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TECHNICAL ARTICLE—PEER-REVIEWED

# Numerical Investigation of the Failure of Stiffened Steel Plates Subjected to Near-Field Blast Loads

**Nurul Syafiqah Abdul Razak · Aizat Alias · Nor Maslina Mohsan · Siti Aliyyah Masjuki**

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**Abstract** This paper study the failure of stiffened steel plates subjected to near-filed blast loads using finite element (FE) analysis. Half-symmetry 3D FE models were developed using Abaqus for unstiffened and stiffened steel plates with different stiffeners configurations and sizes were used using solid brick elements. The behaviour of steel plates was modelled using classical plasticity constitutive equation, and the failure of the plates was modelled using ductile damage criterion. The influence of strain rates was considered using the Cowper–Symonds equation. The blast loads were applied using CONWEP function in Abaqus. The FE model of unstiffened plates was verified and validated against experimental data from literature where a good agreement was achieved. The FE model then was extended to incorporate different sizes and configurations of stiffeners. The study observed that stiffened steel plate tends to fail at lower blast pressure. The failure is influenced by the position and arrangement of stiffeners with respect to the size of stiffeners. Two new sub-modes of failure for stiffened steel plates are proposed namely Mode II*s and Mode IIs for partial plate tearing along stiffener and rupture of stiffener, respectively.

**Keywords** Stiffened steel plate · Ductile damage · Finite element · Damage energy

## Introduction

Stiffened steel plates are used in many applications such as blast walls for offshore structures, military vehicles and ship hull as stiffened plates have higher stiffness compared unstiffened or bare steel plates. In general applications, these plates may subject to known design static load but in extreme condition such as blast due to explosions, the actual loads impacted on the plates may be unknown because of various factors. The response of steel plates subjected to blast loads have been the subject of interest for many years and still on going.

Yuen et al. [1] has provided an extensive review on this subject where the authors compiled and discussed the progress of this subject for more than 20 years of research. The discussion focussed on the dynamic behaviour, modes of failure and dimensional analysis of unstiffened and stiffened steel plates subjected uniform and localised blast loads for various shape of steel plates from experimental programs. The modes of failure in stiffened plates are influenced by types of loading [2, 3, 4] and boundary conditions [5]. Henchie et al. [6] studied the response of circular plates subjected to repeated uniform blasts and the results show the mid-point displacement increases per applied loads. Yuen et al. [7] investigated the response of

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N. S. A. Razak · A. Alias (✉)
Faculty of Civil Engineering Technology, Universiti Malaysia Pahang, Gambang, Kuantan, Pahang, Malaysia
e-mail: aizat@ump.edu.my

N. M. Mohsan
Faculty of Civil Engineering, Universiti Teknologi MARA Pahang, Jengka, Pahang, Malaysia

S. A. Masjuki
Department of Civil Engineering, Kuliyyah of Engineering, International Islamic University, Kuala Lumpur, Malaysia

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