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

I NURROHMAT WIDJAJANTI

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UNIVERSITI TEKNOLOGI PETRONAS
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DECLARATION OF THESIS

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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 $U1 = \pm 6$ cm (point 67), $U2 = \pm 30$ cm (point 68), $U3 = \pm 60$ cm (point 78), $R1 = \pm 3$ radian

(point 80), $R2 = \pm 0.5$ radian (point 67) and $R3 = \pm 1$ radian (point 84). The greatest effect arises at the translation in the direction of Z. In the seabed, the achievement value of $R1 = \pm 5$ radian (point 13), $R2 = \pm 0.3$ radian (point 14), $R3 = \pm 0.1$ 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, kebolehpercayaan 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 Jacket 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 menunjukkan 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 $U1 = \pm 6$ cm (titik 67), $U2 = \pm 30$ cm (titik 68), $U3 = \pm 60$ cm (titik 78), $R1 = \pm 3$ radian (titik 80), $R2 = \pm 0,5$ radian (titik 67) dan $R3 = \pm 1$ radian (titik 84). Pengaruh terbesar terjadi pada translasi ke arah Z. Pada dek dasar laut, nilai pencapaian putaran iaitu $R1 = \pm 5$ radian (13), $R2 = \pm 0.3$ radian (titik 14), $R3 = \pm 0,1$ radian (titik 14) tanpa kesan translasi dalam arah X, Y dan Z. Perubahan translasi dan putaran keatas struktur jelas menunjukkan ianya akan memberi kesan kepada kestabilan pelantar minyak. Ini menunjukkan 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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TABLE OF CONTENTS

STATUS OF THESIS	i
APPROVAL PAGE	ii
TITLE PAGE	iii
DECLARATION OF THESIS	iv
DEDICATION	v
ACKNOWLEDGEMENT	vi
ABSTRACT	viii
ABSTRAK	x
COPYRIGHT PAGE	xii
TABLE OF CONTENTS	xiii
LIST OF TABLES	xvi
LIST OF FIGURES	xviii
1 Chapter 1 – INTRODUCTION	1
1.1 Background	1
1.2 Problem Statement	3
1.3 Objective of Study	4
1.4 Scope of Study	5
1.5 Contribution of Thesis	5
1.6 Organization of Thesis	6
2 Chapter 2 – LITERATURE REVIEW	8
2.1 Previous Research of GPS Application for Deformation Studies	8
2.2 Aspects of Positioning using GPS	18
2.2.1 GPS Segments	18
2.2.2 GPS Measurement Errors	20
2.2.2.1 Control Segment Errors	21
2.2.2.2 Atmospheric Distribution Errors	22
2.2.2.3 Receiver Errors	24
2.2.2.4 Measurement Data Errors	24
2.2.2.5 Environment Errors	25
2.2.3 Positioning Mechanism with GPS	26
2.2.3.1 Pseudorange Positioning	26
2.2.3.2 Charier Phase Positioning	27
2.2.4 GPS Positioning Method	28
2.2.4.1 Absolute Measurement	28
2.2.4.2 Relative Measurement	29
2.2.5 Processing of Differenced Data	32
2.2.5.1 Single Differenced Solution	32
2.2.5.2 Double Differenced Solution	33
2.2.5.3 Triple Differenced Solution	34
2.2.6 Baseline Solution	34
2.2.7 GPS Ephemeris Data	35

2.2.7.1	Precise Ephemeris	35
2.2.7.2	Broadcast Ephemeris	37
2.2.8	Dilution of Precision	39
2.2.9	GPS Processing Packages	41
2.2.10	Global and Local Networks	42
2.2.10.1	IGS Network	42
2.2.10.2	MASS Network	43
2.3	Aspects of Deformation Analysis	44
2.3.1	Basic Concept of Deformation	44
2.3.2	Deformation Analysis Method	45
2.3.3	Monitoring Network	46
2.3.4	Techniques in Deformation Measurement	48
2.3.4.1	Conventional Terrestrial Surveying	49
2.3.4.2	Remote Sensing	50
2.3.4.3	Satellite-based Positioning	51
2.3.5	Deformation Monitoring of Offshore Platform	52
2.4	Offshore Platform Overview	53
2.5	Platform Damage	59
2.6	Structural Integrity	60
2.6.1	Element of Structural Safety	64
2.7	Structural Analysis Program	66
2.7.1	Component of Joints in Structural Analysis	66
2.8	Summary of the Literature Review	69
3	Chapter 3 – METHODOLOGY	72
3.1	GPS Receiver Testing	72
3.2	The GPS Network Simulation for Offshore Platform Deformation Monitoring	75
3.2.1	GPS Data Collection	77
3.2.2	GPS Data Processing	78
3.2.3	The Displacement Test of Deformation Simulation	79
3.3	The Real Offshore Platform GPS Data Processing	82
3.3.1	The Processing Strategy for an Improved GPS Solution	82
3.3.1.1	The Effect of Network Configuration	83
3.3.1.2	The Effect of Session Length	84
3.3.1.3	The Effect of a Priori Coordinate	85
3.3.1.4	The Effect of Station Weighting	87
3.3.2	GPS Data of Pulau Offshore Platform	87
3.3.3	GPS Data Validation	89
3.3.4	GPS Data Processing	95
3.4	The Deformation Monitoring of an Offshore Platform	97
3.4.1	GPS Data of Pulau Offshore Platform	97
3.4.2	GPS Data Processing	98
3.4.3	Deformation Analysis	101
3.5	The Application of GPS Coordinate for Structural Integrity	101

