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REVIEW ON RC COLUMN JACKETING

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Abstract— **This study is discussed about the effectiveness of R.C.C. jacketing method is used to improve the performance of deteriorated structure or rebuilding structure, this technique is successfully applied when the structure is to be retrofitted. Selected paper are Concluded that surrounding key design considerations identified and used the design of structure as per the requirements.**

Keywords— **RC Column, Strengthening, Repair, deformation.**

I. INTRODUCTION

The main aim is to strengthen the existing columns or building before complete collapse due to any failure mode. R.C.C. Jacketing is the most important for strengthening the building columns. There are many methods in RC column jacketing, thus the most common type is reinforced concrete jacketing and cost effective. Behavior of existing RC column is to be known before design or jacketing. It is also recommended to strengthen the column which is affected by earthquake and to use current design codes. The experimental studies will give the proper result for the particular column failure.

II. LITRATURE REVIEW

Eduardo N. B. S. Julio et.al (2008):- The paper studies about the quantifing the influence of four parameters on the bond strength between concretes with various age factor and different characteristics. The parameters are Roughning of the interface surface, utilization of a bonding agent like epoxy resins does not improve the interface strength if sandblasting is used, interface strength will be increased by adding high-strength concrete (HSC) and Objectives of steel connectors. For undamaged RC column subjected to bending moment/shear force ratios greater than 1.0 m (3.281 ft), a monolithic behavior of the composite element can be achieved, even without increasing their surface roughness, bonding agents, before strengthening by adding an RC column jacketing with a thickness lesser than 17.5% of the column width to obtain a monolithic behavior of the composite element.

Eunsoo Choi Young-Soo Chung et.al (2010):- This paper introduces a new steel-jacketing method for RC columns using external pressure, Single and double-layered jackets are introduced. The double-layered jackets are shown that the performance is equal to that of a single jacketed to the same thickness. In double layer jacketed column are more effective to ductile behavior than the single-layered jacketed column. The new steel-jacketing method enhances the displacement ductility and energy dissipation capacity of lap-spliced RC columns. Proposed steel jacketing method for RC columns without grouting and epoxy, no increase in the area of RC column and it can be installed at any position of a column (bottom, middle, or top). That the jackets don't behave compositely with concrete because the circumferential strains are about equivalent to the vertical strains, if there is a composite behavior between the jackets and the concrete, the vertical strains will change from the circumferential strains.

Vedprakash C et.al (2014):- The new jacketing materials should be equal or greater strength than the existing columns. For column minimum reinforcement of 12mm φ bars in the four corners and ties of 8mm φ @ 100 c/c are provided. Minimum thickness of jacketing should be 100 mm using locally available material. R.C column retrofitting technique is significantly improves the Moment resisting, shear strength in Beam and Axial load carrying capacity in columns. Main intension is to avoid buckling in column.

Abd-ELhamed et.al (2014):- In order to investigate the failure of building column by earthquakes or any other aspects, the columns are strengthened by Steel Angels Wrapped with Steel Wire Mesh. In this study the cracked column portion or damaged portion are removed and they are filled by grout mortar. The experimental test are conducted to a specimen of size 120x160x800 mm, with reinforced at 4 edges of specimen by 8mm diameter and 6mm stirrups at 150mm c/c. The test result concludes that when the eccentricity is increased from 0 to 25% the ultimate load bearing capacity is decreased by 112% to 102.5% after strengthening. Due to slight variation in eccentricity, the reinforcement increases from 1100 strain to 2100 micro strain while the load decreased from 608 to 555 KN. The maximum strength can be achieved in four vertical steel angles at the corners wrapped with steel wire mesh. The area of the reinforcement in the transverse direction is recommended to be not less than 50% of the area of vertical reinforcement in longitudinal direction.

