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Effect of Retrofitting On Concrete Filled Aluminium Tubular Section Using Basalt Strips

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Abstract: Over the past few decades, concrete filled tubular column plays an eminent role in the construction industry owing to its structural behaviour like large deformation and energy absorption capacity. These members are ideally suited for all applications because of their effective usage of construction material which leads to high compressive strength, excellent fire resistance, low cost and rapid construction. The steel and the concrete element in a composite member complement each other ideally thus the advantages of both are maximally utilized. But these members get deteriorated due to the environmental effects like corrosion and ageing. In general, retrofitting is a part of Civil, Mechanical Engineering and Medical field. In civil engineering field, to set right the deteriorated, damaged, corroded and aged composite structures by means of repairing, retrofitting, rehabilitating, strengthening processes based on the damage conditions of the structures and up gradation to higher seismic zones are required. Different methods are being adapted for retrofitting and repairing works. The external strengthening of fibre material is emerging as a new trend in enhancing the structural performance of tubular members to counteract the drawbacks in using the past rehabilitation work.

In this paper, an experimental investigation has been carried out according to the behaviour of partially damaged concrete filled rectangular aluminium tubular columns retrofitted with basalt strips in the nominal grade of concrete under axial compression. In the experimental work a total ten concrete filled rectangular aluminium tubes of 44.75mm x 101.6mm x 1.35mm with 425mm height are casted. In that nine specimens are externally bonded by 3 layers of 30mm width of basalt strips with three different spacing of 26.42, 35.83 and 49mm was tested. The retrofitted effects between various percentages of damaged specimens with respect to the wrapping spacing are to be compared. Finally, the experimental results will be compared with the analytical results obtained from ANSYS software.

I. INTRODUCTION

Composite columns consist of a combination of concrete and steel which leads to best usage of these constituent materials. Composite column exists in two forms namely steel encased concrete section and concrete filled steel tubular sections. Composite columns have been widely used in the construction industry mainly due toits high strength, durability, easy construction and cost saving. In composite column the concrete core delays bending and buckling of the tube, while the tube prevents the concrete from spalling. The local buckling of composite column is delayed because it can only buckle outwards due to the concrete core inside. Concrete filled tube columns are suitable in high seismic regions since concrete delays the local buckling of steel hollow sections and increases the ductility of the section significantly.

Aluminium tubular members are increasingly used in structural applications in recent years due to their lightness, corrosion resistance, high strength-to-weight ratio, ease of production, recyclable and availability. The aluminium tubular members are normally manufactured by heat-treated aluminium alloys, because heat-treated alloys have notably higher yield stress than non-heat-treated alloys. It is well known that concrete-filled steel composite columns have many advantages similarly aluminium tube columns filled with concrete can effectively take advantages of these two materials to provide both high strength and high stiffness. Young's modulus of aluminium alloy material is approximately one-third of the carbon steel material thus the load carrying capacity of aluminium alloy columns is lower than that of the carbon steel column but one of the ways to increase the load carrying capacity of aluminium tube columns is to fill it with concrete. The aluminium tubes surrounding the concrete core eliminate permanent formwork hence construction time and cost can be reduced. Tensile coupon tests were carried out to determine the material properties of the aluminium tubular members.

II. SCOPE OF THE STUDY

This experiment suggest a composite column which adequately have structural, architectural and lifecycle benefits like enhanced strength, ductile behaviour, high corrosion resistance, aesthetic appearance, low construction and maintenance cost. The scope of this experiment is to study and compare the behaviour of concrete filled aluminium tubular columns retrofitted by basalt strips. This project involves varying spacing of basalt strips, varying damaged condition and comparing the results.

The main aims of this work are

A. To find the ultimate compressive strength of a sample specimen

B. To study the effects of retrofitting of columns under different percentage of loading.

C. To compare the efficiency of retrofitting by changing the spacing of basalt strips wrapping.

D. To find the ultimate strength of retrofitted specimens.

E. To find the crushing failure load at first yielding.

III. LITERATURE REVIEW

Ghorapade A P & Jadhav H S (2015), this paper presents a test programme on behaviour of Hollow Square Section strengthened with Carbon Fibre Reinforced Polymer is carried out. The test was conducted based on the variation in width and number of layers of carbon fibre reinforced polymer. Epoxy Resin is an adhesive material used for steel and CFRP bonding and it can be made by the combination of Resin and Hardener. In this study CFRP strengthening just delays buckling, it doesn’t make any change in the mode shape of buckling.

