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A REVIEW ON STRENGTHENING OF RC CYLINDER ELEMENTS USING BASALT FIBER REINFORCED POLYMER COMPOSITES

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Abstract

Strengthening of RC structures is to upgrade the resistance of the structure to withstand underestimated loads and increase the load carrying capacity for loads such as seismic loads. The maintenance and rehabilitation of structural members, is perhaps one of the most crucial problems in civil engineering applications. The use of externally bonded Fiber Reinforced Polymer (FRP) systems has been proven to be an effective technique to rehabilitate and strengthen deficient and deteriorated structural members. The FRP materials are known to have high stiffness, high strength to weight ratio, resistance to corrosion and ease of installation. In this external strengthening technique, the FRP materials are attached to the tension side of RC beams or girders to carry the tensile stresses by means of the epoxy adhesive. In general, the FRP plates are bonded to the soffit of the beams and the sheets are attached at anchorage zones to provide a locking mechanism that would increase the load carrying capacity of the structural member. However, the introduction of FRP materials showed better performance than the conventional methods due to the several mechanical advantages of the FRP materialsThis increases the beam strength and its stiffness (load required to cause unit deflection), however decreases the deflection capacity and ductility, curing period. In recent years, retrofitting by bonding of fiber reinforced polymer Basalt fiber-reinforced polymer (BFRP) bars are the newest type of FRP reinforcement used in civil engineering. Nevertheless, BFRP reinforcement is a relatively new material, so behavior of BFRP RC elements should still be thoroughly examined. This paper presents a review summary of detailed literature survey conducted on BFRP composites. This paper briefly review the bond-slip characteristics, retrofitting, and fire, shear strengthening, flexural behaviour, reinforcement ratio of different FRP composites.

Introduction:-

Structural strengthening, describes the process of upgrading the structural system of an existing building to improve performance under existing loads or to increase the strength of structural components to carry additional loads. Strengthening of real-life structures in the field is much more challenging than the strengthening of components or sub-assemblies in the laboratory. The shear size of the structure, limited access to the critical areas, interference due to the internal reinforcement etc. are some of the problems that may not allow an optimum

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application of strengthening. Therefore, a particular strengthening method can be best proven through full-scale structural level tests. This was one such rare opportunity where a full-scale structure previously tested under pushover loads was repaired and strengthened using fiber reinforced polymers (FRP) and re-tested under pushover loads until failure. The strengthening involved repair and restoring of the damaged section, flexural strengthening with FRP laminates anchored in the slots and confinement by FRP wrapping. The strengthening method was motivated by the previously performed research on the strengthening of beam-column joint sub-assemblies. The strengthening was performed for the beams, columns and beam-column joints of the structure. With an economic design of the strengthening, the retrofitted structure could resist 90% of its ultimate load-carrying capacity under as-built condition. However, due to the heavy damage due to previous testing, the stiffness of the structure could not be recovered.

Fiber reinforced polymer (FRP) systems are high-strength, lightweight reinforcement in the form of paper thin fabric sheets, thin laminates, or bars that are bonded to concrete members with epoxy adhesive to increase their load carrying capacity. These systems have been used extensively in the aerospace, automotive, and sport-equipment industries, and now are becoming a mainstream technology for the structural upgrade of concrete structures. Important characteristics of FRPs for structural repair and strengthening applications include their non-corrosive properties, speed and ease of installation, lower cost, and aesthetic appeal.

As with any other externally bonded system, the bond between the FRP system and the existing concrete is critical, and surface preparation is very important. Typically, installation is achieved by applying an epoxy adhesive to the prepared surface, installing the FRP reinforcement into the epoxy and, when required, applying a second layer of the epoxy adhesive. After curing, the FRP composite will add capacity to the element because it has a tensile strength up to 10 times that of steel.In general, the FRP plates are bonded to the soffit of the beams and the sheets are attached at anchorage zones to provide a locking mechanism that would increase the load carrying capacity of the structural member. It should be noted that the externally bonded systems were produced in the early in which steel plates were bonded to bridge girders to carry extra tensile forces introduced by the increasing number of users and vehicles. However, the introduction of FRP materials showed better performance than the conventional methods due to the several mechanical advantages of the FRP materials.To study mechanical, thermal and fire resistance properties of diffferent FRP composites.

