Available online at www.sciencedirect.com
SCIENCE DIRECT®
ELSEVIER
Journal of Constructional Steel Research 61 (2005) 1147–1171
JOURNAL OF CONSTRUCTIONAL STEEL RESEARCH
www.elsevier.com/locate/jcsr

Collapse analysis of steel jacket structures for offshore oil exploitation

Paulo Fernando Neves Rodrigues[a], Breno Pinheiro Jacob[b,*]

[a] *FAU/UFRJ—Department of Structures, Federal University of Rio de Janeiro, Cidade Universitaria—Ilha do Fundão, 21945-970 Rio de Janeiro, RJ, Brazil*

[b] *LAMCSO—Laboratory of Computer Methods and Offshore Systems, PEC/COPPE/UFRJ—Post-Graduate Institute of the Federal University of Rio de Janeiro, Civil Engineering Department, Centro de Tecnologia, Bloco B sala B-101, Cidade Universitaria, Ilha do Fundão, Caixa Postal 68.506, 21945-970 Rio de Janeiro, RJ, Brazil*

Abstract

This work describes the formulation of finite-element based numerical methods for global nonlinear collapse analyses of three-dimensional steel framed structures. Particular emphasis is dedicated to the reassessment and determination of residual strength of steel jackets that support offshore oil exploitation platforms. Two main aspects are considered: (1) the formulation for a three-dimensional geometric and material nonlinear frame element, and (2) the implementation of specialized techniques for the solution of the nonlinear problem. The formulation of the element combines a co-rotational approach to represent geometric nonlinearities, providing an accurate treatment of finite rotations, with the plastic hinge approach to represent material nonlinearities. The stiffness reduction due to yielding is performed through a smooth degradation, following a parabolic function. Effects of strain hardening, geometric imperfections and residual stresses are modeled in an efficient manner. In order to determine the full nonlinear equilibrium path and allow the correct determination of the collapse load, the solution strategies consider specialized "continuation" techniques such as the Arc-Length and the Generalized Displacement Control methods. Case studies are presented in order to demonstrate the accuracy, efficiency, and suitability of the implemented methods and techniques.

© 2005 Elsevier Ltd. All rights reserved.

Keywords: Finite elements; Frame elements; Nonlinear analysis; Collapse analysis; Plasticity

* Corresponding author. Tel.: +55 21 2562 7385; fax: +55 21 2259 4271.
E-mail address: breno@pec.coppe.ufrj.br (B.P. Jacob).

0143-974X/$ - see front matter © 2005 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jcsr.2005.02.005

1. Introduction

In offshore oil exploitation activities, steel jacket structures have been extensively employed to support platforms installed in water depths up to about 200 m. In the Campos basin, southeastern Brazil, several jackets have been installed in the 1970s and 1980s. More recent exploration activities in Brazilian offshore fields have focused on deeper waters, ranging up to 2000 m or more. In such cases, jacket structures cease to be feasible alternatives, and other types of platforms are employed, such as semi-submersibles or even moored ships.

However, many jacket platforms are still operational, and as they reach the limits of their design service lives, the need of re-assessing their behavior has been recognized [1,2]. One of the main motivations for this reassessment may be the need to extend the design life of the structure, due to extended oil reservoir estimates. Other important factors may also require reassessment, including for instance damage or corrosion of structural members of the jacket; the installation of additional equipments, risers or process modules not considered in the original design; and even the reevaluation of the environmental loadings, that continually changes as new metocean data are gathered by the oil companies.

Another important aspect that has been recognized by several authors [3,4] is the need of performing global nonlinear analyses of the overall structure. This complements the traditional design methodology, where nonlinear checks are performed at member level only, using member end forces determined from global elastic analyses.

These facts justify the need of employing computational tools that incorporate sophisticated finite-element based numerical methods, techniques and strategies. Such methods should be able to:

- Capture all relevant nonlinear effects such as yielding, hinge formation, buckling, large displacements and post-buckling. This should be associated to the accuracy of the nonlinear formulation of the three-dimensional frame element;
- Trace the complete equilibrium path, up to the final collapse of the structure, passing through limit points with ‘snap-throughs’ or ‘snap-backs’. This should be associated to the robustness of the solution strategy, reflected in its ability to complete the analysis without abnormal terminations or lack of convergence; and finally,
- Present computational efficiency, in order to minimize CPU costs.

These issues were considered in the development and implementation of a computational tool, oriented towards global nonlinear collapse analyses, and with particular emphasis dedicated to the application on the reassessment and determination of residual strength of three-dimensional steel framed structures such as steel jackets.

In this paper, special attention is given to the implementation of the material nonlinear formulation of the three-dimensional frame element, which is based on the concept of concentrated plasticity or “plastic hinge” approach [5]. In this approach the plasticity effects are concentrated on the element ends, and the incremental relations between the cross-section forces and the element node displacements are expressed assuming that the plastic hinges behave as real elastic hinges. The yielding criterion is based on the cross-section forces, namely bending moments and axial force. Shear and torsion effects are not taken into account in the yielding process.

دریافت فوری ← متن کامل مقاله

ISIArticles
مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات