International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 01 | Jan - 2022 ISSN: 2582-3930

STUDY ON NEAR SURFACE MOUNTED REINFORCEMENT FOR STRENGTHENING DEEP BEAM WITH LONGITUDINAL DUCT

Mr. Abhijith K R [1], Ms. Anila Dani D A[2], D.Bhuvaneswari[3]

[1] II Year, M.E(Structural), RVS Technical Campus, Coimbatore, Tamil Nadu [2]Assistant Professor, Department of Civil Engineering, RVS Technical Campus, Coimbatore, Tamil Nadu
[3]Assistant Professor, Department of Civil Engineering, RVS Technical Campus, Coimbatore, Tamil Nadu

---***---

Abstract - Beams are the important part of structures. They are the primary load carrying member of any concrete structures. Deep beams are having large depth to thickness ratio and are used for heavy load carrying structures. These beams are mainly used in bridges, multistorey building, transfer girders and shear walls. These beams utilize some amount of space as well and is very difficult to provide space for many services like electrical, drainage and other services. In-order to accommodate these services effective alteration are provided within the structures without losing their strength properties, i.e. by providing ducts of different shape and size and also at different locations of beams. Due to introduction of these alterations there are some losses of effective area in the structures which may affect the strength properties. In-order to retain the strength properties strengthening methods is adopted. There are many strengthening methods to adopt. Near surface mounted method (NSM) is a strengthening method in which a shallow groove is provided on the concrete surface, in required direction, for accommodating a strengthening material such as steel, carbon fibre reinforcement, which is fixed by any adhesive material.

1. INTRODUCTION

1.1 GENERAL

Beams and columns are inevitable part of a concrete structure. They are the primary load carrying members and give support for the entire structure. While using the beams with large spans, it perhaps will fail due to flexure. We can use post tensioned beams, composite beams, plate girders and deep beams instead of long spans beams. Deep beams are becoming popular and are progressively used in modern constructions; and have useful applications in a variety of structures. Beams with large depths in comparison with span are called deep beams. As per IS-456 (2000) clause 29, a simply supported beam is classified as deep when the ratio of its effective span L to overall death D is less than 2 and for Continuous beams the ratio of span l to overall depth D is less than 2.5. They have wide applications and are utilized as a part of foundations works, tall structures, seaward structures, and so on. Opening in the deep beams are provided for the accessibility to allow for services including electric and mechanical. The beam strength and stiffness reduces due to this openings and it will leads to excessive cracking and deflection. Codes of practices do not cover the design of deep beams with openings. Deep beams fail by shear instead of flexural failure. There are limitations on the understanding of the behaviour and failure mechanism of high strength concrete deep beams with openings, especially in the context of recent development in the construction materials and techniques. More investigation is required to explore the behaviour and failure mechanism of high strength concrete deep beams with openings and effectiveness of strengthening techniques on them.

1.2. DUCT PROVIDED DEEP BEAM

In modern buildings the duct openings in beams are provided and it is very necessary to accommodate the service pipes and service ducts . Sometimes the duct openings are used for aesthetical purpose also. Beam depth is one of the factors to decide the floor to floor height and overall height of the building. Retaining the load carrying capacity of the beam without increasing the depth is a major problem for the Structural Engineer. If service ducts are provided at the bottom of the beam, then the floor to floor height increases and the overall height of the building also increases. The load carrying capacity and stiffness of the beam reduces due to these ducts provided in the beam. Despite the fact that the presence of openings reduces beam strength and stiffness, as well as causing excessive cracking and deflection, rules of practise do not cover the design of deep beams with openings. Despite attempts to determine the ultimate strength of deep beams, there are still limitations and uncertainties in understanding the behaviour and failure mechanism of high strength concrete deep beams, particularly those with openings, due to recent developments in construction materials and techniques. As a result, research on high-strength concrete deep beams with openings is required. The usual performance concrete does not flow smoothly through the web of a deep beam because it has crowded shear reinforcement within its thin web. It is unlikely that the bottom bulb will be entirely filled. This can result in cavities in the concrete finish, which are commonly referred to as bug holes or a honeycombing effect in the final concrete surface. As a result, researchers choose self-consolidating concrete (SCC) for deep beam casting. The purpose of the opening determines the type of opening. As a result, many shapes are used; the most prevalent types of openings are rectangular and circular in shape, with varying sizes and locations.