Literature Reviews

Reviews on Investigation of Bond-Slip Characteristics

Jiang-Lin Li et al. (2019) investigated the bond-slip behaviors of BFRP-to-concrete interfaces exposed to wet/dry cycles in chloride environment subjected to four-point bending beam specimens were adopted to evaluate the durability of BFRP-concrete interfaces.The aging condition imposed on the BFRP beams was wet/dry cycles in salt water with 3.5% sodium chloride 0-day, 180-day, 270-day, and 360-day, respectively.After exposure,the tests were carried out to investigate the bonding behaviors of BFRP-concrete interfaces.

From the results BFRP composites may become weaker and more brittle after exposure there is a decrease in ultimate tensile strength, shear resistance,ductility and fracture energy after a 180-day with increasing dry/wet cycles,the failure mode may change from the cohesive fracture of concrete to the combined failure of BFRP fracture and adhesive debonding.Based on the experimental results, an empirical constitutive law can be proposed to predict the bond-slip behavior of the interface [1].

Roberto Capozucca (2013) determined the analysis of bond-slip effects in rc beams strengthened with NSM CFRP rods.This paper investigates the experimental bond-slip effects of circular and rectangular carbon-FRP (CFRP) rods inserted in grooves in rc elements through experimental pull-out and bending tests, and using theoretical models. Five rc beams were built.Three of the ones strengthened using NSM CFRP rods were subjected to bending until failure. The experimental results showed changes in the response of beams such as stiffness in the elastic phase,

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reduction of ultimate capacity and ductility due to bond-slip effects. On the other hand, strain measurements on CFRP rods recorded by pull-out tests theoretically valid the linear elastic analysis capable of defining the behavior of CFRP rods before loss of bond.

From result the Strengthening of RC beams using NSM CFRP circular and rectangular rods is a valid technique which increases the capacity of steel reinforced beams.Bernoulli's hypothesis of section planarity is not justified experimentally until ultimate load and structural design developed on the basis of this usual common hypothesis may overestimate the strength of sections.The experimental results confirm the non-planarity of section and the loss of capacity of strengthened beams due to CFRP rod which is influenced by cracking of tensile concrete and intervals of cracks [2].

Reviews on Retrofitting of BFRP and CFRP

Abbas Jamani et al.(2018) conducted experimental investigation on flexural behaviour of corroded rc beam retrofitted with basalt fiber sheet.It deals with the behaviour of beams having corroded reinforcements of varying levels of corrosion such as 5%, 10% and 15% mass loss in reinforcements and the effect of Basalt fiber sheet wrapping on its flexural behaviour. Total of 78 beam specimens will be casted which will consist of 6 control specimen. The control specimen will be of non-corroded reinforcements in group of 3 each for concrete grade of M-20 and M-25. 36 beams will be casted with M-20 grade of concrete. From 39 beam group of 3 beam for 5%, 10% and 15% corrosion reinforcement and its wrapping by 4 different techniques forsame grade will be casted. Similar 39 beams for M25 grades will be casted.

The results indicate that as the corrosion rate increases, the ultimate stress and yield stress of Re-bar were found to decreases significantly. Cracking load carrying capacity and ultimate load carrying capacity of beam specimen reduced with increases of corrosion rate of reinforcement as compared to normal specimen, flexural load carrying capacity also increases with the help of external wrapping of basalt fiber on beam [3].

Shinu Shajee et al.(2018) investigated the flexural behaviour of rcc beams retrofitted with BFRP wraps subjected to two point loading and to rehabilitate the structurally deficient beam and to make it serviceable in flexure. Experiment consists of six RCC beams. Of the six beams two beams were control beams. Remaining four beams were preloaded to 70% of the ultimate load of the control beam. The beams were then retrofitted by wrapping BFRP on the tension zone and flexural zone. Load–deflection behavior, energy absorption, failure modes and crack propagation patterns are studied extensively.Experimental results are validated with ANSYS software.

