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Reduction of the ultimate strength of the CFT column by creep effect

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ABSTRACT

This paper investigates the effect of creep, which occurs over time, on the reduction of the ultimate strength of the CFT (Concrete Filled steel Tube). To compare the reduction of the ultimate strength, P-M interaction diagram is introduced and each points for P-M interaction diagram is set by the specific conditions to calculate the area of the P-M interaction diagram in this paper. Since the ultimate creep coefficient of CFT is different from that of normal concrete, this paper proposed and used an ACI-based creep correction function for CFT. The analysis of the effect of creep on CFT was conducted based on a numerical analysis model. Finally, the results are summarized by comparing the results of this paper with the existing design code (Eurocode).

1. INTRODUCTION

Composite members made of steel with high tensile strength and ductility capacity and concrete with high compressive strength and stiffness have significant advantages in constructing structures. Based on these advantages, the composite member mainly used when making the columns of the structure is the reinforced concrete columns. Reinforced Concrete columns are members that utilize the material advantages of steel and concrete by reinforcing rebar in concrete. Like these reinforced concrete columns, CFT (Concrete Filled steel Tube), which is a composite member column of steel and concrete, is another composite member column that fills an outer steel pipe made of steel with concrete inside and relatively superior in strength, rigidity and ductility than reinforced concrete columns.

Since both reinforced concrete columns and CFT columns are made of concrete, drying shrinkage and creep phenomena due to long-term continuous loads, which occur due to the material properties of concrete, cannot be avoided. However, in general, the effects of long-term continuous loads in CFT columns in reinforced concrete columns show a large difference due to the difference in the shape of members. Unlike reinforced concrete column members, CFT columns surrounding the outside of concrete with steel pipes rarely undergo drying shrinkage due to external exposure. Even in the case of the creep phenomenon, the confinement effect of the CFT column steel pipe prevents the

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horizontal expansion of the concrete, which limits the occurrence of the free creep phenomenon of the concrete in the vertical column direction. As such, CFT members are less affected by the time-dependent effect than reinforced concrete columns.

Current design standards also take this into account. In AISC and Eurocode, which are the design codes for CFT column, the part that deals with creep, which is one of the effects on the long-term continuous load of CFT, is considerably weaker than the part that deals with creep of reinforced concrete in the ACI standard. AISC does not consider the effect of concrete creep in CFT. Eurocode takes some into account when determining the effective flexural stiffness of a sectional column. However, when the p-delta effect is not considered, it is stated that it can be neglected when the ultimate strength of the moment due to creep has a decrease within 10%.

The preceding researchers conducted a study to verify this part because the long-term continuous load test for the existing CFT is insufficient compared to the short-term load test, and the design criteria are hardly dealt with compared to the short-term load test. In this paper, a numerical analysis model is proposed to understand the long-term behavior of CFT based on the research of these preceding researchers. The contents of the design code will be supplemented by verifying the contents of the reduction in strength of the column due to the long-term CFT behavior in AISC and Eurocode, and proposing an equation that can determine the amount of reduction in the ultimate strength of the column due to long-term continuous load.

2. METHOD

In order to reflect the effect of creep on CFT in a numerical analysis model, a creep function for CFT is required. However, since the creep function for CFT is not shown in the existing design code, in this paper, based on the creep function for concrete, a graph such as Fig. 1 was derived through the experiment results of previous researchers to estimate the alpha value constituting the creep function equation. Through this, a creep function CFT was proposed as shown in Eq. (1), and this function was used in this paper.

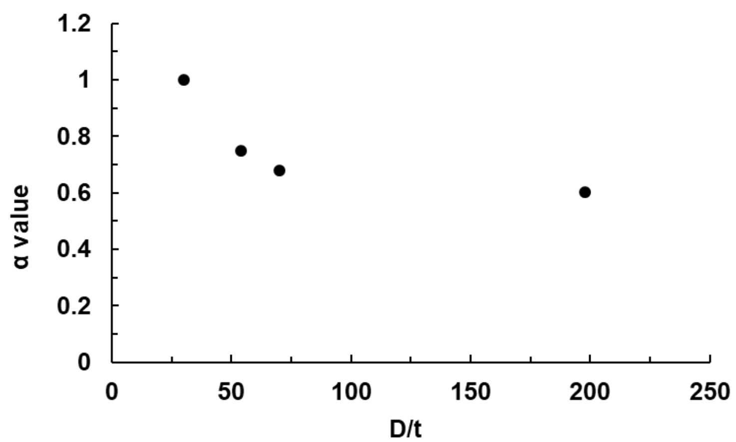

Fig. 1 Estimation of CFT creep function value based on previous study

$$\phi(\mathrm{t}, t_o) = \frac{(t-t_o)^{-0.0082(D/t)+1.2299}}{10+(t-t_o)^{-0.0082(D/t)+1.2299}}\,\phi_\infty, \qquad (D/t) < 76.8 \tag{1}$$

$$\left(\text{When } (D/t) \geq 76.8,\ \phi(\mathrm{t}, t_o) = \frac{(t-t_o)^{0.6}}{10+(t-t_o)^{0.6}}\,\phi_\infty\right)$$