Bedage S D & Shinde D N (2015), this paper deals with comparative study between experimental results and analytical results of concrete filled steel tubes under axial compression. The experimental investigation is carried out with Circular, Square and Rectangular cross section with M20, M30 and M40 grade concrete.

The CFST failure pattern differ for each cross section in which the circular cross section fails in length due to distortional buckling and the failure accurse at both ends in square and rectangular section due to local buckling. From the stress distribution diagram the stresses in steel tubes occurs 1.5 to 2.5 times than concrete is observed.

Kiruthika P et al., (2015), in this study the width, spacing and number of layers of FRP is studied in accordance to its strength. The experiment posse’s steel tube specimen with carbon and glass fiber polymers is used. The top and bottom portion of the specimen was smoothening using surface-grinding machine and the Rust and loose debris was removed using steel wire brush. The specimens were allowed to cure for the period of 10 days under room temperature. The CFRP strips help to delaying the overall buckling under its peak load. Mostly deflection was delayed due to the increased in wrap fibre of CFRP. Delaminating of fibres was not observed in any of the samples due to proper bonding of fibre with the sample.

BurakEvirgen Vet al., (2014), in this study the effects of width/thickness ratio (b/t), the compressive strength of concrete and geometrical shape of cross section parameters on ultimate loads, axial stress, ductility and buckling behaviour are investigated using Circular, hexagonal, rectangular and square steel tubular sections. The sections were welded along the cutting surfaces using an argon welding machine. All the sides of the specimens were covered by hydrated lime to observe possible cracks during the test. In this study two strain gauges were used on the front and at the rear sides of the specimens and a LVDT is used to measure elongation and shortening along a working axis.

Sundarraja M C &Shanmugavalli B (2014), the research paper deals with the behaviour of short columns strengthened using FRP composites under compression. Commonly the buckling problems lead to strength reduction which can be reduced by the wrapping of FRP sheets. Fibre wrapping was done along the full length of the column with a 30mm wide CFRP strips. In this study 20mm, 40mm and 60mm centre to centre spacing between strips and 1, 2 and 3 numbers of CFRP layers were varied to examine the strength. A typical buckling failure (elephant’s foot buckling) is exhibited in all un-strengthened specimens.

Akshay P et al., (2014), the research paper deals an experimental study related to the strengthening of R C short columns strengthened with BFRP wrap under axial loading. For strengthening of reinforced concrete columns, total fourteen columns were cast and tested up to failure of the columns under axial loading. The columns were bonded with BFRP sheets in single layer and double layers with various configurations. The experimental results show that the columns strengthened with BFRP show high load carrying capacity and ductility index.

Anandakumaret R et al., (2013), research paper studied the behaviour of cubes, cylinders, prisms and reinforced piles retrofitted with basalt fibres. Several researches have been done in retrofitting of concrete beams and columns, but no work have done in retrofitting of piles using basalt fibres. The results show that the specimen with double wrapping of basalt fibre gives better performance when compared with conventional and single wrapped specimens. All the results were tabulated and graphically plotted.

Anil Kumar Patidar (2012), this paper presents an experimental Behaviour of Concrete Filled Rectangular Steel Tube Column.

The characteristic strengths of concrete used are M20, M30 and M40. The non-linear finite element analysis program ANSYS has been used to predict the ultimate loads and failure modes of hollow and in-filled light gauge steel section under hinged end conditions. The numerical simulation consists of two stages Eigen value analysis, Nonlinear buckling analysis.

KadhimZuboonNasser (2012), the paper presents an experimental and theoretical study on the behaviour of circular concrete filled aluminium tubular columns and to investigate the effect of diameter, D/t ratio and slenderness ratio of a aluminium tube filled with concrete. An empirical equation is proposed to predict the strength of aluminium concrete composite columns theoretically. The Aluminium pipe provides lateral support and increase the ultimate strength and ductility of the column. The failure mode observed are classical shear mode failure and long column buckling mode failure. It clearly shows Slenderness ratio affects the ultimate compression load capacity of the section.

ZahurulIslam S M &BenYoung (2012), have made an experimental studies on strengthening of high strength aluminium tubular structural members using externally bonded carbon fibre-reinforced polymer. The high modulus CFRP Sika CarboDur H514 laminate plate was used with Araldite as adhesive. To enhance proper bonding the outer surfaces of the aluminium tubular section undergoes surface treatment in which medium grit sand paper with an electric sander was used. Three main failure modes were observed in the tests, namely the adhesion, combination of adhesion and cohesion, and inter-laminar failure of CFRP plate.