3.5.1	Analytical Model of a Jacket Platform	102
3.5.1.1	Modelling of a Prototype Jacket Offshore Platform	102
3.5.2	Displacement Simulation for Restraint	106
3.6	Experimental Work Flow	107
4	Chapter 4 – RESULT AND DISCUSSION	109
4.1	GPS Receiver Testing	109
4.2	The GPS Network Simulation for Offshore Platform Deformation Monitoring	115
4.2.1	The Processed Station Coordinates with Local Station Reference	115
4.2.2	The Processed Station Coordinates with Global Station Reference	122
4.2.3	The Displacement Test of Deformation Simulation	127
4.3	The Real Offshore Platform GPS Data Processing Strategy	129
4.3.1	The Effect of Network Configuration Variation	130
4.3.2	The Effect of Session Length Variation	142
4.3.3	The Effect of a Priori Coordinate Variation	149
4.3.4	The Effect of Station Weighting Variation	159
4.4	The Deformation Monitoring of an Offshore Platform	164
4.4.1	The Primary Indicator of GAMIT and GLOBK Solutions	165
4.4.2	The Estimated Station Coordinates and their Standard Deviations	167
4.4.3	The Displacement Test	169
4.5	The Application of GPS Coordinate for the Structural Integrity	174
4.5.1	The Platform Prototype	174
4.5.1.1	The Platform Structure	176
4.5.1.2	The Jacket Structure	177
4.5.1.3	The Deck Structure	177
4.5.2	The Application of Restraint Simulation	178
5	Chapter 5 – CONCLUSIONS AND RECOMMENDATIONS	193
5.1	Conclusions	193
5.2	Recommendations and Future Works	195
	REFERENCES	197
	PRESENTED PAPERS AND SUBMITTED JOURNALS	211
	APPENDICES	213
	Appendix A RINEX format observation	214
	Appendix B Topcon Hiper dual frequency receiver GPS specification	216
	Appendix C Main window commercial GPS processing software	218
	Appendix D Table t-distribution critical value	223
	Appendix E Trimble 4000 SSI Geodetic GPS receiver specification	224
	Appendix F Aspects of data processing using GAMIT/GLOBK	227
	Appendix G Horizontal and vertical framings	250
	Appendix H Graphics of translation and rotation	262

LIST OF TABLES

Table 2.1	Description of the satellite ephemeris	38
Table 2.2	Types of platform damage	59
Table 3.1	Published slope distance as true value	75
Table 3.2	Name of station in project schemes I and II	83
Table 3.3	GPS order base on session length of observation	85
Table 3.4	File name in various session lengths	85
Table 3.5	Dimension of beam	105
Table 3.6	Dimension of pipe	105
Table 3.7	The interval epoch of restraint simulation	106
Table 4.1	The slope distance for Rover R-2	110
Table 4.2	The slope distance for Rover R-3	111
Table 4.3	The slope distance for Rover R-4	112
Table 4.4	The length of baseline	127
Table 4.5	The coordinate and its standard deviation in the Cartesian system	128
Table 4.6	The result of displacement test	129
Table 4.7	The χ^2/f statistics from global processing for projects A-H	133
Table 4.8	The X-estimated coordinate for projects A-H in the Cartesian system	134
Table 4.9	The Y-estimated coordinate for projects A-H in the Cartesian system	135
Table 4.10	The Z-estimated coordinate for projects A-H in the Cartesian system	136
Table 4.11	The result of the t-test	138
Table 4.12	The χ^2/f statistics from global processing for projects I-M	139
Table 4.13	The X-estimated coordinate for projects I-M in the Cartesian system	140
Table 4.14	The Y-estimated coordinate for projects I-M in the Cartesian system	140
Table 4.15	The Z-estimated coordinate for projects I-M in the Cartesian system	140
Table 4.16	The χ^2/f statistics from processing using various session lengths on doys 183, 184, 185	143
Table 4.17	The processed Cartesian coordinate using a 12-hour session length	144
Table 4.18	The processed Cartesian coordinate using a 6-hour session length	144
Table 4.19	The processed Cartesian coordinate using a 4-hour session length	145
Table 4.20	The processed Cartesian coordinate using a 2-hour session length	146
Table 4.21	Summary of the processed Cartesian coordinate using 2, 4, 6, 12, 24 hour session lengths	147
Table 4.22	The processed spherical coordinate using TEQC <i>L-file</i> on day 183	151
Table 4.23	The processed spherical coordinate using TEQC <i>L-file</i> on day 184	151
Table 4.24	The processed spherical coordinate using TEQC <i>L-file</i> on day 185	152
Table 4.25	The processed spherical coordinate using RINEX <i>L-file</i> on day 183	152
Table 4.26	The processed spherical coordinate using RINEX <i>L-file</i> on day 184	152
Table 4.27	The processed spherical coordinate using RINEX <i>L-file</i> on day 185	152
Table 4.28	The processed spherical coordinate using <i>L-file</i> simulation 10 m on day 183	153
Table 4.29	The processed spherical coordinate using <i>L-file</i> simulation 10 m	

