International Journal of Research in Advent Technology (IJRAT)
(E-ISSN: 2321-9637)
Special Issue National Conference "CONVERGENCE 2018", 09th April 2018

To Check The Impact Of Headed Bars Interms of Anchorage Strength In Concrete : A REVIEW

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Abstract- The introduction of high strength steel and concrete in reinforced concrete structures requires an efficient form of mechanical anchorage. Headed bars provide a practical alternative to hooked bars and eliminate congestion problems caused by standard hooks. Headed bas is also used to minimize slip, ease of placement, and more accurate dimension of reinforcing cages. Recent advances in welding technology have made it cost effective to attach steel plates to reinforcing bars. Headed reinforcing bars have been used in the construction of offshore oil platform and there is interest in using headed reinforcement in concrete members. It is felt that headed reinforcement will offer several advantages over straight and hooked reinforcing bars such as reduced congestion, lower bond slip and improved confinement of joints. This work presents an experimental Investigation on the Pullout capacity of the new developed headed bars to be used in the reinforced concrete structures. The variables used for the experimental work are embedded depth of headed Bar. Different size and shapes of heads of headed bar. The results of the test indicated that Pullout load required for Circular headed bars is maximum as compared to other headed bars at different embedded depth also as the embedded depth increases Strength index, Pullout load and Bond Stress increases. In most of the specimens slip of the Circular headed bar is minimum as compared to other and slip of the Square headed bars is maximum. Higher grade of concrete increases Pullout load, Strength index and Bond stress while it the decreases Slip of the bar. Size of head is kept in such a way that optimum conical fracture cone came during pullout. Due to large head slip of the headed bars decreases because large head holds large concrete in cylindrical specimens. Currently there are no Provisions in Bureau of Indian Standard that cover use of the headed bar in structural design, through this research and the research done by other authors will provide sufficient useful information for the further study.

Index Terms- Headed reinforcing bars, Anchorage Strength, Pullout capacity, Strength index

1 INTRODUCTION-

In structural concrete, the provisions for anchorage of straight bars and hooks, sometimes present detailing problems due to the long development length and large bend diameters that are required, particularly when large diameter reinforcing bars are used as shown in Fig 1.1 (a) and 1.1 (b) Occasionally, the requirements for straight bar anchorage and lap splices cannot be provided within the available dimensions of elements. Hooked bars can be used to shorten anchorage length, but in many cases, the bend of the hook will not fit within the dimensions of a member or the hooks create congestion and make an element difficult to construct. Similarly, mechanical anchorage devices can be used to shorten lap splice lengths, but they frequently require special construction operations and careful attention to tolerances.


Fig.1.1(a): Various headed bars Fig.1.1 (b): Congestion of Beam-column joint

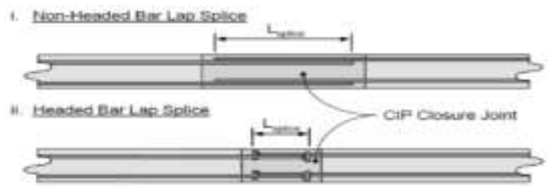

Fig.1.2: Reduction of closure strip width using headed bars

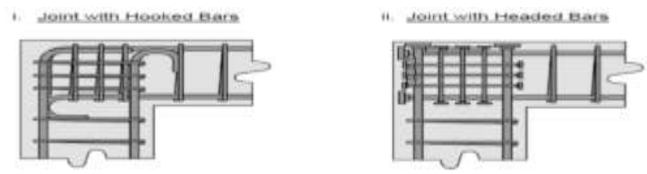

Fig.1.3: Reduction of congestion in a knee joint using headed bars

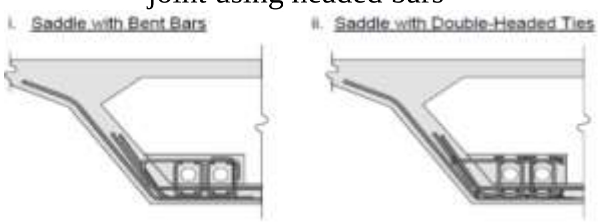

Fig. 1.4: Simplification of bar details in a deviation saddle using headed bars

2 **Headed bars-**

Headed bars were developed for the use in the construction of concrete platform of offshore oil industries. Like hook bars they can develop sufficient anchorage capacity within short distance, but, they do not create much congestion.

