Replacement of Conventional Rebar With Non-Conventional Prefabricated Cage System in RC Column

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ABSTRACT

Nowadays the non-conventional reinforcement system is widely used reinforcement system for RC column reinforcement instead of conventional reinforcement system. In which, a new non-conventional reinforcement system named as Prefabricated Cage System is used recently. PCS is fabricated by perforating hollow steel tubes or steel plates. Various methods could be used to fabricate PCS reinforcement such as punching cutting methods and casting. In this thesis, two types of perforations are to be used in PCS reinforcement instead of two types of conventional rebar reinforcements. PCS reinforcement is prefabricated off-site and then placed inside the formwork eliminating the time consuming and costly labor associated with cutting, bending, and tying steel bars in traditional rebar construction. PCS can be used to reinforce almost any kind of concrete member which involves reinforcement and concrete. PCS can be used as the entire or part of the reinforcement in concrete columns one of the major applications of PCS is it's in axial members, therefore; this study investigates the behavior of PCS reinforced column specimens tested under axial load with conventionally reinforced RC column specimens.

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

I. INTRODUCTION

Reinforced concrete (RC) has been used in the construction of different structures for centuries. Reinforced concrete is defined as concrete which is a mixture of cement, sand, gravel, water, and some optional other admixtures, combined with a reinforcement system, which is usually steel. Concrete is strong in compression but weak in tension, therefore, may result in cracking and failure under large tensile stresses. Steel has the high tensile capacity and can be used in areas with high tensile stresses to compensate for the low tensile strength of Concrete. The combination of concrete, a relatively cheap material with high compressive strength and steel, a material with high tensile strength, has made reinforced concrete a popular construction material for structural and nonstructural members. Historically, steel in the form of rebar has been used as longitudinal and transverse reinforcement. Other forms of steel reinforcement systems, such as tubular and composite sections have been introduced in recent decades. Prefabricated Cage System (PCS) is introduced as a new steel reinforcement system that can be used in reinforced concrete members. PCS is expected to perform as an integral system performing the functions of both longitudinal and lateral reinforcement. The proposed system is anticipated to be a superior alternative to the existing reinforcement systems in reinforced concrete members, most notably in beams and columns .this system is supposed to be a superior alternative to existing conventional reinforcement system in RCC columns. While reinforced concrete is used in the construction of a variety of different structural members, such as shear walls, footings, beams and retaining walls, one of its most common applications is in the construction of columns. It may be extremely difficult to assemble the rebar cage because of stringent special seismic detailing requirements ACI 2005. (Shamsai, M. (2006) [5]. 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.

Fig 1. Rebar reinforcement

Fig 2. Prefabricated cage system (Single opening)

Fig 3. Prefabricated cage system (Double opening)

II. EXPERIMENTS

A total of 6 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 750 mm height and had 175 mm x 175 mm cross section with 12.5mm 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. 2.5mm 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 machine and gas cutting as shown in Fig.4 & Fig.5.The average yield strength for steel plates and rebar's were 250 MPa.

Fig 4. Machine cutting

Fig 5. Gas cutting

III. TEST RESULTS AND OBSERVATIONS

The High strength concrete specimens were tested in the universal testing machine at PSNA College of Engineering, Dindigul. Fig.6 with a capacity of 1000 kN The load and displacement history were recorded 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 6. Universal testing 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.

Table 1.Test specimen's specification

Sl. No	Specimen Name	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 opening	PCS	2.5	114 x 48	51	30
4	S1P12	single opening	PCS	2.5	114 x 48	51	30
5	S2P21	double opening	PCS	2.5	116 x 31	29	28
6	S2P22	double opening	PCS	2.5	116 x 31	29	28

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.	S1R1	345	0.74	664	1.5	734	2.1
2.	S2R2	338	0.8	638	1.6	717	1.9
3.	S1P11 (single opening)	442	0.81	768	2.04	827	2.7
4.	S1P12 (single opening)	440	0.8	765	2.01	823	2.5
5.	S2P21 (double opening)	468	0.74	792	1.86	856	2.3
6.	S2P22 (double opening)	465	0.71	792	1.84	853	2.2

IV. BEHAVIOR OF PCS AND REBAR REINFORCED SPECIMENS

The overall behavior 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&8).

