INFLUENCE OF LOCAL AND OVERALL INITIAL DEFLECTIONS ON LOAD BEARING CAPACITY OF UNSTIFFENED BOX SECTION COLUMNS UNDER PURE COMPRESSION

Nagasaki University Student Member ○Xiang CHEN Nagasaki University Member Shozo NAKAMURA
Nagasaki University Member Toshihiro OKUMATSU Nagasaki University Member Takafumi NISHIKAWA

1. INTRODUCTION

It is well known that the initial deflection has significant influence on the load bearing capacity of box section columns under pure compression. However, there has not been many studies to evaluate the influence quantitatively and parametrically. In this study, the influence of local and overall initial deflections on load bearing capacity of unstiffened box section under pure compression is evaluated by performing a series of finite element analyses of a variety of models with different initial deflections.

2. FE ANALYSIS

FE analyses of 315 models in which the initial deflection and residual stress are considered, are performed by MSC.Marc. Table 1 shows the combination of slenderness ratio parameter (λ) and width-thickness ratio parameter (R) of the models.

Table 1 Combination of buckling parameters

	λ=0.1	λ=0.5	λ=1.0	λ=1.8	λ=2.1
R=0.1	R01L01	R01L05	R01L10	R01L18	R01L21
R=0.5	R05L01	R05L05	R05L10	R05L18	R05L21
R=0.7	R07L01	R07L05	R07L10	R07L18	R07L21
R=0.9	R09L01	R09L05	R09L10	R09L18	R09L21
R=1.2	R12L01	R12L05	R12L10	R12L18	R12L21
R=1.5	R15L01	R15L05	R15L10	R15L18	R15L21
R=2.1	R21L01	R21L05	R21L10	R21L18	R21L21

2.1 Boundary condition

The boundary condition of the models is shown in Fig.1. Only rotation Y is free at the bottom node. At the top node, four degrees of freedom are fixed except rotation Y and displacement Z. In order to get ultimate strength accurately, displacement loading is used in the analyses. And the loading is applied to the top main node.

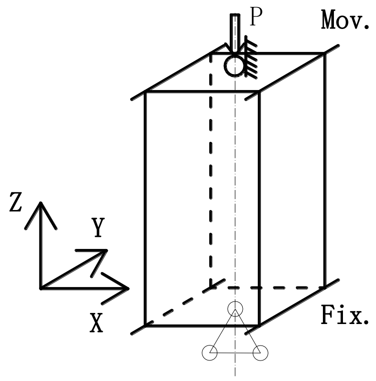

Fig. 1 Boundary condition

2.2 Residual stress

Residual stress is assumed to exist in every plate. According to current specification, mid area of the plate is assumed to possess compressive residual stress approximately equal to 0.25 of yield stress. Therefore, the residual stress distribution in a plate is assumed as shown in Fig. 2 so as to be in self-equilibrium condition.

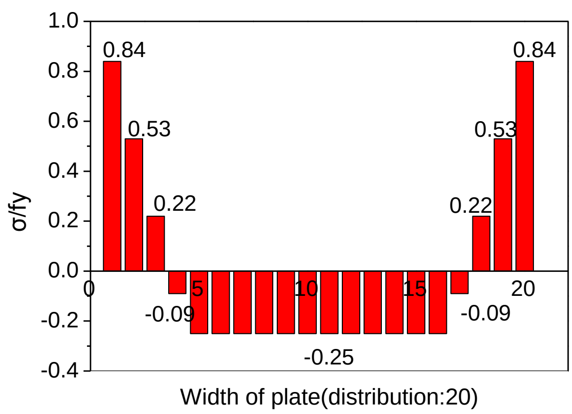

Fig. 2 Distribution of residual stress

2.3 Initial deflection

Initial deflection includes overall deflection along the length of the column w_g and the local deflection on the plate w_l. For the overall deflection, a half sinusoidal wave shape expressed by Eq. (1) is assumed along the length of the columns. On the other hand, double trigonometric function shown in Eqs. (2) and (3) is assumed for local deflection.

$$w_g = A\sin(\frac{\pi z}{L}) \quad (1)$$

$$w_l = w_{l0}\sin\frac{m\pi z}{L}\cos\frac{\pi x}{b} \quad (2)$$

Or $$w_l = w_{l0}\sin\frac{m\pi z}{L}\cos\frac{\pi y}{b} \quad (3)$$

Keywords: Load bearing capacity, Initial deflection, Unstiffened box section, Pure compression
Contact address: 1-14, Bunkyo-machi, Nagasaki, 852-8521, Japan, Tel: +81-95-819-2613

Where, A is the maximum value of overall initial deflection, L is the length of column, m is the number of half sinusoidal wave giving the minimum buckling strength determined by aspect ratio of the plate, b is the plate width, w_{l0} is the maximum value of local initial deflection. And nine conditions combined by local and overall deflections shown in Table 2 are considered to each model.