3 Objectives-

The objectives of this research work to study the effect of bearing ratio of headed bar on anchorage strength in pullout test.

3.1 To determine the effect of different head shapes and its bearing ratio on the bearing capacity of headed bar.

3.2. To study bond stress of headed bar.

3.3 Pull-out behaviour of Headed bar.

3.4 Effect of Grade of Concrete on Pullout Capacity of headed bar

4 Scope-

4.1 The study is an Experimental investigation on Anchorage behaviour of the headed bar in cylindrical specimens.

4.2 In this experimental work Grade of concrete varied (M20 & M30) and bar diameter kept constant.

4.3 Various failure modes of Headed bar were observed and studied and some concluding remarks were suggested from the experimental work.

5 LITERATURE REVIEW-

Headed bars were introduced in reinforced concrete construction because the provisions for anchorage of bars, splices, and continuity between elements pose significant difficulties for designers and contractors. Straight bar anchorages and lap splices are often so long that the resulting dimensions of elements are prohibitively large. The most common solution is to use hooked bars or to incorporate mechanical connectors. However, both options have drawbacks. Hooked bars create congestion problems and may make fabrication of reinforcement cages or placement and consolidation of concrete difficult when large amounts of reinforcement are required . Mechanical connectors require special construction operations and careful attention to tolerances. In order to reduce congestion problems, headed bars have been used instead of bent bars (hooks or ties) for shear reinforcement to anchor large diameter transverse reinforcement bars in the construction of reinforced concrete platforms for offshore development and petroleum production.

5.1 Zdenk P. Bazant et al (1988) the results of tests of the pullout strength of reinforcing bars embedded in concrete are reported. The test specimens are 1.5, 3, and 6-in.cubes with geometrically similar bars. The results are found to be consistent with Bazant's size effect law for the nominal stress at softening failures due to distributed cracking. Based on the size effect law, an approximate formula predicting pullout strength is developed.

5.2 Charles K. Kankam (1997) Author presents an experimental analysis to establish the fundamental relationship between bond stress, steel stress, and slip in reinforcedconcrete structures. Tests were conducted on double pullout specimens reinforced with 25-mm plain round mild steel, cold-worked and hot-rolled ribbed bars that had been fully instrumented internally with electrical resistance strain gauges. The results provided examples of the longitudinal variation of the steel strain (analogous to that between cracks). The method has proved to be capable of providing sufficient data for plotting the distribution of steel stress, bond stress, and slip between flexural cracks. The relationship between bond stress, steel stress, and slip was derived from the steel strain function, and has been represented by empirical formulas.

5.3 P G Bakir et al (2002) In this study, the authors have carried out several parametric studies on an experimental database consisting of concrete members with headed bars situated in the centre, corner and edge respectively. The factors influencing the ultimate load carrying capacity of concrete members are determined. It is apparent that the ultimate load carrying capacity will be much higher if the bar is a centre bar and the ultimate load carrying capacity of concrete members with headed bars will be much lower if the bar is a corner bar. If the bar is an edge bar, the ultimate load carrying capacity will take a value between the load carrying capacity of the centre bar and corner bar. The proposed equation for predicting the ultimate load carrying capacity of concrete members with headed bars is shown in Equation below.

$$Pu = \beta * hd0.8167 * (34.64 * Ahead + 64086)$$

Where Pu is the ultimate load carrying capacity of concrete members with headed bars hd is the embedment depth and Ahead =cross-sectional area of the headed bars and β is constant depending upon location of bar.