Jijin V et.al (2015):- Column jacketing with FRP sheets performs a critical position in improving the overall performance of RC column. FRP is the Advanced Composite Material (ACM) this is extraordinarily new fabric to

strengthening the affected building. After laboratory testing Carbon Fiber Reinforced Polymer (CFRP) is more effective than Glass Fiber Reinforced Polymer (GFRP) jacketing will increase the capacity of columns subjected to eccentric and axial loading of various cross-section. Also CFRP jacketed RC column capacity will increase in the order like rectangular, square, and circular. GFRP and CFRP jacketing resulted in improving the load carrying capacity without increasing the area of existing columns.

Dr. Sayan Sirimontree et.al (2015):- This paper is under concentrically static loading of RC column strengthening by extra reinforcement and ferrocement are contemplated. Strength of RC column can be essentially improved by applying mortar. By studing ACI equation can be utilized to anticipate static strength of RC column strengthened by adding extra steel and ferrocement. Test results shows that, the number of wire mesh wrapping 13 is achieving the more strength. Concrete core can be avoided by ferrocement leading to high ductility of strengthened concrete column due to increase in area of column section.

Mohannad H Al-Sherraw et.al (2015):- This paper studied about the analytical models were referred for the hand computation to construct the N-M in (X and Y axis respectively) interaction diagram for RC column strengthened with steel jacket. Presents systematic models to construct the axial load and bending moment interaction graph of a RC column strengthened with steel jacket. This analysis express for the stress-strain responses of confined concrete and steel reinforcement (steel bars and steel angles are under compression load) can be able to include confined effects induced by steel strips and angles subjected to bending moment and axial forces. The final out put were compared with the experimental columns strength results presented by some researchers and design proposals contained in ANSI/AISC 360-16 and EN 1994-1-1.

K. Pavlo KRAINSKYI et.al (2015):- This paper study is based on developing the stiffness, shear and axial strength of existing RC column by placing additional reinforcement and concreting around the structural member. Steel jacketing will not make much difference in size of member; can significantly increase its stiffness. Fiber Reinforced Polymers (FRP) sheets are very effective method of structural retrofitting, also good for jacketing which are light in weight, durable, easy to install and have high tensile strength. When the cross section of the column increases approximately two times we achieved axial load increase up to 290 %. RC column jacketing has improved its performance when column had almost exhausted it strength. Finally no displacements, cracks, losses between columns and jacketing were noticed.

Mostafa Fakharifar et.al (2015):- This study is about rapid repair of seismically damaged Reinforced concrete (RC) columns. In this method thin cold-formed steel sheet wrapped around the existing column including application of prestressing strands. The material used for Jacketing is light in weight. In this method heavy installation equipment are not required and there will no curing for the adhesive material. This method is well developed in preventing lap splice failure and to withstand ground motions. It improves the flexural stiffness, ductility and energy dissipation. Surface preparation and adhesive epoxy is not required for existing RC column. This method is well developed compare to other rapid repair technique.

Guan Lin et.al (2015):- The main purpose of this study is circular reinforced concrete (RC) columns are more effective than rectangular columns and square columns. In fiber-reinforced polymer (FRP) concrete the rectangular columns will exhibits a softening stress-strain response. The manual calculation results may vary significantly with the number of integrations, showing the non-objectivity of numerical results. This paper has introduced a target numerical methodology for FRP- confined square RC columns under cyclic/seismic loading, in which the force-based beam-column element with the adjusted Scott and Fenves integration plan in Open SEES (Open System for Earthquake Engineering Simulation) is utilized. The improvements and use of a common plastic hinge length model for such columns is carefully examined.

Alberto Meda et.al (2015):- In several buildings Corroded Reinforced Concrete (RC) columns have to be strengthened, in order to increase the life span of the structures. The condition of corroded RC columns is more critical in earthquake region. High Performance Fiber Reinforced Concrete (HPFRC) jacketing is used to strengthening the Corroded or defected RC column. The effectiveness of using HPFRC can reduced crack opening, can protect the inner layer, durability of concrete can be improved and also to sustain the maximum load carrying capacity. By the laboratory test results conclude that the use of 40mm thick HPFRC will give the best performance for Corroded RC columns. Finally the curing temperature in surrounding area and humidity is conceding to achieve full strength and bonding strength between existing and new concreting.

