Confinement of Reinforced Concrete Column: An Overview

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Abstract— This overview gives an introduction to confinement of reinforced concrete column. Confinement is a technique in which components of RCC structure such as column is wrapped around with a confining material in order to improve the performance and durability of existing structure. This technique is implemented in retrofitting and rehabilitation of the existing structure. Concrete structures which are aged between 20 to 25 years may incur corrosion of reinforcement, cracks, scaling, and disintegration due to various environmental factors. Confinement can also be used in infrastructure applications such as marine concrete structures which are prone to corrosion due to saline environment. In this overview an effort is made to study the methodology of confinement techniques

Keywords— Confinement, UPVC, HDPE, PVC, CFT Columns

I. INTRODUCTION

Confinement in RCC structures is a technique in which structural members such as beam, column are wrapped around in materials such as UPVC, HDPE, GFRP, CFRP, PVC in order to improve the performance of the existing structure or to use it as a precautionary measure in order to avoid the deterioration of the structure in the future. Nowadays it is necessary to increase the strength, ductility and energy absorption capacity of RCC columns and it can be achieved by the applications of various confining materials such as HDPE, UPVC, and PVC pipes. Many researchers have carried out their research on other confinement materials such as FRP (fibre reinforced polymers) some of researchers have also used steel tubes as confining material for columns. Most of the researchers have concentrated their work on Column as it is the most important structural member.

2. LITERATURE REVIEW

Fardis and H. Khalili [1], a glass fiber as a new confining material for concrete is presented in this study. The new material is been termed as Fiberglass reinforced polymer (FRP). The authors have carried out an experimental investigation of FRP-encased concrete cylinders in axial compression and of rectangular FRP-encased beams in bending is presented. The results demonstrate the excellent strength and ductility characteristics of FRP-encased members. The behavior of FRP-encased concrete beams-columns is described also, in terms of analytically obtained moment-axial load and ductility-axial-load interaction diagrams and moment-curvature relations.

H. Saadatmaneshet.al [2], Due to failures of bridges in earthquake such as the 1989 Loma Prieta earthquake. The study concentrated there study on the substandard design of Bridge Engineering and how to improve the design in order to withstand seismic forces. In this paper, a new technique for seismic strengthening of concrete columns is presented. The technique requires wrapping thin, flexible high strength fiber composite straps around the column to improve the confinement and, thereby, its ductility and strength. Analytical models are presented that quantify the gain in strength and ductility of concrete columns externally confined by means of high-strength fiber composite straps. A parametric study is conducted to examine the effects of various design parameters such as concrete compressive strength, thickness and spacing of straps and type of strap. The results indicate that the strength and ductility of concrete columns can be significantly increased by wrapping high-strength fiber composite straps around the columns A. Nanni and N. M. Bradford [3], the study carried out an investigation in order to develop the experimental data and check the validity of existing analytical models for the behavior of concrete members jacketed with FRP materials. The test specimen consisted of 150x300mm cylinders of normal weight, normal strength concrete. Specimens loaded statically under axial compression were studied. Three different types of passive FRP confinement technologies were investigated during the project with the objective of performing a qualitative comparison. Experimental results indicate that FRP jacketing significantly enhances strength and pseudo-ductility of concrete.

M. D. O'Shea and R. Q. Bridge [4],in this paper several design methods have been developed that can be used conservatively to estimate the strength of circular thin-walled concrete filled steel tubes under different loading conditions. The test specimen were short with a length-to-diameter ratio of 3.5 and a diameter thickness ratio between 60 and 220. The internal concrete had nominal unconfined cylinder strengths of 50, 80, 90 and 120 Mpa. The bond between the steel and internal concrete was critical in determining the formation of local buckle.

Stephan Pessikiet.al [5], the study presents the result of experimental investigation of the axial behavior of the small scale square and circular plain concrete specimens and large-scale circular and square reinforced concrete columns confined with fiber reinforced polymer (FRP) composite jackets, subject to monotonic, concentric axial loads. Improvement in the axial load-carrying and deformation capacities of FRP jacketed concrete members over unjacketed members were reported. Factors influencing the axial stress-strain behavior of FRP confined concrete, such as traverse dilation and effectively confined regions and their relationship to jacket properties, are identified and discussed.

