A | | | | | |

**Calculation Design Verification Plan:**

1. Checked recommended coefficients against references.

***(Print Name and Sign)***

**Approver: Joseph Mancinelli, Project Manager** 

**Date: 05-10-13**

**Calculation Design Verification Summary:**

1. Checked recommended coefficients against references.

**Based On The Above Summary, The Calculation Is Determined To Be Acceptable.**

***(Print Name and Sign)***

**Design Verifier: Osman El Menchawi** 

**Date: 05-07-13**

**Others:**

**Date:**

| Item | Checklist Items | Yes | No | N/A |
|---|---|---|---|---|
| 1 | **Design Inputs** - Were the design inputs correctly selected, referenced (latest revision), consistent with the design basis and incorporated in the calculation? | X | | |
| 2 | **Assumptions** – Were the assumptions reasonable and adequately described, justified and/or verified, and documented? | X | | |
| 3 | **Quality Assurance** – Were the appropriate QA classification and requirements assigned to the calculation? | X | | |
| 4 | **Codes, Standard and Regulatory Requirements** – Were the applicable codes, standards and regulatory requirements, including issue and addenda, properly identified and their requirements satisfied? | | | X |
| 5 | **Construction and Operating Experience** – Have applicable construction and operating experience been considered? | | | X |
| 6 | **Interfaces** – Have the design interface requirements been satisfied, including interactions with other calculations? | X | | |
| 7 | **Methods** – Was the calculation methodology appropriate and properly applied to satisfy the calculation objective? | X | | |
| 8 | **Design Outputs** – Was the conclusion of the calculation clearly stated, did it correspond directly with the objectives and are the results reasonable compared to the inputs? | X | | |
| 9 | **Radiation Exposure** – Has the calculation properly considered radiation exposure to the public and plant personnel? | | | X |
| 10 | **Acceptance Criteria** – Are the acceptance criteria incorporated in the calculation sufficient to allow verification that the design requirements have been satisfactorily accomplished? | | | X |
| 11 | **Computer Software** – Is a computer program or software used, and if so, are the requirements of CSP 3.02 met? | | | X |

**COMMENTS**:

***(Print Name and Sign)***

| | |
|---|---|
| **Design Verifier: Osman El Menchawi**  | **Date: 05-07-13** |
| **Others:** | **Date:** |

**COMANCHE PEAK COMBINED OPERATING LICENSE APPLICATION**
**Calculation No. TXUT-001-FSAR-2.5-CALC-041**
**COEFFICIENTS OF SLIDING AND SIDEWALL FRICTION**

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**Section** **Page**

## 1.0 PURPOSE AND SCOPE

This calculation package documents the coefficients against sliding and sidewall friction for the proposed seismic category I and II structures for Units 3 and 4 at the Comanche Peak Nuclear Power Plant (CPNPP) for the Combined Operating License Application (COLA) as requested in the Request for Information by URS (Reference 3.1.4).

## 2.0 SUMMARY OF RESULTS AND CONCLUSIONS

This calculation documents the coefficients against sliding and sidewall friction for the proposed seismic category I structures for Units 3 and 4 at CPNPP. The following is a brief summary of the results and conclusions.

- The recommended coefficient of friction against sliding at the base of the structures embedded in Limestone Layer C or placed on the concrete fill is 0.60. The coefficient of friction is to be applied to the net buoyant (dead, normal) loads for the portion of the structure that extends below the groundwater table.
- The recommended coefficient of sidewall friction at the interface between the sidewall and the backfill soil is 0.35.

## 3.0 REFERENCES

### 3.1 Project References

**3.1.1** ENERCON, prepared by Fugro Consultants, Inc. (was William Lettis and Associates, Inc.) (2007), Engineering Stratigraphy, Calculation Package No. TXUT-001-FSAR-2.5-CALC-004, Rev. 0.

**3.1.2** ENERCON, prepared by Fugro Consultants, Inc. (2011), Lateral Earth Pressures, Calculation Package No. TXUT-001-FSAR-2.5-CALC-010, Rev. 3.