Ezz-Eldeen (2016):- In this study strengthening of Reinforced concrete (RC) column by different size of longitudinal steel angle and transverse steel plate to increase the axial load carrying capacity of rectangular reinforced concrete columns under eccentricity. After laboratory test and Finite Element Analysis (FEM), it can be concluded that increase in the dimension of column and steel angels will improve the load carrying capacity of the RC column. Therefore the corresponding final result of laboratory test and FEM analysis will vary by 2.75 to 7.45% and it prevents the shear interaction of RC column jacketing, also improves ductility of concrete.

Joel E. Parks et.al (2016):- There are not many examinations for the repair of severely damaged concrete columns after seismic regions. This paper concerns associations between precast columns to footings, and precast columns to pier caps.

The use of high-performance materials, including headed reinforcing bar, epoxy, nonshrink or on the other hand far reaching cement, and carbon fiber sheets to fix harmed columns developed by Accelerated bridge construction (ABC) methods. In fact that was required for precast concrete components associated with grouted join sleeves, it could be reached out to seismically retrofit and fix existing sections too. It can be potential to use in the retrofitting of column connections before an earthquake as well as in rapid repair of column connections after an earthquake. Therefore it is rapid mode of repair technique for damaged column and extensive concrete spalling at high sesmic region.

In-Yeong Koo et.al (2016):- A trending material recently used in retrofitting is ultra-high performance fiber reinforced concrete (UHPFRC) jacketing is observed in column strengthening. Ultra-High Performance Concrete (UHPC) is most common binding material and having high compressive strength. The laboratory test is conducted to study the effect of material property in structural elements like beams, slabs and columns. The dimensions of specimens are 500×500x1260mm is reinforced with 8 bars of 22mm ϕ and 10mm ϕ stirrups at 150mm c/c. Finally this research concludes that, 50mm thick jacketing will increase the load carrying capacity up to 125% and 30mm thick jacketing is increase the load carrying capacity up to 70%. In UHPFRC major role is to improve high flexural strength, shear strength and also deformation capacity of the building.

Mohannad H. Al-Sherrawi et.al (2017):-This paper describes the analytical model to construct the N-M interaction diagram for reinforced concrete columns strengthened with steel jackets by using the plastic stress distribution method after assuming the behavior of strengthened column to be like composite column and including the effects of confinement on concrete strength. By the results obtained for the proposed analytical model showed the best with the experimental results. This showed that the investigation is conservative and it reveals the ultimate strength of the RC column strengthened by the steel jacket with increase the dimensions of steel angles, yield stress of the steel angles, compressive strength of concrete and the size of the reinforcement bars.

Tabish Rasool Sheikh et.al (2017):- In this study laboratory test is conducted for Reinforced concrete (RC) short square columns with ferrocement jacketing. The dimension of specimens is 120mm (L) x 120mm (B) x 720mm (D) are jacketed with GI steel wire mesh of 1.16 mm diameter and 15 mm spacing in both the direction. Test were conducted after 28 days curing, summary of the test is ultimate load carrying capacity of specimen is 1.62 times greater strength than the unjacketed specimen. Use of polypropylene fibre in ferrocement jacketing is more effective in improving the axial load carrying capacity of RC column.

Alfiya Latheef et.al (2017):- This paper is primarily intends to review the Steel angles and strips jacketing method is very common in structures for strengthening technique for existing RC columns. The tests were conducted to numerical analysis on nine RC columns by ANSIS. Minimize the deformation and stress in RC column. The different size,thichness and number of angles are combined with number of battens at different level were used in the experiment. As per this Journal the optimizing the different methods combination of seven battens with 5 mm depth and angle with size 35 × 35 × 5 mm will give best result for life and damages. Finally it is less expensive and most available technique increases the axial load capacity and available ductility of RC columns.

