A REVIEW ON CONFINEMENT OF REINFORCED CONCRETE COLUMN WITH UPVC

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Abstract - *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.*

Key Words: Confinement, fibre-reinforced polymer, concrete filled tubes, UPVC.

1. INTRODUCTION

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. This is evidenced by the severely deteriorated infrastructure and the inability to guarantee safety against natural hazards such as earthquakes. There have been various cases of collapse of buildings either under construction or when in use. Also, the rapid deterioration of infrastructure, especially those constructed in severe environments such as bridge piles as shown in fig 1.1, 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).However, due to the high cost of advanced composite materials, the use of these materials in composite columns in light construction is not recommended. Another alternative to the advanced composite materials tubing would be the commercially available plastic unplasticized polyvinylchloride (UPVC) pipes. The strength, ductility and energy absorption capacity of new concrete columns can be enhanced by providing external confinement by employing UPVC tubes .The tubes in composite construction will be used as formwork during construction and thereafter as an integral part of the column.

Fig-1: Degradation of Pile

Existing construction technologies have not delivered the reliability that is required. Governments in various countries are now investing heavily to develop unique high performance construction materials and systems. Special interest is being directed towards advanced composite materials and systems. An example of advancement into these types of new composite systems is the concrete-filled steel tube (CFST) column systems. CFSTs have been used for years as piles and columns and extensive research has been established in this area of advanced composite construction materials. However, CFSTs have the problem of corrosion of steel tubes as well as reduced confinement effectiveness at low levels of loading if the tube is also loaded in the axial direction. This is due to the fact that Poisson's ratio of concrete at low levels of loading is smaller than the value for steel .it is observed that the differential radial expansion of steel tube and concrete, at low levels of loading, results in partial separation between the two materials. This separation leads to a premature buckling of the tube. Thus, effective confinement will only be achieved at higher loading when concrete begins to crack as it expands faster than the steel tube and becomes well confined. An alternative to CFSTs is FRP composites which have been used as precast piles, girders, and pier columns. As opposed to steel CFTs, Poisson's ratio of FRP tubes can be controlled through selected design of the laminate structure to provide more confinement effect. The confining pressure provided by steel tubes is limited to a constant value once the tube yields, whereas FRP tubes provide a continuously increasing confining pressure, which adds to both the ultimate confined strength and ductility .However, with the high cost of advanced FRP composite materials, the use of concrete-filled fibre reinforced polymer (CFFRP) material in composite columns in light construction is not recommended. An alternative to the advanced composite materials tubing is the commercially available UPVC plastic pipes. UPVC are the pipes made of unplasticized polyvinyl chloride, which are easily obtained in various diameters.

2. LITERATURE SURVEY

Walter O. Oyawa et al., Kenya has recently experienced worrying collapse of buildings during construction largely attributable to the quality of in-situ concrete and poor workmanship. The situation is further compounded by rapid deterioration of infrastructure, necessitate that measures be taken to develop enhanced structural materials and systems. The work herein presents the findings of experimental and analytical work which investigated the structural response of composite concrete filled plastic tubes under compressive load regime. Key variables in the study included the strength of infill concrete, the length to diameter ratio (L/D) of the plastic tube, as well as the diameter to thickness ratio (D/2t) of the plastic tube. Plastic tubes having varying diameters and heights were used to confine concrete of different strengths. Results obtained in the study clearly demonstrate the effectiveness of plastic tubes as a confining medium for infill concrete, attributable to enhanced composite interaction between the plastic tube and infill concrete medium. It was determined that compressive strength of the composite column specimens increased with increased concrete strength while the same decreased with increased column height, albeit by a small margin since all the columns considered were short columns [1].

Andrew Wheeler et al., Concrete filled steel tubes (CFTs) are efficient members in structural applications including bridges, buildings and piled foundations and their use in the building industry is increasing. To date their primary use has been in axial applications, with the design methodology based on theory and tests of columns under loads applied axially or at relatively small eccentricities. Limited in to research into the behaviour of CFTs subjected to large eccentricities or loading in pure flexure have been conducted, with preliminary experimental investigation suggesting that stiffness of composite members tending towards that of the tube at relative low loads. An ongoing research program on the flexural behaviour of CFTs is being undertaken at the University of Western Sydney with a particular emphasis on thin-walled steel tubes that can provide an economical form of construction. In this paper, the results from additional experimental work will be presented with a particular emphasis on the stiffness of the members when subjected to flexural loading. The experimental work to date has demonstrated that even in composite specimens where there is negligible end slip; the stiffness of the specimens under pure flexure tends to the stiffness of the bare steel tube. A numerical model will also be presented that can accurately generate the bond/slip relationship of the concrete within the steel tubes and consequently the behaviour of the specimens modeled [2]

Ata El-kareim Shoeib et al., the behavior of concrete columns confined by fiber reinforced plastic/polymer (FRP) depends on several parameters, including concrete strength, types of fibers, volume and orientation of fiber in the jacket, jacket thickness and shape of cross section, length-to-diameter (slenderness) ratio of the column. In this paper, the behavior of long concrete columns confined by means of proper plastic tube is investigated including failure mechanisms and subsequently their failure mode with theoretical model for calculation of the column capacity. 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 mechanisms of concrete columns. Results also show that the stiffness of the tested long confined concrete columns specimens increases as slenderness ratio decreases. It is necessary to strengthen the deteriorated and damaged concrete columns to increase their carrying capacity (axial load and bending moment), and ductility to improved seismic performance. Plastic pipes, tubing and profiles are used in a wide variety of industries including, building and construction, automotive, consumer goods, lawn and garden, windows and doors, furniture, plumbing and electrical. One of the most widely used materials for these products is polyvinylchloride commonly known as PVC [3].