on day 184	153
Table 4.30 The processed spherical coordinate using <i>L-file</i> simulation 10 m on day 185	153
Table 4.31 The processed spherical coordinate using <i>L-file</i> simulation 25 m on day 183	154
Table 4.32 The processed spherical coordinate using <i>L-file</i> simulation 25 m on day 184	154
Table 4.33 The processed spherical coordinate using <i>L-file</i> simulation 25 m on day 185	154
Table 4.34 The processed spherical coordinate using <i>L-file</i> simulation 50 m on day 183	155
Table 4.35 The processed spherical coordinate using <i>L-file</i> simulation 50 m on day 184	155
Table 4.36 The processed spherical coordinate using <i>L-file</i> simulation 50 m on day 185	155
Table 4.37 The processed spherical coordinate using <i>L-file</i> simulation 100 m on day 183	156
Table 4.38 The processed spherical coordinate using <i>L-file</i> simulation 100 m on day 184	156
Table 4.39 The processed spherical coordinate using <i>L-file</i> simulation 100 m on day 185	156
Table 4.40 The χ^2/f statistics from daily processing using TEQC and RINEX <i>L-file</i>	157
Table 4.41 The processed Cartesian coordinate and its standard deviation using RINEX <i>L-file</i>	157
Table 4.42 The processed Cartesian coordinate and its standard deviation using TEQC <i>L-file</i>	158
Table 4.43 The value of weight in various types of <i>sittbl.-file</i>	160
Table 4.44 The χ^2/f statistics from daily processing using various types of <i>sittbl.-file</i> ..	161
Table 4.45 The processed Cartesian coordinate using various types of <i>sittbl.-file</i>	162
Table 4.46 The χ^2/f statistics from daily and global processing	166
Table 4.47 The estimated coordinate in local system	167
Table 4.48 The horizontal differences between two epochs	169
Table 4.49 The displacement, its standard deviation and <i>T</i> -computed	172
Table 4.50 The numbers of selected joints at each elevation	185

LIST OF FIGURES

Figure 2.1	GPS system segments	18
Figure 2.2	Location of GPS control segments	19
Figure 2.3	GPS measurement errors	21
Figure 2.4	Layer of earth's atmosphere	23
Figure 2.5	GPS relative positioning	30
Figure 2.6	Good and bad satellite geometries	39
Figure 2.7	Global IGS network	42
Figure 2.8	The continuum medium of deformation	44
Figure 2.9	Absolute monitoring networks	47
Figure 2.10	Relative monitoring networks	47
Figure 2.11	Flowchart of deformation observation	52
Figure 2.12	Jacket platform	54
Figure 2.13	Compliant Tower platform	55
Figure 2.14	GBS platform	56
Figure 2.15	TLP	56
Figure 2.16	Semi Submersible platform	57
Figure 2.17	Spar platform	58
Figure 2.18	FPSO	58
Figure 2.19	Six displacement degrees of freedom in a joint local coordinate system	68
Figure 3.1	JUPEM's pillar	72
Figure 3.2	The scenario of data measurement for all observed sub-baselines (top) and all observed distances (bottom)	73
Figure 3.3	Network configuration of platform deformation simulation inside UTP campus (satellite image taken from Google earth™)	76
Figure 3.4	Map of the global stations from IGS	77
Figure 3.5	Map of the Malaysian primary GPS stations	88
Figure 3.6	TEQC program	90
Figure 3.7	Report of TEQC describing satellite visibilities	91
Figure 3.8	Supplementary information of TEQC report	93
Figure 3.9	The scenario of GPS Pulaui platform observations	97
Figure 3.10	The scenario of GPS Pulaui platform computations	98
Figure 3.11	Define frame section in SAP2000	101
Figure 3.12	Shape types of frame section	102
Figure 3.13	Methodology flow of the research	106
Figure 4.1	The difference of slope distance between JUPEM value and GPS measurement using receiver 2	111
Figure 4.2	The difference of slope distance between JUPEM value and GPS measurement using receiver 3	112
Figure 4.3	The difference of slope distance between JUPEM value and GPS measurement using receiver 4	112
Figure 4.4	The processed latitude with PGOD as reference station on day 1	114

