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The activities of UEG are outlined in the UEG Annual Report available free of charge from the address below

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REPORT UR22 1984

Node flexibility and its effect on jacket structures – a pilot study on two-dimensional frames

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The project leading to this report was carried out under contract to UEG by W S Atkins & Partners where the staff engaged on the work were N P D Barltrop BSc CEng MICE MRINA, A Culverhouse BSc and MJ McLoughlin BEng CEng MICE MIStructE. The work was financed through UEG by a joint venture of thirteen organisations including the Department of Energy. The report has been prepared with the assistance of a Project Steering Group comprising representatives of the sponsoring organisations and Professor Fessler of the University of Nottingham.

Mr R K Venables (Chairman) UEG

Mr N P D Barltrop W S Atkins & Partners
Dr C J Billington Wimpey Offshore Ltd
Mr J Chattaway Posford, Pavry & Partners
Professor H Fessler University of Nottingham

Dr S L Fu Gulf Oil Exploration and Production Company

Mr M B Gibstein Det norske Veritas

Mr B Marlow Marine Technology Support Unit
Mr D McManus Shell UK Exploration and Production

Mr M J McLoughlin W S Atkins & Partners

Mr P E G O'Connor Amoco (UK) Exploration Company
Mr M C O'Flynn Taylor Woodrow Construction Ltd.

Mr A G Reynolds BP International Ltd

Mr B Ringstrom Norwegian Petroleum Directorate

Mr R J Simpson UEG, (Research Manager for the project)

Mr S G Stiansen American Bureau of Shipping

Mr F E S West Harris & Partners

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These results enabled the authors to do much more work on the effects of flexible nodes on structural behaviour than would otherwise have been possible.

The United Kingdom Offshore Steels Research Project have also allowed the use of their finite element results so that flexibility matrices derived from finite element and model tests could be compared.

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Summary

This Report presents an investigation of the commonly ignored effect of chord wall flexibility at brace connections on the behaviour of oil production jacket structures.

It considers the effects on the in-plane deflections, axial forces, bending moments, brace buckling and natural frequencies of three 100 m tall vertical plane frames. The effects of out-of-plane loading and joints with braces in more than one plane were outside scope of the study.

Results from conventional analysis, in which the braces are extended to connect rigidly with the chords at their centre line intersection points, are compared with other analyses in which the joints are represented by a stiffness matrix. Approximate 'hand' methods for assessing the effect of joint flexibility on other structures are suggested.

Notation

A	measure of chord wall bending stiffness/brace bending stiffness (End 1)
A	cross-sectional area
В	measure of chord wall bending stiffness/brace bending stiffness (End 2)
C	compressive forces
d	diameter of braces
D .	diameter of chords
e ·	eccentricity of brace intersections on chord centre line
e _p	eccentricity of brace intersections perpendicular to chord centre line
Ė	Young's Modulus
f	flexibility
F, f	flexibility matrix
g	brace-brace gap
G	modulus of rigidity
H	height of wave
H	equilibrium matrix
I	inertia
k	stiffness
K, k	stiffness matrix
L	length
L_b	length (between chords)
L_{e}	length (effective)
M	moment
M	mass matrix
P	force
P_{crit}	$\pi^2 \mathrm{EI}/\mathrm{L}^2$
t	brace thickness
<u>t</u>	time
T	chord thickness
T	tensile force
u, v	lengths
x,y,z	lengths of co-ordinates
X	response
X	vector of displacements of nodes on a structure
X V V D7	vector of accelerations of nodes on a structure
X, Y, RZ	nodal freedoms in plane frame analysis
α	chord wall rotational stiffness
β	chord wall rotational stiffness
γ .	brace-chord angle
δ	deflection
δ	change
η	reduction factor on bending stress
θ	angle or rotation Poisson's Ratio
v G	
σ	stress
φ	angle or rotation brace direction freedom
Ψ	
ω	frequency

Abstract of report, results and conclusions

INTRODUCTION

Jacket type offshore structures are conventionally analysed as frames with members connected at rigid joints.

In fact the joints are not rigid.

This report is concerned with the errors in deflections, nominal stresses, buckling load and natural frequencies involved in assuming rigid joints. The nominal stress excludes any stress concentration factor.

The study is limited to in-plane effects in vertical frames.

SCOPE OF WORK

A method was developed for using joint flexibility data, including the important brace to brace coupling terms, within a jacket analysis.

A number of jacket frames were then analysed both conventionally and with flexible joints.

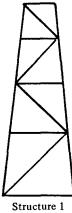
The results were compared numerically and qualitatively. Recommendations were made concerning analysis and design.

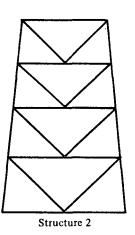
THE ANALYSIS

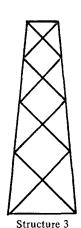
Stiffness matrices representing brace-chord and brace-brace in-plane connectivity, for various tubular joints, were calculated from flexibility data made available by Professor Fessler ⁽¹⁾ of Nottingham University. The data in the form of flexibility matrices covered the required range of T-joints but only the standard D/T = 25.3, d/D = 0.53 K-joints. To estimate the required matrices for the other K-joints it was necessary to obtain flexibility ratios from the T-joints and to apply those to the available K-joint values. A YT-joint with D/T = 50.6 and d/D = 0.53 was also available.

Three structures representative of North Sea jacket frames were each analysed with seven different types of joint.









Main chords were 1700 x 30; inclined braces 900 x 25; horizontal braces 750 x 25.

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