B. R Niranjan et al., substantial efforts have gone into understanding the behaviour of CFST columns to develop better composite columns. Emphasis has been made regard to, shape of the column, L/D ratio, type of failure of the members depending upon the shape and boundary condition of the column. Study has been made both on experimental and analytical investigations. Technology of concrete filled steel tubular column was evolved as early as 1970's, itself, and there has been enough research carried out to understand the complete behaviour of these columns. CFST is a composite structural member, which resists the applied loads through the composite action of steel as well as concrete. The interactive and integral behaviour of concrete and structural steel elements makes it a cost effective alternative. In addition to its improved load carrying capacity, it is also aesthetically pleasing. Due to the presence of concrete core, local buckling of steel tube is delayed and the strength deterioration after local buckling is moderated, both due to restraining effect of concrete. The strength of concrete is increased, due to the confining effect provided by steel tube and on other hand the Strength deterioration is not that severe because concrete does not spall due to the confinement. Drying shrinkage and creep of concrete are much smaller in these columns as compared to other structural forms. Having listed all the advantages, however the major disadvantage of a composite column is the exposure of tube to the environmental effects (such as heat, cold, UV etc.). For steel tubes, this raises concerns related to susceptibility to corrosion and fire safety. The structural properties of CFST columns include high strength, high ductility and high energy absorption capacity. The load carrying capacity and behaviour in compression, bending and shear are all superior to reinforced concrete. The reduction of the steel tube thickness in thin-walled CFST columns has the potential to significantly reduce construction costs [4].

Abhale et. al., Poly Vinyl Chloride (PVC) tubes filled with concrete are axially loaded until failure of the specimen to investigate their load carrying capacity. Twenty four specimens are cast and tested, out of which twelve are of PVC pipe and twelve of steel tube. PVC tubes are of dia. 152.4 mm, thickness 5mm with effective length of 500 mm and 600 mm. One of the main advantages in the interaction between PVC tube and concrete is, local buckling and PVC tube Delayed by restraint of concrete and strength of concrete is increased by the confining effect of PVC tube. In current international practice, concrete filled tube (CFT) columns are used in the primary lateral resistance systems of both braced and unbraced building structures. CFTs are also used as bridge piers. Moreover, CFTs may be utilized for retrofitting purposes for strengthening concrete columns in earthquake zones. The CFT structural member has a number of distinct advantages over an equivalent steel, reinforced concrete, or steel reinforced concrete member. The orientation of the PVC and concrete in the cross section optimizes the strength and stiffness of the section. The PVC lies at the outer perimeter where it performs most effectively in tension and in resisting bending moment. Also, the stiffness of the CFT is greatly enhanced because the PVC, which has a greater modulus of elasticity than the concrete, is situated farthest from the centroid, where it makes the greatest contribution to the moment of inertia [5].

N. Gopi et al., behaviour of Concrete Filled PVC Plastic Tubes (CFPT) Placed in Columns Concrete filled PVC plastic tubes are placed at columns. Generally the plastics are having low bonding with concrete so, to increase the bonding strength by forming of scratches on plastic pipes. It may increase bonding strength compare with actual strength of bonding. In this study 10.5cm, 7.5cm, 4.5cm and 2.5cm inner diameter pipes are used in making of cube. In plastic pipe placed on center of concrete cube .the cube specimens are made by M40 mixing ratio of concrete .After the curing process the cube specimen tested for axial loading in the UTM machine. All the specimens loading are noted from the UTM machine. In this investigation 7.5cm pipes are increase the strength of concrete .it can be used in columns to improve the strength. Confinement of concrete columns with PVC tubes improves their compressive strength. The improvement in strength is dependent on the concrete strength and geometrical properties of the tubes. Higher compressive strength of UPVC column can be obtained by using smaller coarse aggregates. In this investigation explained in small diameter of pipes increase the concrete strength [6].

Amir Mirmiran et al., behavior of Concrete Columns Confined by Fiber Composites by It is generally recognized that hybrid construction can result in a more efficient structural system. In recent years, concrete-filled steel tubes have been reconsidered in construction industry, especially in seismic regions. Their benefits include high stiffness and strength, large energy absorption, and enhanced ductility and stability. The tube interacts with the core in three ways: (1) it confines the core, thereby enhancing its compressive strength and ductility; (2) it provides additional shear strength for the core; and (3) depending on its bond strength with concrete and its stiffness in the axial direction, it develops some level of composite action, thereby also enhancing the flexural strength of concrete. The core, in return, prevents buckling of the tube. Since steel is an isotropic material, its resistance in the axial and hoop directions cannot be uncoupled nor optimized. Also, its high modulus of elasticity causes a large portion of axial loads to be carried by the tube, resulting in premature buckling. Furthermore, its Poisson's ratio is higher than that of concrete at early stages of loading. This differential expansion results in partial separation of the two materials, delaying the activation of confinement mechanism. Finally, outdoor use of steel tubes in corrosive environments may prove costly. External confinement of concrete by means of high-strength fiber composites can significantly enhance its strength and ductility as well as result in large energy absorption capacity [7].