Houssam Toutanji and Mohamed Saafi [6], the study proposes a new hybrid column. The proposed hybrid column, cast in place, consist of an exterior PVC-fiber reinforced polymer (FRP) shell with a concrete core. The exterior shell is commercially available cylindrical PVC pipe externally reinforced with impregnated continuous fiber in the form of hoops at different spacing. The proposed system uses less fibers than current FRP confining methods but has similar strength and toughness characteristics. This paper presents the results of an experimental study on the performance of hybrid concrete columns subjected to different environment conditions such as room temperature, freeze and thaw, wet and dry conditions. Test variables included the type of fiber, the spacing between the FRP hoops and the environmental exposure conditions. The stress-strain behavior was used to evaluate the effect of exposure condition on the strength, stress-strain behavior and ductility of confined specimens. Test results show that the external confinement of concrete columns by PVC-FRP tubes results in enhancing compressive strength, ductility and energy absorption capacity.

Walter O. Oyawaet.al [7], as per the findings of the study structures are rapidly emerging as one of the inevitable structural systems for earthquake resistance, as they have been known to exploit the best attributes of both steel and concrete, resulting in higher stiffness, strength and ductility. However, the limitations imposed by certain drawbacks of cement concrete and which are not alleviated or moderated by the encasing steel tube, e.g. its high shrinkage, creep, brittleness, reactivity and low tensile strength, may be a hindrance to the rapid and diversified application of CFTs, in line with current emphasis on ductility-based seismic design. In this context, studies are presently being conducted on filled steel composite members, employing lighter, more ductile, high tensile strength and inert polymer-based fill materials for the steel tube. Findings of these studies relating to the elasto-plastic response of filled steel composite stub columns subjected to axial compression highlight the significant increase in strength and or ductility of epoxy polymer concrete-filled steel columns.

Yutian Shao and Amir Mirmiran [8], the experimental investigation of cyclic behavior of concrete filled Fiber reinforced Polymer Tubes are presented. The focus of research, however, has been exclusively on their monotonic behavior, with little or no attention to the implications of using CFFT in seismic regions. A total of six CFFT specimens were tested as simple span beam columns under constant axial loading and quasi-static reverse lateral loading in four point flexure. Three of the tubes were made using centrifuge ~spin! casting with 12.7 mm thickness with the majority of the fibers in the longitudinal direction, whereas the other three were filament wound with 5 mm thickness and ±55° fiber orientation. One specimen for each type of tube had no internal reinforcement, whereas the other two incorporated approximately 1.7 and 2.5% steel reinforcement ratios, respectively. The two types of tubes represented two different failure modes; a brittle compression failure for the thick tubes with the majority of the fibers in the longitudinal direction, and a ductile tension failure for the thin tubes with off-axis fibers. The study showed that CFFT can be designed with ductility behavior comparable to reinforced concrete members. Significant ductility can stem from the fiber architecture and inter laminar shear in the FRP tube. Moderate amounts of internal steel reinforcement in the range of 1–2% may further improve the cyclic behavior of CFFT.

S. Matthyset.al [9], presented an experimental and analytical results of axially loaded large-scale columns confined with FRP wrapping reinforcement. The effective circumferential FRP failure strain and the effect of increasing confining action were investigated. One of the main objective of this study was to compare different existing compressive strength models to the results presented in the study.

G. Wu et.al [10],the research covers a number of parameters in reference to the confinement of concrete cylinder. In this research was carried out around 300 specimens of FRP confined concrete cylinder. This paper covered the parameters like, the analysis of confinement effect and failure mechanisms. Special attention is given to predict whether FRP-confined concrete cylinder has a strain-hardening or a strain-softening response. In the case of FRP-confined concrete cylinder with a strain-hardening response, it is found out that the ultimate Poisson's ratio of FRP-confined concrete tends to an asymptotic value.

Yong-changGuoet.al[11], This study carried out an experimental investigation on axially loaded normal strength concrete columns confined by ten different types of materials, including steel tube, glass fiber confined steel tube (GFRP), PVC tube, carbon fibre confined PVC (CFRP), glass fiber confined PVC tube (GFRP), (CFRP), polyethylene (PE), PE-hybrid CFRP and PE hybrid GFRP. The deformation, macroscopical deformation characters, failure mechanism and failure nodes are studied in this paper. The ultimate bearing capacity of these 10 types of confined concrete columns and the influences of the confining materials on the ultimate bearing capacity are obtained. The advantages and disadvantages of these 10 types of confining methods are compared Ata El-kareimShoeibSoliman [12], the behavior of long concrete columns confined by means of proper plastic tube is investigated including failure mechanisms and subsequently their failure model for calculation of the column capacity is studied. The influence of column slenderness ratio on their axial load capacity, axial strains and radial strains is also investigated. The experimental program was classified into three different groups with slenderness ratios from 9 to 18. Test results show that, utilizing plastic tube for confinement significantly influences the failure mechanism of concrete columns. Results also show that the stiffness of the tested long confined concrete column specimens increases as slenderness ratio decreases M. Dundu [13],This study includes an experimental study was undertaken to investigate the behavior of 24 concrete-filled steel tube (CFST) columns, loaded concentrically in compression to failure. Variables in the tests include the length, diameter, strength of the steel tubes and the strength of the concrete. The large slenderness ratio caused all composite columns in Series 1 to fail by overall flexural buckling. Although overall flexural buckling was also experienced in the composite columns of Series 2 tests, the stockier columns failed by crushing of the concrete and yielding of the steel tube. A comparison of the experimental results with the loads predicted by the South African code (SANS 10162-1) and Eurocode 4 (EC4) shows that the codes are conservative by 8.4% and 13.6%, respectively, for Series 1 tests, and 10.5 and 20.2%, respectively, for Series 2 tests. A plot of the compressive load versus the vertical deflection shows the composite columns to be fairly ductile.

