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

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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. This study primarily focuses 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. The concrete cube design and casting for M20, M25 & M30 grade (7 days, 14 days, and 28 days) carried out and compressive strength is determined. In further study, concrete cube (150mmx150mm X150 mm) with constant embedded reinforcement length of different size diameter (6, 8, 10, 12, 16, mm) steel having variation in development length bar angle from 0, 45, 90, 135 and 180 degree were tested for pull out test on concrete and casting for M20, M25 & M30 grade (7 days, 14 days, and 28 days) carried bond strength results were obtained.

KEYWORDS: Development length, Plain and tor steel bar, UTM, Compressive strength, bond strength.

INTRODUCTION

It is well known that the use of deformed bars can greatly enhance the steel–concrete bond capacity. Basis some important 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 tension cracking and avoid concrete failure, reinforcement using steel bars is carried out within the concrete mass. Steel reinforcement for concrete because it joint 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..

Anchorage bond stress arises when a bar carrying certain force is to be terminated in such case it is necessary to transfer this over a certain length. The length of the bar 'Ld' required to transfer the force in the bar to the surrounding concrete through bond is called anchorage length this length of embedment ld of the bar beyond theoretical terminatations point is required so that the bar does not get pulled out.

The development length L_d is given by,

$$Ld = \frac{0.87 fy \dot{A} \Phi}{4 \zeta bd}$$

Where, Φ=Nominal diameter of the bar

τ_{bd} = Design bond stress

LITERATURE REVIEW:

N Subramanian et.al(2000)**,** presented the composite action of concrete and steel in reinforced concrete structures is provided by bond strength. The required bond strength is achieved by providing sufficient development length. Non-provision of adequate development lengths often results in failures, especially in cantilever supports, lap splices and beam - column joints. The bond strength is influenced by several factors which include: bar diameter, cover concrete, spacing of reinforcement, transverse reinforcement (such as stirrups), grade of concrete, Confinement of concrete around the bars, aggregates used in concrete, coating applied on bars to reduce corrosion, and type of reinforcement bars used. Though the Indian code was revised recently, mainly to take care of durability considerations, the development length provisions remain unchanged and do not cover the effect of several parameters.

Ahmed M. Diab et.al 2014, shown that concrete with the same compressive strength, the tensile pull-out bond strength is lower than the single pull-out bond strength. High strength concrete specimens fail in a brittle manner, and the specimens fail abruptly forming longitudinal splitting cracks. As the pre-crack length increases, the bond tensile strength decreases and the corresponding slip increases. The fully cracked specimen losses 30% of the ultimate bond strength of un-cracked section bond strength. Proof bond strength is proposed to represent the bond stress used in ultimate design.

Nipun Verma et.al 2014**,** presented the Self-compacting concrete is gaining attention worldwide owing to its ability to compact without the need for either internal or external vibration even in areas of highly congested reinforcement such as beam-column joints. Since last two decades, several researches have been conducted on Self-compacting concrete and now application of SCC has gained momentum. In the present study, bond stress corresponding to the maximum pull-out load that can be regarded as the bond strength or ultimate bond strength was conducted. The slow development of compressive strength and bond strength in SCC at early age is generally due to the retarding effect of the super plasticizer used. Further bond strength varies with changes in mix design and grade of cement used and curing conditions.

Xiaobin Song et.al 2015**,** compared the results of early age concrete bond tests in specimens with small concrete cover-to-bar-diameter ratios (C/D) that mostly suffered from concrete splitting failure modes. The influences of concrete strength and c/d on the key parameters (bond strength, bond slip and two shape parameters) of such bond behavior were discussed, Bond strength s1 and shape parameter k of the post-peak branch were in proportion with the time-dependent concrete compressive strength of prism. However, slip s1 and shape parameter of the ascending branch exhibited significant variation, and no solid dependence on the concrete strength was found. Normalized bond strength s1/fc was linearly related to c/d up to 1.39, beyond which no correlation was observed. The other three parameters showed no correlation with c/d in all cases.