Dundu M (2012), an experimental study was undertaken to investigate the behaviour of concrete-filled steel tube (CFST) columns, loaded concentrically in compression to failure. A plot of the compressive load versus the vertical deflection shows the composite columns to be fairly ductile. The characteristic cubic strength used in these studies ranged from 50 to 120 MPa. Each circular hollow section was filled with concrete in 4 layers and an extra 15 mm layer was cast at the top of the columns to account for possible concrete shrinkage. The finished CFST columns were sealed with plastic sheeting at the top to retain moisture in the concrete and the specimens were allowed to cure for 28 days. This was done to ensure that the hydration of cement can continue properly without premature hardening of the concrete.

Zahurul Islam S M & Ben Young (2011), this paper presents a test programme on aluminium tubular structural members that have experienced web crippling failure due to localized concentrated loads. From this study more flexible and less stiff adhesive are highly efficient than high rigid adhesives since high rigid adhesives possess low bonding strength has been studied.

Darshika K et al., (2010), this paper presents an experimental behaviour of concrete filled steel tube column. The confinement effect provided by the steel tube with a concrete-filled steel tubular (CFST) short column increases the strength of the concrete core. The concrete is enhanced in its performance as it suffers less creep and shrinkage and the quality improves, thus allowing a larger compressive stress to be resisted by the internal concrete. The design strengths predicted by the Euro-code 4 are generally un-conservative.

FengZhou & Ben Young (2009), the research paper deals with experimental investigation of concrete-filled aluminium circular hollow section (CHS) stub columns. The ends of column where cast in plaster to ensure uniform loading. In this Three displacement transducer were used in each column specimens to measure the axial shortening and five strain gauges (one strain gauge near both ends and three strain gauges in the middle height of the columns) were used to monitor the axial strain of the sample. It is also shown that the ductility of concrete- filled aluminium stub columns decrease with the increase of the concrete strength and also the concrete- filled aluminium CHS stub columns reach the ultimate loads before the aluminium CHS tubes reach the yield stress it shoes that for high strength concrete the aluminium tube is not fully utilised.

Feng Zhou & BenYoung (2008), studied about an experimental investigation of concrete-filled aluminium tube columns. A series of tests was conducted to investigate the effects of the shape of the aluminium tube, plate thickness and concrete strength on the behaviour and strength of concrete-filled aluminium tube columns using square and rectangular hollow sections. Due to the split of aluminium tube near the corner of the section the ductility of the concrete-filled aluminium tube columns only slightly improve as compared with the aluminium tube columns.

Zeghichea J &Chaouib K (2008), the research paper deals with the column slenderness ratio, loaded columns with single or double curvature bending and the compressive strength of the concrete core. In this circular hollow steel specimen with normal concrete is used. Progressive vibration was employed in order to eliminate air pockets in the concrete and to make a homogeneous mix. The steel yielding process started first in the compression zone for small eccentricities and reached the tension zone for columns with higher eccentricities.

JiHua Zhu & Ben Young (2008), this paper presents an experimental investigation of aluminium alloy circular hollow sections subjected to pure axial compression between fixed ends and the effects of welding on aluminium alloy columns have been investigated. In this the samples are transversely welded to aluminium end plates using the Tungsten Inert Gas welding. In this study the transverse welded columns reached 54–76% of the test strength of non-transverse welded column. The material yielding accurse in the heat-affected zone in short welded columns.

IV. MOTIVATION STUDY FROM THE REVIEWED LITERATURE

The reviewed literature shows that the concrete filled tubular columns depends on various factors loading condition, stress-strain relationship, width to thickness ratio, slenderness limits, confinement effect, local buckling etc.,. The reviewed literatures clearly showed there is lack of experimental studies on increases strength of columns retrofitted with basalt fibre reinforced plastic in aluminium tubes. So far, GFRP laminates was used since basalt fibers shows superior retrofitting properties than glass fiber and carbon fiber. So basalt fibers are used as an external wrapping of the tubular columns. The aluminium tubes have both good material properties and corrosion resistance so aluminium tube is used as a tubular layer. In the past researches all the samples are retrofitted from the initial stage of loading but in this project the columns are retrofitted after initial cracking load as this project is concerned about the rehabilitation of damaged structures.

V. FUTHER POSSIBILITIES

A. Replacement of concrete components with other materials
B. To study the seismic behaviour of retrofitted sections.
C. To study the durability behaviour of the section.
D. By increasing the number of basalt layers for retrofitting the tubular section.
E. By changing the rapping spacing of basalt fibers.