The rebar reinforced specimens S1R1, S2R2 had satisfies the designed load carrying capacity. While comparing these rebar's reinforced columns with PCS 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 2.5mm (**S1P21&S2P22**) PCS steel.

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Fig.7 S1R1

Fig.8 S2R2

Fig.9 S1P1

Fig.10 S2P12

Fig.12 S2P22

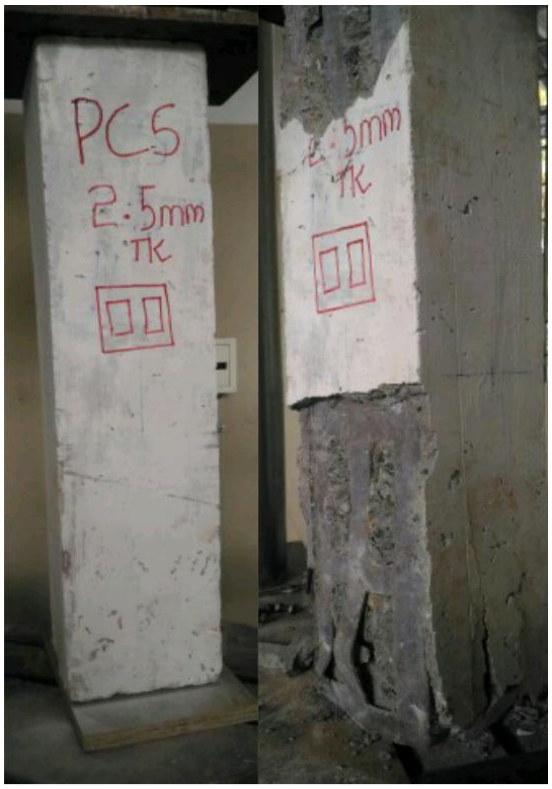

Fig.11 S1P21

V. GRAPHICAL REPRESENTATION

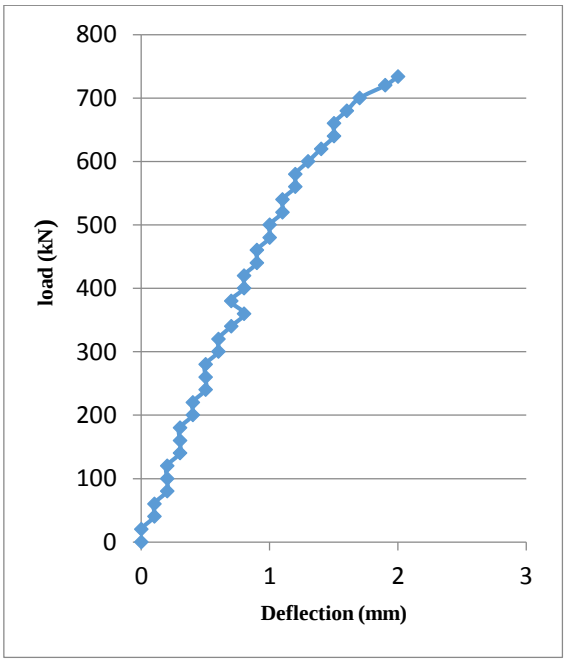