The test result shown that the stiffness of the retrofitted beams considerably increased in the initial stage and further increases in later stages of loading.The load carrying capacity of the retrofitted beams is increased with flexural zone wrapping showed a percentage increase of 14.94% and that with tension zone wrapping is 50.56%. There was an increase of 14.3% for flexural zone wrapped beams and 57.14% for tension zone wrapped beams in first crack load.Energy absorption of flexure zone wrapped beam was 29.7% and tension zone wrapped beam was 265.15% more than the reference beam.The Experimental results and analytical results show a maximum percentage difference of 9.6 % which is less than permissible hence results are validated. As the number of layers of wrapping increased ultimate load and ultimate deformation increased [4].

Yasmeen Taleb Obaidat (2010) carried out structural retrofitting of reinforced concrete beams using carbon fiber reinforced polymer.The objectives of this study were to investigate the behaviour of retrofitted beams experimentally, develop a finite element model describing the beams, verifying the finite element model against the experimental results and finally investigating the influence of different parameters on the behaviour of the retrofitted beams which were loaded in four-point bending.The ABAQUS program was used to develop finite element models for simulation of the behaviour of beams.

The results indicated that an increase in CFRP stiffness always gives an increase in beam stiffness. Different failure modes will occur depending on the values of CFRP stiffness and width ratio. High stiffness and low width ratio will result in debonding failure before steel yielding due to stress concentration at the plate end. This failure occurs at a small load value and should always be avoided. For some width ratios there is an increase in maximum load and for others there is a decrease. For medium stiffness and medium to high width ratio, debonding failure will occur after steel yielding. Debonding may initiate at the plate end or at a flexural crack and will in some case include concrete splitting.Maximum load ratio increases with increasing CFRP stiffness until a certain value of the stiffness, thereafter the maximum load ratio decreases with increasing CFRP stiffness.Another reason is that a high width ratio will lead to that a larger part of the axial load is carried by the CFRP, which means that steel yielding will occur at a higher external load. The best maximum load ratio obtained in this study was 1.78, and it was reached for a CFRP stiffness of 2Ko and a width ratio of 1 [5].

Reviews on Effect of Fire Conditions

Thiago B. Carlos et al.(2018) conducted an experimental analysis on flexural behaviour of RC beams strengthened with CFRP laminates and under fire conditions. Carbon fibre reinforced polymer (CFRP) laminates have been used on strengthening reinforced concrete, steel and timber members due to their excellent flexural performance, lightness, ease of application and corrosion resistance. However, in a fire, other detrimental factors may arise due to the high thermal exposure. This paper presents the results of an experimental investigation on the flexural behaviour of reinforced concrete (RC) beams strengthened with CFRP laminates in fire conditions. The main objective was to assess the behaviour in fire of the strengthening system on the beams thermally insulated with different fire protection systems. Fire resistance tests on beams protected with sprayed vermiculite-perlite (VP), expanded clay aggregates (EC) or ordinary Portland cement (OP) based mortars, were carried out. The tests carried out under the present research were innovative because unlike the ones conducted by other authors the beam in testing and its supports were completely inside the furnace. Furthermore, the testing beam supported a concrete slab that tried to simulate its interaction with the surrounding building structure. The results showed above all that the beams with passive fire protection materials provided integrity of their resistance for long periods of fire exposure, especially the ones protected with VP mortar.