In order to understand the influence of creep on the CFT, the strength of the CFT column was reduced based on the P-M correlation. Each point required to draw the P-M correlation diagram of CFT was based on the points mainly used in the design code. When the effect on time is not considered, the decrease in the strength of the CFT column according to the slenderness is based on the decrease in each point, which is explained by introducing the strength reduction factor F in Fig. 2 (Hwang et al. 2018). In this paper, the strength reduction factor *C* according to creep was proposed, and the effect of creep on the CFT column was investigated by additionally multiplying the strength reduction value of the CFT column according to the slenderness by *C*.

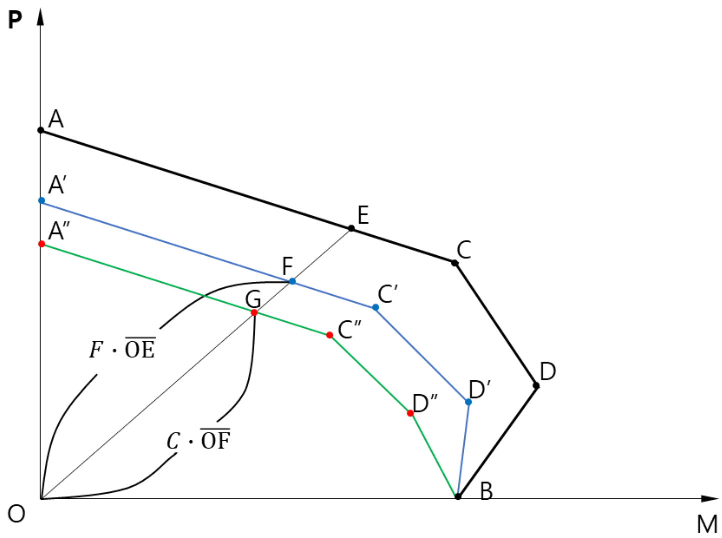

Fig. 2 Decrease of Linearized P-M interaction diagram by length and creep effect

In Fig. 2, the intensity reduction value at point A, which is most affected by creep, is shown in the figure as Fig. 3. It can be seen from Fig. 3 that a significant decrease in strength occurs in both the relatively long and short columns.

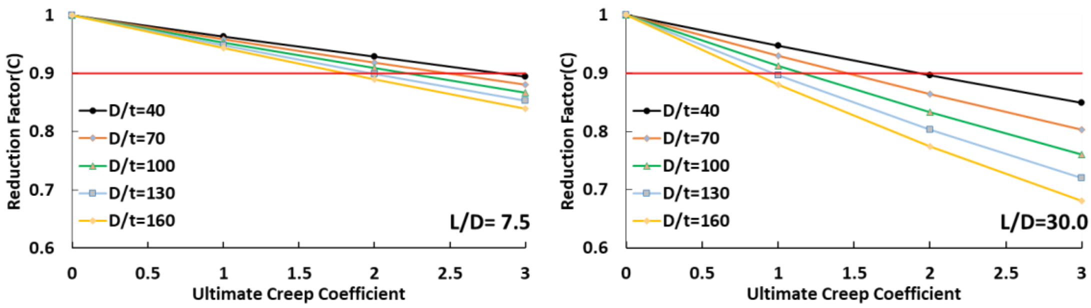

Fig. 3 Reduction of ultimate strength by creep at different slenderness ratio and D/t

3. CONCLUSIONS

A parametric study was conducted by constructing a numerical analysis model by applying the creep effect to the CFT column.The results and discussion can be summarized as follows

A. Although it is smaller than reinforced concrete, a significant decrease in strength occurred in the CFT column by creep. Since this is not negligible as it is dealt with in the existing design code, it is necessary to supplement the contents of the design code.

B. The effect of creep is greater as the thickness of the CFT steel pipe is slender, because the ratio of the concrete constituting the CFT cross section increases. In addition, the larger the slenderness, the greater the influence of creep, and if the cross-section is the same, the longer the length of the column, the more the decrease in the column strength due to creep occurs.

With the results of this study, the effect of creep on the reduction of CFT columns was investigated. This numerical analysis model proposes a strength reduction factor C that can predict the strength that CFT decreases due to creep, which makes it possible to understand the time-dependent behavior of CFT in detail.

ACKNOWLEDGEMENTS

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