Study on Flexural Behavior of Corbel Wrapped With FRP Sheet

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Abstract- *The non prismatic and non linear members like deep beams, dapped ended beam and corbels etc.are not satisfied with normal beam theory. These structures generally fail by shear in spite of flexure and could not be possible to analyses and designed by normal beam theory. Strut and tie method is one of method can be used to design and analyses for non prismatic and non linear member. This research paper deals with behavior of corbels wrapped with FRP sheet under loading. In this methodology we have used specimen as corbel designed and analyzed as strut and tie method and tested in lab for monotonic loading. The test load is compared with design load. The result of corbels testing will be in term of load – deflection curves .from that comparison we can prove the strut and tie method would be a start-up solution for non prismatic and nonlinear member*

Keywords- corbel, strut and tie method, FRP, monotonic loading, load-deflection curve, etc.

I. INTRODUCTION

In recent years, there has been an increasing effect in India to provide adequate civil engineering infrastructures for boosting the economic growth and development of the country. In the process of development, construction of new infrastructures has always attracted greater attention. However, the maintenance and retrofitting of existing infrastructure has also become increasingly important mainly due to the earthquake disaster everywhere in the world and more so in India.

The issue of upgrading the existing civil engineering infrastructures has been one of great importance for over a decade. Failure of bridge decks, beams, girders and columns, buildings, parking structures and others may be attributed to ageing, induced degradation environmentally, poor design and/or construction, and also lack of maintenance to accidental events.

Composite structures are defined as structures built up by structural self-carrying sub element by shear connectors to from an interacting unit. Composite structures have seen widespread use in recent decades because of the benefits of combining the two construction materials.

Corbels:

Corbel or bracket is a RC member is a short-cantilever used to support the reinforced concrete beam element. Corbel is structural element mostly used to support the pre-cast structural system such as pre-cast beam and pre-stressed beam. Mostly the corbel is casted monolithic with the column or wall element.

Fiber Reinforced polymer (FRP):

In the recent years, there have been considerable worldwide attentions among engineers for the fiber reinforced polymer (FRP) material in construction industry. These materials have more strength to weight ratio, effective resistance to corrosion, chemical resistance, electrically non-conducting, light-weight and also twice to four times as strong as steel in tension. Comparatively it is easy to use, fast, and results in small changes in structural size generally in the order of millimeters. it is expected to replace most of previous existing repairs and strengthening techniques. Because these materials can be applied while the structure is in use also.

1. Objectives

The Objective of this research study is following

1) To examine experimentally the flexural strength of RC corbel using externally bonded Glass FRP sheets.
2) To study different failure pattern of corbel.

2. Limitation

1) The shear span/depth ratio is less than 1.0; it makes the corbel behave in two-dimensional manner.
2) Shear deformation is significant is the corbel.
3) There is large horizontal force transmitted from the supported beam result from long-term shrinkage and creep deformation.
4) Bearing failure due to large concentrated load.

5) The cracks are usually vertical or inclined pure shear cracks.
6) The mode of failure of corbel is: yielding of the tension tie, failure of the end anchorage of the tension tie, failure of concrete by compression or shearing and bearing failure

II. LITERATURE REVIEW

Zeller(2007), concluded, from previous tests done on corbels, that for double corbels, having depth of 690mm and width 300mm, vertical stirrups would be more sufficient when the compression strut have an angle less than 45o with the horizontal. On the other hand, horizontal stirrups would be sufficient when that angle exceeds 45o, as in the case of corbels having (av/d) ratios less than.

Khalifa(2011) proposed a macro-mechanical strut and tie model to analyse fibrous high-strength concrete corbels. The fibers were applied as partial or full replacement of horizontal stirrups. The parameters studied were, the effect of fiber volume, fiber length, and fiber diameter, random distribution of fibers, fiber HSC interface, shear span to depth ratio and concrete strength. Results showed that the maximum vertical load carrying capacity applied on corbels was increased with the increasing of the fiber volume fraction, fiber aspect ratio and the increasing in concrete compressive strength.

