An Experimental Investigation on High Strength RC Column using Prefabricated Cage System

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***Abstract*— Prefabricated Cage System (PCS) is a non-conventional reinforcement system that can used to replace the conventional longitudinal and transverse steel in reinforced concrete (RC) columns. The PCS also have equal or higher strength compared to the conventional rebar reinforcement provided in columns. The PCS is fabricated by perforating hollow steel tubes or plates by punching or cutting. The cost of PCS is nearly equal to the conventional rebar reinforcement. Using PCS the construction time may be greatly reduced. In this thesis four types of perforations are to be used in PCS reinforcement instead of two types of conventional rebar reinforcements. In this paper a comparative study is done between the PCS reinforcement and the conventional rebar reinforcement for the columns under axial loading.**

***Key words: Reinforcement, PCS, Column strength, cracking, cover spalling*.**

I. Introduction

A Column is a structural element that transmits, through axial compression or tension, the weight of the structure above to other structural elements below. Other compression members also often termed as "column" because of the similar stress condition. Nowadays columns made of steel and reinforced concrete columns are widely used. Steel is also used in the form of rebar, as longitudinal and transverse reinforcement systems such as tubular and composite sections have been introduced in recent years.

Prefabricated Cage System (PCS) is a new non-conventional steel reinforcement system that can be used in reinforced concrete columns. PCS is expected to perform as an integral system performing the function of both longitudinal and lateral reinforcement. The system is supposed to be a superior alternative to existing conventional reinforcement system in RC columns.

The openings on the PCS can be provided either by punching methods or by various cutting methods such as laser cutting, plasma cutting. Manufacturing small quantities of PCS reinforcement by any of these methods may be more expensive than rebar production; mass production of PCS can result in smaller cost differences. Mass production of PCS can be accomplished by punching holes in the steel tube during the hot rolling process. The soft steel can be punched easily, and extra steel pieces can be recycled during the hot rolling process. This could result in even more economical PCS production.

In general, PCS can be used as the reinforcement in reinforced concrete columns. Two similar reinforced concrete columns, one with columns reinforced with PCS and the other reinforced with conventional rebar, are compared in this paper.

Figure 1. Rebar reinforcement and Prefabricated Cage System

II. Experiments

A total of 9 specimens were constructed and tested under axial loading. The strength and displacement capacity provided by PCS were investigated. The results from PCS and rebar reinforced specimens with equal amounts of transverse and longitudinal steel were compared. The PCS and rebar specimens had longitudinal reinforcement ratio of 1.8% to 2%. The specimens were 1000mm height and had 150mmx150mm cross section with 25mm clear cover over the reinforcement. The specimen specifications are provided in Table-1.

In the specimen names, the number following the letter S indicates the number of longitudinal steel strips or bars. P and R represent PCS and rebar specimens. 2mm and 3mm thickness steel plates used in PCS specimens. The transverse reinforcement for rebar specimens has 6mm dia bars @ 150mm spacing. The amount of transverse and longitudinal reinforcement satisfies the requirements provided in the IS 456-2000.

PCS reinforcement was made out of Standard mild steel plates. The openings on the steel plates were cut by Plasma cutting as shown in Fig.2 & Fig.3. The average yield strength for steel plates and rebars were 250 MPa.

III. Test Results and Observations

The High strength concrete specimens were tested in column testing machine at Thiagarajar Engineering College, Madurai Fig.4 with a capacity of 2000 kN. The load and displacement history were recorded electronically to obtain the load displacement relationship for each specimen. Photographs were taken during critical stages such as crack initiation, cover concrete spalling, longitudinal reinforcement buckling and at the end of loading. (Fig.5 & Fig.6)

Table-1. Test Specimen specifications.