**3.1.3** Mitsubishi Heavy Industries (2012), Nuclear and Turbine Island Excavation Plan and Sections, Document No. 4CS-CP34_20110023, Rev. 1, Final, issued December 14.

**3.1.4** Mitsubishi Heavy Industries (2013), Request for CPNPP 3 & 4 Friction Coefficients for Sliding Calculations, Transmittal No. 5ZL-MNS-13023.

### 3.2 General References

**3.2.1** American Concrete Institute (ACI) (2011), Building Code Requirements for Structural Concrete.

**3.2.2** Bowles, J.E. (1997), Foundation Analysis and Design, McGraw-Hill Companies, New York, Fifth Edition.

**3.2.3** Naval Facilities Engineering Command (NAVFAC) (1986), Foundations and Earth Structures, Design Manual 7.02.

## 4.0 ASSUMPTIONS

The following assumptions were made for evaluation of the coefficients:

- All foundations for seismic category I and II structures are of mat type foundation founded embedded on competent Layer C limestone (defined in Reference 3.1.1) or on concrete fill.
- The coefficients of friction against sliding are for the interface at the concrete foundation base of the structure with the competent Layer C limestone (defined in Reference 3.1.1) or concrete fill.
- The coefficient of sidewall friction is for the interface between the sidewall and the backfill soil.

## 5.0 DESIGN INPUT

- Description of the limestone Layer C is provided in Reference 3.1.1.
- The excavation plan is provided in Reference 3.1.3.
- Properties of the backfill soil are provided in Reference 3.1.2.

## 6.0 METHODOLOGY

The recommended coefficients of friction against sliding for the base foundation are to be determined in accordance with Ref. 3.2.1 and 3.2.3. The recommended coefficient of sidewall friction is to be determined in accordance with Ref. 3.2.2 and 3.2.3.

### 6.1 Concrete Foundation/Limestone Layer C Interface

Table 1 in Ref. 3.2.3 provides a coefficient of friction against sliding for mass concrete on clean sound rock of 0.70, and for mass concrete on clean gravel, gravel-sand mixtures, and coarse sand of 0.55 to 0.60. The Glen Rose Formation limestone Layer C typically is massive and well-cemented. As a result, Table 1 recommendations would indicate that a value of 0.60 would be a conservative lower bound for use as the coefficient against sliding friction for the interface between concrete foundation and the subgrade limestone Layer C.

### 6.2 Concrete Foundation/Concrete Fill Interface

Section 11.6.4.3 in Ref. 3.2.1 provides a coefficient Table 1 in Ref. 3.2.1 provides a coefficient of friction against sliding for concrete placed against hardened concrete not intentionally roughened of 0.60 (for normal concrete).

As a result, the base coefficient of friction against sliding for the concrete foundation/Limestone Layer C interface and concrete foundation/concrete fill interface is 0.60.

The coefficient of friction is to be applied to the net buoyant (dead, normal) loads for the portion of the structure that extends below the groundwater table.

### 6.3 Sidewall Friction (Concrete/Backfill Interface)

Table 1 in Ref. 3.2.3 provides a range of coefficients of sidewall friction for formed concrete against clean sand, gravel or sand mixed with silt or clay of 0.30 to 0.40 based on side wall friction angles ($\delta$) ranging between 17° to 22°.

The backfill material was considered to have an internal effective friction angle ($\phi'$) of 32° (Reference 3.1.2). Depending on the smoothness of the concrete sidewall, the side wall friction angle ($\delta$) could vary between $0.6\phi'$ *to* $\phi'$ (Reference 3.2.2) or 19.2° to 32°. The coefficient of sidewall friction is the tangent of the sidewall friction angle ($\delta$). As a result, the sidewall coefficient of friction could vary between 0.35 and 0.62.

Based on the above, and using the lower bound from Reference 3.2.2, the recommended coefficient of sidewall friction is 0.35. This falls within the range recommended in Ref. 3.2.3, and is considered appropriate since Ref. 3.2.3 is for an equivalent wider range of effective friction angles.