Fig. 13 Load Vs Deflection for S1R1

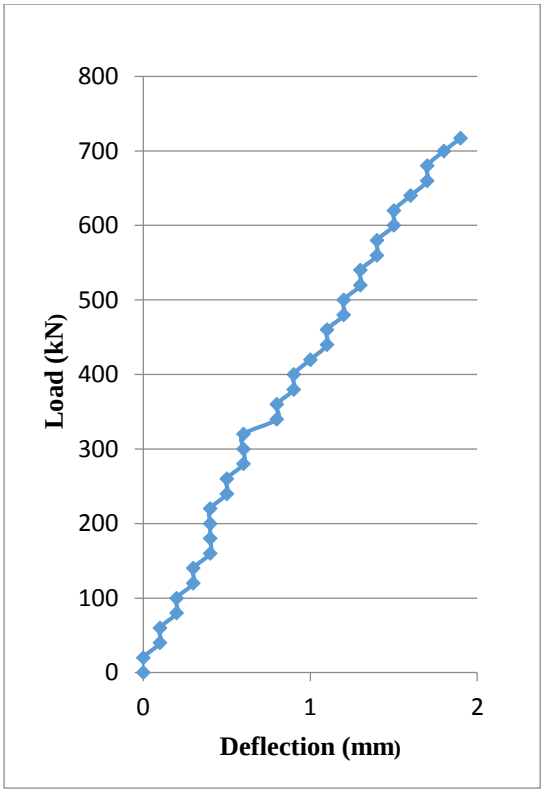

Fig. 14 Load Vs Deflection for S1R2

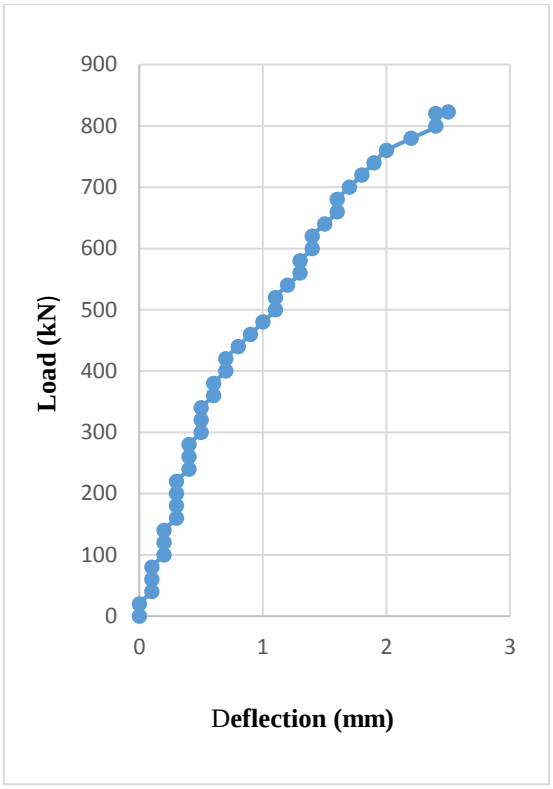

Fig. 16 Load Vs Deflection for S1P12

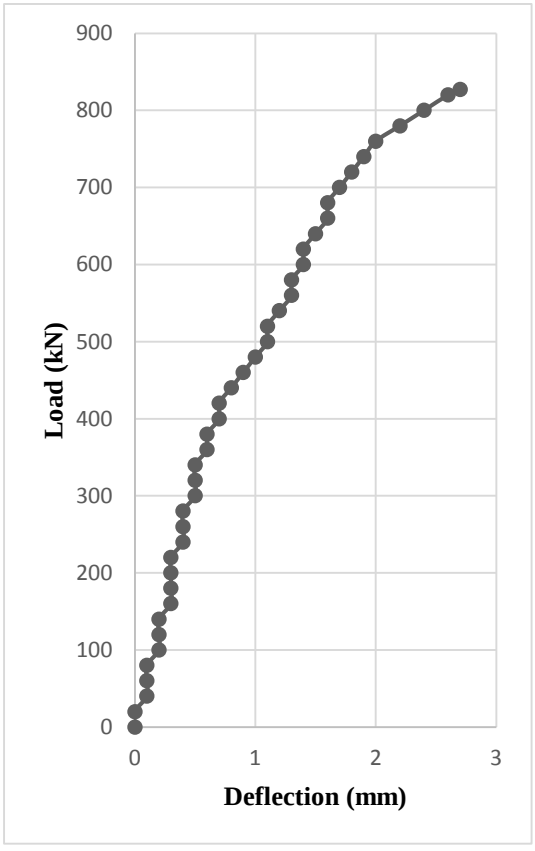

Fig. 15 Load Vs Deflection for S1P11

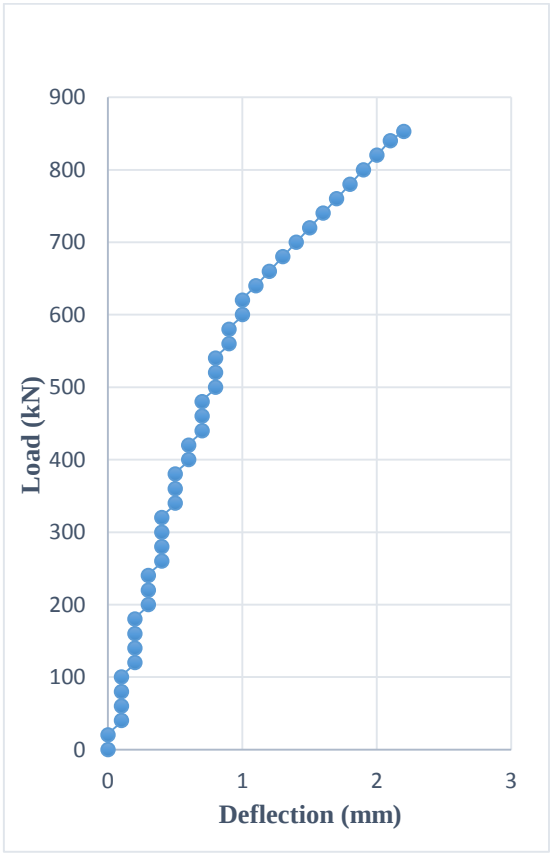

Fig. 17 Load Vs deflection for S1 P21

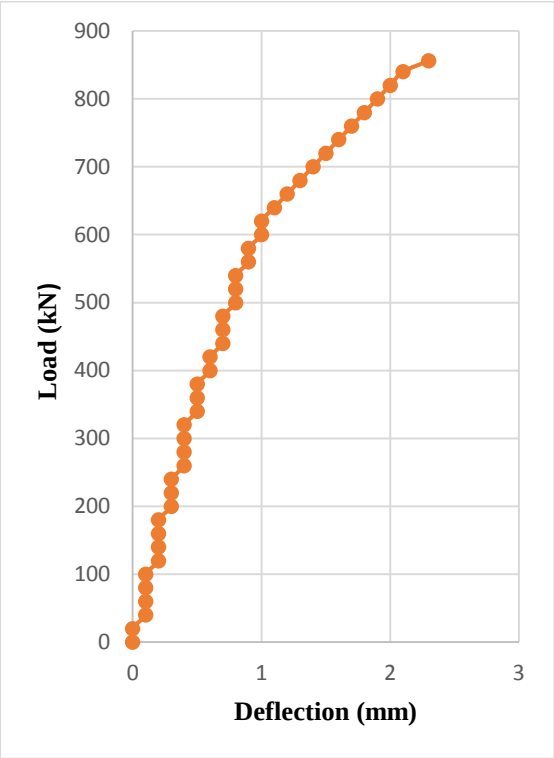

Fig. 18 Load Vs Deflection for S1 P22

VI. CONCLUSION

The behavior of PCS reinforced columns with rebar reinforced column is experimentally investigated. A total of 6 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 2.5mm (S1P21&S2P22) plates provide higher strength and better displacement capacity. The ultimate load of 2.5mm (S1P21&S2P22) plates shows 18% higher than rebar (S1R1 & S2R2). The proposed model predicted the behavior of PCS specimens reasonably well.

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