# INFLUENCE OF SHAPE MODIFICATION AND STIRRUPS ON THE AXIAL CAPACITY OF CONCRETE COLUMNS

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# INTRODUCTION

- Columns are very important structural elements.
- Main function of columns is to support forces acting on plates and beams, and forward them to the foundation.
- Columns predominantly support axial compressive forces.
- Generally, the failure or collapse of the compressive structural element does not start with a clear warning, but occurs suddenly.
- Therefore, column structures should be carefully designed by providing higher reserve strength (Tavio et al., 2009).

## Introduction …

- The ductility of axial and bending structural elements is strongly influenced by confinement i.e. by stirrups.
- Confinement by stirrups on the axial structural elements will only work after a considerable crack and compressive force at the time approaching the axial force without confinement (Park and Paulay, 1975).
- A number of researches on the stirrups in short columns of rectangular sectioned reinforced concrete concluded that confinement can increase the ductility and strength of the column (Sheikh and Uzumeri, 1982; Binawati, 2004; and Purnawan, 2011).
- The smaller the spacing of the stirrups the larger the ability of the column in supporting the load.

## Introduction …

- In the field, reinforced concrete columns that have been designed according to structural requirements in fact experienced a condition where the load capacity is less than the design load after the construction process, may be due to damage caused by poor construction processes.
- Therefore, it is required to restore the strength of the column back to the designed strength.
- One method, for example, is by structural retrofitting or rehabilitation method, commonly done by wrapping columns with FRP (FRP confinement). This method works effectively for circular columns. But in reality, section of columns generally are square or rectangular.
- Based on this background, the effect of changes in the dimension and shape of the columns (shape modification) to the axial capacity of concrete columns were investigated. At the same time, confinement with stirrups was applied. The addition of stirrups bars is applied outside the existing concrete column.

# EXPERIMENTAL PROGRAM

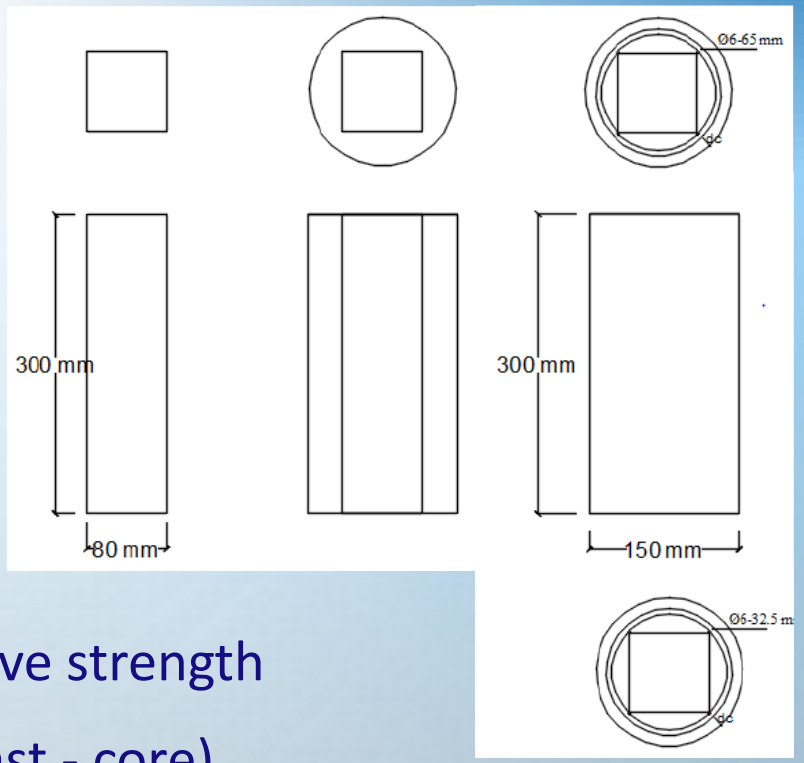
- Test specimens:

  12 column specimens in 4 groups

  Dimension:

  80 x 80 x 300 mm (core)

  Dia. 150 mm, h : 300 mm (cylinder)




- Material properties:

  Concrete: average 28-day compressive strength

  - $f_c'$ = 39.24 MPa (first cast - core)

