NOVATEUR PUBLICATIONS
International Journal of Research Publications in Engineering and Technology [IJRPET]
ISSN: 2454-7875
VOLUME 3, ISSUE 5,May -2017

TO STUDY EFFECT OF BOND STRENGTH WITH PROVIDED EFFECTIVE DEVELOPMENT LENGTH IN CONCRETE STRUCTURE

MR. AMAR PAWAR
Department .of Civil Engineering PDVVP, College of Engineering Ahmadnagar, India, Email id: amarpawar100@gmail.com

PROF. AUTADE P.B
Department .of Civil Engineering PDVVP, College of Engineering Ahmadnagar, India, Email id: pankajautade@gmail.com

ABSTRACT:

The bond between concrete and reinforcement is very important to work as a composite behavior of Reinforced Concrete (RC). The several factors which influences the Bond stress in RC are embedment length, diameter of bar, cover, spacing of bars, transverse reinforcement, grade and confinement of concrete around the bars, type of aggregates used in concrete, type of bars and coating applied on bars, if any, for corrosion prevention. Adequate bonding between reinforcing bars and concrete is essential for the satisfactory performance of RC structures. The study primarily should focus to achieve best possible outcome for desired provision of development length in terms of strength and effect of development length on concrete structure for bond stress.

KEYWORDS: Development length, steel bar, UTM, Compressive strength, pull out test , bond strength.

I. INTRODUCTION:

It is well known that the use of deformed bars can greatly enhance the steel–concrete bond capacity. Three main components determine the bond strength between the adjacent ribs of a reinforcement bar. The three main reasons which will contribute the bond strength between the adjacent ribs of a reinforcement bar are shear stresses due to adhesion along the bar surface, the bearing stresses against the faces of ribs (mechanical interlock), and the friction between bars with concrete in the rib dales and the surrounding concrete. From these the highest contribution to bond strength is achieved from mechanical interlock and because of their widespread application the deformed steel bars were considered in this study.

To improve the tensile cracking and prevent concrete failure, reinforcement using steel bars is carried out within the concrete mass. Concrete reinforcement increases the flexural behavior and loading capacity of concrete and Thermo Mechanically Treated (TMT) bar enhances the bond.

Steel works well as reinforcement for concrete because it bonds well with concrete and this bond strength is proportional to the contact surface of the steel to the concrete. The bond strength greatly varies with changes in mix design and grade of cement used and by providing intensive heat curing, high early bond strength can be achieved.

It is the mechanism that allow the anchorage of straight reinforcing bars and influence of many other important features of structural concrete such as cracks control and section stiffness similarly the bond between concrete and development length of reinforcing steel is essential for composite action in reinforcing concrete construction it is well known that the use of deformed bars can greatly enhance the steel concrete bond capacity. Adequate bonding between reinforcing bars and concrete is essential for the satisfactory performance of reinforced concrete structure.one of the main assumption in developing the theory of reinforced concrete is that the reinforcement do not from the surrounding concrete when concrete sets and thus hardness it will adhere to the surface of the embedment reinforcing bars will grip around it, there are basic components contributing to bond there are adhesion friction and mechanical anchorage.

II. LITERATURE REVIEW:

3.1. Muhd Fauzy Sulaiman, Chau-Khun Ma, et al, Review on Bond and Anchorage of Confined High-strength Concrete, Istruc(2017), doi: 10.1016/j.istruc.2017.04.004
It is important to understand the behaviour of bond and anchorage of reinforcement bars with the surrounding concrete. The interaction between reinforcement bars and concrete is essential to predict the ultimate failure of Reinforced Concrete (RC).

The codes of practice for Normal Strength Concrete (NSC) give designing anchorage length and can also be extrapolated from the experimental results of NSC for the high-strength concrete (HSC). Results shows the bond and anchorage of bars in HSC is relatively weaker as compared in NSC.

