Experimental Investigation on Conventional Rebar RC Column with Non-Conventional Prefabricated Cage System

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Abstract: A new steel reinforcement is recommended in the name Prefabricated Cage System (PCS) in the column. PCS is a non-conventional prefabricated cage reinforcement system that allows for simpler, quicker and more durable construction which can be utilized in Reinforced Concrete (RC) columns to replace traditional longitudinal and transverse steel. Besides having alike or greater strength correlated with the traditional reinforcement given in columns, the PCS decreases the construction schedule time and reduces the overall construction expense. The PCS was manufactured through punching or cutting hollow steel tubes or plates by perforation, and PCS costs are often almost equal to traditional rebar reinforcement. The construction time can be greatly decreased by using PCS. In this article, instead of two types of traditional rebar reinforcements, two types of perforations were used in PCS reinforcement. Comparative research was performed for the columns under axial loading among the PCS reinforcement and the traditional rebar reinforcement. Test results showed that the axial load carrying capacity of PCS specimens was comparable or superior to that of conventional reinforced concrete columns.

1. Introduction
A column is a structural element that transfers the weight of the structure above to other structural elements below by means of axial compression or tension. Due to the same stress state, other compression members are also often referred to as a column. Reinforced concrete columns are widely used today. Reinforced Concrete RC is used in the construction of various structures such as shelters, underground parking, high-rise structures and bridges as a very common material. High compression strength concrete and high tensile strength steel work together to provide a mechanism to withstand the load applied[1][2][3]. Examples of such variations used in structural members are the conventional RC column, in-filled tubular system, composite structure, and welded wire fabric structure. Similarly, Steel was used in the rebar system, as longitudinal and transverse reinforcement have been implemented in recent years, such as tubular and composite parts [4][5][6].

An innovative steel reinforcement has been introduced as column as a PCS, is a modern non-conventional steel cage system that can be implemented in the traditional columns [7-10]. As an
integral structure, PCS is likely to serve all reinforcement purposes in the column, such as longitudinal and lateral reinforcement [11-14]. A remarkable alternative to the present traditional reinforcement method in RC columns is assumed to be the PCS. Modern structural elements and components should be designed with endurance and also sustainable, hence usage of sustainable construction materials in developing those structural elements should be pursue added [15-20].PCS reinforcement has resistance to corrosion and withstand in the fire, which is better than steel members and steel tubes filled with concrete that are susceptible to corrosion and also fire because the steel is exposed.

2. Research Significance
This paper describes the compressive behaviour of traditional Rebar with Non-conventional Prefabricated Cage System (PCS) in reinforced concrete square Column.

3. Experiment Setup and Experimental Observations

3.1. Preparation of PCS
The openings on the PCS reinforcement will be created either by punching or by different cutting methods such as machine cutting and gas cutting are shown in Figure 1 and 2 respectively. Production by any of these methods of small amounts of PCS reinforcement may be more classy than rebar production; however, mass production of PCS may effect in lower rate variances. Mass PCS production will be consummate by punching holes during the hot rolling phase in the steel tube. It is quick to punch the soft steel, and in the course of the hot rolling process, extra steel parts can be recycled. This could result in PCS output becoming much more fair.

3.2. Specimen
A total of 6 specimens under axial loading have been cast and checked. It investigated the ultimate load carrying capacity and deflections acquired by PCS. Comparisons were made between the findings of non-conventional and traditional reinforced columns with equivalent quantities of longitudinal and transverse steel. The longitudinal reinforcement ratio for the PCS and traditional reinforced specimens was 1.8 percent to 2 percent. The samples were 750 mm long and had a cross sectional widths of 175 mm x 175 mm with a 12.5 mm nominal cover over the reinforcement. Table 1 provides the details of the specimens.

The number following the letter S in the specimen names shows the number of reinforcement bars in the longitudinal directions. P and R denote Prefabricated Cage System and traditional samples. The S1R1 and S2R2 are conventional column reinforcement as shown in Figure 3. The column was designed as per IS 456 -2000 consisting of 4 numbers of 12 mm diameters as longitudinal reinforcement for S1R1 and 8 numbers of 8 mm diameters as longitudinal reinforcement for S2R2. The transverse reinforcement has 6 mm diameter bars @ 150 mm spacing for both conventional specimens. PCS reinforcement cage was fabricated by using Standard mild steel plates with 2.5 mm thickness. As shown in Figures 1 and 2, the openings were created on the PCS by machine cutting and gas cutting. The S1P11, S1P12, S2P21 and S2P22 of PCS system are shown in Figure 4 and 5.
Table 1. Test specimen’s specification

| Sl.No | Specimen Designation | Opening faces | Reinforcement | Plate Thick (Or) Rebar (mm) | Opening Dimension (mm) | Width of corner reinforcement (mm) | Height of transverse reinforcement (mm) |
|-------|----------------------|---------------|---------------|----------------------------|------------------------|-------------------------------------|----------------------------------------|
| 1.    | S1R1                 | -             | Rebar         | 4#12                       | -                      | 4#12                                | 6mm dia @ 150mm c/c                   |
| 2.    | S2R2                 | -             | Rebar         | 8#8                        | -                      | 8#8                                 | 6mm dia @ 150mm c/c                   |
| 3.    | S1P11                | Single        | PCS           | 2.5                        | 114 x 48               | 51                                  | 30                                     |
| 4.    | S1P12                | Single        | PCS           | 2.5                        | 114 x 48               | 51                                  | 30                                     |
| 5.    | S2P21                | Double        | PCS           | 2.5                        | 116 x 31               | 29                                  | 28                                     |
| 6.    | S2P22                | Double        | PCS           | 2.5                        | 116 x 31               | 29                                  | 28                                     |