Fire resistance tests on specimens confirmed the vulnerability of the CFRP-strengthening systems when directly exposed to fire. This could be observed by the sudden failure of the strengthening system immediately after the collapse of the fire protection system.The CFRP-strengthening system failed at temperatures above Tg of the adhesive. The bond between the CFRP and the concrete is severely affected for this temperature conditions (ranging from 85 to 110 ºC), losing its bond strength.The use of passive fire protection delayed the increase of temperature in the CFRPconcrete interface confirming its importance in the increasing of the fire resistance of the beams. It was possible to observe for all fire protection systems that the thicker insulations were more effective in the thermal response of the specimens, maintaining the effectiveness of the CFRP-strengthening system for a longer period of fire exposure. As a result, the mechanical resistance of the strengthening system and the assembly had their capacity extended. The VP mortar was significantly more effective than the EC and OP mortars in the fire protection of the CFRP-strengthening system, preserving their integrity for longer periods of time. For the same thickness of fire protection material, the beam VP-50 (50 mm thick) presented 120.3 min of fire protection to the strengthening system, while the beams OP-50 and EC-50 (both also with 50 mm thick) presented 51.7 min and 31.2 min, respectively. This represented an increase on fire resistance of CFRP system of 133% and 286% in comparison to the beams OP-50 and EC-50, respectively.The final deformed shape of the specimens after fire test has occurred predominantly at mid-span of the beams due to tensile rupture and excessive elongation of the bottom rebars. These results confirmed a typical behaviour in fire of an axially non-restrained RC 23 beam. These models will be used in a parametric study to elaborate a suitable analytical guidance in the fire design of CFRP-strengthened RC beams subjected to fire. The numerical simulations will enable the development of design methods and possibly best application techniques for these strengthening systems. In addition, this numerical implementation will be important to understand the phenomena observed in the fire tests as well as the difficulties revealed in this experimental study [6].

Review on Effect of Shear Shrengthening

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M.Breveglieri et al.(2015) reviewed that the embedded through-section (ETS) technique is a promising technique for the shear strengthening of existing rc elements by drilling the holes through the beam section, and bars of steel or FRP material are introduced into these holes and bonded to the concrete with adhesive materials. An experimental program was carried out with RC T-cross section beams strengthened in shear using the ETS steel bars and ETS CFRP rods. The research is focused on the evaluation of the ETS efficiency on beams with different percentage of existing internal transverse reinforcement (qsw = 0.0%, qsw = 0.1% and qsw = 0.17%).

They had concluded that the vertical ETS bars provided an increase of load carrying capacity in the interval of 5%–68%. The inclined ETS bars have assured a higher strengthening effectiveness, since an increase of load carrying capacity from 53% to 136% was obtained.By comparing the shear strengthening effectiveness obtained with the ETS technique proposed in the present work and the one assured by using the externally bonded reinforcement (EBR) and the near surface mounted (NSM) techniques it was verified that the former one is more effective.For similar shear strengthening ratio, the CFRP bars provided higher shear strengthening effectiveness than steel bars, due to the larger ultimate force capable to be mobilized in inclined bars. It was also verified that the steel stirrups have exceeded its yield strain, even in the beams with the highest percentage of steel stirrups. In this case the high level of shear strengthening effectiveness obtained in this experimental program, it can be concluded that ETS can assure ductile flexural failure mode in RC beams susceptible to brittle shear rupture. [7].

Reviews on Effect of Sprayed FRP Composites

M.Shahria Alam et al.(2017) reviewed on the application of sprayed-FRP composites for strengthening of concrete and masonry structures in the construction sector,as an external reinforcement is an effective means to obtain a higher level of fiber utilization before premature failure.There are limited researchers have dedicated on the investigation on sprayed-FRP retrofitted masonry and concrete structures. It involves advanced investigation of sprayed-FRP strengthening of RC and masonry structures that are lacking in the design or serious need for repair.

They observed that sprayed-FRP retrofitting method is a promising and cost-effective technique in increasing the strength, stiffness, and energy absorption capacities of the reinforced concrete and masonry structures is a feasible alternative for a repair scheme of concrete and masonry structures.The simplicity of application and fast curing time also enhance its feasibility and effectiveness as retrofitting materials. However, there are no design guidelines or standards available in the literature, and how the sprayed-FRP coating perform under more realistic conditions, such as over-head or perpendicular faces as retrofitting materials [8].

