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A Review on Effect Analysis of Punching Shear on FRP Strengthened Slab

Mohd Tanjeem Khan[1], Md. Raja[1], Md. Sawood Ansari[1], Adib Maaz Ansari[1], Khan Rahim Saud[1], Umarfarook H. Momin[2], Shaikh Ibrahim[3]

[1]UG Student,Civil department, Jamia Institue of Engineering & Management Studies,Akkalkuwa,Maharashtra, India

[2]PG Student,Civil department, Padmabhooshan Vasantraodada Patil Institute of Technology, Sangli, Maharashtra, India

[3]Assistant Professor,Civil Department, Jamia Institue of Engineering & Management Studies, Akkalkuwa, Maharashtra, India

ABSTRACT

Punching in slabs is usually associated to the application of concentrated loads or to the presence of columns. One of the main concerns related to flat slabs is its punching shear capacity at slab column connection. Provided that bending capacity is installed, punching shear failure is hence characterized by the development of a truncated cone shaped surface at the slab-column connection. Frequently, there is the need to strengthen existing flat slabs against punching shear failure. One of the strengthening practices, which have been tested within current experimental programmer, consists on gluing carbon fibre reinforced polymers on concrete surface. Moreover, we want to know the behaviour of RC flat slab under FRP material against punching shear. The effect of FRP bars against punching shear is checked.The objective of the current study was to explain the feasibility of RC flat slab to examine the application of steel rods, FRP rebar on the improving of punching shear. Extensive applications of the fiber-reinforced polymer (FRP) as new construction materials have been recently accomplished. FRP materials are lightweight, high strength, and no-corrosive materials. By virtue of these advantages, there is a wide range of recent, current, and potential applications of these materials that covers both new and existing structures. Among different types of FRP materials, a fiber-reinforced polymer (FRP) is used extensively in the structural engineering field. This study was carried out to examine the viability of using FRP bars for the punching shear strengthening of slab.

Keywords : FRP, Reinforced Concrete, CFRP, GFRP, CFRTP, CRP, Punching Shear In Slab & footing, Shear , Punching, BFRP Strengthen Slab, Footing & Slab

I. INTRODUCTION

Throughout the world, an increasing number of reinforced concrete (RC) structures are being assessed as unsafe. The reasons for this include loads greater than the design capacity arising from alteration; new stringent design codes requirements, especially for earthquakes resistance and, in some cases, deterioration of the structural members. Such structures must be strengthened or retrofitted in order to serving their intended purpose.

In general, concrete structures need strengthening for the following reasons:

- ✓ To increase live-load capacity for buildings or bridges to meet new use requirements.
- ✓ To add reinforcement to a member that has been under designed or wrongly constructed.

- ✓ To improve seismic resistance, by improving the member behavior, or improving continuity between members.
- ✓ To replace or supplement reinforcement lost by impact or corrosion.
- ✓ To improve the explosion resistance.

Punching shear

The punching shear is a failure mechanism in structural members like slabs and foundation by shear under the action of concentrated loads.

The action of concentrated loads is on a smaller area in the structural members. In most cases, this reaction is the one from the column acting against the slab. Eventually the slab will fail. One possible method of failure is that the load punches through the slab.

Some examples of the occurrence of concentrated loads on a slab are a column, particularly on a pad foundation, and wheel loads. This same type of failure could also happen in another way. Turning the structure upside down we get a flat slab supported by a column, where there is a high concentration of shear force around the column head.

When the total shear force exceeds the shear resistance of the slab, the slab will be pushed down around the column, or this can be viewed as the column being punched through the slab.

Punching shear failure mechanism is observed in normal floor slabs, flat slabs, and in the foundation slabs below the column. In pad foundations, where weight and depth are not so critical, it's effects are satisfied by providing sufficient depth.

Carbon Fiber Reinforced Polymer (CFRP)

Carbon fiber reinforced polymer, carbon fiber reinforced plastic or carbon fiber reinforced thermoplastic (CFRP, CRP, CFRTP or often simply carbon fiber, carbon composite or even carbon), is an extremely strong and light fiber-reinforced plastic which contains carbon fibers. The spelling 'fibre' is common in British Commonwealth countries. CFRPs can be expensive to produce but are commonly used wherever high strength-to-weight ratio and rigidity are required, such as aerospace, automotive, civil engineering, sports goods and an increasing number of other consumer and technical applications.

CFRPs are composite materials. In this case the composite consists of two parts: a matrix and a reinforcement. In CFRP the reinforcement is carbon fiber, which provides the strength. The matrix is usually a polymer resin, such as epoxy, to bind the reinforcements together. Because CFRP consists of two distinct elements, the material properties depend on these two elements.