3. INFLUENCE OF INITIAL DEFLECTION

Load bearing capacity of condition b150L1000 is set as a standard, and initial deflection influence coefficient is defined as load bearing capacity of other conditions divided by the standard. Using the coefficient, influence of initial deflection under different conditions is studied.

3.1 Influence of local initial deflection

Models with λ equal to 1.0, overall initial deflection equal to L/1000 are selected as example. Fig.3 shows the influence coefficient versus local initial deflection. It can be seen that load bearing capacity decreases as the local initial deflection increases. When the width-thickness ratio parameter is small such as R=0.1, the decrease may be not obvious. As the width-thickness ratio parameter increases, the decrement on load bearing capacity caused by local initial deflection increases. Especially with R equal to 0.9, decrement reaches the largest of 19.2%. When R is bigger than 0.9, the decrement on load bearing capacity starts to decrease. Table.3 shows the slope of influence coefficient curve and decrement of load bearing capacity.

3.2 Influence of overall initial deflection

Models with R equal to 0.9, local initial deflection equal to b/150 are selected as example. Fig.4 shows the influence coefficient versus overall initial deflection. It can be seen that load bearing capacity decreases as overall initial deflection increases. When the slenderness ratio parameter is small such as λ=0.1, the overall initial deflection has little influence on load bearing capacity. As the slenderness ratio increases, the decrement on load bearing capacity caused by overall initial deflection increases. When λ is bigger to 1.0, decrement reaches around 13%.

4. CONCLUSIONS

Main conclusions of this study can be summarized as follows.

(1) As the local initial deflection increases from b/450 to b/75, load bearing capacity decreases at most 19.2%.

(2) As the overall initial deflection increases from L/3000 to L/1000, load bearing capacity decreases at most 13.5%.

The influence of local and overall initial deflections on coupled buckling strength was evaluated quantitatively in this study, and will be formulated as the function of key parameters in the future study.

Table 2 Conditions of initial deflection

	b/75	b/150	b/450
L/500	b75L500	b150L500	b450L500
L/1000	b75L1000	b150L1000	b450L1000
L/3000	b75L3000	b150L3000	b450L3000

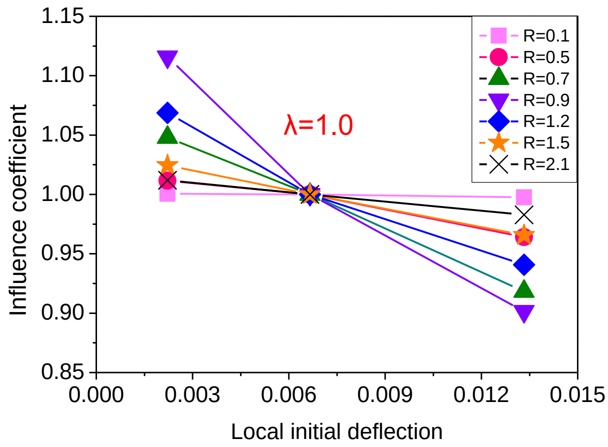

Fig. 3 Influence coefficient versus Local deflection

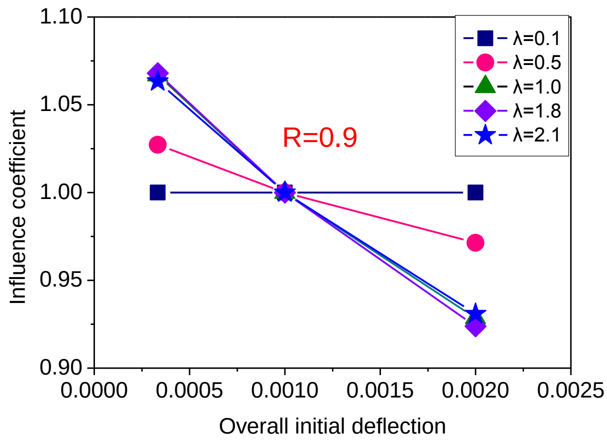

Fig. 4 Influence coefficient versus overall deflection

Table 3 Slope and decrement of influence coefficient

R	slope	load bearing capacity decrement	λ	slope	load bearing capacity decrement
0.1	-0.27	-0.3%	0.1	-0.60	-0.1%
0.5	-4.27	-4.7%	0.5	-33.51	-5.4%
0.7	-11.67	-12.4%	1.0	-83.02	-13.0%
0.9	-19.28	-19.2%	1.8	-86.49	-13.5%
1.2	-11.51	-12.0%	2.1	-79.48	-12.5%
1.5	-5.30	-5.7%	—	—	
2.1	-2.62	-2.9%	—	—	