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A Literature Review on Various Types of Materials used for Full/U-Shaped Beam Jacketing Subjected to Pure Torsion

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Abstract: ***When an eccentric load/force is acted on a structural member other than bending plane which creates rotational moment in the body known as torsion. Concrete is most used worldwide material in construction industry and having weak in tensile strength. So it gets cracked when external load/force crosses equilibrium/compatibility conditions of the concrete body. Improvement in ductility effect, durability and strength etc. of existing structure or earth quake affected structures the most preferably repairing work can be done by using retrofitting method. Since from last three decades the retrofitting of required structures are done by using polymer fiber materials. The polymer fiber jacket are having types like FRP,GFRP,CFRP and aramid etc. Recently remarkable researches has been seen on utilization of ferrocement full, U-shaped jacketing with continue wrapping sheets or in strips. All above said jacketing can be apply in execution work with respect availability, suitability, amount of need and costing etc.***

Keywords: Quassi brittle material, Polymer fiber jacket, ferrocement jacket.

I. INTRODUCTION

It is well known that there are four actions like axial, shear, bending and torsion are developed with respect to their nature of loading on the structure. Torsion is always considered as a secondary effect up to 1960's. After that we moved from working stress to limit state and shall go to ultimate one to reduce the factor of safety. Concrete is quassi brittle material weak in tensile strength it gets fractured even introduction of reinforcement in the body of the concrete. Polymer fiber is a composite material used for strengthening purpose of existing structural member to predominant torsion effect. The fibers are generally plastic fiber, glass fiber, carbon fiber, aramid etc. Also other fibers such as paper, wood or asbestos sheet have been used. However all above fiber sheets required a well adhesive like epoxy, vinylester etc. to achieve proper surface bonding. Although polymer fiber has near about more than one century history since from 1905 but such material is utilized for concrete as a mainstream technology effectively since from last three decades. Polymer fiber have very high tensile resistance property but relatively less young's modulus than concrete and poor stability in compression so it is utilized as a composite material with concrete. Such material are named as a FRP,GFRP,CFRP,aramid etc. with respect the material used for application. Recently there is also utilization of Ferrocement all sides, U-shaped jacketing with continued wrapping sheets or in strips. All above said polymer fibers can be used in our engineering application with respect to availability, requirement, costing, suitability etc.

II. LITERATURE REVIEW

A. Polymer fiber jacketing like FRP, CFRP, GFRP, ARAMID fiber etc.

Constantin E.Chalioris [1] (2007) has predicted an analytical approach to observe the torsional response of reinforced concrete beams strengthened with fiber reinforced polymer material. To form the theoretical equations he casted twelve tests specimen and took additional database of experimental information for twenty four specimens compiled from other researchers. He introduced that the analysis method employs the combination of two different theoretical models i.e a smeared crack model up to pre cracking stage and soften truss model for post cracking response. Such proposed methodology is achieved through extensive comparisons between analytically predicted behaviour curves and experimentally obtained results. This study allows the realistic modeling of the elastic and the post cracking response of FRP strengthened RC beams under torsion.

Constantin E.Chalioris[2] (2008) investigated the full torsional behavior of RC beams strengthened with FRP materials and made theoretical analysis of that. The present experimentation deals with the observation of the torsional strengthening of concrete beams without stirrups using epoxy-bonded carbon fibre-reinforced-polymer (FRP) sheets and strips as external transverse reinforcement.

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In experimental program there are 14 rectangular and T-shaped beams tested under pure torsion. In this paper the useful concluding remarks are indicated based the torsional moment at cracking and at ultimate and concerns twists, precracking and post cracking regions in the curves and the failure modes of the beams,. The strengthened rectangular beams using full wrapping with continuous FRP sheets performed well which increases torsional behaviour and higher capacity than the strengthened beams with FRP strips. Also in T-shaped beams there is an occurrence premature debonding failure of U-jackets and substantial reductions of the potential torsional capabilities are reported. At last he reported that FRP fabrics could effectively be used as external torsional reinforcement in under-reinforced concrete elements without steel transverse reinforcement.