Sl. No	Specimen Name	Reinforcement	Plate Thick (Or) Rebar	Opening dimension (mm)	Width of corner reinforcement	Height of transverse reinforcement
1	S4 R11	Rebar	4#12mm	-	4# 12mm	6mm@ 150c/c
2	S4 R12	Rebar	4#12mm	-	4# 12mm	6mm@ 150c/c
3	S4 R13	Rebar	4#12mm	-	4# 12mm	6mm@ 150c/c
4	S4 P11	PCS	2mm	48x 127	26mm	30mm
5	S4 P12	PCS	2mm	48x 127	26mm	30mm
6	S4 P13	PCS	2mm	48x 127	26mm	30mm
7	S4 P21	PCS	3mm	65x 145	17.5mm	15mm
8	S4 P22	PCS	3mm	65x 145	17.5mm	15mm
9	S4 P23	PCS	3mm	65x 145	17.5mm	15mm

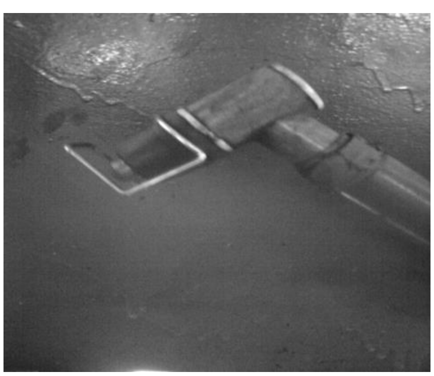


Fig.2. Plasma cutting machine

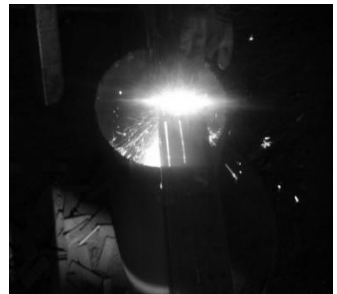


Fig.3. Openings cut by Plasma cutting machine

The cracking usually started near the corner either at the top or bottom of the specimen. The specimen reached its ultimate strength shortly after cracking, followed by a small strength drop. The cover failure usually happened after this small drop. The measured axial load and displacement values at these critical stages are presented for each specimen in Table.2.