6 Gap in Research-

6.1 No special code and clause is design for headed bar in current Bureau of Indian standard.

6.2 Pull-out study on cylindrical specimens with different head sizes and shapes with different embedment depth Research done by very few people.

6.3 Headed bar as an anchorage requirement at what extent is useful in joint, research done by very few people.

6.4 Use of standard 90˚and 180˚ hooked bars up to required development length often results in steel congestion, difficult fabrication and construction, as well as poor concrete placement. Use of the headed Reinforcement bar can offer a potential solution for these problems and may also ease fabrication, construction, and concrete placement.

6.5The purposed study will developed basic data on anchorage of high-strength reinforcing bars and use those results to formulate design criteria for reinforced concrete structures.

7 Bond And Development Length Of Deformed Bars

A brief overview of conventional anchorage of reinforcing bars will be presented. In this chapter, the nature of bond stress and how it is utilized to achieve development of reinforcement will be discussed. Bond refers to the interaction between reinforcing steel and the surrounding concrete that allows for Transfer of tensile stress from the steel into the concrete. Bond is the mechanism that allows for anchorage of straight reinforcing bars and influences many other important features of structural concrete such as crack control and section stiffness. The bond mechanism is considered to consist of three mechanisms as chemical adhesion, friction and mechanical interlocking between indentations of reinforcement bars and concrete, the bond resistance resulting from chemical adhesion is usually very small and often lost after initial slip.

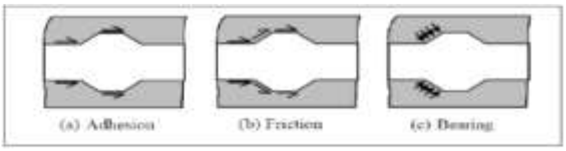

Fig.7.1: Idealized force transfer mechanism

7.1 **Plain bars**

As it has been said before the bond mechanism depends on the chemical adhesion, the friction and the mechanical interaction between concrete and steel. In plain bars the Bond depends mainly on chemical adhesion and after slip on friction. There is also some interlocking due to the roughness of the bar surface. In the anchorage zone the stresses, even when slip and separation are taken into consideration suggest that additional transverse cracks and splitting cracks are very probable with increasing force in the bar, the adhesion is lost first then the friction between concrete and steel. This means that there will be radial bond forces capable of splitting the concrete cover.

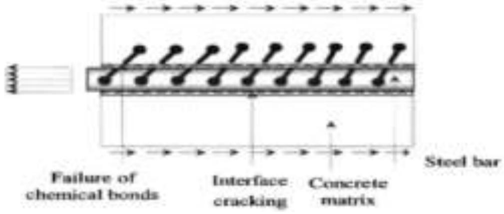

Fig.7.2: Deformations of concrete around steel reinforcing plain bar after formation of internal cracks

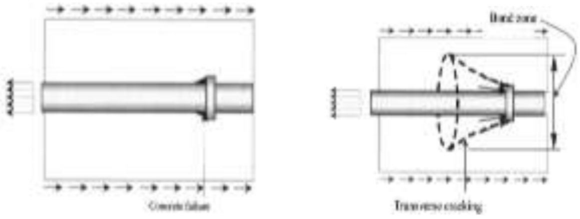

Fig 7.3: Mechanical interaction between deformed bar and the concrete.

7.2 Deformed bars-

In deformed bars with ribs the bond depends mainly on mechanical bond. The effect of chemical adhesion is small and friction does not occur until there is slip between bar and Concrete.

7.3 Bond stress-

Bond stress is the shear stress acting parallel acting to the bar on the interface between the bar and the concrete. Bond stress may be considered as the rate of transfer of force between concrete and steel. In other words, if there is bond stress there is change in steel stress and vice versa. Shows a straight bar embedded into a block of concrete. When the bond stress is sufficient to resist design tensile loads in the bar, then the bar is developed and the embedment length necessary for anchorage of the fully stressed reinforcing bar is referred to as its development length.