1.2.1 LONGITUDINAL OPENING IN DEEP BEAM

Beams with longitudinal apertures are RC beams with openings parallel to the longitudinal axis. Longitudinal openings of many forms are employed, including circular, rectangular, diamond, triangular, trapezoidal, and even irregular shapes. The corners of the rectangular longitudinal hole are sometimes rounded off, with the goal of lowering stress concentration at sharp corners and thereby improving the beam's cracking behavior in service

1.3 NEAR SURFACE MOUNTED METHOD

There are several methods available to provide shear and flexural strengthening, they are by adding external stirrups, jacketing, bonding external plates using epoxy or bolts and bonding external FRP laminates

After the research of fiber polymer, newer class of FRP strengthening techniques have been used: externally bonding technique (EBR) and near surface mounting reinforcement (NSMR) FRP materials can be bonded to the outside of concrete structures with high-strength adhesives to offer additional reinforcement in addition to the internal reinforcing. In addition to external bonding, FRP reinforcements can be put inside grooves cut into structural components in a technique known as typically near surface mounting (NSM), as seen in figure 1.1

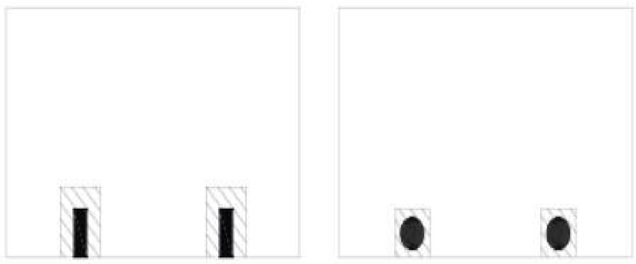

Figure 1.1 near surface mounted FRP, rectangular shapes and rods
(Source: Parth D Shahand (2015))

Near surface mounting technique has many advantages vs. externally bonding technique (EBR): NSMR resists end peeling significantly better than bonded laminates, has superior corrosion resistance, can mobilize a higher percentage of tensile strength, has better anchorage capacity, and requires no preparation work other than grooving. Because the FRP reinforcement is insulated from mechanical impacts by the surrounding concrete due to the specific mounting setup, this technology is appealing for reinforcing in the negative moment area. The reinforcement provides better resistance to freeze/thaw cycles, high temperatures, fire, UV radiation, and vandalism. According to the available research, the material qualities of FRP strips and adhesives have a significant impact on the NSM strengthening effectiveness, although there is no thorough investigation in this area.

1.3.1 WORKING STEPS

Near surface mounted method working step are:

(1) According to research, cut the groove with a saw with one or two diamond blades or a 1.5d grinder, depending on the reinforcement size.

(2) Vacuum or compressed air is used to clear the surface of dust and loose pieces, then the groove is filled halfway with adhesive, then the FRP rod/strip is inserted and lightly pressed to allow the adhesive to set.

(3) As illustrated in figure 1.2, the groove is filled with extra paste and the surface is smoothed.

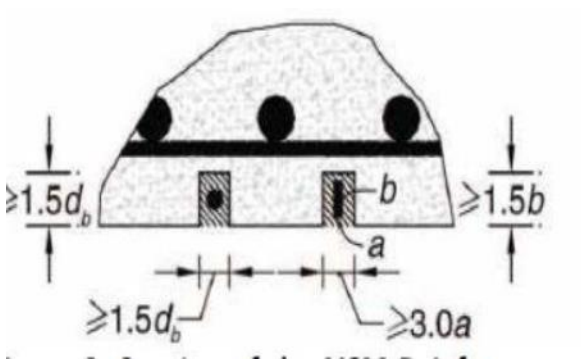

Figure 1.2 Spacing of the NSM Reinforcement
(Source: Parth D shahandam (2015))

The grooves' minimum dimension should be at least 1.5 times the diameter of the bar. The minimum measurements for a rectangular bar (strip) with a high aspect ratio must be 3 times the bar width and 1.5 times the bar height (Fig. 1.2). The groove's optimal size may be determined by adhesive properties, bar surface treatment, and concrete tensile strength, surface, and particles.

