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Load-Deformation Relationships for Gusset-Plate to CHS Tube Joints Under Compression Loads

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ABSTRACT

Gusset-plate to CHS tube joints are connections where the end of a plate is directly welded to the outer surface of a tube. This study proposes equations for ultimate and yield strength, initial stiffness and local deformation at ultimate strength for these types of connections. These equations are based on a ring model with an effective width using multiple nonlinear regression analyses. To describe the load-deformation behavior of gusset-plate to CHS tube joints, each load-deformation curve is approximated by 2 straight lines using these equations.

INTRODUCTION

A database for gusset-plate to CHS tube joints has been compiled at Kumamoto University to provide other researchers with a starting point for their own work on this topic. Many studies have been carried out in Japan with results published in Japanese journals and conferences. Because the language barrier has prevented these results from being found and subsequently utilized in research problems outside Japan, the authors compiled the "Database of Test and Numerical Analysis Results for Gusset-Plate to CHS Tube Joints" (Makino et al., 1998).

This investigation aims to produce simple load-deformation relationships for the joints mentioned in the database. This paper proposes the ultimate and yield strength equations and the equations for initial stiffness and deformation values at ultimate strength for gusset-plate to CHS tube joints under compression loads. Each load-deformation curve is described by 2 straight lines as shown in Fig. 1. Functions F_1 and F_2 are derived using the geometrical and material parameters of the connections. Hence, these relationships estimate loads and deformations at yield and collapse for gusset-plate to CHS tube joints of any given geometry.

The only existing study of the strength equations of gusset-plate to CHS tube joints to the authors' knowledge is that of Makino (1984) / Makino et al. (1986), in which equations for ultimate strength were developed. However, yield strength, initial stiffness and deformation values were not considered in Makino's paper because of insufficient test and analysis data. In this paper, the equations are given not only for ultimate strength but also for yield strength, initial stiffness and deformation values. The ultimate goal of this project is to offer available material on strength and deformation and to acquire design formulae for every type of gusset-plate to CHS tube joint.

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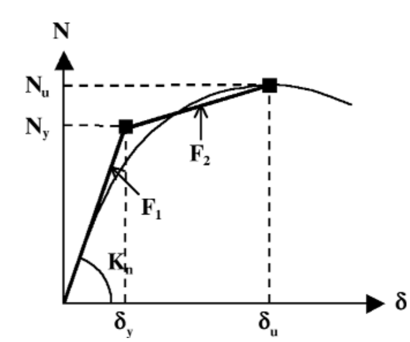
KEY WORDS: Effective width, strength equation, gusset-plate to CHS tube joint, load-deformation curve, regression analysis, ring model.

CLASSIFICATION OF JOINT TYPES

The joints studied in this paper consist of gusset-plates and a CHS tube. The configurations are similar to tubular X or T-joints with welded gusset-plates instead of braces. This paper deals only with those configurations where a stiffener is added to the CHS tube to resist shear and bending moments across the cross-section of the CHS tube. Other configurations, where load-transmission is axial and the connection strength is not dependent on the deformation of the cross-section, are excluded from this paper. The forms of gusset-plate to CHS tube joints are XP and TP-joints, which correspond to tubular X and T-joints, respectively. Each joint type is classified into 5 types by the shape of the joints, as shown in Table 1. In addition, 2 types of gusset-plates are distinguished: in one, the extension is oriented laterally, a rib-plate; in the other, the extension is oriented longitudinally, parallel to the axis of tube, a gusset-plate.

Generally, joints are subjected not only to simple loads but also to combined loads. In this paper, only joints subjected to simple compressive loads are considered, as presented in Table 1. This paper uses 85 tests and numerical analyses to develop the equations. The numbers of each joint type and the parameter ranges are shown in Table 2.



i.e. $F_n = f_0(N_u, N_y, \delta_u, \delta_y)$

where $N_u = f_1(\alpha, \beta, \gamma, \ldots)$ $\quad \delta_u = f_2(\alpha, \beta, \gamma, \ldots)$

$N_y = f_3(\alpha, \beta, \gamma, \ldots)$ $\quad \delta_y = f_4(\alpha, \beta, \gamma, \ldots)$

Fig. 1 Load-deformation relationship