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Fatigue Behaviour of Nailed Tubular Connections

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ABSTRACT

Tests on nailed connections under static axial tension or compression loading have resulted in published limit states design procedures for these types of splice connections. This paper represents the results of an experimental study on the fatigue behaviour and performance of similar nailed tubular connections. A total of 14 lapped splice nailed tubular connections has been tested in fatigue under constant amplitude loading, with variables including tube thickness, number of nails and stress range. The performance of nailed tubular connections has consistently proven to be both reliable and predictable, both under static and now fatigue loading conditions. As such, design criteria for nailed connections can safely and easily be included in structural design codes.

NOMENCLATURE

A_{br} = bearing area
A_n = net cross-sectional area
A_v = shear area
d = diameter of a fastener shank
D_i = outside diameter of an inner tube
D_o = outside diameter of an outer tube
f = frequency of applied load (hertz = cycles/s)
F_u = ultimate strength of material
F_y = yield strength of material
n = number of fasteners
N = total number of cycles to failure
ΔP = load range (force) = $P_{max} - P_{min}$
ΔP_n = load range per nail = $\Delta P \div n$
P_{max} = maximum load (force)
P_{min} = minimum load (force)
S_{br} = nominal bearing stress range
S_n = nominal normal stress range
S_v = nominal shear stress range
t_i = inner tube wall thickness
t_o = outer tube wall thickness

INTRODUCTION

Steel nailing was developed, and is primarily used, for fastening sheet metal to structural steel, for metal roof decks and cladding. Research undertaken at the University of Toronto has shown that the existing technology of steel nailing can also be used to connect structural steelwork, particularly hollow structural steel members. Splice connections between tubular members have traditionally been made by butt welding or high-strength, bolted connections. Both of these connections are relatively expensive as they rely on shop fabrication or site welding. A simple and versatile telescoping-type splice connection can be made by inserting one circular section inside another. This insertion, for which the inside diameter of the larger equals the outside diameter of the smaller, creates a tube-in-tube splice connection. Joining of the tube walls can then be accomplished by site welding or so-called blind bolting (Korol et al., 1993), but even the latter involves careful site alignment of shop-drilled holes. Alternatively, the tube walls can be nailed together. The steel nailing process involves an independent powder-actuated tool (or gun), which drives a high-strength ballistic point pin (or nail) into the steel. These structural connections are made very quickly and safely after minimal training with the equipment. Fig. 1 shows a typical tube-in-tube splice connection being made. As this method avoids all shop fabrication and field bolting procedures, erection can be performed by relatively unskilled workers on site, at an extremely fast rate.

An immediate application for the nailed, lapped splice connec-

Fig. 1 Steel nailing

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KEY WORDS: Steel structures, tubes, splices, connections, nailing, fatigue.