Glass Fiber Reinforced Polymer (GFRP)

Fiberglass (US) or fiberglass (UK) is a common type of fiber-reinforced plastic using glass fiber. The fibers may be randomly arranged, flattened into a sheet (called a chopped strand mat), or woven into a fabric. The plastic matrix may be a thermoset polymer matrix – most often based on thermosetting polymers such as epoxy, polyester resin, or vinylester - or a thermoplastic.

Cheaper and more flexible than carbon fiber, it is stronger than many metals by weight, and can be molded into complex shapes. Applications include aircraft, boats, automobiles, bath tubs and enclosures, swimming pools, hot tubs, septic tanks, water tanks, roofing, pipes, cladding, casts, surfboards, and external door skins.

Other common names for fiberglass are glass-reinforced plastic (GRP), glass-fiber reinforced plastic (GFRP). Because glass fiber itself is sometimes referred to as "fiberglass", the composite is also called "fiberglass reinforced plastic." This article will adopt the convention that "fiberglass" refers to the complete glass fiber reinforced composite material, rather than only to the glass fiber within it.

Basalt Fiber Reinforced Polymer (BFRP)

Basalt fiber is a material made from extremely fine fibers of basalt, which is composed of the minerals plagioclase, pyroxene, and olivine. It is similar to fiberglass, having better physicomechanical properties than fiberglass, but being significantly cheaper than carbon fiber. It is used as a fireproof textile in the aerospace and automotive industries and can also be used as a composite to produce products such as camera tripods.

Basalt fiber is made from a single material, crushed basalt, from a carefully chosen quarry source. Basalt of high acidity (over 46% silica content) and low iron content is considered desirable for fiber production. Unlike other materials, such as glass fiber, essentially no materials are added. The basalt is simply washed and then melted.

The manufacture of basalt fiber requires the melting of the quarried basalt rock at about 1,400 °C (2,550 °F). The molten rock is then extruded through small nozzles to produce continuous filaments of basalt fiber. There are three main manufacturing techniques, which are centrifugal-blowing, centrifugal-multiroll and die-blowing. The fibers typically have a filament diameter of between 9 and 13 µm which is far enough above the respiratory limit of 5 µm to make basalt fiber a suitable replacement for asbestos. They also have a high elastic modulus, resulting in excellent specific strength—three times that of steel.

II. LITERATURE REVIEW

Punching Shear

Husain Abbas, Aref A. Abadel, Tarek Almusallam, Yousef Al-Salloum (2015), Punching shear failure of reinforced concrete (RC) slabs is a major concern for the structural de-signers of buildings and bridges. This type of failure is more common in bridge decks supported by girders under the action of repeated wheel loads. The bridge decks are often strengthened for flexure by external bonding of Fiber Reinforced Polymer (FRP) sheets but the consequent enhancement in shear strength is generally low and not well known.

One of the main concerns related to two-way flat slabs is the punching shear capacity at slab column connection, which is subjected to a very complex three-dimensional stress state. Punching shear failure is hence characterized by the development of a truncated cone shaped surface at the slab-column connection. Punching shear can thus result from a concentrated load or reaction acting on a relatively small area, called the loaded area, of a slab or a foundation. This type of failure is usually both brittle and catastrophic since it may generate the global collapse of the structure due to the increasing load transfer to neighboring columns and to the slabs located underneath. The load carrying capacity of reinforced concrete (RC) slabs may be compromised for a number of reasons, including structural damage, design errors, building code changes and alteration of functional use.

The slab–column connection of a flat plate is susceptible to punching shear failure. Once punching shear failure occurs, the overall resistance of the structure against gravity load is considerably reduced, which causes the separation of the slab and column, and might even cause progressive collapse of the whole structure.

FRP Materials

Elsanadedy (2011) ,There are number of fibers which may be used for strengthening applications *viz.* CFRP, GFRP, BFRP, SFRP, etc. All fibers have a linear elastic response up to ultimate load, with no significant yielding. Many previous studies have examined the punching shear strength of FRP strengthened RC slabs; however, there are some theoretical deficiencies in the conventional theory, which are not able to explain the influence of FRP strengthening on punching resistance of RC slabs.

FRP materials are nowadays commonly used for the strengthening of structural RC elements. There are several studies on flexural strengthening of RC slabs using externally bonded FRP sheets. However, the FRP strengthening technique for punching shear failure is fairly new, with little research reported in this area.

Carbon Fiber Reinforced Polymer (CFRP)

Nigro, Ludovico & Bilotta (2008) ,The use of carbon fibre reinforced polymers (CFRP) on structural repair and strengthening has continuously increased during the last years due to the following main advantages of this composite material when compared to conventional materials like steel and concrete: low specific weight, easy installation, high durability and tensile strength, electromagnetic permeability, and practically unlimited availability regarding size, geometry and dimensions (ACI 2008). The most widely used technique aiming to increase load carrying capacity is to apply CFRP plates on the tension surface of the RC slab as externally bonded (EB) reinforcement.