Pavlo Krainskyi et.al (2018):- This paper is studied on experimental test on effect of reinforced concrete columns jacketed under service load. Need of structural retrofitting and strengthening of different structures are material deterioration, improper maintenance and reconstruction or modification of the building, etc.

Laboratory test result for 6 specimens before jacketing the cross sectional dimension are 2.2, 0.14 and 0.18m (L-B-D),after jacketing the cross sectional dimension are 2.2, 0.2 and 0.26m.casted with same material and cured for 28 days.C-1 and C-2 are tested without strengthening to determine the bearing capacity of the specimen, C-3 and C-4 are tested after strengthening but without any initial load and C-5 and C-6 were initially loaded to a service load which was adopted as 65-70% of C-1 and C-2 reference columns bearing capacity. Finally strength effect of specimens C-3 and C-4 was 172%, for specimens C-5 and C-6 was 146%. Improving the Bearing capacity was 2.6 times while serviceability capacity.

Riaz Mahmud et.al (2018):- In all published experimental studies the structural capacity enhancement of concrete columns due to reinforced concrete (RC) jacketing was investigated. Many researchers have been developed for Concrete jacketing using fibre-reinforced polymers (FRPs) extensively over the years and higher strength concrete was also used for RC column jacketing. The behavior of cracking is observed in testing are; cracks were seen at the longitudinal section and ultimately propagated to full and partial lengths of the columns and Transverse cracks were observed at a lower point from the top or bottom face connected to the longitudinal crack.

This concludes that RC column jacketing significantly increased the column capacity, and enhancement will depends on the material properties, the jacket thickness and more importantly, the type of interface between the new and old concrete, also it includes failure patterns in experiment that the outer jacket failed earlier than the core, mainly due to an inability to maintain strain compatibility between the proposed and existing concrete jacketing.

Dr. Ragheed Fatehi Makki et.al (2018):- In this study, the failure or cracked column is jacketed to improve the strength and life of the building by Using Steel Angles. The laboratory test was conducted for a square reinforced concrete column of size 120x120x1000mm. There are different cases in this study;

In column corner steel angles with different sizes A1 {1"x1"x1/8"}, A2 {1.25"x1.25"x3/16"} and A3 {1.5"x1.5"x3/16"} are connected to 1" width and 3mm thickness plate. Final results were (83.1%) for B1, (113.3%) for (B2) and (121.7%) for (B3) was increased the ultimate load carrying capacity compare to unstrengthened RC column. Another case column corner steel angles with common size {1"x1"x1/8"} are connected with different plate size {100, 200, 300} mm with thickness of 3mm. Then the final results were (42.2%) for B1, (53.1%) for B2 and (78.3%) for B3 was increased the ultimate load carrying capacity compare to unstrengthened RC column.

It concludes that improving the strength by the means of rehabilitation technique; such that the use of external steel jacket comprising of steel angles and steel plates can improve the ultimate load carrying capacity for all cases of strengthening from 42.2 to 121.7%.

Jose C. Alvarez et.al (2018):- This research paper presents a idea that can be implemented practically to construct the nonlinear backbone force-deformation of FRP- or steel-jacketed columns.

Based on the Section (fiber) models can be utilized to determine the lateral load at yield (Vy) and peak (Vpeak) of jacketed member, as long as the column shear strength exceeds the force required to reach the nominal flexural strength of the section. In FRP jacketing orientation in transverse direction steel jacketing contributes flexural strength, also it can be omitted due to capacity of slipping between jacket and column cross section. Jackets that stretch out all through the plastic hinge region of columns can get good concrete confinement and clamping of short lap splices within the area. The compression strength can be determined using models for confined concrete found in both FRP and steel-confined concrete. It can be concluded that highest number of FRP-jacketed columns with rectangular cross sections and the few number of specimens obtained correspond to steel-jacketed circular columns.

Pavlo Krainskyi et.al (2018):- The main aim of this research is to determine the strengthening of reinforced concrete jacketing applied to columns under service load. Commonly high-strength concrete is preferred for strengthening but in this study the special mineral additives like zeolite is used. It improves the durability and corrosion resistance of concrete.