S.S. Mousavi et.al 2016 presented Increase of bond length leads to decreasing of the maximum normalized bond stress for both types of tests (direct pull-out and beam). Contradictory to the case of direct pull-out tests, maximum normalized bond stress increases for increasing rebar diameter the magnitude of this increase being dependent upon both the bond length and the oven-dry density of the mix (larger for lower mix densities and for shorter bond lengths). A plausible explanation of this phenomenon is given in the paper. For the case of direct pull-out tests (resulting in splitting failure modes), the maximum normalized bond stress and the ultimate slip increase with increasing concrete density being the result of partial or full replacement of lightweight aggregates with normal-weight ones. This increase is significant (more than 40%) for oven-dry densities in the range of 1550 kg/m3– 1700 kg/m3. Strength gains for densities close to or higher than the upper oven-dry density limit for lightweight concrete (2000 kg/m3) are limited. Moderate bond strength gains due to concrete density increase are also noted for the case of beam tests (resulting in pull-out failure modes). More specifically, if rebar pull-out takes place the all-lightweight SCC bond strength is up to 30% lower than that of NWSCC.

Pieter Desnercks et.al 2015, studied that for specimen with a single crack the reduction was on average 44% and for double cracked specimens the reduction was 54%. The measured values for single and double cracked specimens are within the relatively wide range of values reported by other researchers in the past. The crack orientation with respect to the rib pattern of the reinforcing bars has little or no effect on the obtained bond properties. Three different crack orientations were tested and the results showed similar ultimate bond strengths. For double cracked specimens the order in which the cracks are formed (linked to the test method) has no significant Influence on the bond behavior. Confinement influences the ultimate bond strength of a pre-cracked specimen. In the absence of a restraining force, existing, the residual bond strength after cracking is reduced as well. For smaller covers the failure mode of the uncracked concrete shifts from a pull-out failure to a splitting failure. However, the obtained values are higher than those obtained for concrete with a single crack extending through the entire concrete cover but confined by a plastic tube of 2.1 mm thick. The obtained test results indicate that the presence of longitudinal cracks can significantly influence the bond behavior of ribbed reinforcing bars in concrete. It is suggested that bond reduction factors are necessary for cracks that run along the reinforcement bars when undertaking load bearing capacity checks of existing reinforced concrete structural.

OBJECTIVES OF PROJECT WORK

1. To investigate the bond strength of plain steel and Tor steel with varying diameter of bar.
2. To study the effect on bond strength of concrete of plain steel and Tor steel with change the development length angle.
3. To achieve the best possible outcome for desired provision of development length in terms of strength.
4. To investigate the plain steel in tension bond strength value to IS code 456-2000 bond strength value.

SCOPE OF WORK

The Pullout test results are to be shown on the effects of bond strength with consider various parameters on the of the normal and high grade concrete. Research is going on bond strength with engineering applications of normal and high grade concrete. This particular work is to be presented in this project to deals with investigating bond strength for M20, M25 & M 30 Mix design of normal and high grade concrete. In the present work, evaluated bond strength of various parameter consider such as grade of concrete bar diameter size and development length angle of the normal and high grade concrete. The scope of present work, if we check to provided less quantity of steel and concrete and achieve economical in construction world.

MATERIALS & METHODOLOGY

1) CEMENT

Ordinary Portland cement of grade 53 was used. The initial setting time of cement is 30 minutes and the specific gravity of cement is 3.15.

2) FINE AGGREGATE

Fine aggregate used in this research work was conforming to IS and was clear sand passing through 4.75mm sieve with a specific gravity of 2.68. The grading zone of aggregate was zone II.

3) COARSE AGGREGATE

Coarse aggregate used in this research work was conforming to IS and was angular crushed aggregate with a specific gravity of 2.70.

4) WATER

Potable water available in the laboratory with the pH of 7.0 ± 1 and conforming to the requirement of IS: 456-2000 was used for mixing concrete and also for curing of specimens.

