コンクリート工学年次論文報告集, Vol.16, No.2, 1994

論 文

[2111] Effect of Flexural Stiffness of Lateral Reinforcement on Confinement of Reinforced Concrete Columns

Paulus IRAWAN*1 , Tirath Manojya PALLEWATTA*2 , Koichi MAEKAWA*3

1. INTRODUCTION

A way to achieve the required ductility in the critical regions of seismic resistant reinforced concrete columns is to use lateral reinforcement. Lateral bars that surround the core concrete will give some resistance in the form of three-dimensional confinement to the core concrete. As widely known, this confinement will increase the strength and ductility of the core concrete. Degree of influence of lateral bars to three-dimensional stresses and in turn to the strength gain and ductility of core concrete depends on geometrical factors, such as volumetric ratio of steel, shape and distribution of reinforcement, spacing, and properties of steel and concrete.

Since lateral bars will affect the stress distribution inside core concrete, accurate modeling of the lateral bars in the analysis is crucial. In general, truss modeling of lateral bars, which is rooted in axial stiffness of bars and causes "corner action", is regarded as appropriate for lightly reinforced lateral steel [1,2,3]. However, it was also reported that large reinforcement induces additional confinement owing to the shear and flexural stiffness of bars [4]. The aim of this study is to experimentally and analytically verify how large the influence of beam actions of ties to the confinement of core concrete and how effectively it gives rise to the strength and ductility gain.

2. FLEXURAL RESPONSE OF LATERAL TIES

Most of previous analytical studies discussed the confinement action based on the concept that reinforcing bar work as truss element with just axial stiffness. On the basis of this model, for square and rectangular sections, the confinement action comes from corners of the section as shown in Fig. 1. Truss modeling of ties corresponds to no contact between tie arms and core concrete. On the other hand, if reinforcing bar is modeled as beam elements with axial, shear and flexural stiffness, confinement action develops not only at the corners, but also from the contact between tie arms and core concrete.

Truss modeling can be justified, if the diameter of the lateral bar is small enough compared to the core size where shear and flexural stiffness of reinforcing bars can be neglected compared to the axial

*1 Graduate Student, The University of Tokyo
*2 Former Graduate Student, The University of Tokyo
*3 Associate Professor, The University of Tokyo

stiffness. However, when larger diameter is used and contact between tie arms and concrete is present, the validity of this modeling is questionable [4].

The difference between both mechanisms of confinement can be recognized from the curvature profile which arises along tie arms of reinforcing bars. Induced moment along the tie bar is proportional to the curvature profile under elasticity. Beam action is not prominent if the curvature along the bar is negligibly small and truss-element assumption for ties can be adopted for this case..

To consider the effect of beam action of reinforcing bars, two pairs of experiments were conducted. Each pair consists of two columns with the same size of bar diameter. Size of core concrete in the first pair is different, but the ratio of spacing is relatively similar. The core size of the first column is 200 mm x 200 mm, and another one is 150 mm x 150 mm. It can be seen from Fig. 2a that column with smaller core section produces higher curvature in its tie arms than the one with larger core size. In the second pair, two columns with the same size of core and bar diameter, but different spacing are compared. Fig. 2b shows that the column with smaller spacing gives higher curvature in its tie arm. From these experiments, it is shown that the curvature is influenced significantly by the confinement arrangement.

Different curvature profile from the above observations will give rise to different bending moment in the ties. This moment must be equilibrated with both the shear of steel and contact forces acting on the core concrete. The higher the moment, the larger contact forces and confinement along the tie arms will be induced.

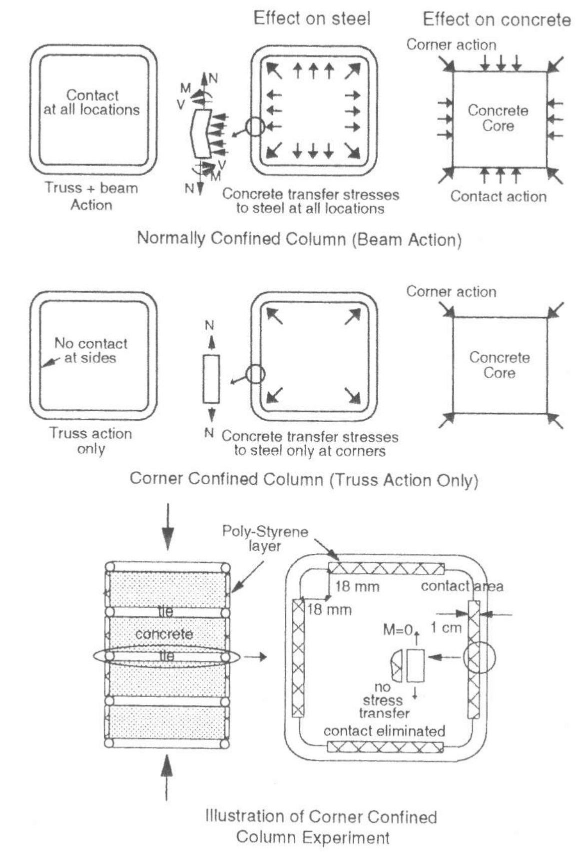

Fig.1 Different Mechanisms of Confinement

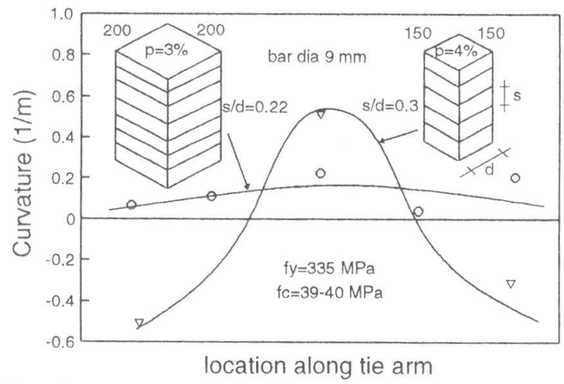

Fig. 2a Curvature Profiles along Lateral Tie in Columns with Different Core Size

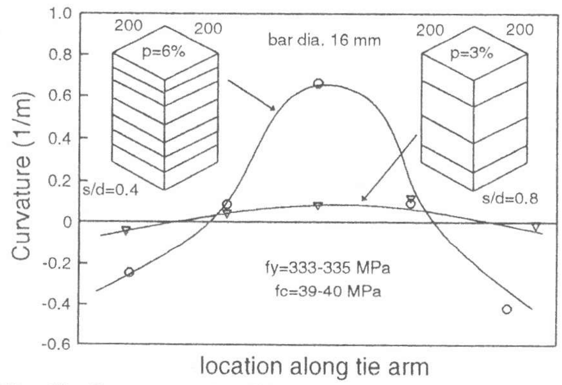

Fig. 2b Curvature Profiles along Lateral Tie in Columns with Different Spacing