Performance-based Seismic Design of Fixed Offshore Platforms and Comparison with ISO and API Seismic Design Guidelines

Abe Nezamian
Asset Integrity Management, WorleyParsons
Melbourne, Victoria, Australia

Patrick M Morgan
Asset Integrity Solutions, WorleyParsons
Melbourne, Victoria, Australia

ABSTRACT

Performance-based seismic engineering is now an established technology for buildings that can be adopted for offshore platforms. The development of performance-based seismic design criteria and applicability of this method for fixed offshore platforms was discussed in this paper. An analytical example including the inelastic time history analysis was presented. Structural performance and performance based assessment results was then compared with API and ISO recommendations. The results demonstrated that the performance based assessment is more reliable and may improve the integrity of the design to resist earthquakes. The results also indicated a better match between ISO standard and performance based design for the example platform.

KEY WORDS: Performance-based; seismic; design; fixed platform; ISO; API; comparison.

INTRODUCTION

Seismic design methods have been improved significantly during the past decade with more advanced computational techniques and introduction of the performance-based design method. Performance-based seismic engineering is now an established technology which can be used to create a more economical design and improve integrity management of existing structures to resist earthquakes. This has become possible through the marriage of state of the art numerical simulation technology with experimental and field data. Vast research programmes into the performance of structural elements subjected to earthquake ground motions in the USA and Japan have obtained this data. The performance-based approach enables us to design new and more economical structures with improved safety. The approach also allows risk and safety requirements to be addressed more effectively and based on the structural performance of a specific platform. The approach is also a powerful tool for assessing existing structures more realistically, often resulting in effective mitigation for a retrofit. In addition, we can develop (and validate by advanced simulation) innovative solutions that make step change improvements to the integrity of the design and the financial viability of a project.

Offshore structures are designed according to ISO or API standards. The ISO 19901 series lists specific requirements for design, construction and operation of offshore facilities with provisions that are applicable to different facility types, different materials and the possible range of operating environments. The ISO and API standards for offshore structures generally follow reliability-based design. In other words, the design procedures have been developed or calibrated to ensure minimum target reliability levels depending on the life safety, environmental and economic consequence of failure. It is important to recognize that the ISO and API procedures enforce minimum standards on a wide range of assumptions and activities: description of actions, modelling and simulation of action scenarios, structural or global analysis, design rules, model testing, workmanship, quality control, and so on. Hence the modification of one or more aspects of design standards can disturb the delicate balance in the design and lead to unintended consequences in the target reliabilities. The latest ISO standard for the seismic design was published in 2004 to include recent improvements in seismic design. The new features of ISO 19901-2 (2004) include worldwide offshore maps of site seismic zones, the recommended response spectrum shape and associated accelerations with various damping ratios. This is also required to perform the analysis for minimum 4 sets of ground motion records. The site soil classifications are expanded to include types A, B, C, D, E, and F in comparison to the soil types of A, B, and C recommended in API. These new developments in ISO will improve the safety and reliability of seismic design by refining the loading criteria. However this does not recognise the structural behaviour and performance requirements of specific structural systems, in a specific geographic zone.

Performance-based methodologies are becoming commonplace for seismic design and evaluation of building structures; it is becoming more recognized that designs based on conventional code methodologies may result in inconsistent seismic performance. Structural adequacy is evaluated through AISC-LRFD (2010) criteria using linear response spectrum analysis and through the performance-based provisions of FEMA 356 (2000) and FEMA 450 (2003) for life safety using a nonlinear pushover analysis. However use of the