Reviews on Investigation of Externally Strengthened Structures

J.A. Abdalla et al. (2018) conducted test to determine the performance of externally strengthened rc beams with side-bonded CFRP sheets laminates to the beams soffit.Total of nine RC beams have been cast, eight of which were strengthened in flexure with different configurations of bottom-bonded and side-bonded CFRP sheets, and tested under four-point bending till failure and recorded the load-deflection response curves, failure modes, and ductility of the tested specimens and compared.

The experimental results showed that the external side-bonded strengthening technique is slightly less effective in enhancing the flexural properties and increase in the flexural strength of the bottom and side-bonded strengthened RC beam specimens ranged from 62-92% and 39.7-93.4%, respectively there by decrease in ductility reduction at the failure load that ranged from 42.3-62.5% lower than the un-strengthened control beam.If the effective reinforcement ratio increases, the debonding strain decreases leading to CFRP debonding prior to concrete crushing. The increase in CFRP width on the sides has indicated low improvement in strength as well as in ductility.The strength improvement took a logarithmic trend, and the single ply side-bonded specimens have recorded 34% capacity enhancement by doubling the width of the CFRP sheets. For the double-ply side-bonded CFRP specimens, doubling the width of the sheets has led to a strength enhancement of 22% only. The difference between the predicted and experimental results ranged from 2.4% to 6.8%.It is recommended for future studies to examine the effect of different shear span to depth (a/d) ratios on the performance of strengthened RC beams with side-bonded CFRP laminates in terms of strength, ductility, and mode of failure was concluded [9].

Al-Tamimi, A. K. et al.(2014) investigated the behaviour of reinforced concrete beams strengthened with externally bonded hybrid fiber reinforced polymer systems by flexure means of different combinations of externally bonded hybrid Glass and Carbon Fiber Reinforced Polymer (GFRP/CFRP) sheets subjected to four point loading to determine the load-deflection response, strain readings at certain locations and associated failure modes of the tested specimens had been recorded. They concluded that there is increase in the load capacity of the strengthened beams ranged from 30% to 98% of the un-strengthened control RC beam depending on the combination of the Carbon/Glass sheets.The ductility at failure for glass and hybrid sheets is higher than that with a single carbon sheet. Strains in the FRP, around 40% or more of the FRP strength have been utilized. Specifically, 41.18%, 63.08%, and 39.64% of the capacity of the BC, BGC, and BGCG laminates were utilized, respectively.The ACI 440 provisions gave very accurate prediction of the ultimate load capacity for for the hybrid specimens by margins of 13% and 17% for the BGC and BGCG specimens.They concluded that ACI prediction is less accurate for hybrid specimens [10].

Xu Yang et al.(2018) carried out test on flexural strengthening of rc beams externally bonded with CFRP grid-reinforced ECC matrix.A total of 15 RC beams, including three control and twelve strengthened, were prepared and tested and determined the longitudinal reinforcement ratio, the strengthening configurations that consisted of different cementitious matrices (ECC versus epoxy mortar), different installation methods (prefabricated versus cast-in-place), and different stiffness of CFRP grids.

The test results showed that the use of ECC or epoxy mortar alone as the matrix and bonding adhesives of CFRP grids to strengthen RC beams needed the provision of reliable end anchorage to prevent plate end debonding failure. The use of ECC alone could not inhibit the IC debonding completely because the weak link might still exist at the ECC-to-substrate concrete interface. Both the IC debonding and the plate end debonding could be successfully inhibited with no need of additional anchorage countermeasures. The use of the higher stiffness CFRP grid led to more increase in the flexural capacity of the strengthened beam. However, the large strength enhancement may trigger the CDC debonding failure. If such a ratio is controlled below 0.6, the tensile strength of CFRP grid can be fully utilized. In spite of the existence of a certain level of local IC debonding, the flexural capacity of RC beams strengthened with CFRP grid-reinforced cast–in-place epoxy mortar or ECC matrix and epoxy bonded prefabricated CFRP grid-strengthened ECC matrix can be predicted with acceptable accuracy using the sectional analyses presented in the paper. The average predicted values to the experimental ones were 1.05 with the coefficient of variation of 0.04 [11].