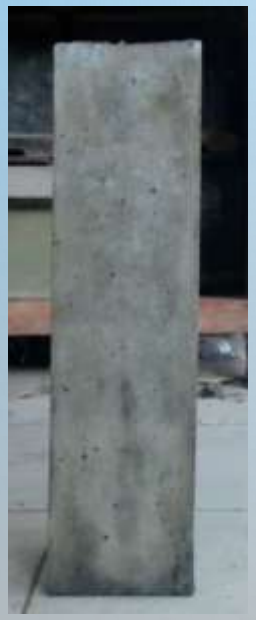
  - $f_c'$ = 38.44 MPa (second cast – outside core)

  Reinforcing Steel bars: dia. 6 mm for stirrups with $f_y$ = 400 MPa

  (No longitudinal reinforcement)

# SPECIMEN CONFIGURATION

| Specimen group | Reinforcement | Initial dimension (mm) | Tested dimension (mm) |
|---|---|---|---|
| K | No stirrup | 80 x 80 x 300 | 80 x 80 x 300 |
| S0 | No stirrup | 80 x 80 x 300 | Diameter 150 mm, height 300 mm |
| S1 | With stirrup spacing at s = 65 mm | 80 x 80 x 300 | Diameter 150 mm, height 300 mm |
| S2 | With stirrup spacing at s = 32.5 mm | 80 x 80 x 300 | Diameter 150 mm, height 300 mm |



Without stirrup

With stirrup s=65 mm

With stirrup s=32.5 mm

The initial tested specimens were square columns, after which the specimens were modified into a circular shape. Then the axial capacity of unmodified concrete columns was compared with that of the modified concrete columns, either with or without stirrups.

# EXPERIMENTAL RESULTS

## FAILURE OF COLUMN SPECIMENS

- The failure of the Columns K and S0 started with hair cracking. As the load increased and the column specimen shortened, the crack widened and extended.
- Failure occurred at an average compressive strength of 25.52 MPa for the Columns K and 28,47 MPa for the Columns S0 (increament is about 12%)


K Columns


S0 Columns

## Experimental Results …

### FAILURE OF COLUMN SPECIMENS

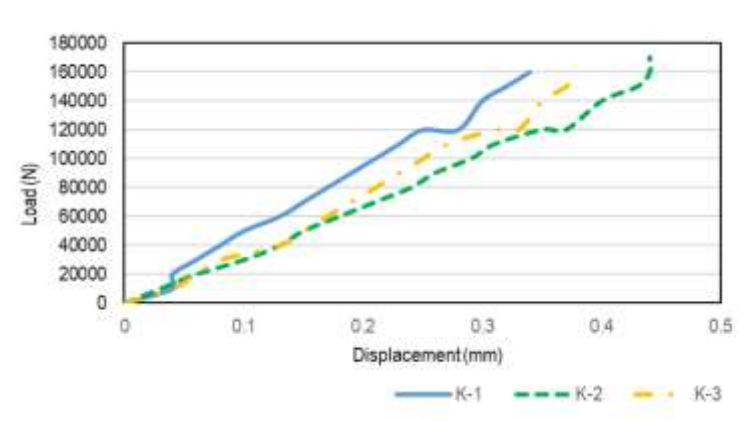
- In columns with shape modifications and stirrups (Columns S1 and S2), the failure started with a hair crack. Then the crack widened and extended as the load increased. At the same time the lateral dimension changed and the column specimens shortened which caused the concrete cover to peel off (spalling). The core of the column specimens was not split
- Failure occurred at an average compressive strength of 29,99 MPa for the Columns S1 and 32,03 MPa for the Columns S2 (increament is about 17.5% & 25.5%)