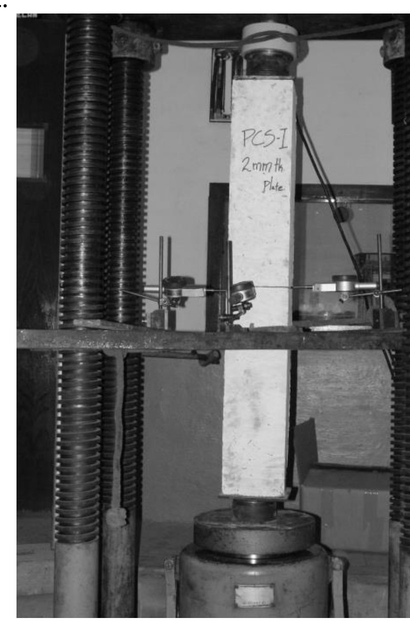


Fig.4. Experimental Setup

Fig.5. S4R11 and S4P11 Specimens

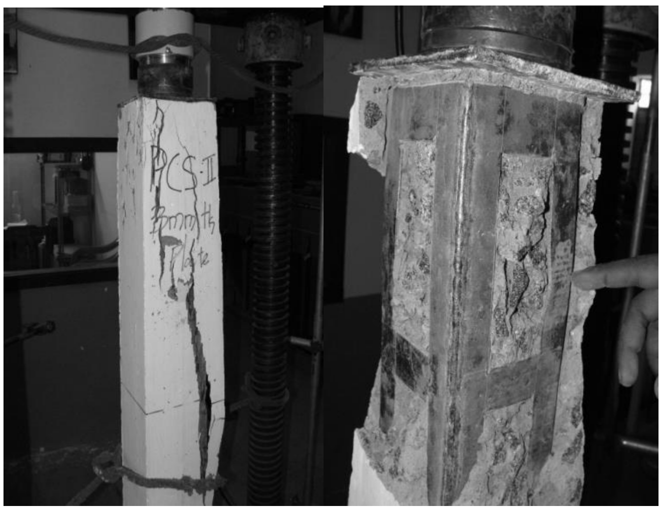


Fig.6. S4P21 and S4P22 Specimens

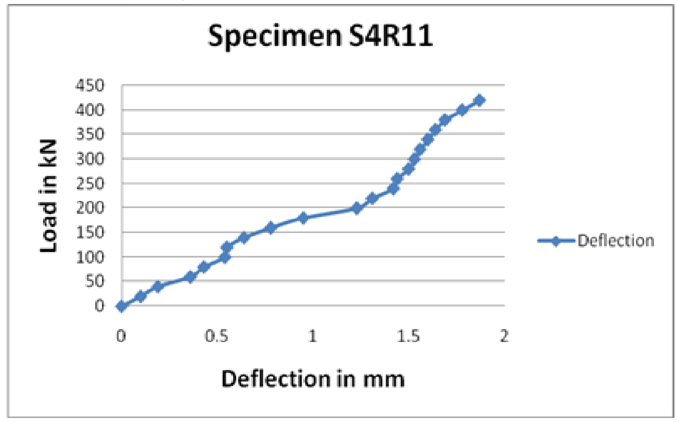
Table.2. Measured Load-Deflection Values at Critical Stages.

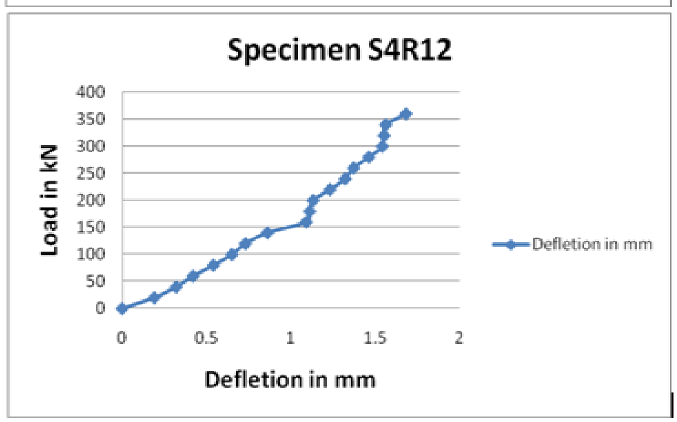
Sl. no	Specimen Name	Initial Cracking		Cover Failure		Ultimate Load	
		Load (kN)	Deflection (mm)	Load (kN)	Deflection (mm)	Load (kN)	Deflection (mm)
1	S4R11	341	1.6	423	1.87	478	1.75
2	S4R12	327	1.56	405	1.72	452	1.61
3	S4R13	317	1.38	417	1.56	449	1.39
4	S4P11	337	1.79	413	1.92	466	1.86
5	S4P12	359	2.28	427	2.72	472	2.65
6	S4P13	385	2.37	453	2.85	515	2.71
7	S4P21	347	2.23	438	2.89	503	2.85
8	S4P22	378	2.11	461	2.76	519	2.63
9	S4P23	389	2.46	452	2.81	523	2.73

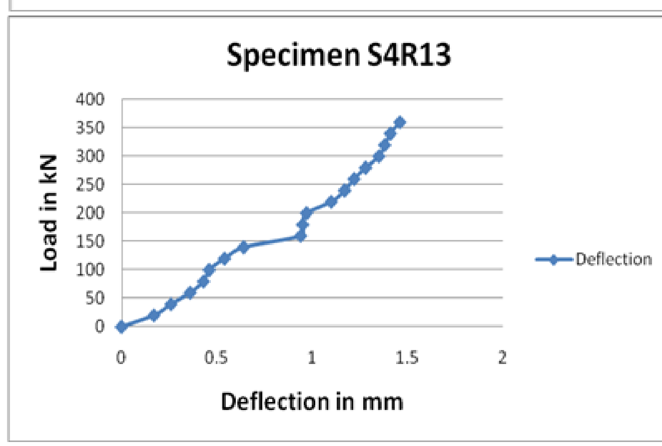
III. Behavior of PCS and Rebar Reinforced Specimens

