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EXPERIMENTAL STUDY ON USE OF FALL PREVENTION MEMBERS IN WALL AND COLUMN DEMOLITION

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At demolition sites in Japan, columns and walls are pulled down and demolished by heavy machinery or wire ropes. In a small-scale building in urban areas, columns and walls are pulled down by wire ropes. Before pulling down, workers damage the bottom part of the columns and walls for weakening them. However, if the damage of the columns and walls are too much, they fall down before use of wire ropes. As a result, they may crush workers. In this study, a fall prevention material was proposed with its installation method and verified its effectiveness by experiments. In an experiment of this study, steel pipes for supporting 3m-column were examined. The steel pipes were installed diagonally to the column. The column was loaded horizontally. We measured load and deformation until the steel pipe failed. As a result of experiments, it was found that the steel pipe buckled or the bolt supporting the steel pipe damaged. We concluded that this method is effective because the steel pipes were found to be sufficiently strong against the load generated in the steel pipes when the columns fell.

Keywords: Fatal accident, Demolition work, Steel pipe, Bolt, Fall-down, Reinforced concrete.

1 INTRODUCTION

Large-scale construction machinery is usually used to demolish reinforced concrete buildings. However, it is difficult to install such heavy and big machines in a small-scale building in urban areas. Therefore, in such a small area, columns and walls are pulled down by wire ropes (Japan Construction Occupational Safety and Health Association 2012). Before pulling down, workers damage bottom part of columns and walls for weakening them. However, if the damage of the columns and walls are too much, they fall down before use of wire ropes. It is common to damage the bottom part of the columns or walls beforehand in order to facilitate the pulling down process. However, this operation may cause to crush workers by the column or wall. Therefore, we proposed a simple method to provide the safe working area for workers using steel pipes (Study Group on Demolition Method 2017). The effectiveness of the method was verified in the experiments. The purpose of the experiment is to investigate the strength characteristics of the column and wall until they fall.

2 OUTLINE OF THE EXPERIMENTS

The experiments were conducted to confirm the steel pipes could be provide a safety working area. The steel pipes were installed on steel column simulated reinforced concrete column. The steel pipes were used because installation of them was simple and easy in the demolition site. Figure 1 shows the schematic experimental situation. It is assumed that the concrete at the bottom of the column was damaged and the reinforcing bars had already been cut, so the bottom of the steel column is a pin structure. The pulling down of the column was simulated by loading rightward to the top of the column with a hydraulic jack. The loading was statically and monotonically by a manual pump. One of the parameters of the experiments was the lengths of steel pipes (1.0 m, 1.5 m and 2.0 m). The steel pipe was installed at 30 degrees to the steel column. The diameter of the bolts supporting the steel pipe was also a parameter of the experiments and M13 and M16 bolts were used. Additionally, each bolt was tested with a normal bolt and a high-strength bolt. According to the combination of them, 12 types of experiments were conducted. The nodal point between the bolts and the steel pipe and the bottom end of steel pipe are shown Figure 2 and Figure 3, respectively.

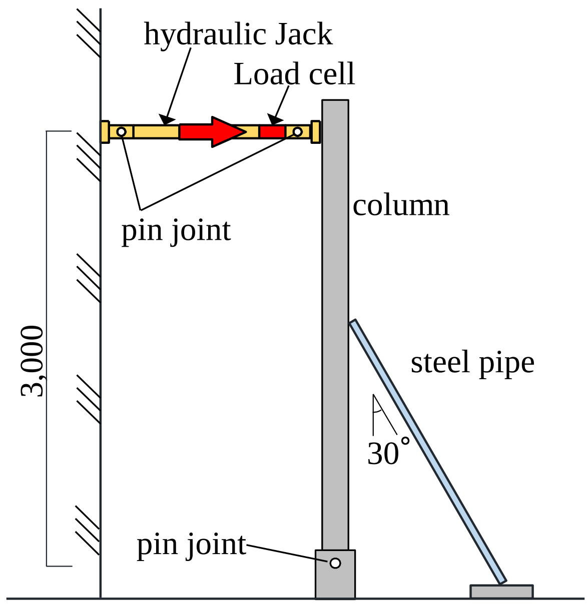

Figure 1. Schematic experimental situation.