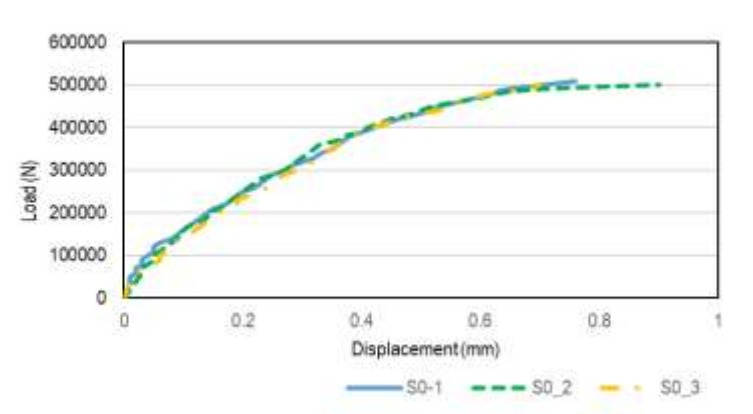

S1 Columns

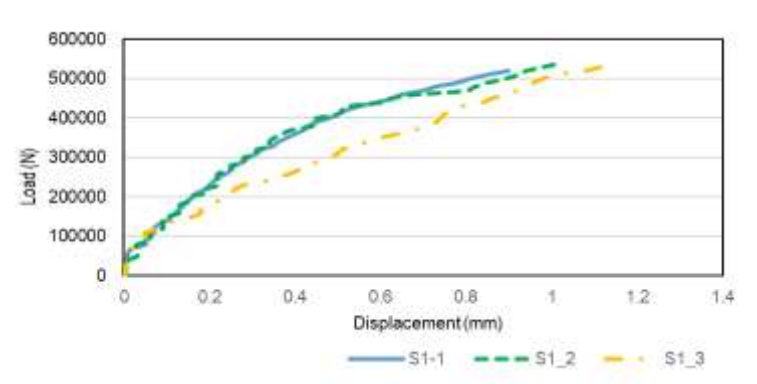

S2 Columns

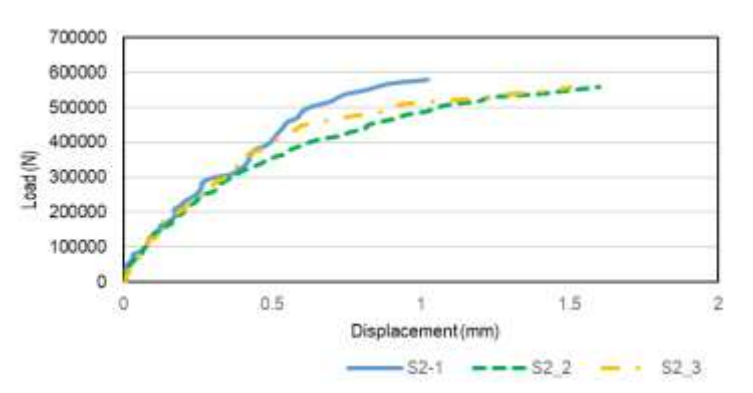
Experimental Results …

# LOAD-DISPLACEMENT RELATIONSHIP



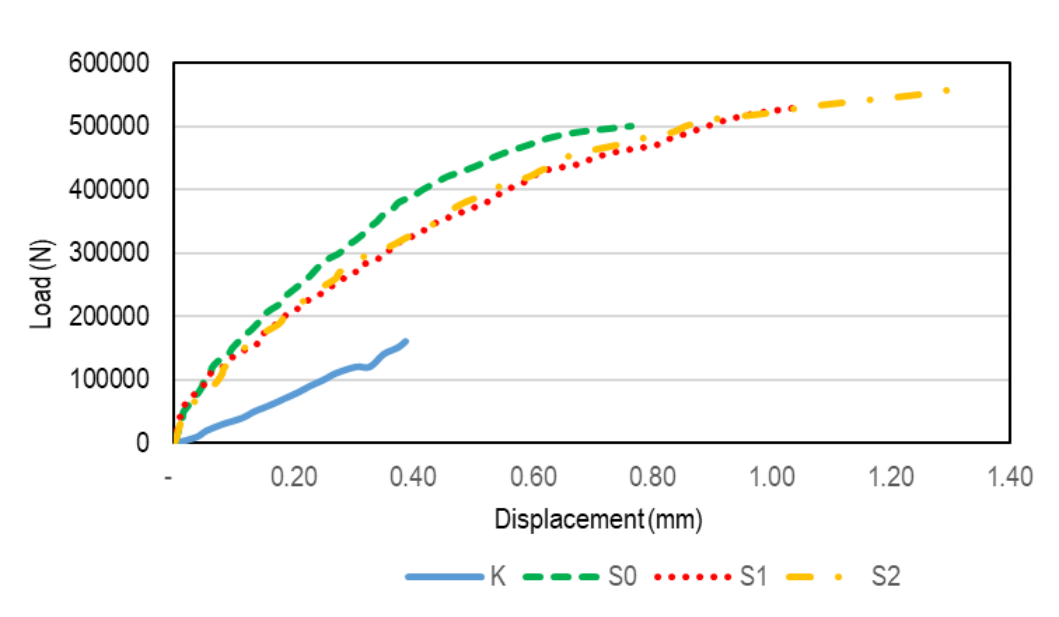




In Group K, the load increased proportionally with the shortening of the columns until the column failed. While in the Columns S0, S1 and S2, the increasing load was not proportional with the displacement of the columns.