R. Masmoudi et al., behavior of steel and carbon FRP-reinforced concrete-filled FRP tube columns under eccentric loads. This paper presents the performance of the reinforced concrete-filled FRP tubes (RCFFTs) columns under eccentric loads. The experimental program included two CFFT cylinders and ten RCFFT columns (152×912 mm). The main parameters examined include the type of internal reinforcement (steel and carbon FRP bars) and the eccentricity values. The load eccentricity-to-diameter (e/D) ratios were 0, 0.1, 0.2, 0.3 and 0.4. The test results indicated that the CFRP-CFFT columns successfully maintained the axial load carrying capacities and the induced moment under different eccentricities as compared with the counterpart steel-RCFFT columns. Also, the CFRP-specimens performed similarly to the specimens reinforced with steel bars up to the peak load in terms of stiffness, axial and lateral deformations. However, the strength and behavior of the test specimens were mainly affected by the eccentric loading. The compressive strength of CFFT columns was reduced by 42% to 75% with increasing the e/D ratio from 0.1 to 0.4 [08].

H. M. Mohamed et al. (2011) Slenderness ratio effect on the behavior of steel and carbon-FRP reinforced concrete-filled FRP tubes. Concrete-filled fiber-reinforced polymer (FRP) tubes (CFFTs) system is one of the most promising techniques to protect the reinforced concrete structures from aggressive environmental conditions. This paper presents the results of an experimental investigation on the strength and failure modes of ten CFFT columns. The effect of two parameters and their interactions on the buckling behavior were investigated; namely, the type of internal reinforcement (steel or carbon FRP bars) and the slenderness ratio. The eleven CFFT columns of different slenderness ratio 4, 8, 12, 16 and 20 were tested under pure compression load. The internal diameter and the thickness of the FRP tubes are 152 mm and 2.65 mm, respectively. The test results indicated that the axial compressive strength of steel and CFRP-reinforced CFFT columns was reduced by 13% to 32% with increasing the slenderness ratio from 4 to 20. Also, it was found that the axial capacity of CFRP-reinforced CFFT columns resulted in average 12.5% reduction as compared to the counterpart steel-reinforced CFFT columns. The application of composite materials has been propagated by the deterioration of the old conventional concrete, steel, and timber structures. The fiber-reinforced polymers (FRP) tubes can play an important role in replacing transverse steel by providing ductility and strength for reinforced concrete columns. The use of FRP composite tubes in civil engineering applications offers several advantages such as confinement, protecting the concrete core, providing shear or/and flexural reinforcement and finally, act as a permanent formwork which save the time and cost of the construction [9].

Miguel A. Pando et al., of Concrete-Filled Tubular FRP Piles Traditional pile materials for bridge foundations include steel, concrete, and timber. These pile materials have limited service life and high maintenance costs when used in harsh marine environments due to corrosion, degradation, and marine borer attack. Overall it has been estimated that repair and replacement of piling systems costs the U.S. over $1 billion annually. High repair and replacement costs have led North American highway agencies and researchers to investigate the feasibility of using composite materials for transportation and civil engineering structures including bridge pile foundations. Since the 1980's, a number of American manufacturers have begun marketing alternative pile products known as "composite piles". The term "composite piles" usually refers to piles composed of fiber reinforced polymers (FRP), recycled plastics, or hybrid materials. Some of the commercially available composite piles are shown. In this paper, concrete-filled tubular FRP piles were studied this type of composite pile has two main structural components: a fiber reinforced polymer (FRP) shell and a concrete infill (no steel reinforcement). The FRP shell provides, among other things, a stay-in-place concrete form, confinement to the concrete, tensile reinforcement and corrosion protection. The concrete infill provides primarily compressive load capacity [10]

3. CONCLUSION

[1] The price of formwork reduces as the confinement material is economical than wooden or steel formwork.

[2] The formwork is partly eliminated due to permanent confinement while casting.

[3] The confinement material is not dismantled as it will act as the part of structure.

[4] Large amount of cost on formwork can be reduced effectively for Infra-structure projects.

[5] The confinement can be provided with different materials like PVC pipes, fiber-reinforced polymer, steel, etc.

[6] UPVC confinement decreases the environmental impact on the structure, which is recyclable.

[7] UPVC is impermeable to fluid or chemically inactive on the structure, which is non-corrosive in nature.

[8] The UPVC confinement helps in load carrying capacity of column or the member which is confined.

[9] The life of structure increases due to above characteristics of UPVC confinement.

[10] Most effective application in Marine structure and bridge piers, where corrosion of member affects the life structure.

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