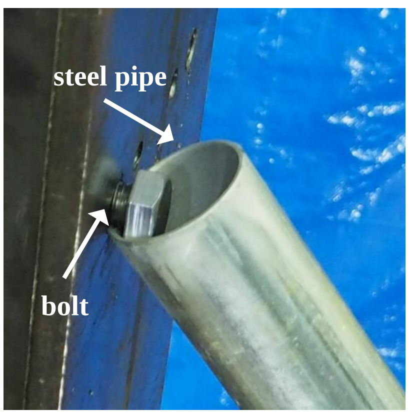

Figure 2. Set-up of the top end of steel pipe.

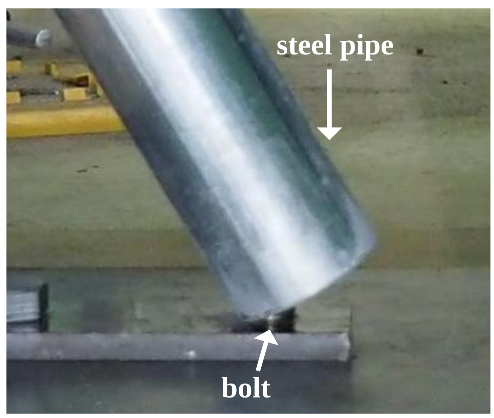

Figure 3. Set-up of the bottom end of steel pipe.

3 RESULTS OF THE EXPERIMENTS

Figure 4 shows the relationship between the axial force of the steel pipe and the inclination angle of the column in where M16-normal bolts. The blue and red lines are based on experiments and calculations, respectively. The axial force of the steel pipe in the experiments was calculated based on the measured data of the load cell installed into the hydraulic jack. The calculated axial force of the steel pipe was calculated according to the inclination angle of the column, taking into account the weight of the column, wall, beam, floor slab, and veranda. This was calculated based on the following assumptions. The specific gravity of the reinforced concrete is 24 kN/m^{3,} (Japanese Industrial Standards Committee 2012) the height of the column and wall is 3000 mm, the cross-sectional dimension of the column is 700 mm x 700 mm, the thickness of the wall is 180 mm, the cross-sectional dimension of the girder is 350 mm x 600 mm, the thickness and length of the slab is 150 mm and 710 mm, the thickness and length of the veranda is 150 mm and 1000 mm. The width of the wall, beam, floor slab and verandah are 6000mm. Comparing the experimental and calculated results, it was found that the steel pipe is sufficiently strong for the calculated axial force. Therefore, it was proved that this way could secure a safe working space for the workers.

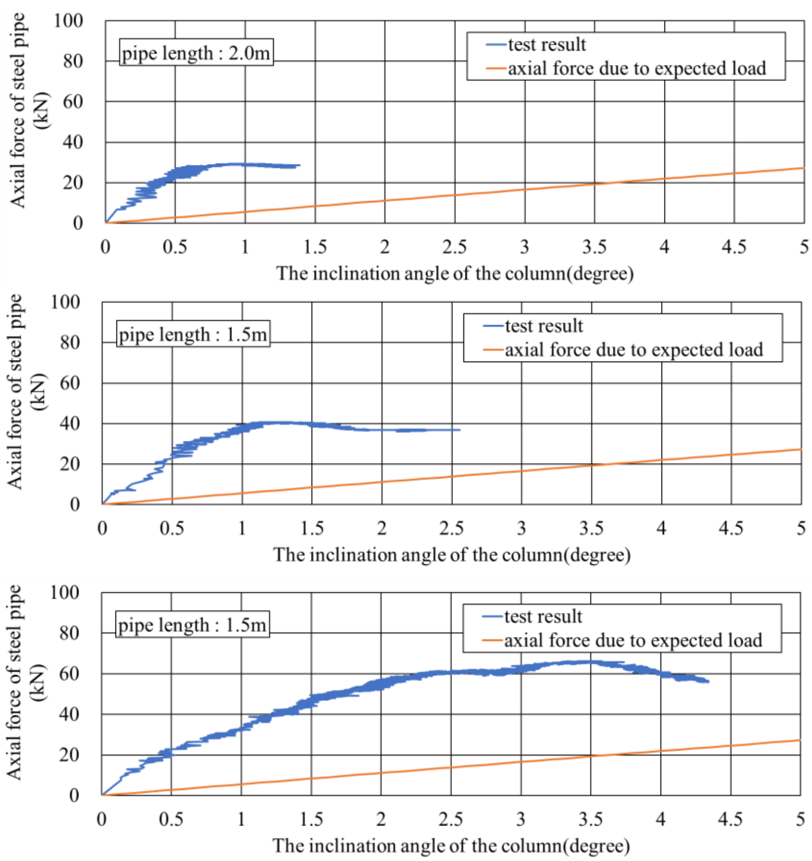

Figure 4. Relationship between axial force and inclination angle of the column.