5) CONCRETE MIX DESIGN

As per the recommended procedure of Bureau of Indian Standards IS 10262: 2009, design concrete mix is adopted to attain 20N/mm^2,25N/mm^2 and 30 N/mm^2. The water cement ratio of 0.5 after several trials is used. many cubes were casted for each bar with various development lengths and tested after curing for 7days, 14days and 28 days (3each). Respectively

6) COMPRESSIVE STRENGTH

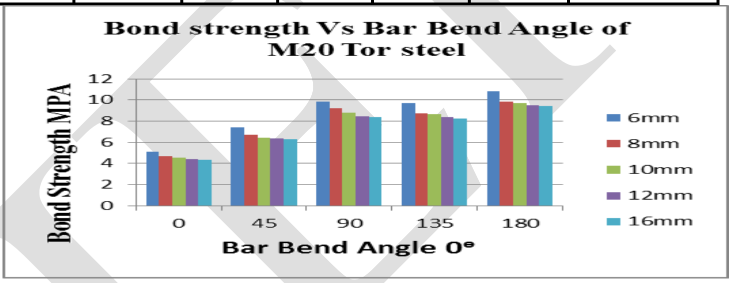
Three cubes of size 150x150x150mm were casted to work out the 7day, 14 days, and 28 days compressive strength for M20, M25 & M30 proportions. The results for 7, 14 and 28 days compressive strength were obtained.

7) PULL OUT TEST-

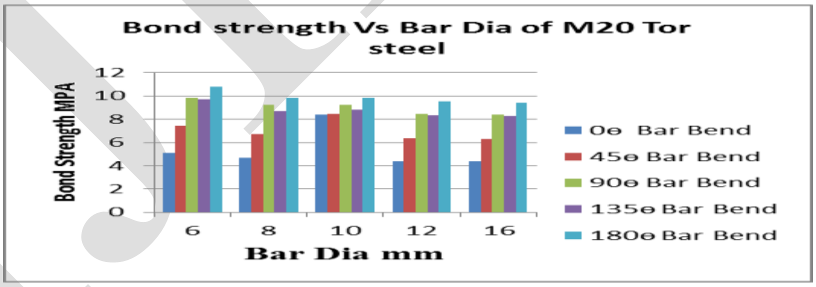
Three cubes of size 150x150x150mm with placed steel bar (plain and tor) of various diameter and provided various angle for development length 0,45,90,145,180 angle) of M20, M25 and M30 grade concrete and casted to work out 7, 14 and 28 days respectively. The results of Bond strength were obtained.

4.1 Pull out test of Tor steel for M20 Grade

Sr No	Bar dia in mm	Avg. Bond Strength (Mpa) with Bar Bend Angle(0°)				
		0°	45°	90°	135°	180°
1	6	5.13	7.43	9.84	9.69	10.82
2	8	4.69	6.7	9.23	8.72	9.84
3	10	4.57	6.44	8.82	8.68	9.73
4	12	4.4	6.38	8.44	8.36	9.52
5	16	4.37	6.3	8.4	8.25	9.43



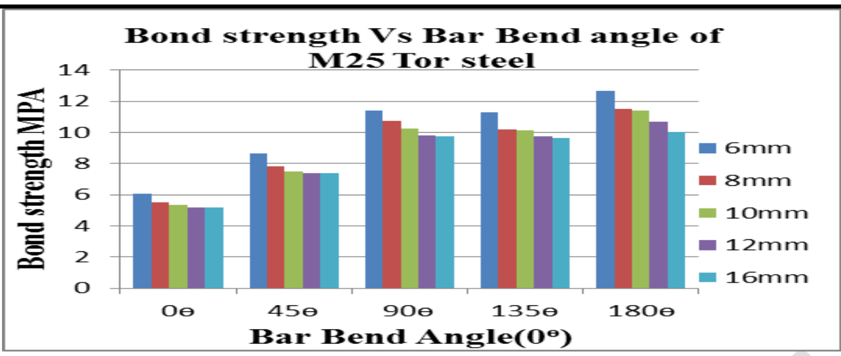
Graph 4.1 Bond strength Vs Bar Bend Angle of M20 Tor steel



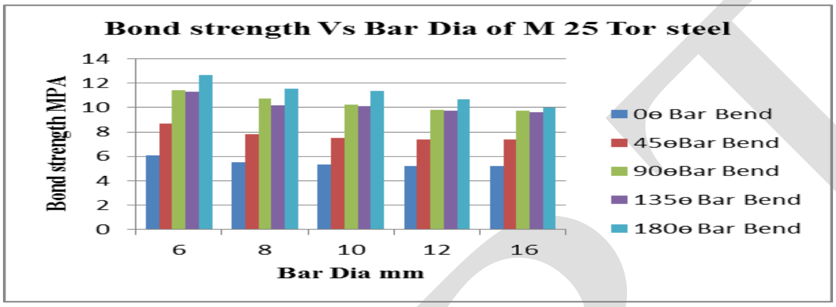
Graph 4.2 Bond strength Vs Bar Diameter when M20 Tor steel