The methods adopted for the testing of bond and anchorage behaviour are pullout test, four-point bending test and cyclic uniaxial flexure under constant axial load test. Studies shows that the confinement effect can improve the bond and anchorage behaviour of RC, as Most of the studies were focused on other parameters such as concrete cover, embedment length, concrete type and rib geometry. Therefore, understanding gap and to be filled of the effects of confinement on the bond and anchorage behaviour of RC. Thus the performance of RC structures depends upon` the bond interaction between ribbed bars and concrete. The parameters to be tested should include the effects of concrete cover, embedment length, concrete type, rib geometry of reinforcement, bar diameter, number of stirrups, lap splice region, type of confinement, shape of transverse reinforcement, pre-flexural crack condition, water/cement ratio, cement content and transverse reinforcement ratio.

Based on review studies, highlights, on the types of tests used for evaluation of bond and anchorage of reinforcement bars in concrete considering different parameters such as concrete cover, concrete strength, bar diameter and embedment length which indicates that bond and anchorage behaviour of concrete are dependent on the types of reinforcement used. With different reinforcement bars gives different bond behaviour. The test most commonly adopted to investigate the bond strength of embedded reinforcement is pull-out test. It is generally reported that bond strength is lower for reinforcing bars with larger diameters and specimen with larger diameter needs more embedded length to provide minimum condition of acceptable bond strength.

3.2. N. Verma, A.K. Misra, Bond characteristics of reinforced TMT bars in Self Compacting Concrete and Normal Cement Concrete, Alexandria Eng. J. (2015), http://dx.doi.org/10.1016/j.aej.2015.06.011.

Concrete is the structural material extensively used globally. The plain concrete does not have the ability to carry tension. Hence to improve the tensile cracking and to prevent concrete failure, steel reinforcement is used within the concrete mass. Thermo Mechanically Treated (TMT) steel reinforcement increases the flexural behavior and loading capacity of concrete and also enhances the bond strength between reinforcements and concrete. The bond strength is proportional to the contact surface of the steel to the concrete, greatly varies with changes in mix design and grade of cement used and by providing intensive heat curing, high early bond strength can be achieved are some of the characteristics. Thus, concretes compressive strength, bar diameter, concrete cover, embedded length, and pre-flexural crack length also affect the bond strength.

The bond strength is resistance for separation of mortar and concrete from reinforcing steel (or other materials) with which it is in contact. In these days different kinds of concrete with different properties are manufactured, but bond strength is essential for quality for any RCC structure. Bond strength of concrete is determined by standard pull-out test, measured using Universal Testing Machine (UTM) with some modified arrangements.

3.3 Development length of reinforcing bars — Need to revise Indian code provisions

The bond between concrete and reinforcement bars is very important to develop the composite behaviour of reinforced concrete. Bond strength is influenced by several factors such as bar diameter, cover of concrete over the bar, spacing of bars, transverse reinforcement, grade and confinement of concrete around the bars, aggregates used in concrete, type of bars and coating applied on bars, if any, for corrosion prevention Bond in reinforced concrete refers to the adhesion between the reinforcing steel and the surrounding concrete. The bond between steel and concrete ensures strain compatibility (the strain at any point in the steel is equal to that in the adjoining concrete) and thus composite action of concrete and steel.

Bond in reinforced concrete is achieved through the following Mechanisms chemical adhesion due to the products of hydration

- frictional resistance due to the surface roughness of the reinforcement and the grip exerted by the concrete shrinkage.
- mechanical interlock due to the ribs provided in deformed bars. Since plain bars do not provide mechanical interlock many codes from other advanced countries prohibit their use in reinforced concrete and allow their use only for lateral spirals, stirrups and ties smaller than 10 mm in diameter. However, there is no such restriction in the Indian code.

Special checking of anchorage length is required in the following cases:

- in flexural members that have relatively short length
- at simple supports and points of inflection
- at points of bar cut-off
- at cantilever supports
- at beam-column joints in lateral load (wind and earthquake) resisting frames
- for stirrups and transverse ties and
- at lap splices.