The cross section dimensions of the testing specimen before jacketing was 2.20x0.14x0.18 m, after RC column jacketing increase in cross- section dimensions was 2.20x0.20x0.26 m for six RC column specimen. From the practical result the strengthening effect by load bearing capacity of specimens C-3 and C-4 was 172%, for specimens C-5and C-6 was 146%, the strengthening effect by loading of maximum allowable deflection for specimens C-3 and C-4 was 218%, for specimens C-5 and C-6 was 55%. The effect of strengthening has been decreased from 172% to 146% by load bearing capacity and from 218% to 55% by loading of maximum allowed deflection when existing loading was 65-70% from load bearing capacity.

Bassam A. Tayeh et.al (2019):- This study is based on the experimental investigate of bonding among the column cores and their jacketing.

Two coated jacketing thicknesses of 25 and 35 mm applied to the column cores (A-B and X-Y) jacketing types extensively improves ultimate load-carrying capacity in jacketing area. Retrofitting using Ultrahigh-Performance Fiber-Reinforced Self compacting Concrete (UHPFRSCC) and Normal Strength Concrete (NSC) jackets significantly increases the ultimate load-carrying capacities and axial displacements of the specimens with respect to the unjacketed column (UC) and monolithic column (MC).

Repairing and strengthening RC columns using UHPFRSCC is more effective due to the implementing the steel fibers in concrete. It also reduces the total strengthened column sections and without segregation or honeycombing problems. By the experiment results the slopes of the initial parts of the plotted load displacement curves of the UC and MC reference columns are nearly the equivalent, ultimately becoming steep during repairing and strengthening. Steep slopes imply that the modulus of elasticity of strengthened columns increases. Lastly applying the three methods of surface roughening, i.e., surface roughening by mechanical wire brushing, mechanical scarification, and using shear studs, compare to these three methods using shear studs is the best.

Pavlo Krainskyi et.al (2019):- This describes the theoretical calculation method for crack resistance of jacketed RC columns. The parameter in this experiment is initial load is applied to the column before strengthening with the RC jacketing.

It concludes that investigation of the crack resistance parameters for RC columns, strengthened by RC jacketing under the influence of various initial loads the crack width for specimen was 0.3 mm. Experimental result values are higher than theoretical result and Final results of theoretical calculation are varying from test results by 13.6 to 27.9%.

Ahmed Shaban Abdel-Hay et.al (2019):- In this research paper we study about two types of parameters on R.C columns, the first is decreasing the characteristic compressive strength of the part of R.C column and the second is bad stirrup arrangements.

It was seen that Strengthening technique for Increasing in the thickness plates of Column (C1,C2), Increasing the number of external ties or decreasing the spacing (C3,C4) and Increasing the length of external angles (C5,C6) will improve the overall behavior and ductility. The laboratory test results of different specimens criteria are Ultimate loads of specimen C4 has an load equal to 131% and specimen C6 has an ultimate load equal to 121% that of C1. Likewise also for other specimens, this ratio was 95%, 97%, 91% and 83%, for specimens C1, C2, C3 and C5 respectively. Lastly achiving the strength of column by increasing the thickness of external plate, the number of external ties, and the length of steel angles improves the overall strength and behavior of columns.

Mahmoud F. Belal et.al (2019):- Reinforced concrete columns are the main components in the structure often it needs cover the surface area of existing concrete by steel jacketing to increase the effect of confinement and strength. For that study of behavior of RC columns in the shape factor strengthening system using C-sections and plates, size and number of batten plates. Experimentally investigated on specimens divided into two they are un-strengthened specimen and strengthened specimen. The main batten plate's effects on the failure load for specimen strengthened with angles where as C-channels are more effective for the RC column jacketing. Thus it increase the size of batten plates, the column capacity, due to the improvement in confining stress and to be effective since it increases the column capacity to a minimum of 20%. The failure mode of RC column was brittle while improving the strength with steel jacketing changes failure mode to be more ductile.