TogayOzbakkalogluet.al [14] an important application of FRP composites is as a confining material for concrete, in both the seismic retrofit of existing reinforced concrete columns and in the construction of concrete-filled FRP tubes as earthquake-resistant columns in new construction. Reliable design of these structural members necessitates clear understanding and accurate modeling of the stress– strain behavior of FRP-confined concrete. To that end, a great number of studies have been conducted in the past two decades, which has led to the development of a large number of models to predict the stress–strain behavior of FRP-confined concrete under axial compression. This paper presents a comprehensive review of 88 models developed to predict the axial stress–strain behavior of FRP-confined concrete in circular sections. Each of the reviewed models and their theoretical bases are summarized and the models are classified into two broad categories, namely design-oriented and analysis-oriented models. This review summarizes the current published literature until the end of 2011, and presents a unified framework for future reference. To provide a comprehensive assessment of the performances of the reviewed models, a large and reliable test database containing the test results of 730 FRP-confined concrete cylinders tested under monotonic axial

compression is first established. The performance of each existing stress–strain model is then assessed using this database, and the results of this assessment are presented through selected statistical indicators. In the final part of the paper, a critical discussion is presented on the important factors that influenced the overall performances of the models. A close examination of results of the model assessment has led to a number of important conclusions on the strengths and weaknesses of the existing stress–strain models, which are clearly summarized. Based on these observations, a number of recommendations regarding future research directions are also outlined

P. K. Gupta [15], the experimental results are presented to investigate the effectiveness of UPVC tube for confinement of concrete columns. UPVC tubes having 140 mm, 160 mm and 200 mm external diameters were used to confine the concrete having compressive strength 20 MPa, 25 MPa and 40 MPa. The concrete has been designed using IS code 10262-1982(Reaffirmed−2004) (BIS:10262–1982, Reaffirmed −2004). The testing of the specimens was carried out on a displacement controlled Instron make Universal Testing Machine of 2500 kN capacity. During the experiments mode of deformation and corresponding load-compression curves were recorded and obtained results are compared with the existing models for confined concrete available in the literature. It is found that the predicted capacities of columns using different models are within ±6% of the experimental capacities. It is found that UPVC tubes can be effectively used for confinement of the concrete columns and to enhance their load capacity, ductility as well as energy absorbing capacity.

J. Shaofeiet.al [16], this study presents experimental results on the behavior of circular concrete columns reinforced by BFRP-PVC tubes under uniaxial loading. A total of six specimens were prepared and tested under uniaxial loading. The main parameters varied in the tests were strengthening ratio and strengthening approach of BFRP. The performance, such as failure modes, ultimate bearing capacity and stress-strain curves, was investigated in details and a formula was proposed to predict the compressive ultimate strength. The results show that this kind of confined columns obviously improves the ultimate bearing capacity, and the ultimate bearing capacity increases with the strengthening layers The formula proposed is applicable and efficient for prediction of the ultimate bearing capacity as well.

Usha. C. M and Dr. H. Eramma [17], in this study, unplasticised poly vinyl chloride (UPVC) tubes filled with concrete are axially loaded until failure of the specimen to investigate their load carrying capacity. Total eighteen specimens of UPVC tubes of diameter 150mm, thickness 7.11mm with effective lengths of 500mm, 600mm, and 700mm were cast. M20 grade of concrete of two different mixes having two different sizes of coarse aggregate 6.3mm and 10mm was filled inside the tubes for casting of UPVC concrete filled tube (CFT) column specimens. The column

specimens were tested for axial loading in the UTM machine of capacity 1000kN. Their load-displacement curves and stress-strain curves were recorded. All the columns fail by local buckling. As the length increases the strength was increased and it was higher for the mix which have 6.3mm size of coarse aggregate compared to 10mm size of coarse aggregate. It was found that about 1.6% increases in compressive strength of UPVC CFT columns experimentally when compared with theoretical value.