A.R. Zojaji, M.Z. Kabir[3] (2012) has produced a new computational Softened Membrane Model for Torsion (SMMT) to predict the full torsional response of reinforced concrete beams strengthened with Fiber Reinforced Plastics (FRPs).For validating the proposed analytical model, torque-twist curves obtained from current theoretical approaches are compared with experimental ones for both solid and hollow rectangular sections. The good agreement results of this comparison showed that the proposed analytical model is reliable for predicting the torsional behavior of FRP-strengthened reinforced concrete beams before and after cracking. By means of the developed approach, the power of the SMMT method, in extending to FRP-strengthened reinforced concrete beams, is demonstrated in this paper. Moreover, the contribution of FRP fabrics to the torsional response, as an external bonded reinforcement, is studied in various practical strengthening configurations. Therefore, the efficiency of each configuration is illustrated as well.

Shraddha B. Tibhe , Vijaykumar R. Rathi[4] (2015) studied the fiber reinforced polymer (FRP) as an external reinforcement is used to enhance the torsional strength of members . In present experimental study total Thirty nine rectangular beams of size 150mm × 300 mm and 1200 in length are casted. In that three beams are control beam and remaining thirty six beams are classified into two groups. One with CFRP fabric wrapping and another with GFRP fabric wrapping. With various wrapping patterns. The wrapping patterns include U-jacketed, vertical strips with spacing, and edge strips along with vertical strips along its entire length by using CFRP and GFRP configurations. Torsional capacity of beams of two groups is compared with control specimen with respect to torsional moment, angle of twist and ductility factor and it was observed that CFRP fabric bonded beams show more torsional strength than the GFRP bonded beams.

Rafid Saeed Atea[5] (2017) casted and tested twelve numbers of T- shaped reinforced beams without and with having strengthen in the form of carbon fiber reinforced polymer (CFRP). Such FRP is used for strengthening of beam specimens with stepped U wrap (three sides) in the web and flange. This work aims at studying the strengthening of T beams in torsion by using carbon fiber reinforced polymer (CFRP). Out of twelve numbers beams first two numbers beams are control specimens contains only reinforced concrete. The remaining ten beams variables considered in the test program include; effect of flange strengthening, effect of fiber orientation (90° or 45° CFRP strips with respect to the longitudinal axis), effect of using additional longitudinal CFRP strips with transverse CFRP strips, effect of bolt anchoring CFRP strips in the web and flange and effect of continuous CFRP strips between web and flange (isolated T section). Test results were discussed based on torque – twist behavior, beam elongations, CFRP strain, concrete strain and influence of CFRP on cracking torque, ultimate torque and failure modes.

Sachin B. Kandekar , Rajshekhar S.Talikoti[6] (2018) presented the study on the torsional behaviour of reinforced concrete (RC) beam having M30 grade of concrete strengthened with aramid fiber. They considered that as torsional failure mostly occurs in seismic affected areas subjected to sudden failure viz. brittle type failure occurs due to undesirable loading. So introduction of ductility at post cracking stage of reinforced concrete beam can offered by using aramid fiber as a composite material applied on surface of beam having U-shaped rather than all sides. The authors casted twelve numbers of beams having the cross section of 150 mm x 300 mm and of 1 m in length. In that three beams were designed for torsional reinforcement and nine as conventional beams. Beam is designed for torsion as per IS456-2000. The aim of study is to observe torsional response of strengthened beams by aramid fiber fully wrapped and wrapped in strips at width 100 mm of U shape on three faces of beam by using epoxy resin. They also observed ultimate loads & first cracking loads, angle of twist and twisted shape of the beam. Results show that fully wrapped RC beams give more torsional strength as compared to controlled beams and there are significant improvement in torsional strength of beams wrapped in strips. After first crack, beams show tendency to carry load with increase in angle of twist. Thus it is easy method for strengthening of RC beams.

B. Ferro-Cement Jacketing

Dr. Gopal Charan Behera[7](2016) investigated the an attempt of research which made to quantify the improvement in the behaviour of “U” wrapped rectangular concrete members subjected to torsional loads “U” wraps. They proved that ferrocement wrapping technology is one of the effective ways of strengthening concrete elements and can be an alternative of Glass fiber reinforced polymers and carbon fiber reinforced polymers to overcome their drawbacks. In this investigation Beams were casted with different

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number of mesh layers with different reinforcement viz. only longitudinal, only transverse, fully under, partial and over reinforced one. Analytical model is developed using softened truss model of Hsu with modification on material properties. The beams were also analyzed by soft computing method using MARS. They observed that the predictions were in good agreement with experimental test results.