4.2 Pull out test of M25 Tor steel

Sr No	Bar dia in mm	Avg. Bond Strength (Mpa) with Bar Bend Angle(0°)				
		0°	45°	90°	135°	180°
1	6	6.07	8.68	11.41	11.29	12.67
2	8	5.52	7.83	10.74	10.2	11.54
3	10	5.36	7.49	10.26	10.12	11.39
4	12	5.19	7.41	9.79	9.75	10.67
5	16	5.18	7.38	9.77	9.62	10.01



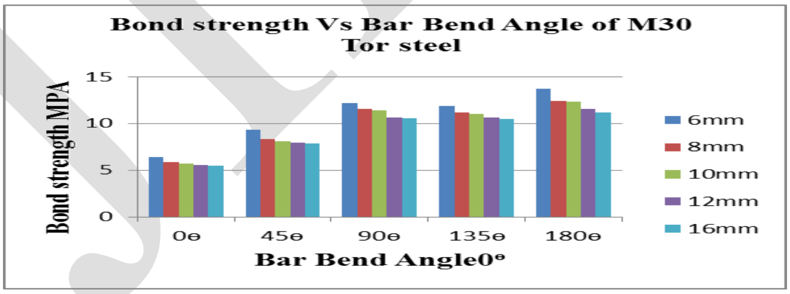
Graph 4.3 Bond strength Vs Bar Bend Angle of M25 Tor steel.



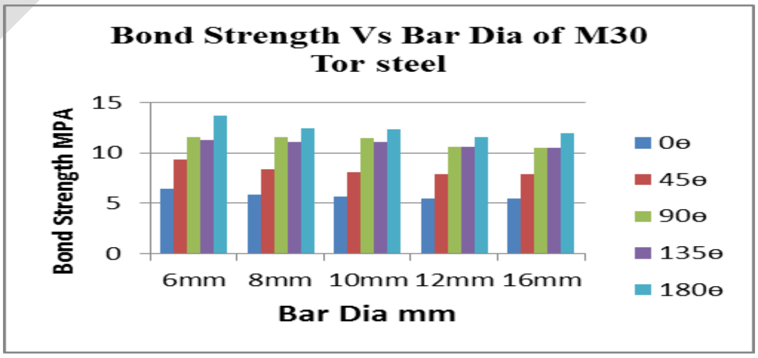
Graph 4.4 Bond strength Vs Bar Diameter when M25 Tor steel

4.3 Pull out test of of M30 Grade Tor steel

Sr No	Bar dia in mm	Avg. Bond Strength (Mpa) with Bar Bend Angle(0°)				
		0°	45°	90°	135°	180°
1	6	6.43	9.32	12.52	11.32	13.70
2	8	5.87	8.36	11.57	11.06	12.44
3	10	5.72	8.07	11.42	11.05	12.34
4	12	5.52	7.92	10.61	10.60	11.56
5	16	5.47	7.90	10.53	10.46	11.21



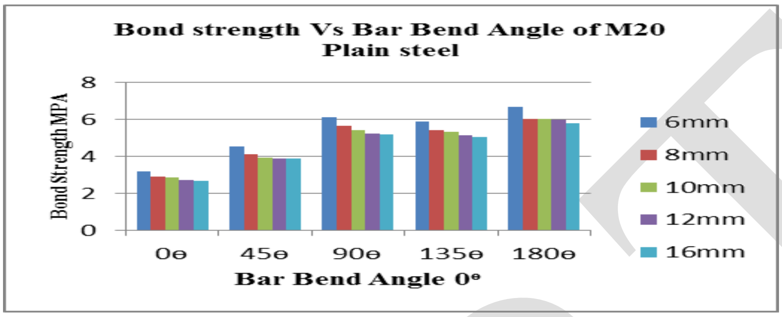
Graph 4.5 Bond strength Vs Bar Bend Angle of M30 Tor steel



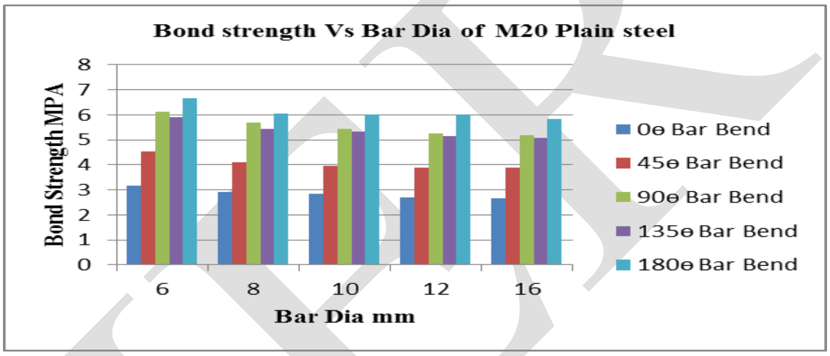
Graph 4.6 Bond strength Vs Bar Diameter when M30 Tor steel

4.4 Pull out test of M20 Grade Plain steel

Sr No	Bar dia in mm	Avg. Bond Strength (Mpa) with Bar Bend Angle(0°)				
		0°	45°	90°	135°	180°
1	6	3.18	4.53	6.13	5.90	6.67
2	8	2.91	4.12	5.68	5.43	6.05
3	10	2.85	3.95	5.43	5.34	6.03
4	12	2.70	3.90	5.24	5.14	6.00
5	16	2.68	3.89	5.17	5.07	5.82



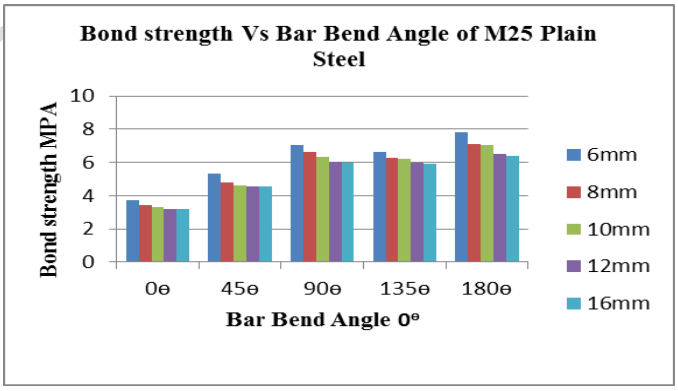
Graph 4.7 Bond strength Vs Bar Bend Angle of M20 Plain steel



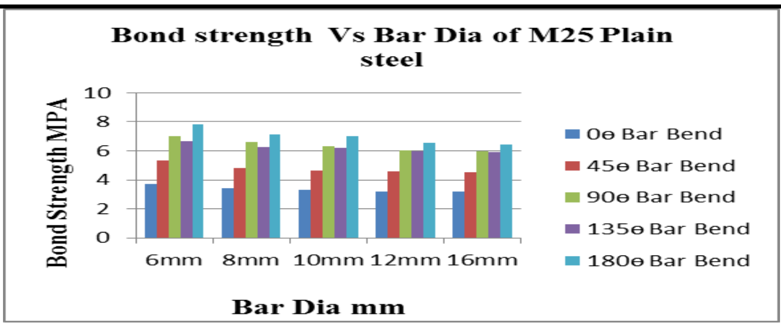
Graph 4.8 Bond strength Vs Bar Diameter when M20 Plain steel

4.5 Pull out test of M25 Grade Plain steel

Sr No	Bar dia in mm	Avg. Bond Strength (Mpa) with Bar Bend Angle(0°)				
		0°	45°	90°	135°	180°
1	6	3.74	5.34	7.02	6.65	7.82
2	8	3.42	4.82	6.62	6.27	7.10
3	10	3.31	4.62	6.32	6.21	7.04
4	12	3.19	4.57	6.03	5.99	6.53
5	16	3.17	4.54	5.98	5.92	6.42