Reviews on Effect of Different End Conditions

R.M. Reda et al. (2016) reviewed the flexural behavior of rc beams strengthened by NSM GFRP bars having different end conditions.This is because it increases the bond capacity and makes a protection against external damage. Most of previous related researches stated that the failure of the tested RC strengthened beams with NSM FRP is due to debonding or concrete cover separation. In this research the ends of the NSM glass fiber reinforced polymer (GFRP) bars were bent to delay or prevent NSM FRP debonding and concrete cover separation and thus increasing the load carrying capacity of the strengthened beams. The inclination angles of GFRP bars with bent ends were 90 and 45 degree. Straight GFRP bars with variable lengths were also used for comparison.

The test results demonstrated that the GFRP bars with bent ends prevented the concrete cover separation and increased the load carrying capacity of the strengthened beams. The load carrying capacity of the strengthened beams by straight NSM bars and those having 45o & 90o inclined ends were 177%, 201%, and 185% of that of their control beam, respectively.The strengthened beam by 45 degree inclined anchorage showed superior flexural behavior over strengthened beam without end anchorage or with end anchorage of 90 degree.This effect was more pronounced in the case of strengthened beam with NSM GFRP bars equal to or less than twice the constant moment region length.The load- deflection, load –GFRP strain and moment curvature was observed as good for both analytical and experimental results. [12].

Reviews on Investigation of Flexural Behaviour of Structures

S.J.E. Dias et al. (2018) reviewed the behavior of rc beams flexurally strengthened with NSM CFRP Laminates. Four beams were tested, a reference beam without CFRP, and three beams flexurally strengthened using different percentage of laminates. The experimental results show that NSM CFRP laminates is an effective solution to increase cracking, yielding and maximum loads of beams failing in bending.A numerical strategy was used to evaluate the load-deflection relationship of the tested beams and to highlight the influence of the longitudinal bars percentage, the CFRP percentage and the concrete strength on the NSM flexural strengthening effectiveness of RC beams.

In fact, the adopted CFRP flexural strengthening configuration has provided an increase in terms of maximum load that ranged between 42% and 103% of the maximum load of the reference RC beam. For the range of CFRP percentage values (f) considered in this work. For beams strengthened with one (f = 0.03%), two (f = 0.06%), and three (f = 0.09%) NSM CFRP laminates, the increase in terms of yielding load was, respectively, 10%, 23% and 34% of the yielding load of the reference beam, while in terms of maximum load the increase was, respectively, 42%, 80% and 103%. The maximum strains in the CFRP laminates ranged from 14.9% (S3L beam) to 17.9% (S1L beam). The average value of the maximum strain for the three tested beams was 16.7‰ which corresponds to 93% of its ultimate strain, indicating that this strengthening technique can mobilize stress levels in the CFRP reinforcing elements close to the tensile strength of this advanced composite material (high effectiveness of the NSM technique for the flexural strengthening of RC beams).The failure mode of the NSM beams depends on the percentage of the CFRP.Based on these results, by increasing the percentage of the CFRP, the strain in the CFRP laminates at failure decreases which shows that by increasing the percentage of the CFRP, the probability of using more capacity of CFRP laminates decreases [13].

R.Capozucca (2016) analysed the strengthening of damaged reinforced concrete rc beams through near surface mounted (NSM) fiber reinforced polymers (FRPs) has been shown to be a suitable method in practice. .This paper analyses experimental vibration of four RC beam models without strengthening and strengthened with NSM carbon-FRP rectangular rods after damage due to bending cracking of concrete by static tests. The investigation of vibration was carried out considering rc beams at different static loading damages in different constrain conditions: two beam models were studied assuming free-free end condition and the other two with hinge-hinge end condition.Finally, a comparison between experimental and theoretical dynamic values obtained by finite element analysis is developed to verify the control of RC beams strengthened with NSM CFRP rods.