G.C. Behera, M.R.Dhal[8] (2016) has utilized the wrapping technology with U-shaped ferrocement jacketing for strengthening concrete elements and they checked the ductility of beam specimen viz. the twist at ultimate torque. In this investigation the author has casted the beams with normal and high strength mortar and concrete with an attempt is made to quantify the improvement in twist of "U" wrapped rectangular concrete members subjected to torsional loads. Ferrocement is taken here as a wrapping material. Thirty beams were casted with different number of mesh layers with different torsional reinforcement and tested under pure torsion. The variation in longitudinal and transverse reinforcement with and without ferrocement jacketing has been done. The beams were analyzed with MARS. The predictions for twist at ultimate torque are in good agreement with experimental test results.

Gopal Charan Behera* et .al.[9] (2013) concentrated study on ferrocement jacketing to structural repair and rehabilitation of concrete beams to restore and enhance the load bearing capacity which increase the life span of the structure. In the recent past decades of construction technology (retrofitting, repair and rehabilitation) became popular and use of FRPs have been gaining world wide acceptance as retrofitting material for their high strength, light weight and good fatigue life but have a high cost . So the author tried to replaced the FRP by ferrocement technique which also has better crack arresting capacity, higher tensile strength to weight ratio, ductility and impact resistance. Torsion forms due an eccentric load acted on other than bending plane with induces shear stresses on all four side faces and shall be well resist by closed form reinforcement. But due to continuity in beam and slabs, U wrap retrofitting is the most practical solution. The author has conducted the experimental investigation to observe the torsional capacity and angle of twist of reinforced concrete beams with U-shaped retrofit jacket. They casted total six numbers of beams specimens with variation number of layers of wire mesh with and without only shear reinforcement. The results showed that the torque twist response of beams with ferrocement U-jacketing is seems like reinforced concrete beams and single type of reinforcement (only on transverse direction) is not an effective way of increasing the torsional strength but only increase in toughness is found to be marginal.

Gopal Charan Behera* et .al.[10] (2016) has done an attempt to observed the torsional behavior of reinforced concrete with ferrocement U-jacketing. They were casted 12 numbers of rectangular beams with variation of longitudinally, transversely and fully reinforcement with ferrocement U-jacketing. The "U" wrap jacketing are found to contribute better torque carrying capacity under all states of torsion while under reinforced members provide better toughness over other states of torsion. Similarly completely over reinforced beams provide more torque resisting capacity than the others. Increase of torsional capacity is more prominent in states of torsion while improvement in torsional strength with number of mesh layers in ferrocement "U" wrap is minimal.

III.CONCLUSION

On the basis of literature view there may classify two types of jacketing 1) Polymer fiber jacketing 2) Ferrocement jacketing. Polymer fiber jacketing are categorized in fiber reinforced plastics/polymer, carbon fiber reinforced polymer, glass fiber reinforced polymer and aramid fibers etc and in ferrocement jacketing steel wire meshes having various sizes are used.

Authors from both classifications has studied well and also made theoretical analysis in the form of FEM model, softened truss model of Hsu with modification on material properties some of them developed equilibrium and compatibility equations by using elastic theory. Materials for fiber polymer jacketing are most efficient which give proper bonding with concrete, good in crack arresting capacity, high tensile strength to weight ratio, ductility and impact resistance. But having higher cost, required special adhesive materials and manpower, prone to fire attack etc. Also in any type of deficiency there are chances of premature debonding failure so substantial reduction in torque carrying capacity etc. In case of ferrocement jacketing it is observed that application of ferrocement can be applied to replacement of fiber polymer jacketing to avoiding demerits created due to these materials. However ferrocement jacketing requires number of wire mesh layers more than single one to achieving considerable increase in torque carrying capacity of beam specimen. Also it is not defined that the ratio of percentage increase in torque carrying capacity with increase in number of wire mesh layers. Also one of author has mentioned that improvement in torsional strength with number of mesh layers in ferrocement U-shaped jacketing is negligible.

