INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

Experimental Study on Direct Pull out Test: Straight Bar, Bent-Up and Headed Bar

Mayur Parmar
Applied Mechanics Department, Government Engineering Collage, Dahod, Gujarat, India
M. A. Jamnu
Professor, Applied Mechanics Department, Government Engineering Collage, Dahod, Gujarat, India

Abstract:
Results from 45 bond tests conducted using the so-called direct tension pullout specimen type are presented. Anchorages of steel bars with machined deformations were tested so as to enable a targeted study of the straight bar, bent-up bar and headed bar on bond behaviour, tests were conducted with or without the combined presence of external confinement over the embedded length. The novel specimen form presented in the paper was designed to simulate the state of stress and strength arising in usual bar anchorages in the tension zones of flexural members where both cover concrete and bar are stressed in tension. This development was motivated by the need to eliminate spurious influences of the test setup on specimen behaviour, which are known to interfere with bond mechanics. Additional parameters studied in the experimental program were the development length, the cover thickness, the effect of confinement, and the tensile strength of concrete.

Keywords: *Straight bar, Bent -up bar and Headed bar, Bar size, Pull out, Anchorage length*

1. Introduction

Bond is the interaction mechanism that enables force transfer between reinforcing bars and the surrounding concrete thereby securing composite action between the two materials. Essential features of the physical mechanism are as follows: When a reinforcing bar embedded in concrete is pulled in tension it tends to displace in the direction of the applied force breaking down the initial chemical adhesion that has been formed during hardening of concrete. If the bar is ribbed, then, The coefficient of friction is a variable that depends on the normal pressure, the surface roughness, the rib profile, and the slip magnitude. Increasing slip implies that larger segments of the bar-concrete interface have been locally crushed by the displacing ribs; for this reason, it is customary to assume that negligible residual friction remains on the bar concrete contact surface in areas where slip has exceeded the spacing of ribs i.e., when a rib has succeeded the previous one in engaging within the concrete cavity relief of the rib profile, Fig. 1.

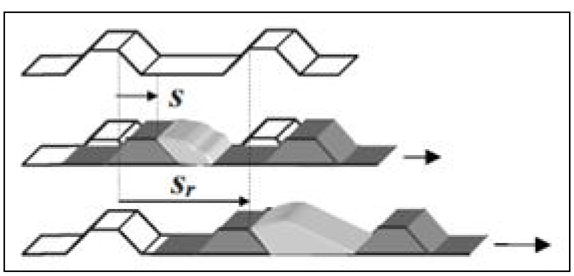


Figure 1: Ongoing crushing of concrete in front of the rib as bar slipsgray: displaced rib position

1.1. Literature

The simplest physical model representing the stress transfer between steel and concrete is the so-called frictional concept Cairns and Jones 1996 as depicted by the Mohr-Coulomb failure envelope. In this model apart from the initial adhesion, fadh, the bond strength, fb max, that may develop along the lateral surface of the bar is proportional to the normal confining pressure mobilized on the bar surface over the anchorage, the constant of proportionality being the coefficient of friction, The normal confining pressure, n, may be calculated by establishing force equilibrium along a diametric plane in a thick hollow cylinder that idealizes concrete surrounding the bar, its thickness being the smallest cover dimension over the bar Fig. 2

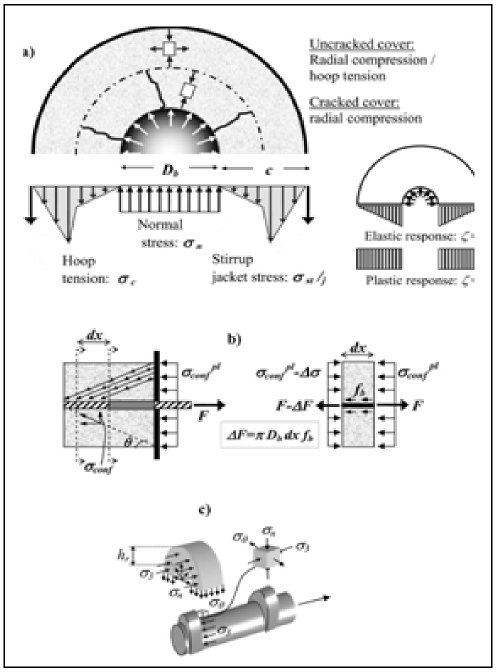


Figure 2: a) Transverse stresses around a pulled bar;
b) Stress state in the standard pullout test; and c) concrete local stress state in front of a rib

