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Compressive strength evaluation of circular tubular short columns with locally corroded ends

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ABSTRACT

When structural steel members are in contact with horizontal members, such as concrete slabs, dust and moisture easily accumulate at their junction. This can induce local corrosion at their ends, and consequently, reduce their compressive strengths. In this study, compressive tests were conducted on circular tubular short columns to examine the change in compressive strength with local corrosion at the ends of the columns. The columns were fabricated to have corrosion levels of various depths, heights, and circumferences. As a result, local buckling occurred near the column ends. Moreover, residual compressive strengths linearly decreased as the corroded depth, height, and circumference increased. An evaluation method using the effective volume was proposed to assess the residual critical compressive strengths of circular tubular short columns with locally corroded ends.

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1. Introduction

Corrosion is among the reasons for the deterioration of steel structures. It reduces the cross-sectional areas of steel members, and consequently, the strength and service life of steel structures are decreased [1–3]. For instance, the Mianus River Bridge collapsed after 25 years of service life because the assemblies of pins and hangers failed as a result of corrosion within the bearings of the pins [4]. In 2003, some sections of the Kinzua bridge collapsed because the base bolts holding the bases of the towers corroded and were subsequently destroyed by wind load [5]. Evidently, as observed from previous accidents, corrosion can reduce the service life of steel structures.

In the construction field, circular tubular short columns are widely used in offshore structures, power plants, bridges, and guardrails, as shown in Fig. 1. Recently, they have been applied to prestressed composite truss girder bridges in Korea. Because columns have relatively thin walls compared to their diameter, their structural performance is easily affected by corrosion damage.

Ahn et al. [6, 7] conducted compressive tests on circular tubular columns having replicated local corrosion damages that occur in marine environments and suggested a method for evaluating the ultimate strength according to corrosion level. Lutes et al. [8] and Yamane et al. [9] analyzed changes in compressive strengths of circular tubular columns with local corrosion, and thereafter, proposed an evaluation method for residual critical and ultimate strengths. Nazari et al. [10] and Nishimura et al. [11] investigated locally corroded circular tubular columns using a numerical approach and suggested an evaluation method for determining their critical and ultimate strengths based on dimensional aspect ratios and corrosion geometries.

As shown in Fig. 2, circular tubular columns are frequently embedded in concrete foundations or welded to steel base plates. As a result, dust and moisture more easily accumulate along the junction of vertical and horizontal members. Consequently, local corrosion frequently occurs at the bottom ends of columns. Moreover, even if corrosion is detected by periodic inspections, it is difficult to remove the rust and repaint these ends. It has been reported that eventually, local corrosion can cause a reduction in the cross-sectional area, as shown in Fig. 3. In extreme cases, complete failure at the ends of steel truss members can occur. However, the compressive strengths of columns with locally corroded ends have not been investigated.

In this study, compressive tests were conducted on circular tubular short columns with locally corroded ends to examine changes in compressive strengths according to corrosion levels. A total of 16 circular steel pipe specimens were made into short columns and fabricated with corrosion levels of different depths, heights, and circumferences. Changes in compressive strengths were evaluated, and an equation for evaluating the residual critical compressive strength of circular tubular short columns was proposed based on the effective volume.

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(a) offshore structure

(b) power plant

(c) prestressed composite truss girder bridge

(d) guardrail

Fig. 1. Circular tubular short columns in steel structures.

2. Experimental procedures

2.1. Fabrication of specimens

Test specimens were made from two different sizes of STPG 370 structural steel pipe based on ASTM A 500 [12]. Eight pipes, referred to as type A in this study, each has an external diameter of 165.2 mm and a thickness of 7.1 mm, whereas the other eight pipes, called type B, each has an external diameter of 267.4 mm and a thickness of 9.3 mm. The material properties and chemical composition of the pipes are summarized in Table 1. Types A and B specimens were made into short columns with lengths of 600 and 920 mm, respectively. Moreover, 20-mm thick steel plates with widths of 300 and 400 mm were welded to both ends of types A and B specimens, respectively, to replicate the contact of columns with horizontal members.

Prior to welding, artificial local corrosions were introduced to the bottom ends using a milling machine. As shown in Figs. 4 and

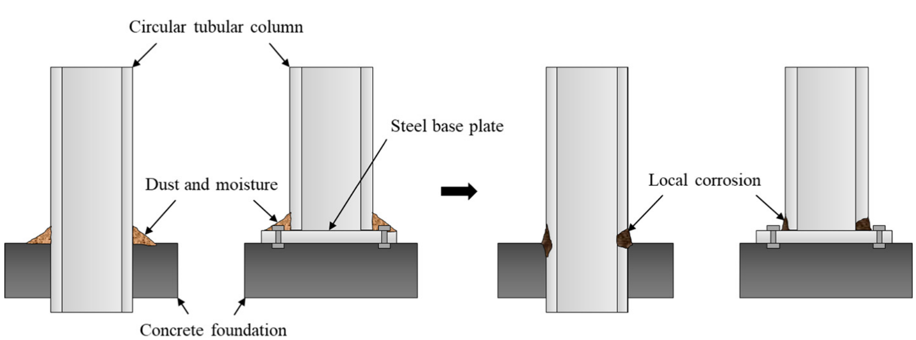

Fig. 2. Occurrence of local corrosion at the bottom end of a column in contact with a horizontal member.

Fig. 3. Local corrosion at bottom ends of steel columns.

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