1.3.2 REINFORCEMENTS USED IN NSM

Different types of reinforcements, such as steel, carbon bars, and carbon-fiber-reinforced polymer (CFRP) plates are used.

1.3.3 GROOVE FILLER

The groove filler serves as a conduit for stress transfer between the FRP bar and the concrete. The tensile and shear strengths are the most important mechanical parameters in terms of structural behavior. When the inserted bars have a deformed surface, substantial circumferential tensile stresses in the cover formed by the groove filler as a result of the binding action are created. A two-component epoxy is the most popular and best performing groove filler. Low viscosity epoxy, which may be "poured" into the grooves, is a good choice for strengthening in negative moment zones. The use of cement paste or mortar as a groove filler instead of epoxy has recently been investigated in an effort to reduce material costs, reduce worker hazard, reduce environmental impact, allow effective bonding to wet substrates, and achieve better resistance to high temperatures and improved thermal compatibility with the concrete substrate.

2. LITERATURE REVIEW

Limited studies have been reported in the literature of transverse opening provided deep beam and a fairly common structural element used in bridges, multistory building and shear walls.

Ahmed Ismail el-kassas et al. (2020) : The influence of longitudinal opening on the structural behaviour of reinforced high-strength self-compacted concrete deep beams was investigated by Ahmed Ismail el-kassas et al. (2020). The influence of different locations, shapes (circular & square) and sizes of longitudinal opening on the behaviour of reinforced high-strength self-compacted concrete (RHSSCC) deep beams is investigated using a total of 8 samples.

Hayder Mirdan Abdzaid and Hayder Hussein Kamonna (2019) studied the Flexural Strengthening of Continuous Reinforced Concrete Beams with Near-Surface-Mounted Reinforcement method. The NSM reinforcement technique increased the strength of RC beams and this was accompanied by some reduction in ductility and undesirable concrete cover separation failure. Unexpected and undesirable concrete cover separation failure near the ends of the NSM reinforcement was the predominant failure mode of the strengthened beams

Parth D. Shahand Prof.Yashwant sinhzala (2015) .carried out a study on Comprehensive review of near surface mounted technique used in Flexural strengthening. It is observed that In structural behavior of flexure and shear strengthened RC beams/slabs, the same amount of NSM reinforcement provides higher load bearing capacity and higher deflection up to failure compared to External bonded FRP laminates method. The technique can be used to increase both stiffness and flexural strength of concrete elements

Dr. Yaarub Gatia Abtan et al. (2019), conducted experimental Study to Investigate the effect of Longitudinal and Transverse Openings on the Structural Behavior of High Strength Self Compacting Reinforced Concrete Beams to investigate and evaluate the optimum hollow zone in beam section, also to show effect of different web-opening locations in RC beams with longitudinal and transverse opening (BLTO) on load carrying capacity, deflection, crack pattern and failure mode.

Sadjad A Hemzah et al. (2020) carried out experimental investigation for structural behaviour of self-compacting reinforced concrete hollow beams with in-place circular openings strengthened with CFRP laminates and they found out strengthening configurations by CFRP laminates for beams with in place openings succeeded in preventing cracks from propagating towards the openings and/or decreasing the hairline cracks to a minimum number due to the redistributing process of stresses during loading .

Abdur Rashid (2018) studied behaviour of Reinforced Concrete Deep Beam under Uniform Loading, a total of 14 concrete deep beams were tested under four-point loading condition simulating approximately the uniform distributed load. The test beams were simply supported and were made with brick aggregate concrete. The test beams were divided into two series in which first beam of each series was designed and detailed as per recommendations of the ACI Building Code 318-89 (ACI, 1989). In the remaining six beams of each series, the amount of either the flexural reinforcement or, the horizontal web reinforcement or, both were increased in relation to that of first beam of the corresponding series. Results shown that the diagonal crack develops first in relatively deeper beams and flexural cracks develop first in the shallower beams provided the beams have sufficient reinforcements.

