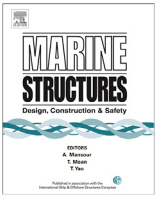
Marine Structures 46 (2016) 1–29

Contents lists available at ScienceDirect

Marine Structures

journal homepage: www.elsevier.com/locate/marstruc



A comparative study on damage assessment of tubular members subjected to mass impact

Burak Can Cerik [a, *], Hyun Kyoung Shin [b], Sang-Rai Cho [b]

[a] School of Marine Science and Technology, Newcastle University, UK
[b] School of Naval Architecture and Ocean Engineering, University of Ulsan, Republic of Korea

A R T I C L E I N F O

Article history:
Received 13 August 2015
Received in revised form 9 November 2015
Accepted 20 November 2015
Available online 20 December 2015

Keywords:
Tubular member
Mass impact
Non-linear finite element analysis
Damage assessment
Simplified methods

A B S T R A C T

This paper focuses on the behaviour of tubular members when subjected to low-velocity mass impact. Particular emphasis is given to the numerical assessment of impact damage and the classification of impact response of tubular members. Damage extents of 12 tubular frame test models were predicted and used for quantifying the modelling uncertainties of the numerical tools. USFOS and ABAQUS software packages were used with beam and shell elements, respectively. Based on the test results and the parametric studies performed, the influence of the geometrical parameters and the interaction between the local shell denting and the global beam deformation modes are discussed. A classification of the impact response of the tubular members based on their relative resistance against shell denting and beam plastic collapse load is proposed. Finally, existing analytical models for each energy dissipation mode are visited and modifications are proposed.

1. Introduction

Unstiffened cylindrical shells with relatively small radius to thickness ratio, called tubular members, are widely used in supporting structures of fixed offshore platforms such as jackets and jack-ups and as bracings in floating offshore platforms. Collision with supply vessels and the impacts of dropped heavy

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* Corresponding author.
E-mail address: burak.cerik@ncl.ac.uk (B.C. Cerik).

http://dx.doi.org/10.1016/j.marstruc.2015.11.002

Notation

a	defined in Fig. 3
m_o	fully plastic bending moment of cylinder wall per unit width
n	strain hardening exponent in Eq. (20)
q	exponent in Cowper–Symonds equation
r_o	radius of deformed cross-section
t	cylinder shell thickness
w	global beam deformation
B	impact contact width
C	coefficient in Cowper–Symonds equation
D	outside diameter of a tubular beam
D_{max}	maximum diameter of deformed cross-section, defined in Fig. 3
D_{min}	minimum diameter of deformed cross-section, defined in Fig. 3
E	Young's modulus
I	second moment of area of a tubular beam cross-section
K	strain hardening parameter in Eq. (20)
L	length (span) of a tubular beam
M	bending moment
M_p	fully plastic bending moment
N	axial force
N_p	fully plastic axial force
P	external applied lateral concentrated force
P_c	characteristic load for local indentation
P_o	plastic collapse load of a fully fixed tubular beam
$P_{o,red}$	reduced plastic collapse load of a fully fixed tubular beam
X_m	modelling uncertainty factor
α	mass proportional damping factor
β	stiffness proportional damping factor
δ	local shell dent depth
δ_1	displacement of top surface of a tubular beam, defined in Fig. 3
δ_2	displacement of bottom surface of a tubular beam, defined in Fig. 3
ε	engineering strain
ε_e	elastic strain
ε_{plat}	strain at the end of yield plateau
ε_t	true strain
μ	modification factor as defined in Eq. (32)
ρ	reduction factor as defined in Eq. (29)
σ_o	static flow stress
$\sigma_{o,d}$	dynamic flow stress
σ_t	true stress
σ_u	ultimate tensile strength
σ_Y	yield strength

objects, for instance a drilling collar, are a potential threat to these structures. It is of practical interest to consider the impact response and probable extents of damage for safety concerns.

This subject has attracted many researchers over the last few decades because of increased operations and incidents in the offshore industry. Among others, Furnes and Amdahl [1], Søreide and Amdahl [2], Søreide et al. [3], Ellinas and Walker [4], and Ong and Lu [5] reported experimental investigations on the behaviour of tubular members under quasi-static lateral loads. Thomas et al. [6] and Watson et al. [7,8] described various aspects of the tubular member deformation under lateral concentrated loading based on the experiments. Cho [9] and Frieze and Cho [10] described dynamic