From the result cracking of concrete represents the actual damaged also in strengthened beams and strengthened of rc beams damaged with NSM CFRP rectangular rods is suitable in practice because bond between CFRP and concrete was maintained up to failure of the beams.The presence of NSM CFRP rod as strengthening allows to decrease the effect of concrete cracking on frequency values under vibration.In the resut of beam models under vibration, with or without strengthening, with hinge end condition, the variation of frequency measures reaches for the first four modes 10% only at high damage degree levels [14].

Liang Huang et al.(2017) investigated the flexural behavior of U-shape FRP Profile-rc composite beams with inner GFRP tube confinement at concrete compression zone.Total of 15 medium-sized (i.e. 1800 mm in length, 100 mm in width and 160 mm in depth) beam specimens were constructed and tested under four-point bending, including one ordinary RC beam as reference, 10 hybrid beams with and four hybrid beams without inner GFRP tube confinement. The examined experimental variables included different arrangements of G/CFRP layer in U-shape FRP profile, inner GFRP tube, conventional steel rebar, and different types of FRP profile and concrete interfacial bond. Based on the testing, the failure mode, load-deflection relationship, ductility, energy absorption capacity and load-strain relationship of the beams were analyzed.

Result compared with ordinary RC beams, the increase in the ultimate load capacity ranged from 8.3% to 102.9%. The hybrid beams with or without inner GFRP tube confinement showed different failure modes. The hybrid beams with GFRP tube failed with steel yielding, followed by CFRP rupture while the hybrid beams without inner GFRP

ISSN: 2320-5407 *Int. J. Adv. Res. 12(03), XX-XX*

tube failed with concrete crushing but no CFRP rupture, indicating that the presence of GFRP tube confinement enhanced the strength of the concrete at the compression zone of hybrid beams.Two hybrid U-shape FRP-concrete beams without internal steel rebar failed in the catastrophic brittle manner, namely, the concrete beam was broken into two halves and the U-shape FRP profile completely separated from the concrete beam at the mid-span of the beam.Both the inner GFRP tube at concrete compression zone and the U-shape hybrid FRP profile were beneficial for the increase in ductility of the RC beams. The effect of U-shape hybrid FRP profile was more pronounced for load carrying capacity enhancement for the RC beams. Overall, current study showed that the novel U-shape FRP-RC composite beams with inner GFRP tube confinement at concrete compression zone have high performance in load capacity and ductility, especially in the aspects of ductility, which is favorable for structural design where high demand of deformation capacity of structural concrete is required, i.e. in the design of seismic-resistant structures [15].

Dr. A. Ramachandra Murthy et al.(2017) conducted the test on rc beams wrapped with GFRP sheets to determine the flexural behaviour using a symmetrical two point static loading system. Six Reinforced Concrete Beams have been cast for this experimental test.The experimental result shows, that full bottom GFRP sheet wrapping in 70% preloaded beam can increase flexural capacity of the beam by 14%(on ultimate load) as compared to Controlled Beams.

From the results we determined that the ultimate load carrying capacity of the strengthened beam is 14 % more than the controlled beam experimentally and the results were compared with Analytical analysis and it was predicted as lower than the former.Flexural strengthening up to the neutral axis of the beam increases the ultimate load carrying capacity, but the cracks developed were not visible up to a higher load. Use of FRP laminate improves load carrying capacity; delays crack formation and energy absorption capability of beam reinforced with FRP laminates.The 70% damage degree beams increases load carrying capacity 14% when strengthened with 100 mm width and 1.2mm thick of GFRP sheet in single layer for bottom full as compared with control beam [16].

Mithunkumar et al.(2016) conducted an experimental study of basalt chopped fibers of 0, 0.5, 1.0, 1.5,2.0,2.5,3.0% in reinforced concrete to determine the compressive, tensile, and flexural behavior with plain M40 grade concrete. Total 84 No's of specimens are casted for M40 grade concrete (42 cubes, 21 cylinders and 21 prisms).

