Proceedings of the Eighth (1998) International Offshore and Polar Engineering Conference
Montréal, Canada, May 24-29, 1998

ISBN 1-880653-34-6 (Set); ISBN 1-880653-38-9 (Vol. IV)

Simplified Strength-Level Earthquake Assessment of Jacket-Type Platforms

J.D. Stear and R.G. Bea
University of California at Berkeley
Berkeley, CA, USA

ABSTRACT

This paper summarizes a simplified method with which strength-level earthquake analyses of jacket-type platforms can be performed. By examining the primary bending, shear, and foundation rotation responses, estimates of platform vibration characteristics can be obtained from which earthquake forces can be estimated by the response spectrum method. This process is referred to as SRSA (Simplified Response Spectrum Analysis). These forces can then be taken together with capacities derived from ULSLEA (Ultimate Limit State Limit Equilibrium Analysis) to develop an evaluation of the demand-capacity behavior of the platform. The ULSLEA-SRSA method is applied to the assessment of two platforms. Results from 3-D frame analyses of the two platforms are used for validation of the simple approach. Agreement between the ULSLEA-SRSA and detailed 3-D analyses is excellent.

Several studies related to the simplified assessment of platforms subject to earthquakes are documented in this paper. In the first, a design code approach to earthquake forces based on that contained with the Uniform Building Code is demonstrated and compared to more detailed earthquake force estimates. Next, common simple approximations to pile-head stiffnesses are reviewed, and the impact of foundation flexibility on platform response examined. Last, the impact of local inertia forces on brace axial capacity is studied.

KEY WORDS: Earthquakes, platforms, loading capacities, ultimate limit state, foundations, structures, dynamic analysis, design, requalification

INTRODUCTION

During the past five years there has been growing interest in the development of simplified structural analysis methods which are inexpensive to apply yet provide sufficiently accurate results to help make timely and economic engineering assessments. A major reason for this development is the re-assessment of aging infrastructure. As many structures (buildings, bridges, offshore platforms, etc.) approach the end of their original service lives, many owner/operators desire to keep these structures in service. As many of the structures in existence today were designed for much less stringent load criteria than current code recommendations, some form of analysis must be performed.

While there are many structural analysis tools available today to perform detailed assessments, these tools usually require a high degree of expertise to operate, and to apply to a large number of structures would be prohibitive in terms of time and money. What is needed is a staged process of assessment, by which the bulk of the structure population can be assessed quickly using cheap, conservative methods, leaving the more problematic cases for further rigorous analysis.

Previous work has been performed by the Marine Technology and Management Group at U. C. Berkeley concerning the development and verification of simplified analysis methods for offshore platforms. This earlier effort addressed the evaluation of jacket-type platforms subject to wind and wave forces, and resulted in the procedure known as ULSLEA (Ultimate Limit State Limit Equilibrium Analysis). Based on a simple demand-capacity format, and considering only the primary failure mechanisms in a platform (hinging of unbraced deck legs, diagonal brace buckling in the jacket bays, exceeding of pile group lateral or overturning capacity), procedures were developed to estimate loads and platform component capacities (Bea, Mortazavi, 1995). This demand-capacity procedure has been the subject of much testing and verification; readers are referred to Bea, et al. 1995; Mortazavi and Bea, 1997; and Stear and Bea, 1997.

This paper documents a simplified procedure for estimating earthquake forces which is intended to compliment ULSLEA-based capacity procedures. Using simplified estimates of the primary bending, shear and foundation responses of the platform, vibration properties for the platform are approximated. Then, through application of response spectrum analysis, earthquake demands on the platform are estimated. This process is referred to as SRSA: Simplified Response Spectrum Analysis. It is intended to allow for the estimation of earthquake forces without resorting to detailed finite-element models.

The ULSLEA-SRSA approach is used to assess two platforms: a 4-leg and an 8-leg. To verify the accuracy of the ULSLEA-SRSA approach, 3-D frame analyses of these platforms has been performed, and the results from these more detailed analyses compared to those