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Date : September 2010	Date : September 2010

UNIVERSITI TEKNOLOGI PETRONAS

DEFORMATION ANALYSIS OF OFFSHORE PLATFORM USING GPS TECHNIQUE AND ITS APPLICATION IN STRUCTURAL INTEGRITY ASSESSMENT

by

NURROHMAT WIDJAJANTI

The undersigned certify that they have read, and recommend to the Postgraduate Studies Programme for acceptance this thesis for the fulfillment of the requirements for the degree stated.

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DEFORMATION ANALYSIS OF OFFSHORE PLATFORM USING GPS TECHNIQUE AND ITS APPLICATION IN STRUCTURAL INTEGRITY ASSESSMENT

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NURROHMAT WIDJAJANTI

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SEPTEMBER 2010

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hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UTP or other institutions.

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DEDICATION

To my beloved husband, Joko Waluyo, and my children, Fawwaz Daniswara and Shabrina Tias Warastri for being with me during this time.

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ABSTRACT

One of a major problem with offshore platform is the occurrence of deformation which can have serious and potentially fatal consequences. The implementing of a deformation monitoring system to maintain regular surveillance of the stability is a means to address both human safety and company profitability. The approach developed in this study uses a precise relative Global Positioning System (GPS) which is advantageous for deformation monitoring in terms of long-baseline data as offshore platforms are located hundreds of kilometres from shore. This research focused on customizing GPS data processing of offshore platform deformation and its implementation for structural integrity assessments. A preliminary investigation was performed on simulated GPS network to ensure tool reliability, processing method feasibility and enhanced precision of the processed data. Additionally, preventative steps were taken on the network simulation to ensure that the technique was capable of detecting any deformation. Commercial software was found to be inadequate for long-baseline processing and was substituted with GAMIT/GLOBK scientific software, capable of processing GPS data for offshore platforms. This case study refers a Jacket-type offshore platform using secondary three epochs GPS data to analyze deformation. The results of data processing revealed deformation magnitude in the form of three dimensional displacement, dx, dy and dz which was then used to assess platform's structural integrity, focusing on four points of the main pile located on the upper deck. The structural integrity assessment identified that translation and rotation of all structural joints was influenced by any displacements of restrained joints. These translations and rotations increase almost nearly proportional to the increased displacement value. In the simulation epoch of 10 years, the greatest value displacement of North is approximately 18-26 cm, East is around 6-18 cm and Up is about 15-50 cm. These values are assumed as linear function of the displacement of two month epochs. The great effect occurs on the upper deck with the value of U1 = ±6 cm (point 67), U2 = ±30 cm (point 68), U3 = ±60 cm (point 78), R1 = ±3 radian

(point 80), R2 = ±0.5 radian (point 67) and R3 = ±1 radian (point 84). The greatest effect arises at the translation in the direction of Z. In the seabed, the achievement value of R1 = ±5 radian (point 13), R2 = ±0.3 radian (point 14), R3 = ±0.1 radian (point 14) with no translation effect of in the directions of X, Y and Z. The occurring translations and rotations in the structural joints contribute to the stability of the platform, confirming deformation monitoring to be a viable technique in structural integrity assessment. The deformation analysis indicated coordinate differences among the three epoch observations, however, a significant test did not categorise these as a significant displacement. To conclude, a precise GPS relative positioning technique was found to be a reliable approach for offshore platform monitoring deformation, enabling precise detection to a few millimeters. This level of precision could be increased with implementation of processing and observational strategies.

ABSTRAK

Satu daripada masalah utama struktur kejuruteraan seperti pelantar minyak di luar pantai adalah kejadian deformasi, yang mana ianya boleh menyebabkan bencana terhadap pekerja dan juga pelantar minyak itu sendiri. Aktiviti pemantauan secara berterusan terhadap deformasi pelantar dapat menjamin ciri-ciri keselamatan dan juga dapat meningkatkan keuntungan dalam industri minyak dan gas. Memandangkan kedudukan pelantar tersebut terletak beratus kilometer daripada pesisir pantai, penggunaan alat sistem penentududukan sejagat (GPS) secara relatif dilihat mempunyai kelebihan bagi tujuan kerja-kerja pemantauan deformasi. Justeru itu, satu kajian penggunaan teknologi GPS dalam pemantauan deformasi pelantar minyak telah dilaksanakan untuk tujuan semakan kestabilan. Di dalam kajian ini, siasatan awal telah dilaksanakan dengan menggunakan jaringan pelantar secara simulasi bagi tujuan memastikan peralatan yang digunakan berada di dalam keadaan baik, kebolehcayaan kaedah pengolahan data dan ketepatan di dalam pemprosesan data. Selain daripada itu, langkah itu telah dijalankan bagi memastikan teknik tersebut mampu mengesan mana-mana deformasi pelantar minyak pada simulasi jaringan. Namun begitu perisian komersil tidak mampu memproses serta mengatasi masalah jaringan garis dasar yang panjang. Untuk tujuan itu, perisian saintifik GAMIT/GLOBK telah digunakan. Penyelidikan dijalankan berdasarkan ke atas satu Jaket pelantar minyak. Tiga epok sekunder data GPS telah diperolehi bagi menganalisis deformasi pelantar minyak tersebut. Hasil pemprosesan data GPS ditunjukkan berdasarkan kepada perubahan nilai deformasi dalam mengesan sebarang corak anjakan tiga dimensi iaitu dx, dy dan dz dimana keberertian perubahan nilai anjakan ini ditentukan melalui uji statistik untuk membuat semakan kestabilan keatas struktur pelantar minyak berdasar translasi dan putaran terhadap sambungan struktur penahan penjuru pelantar. Faktor translasi dan putaran menunjukan ianya hampir bercorak linear dan ianya berkadar terus dengan nilai perubahan anjakan struktur dengan meletakkan penahan atas empat penjuru pada pelantar minyak. Dalam simulasi epok 10 tahun, perubahan nilai deformasi terbesar arah Utara adalah sekitar 18-26 cm, arah Timur adalah sekitar 6-18

cm dan arah Up adalah sekitar 15-50 cm. Nilai-nilai ini diandaikan sebagai fungsi linear dari perubahan nilai deformasi dalam epok satu bulan. Pengaruh translasi dan putaran pada dek paling atas iaitu U1 = ± 6 cm (titik 67), U2 = ± 30 cm (titik 68), U3 = ± 60 cm (titik 78), R1 = ± 3 radian (titik 80), R2 = ± 0,5 radian (titik 67) dan R3 = ± 1 radian (titik 84). Pengaruh terbesar terjadi pada translasi ke arah Z. Pada dek dasar laut, nilai pencapaian putaran iaitu R1 = ± 5 radian (13), R2 = ± 0.3 radian (titik 14), R3 = ± 0,1 radian (titik 14) tanpa kesan translasi dalam arah X, Y dan Z. Perubahan translasi dan putaran keatas struktur jelas menunjukan ianya akan memberi kesan kepada kestabilan pelantar minyak. Ini menunjukan relatif GPS dapat digunakan di dalam pengawasan deformasi sesuatu pelantar minyak. Hasil analisa menunjukkan dari cerapan GPS terdapat perbezaan koordinat antara tiga epok cerapan. Walaubagaimanapun, bagi membuktikan bahawa pergerakan adalah bererti ujian statistik telah digunakan. Hasil analisa menunjukkan bahawa teknik GPS secara relatif boleh mengesan deformasi dalam kejituan milimeter. Tahap itu boleh ditingkatkan, dengan melaksanakan strategi tertentu untuk cerapan dan pemprosesan.

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