Ain Shams University
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Behaviour and Strengthening of Steel Hollow Section Connections Subjected to Axial and Eccentric Loading

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سلوك و تقوية وصلات القطاعات المعدنية المفرغة المعرضة لقوى محورية و غير محورية

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ABSTRACT

Circular hollow sections are most often found in heavy offshore structures subjected to oscillating wave loads. The joints between hollow sections are simple in form, but not simple when stress distribution and design calculations are considered. Extensive studies have been carried out on unstiffened joints, as a result of which their behaviour under various types of loading have been well understood. Methods of assessing their strengths have also been very well developed. But little effort has been made to study in detail the behavior of stiffened hollow section joints in intact conditions and the development of a methodology to assess their strengths. Information on the strength and behavior of these joints in their intact conditions are seldom available. They are useful in the development of guidelines for the design of such joints in offshore structures and also in the evaluation of the reduction in their strengths in case they are damaged due to various causes.

The behaviour and strength of both stiffened and unstiffened hollow section joints subjected to both axial compression force and in plane bending moment have been studied theoretically in this work. A nonlinear finite element model which allows for geometric non-linearities is constructed for the study using the nonlinear finite element program ABAQUS. A pre-study is performed in order to verify the developed numerical finite element model and its capability to investigate the behaviour of the joints.

Large numbers of joints with different chord and branch dimensions are selected, in order to draw complete Load-displacement curves and to study the different failure modes. Different strengthening

techniques are used which are: a) Strengthening using external gusset plates, b) Strengthening using internal ring stiffeners, c) Strengthening using collar plates and d) Strengthening using knife plates. Strength equations are proposed for the case of using internal ring stiffeners.

Finally, comparison between different strengthening methods is made to find the most applicable strengthening technique.

STATEMENT

This dissertation is submitted to Ain Shams University for the degree of Master of Science in Structural Engineering.

The work included in this thesis has been carried out by the author in the Department of Structural Engineering, Ain Shams University, from March 2006 to September 2011.

No part of this thesis has been submitted for a degree or a qualification at any other university or institution.

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NOTATIONS

The following symbols are used in the present thesis; other symbols not listed below are defined where they are first used.

d_o: chord outer diameter;

d_1: branch outer diameter;

d_{st}: depth of the external stiffener (external plate);

d_r: depth of the internal ring stiffener;

d_c: depth of the collar plate;

d_k: depth of the knife plate;

f_{op}: chord stress as a result of additional axial force;

L_o: chord length;

L_1: branch length;

$M_{j,un}$: ultimate bending strength of the unstiffened joint, at (P=0);

$M_{j,st}$: ultimate bending strength of the stiffened joint, at (P=0);

$P_{j,un}$: ultimate axial strength of the unstiffened joint, at (M=0);

$P_{j,st}$: ultimate axial strength of the stiffened joint, at (M=0);

P_o: chord preload

P_{yo}: yield normal capacity of the chord ($= F_y .A_{chord}$)

R: P_o/P_{yo};

t_o: chord wall thickness;

t_1: branch wall thickness;

t_{st}: thickness of the external stiffener (external plate);

t_r: thickness of the internal ring stiffener;

t_c: thickness of the collar plate;

t_K: thickness of the knife plate;

β: diameter ratio (=d_1/d_o);

γ: chord radius/thickness ratio (=$d_o/2t_o$);

τ: wall thickness ratio (t_1/t_o); and

α: chord length parameter ($2L_o/d_o$).

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