Al-Zahawi(2009), investigated the shear strength and the behavior of reinforced concrete corbels containing chopped carbon fibers subjected to concentrated vertical loads. His work was divided into two categories: experimental and theoretical. To perform the experimental part, 15 reinforced concrete corbels were cast with and without chopped carbon fibers, all specimens had the same dimensions and main reinforcement; the shear span to depth (av/d) ratios ranged from 0.3 to 0.6.

The variables studied were the (av/d) ratios, the volume fraction of carbon fibers and the presence or absence of the secondary reinforcement. Most of the specimens failed in a diagonal splitting mode. Test results showed that the presence of carbon fibers in the concrete has enhanced the tensile strength of the corbels and delayed the formation of inclined diagonal shear cracks.

III. DATA COLLECTION

1. Types of FRP :

Now days, different types of FRP material are commonly produced. The most suitable fibers for strengthening are Carbon, Aramid and Glass fibers. Fig. gives the idea of different types of Fiber.

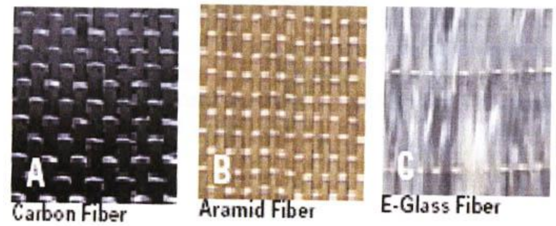

Figure 1.

2. Carbon Fibers

Carbon fibers are classified as either high strength or high modulus, although in reality both the strength and modulus of most common carbon fibers are very high. Carbon fibers are produced by precursors of cellulose and poly-acrylonitrile (PAN) - which is very similar to rayon. The precursors are heated to temperature up to 2600º C for high strength fibers and 3000º C for high modulus fibers.

Carbon fibers are available in a wide range of grades offering different mechanical properties. All Carbon fibers offer relatively high strengths and stiffness, but are brittle and fail at reasonably low strain levels. They have a negative coefficient of thermal expansion. Carbon fibers are the only fibers considered here that are electrically conductive. They are very small, usually about 7 microns in diameter. The dry carbon fibers have about 10 times the strength of steel i.e. 4500 N/mm2. Once mixed with resin, this drops to approximately 1200 to1500 N/mm2; still significantly stronger than steel. They are the most expensive of fibers.

3. Aramid fibers

Aramid or polyaramid fibers, such as Kevlar 49, are man-made organic fibers offering very high tensile strength and relatively high elongation at failure. This results them very good for absorbing large amount of energy, e.g. in structures subjected to impact forces. The fiber has very low density and therefore results in extremely lightweight structures. They are used in numerous applications such as bullet proof vests, vehicle tyres, high speed boat hulls, lightweight high tensile ropes and some aerospace applications. Aramid fabrics are very soft and easy to handle. They can prove difficult to cut with conventional tools due to their very high stiffness, but this can overcome by using specialized tools.

Although strong, Aramid fibers have some properties that make it less desirable for strengthening work. The fibers are hydroscopic, and should only be used when they are protected from environment. The fibers themselves are quite abrasive, and under repeated loading, they can abrade against each other by weakening the laminate.

4. Glass Fibre.

E-Glass (E for electrical grade) is the most widely used general purpose form of composite reinforcement. Other glass fibers are – S Glass (S for strength) and AR glass (AR for alkali resistant).

E-Glass is of lower strength and stiffness than other fibers being considered. But it is considerably lower in cost. The fiber is electrically non –conductive and offers good corrosion resistance.

Properties of Fibre

The other properties are given below:

Chemical Resistance:

Carbon and Aramid fibers have highest resistance to chemical attack. Glass fibers are attacked by alkalis (pH greater than about 11) but not by acids. Aramid absorb much more water than other two fibers, which can cause problems with the resin/fiber interface. In the presence of salts, fracture of all types of fiber occurs due to the formation of angular crystals.