Normal pressures caused by boundary restraints, conf, may be taken into account using simple strut and tie analysis Fig. 2b, Tastani and Pantazopoulou 2007. anchorages that usually fail by splitting where the magnitude of confining stirrup contribution is limited by stirrup yielding and stirrup spacing reduced effectiveness as compared to hydraulically applied confinement. The equation practically implies a linear increase of bond strength with normal pressure. However, it is well known from experimental observation that for higher confining pressures, the failure mode changes to a mixed splitting-pullout failure, and in the case of excessive confinement, a pullout failure may be observed. To define a limit in the magnitude of confining pressure n, beyond which no additional strength increase may be obtained in the frictional mechanism, owing to the change in mode of failure, the state of stress in the vicinity of a displacing rib is examined in Fig. 2c. On the normal face of an elementary sector in the vicinity of the bar, the rib exerts direct local compression, Fig. 2c. The confining pressure is the radial stress n. A possible plane of failure occurs along the inclined conical surface extending from the tip of one rib to the base of the next Fig. 1. The strain in the hoop direction is tensile, and therefore any tensile stress, in that direction, is taken equal to zero after cracking. This local stress state at the rib front is idealized as a plane stress state, and failure is approximated by plane stress failure criterion of Kupfer and Gerstle 1973.

In light of the conflicting performance of the various bond tests and bond models, this problem is revisited in the present paper, through a carefully conducted experimental study. Objective is to experimentally isolate bond from spurious influences that often hamper bond experiments through the use of a specially designed test specimen form. Using this novel specimen, the study aims to quantify the effect of the prominent design parameters affecting bond mechanics, namely, the coefficient of friction To control the influence of the bar profile, steel bars with machined ribs were used.

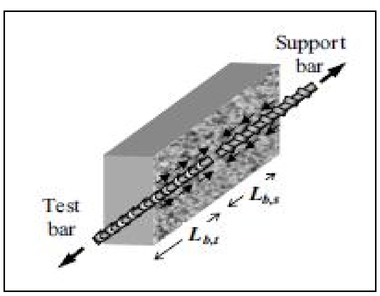


Figure 3: Morphology of the Direct Pull out Bond Test

2. Experimental Program

The direct tension pullout DTP specimen used in this study comprises a concrete prism with a concentric test bar, anchored end to end with a support bar without splicing Fig. 3 a. In the test the two bars are pulled in tension, gradually transferring normal tensile stresses to the surrounding concrete cover. The presence of a longitudinal tensile stress in the cover away from the ribsis, an essential point of difference between the DTP bond test and the classical pullout test where the concrete block is subjected to direct compression parallel to the bar axis Fig. 2b. Additional stresses arise in the conventional pullout test setup due to friction that develops under the support plates, thus further enhancing spuriously the observed bond resistance. Cover stress conditions in the DTP bond test resemble those occurring in the tension zone of flexural members where both materials concrete cover and longitudinal reinforcement are mobilized in tension. Especially regarding cover resistance and its contribution to bond mechanics, these are the most unfavourable conditions possible, because shear transfer occurs in the presence of a biaxial tensile stress field i.e., along the longitudinal and hoop directions of the bar axis, Tastani and Pantazopoulou 2006 ; in this light, it is anticipated that the DTP test quantifies the lowest possible bound of bond strength that may be supplied by the concrete cover. The mean local bond-slip relationship of short and moderate length steel-machined bar anchorages is explored experimentally using 40 DTP bond specimens of normal concrete strength.