VI. PROPOSED WORK

After having a detailed literature survey, the following work was proposed. It was decided to carry out the experimental work on aluminium tube filled with M20 grade concrete. Totally ten specimens are going to be casted on concrete filled aluminium tubular composite column. Among these, one specimen is to be tested to calculate its ultimate load. Rest of the specimens are to be damaged under 60%, 70% and 80% of ultimate load. Basalt fibbers are to be wrapped around the damaged specimens with a different wrapping spacing of 26.42mm, 35.83mm and 49mm. Then these retrofitted specimens are to be tested to its ultimate load. Then the retrofitted effects between various percentages of damaged specimens with respect to the wrapping spacing are to be compared. The test results between normal and retrofitted sample is to be studied. Then the experimental values of all specimens are to be compared with the analytical value obtained from ANSYS.

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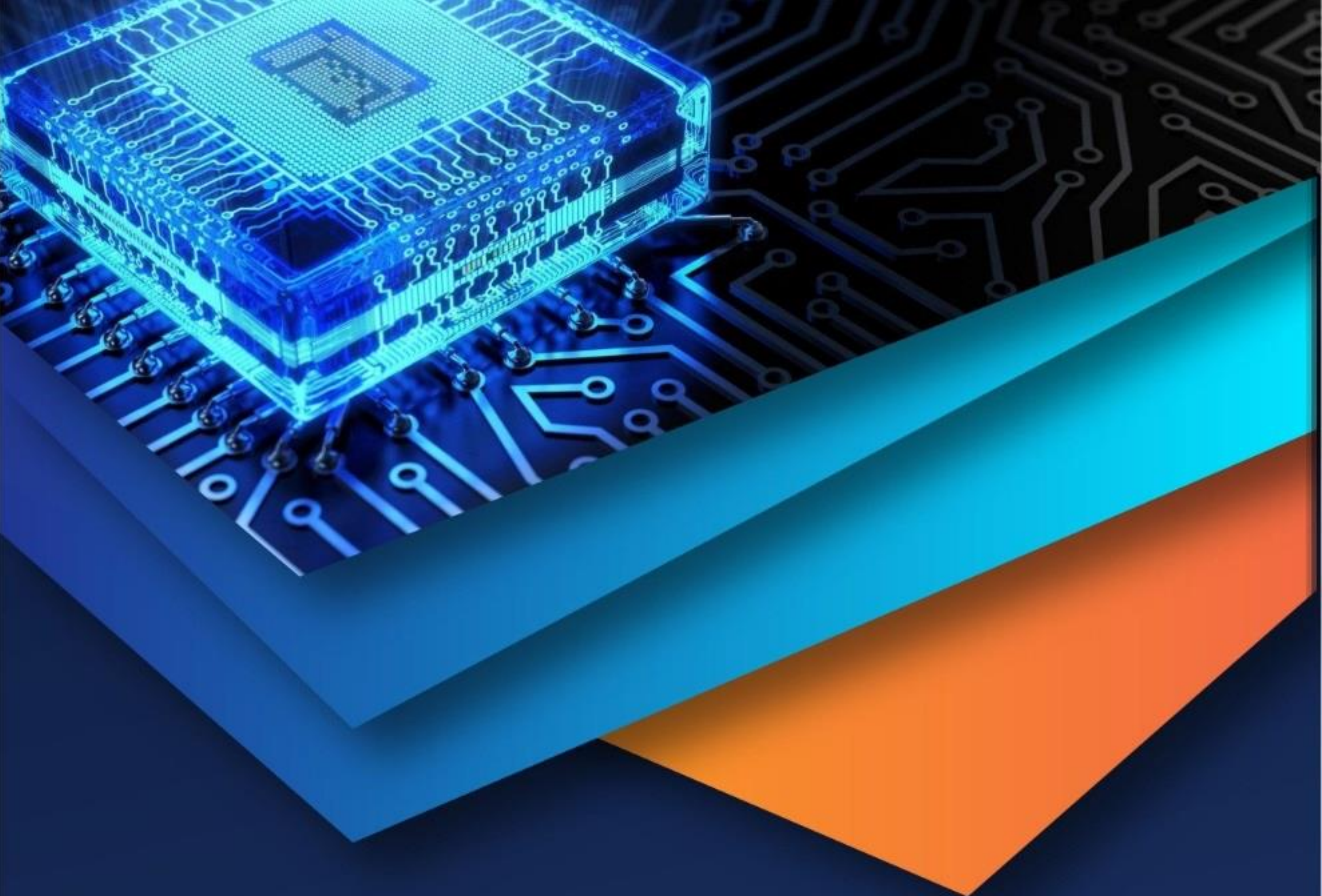

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