Figure 5 shows the maximum load measured by the load cell installed into the hydraulic jack. The maximum horizontal load was independent of the length of the pipe. The steel pipe buckled in almost all conditions of the experiments. The buckling of a steel pipe is shown in Figure 6. However, shear failure of the bolts occurred under the condition that the steel pipes of 1.0m and 1.5m length were supported by M12 normal bolts. Therefore, the strength was lower than the other experimental results. The shear failure of bolt is shown in Figure 7. Figure 8 shows a steel pipe when the bolt has shear failure.

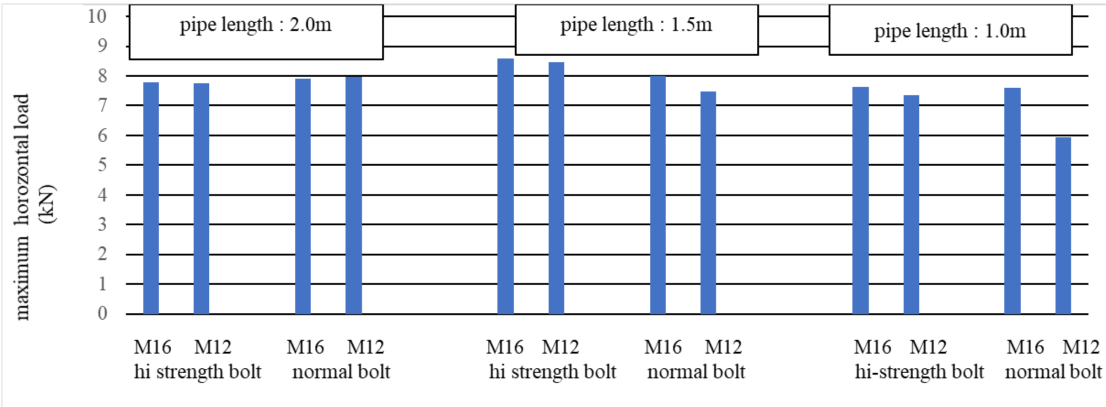

Figure 5. The maximum load measured by the load cell built into the jack.

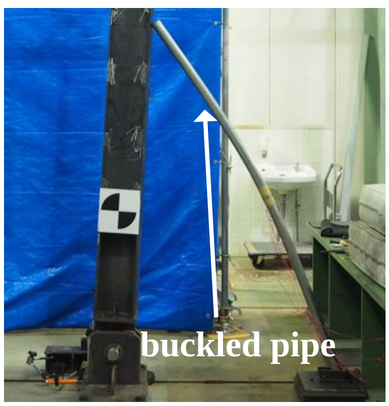

Figure 6. The buckling of a steel pipe.

Figure 7. Shear failure bolt.

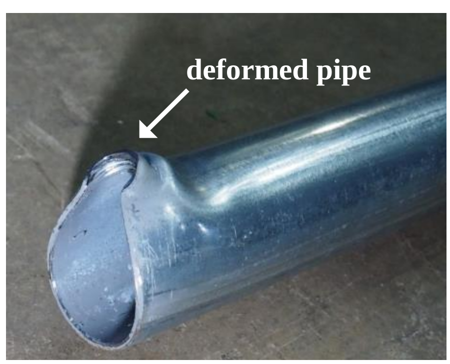

Figure 8. Steel pipe when thebolt had shear failure.

4 CONCLUSION

In this study, the method by using a steel pipe to improve the safety of the pull-down method while demolishing a reinforced concrete building was proposed. And the effectiveness of the method was verified by experiments. The results showed that a very easily installed steel pipe could ensure the safety of workers.

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