Md. Akter Hosen, Mohd Zamin Jumaat, Ubagaram Johnson Alengaram (2016): A study on Near Surface Mounted Composites for Flexural Strengthening of Reinforced Concrete Beams was conducted by Md. Akter Hosen, Mohd Zamin Jumaat, and Ubagaram Johnson Alengaram. The NSM strengthening technique with steel bars is a particularly cost-effective way to boost the flexural strength of an RC beam in this case. The use of NSM steel or CFRP bars increased the initial fracture load. The crack spacing was narrower in the strengthened beams than in the control beam. As a result, beams reinforced with NSM bars develop more and finer cracks with closer spacing than beams that are not strengthened.

Nafzin A A, Preetha Prabhakaran (2018) studied on the effect of Near Surface Mounted (NSM) Steel Bars on Shear Strength of RC Beams. It is observed that Shear strengthening of RC beams by NSM method is very effective in increasing its load carrying capacity. As the diameter of NSM bars increases, its contribution towards the load carrying capacity of RC beam also increases irrespective of varying NSM bar orientation.

Khattab saleem Abdul-razzaq (2017) conducted a study on A New Strengthening Technique for Deep Beam Openings Using Steel Plates. It is observed that the structural behavior of deep beams that had openings was primarily dependent on the interruption degree of the inclined compressive strut. Constructing openings led to decrease ultimate capacity. strengthening those openings via steel plates and adding studs to the strengthening plates was found very effective in upgrading the RC deep beam shear strength.

J.Suresh Research Scholar, R. Angeline Prabhavathy (2014) carried out a study on Behavior of Steel Fiber Reinforced Concrete Beams with Duct Openings Strengthened by Steel Plates. The main findings are

1. The Presence of duct openings in the shear zone of reinforced concrete beams reduces the load carrying capacity by 45% to 70% and the deflection reduces from 20% to 55%. The load carrying capacity decreases as the size of the duct opening increases.

2. Using steel fibers in beams with openings increases the load carrying capacity in the range of 5 to 30%. Steel fibers used in beams with openings increase the ductile characteristics of the beam

L. De Lorenzis a, J.G. Teng (2007) studied on Near-surface mounted FRP reinforcement: An emerging technique for strengthening structures. It is observed that The near surface monted FRP technique offers some significant advantages over the externally bonded FRP, including the more efficient use of the FRP material due to a reduced risk of debonding failure and the better protection of the FRP material from external sources of damage.

Amir Mofidi et al. (2015) investigated the use of Fiber Reinforced Polymer Composites in a near-surface mounted method for shear rehabilitation of reinforced concrete beams. From the creation of the first fracture to final collapse, this study provides an informative and thorough explanation of the behaviour of strengthened T-beams under increasing stress. When failure modes unrelated to shear resistance of RC beams were averted, the results of this study and those obtained in the database reveal that existing steel stirrups and strengthening NSM FRP did not lessen each other's effect.

Arun Murugesan et al., (2017) studied on the influence of a Longitudinal Circular Hole on Flexural Strength of Reinforced Concrete Beams and analysed the flexural strength of simply supported rectangular RC hollow beams (with a longitudinal circular hole) subjected to gradually increased and symmetrically applied two-point loads. Each hollow beam had a 25-, 40-, or 50-mm-diameter hole, and the position of the centre of the hole also varied from 45 to 180 mm from the top and comes into a conclusion that increase in the size of the hole resulted in a decrease in both the first cracking load and the ultimate load and the ultimate load-carrying capacity of hollow RC beams that have a longitudinal hole fully below the stress block is higher than that of all other hollow beams.