T. M. Pham [19], the study aims to investigate the structural behavior and failure modes of fiber-reinforced-polymer (FRP) confined concrete wrapped with different FRP arrangements. A total of twenty four specimens were cast and tested, with three of these specimens acting as reference specimens and the remaining specimens wrapped with different types of FRP (CFRP and GFRP) by different wrapping arrangements. They include fully wrapped, partially wrapped and non-uniformly wrapped concrete cylinders. The non-uniformly wrapped concrete cylinders provided higher compressive strengths and strain for FRP-confined concrete, in comparison with conventional fully wrapping arrangements. The effect of confinement level on the effectiveness of FRP confinement is also investigated. In addition, the partially wrapping arrangements changes the failure modes of the specimens and the angle of the failure surface.

D. Nandan and A. Pahal [20], presented the results of an experimental programme which investigated the effect, on compressive strength of concrete, of using steel, FRP & UPVC tubes in compression. Concrete filled tubes are new areas of application and Investigation for the confinement. Major researches so far has been with concrete filled steel tubes (CFST).Confinement helps in improving the compressive strength of the column and increasing in its energy absorption prior to failure. Although because of the limitations of the corrosion of the steel tubes, in recent years, some investigations with fibre reinforced polymer (FRP) tubes and with PVC tubes have been investigated.

D. H. Galpade [21], this review study explains the use of confined materials in columns in order to use it as stay-in-place formwork. Experience gained over the years in countries such as Japan, Europe and the USA reveal that existing construction technology has not delivered the reliability needed. The rapid deterioration of infrastructure, especially those constructed in severe environments such as bridge piles, has increased the demand for rehabilitating and retrofitting existing concrete columns in building and bridge substructures. It is necessary to strengthen the deteriorated and damaged concrete columns to increase their carrying capacity (axial load and bending moment). The cost of formwork was about 40% of the cost of concrete works, the rest being accounted for by labour and the cost of materials. Eliminating or reducing this formwork in construction can significantly reduce the cost of construction. The use of plastic tubes will act as a confinement material as well as a permanent formwork and this will eliminate the need for temporary formwork. Steel and FRP tubes have been widely researched on and used to confine concrete in CFT columns systems. However steel is prone to corrosion, weathering, and chemical attacks especially when used in severe environments such as under-sea piling.

S. W. N. Razviet.al [22], In this study experimental programme a series of nine one-third scale square reinforced concrete column specimens having cross sectional dimension as 150mm with height of 960 mm were tested. The experiment is performed for control column, columns with ferromesh jacket as confinement reinforcement in addition to stirrups and column with ferromesh jacket only as confinement reinforcement. The overall response of the specimens was investigated in terms of load carrying capacity, axial displacement, stress, strain, lateral displacement and ductility. The test results indicated that column wrapped with additional ferromesh as confinement gives 20% increase in axial strength compared to regular control column. It is observed that columns with ferromesh jacket as confinement reinforcement in addition to stirrups gives better ductility and the column wrapped only with ferromesh as additional confinement fails in ductile manner.

[1] METHODOLOGY

As per the requirement of the study, materials will be collected at first. Tubes of required dimension are collected from the source. Aggregates and cement too have to be collected. A careful study will be carried out on the properties of the materials such as aggregates. Based on those properties mix design will be carried out. Afterwards casting of concrete is carried out in UPVC, HDPE and PVC pipes. Concrete is then cured. After curing testing is carried out. Based on the results obtained from testing, comparative study will be carried out.

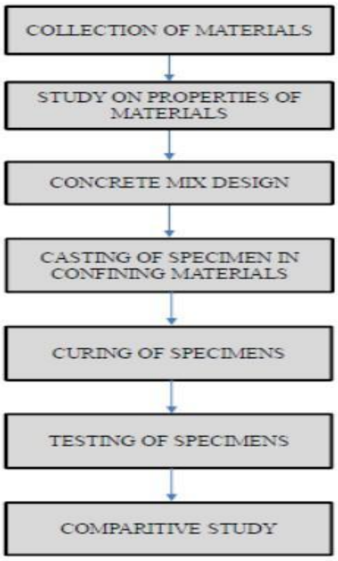

Fig-1: Methodology

IV. CONCLUSION

On perusal of literature, in the various study it has been observed that different types of materials have been used for confinement.