Figure 3. S1R1 & S1R2
Figure 4. S1P11 & S1P12
Figure 5. S2P21 & S2P22

3.3. Test Results and Observations

As shown in Figure 6, the columns were tested on a Universal Testing Machine (UTM with a capacity of 1000 kN. To obtain the load-deflection correlation for each sample, the load and the corresponding deflection were recorded using a deflectometer. First crack was noted and indicated in a beam. At end of each load increment, the cracks were detected and marked with marker and also simultaneously the photographs were taken during initial crack formation, concrete cover infringement, longitudinal reinforcement buckling and at the ultimate load.

The initial cracks usually initiated at the upper or end of the specimen near the corner. Shortly after initial cracking at the corner, the sample attained the ultimate strength, trailed by a decrease in the strength. Afterwards the strength decrease, the cover failure typically occurred. Table 2 displays the initial cracking, cover loss and ultimate load deflection values at the critical points.

4. Behavior of PCS and Rebar Reinforced Specimen

4.1 Failure of specimens
The failure patterns of Rebar (S1R1 and S2R2) are shown in Figure 7 and 8 respectively. Similarly the failures patterns of PCS S1P11, S1P12, S2P21 and S2P22 are shown in the Figure 9, 10, 11 and 12 respectively.

![Testing of column specimen](image)

**Figure 6.** Testing of column specimen

| Sl.No | Specimen Designation | Initial Cracking Load (KN) | Deflection (mm) | Cover Failure Load (KN) | Deflection (mm) | Ultimate Load Load (KN) | Deflection (mm) |
|-------|----------------------|---------------------------|-----------------|-------------------------|-----------------|-------------------------|-----------------|
| 1.    | S1R1                 | 345                       | 0.74            | 664                     | 1.50            | 734                     | 2.10            |
| 2.    | S2R2                 | 338                       | 0.80            | 638                     | 1.60            | 717                     | 1.90            |
| 3.    | S1P11                | 442                       | 0.81            | 768                     | 2.04            | 827                     | 2.70            |
| 4.    | S1P12                | 440                       | 0.80            | 765                     | 2.01            | 823                     | 2.50            |
| 5.    | S2P21                | 468                       | 0.74            | 792                     | 1.86            | 856                     | 2.30            |
| 6.    | S2P22                | 465                       | 0.71            | 792                     | 1.84            | 853                     | 2.20            |

Both Prefabricated Cage Systems and traditional conventional reinforced specimens are identical in behaviour. The ultimate load carrying capacity of the Prefabricated Cage Systems can be concluded to be marginally higher compared to that of traditional conventional reinforced columns. PCS and rebar specimens, however, show a comparable deflection.

In comparison with PCS specimens, the rebar reinforced specimens S1R1 and S2R2 were intrigued by the design load carrying ability. As described in Table 2, the PCS specimens showed a higher ultimate load. The influence of steel plate thickness and openings has not shown significant variations on the maximum strength and deflection, nevertheless the extreme strength of PCS column specimen with 2.5mm (double opening) are slightly better compared to single opening and rebar specimens. The load deflection behavior of S1R1, S1R2, S1P11 and S2P22 are shown in Figure 13, 14, 15 and 16 respectively.
Figure 7. S1R1

Figure 8. S2R2

Figure 9. S1P11

Figure 10. S2P12

Figure 11. S1P21

Figure 12. S2P22

Figure 13. S1R1 Load vs Deflection

Figure 14. S1R2 Load vs Deflection
The area under load-deflection curve is similar for rebar and PCS. It is also observed that the all the columns made with PCS S1P11, S2P22 showed higher peak value compared to rebar S1R1, S1R2. Moreover the load-deflection curves for all columns with PCS are steeper than the other two rebar in the prepeak stage.

4. Conclusion

- The performance of non-conventional column and traditional conventional column were experimentally explored. Based on the investigation carried out on 6 specimens made of PCS and traditional columns.
- The test results indicated that non-conventional columns exhibits higher ultimate strength and similar displacement compared to the conventional reinforced columns.
- The experimental results indicated that 2.5 mm (S1P21 & S2P22) PCS reinforcement plates have greater strength and better ability for displacement. The ultimate load of 2.5mm (S1P21 & S2P22) plates shows 18% higher than rebar (S1R1 & S2R2). The suggested model realistically prophesied the performance of Prefabricated Cage System specimens well.

5. References

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