Experimental Results …

# LOAD-DISPLACEMENT RELATIONSHIP




The K Columns failed at the average load and displacement 163 kN and 0.39 mm.
Meanwhile Columns S0, S1 and S2 failed at the average load and displacement of 503 kN, 530 kN, 566 kN and 0.79 mm, 1.01 mm, 1.37 mm, respectively.

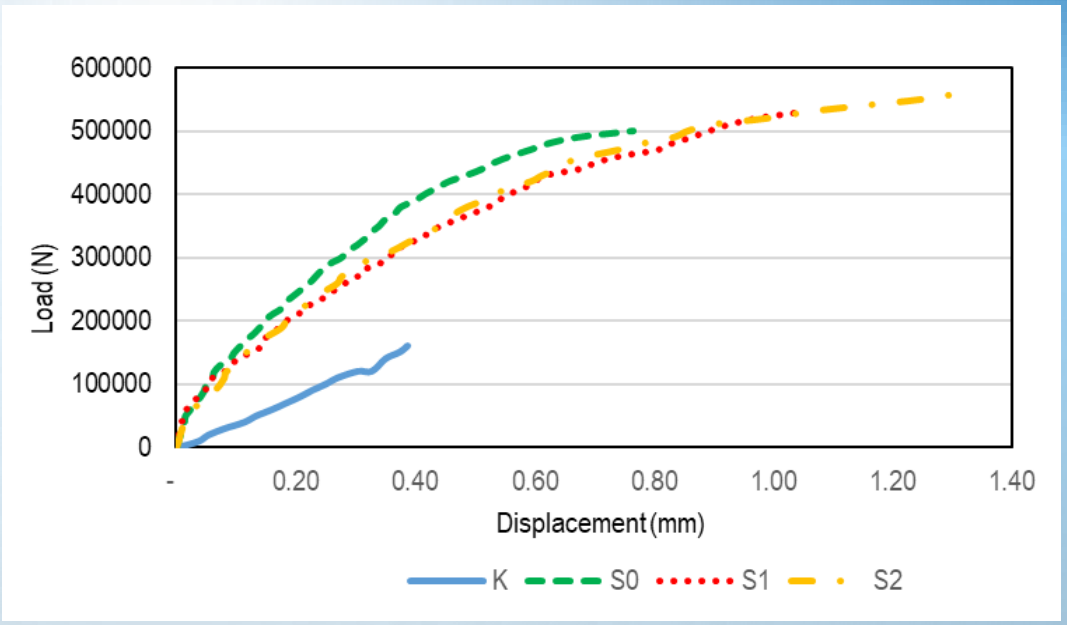
Shape modification from squares (Group K) into a circular shape (Group S0) increased the axial capacity of the columns by 209%. Meanwhile, the effect of adding stirrups and shape modification increased the axial column capacity by 225% (Group K to Group S1) and 247% (Group K to Group S2).

Experimental Results …

# PERFORMANCE OF COLUMNS

Columns' performance can be assumed to be the area under the load-displacement diagram of the columns.

The performance of the column relates to the column ductility: the greater the performance of the columns, the greater the ductility.




From the figure: shape modification and addition of stirrups improved the performance of the columns. In the columns with stirrups, minimizing the spacing of the stirrups (from Group S1 to Group S2) improved the performance of the columns.

# CONCLUSIONS

Based on the analysis of the experimental results, some conclusions are drawn as follows:

- The addition of stirrups increased the axial capacity of the concrete columns.
- Change in the spacing of the stirrups affected the axial capacity of the concrete columns.
- Shape modification, which is the change of dimension and section shape, increased the axial capacity of the concrete columns.
- Shape modification and addition of stirrups improved the performance of the columns.

THANK YOU