第Ⅰ部門 INFLUENCE OF STIFFENER GAPS ON ULIIMATE BEHAVIOR OF PLATES UNDER BENDING

Osaka University Student M. ○Nobuaki Matsui
Technical University Budapest Laszlo Dunai
Osaka University Member Ichiro Okura
Osaka University Member Yuhshi Fukumoto

1 Introduction

The modified structural details of horizontal and vertical stiffeners to meet the requirement of robotic welding are needed in steel bridge fabrication. This paper presents the applied FE program and the effects of stiffener gaps on the ultimate behavior of stiffened plates under bending.

2 FE Program

A geometrical and material nonlinear FE program was developed to analyze the interaction between strength and stability phenomena of plated structures [1]. An isoparametric, 8-node Serendipity element is adopted in the FE program. Features of the applied elasto-plastic material models are as follows: (a)monotonic plasticity model; von Mises yield criterion, linear isotropic hardening. (b)cyclic plasticity model; multi-surface extended Mroz model with combined isotropic and kinematic hardening. The total Lagrangian approach and the von Karman's hypothesis are used for the geometric nonlinearity. Combined Newton-Raphson techniques are introduced to solve the nonlinear equation system.

3 Influence of Stiffener Gaps on Ultimate Behavior of Plates under Bending

Numerical studies were carried out to analyze the effects of stiffener gaps on the ultimate behavior of square stiffened plates under bending. Geometry and material properties of the plates are shown in Fig. 1. The following stiffener gaps were considered:
- full length horizontal stiffener welded to the vertical stiffener (g=0).
- full length horizontal stiffener without welding to the vertical stiffener (g=0).
- partial length stiffener with gap sizes (g= 35, 55, 70, 85, 100, 140, 192, 384, 768 mm).
- plate without horizontal stiffener (g=1152 mm).

Due to the symmetry of the geometry, loading, and boundary conditions, one half of the plate was divided into finite elements. All edges of the plate are simply suported in the out-of-plane direction. The edges of y=0 and 2304 are free to move in the in-plane direction. The bending load was applied at x=0 by prescribing displacements. The material of the plate is elastic-perfectly plastic. The shape of the initial out-of-plane deflection of the plate and its maximum value are given in Fig. 1. For the unstiffened plate, the first buckling mode of plates in pure bending was used for the initial imperfection shape.

The nonlinear computations were controlled by the Euclidean norm of the unbalanced forces and the negative eigenvalues of the tangent stiffness matrix. The calculations were

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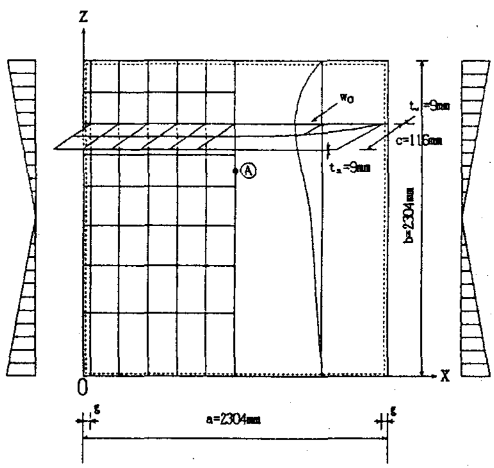
Nobuaki Matsui, Lazslo Dunai, Ichiro Okura, Yuhshi Fukumoto carried out up to the ultimate strength level. The moment was derived from the reaction forces at the loading edge of x=0. The relationship between normalized moment and out-of-plane deflection at the point A is drawn in Fig. 2. The plate with the horizontal stiffener welded to the vertical stiffener has the largest ultimate strength. The curves for the full length horizontal stiffener without welding to the veritcal stiffener and the partial length horizontal stiffeners with g=35 and 50 mm are very close to each other. The relationship between ultimate moment and gap size and the relationship between additional out-of-plane deflection at the service load level of M/M_Y=0.6 and gap size are shown in Fig. 3 and 4, respectively. The ulimate strength takes almost the same magnitude for 0<g<55 mm, and sharply decreases for 55 mm<g<100 mm. The additional out-of-plane deflection increases linearly for 55 mm<g<384 mm. Further studies on different loading conditions and whole plate girder models are in progress.



a/b=1.0

$$w_0=\frac{b}{250}\sin\left(\frac{\pi x}{a}\right) f(z)/f(0.8b)$$

$$f(z)=\frac{495.0z^{8}(b-z)^{2}}{b^{11}}$$

SS400 (E=210000MPa, ν=0.3, σ_Y=240MPa)

Figure 1 Analytical model

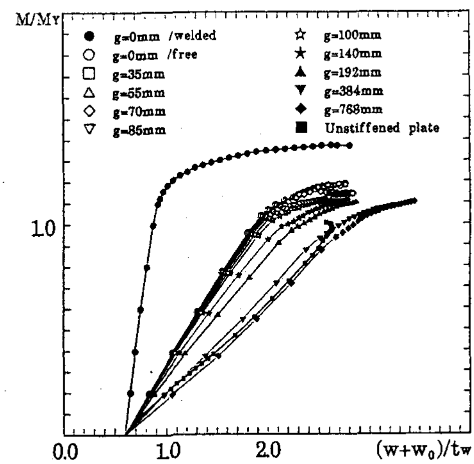


Figure 2 Moment versus out-of-plane deflection curves

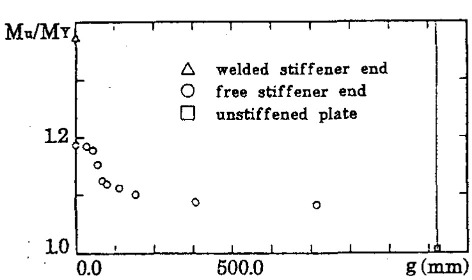


Figure 3 Relationship between ultimate moment and gap size

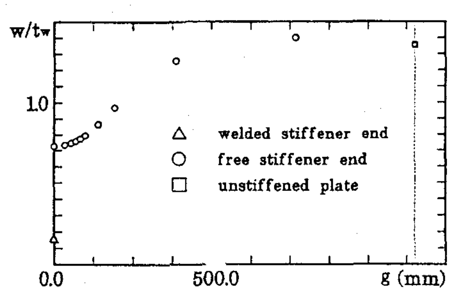


Figure 4 Relationship between additional out-of-plane deflecion and gap size (M/M_Y=0.6)

References

[1] Dunai L.: "Nonlinear Finite Element Analysis of Steel Plated Structures," University Doctoral Thesis, Technical University of Budapest, 1987, (in Hungarian)