Several failures have occurred due to the non-provision of adequate anchorage lengths, especially at cantilever supports, lap splices and beam-column joints. Hence, the provision for anchorage length assumes greater importance.

This paper discusses the Indian code provisions on anchorage length as compared with the ACI code provisions. The various drawbacks of the Indian code provisions are discussed and a suitable expression based on recent research is suggested.

Factors affecting the bond strength-

Bond strength is influenced by the following parameters.1,5

(i) Bar diameter: A beam reinforced with a larger number of small bars requires a smaller development length than a beam reinforced with smaller number of larger bars of the same total area

(ii) Cover concrete over the bar: If the concrete cover is increased, more concrete tensile strength can be developed, which will delay vertical splitting

(iii) Spacing of bars: If the bar spacing is increased, more concrete per bar would be available to resist the horizontal splitting

(iv) Transverse reinforcement such as stirrups: Stirrups with increased area, reduced spacing and / or higher grade of steel resist both vertical and horizontal splitting

(v) Grade of concrete: Higher grade of concrete has improved tensile strength and increased bond strength

(vi) Confinement of the concrete around the bars

(vii) Aggregates used in concrete: Light weight aggregate concrete will require more development length than normal weight concrete

(viii) Coating applied on reinforcement to reduce corrosion: Epoxy coating and galvanization prevent adhesion between the concrete and the bar and for typical cases a factor of 1.5 is imposed on development length. If the cover and spacing is large, the effect of epoxy coating is not so pronounced and the factor is reduced to 1.25,6.

(ix) Type of reinforcement: Deformed (ribbed) bars have enhanced bond strength than plain bars.

Another factor which influences bond strength is the depth of fresh concrete below the bar during casting. Excess water (often used in the mix for workability) and entrapped air invariably rise towards the top of the concrete mass during vibration and tend to get trapped beneath the horizontal reinforcement, thereby weakening the bond at the underside of these bars. This effect is called the top bar effect. The code provisions should include all these factors, so that the development length is correctly computed Bundled bars Increased development length for individual bars within a bundle, whether in tension or compression, is required when 3 or 4 bars are bundled together. The additional length is required because the grouping makes it more difficult to mobilise resistance to slippage from the "core" between the bars8. The ACI code given a modification factor of 1.2 for a three-bar bundle and 1.33 for a four-bar bundle. For the factors of Equation (6) which are based on bar diameter, db , a unit of bundled bar must be treated as a single bar of a diameter derived from the total equivalent area6. In the Indian\ code, the development length is increased by 10 percent for two bars in contact, 20 percent for three bars in contact and 33 percent for four bars in contact — which are similar to ACI Code Standard hooks in tension Development length, Ldh , measured from the critical section to the outside end of the standard hook (that is, the straight embedment length between the critical section and the start of the hook, plus the radius of bend of the hook, plus one bar diameter)