7.4 Development length and anchorage length-

The development length is defined as the length of the bar required on either side of the section to develop the required stress in steel at that section through bond. In other words development length is an embedded length of the bar required to develop the design stress in reinforcement at the critical section (shah and karve, 2007; Thompson et al., 2003) Anchorage length is a length required to transfer the forces from steel to concrete. Anchorage bond stress arises when a bar carrying certain force 'T' is to be terminated. In such a case, it is necessary to transfer this force 'T' in the bar to the concrete through bond. let the length required to transfer a force 'T' n the bar to the surroundings concrete by means of bond, before it is terminated, be Ld then bond considerations require that the bar must extend beyond that section by a length Ld before it is terminated so that it does not get pulled out. This length Ld of embedment of bar beyond the theoretical termination point is known as anchorage length Thus the development length and the anchorage length are in fact one and the same except in the former, the force in the bar is developed by transfer of force from concrete to steel while in the case, there is dissipation of force from steel to concrete.

7.5 Transverse cracking at deformations-

As a rib begins to bear on the concrete a wedge of crushed paste is formed in front of the rib. This wedge acts to change the effective face angle of the rib (Fig 3.5). Thus, the bond angle tends to change as a reinforcing bar acquires load. The effect of this is that radial splitting stresses tend to increase at a rate greater than the longitudinal bond stresses as tensile load in the reinforcing bar rises.

7.6 Top cast bar effect-

When concrete is placed and vibrated, lighter components of the mix will rise as heavier components settle to the bottom. When this occurs near reinforcing bars, air pockets and bleed water tend to collect on the undersides of the bars in place of coarse aggregates as shown in Fig . When the concrete sets, the bond around the bar is weaker on its underside because of the inferior quality of the concrete there. This effect is more pronounced for bars that have greater quantities of concrete placed under them than bars that are positioned close to the bottom surface of forms.

8 Background on Headed Bars and Pullout Test-

Headed bars are created by the attachment of a plate or nut to the end of a reinforcing bar to provide a large bearing area that can help anchor the tensile force in the bar. Fig 8.1 shows an example of a headed bar. The tensile force in the bar can be anchored by a combination of bearing on the ribs and on the head. This chapter discusses the current state-of-the-art of headed bar technology. The current products available on the market are discussed the available research is reviewed and pertinent code provisions are discussed

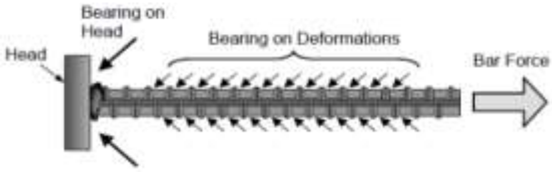

Fig.8.1: Anchorage of a headed

Throughout this chapter and through most of this report, the central parameter used for comparing different heads will be the area of the heads. In order to normalize results with respect to same bar sizes the ratio of head area to nominal bar area is repeatedly used. Specifically, this ratio, termed the relative head area, is defined as the net head area divided by the nominal bar area; the net head area being the gross head area (defined by the outer dimensions and shape of the head) minus the nominal bar area.

$$\text{Relative Head Area} = \frac{Anh}{Ab} = \frac{Agh - Ab}{Ab}$$

Anh = the net head area (mm2)

Agh = the gross head area (mm2)