Mohd. Zamin (2011) investigated the Stress-Strain Distribution in High Strength Concrete Deep Beams in an experimental study. The behaviour, design, and analysis of high-strength reinforced concrete (HSC) deep beams in terms of neutral axis variation are discussed in this work. Self-compacted concrete was used to design and cast six (HSC) deep beams (SCC). The study of the stress-strain distribution along the beam section at mid-span and the fluctuation of the neutral axis inside the depth is the subject of this research. Strain gauges were installed on the concrete surface, tensile reinforcement, and horizontal and vertical web bars to monitor the strains in the concrete and reinforcement bars. The statistics clearly reveal that the deep beams, which were designed and produced with self-compacted concrete, have a distribution of strains and, thus, stresses (SCC). The study of the stress-strain distribution along the beam section at mid-span and the fluctuation of the neutral axis inside the depth is the subject of this research. Strain gauges were installed on the concrete surface, tensile reinforcement, and horizontal and vertical web bars to monitor the strains in the concrete and reinforcement bars. The statistics clearly reveal that the distribution of strains, and thus stresses, in the deep beams tested differs dramatically from the linear distribution generally assumed for ordinary beams. Deep beams also have more than one neutral axis, rendering the conventional beam theory employed in flexural design invalid.

Zsombor Kálmán Szabó et al., (2007) studied on Near surface mounted FRP reinforcement for strengthening of concrete structures and made a literature review regarding fibre reinforced polymers (FRP) used as near surface mounted (NSM) reinforcement for strengthening of concrete structures and different types of failure its causes and remedial measures.

3. CONCLUSIONS

When we provide duct openings in deep beam, some reduction occur in strength and stiffness due to reduction in effective area. To avoid this defect Near surfaces mounted reinforcement method is adopted and it has more advantages on compared to rest of methods like externally bonded technique, jacketing, bonding external plates using epoxy etc.

Going through the literatures it is observed that a deep study is very essential in the shear and flexural strengthening of deep beam with longitudinal duct, since it is used in large span heavy load coming areas. The strength and stiffness reduction varies as per the size, shape and position of the duct opening. So, an analytical study is needed to determine these changes this may help the future constructions.

REFERENCES

1. Ahmed Ismail el-kassasa, Hassan Mohammed Hassanb , Mohammed Abd El Salam Arabc, “Effect of longitudinal opening on the structural behavior of reinforced high-strength self-compacted concrete deep beams” (2020)

2. Dr. Yaarub Gatia Abtan, Hassan Falah Hassan, “A review of behavior of reinforced concrete deep beams” (2020)

3. Dr. Yaarub Gatia Abtan, Hussain Dhafer Abdul Jabbar “ Experimental Study to Investigate the effect of Longitudinal and Transverse Openings on the Structural Behavior of High Strength Self Compacting Reinforced Concrete Beams “(2019)

4. Hayder Mirdan Abdzaid and Hayder Hussein Kamonna “Flexural Strengthening of Continuous Reinforced Concrete Beams with Near-Surface-Mounted Reinforcement” (2019)

5. Khattab Saleem Abdul-Razzaq, Hayder I. Ali and Mais M. Abdul-Kareem “A New Strengthening Technique for Deep Beam Openings Using Steel Plates”

6. Arun Murugesan, Ph.D.1; and Arunachalam Narayanan, Ph.D. “Influence of a Longitudinal Circular Hole on Flexural Strength of Reinforced Concrete Beams” (2017)

7. Amir Mofidi; Omar Chaallal; Lijuan Cheng; and Yixin Shao "Investigation of Near Surface–Mounted Method for Shear Rehabilitation of Reinforced Concrete Beams Using Fiber Reinforced–Polymer Composites" (2015)

8. Parth D. Shahand, Prof. Yashwant sinhzala "Comprehensive review of near surface mounted technique used in Flexural" (2015) Volume: 5 Issue: 3 ISSN - 2249-555X

9. J.Suresh Research Scholar, R. Angeline Prabhavathy "Behaviour of Steel Fibre Reinforced Concrete Beams with Duct Openings Strengthened by Steel Plates" ISSN: 2319:2682 Vol.28, No.28, August 2014

10. L. De Lorenzis a, J.G. Teng "Near-surface mounted FRP reinforcement: An emerging technique for strengthening structures" (2006)