Some of them have used Glass-fiber reinforced polymer (GFRP), Carbon-fiber reinforced polymer (CFRP), FRP wraps, High Density polyethylene (HDPE) tubes, Unplasticized polyvinyl chloride(UPVC), polyvinyl chloride(PVC).

But most of the research has been concentrated on UPVC, HDPE and PVC, as they are readily available and are less costly as compared to CFRP, GFRP.

It can also serve the purpose of stay-in-place formwork along with the confinement. It can be used in marine structures due to its high resistance against salts.

REFERENCES

Fig. 1. M. N. Fardis, H. Khalili "FRP-encased concrete as a structural material," Magazine of Concrete Research: VOL 34, NO. 121 : December 1982

Fig. 2. H. Saadatmanesh, M. R. Ehsani, M. W. Li "Strength and Ductility of Concrete Columns Externally Reinforced with Fiber Composite Straps" ACI Structural Journal / July-August 1994. P. 434

Fig. 3. A. Naani, N. M. Bradford "FRP jacketed concrete under uniaxial compression," Construction and Building Materials, Vol 9, No 2, pp 115- 124, 1995

Fig. 4. M. Demers, N. W. Neale," Confinement of reinforced concrete column with fibre-reinforced composite sheets —an experimental study," Can. J. Civ. Eng. 26: 226–241 (1999)

Fig. 5. M. D. O'Shea "Design of Circular thin-walled concrete filled steel tubes," Journal Of Structural Engineering/ November 2000/ P.1295

Fig. 6. Stephan Pessikiet.al," Axial behavior of reinforced concrete columns confined with FRP jackets," Journal of Composite for Construction/November, pp 237-245, 2001

Fig. 7. Houssam Toutanji, Mohamaed Saafi," Durability studies on concrete columns encased in PVC-FRP composite tubes," Composite Structures, pp 27-35, 2001

Fig. 8. Walter O. Oyawa, et.al, "Polymer concrete filled steel tubes under axial compression," Construction and Building materials 15, pp 187-197, 2001

Fig. 9. Yutian Shao, Amir Mirmiran, Chicago,"Experimental investigation of Cyclic Behavior of Concrete-filled Fiber Reinforced polymer tubes ,"Journal of Composites for Construction, ASCE, pp 263-273, May-June 2005

Fig. 10. S. Matthyset.al, "Experimental investigation of Cyclic Behavior of Concrete-filled Fiber Reinforced polymer tubes ," ACI Structural Journal, pp 258,

Fig. 11. G. Wu et.al," Strength and ductility of concrete cylinders confined with FRP composites," Construction and Building materials 20, pp 134-148, 2006.

Fig. 12. Yong-changGuoet.al, "Experimental studies on axially loaded columns," Key Engineering Materials Vol 400-402, pp 513-518, 2009.

Fig. 13. Ata El-kareim Shoeib Soliman,"Behavior of long confined concrete column," Ain Shams Engineering Journal 2, pp 141-148, 2011.

Fig. 14. M. Dundu, "Compressive strength of circular concrete filled steel tube columns," Thin-walled Structures 56, pp 62-70, 2012

Fig. 15. Togay Ozbakkalogluet al., "FRP confined concrete in circular sections: Review and Assessment of stress-strain models," Engineering Structures 49, pp 1068-1088, 2013.

[16]P. K. Gupta," Confinement of Concrete Columns with Unplasticized poly-vinyl chloride tubes," International Journal of Advanced Structural Engineering, 2013.

[17]J. Shaofei, "Experimental study on concrete columns confined by BFRP-PVC tubes under Uniaxial loading," Journal of ShenyangJianzhu University VOL 28, JAN 2012.

[18]Usha. C. M. and Dr. H. R. Eramma, "Experimental study on concrete filled, Unplasticized poly-vinyl (UPVC)tubes," International Journal of Advanced Technology in Engineering and Science, Volume No.02, July 2014.

[19]T. M. Pham et al.," Effect of different FRP wrapping arrangements on the confinement mechanism," Procedia Engineering 142, pp 306-312, 2016.

[20]D. Nandan, A Pahal, "Properties of concrete filled by steel, FRP & UPVC tubes in compression," International Journal of Engineering Technology Science and Research Vol 2, Issue 3, pp 71-76, December 2016.

[21]D. Galphade, "A review on confinement of reinforced concrete column with UPVC," International Research Journal of Engineering and Technology, Vol 5, Issue 5, pp 3405-3409, May 2018.

[22]Syed Wasim N Razvi, "Effect of confinement on behavior of short concrete column," Procedia Manufacturing 20, pp 563 – 570, 2018