CFRP laminates and sheets are generally applied on the faces of the elements to be strengthened configuring which is commonly designated as the EB reinforcing technique. The research carried out up to now has revealed that this method cannot mobilize the full tensile strength of CFRP materials due to the occurrence of premature de-bonding phenomenon. Due to the fact that CFRP is often directly exposed to the weathering conditions the reinforcing performance of this technique should be accounted for. EB systems are also vulnerable regarding fire action and vandalism acts.

Glass Fiber Reinforced Polymer (GFRP)

Chen and Li (2005),They used Glass Fiber Reinforced Polymer (GFRP) laminates for the shear strengthening of slabs. They showed that the flexural strengthening of slabs by external bonding of GFRP laminates can increase the punching strength, significantly. However, GFRP laminates were more effective for the slabs with low steel reinforcement ratios. They proposed analytical equations to calculate the punching strength of strengthened slabs.

Basalt Fiber Reinforced Polymer (BFRP)

Marek Urbanski, Andrzej Lapko, Andrzej Garbacz (2013), Basalt bars of BFRP group (basalt fiber reinforced polymer) have a number of advantages comparing to steel reinforcement and other FRP composites, such as glass GFRP (glass fiber reinforced polymer) or carbon CFRP (carbon fiber reinforced polymer). The chemical composition of basalts, which are made BFRP basalt fiber is somewhat different. In addition to the chemical composition, mechanical properties of basalt fibers originating from different sources are varied, probably due to the different chemical components and processing conditions such as the temperature of the fiber production. Basalt fiber tensile strength tends to increase from 1.5 to 2.9 GPa as the production temperature increases within the range of 1200 ~ 1375°C. This is due to the increase in the proportion of crystal nuclei basalt at lower temperatures.. Basalt fiber Young's modulus ranging between 78 and 90 GPa, depending on the source, the highest values of BRFP modulus 90 GPA was reported in Russia. Most reports indicate, that comparing to glass, the basalt fiber has higher or comparable modulus and strength , and there have been reported some cases of significantly lower strength of basalt fiber than it was declared. In addition to good mechanical properties, basalt has a high chemical and thermal stability, good thermal, insulating, electrical and sound properties. Basalt thermal insulation is three times greater than the asbestos' one. Due to good insulating properties, basalt is successfully used for fire protection. Furthermore, basalt fibers have 10 times better electrical characteristics - insulating than glass fibers. Basalt fibers are also significantly better chemically resistant than glass fibers, particularly in a strongly alkaline.

Steel Fiber Reinforced Polymer (SFRP)

Nguyen-Minh(2011), They studied behavior and capacity of steel fiber reinforced concrete (SFRC) flat slabs of different dimensions. In addition, **Amen Agbossou** studied the experimental and theoretical behavior of slabs strengthened by FRP. The experimental results show that FRP significantly increases punching failure stress, resulting in a reduction of slab rotation around the loading column. The theoretical investigation presents a finite element model for the bending of strengthened slabs.

Nguyen-Minh performed an evaluation of accuracy of existing models and formulas in previous studies that used to predict punching shear resistance of steel fiber reinforced concrete (SFRC) that results from the evaluation show that the existing formulas gave inaccurate results with a large scatter in comparison with the testing results. Also, Maya et al. presented a mechanical model for predicting the punching strength of SFRC slabs as well as conventional reinforcement. This was validated against a wide number of available experimental data and its accuracy was verified.

III. OBJECTIVE OF WORK

1. To explain the feasibility of RC flat slab to examine the application of steel rods, FRP rebar on the improving of punching shear.
2. To check the feasibility of RC flat slab by using different material.
3. To know the behaviour of RC flat slab under FRP material against punching shear.
4. To compare the results computed from the experimental analysis.
5. To suggest best suited material with response of different parameters.
6. To determine cost analysis.

IV. PROPOSED WORK

1. Casting of flat slab specimen to test against punching shear failure.
2. Flat slabs are casted with different FRP Materials.
3. Testing is to be done by sub sequent recommendations & try to find alteration.
4. Evaluate probable possible design procedure to resist punching shear flat slab.
5. Compare the results found after experimental analysis.
6. Compare the cost analysis to know effective cost.

V. CONCLUSION

- ✓ We expect that the FRP material which we used as reinforcement may be feasible to resist the shear failure i.e. punching shear.
- ✓ At the same time we come to know that how much cost effective material is FRP.
- ✓ Coefficient of thermal expansion of BFRP is similar to concrete which ensures the simultaneously deformation of concrete & reinforcement. Hence, we extremely believe that BFRP used as reinforcement.
- ✓ In our study we come to know that china has intellectual rights of BFRP & USA has intellectual rights of CFRP. But in recent days, china tried to take the intellectual rights of CFRP with many recent researches. If we Indian also tried to take the intellectual rights of BFRP to carried out various research then it is possible with proud moment.
- ✓ If BFRP becomes locally available material then it became very cheap.

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