However authors having both categorizations are given considerable theoretical validation but still there is need to give thorough theoretical equations in each material jacketing categories.

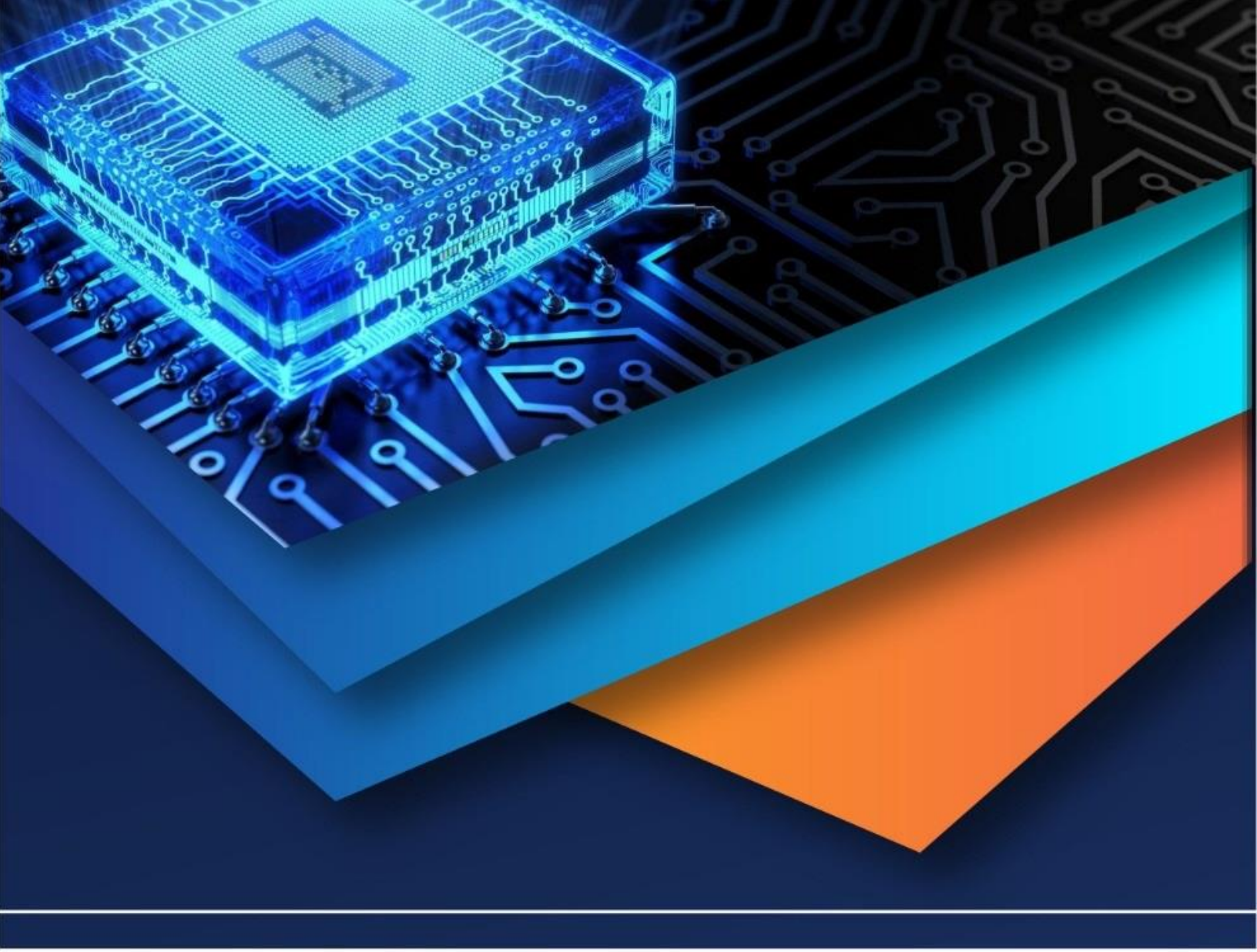
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