Figure 4.5	The processed latitude with PGOD as reference station on day 2	114
Figure 4.6	The processed latitude with PGOD as reference station on day 3	115
Figure 4.7	The processed longitude with PGOD as reference station on day 1	116
Figure 4.8	The processed longitude with PGOD as reference station on day 2	116
Figure 4.9	The processed longitude with PGOD as reference station on day 3	117
Figure 4.10	The processed height with PGOD as reference station on day 1	118
Figure 4.11	The processed height with PGOD as reference station on day 2	118
Figure 4.12	The processed height with PGOD as reference station on day 3	119
Figure 4.13	The processed standard deviation of latitude with IGS as reference station on days 1, 2 and 3	121
Figure 4.14	The processed standard deviation of longitude with IGS as reference station on days 1, 2 and 3	122
Figure 4.15	The processed standard deviation of height with IGS as reference station on days 1, 2 and 3	123
Figure 4.16	The postfit nrms from daily GAMIT processing for scheme I.....	128
Figure 4.17	The mean and standard deviation of postfit nrms for scheme I	128
Figure 4.18	The postfit nrms from daily GAMIT processing for scheme II	129
Figure 4.19	The mean and standard deviation of postfit nrms for scheme II	130
Figure 4.20	The standard deviation of X-coordinate for projects A-H	134
Figure 4.21	The standard deviation of Y-coordinate for projects A-H	134
Figure 4.22	The standard deviation of Z-coordinate for projects A-H	134
Figure 4.23	The standard deviation of X-coordinate for projects I-M	138
Figure 4.24	The standard deviation of Y-coordinate for projects I-M	138
Figure 4.25	The standard deviation of Z-coordinate for projects I-M	138
Figure 4.26	The postfit nrms from processing using various session lengths on doys 183, 184 and 185	139
Figure 4.27	The processed standard deviation of X using 2, 4, 6, 12 and 24 hour session lengths	145
Figure 4.28	The processed standard deviation of Y using 2, 4, 6, 12 and 24 hour session lengths	145
Figure 4.29	The processed standard deviation of Z using 2, 4, 6, 12 and 24 hour session lengths	146
Figure 4.30	The postfit nrms from processing using various a priori coordinates on doys 183, 184 and 185	147
Figure 4.31	The processed standard deviation of X using TEQC and RINEX <i>L-file</i>	155
Figure 4.32	The processed standard deviation of Y using TEQC and RINEX <i>L-file</i>	155
Figure 4.33	The processed standard deviation of Z using TEQC and RINEX <i>L-file</i>	156
Figure 4.34	The postfit nrms from processing using various types of <i>sittbl.-file</i>	157
Figure 4.35	The processed standard deviation of X using various types of <i>sittbl.-file</i> ...	159
Figure 4.36	The processed standard deviation of Y using various types of <i>sittbl.-file</i> ...	159
Figure 4.37	The processed standard deviation of Z using various types of <i>sittbl.-file</i> ...	160
Figure 4.38	The primary quality from daily GAMIT processing	162
Figure 4.39	The standard deviations of N, E and U coordinates	165
Figure 4.40	The vertical differences between two epochs	166

Figure 4.41 The graphic of horizontal movement	168
Figure 4.42 The prototype of the offshore platform	172
Figure 4.43 The schematic diagram of the platform at different levels	172
Figure 4.44 The jacket structure	173
Figure 4.45 The deck structure	174
Figure 4.46 The simulation of North displacement	174
Figure 4.47 The simulation of East displacement	175
Figure 4.48 The simulation of Up displacement	175
Figure 4.49 Joint restraints on the upper deck	176
Figure 4.50 Joint restraints on the mezzanine deck	177
Figure 4.51 Joint restraints on the lower deck	177
Figure 4.52 Joint restraints on the sump deck	178
Figure 4.53 Joint restraints at elevation (+)4.5 m	179
Figure 4.54 Joint restraints at elevation (-)10.5 m	179
Figure 4.55 Joint restraints at elevation (-)28.5 m	180
Figure 4.56 Joint restraints at elevation (-)46.8 m	180
Figure 4.57 The translation on the upper deck	183
Figure 4.58 The rotation on the upper deck	184
Figure 4.59 The translation and rotation at elevation (-)46.8 m	186
Figure 4.60 Deformed platform	187