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Chord Stress Functions for K Gap Joints of Rectangular Hollow Sections

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In the current design codes, the equations for the effects of chord stress in circular (CHS) and rectangular hollow section (RHS) joints are inconsistent. For CHS joints, the chord stress function is based on the chord pre-stress, while for RHS joints the maximum chord stress is used. In the framework of the CIDECT (Comité International pour le Développement et l'Étude de la Construction Tubulaire) program 5BK, it was decided to re-analyze the chord load effects for CHS joints in order to establish a chord stress function based on the maximum chord stress. In a second CIDECT program 5BU, the existing chord stress functions for RHS joints were re-analyzed in order to establish chord stress functions consistent with those developed for CHS joints in CIDECT program 5BK. Further, the developed formulae had to be presented in a simplified form suitable for the new updated design recommendations of IIW Sub-commission XV-E, whose recommendations were in the past the basis for the CIDECT Design Guides and also for most international standards, e.g. Eurocode 3. In this paper, taking into account the numerical results presented by Liu and Wardenier (2006), new chord stress functions are presented for RHS K gap joints. The accuracy of these newly proposed chord stress functions is assessed by comparing the predictions with available FE data.

NOMENCLATURE

CHS circular hollow sections
RHS rectangular hollow sections
A_0 cross-sectional area of chord
$M_{pl,0}$ chord plastic moment resistance for class 1 and 2 sections
$M_{el,0}$ chord elastic moment resistance for class 3 sections
M_0 bending moment applied to chord
N_i axial brace load ($i = 1$ or 2)
$N_{pl,0}$ chord plastic axial load resistance
N_0 chord axial load
N_{0p} external axial chord load
a exponent for m
b_i external width of brace i ($i = 1$ or 2)
b_0 external width of chord
e eccentricity
$f_{y,0}$ yield strength of chord
g gap size
h_i external height of brace i ($i = 1$ or 2)
n nondimensional chord stress ratio; in analysis $N_0/N_{pl,0}$
m nondimensional moment ratio for chord $M_0/M_{pl,0}$
t_i wall thickness of brace i ($i = 1$ or 2)
t_0 wall thickness of chord
β width ratio between braces and chord
γ half width to thickness ratio of chord, $\gamma = b_0/2t_0$
θ_i angle between brace member i ($i = 1$ or 2) and chord

INTRODUCTION

In current design rules, insufficient emphasis is put on the consistency of various design equations. For circular hollow section (CHS) joints, the external chord "pre-load" (i.e. the additional load in the chord which is not necessary to resist the horizontal components of the brace forces) is used to account for the effects of chord loading. However, for rectangular hollow section (RHS) joints, the chord stress formulation is based on the maximum chord stress, i.e. the stresses as a result of axial force and (where applicable) the bending moment.

To a designer, it is confusing that different approaches are used for different categories of joints, which leads to misinterpretations and errors. Hence, in the framework of CIDECT (Comité International pour le Développement et l'Étude de la Construction Tubulaire) program 5BK, it was decided to re-analyze the chord stress effects on the ultimate strength of CHS joints, and to establish chord stress functions related to the maximum chord stress, being consistent for CHS and RHS joints. The various available chord stress functions for CHS and RHS joints are mostly based on individual numerical and/or experimental results for individual joint configurations. The second objective of the CIDECT program then was to establish a simplified chord stress function which can preferably be applied to different CHS and RHS joints.

In CIDECT program 5BK (Van der Vegte et al., 2002, 2003), the influence of chord stress on the axial strength of CHS T, X and K gap joints was re-analyzed. Many combinations, varying from $\beta = 0.25$ to 0.98 for X and T joints and $\beta = 0.25$ to 0.67 for K gap joints with 2γ ($25.4 \le 2\gamma \le 63.5$), were analyzed numerically for different values of the chord stress ratio n. The applied chord stress ratio n varied from $-0.9\ f_{y,0}$ to $+0.9\ f_{y,0}$.

The numerical results for the various types of joints were also compared with the chord (pre-)stress functions, among others adopted by CIDECT Design Guide (Wardenier et al., 1991), Pecknold et al. (2001), ISO Draft (Dier and Lalani, 1998), and API RP2A (1993).

In the re-analysis of all CHS joint strength formulae by Van der Vegte et al. (2003), a simplified form of chord stress function was established for CHS joints using the maximum chord stress ratio n as primary variable, in line with the current chord stress functions adopted for RHS joints. The accuracy of the proposed chord stress functions was assessed by comparing the predictions with the available experimental results and FE data.

As part of program 5BK, Liu et al. (2004) presented an overview of all available chord stress functions for RHS joints with possible modifications.

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