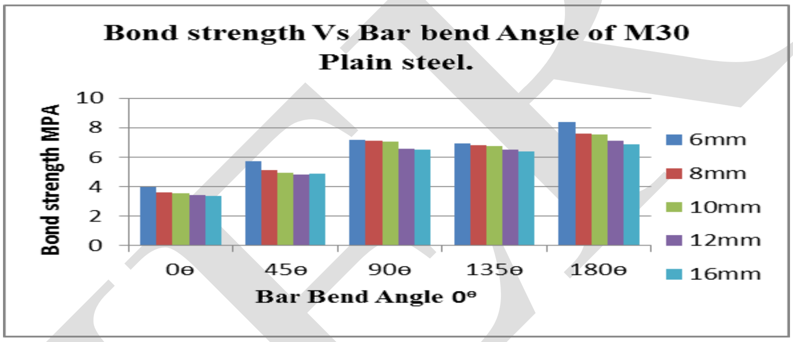
Graph 4.9 Bond strength Vs Bar Bend Angle of M25 Plain steel



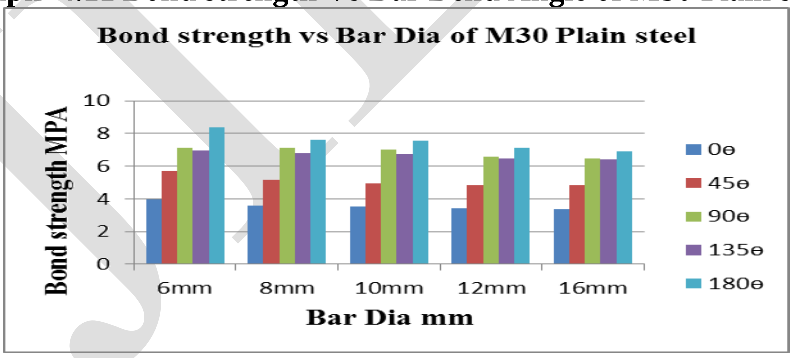
Graph 4.10 Bond strength Vs Bar Diameter when M25 Plain steel

4.6 Pull out test of Plain steel of M30 Grade.

Sr No	Bar dia in mm	Avg. Bond Strength (Mpa) with Bar Bend Angle(0^o)				
		0^o	45^o	90^o	135^o	180^o
1	6	3.95	5.72	7.15	6.95	8.39
2	8	3.61	5.14	7.12	6.78	7.62
3	10	3.52	4.94	7.03	6.76	7.54
4	12	3.41	4.89	6.58	6.48	7.12
5	16	3.37	4.86	6.49	6.40	6.88



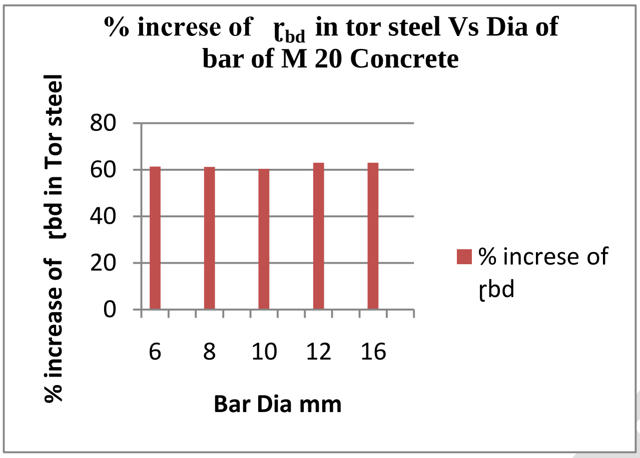
Graph 4.11 Bond strength Vs Bar Bend Angle of M30 Plain steel



Graph 4.12 Bond strength Vs Bar Diameter when M30 Plain steel

Table 4.7% Increase of τ_{bd} in Tor Steel of M20 Grade

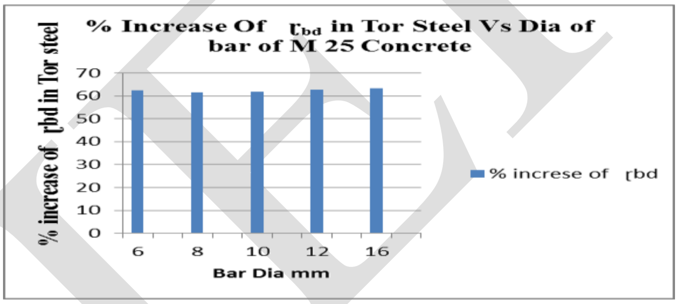
Sr N0	Dia of bar in mm	τ_{bd} of plain bar in MPA	τ_{bd} of Tor bar in MPA	% increased of τ_{bd} in Tor steel
1	6	3.18	5.13	61.32
2	8	2.91	4.69	61.17
3	10	2.85	4.57	60.35
4	12	2.70	4.40	62.96
5	16	2.68	4.37	63.06



Graph 4.13 % Increase Of τ_{bd} In Tor Steel Vs Bar Dia of M20 Grade Concrete.