Ab = the nominal bar area defined by ASTM A970/A970M-15

8.1 **Pullout Test-**

The purpose of this chapter is to provide basic and practical information about the pullout test. The pullout test measures the force needed to extract an embedded insert from a concrete mass. This chapter reviews the history of the development of this test method, including the various analytical studies conducted to understand the underlying failure mechanism for the test. Statistical characteristics of the method, such as within-test variability and the nature of the correlation with compressive strength, are discussed. It is shown that the characteristics of the coarse aggregate play an important role in the statistical properties of the test. Figure 1.6 illustrates the configuration of a pullout test. The insert is pulled by a loading ram seated on a bearing ring that is concentric with the insert shaft. The bearing ring transmits the reaction force to the concrete. As the insert is pulled out, a conical-shaped fragment of concrete is extracted from the concrete mass. The idealized shape of the extracted conic frustum is shown in Fig (8.2). Frustum geometry is controlled by the inner diameter of the bearing ring (D), the diameter of the insert head (d), and the embedment depth (h). The apex angle (2α) of the idealized frustum is given by

$$2\alpha = 2\tan^{-1}\left(\frac{D-d}{2h}\right)$$

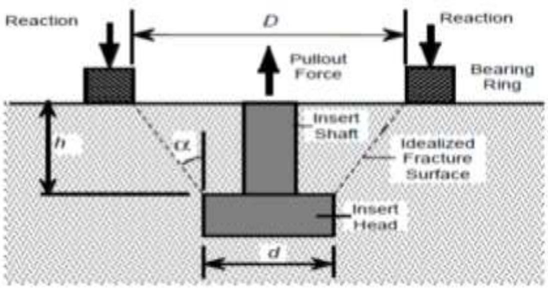

Fig.8.2: Schematic of the pullout test

The pullout test is used during construction to estimate the in-place strength of concrete to help decide whether critical activities such as form removal, application of post-tensioning, or termination of cold weather protection can proceed. Because the compressive strength is usually required to evaluate structural safety, the ultimate pullout load measured during the in-place test is converted to an equivalent compressive strength. Unlike some other tests used to estimate the in-place strength of concrete. The concrete to a slowly applied load and measures an actual strength property of the concrete. The concrete is subjected, however, to a complex three-dimensional state of stress, and the pullout strength is not likely to be related simply to uniaxial strength properties. Nevertheless, by use of a previously established correlation, the pullout test can be used to make reliable estimates of in-place strength. An important step in implementing the method is choosing the locations and number of pullout tests in a given placement of concrete. The inserts should be located in the most critical portions of the structure and there should be a sufficient number of tests to provide statistically significant results. Additional inserts are recommended in the event that testing begins too soon, and the concrete has not yet attained the required strength. The use of maturity meters along with pullout tests is encouraged to assist in selecting the correct testing times and in interpreting possible low-strength results. Techniques have been developed that permit testing in existing construction by drilling a hole and inserting some type of expansion anchor. Some methods subject the concrete to different stress conditions and have different failure mechanisms than the standard cast-in-place pullout test however, these methods have not found widespread acceptance because of their high variability. One method produces a failure surface that is similar to that of the cast-in-place test, and it has been included in the ASTM Standard. In summary, the pullout test has been standardized and is recognized as a reliable method for assessing the in-place strength of concrete during construction so that critical activities may be performed safely. As with other in-place tests, the active involvement of a qualified individual in all aspects of the testing program, from the correlation testing to the analysis of in-place data, is recommended to realize the potential benefits of the method.

9 CONCLUSION

This Analytical study was implemented to check the general application of headed bar with practical head size and embedded depth. Finding from this study are summarized as follows.

9.1 The reinforcement can be placed exactly at the desired location. It develops full anchorage strength with very small embedded length, which reduces considerable steel consumption at the junction. It also saves considerable construction costs because the concentrated can minimize the member size, for example reduced concrete depth, formwork and excavation for footings.

9.2 Fabrication and lying of 90˚and180˚ hooked bars with transverse reinforcement at the junction is really time consuming and laborious job. Headed bar are easy to place, even if no of bars are more which saves considerable time and labour. Reduced congestion and ease of placing of headed bars will improve construction thus speeding up a project.

9.3 The concrete also benefits because adequate space for pouring and vibration will give better concrete up a project.

9.4 Anchorage without utilisation of bond improves robustness at overload and accidental conditions. If spalling of concrete cover occurs (e.g. from fire or seismic loading) the heads still provide full anchorage without cover.

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