Resistance to ultraviolet light:

Glass and Carbon fibers are not affected by ultraviolet light. Aramid fibers change colour under ultraviolet light and the strength is reduced. However, when embedded in a resin matrix this degradation only occurs near the outer surface and there is little effect on the overall mechanical properties.

Electrical Conductivity:

Aramid and Glass fibers are electrically non-conductive and hence are suitable for use close to power lines, railway lines etc. Carbon fibers conduct electricity and therefore it should be handled with care and must be electrically isolated.

Compressive Strength: The compressive strengths of Carbon and Glass fibers are close to their tensile strength; that of Aramid is significantly lower.

Fire :

Glass fibers retain strength up to their melting point (over 1000º C) while carbon fiber oxidize in air above 650º C. Aramid fibers are normally used above 200º C. None of the fibers will support combustion. In composites the resin behavior will dominate performance; most generate toxic smoke.

IV. EXPERIMENTAL WORK

Corbels were designed, so they are failed in flexure and strong in shear. To improve the capacity or performance level of a corbel, it is necessary to strengthen or retrofit the corbel in flexure. To improve the flexural strength, corbel were retrofitted at bottom and side face by using GFRP material. To achieve the required aim, the experimental program has been made. Designed corbel were cast. These corbels were classified into different groups. Out of these groups, first group was made of control beams.

The two control unplated corbel (CC) failed at an ultimate load. Then take the average load of these corbels as the ultimate load. The corbels failed in conventional ductile flexure with yielding of the tension steel, followed by crushing of the concrete in the compression zone.

The bureau of Indian Standard, recommended a set of procedure for design of concrete mix, mainly based on the work done in national laboratories. The mix design procedure is covered in IS: 10262:2009. The method given can be applied for both medium strength and high strength concrete.

V. EXPECTED OUTCOME

The test result observed are approximately same, this can be prove that for non prismatic and non linear sections strut and tie method would be a better solution method. The use of FRP material increases load carrying capacity of the section.

VI. APPILICATIONS

1. Many researchers have proposed models which can predict the failure pattern of strengthened corbels. The experimental research on FRP strengthened RC corbels has highlighted five most common modes, which include rupture of FRP strips; compression failure after yielding of

steel; compression failure before yielding of steel; delamination of FRP strips due to crack; and concrete cover separation.

2. The present work deals with the flexural behavior of reinforced concrete beams strengthened with glass-fiber-reinforced-polymer (GFRP) laminates. The results of an experimental and numerical study of the flexural behavior of reinforced concrete beams strengthened with glass-fiber-reinforced-polymer (GFRP) laminates are discussed in the report.
3. Based on experimental results different analytical models to predict the flexural behavior of RC-FRP strengthened beams has been examined. Model which predicts the behavior reliably is investigated.
4. Applicable to non-uniform and irregular sections: The fiber sheets are flexible, can follow a curved profile. Hence they can be bound to any irregular section and provides confinement.
5. Ease in application: FRPs can be easily cut to require length on site. While steel plates are to be held in place by bolts till adhesive gains strength; FRP may be left unsupported due to adhesion between epoxy and FRP. In general, no bolts are required to drill into the structure, which can also weaken the existing concrete and reinforcement.
6. Versatile design of systems: Steel plates are limited in length by their weight and handling difficulties. Welding in situ is not possible, because of damage to adhesives, and expensive fixing of lap plates is
7. therefore required. In contrast, composite plates are of unlimited length, may be fixed in layers to suit strengthening requirements, and are so thin that fixing in two directions may be accommodated by varying the adhesive thickness.
8. Reduced construction period: Many of the practical advantages de¬scribed above combine to enable composite plates to be installed in greatly reduced time periods when compared with steel plates. As well as lower contract costs, the traffic delay costs are minimized.
9. Maintenance of strengthening system: Steel plates will require maintenance, painting and may incur traffic disruption and access costs as well as the works costs. Composite plates will not require such maintenance, reducing the whole life cost of this system.

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