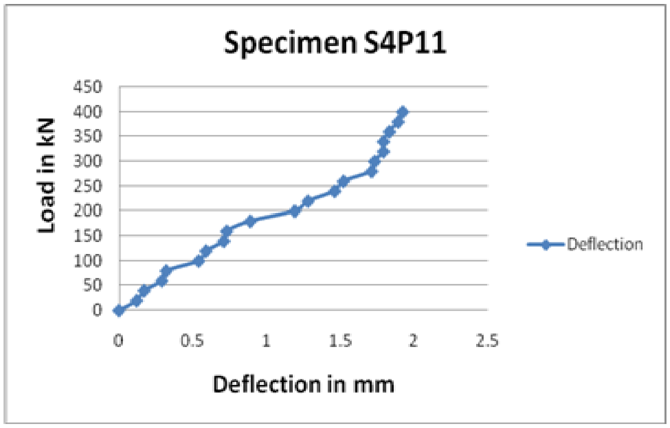
The overall behaviour of both PCS and rebar reinforced specimens are similar. It can be concluded that the axial load carrying capacity of the PCS specimens are comparable to that of rebar reinforced specimens. However, PCS specimens exhibit a larger residual displacement capacity. (Fig.7)

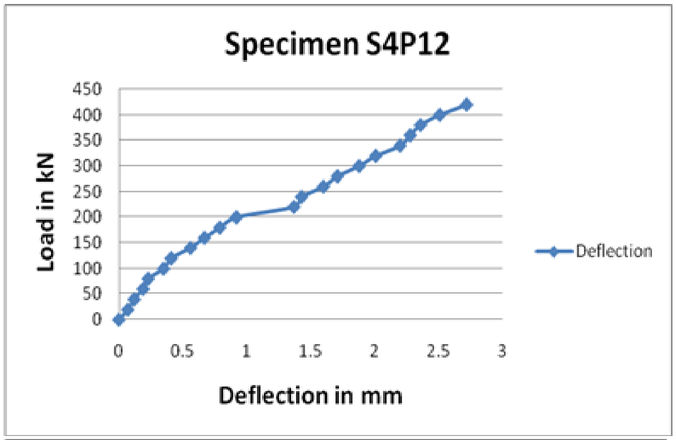
The rebar reinforced specimens S4R11, S4R12 and S4R13 had satisfies the designed load carrying capacity. While comparing these rebar reinforced columns with PCS