3.4 Bond behavior and assessment of design ultimate bond stress of normal and high strength concrete

Bond refers to the interaction between reinforcing steel and the surrounding concrete, which allows transferring of tensile stress from the steel into the concrete. It is the mechanism that allows the anchorage of straight reinforcing bars and influences many other important features of structural concrete such as crack control and section stiffness [1]. Similarly the bond between concrete and development length of reinforcing steel is essential for composite action in reinforced concrete construction [2,3]. It is well known that the use of deformed bars can greatly enhance the steel–concrete bond capacity. Three main components determine the bond strength between the adjacent ribs of a reinforcement bar. These components are shear stresses due to adhesion along the bar surface, the bearing stresses against the faces of ribs (mechanical interlock), and the friction between bars with concrete in the rib dales Adequate bonding between reinforcing bars and concrete is essential for the satisfactory performance of reinforced concrete structures. In the absence of sufficient bond strength, effective beam action, as required by codes of practice, cannot be achieved, and hence, the specified design equations are no longer valid. Loss of strain compatibility at the depth of a reinforcement results in a redistribution of stresses in the reinforced concrete element, which may lead to excessive service deflections and altered load capacities Also some factors affect negatively the bond strength such as epoxy coating. This effect is due to reduction in adhesion and frictional components along the smooth epoxy surface [13]. Compared with uncoated bars, the decrease in bond strength was found to range from 15% to 50% depending on several factors such as the coating thickness, bar size and location, deformation patterns, concrete properties, and casting conditions The confinement was defined as one of the key parameters which influenced the value of the maximum bond stress. This point is of great concern especially in the case of structures which are reinforced with stirrups or submitted to a tri-axial state of stress [10,11]. Torre-Casanova et al. showed [12] that the splitting and pullout failures depend on the concrete cover 3.4. Effect of bar diameter Fig. 11 shows the effect of bar diameter on ultimate tensile bond strength and ultimate slip. It is shown that as the bar diameter increases, the bond strength decreases, and the corresponding slip increases. As an example, the ultimate tensile bond strength decreases by 10%, 6%, 6% and 5% when the bar diameter increases from 16 to 18 mm for concrete compressive strength 30, 50, 70 and 90 MPa, respectively. Effect of embedded length- the effect of embedded length on both ultimate tensile bond strength, and ultimate slip. It is shown that as the used embedded length increases, the ultimate bond strength increases, and the corresponding slip increases. When the\ development length increases from 5 bar diameter to 7.5 and 10 bar diameter the bond strength increases by 4.3% and 10.0%, respectively.

The bond stress–slip relationship proposed in [27] consists of an increasing first branch up to the bond strength. the slip is increasing for constant bond strength, after which bond strength starts to decrease for increasing slip values. Finally, a constant residual bond strength is reached which is due to pure friction between the steel bar with the cracked concrete lugs and the surrounding concrete. However, experimental study on the early-age bond stress–slip relationship between steel bars and HSC remains lacking. Thus, the model for early-age bond stress– slip relationship between steel bars and HSC must be studied for better understanding the cracking resistance of HSC structures. Although the relationship between steel bars and normal strength concrete has been studied, the early-age bond stress–slip relationship between steel bars and HSC considering the effect of concrete age is still lacking. Thus, the bond stress–slip relationship between steel bars and HSC of different ages must be investigated. Tests on the effect of concrete age and concrete strength on bond strength, the slip corresponding to bond strength and the prediction model for bond stress–slip relationship between steel bars and HSC of different ages were conducted in present study for better understanding the bond behavior of HSC structures.

Relationship between bond strength and concrete age- Fig. 4 shows the bond stress–slip relationship between steel bars and HSC at the age of 1, 3, 5, 7, 14, and 28 days. The pullout load between steel bars and HSC increased rapidly with the slight slip value, and later decreased with high slip value once the maximum pull-out load was reached. The comparisons of bond stress–slip relationship for specimens at different ages are shown in Fig. 5. The basic nature of the relationship seemed almost the same regardless of concrete age. Fig. 6 shows the effect of concrete age on bond strength and clearly shows that concrete age has a great influence on bond strength, which is in good accordance with results in [21,23,24,42]. Moreover, the effect is more noticeable during the first 7 days after casting. The bond strengths were 5.89, 14.81, 19.82, 21.95, 22.56, and 25.54 MPa when the concrete age was 1, 3, 5, 7, 14, and 28 days, respectively, as shown in Table 4 and Fig. 6. The bond strength increased by 151%, 237%, 273%, 283%, and 334% when concrete age increased from 1 day to 3, 5, 7, 14, and 28 days, respectively. As shown in Fig. 6, the relationship between bond strength and concrete age was nonlinear and could be written.