4.8 % Increase of τ_{bd} in Tor Steel of M25 Grade

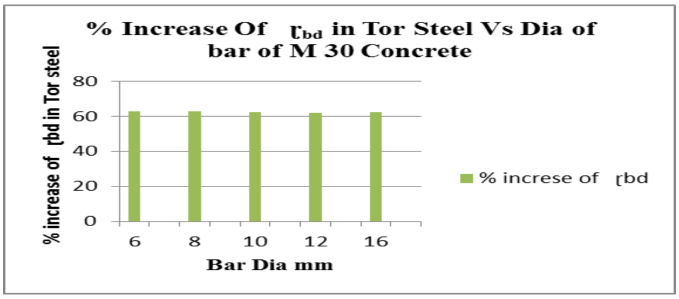
Sr N0	Dia of bar in mm	τ_{bd} of plain bar in MPA	τ_{bd} of Tor bar in MPA	% increased of τbd in Tor steel
1	6	3.74	6.07	62.30
2	8	3.42	5.52	61.40
3	10	3.31	5.36	61.93
4	12	3.19	5.19	62.70
5	16	3.17	5.18	63.41



Graph 4.14 % Increase Of τ_{bd} In Tor Steel Vs Bar Dia of M25 Grade Concrete

4.8 % Increase of τ_{bd} in Tor Steel of M30 Grade

Sr N0	Dia of bar in mm	τ_{bd} of plain bar in MPA	τ_{bd} of Tor bar in MPA	% increased of τbd in Tor steel
1	6	3.95	6.43	62.78
2	8	3.61	5.87	62.60
3	10	3.52	5.72	62.50
4	12	3.41	5.52	61.88
5	16	3.37	5.47	62.31



Graph 4.15 % Increase Of τ_{bd} In Tor Steel Vs Bar Dia of M30 Grade Concrete

CONCLUSIONS

Pull out test on cube test were conducted to determine bond strength of concrete with various paramerer such as comparisons between bond strength of plain steel vs Tor steel ,development length angle and various diameter of bar of M20,M25&M30 grade. The main conclusions of this study are as fallows,

1. For deformed bars in tension bond strength increased by 62 percent approximately as comparative to plain bars in tension. because hardness of concrete is related to the mechanical interlock of deformed bars, However the bond strength of plain bars is mainly composed of adhesive stress and friction which does not mechanical interlock.
2. The bar diameter increased, the bond strength decrease, As an example, the ultimate tensile bond strength decreased by 10%, 4%, 5% and 7% approximately, when the bar diameter increases from 6mm to 16 mm for concrete compressive strength 20, 25, and 30 MPa, respectively. If loading increased up to ultimate stress, then test specimen pulled out quickly from concrete block and the corresponding slip occurred as well as concrete block specimen damaged, when the reinforcing bars was pulled out.
3. If grade of concrete increases improved tensile strength and increased bond strength as 18% and 8% from M20 to M25 and M25 to M30 Grade respectively.because if the grade of concrete increased more surface area of cement particle is available for hydration and reduce W/C ratio, corresponding improved the bond capacity in-between cement mortor concrete and steel.
4. when first time bar bend angle increased from 0^{o} to 45^{o} bond strength increased approximately. 40-45% approximately, again second time the bar bend angle increased from 0^{o} to 90^{o} bond strength increased 90-95% approximately, as well as third time the bar bend angle increased from 0^{o} to 135^{o} bond strength increased as 85-90% approximately and last time when again the bar bend angle increased from 0^{o} to 180^{o} bond strength increased as 101-110% approximately because if the angle increased more contact area available friction so increase angle increase the bond strength.
5. The plain bars in tension the value of bond strength is more than 2-3 times more than IS456-2000.
6. If we replaced bar bend angle from 0o to 180o reduce embedment length and we saved steel approximately 15-25% in embedment length.

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