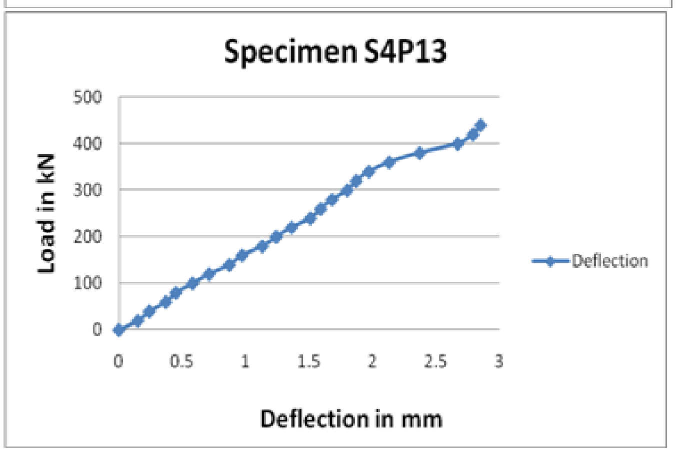


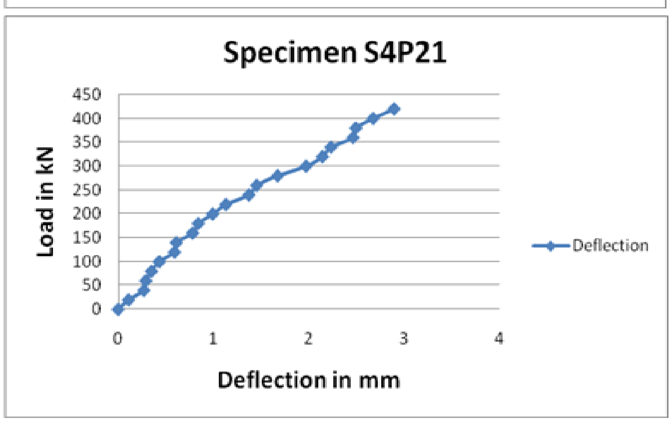


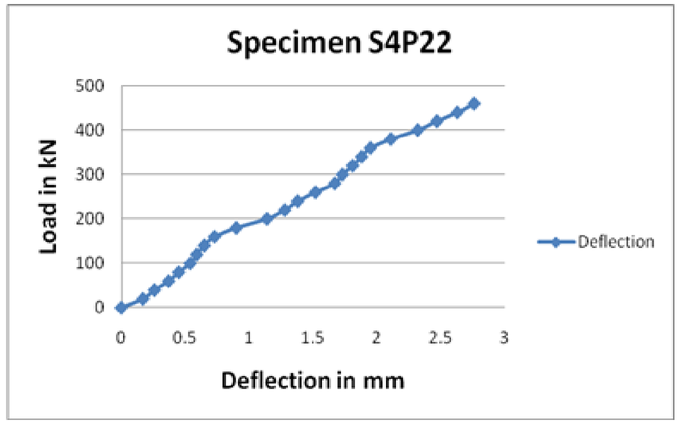












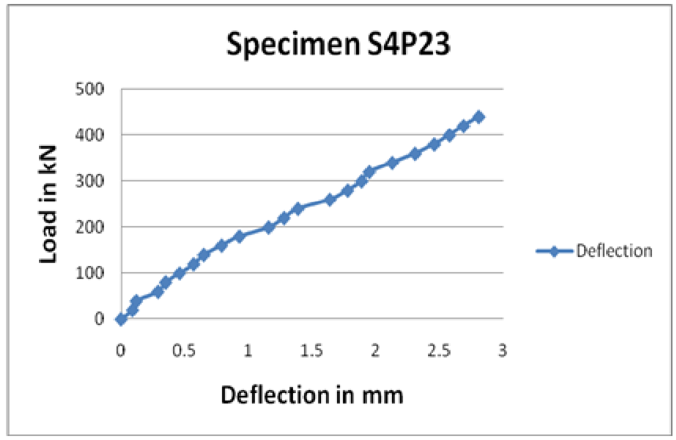


Fig.7. Load-Displacement Curve for Specimens

specimens, the PCS specimens had some higher strength listed in Table.2. The effect of steel plate thickness on the maximum strength and displacement capacity is not significant; however the maximum strength of PCS specimens with very thin plate thickness is smaller than the strength of specimens with thicker PCS steel.

VI. Conclusion

The behavior of PCS reinforced columns with rebar reinforced column is experimentally investigated. A total of 9 specimens were constructed and tested to investigate the strength and displacement capacity of PCS reinforced columns and conventional reinforced columns. The test results indicate that PCS reinforced specimens have similar displacement capacity, comparable ultimate strength and better performance beyond the ultimate strength.

Test results indicate that PCS reinforcement with thicker plates provide higher strength and better displacement capacity. Theoretical axial load-displacement relations are calculated and compared with the experimental results. The proposed model predicted the behavior of PCS specimens reasonably well.

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