3.5. Bond behavior of normal/recycled concrete and corroded steel bars

Adequate bonding between reinforcing bars and concrete is essential for the satisfactory performance of reinforced concrete structures. In the absence of sufficient bond strength, effective beam action, as required by codes of practice, cannot be achieved, and hence, the specified design equations are no longer valid. Loss of strain compatibility at the depth of a reinforcement results in a redistribution of stresses in the reinforced concrete element, which may lead to excessive service deflections and altered load capacities

The available bond strength at the interface between a steel bar and concrete is affected by the corrosion of the steel bar. Corrosion products can alter the surface conditions at the boundary between the reinforcement and concrete and hence influence the development of bond stresses. Additionally, corrosion-induced cracking or spalling of the cover will reduce the confinement provided by the concrete to the reinforcement, which is accompanied by a corresponding reduction in the bond strength. The consequences of each of these effects have a great influence on the serviceability and loading capacity of concrete structures. Research on the topic of bond degradation due to reinforcement corrosion has produced a wide range of results

Bond-slip relationship varying with different locations

Local relationship between bond stress and slip- The slip at different locations can be calculated according to the method introduced in a previous study Based on the bond stress distributions and the slip distributions, the stress–slip relationship can be obtained. The typical stress–slip relationship of the specimen 00-N-0 is shown in Fig. 21. The local bond–slip curves of other specimens are illustrated in Appendix A. It can be clearly observed that the stress–slip relationships are different at each location along the steel bars10 mm size

III. CONCLUSION:

The paper present the bond strength with provided effective length in concrete structure as well as to achieve best possible outcome for desired provision of development length in terms of strength. if we changed the development length angle ,it will give good outcome for civil structure. It concludes that effective development length angle can be give good strength in concrete structure.

REFERENCES:

1) Kuihua Mei a, Rudolf Seracino b,⇑, Zhitao Lv An *experimental study on bond-type anchorages for carbon Fiber-reinforced polymer cables.*

2) Ahmed M. Diab, Hafez E. Elyamany *, Mostafa A. Hussein, Hazem M. Al Ashy, Bond *behavior and assessment of design ultimate bond stress of normal and high strength concrete*
3) Muhd Fauzy Sulaiman, Chau-Khun Ma, Nazirah Mohd Apandi, Sofrie Chin, Abdullah Zawawi Awang, Shaiful Amri Mansur,Wahid Omar, *A Review on Bond and Anchorage of Confined High-strength Concrete*.
4) S.S. Mousavi a, M. Dehestani b,⇑, K.K. Mousavi c Bond *strength and development length of steel bar in unconfined self-consolidating concrete.*
5) N. Subramanian, *Development length of reinforcing bars Need to revise Indian code provisions.*
6) Dejian Shen a,b,⇑, Xiang Shi a,b, Hui Zhang a,b, Xiaofang Duan a,b, Guoqing Jiang *Experimental study of early-age bond behavior between high strength concrete and steel bars using a pull-out test*
7) Nipun Verma, Anil Kumar Misra, *Bond characteristics of reinforced TMT bars in Self Compacting Concrete and Normal Cement Concrete .*
8) Yuxi Zhao ⇑, Hongwei Lin, Kang Wu, *Weiliang Jin Bond behaviour of normal/recycled concrete and corroded steel bars*
9) Al-Sulaimani GJ, Kaleemullah M, Basunbul IA, Rasheeduzzafar. *Influence of Corrosion and cracking on bond behavior and strength of reinforced concrete Members*. ACI Struct J 1990; 87:220–31. 3] Almusallam AA, Al-Gahtani AS, Aziz.
10) Amleh L, Mirza S. *Corrosion influence on bond between steel and concrete*. ACI Struct J 1999; 96:415–23.
11) Li F, Yuan Y. *Effects of corrosion on bond behavior between steel strand and concrete*. Constr Build Mater 2013;38:413–22.
12) J.A. Joseph, A.I. Camille*, Bond strength of epoxy-coated bars in Underwater concrete,* Constr. Build. Mater. 30 (2012) 667–674.