

SEISMIC STRUCTURE LOADING

Prepared for
San Diego Gas & Electric Company
Sunrise PowerLink Project



July 9, 2009
Revised August 10, 2009

Prepared by



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1. Introduction and Executive Summary

As one of the engineering tasks for the Sunrise Powerlink (Project), Sargent & Lundy Engineers, Ltd (S&L) has performed a review of load cases to be applied to the transmission structures to evaluate the impact of considering a seismic loading case.

A review of applicable industry codes and standards and published papers and reports was performed. Simplified calculations specific to the Sunrise Powerlink Project were also performed to evaluate the value of considering a seismic design load for the Project. As a result of these efforts, it was found that industry practice is not to consider seismic design loads since other environmental loads such as extreme wind and ice loadings produce larger structure forces. The calculations prepared supported this concept. Based on these findings, it is recommended that a seismic loading case is not required in the design of the transmission line structures for the Project.

2. Scope of Study

The purpose of this study was to evaluate the need to consider seismic loadings for the Sunrise Powerlink transmission structures. Past experience at SDG&E and other utilities has been to not consider seismic loading cases since other environmental loadings including extreme ice and wind cases have historically produced heavier loading conditions. This study includes a review of codes and standards in use within the U.S. and in two other countries where earthquakes are known to occur. Research by others in this area was also reviewed and presented. Finally, a simplified series of calculations was prepared for the Project to compare tower base reactions from extreme wind loading against seismic loading.

3. Industry Codes and Standards

Several codes and standards were reviewed for seismic requirements. Of these, very few make any reference to seismic loading, and none had a design requirement associated with seismic loadings.

3.1 California General Order 95

California General Order 95 (GO 95) is used for the design of all transmission lines within the State of California. The Code specifies two conditions for temperature and loading based on elevation and provides requirements for longitudinal and transverse structure capacity. A seismic design requirement is not provided.

3.2 National Electrical Safety Code

Although not used by SDG&E and many other utilities in California, the National Electrical Safety Code (NESC) is the main code source for transmission line design in the U.S. The Code specifies basic loading requirements including:

- Combined ice and wind district loading

- Extreme wind loading
- Extreme ice with concurrent wind loading

These load cases are used to develop intact, terminal, and broken wire loading cases. A seismic loading case is not specified.

3.3 American Society of Civil Engineers Guide 74

This guideline is widely accepted and has been used extensively for determining extreme wind and combined ice-wind loading cases prior to their adoption by the NESC. The Guide discusses structure vibrations caused by wind or earthquake events and goes on to state that wind induced vibration damage such as fatigue failures and loose bolts can be mitigated through proper design and detailing practices. These practices include not allowing members to become too slender and using additional bolts in critical connections. These same measures will protect structures from earthquake induced vibrations. The guide also states that typically structures are not designed for earthquake loadings since ice and wind loadings are more severe. The exceptions to this statement may involve cases where structures are partially erected or earth fracture or liquefaction occurs at the structure site. Tower erection by either helicopter or conventional crane techniques result in very short windows where towers will be partially erected. Reviews of structure locations to date do not indicate any towers sitting on faults subject to rupture or liquefaction zones.

3.4 Foreign Codes and Standards

Transmission design codes from Canada and Japan were reviewed to determine practices in other countries where seismic events are known to occur. The Canadian Code CSA22.3 does not specify any seismic requirements. The Japanese Code JEC-127-1979 and documentation from the Japanese Society of Civil Engineers provides information related to seismic design. The Code does not define a seismic load nor requires an earthquake resistant design. An appendix in the Code provides a comparison of seismic and wind loadings indicating that seismic loads do not control the structure design.

4. Published Studies

Several studies have been prepared both in the U.S. and abroad to compare seismic and other environmental loads on transmission structures. In the U.S., much of this study has been concentrated at Portland State University with support from the Bonneville Power Authority. Their studies have included both standard and river crossing double circuit 500-kV structures. Although the scope of their dynamic analysis has been somewhat limited, they have found that tower leg forces under seismic loading are less than the forces encountered under extreme wind loading.

5. Calculations

A series of calculations was prepared for the Project to compare tower base reactions generated by extreme wind and seismic loads. Seismic loads were calculated using the California Building Code and ASCE 7 as references. An equivalent lateral force procedure as detailed in Section 12.8 of ASCE 7 was used. It was assumed that the conductors and shield wires provided no damping and add directly to the effective

seismic weight of the structures. The EXMT and EXHD towers were considered for analysis to see how differences in structure mass and geometry would affect the results. The following seismic coefficients were used as provided by URS: $S_S=1.1$, $S_1=0.369$, $S_{DS}=0.78$, $S_{D1}=0.41$.

The seismic reactions were compared against reactions for the towers subjected to extreme wind loadings of 27psf applied to the conductors and 44 psf applied to the tower surfaces.

The calculations determined that the tower base shears for the seismic loading were twelve and nine percent of the shears identified under the extreme wind loads for the EXMT and EXHD towers respectively.

6. Conclusions

A study was performed to evaluate the need to consider a seismic design loading case for the Sunrise Powerlink transmission structures. Review of applicable Codes, Standards, and published works; and preparation of simplified calculations all conclude that tower forces resulting from seismic loads will be less than the forces generated by extreme wind loading events on the towers. As a result it is recommended that seismic loads are not required for the Project.

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Sunrise Powerlink Design Criteria SPL-T-000

S&L Calculation 11877-138-S1

Prepared:

B. C. Wood
B. C. Wood

8/10/09
Date

Reviewed:

T. A. Amundsen
T. A. Amundsen

8/10/09
Date

Approved:

B. C. Wood
B. C. Wood

8/10/09
Date



BC Wood 8/10/09