From the results it can be noted that the compressive strength at 1.5 percentages was 34.31 N/mm^2 with the increase percentage of strength at 1.5 percentage basalt chopped fiber was 9.65 % over controlled concrete cube strength 31.29 N/mm^{2,} which was an optimum percentage of basalt chopped fiber content (1.5 %) and the compressive strength at 1.5 percentages was 46.27 N/mm^2 with the increase percentage of strength at 1.5 percentage basalt chopped fiber was 11.20 % over controlled concrete cube strength 41.61 N/mm^2, which was an optimum percentage of basalt chopped fiber content (1.5 %) for 7 and 28 days curing period.The split tensile strength at 1.5 percentages was 3.1 N/mm^2 with the increase percentage of strength at 1.5 percentage basalt chopped fiber was 12.32 % over controlled concrete cylinder strength 2.76 N/mm^2, which was an optimum percentage of basalt chopped fiber content (1.5 %) for 28 days curing period.The flexural strength at 2.0 percentages was 7.9N/mm^2 with the increase percentage of strength at 2.0 percentage basalt chopped fiber was 48.21 % over controlled concrete prism strength 5.33 N/mm^2, which was an optimum percentage of basalt chopped fiber content (2.0 %) for 28 days curing period.The achievable strength can be obtained by adding basalt chopped fibers from 0.5 to 1.5 % further increase in basalt chopped fibers in concrete decrease in strength. The desired percentage of fiber content in concrete would be 0.5 to 1.5% [17].

H.S. Jadhav et al.(2014) conducted an experimental study of the flexural behaviour of damaged rc beams strengthened in bending moment region with basalt fiber reinforced polymer (BFRP) sheets.Total twenty-two beams were cast and tested over an effective span of 900 mm up to failure of the beam under two-point loading and the beams were designed as under-reinforced beams. The beams were bonded with BFRP sheets in single layer and double layers in the bending moment region at the bottom face of the beams were strengthened after being damaged for various degrees of damage (0 %, 70 %, 80 %, 90% and 100 %).

ISSN: 2320-5407 Int. J. Adv. Res. 12(03), XX-XX

The result shows that 0%, 70% and 80% damaged degree beams showed higher performance in terms of load carrying capacity, while 90% and 100% damage degree beams did not show appreciable increase in load carrying capacity.BFRP wrapping with 100mm wide in single and double layer showed increase in ultimate load carrying capacity by 44% and 20% respectively in 0% damaged beam, with increase in degree of damage, deflection at ultimate load is found to be decreasing [18].

Nagesh R. Iyer et al.(2015) studied the flexural behaviour on basalt fiber reinforced composite sandwich panel with profile sheet as core to act as composite in effectively resisting flexure where as the core is constituted by the web portion of profile sheet in resisting shear. The panel exhibited 200% ductility over the deflection at the ultimate load with 10% loss in the ultimate load making it an ideal for flooring units. Further, numerical study has been conducted to assess the integrity of the connection between skin and core and to find the effectiveness of connection on overall strength, stiffness of the panel.

The test result shows that from the experimental studies, it was observed that the ultimate load for the BFRC panel is 25 kN for a deflection of 10 mm. In the post peak region of the ultimate load, the panel exhibited 200% more deflection than the deflection observed at ultimate load with less than 10% reduction in the ultimate load and hence suitable for flooring units.The failure of the BFRC panel is mainly governed by crushing of top skin of BFRC panel. The FE model (Top and bottom partially tied) is created by assuming 70% frictional slip in both top and bottom skin and the model exhibited 27 kN load carrying capacity for a deflection of 6 mm. This model is found to have better correlation with experimental behaviour of the panel with error of 3.84% corresponding to ultimate strength of the panel. Further from the numerical studies it can be concluded with improved connection mechanism between skin and core, both strength and stiffness of panel can be enhanced [19].

Conclusion:-

1. When compared to other FRP composites BFRP has excellent density, elastic modulus, tensile strength, softening point, thermal conductivity and sound absorption. BFRP possess high fire resitance over a long period of exposure.
2. The flexural strength increases with increase in different layers of wrapping.
3. The moment carrying capacity, ductility, stiffness and energy absorption capacity increases than other fibers.
4. It can thus be concluded that BFRP has excellent mechanical, thermal, fire resistance properties than other fibers.

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