K. P. Billimoria et.al (2019):- The retrofit is intended to mitigate the effect of modification and improvement of their performance during their service life. The experimental study for different grades of concrete specimens of (M20, M25, M30) were designed and casted as per IS: 456-2000 and were tested for compressive strength under Compressive testing machine (CTM). Then column specimens were retrofitted using concrete jacketing method according to IS: 15988-2013 and were tested for Compressive strength under (CTM).

One of the best method of retrofitting in RC column is concrete jacketing, it proves that easy and successful technique among other retrofitting methods without damaging the building. The test result shows that increment in strength by 4 to 6 % once after failure of the actual specimen under CTM machine and Exhibit that jacketing method used in the investigation study increases the load carrying capacity of the columns.

Ehsan Noroozieh et.al (2019):- In this study Fiber-reinforced polymer (FRP) is used to improve the shear capacity, ductility and prevent buckling in the longitudinal reinforcements of the Reinforced Concrete (RC) columns. Other type of jacketing is near surface mounted (NSM) reinforcement has been proven effective in improving the flexural strength of RC columns. This paper includes making a series of grooves in the concrete cover and inserting steel bars or strips inside so it will improve the flexural strength of the column. Surface preparation is not required in this method so work is easy and can be fasten the installation compare to other method.

It concludes that Increase in proportion of NSM reinforcement from 0.16% of the total cross-sectional area to 1% led to approximately 28% increase in the lateral strength and 50% decrease in the ductility of column. Use of both the methods together led to increase 67% in the load bearing capacity of non-damaged columns and increases 46% in the load bearing capacity of damaged columns. The use of NSM rebars alone is not a good strengthening approach, particularly under high axial loads, and it is also prescribed to apply an FRP jacket to improve the ductility of the column.

Praveen Anand et.al (2020):- The study of strengthening the column was an important role to increase the load carrying capacity of the existing building that needs to be improved desired purpose. The strength of the column member subjected to concentrically axial compressive load increases significantly after jacketing. According to results increase in the load carrying capacity of the RC column jacketing as per design is 156.46% while it is 140% as per simulation done in ABAQUS. From this study, by increase in load carrying capacity was observed to be around 110% under uniaxial load for 50 mm thick jacketing. The use of thick jackets around the four sides which is 100mm as well as the TIE constrained used in the modelling which impacts perfect surface to surface bond between the existing concrete surface and jacketing. Binding between the existing and new concrete surface is assumed to be perfect bonding. The difference among these new design and values obtained after experiment will vary between 16.60 to 24.60%. The results of this study will be helpful in comparing the overall efficiency of this technique with that of the other jacketing techniques that are available. Further, suitable approach can be adopted depending upon Carpet area available, Cost analysis also needs to be done prior to choosing any of the Retrofitting methods.

S. Boukais et.al (2020):- Numerical analysis of Reinforced Concrete (RC) Column jacketing is studied before the strengthening to predict correct behavior of the RC column. Earthquake resistance standards are considered while designing. 6 No's of 10 mm diameter for longitudinal bars, 6 mm diameter stirrups at 150mm C/C and to avoid shear force at the top spacing is reduced to 75mm C/C. It concludes that ultimate load is around 57 kN in experimental test and in finite element model is 54.33 kN. Finally the difference in finite element model and experiment results was 4.1%. The finite element analysis was carried out by using Abaqus software is verified in this study.

III. CONCLUSION

R.C.C. Jacketing is the most important for strengthening the existing building columns. The thickness and type of jacketing is very important in all the cases. It increases the member stiffness and is useful where deformation is to be controlled. If columns in the building are found to be slender, RC jacketing provides a better solution for avoiding buckling problems. Design for the strengthening repair work is based on the composite action of the old and new work. Ultimately it will be economical for Rehabilitation of Structural Columns will be uniformly distribute the load and increase in strength of RC columns without damaging the existing column. Thus durability of the existing column and the structure will be increased economically. It is recommended to use FRP in the concrete for best results.

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