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Seismic Design Criteria for the Maleo Producer, Madura Straits

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Abstract

The Maleo Producer is located in the Santos' Maleo Field in the Madura Straits, Indonesia. The site is located near the southeastern tip of the Madura Island, north of Java in an area of active tectonics. The driving mechanism for earthquakes in this region is the Sunda Arc subduction zone, a 5,600 km long zone of seismic activity that defines the tectonic boundary between the Indian Ocean part of the Australian tectonic plate and the continental crust of the Eurasian tectonic plate.

The Maleo Field is underlain by very soft normally consolidated highly plastic lightweight marine clay requiring a detailed site response analysis that included modeling of soil structure interaction. This paper discusses the development of seismic design criteria for the project and the input parameters for analyses of successively increasing complexity for the evaluation of the platform. The seismic design criteria included development of site-specific seabed response spectra for different return periods for an initial set of response spectrum analysis followed by the development of acceleration time histories for use in the detailed non-linear soil-structure interaction model. The paper also discusses practical considerations in the development of time histories to facilitate reasonable runtime for the global soil-structure interaction analyses.

Introduction

This paper presents the results of a site-specific seismic hazard study for the development of seismic design criteria for the Maleo Producer platform located in Madura Straits, Indonesia. The site is located near the southeastern tip of the Madura Island, north of Java. The general location of the site is shown in Figure 1.

The seismic design criteria were developed for assessing the seismic stability of the platform meet the class requirements of American Bureau of Shipping (ABS, 1997). The seismic analysis methodology and the development of seismic design criteria followed the general guidelines of American Petroleum Institute's API RP2A (API, 2000). Accordingly, site-specific response spectra and acceleration time histories were developed for Strength Level Earthquake (SLE) and Ductility Level Earthquake (DLE) for an increasingly complex set of structural analyses (Jacob and Stewart, 2008 and Templeton, 2008). The analysis ranged from linear elastic response spectrum analysis to nonlinear fully coupled soil-structure interaction analysis. The seismic design criteria and the methodology employed for the development of the SLE and DLE spectra and acceleration time histories were independently evaluated and accepted by the class society.

Background

The Maleo Producer was originally designed as a mobile offshore drilling unit (MODU). The platform is a 1970's vintage mat supported jack-up (designated as the Cliff's Drilling – CD10) that was converted to a mobile offshore production unit (MOPU) in 2005-2006 to operate as a gas production platform in the Santos' Maleo Field in the Madura Straits. Prior to conversion, the Maleo Producer was operating in the Arabian Gulf. Following conversion, it was dry towed from the Arabian Gulf to its current operating location.

The site is located in an area of active tectonics defined by the Sunda Arc subduction zone, which is capable of generating very large earthquakes such as the December 2004, Magnitude 9.3, Banda-Ache earthquake. The original design of the platform did not include seismic loading. However, seismic evaluation of the platform was a requirement of class approval for its current operation. This paper discusses the development of seismic design criteria in terms of site-specific response spectra and acceleration time histories for use in the structural analysis of the Maleo Producer.