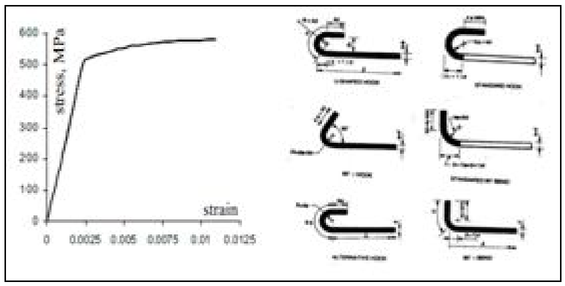


Figure 4: Stress strain curve of HYSD bar and bent-up bar

2.1. Material Properties: Steel Reinforcement and Concrete, FA and CA Quality

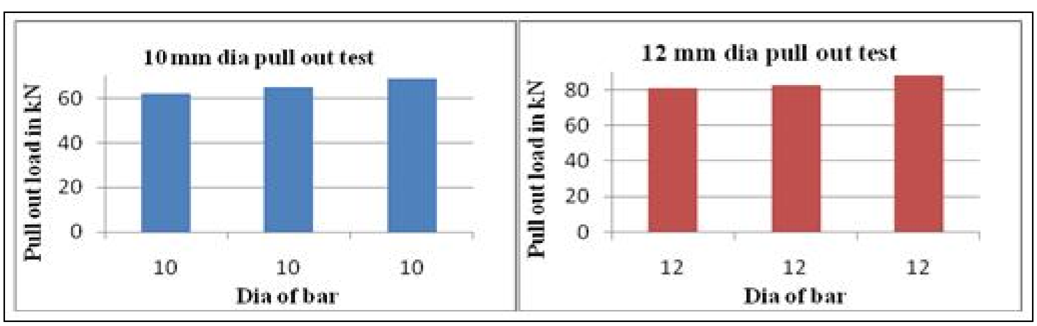
For the configuration of the outer surface of the machined bars, 45 steel coupons were taken from the same batch of smooth steel bars 10mm,12mm,16mm and a nominal yield stress fy=500 MPa Fig. 4. All rib-machined bars had the ribs oriented orthogonally to the longitudinal axis, rib width of 1 mm, cement grade 53 , Specific gravity is 3.15, consistency 30%, initial setting time is 120min, final setting time is 250min. And compressive strength of 28 days is 59 N/mm^2. Fine aggregate takes from natural river sand , fineness modules is 3.5 (Zone II) and specific gravity is 2.645 , course aggregate 20mm and specific gravity is 2.852 .Fig. 4. Including the table

3. Preparation Procedure

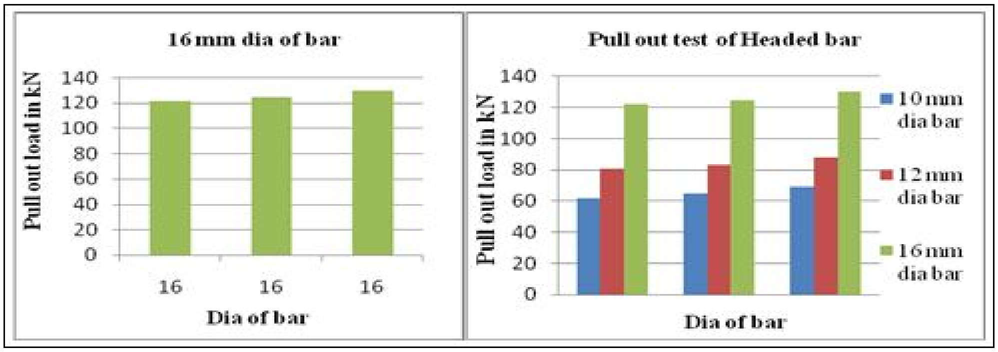
In conducting the Direct pull out bond test, both the test and the support bar are pulled in tension simultaneously. Force transfer is achieved from one anchorage to the next by tension of the core concrete in the central unreinforced portion of the specimen.

4. Experimental Results

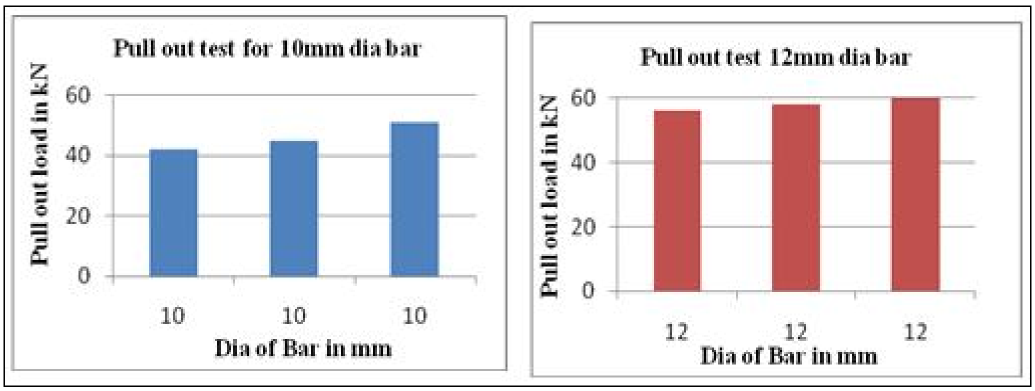
In this result the grade of concrete is different and the maximum bond strength is achieved on 16mmbar size and 40grade of concrete. Embedded length is same in this group. Only change the bar size and grade of concrete. The cube size is 225mm x 225 x 350 mm. and cylinder size is 150mm is dia. 300mm is height.



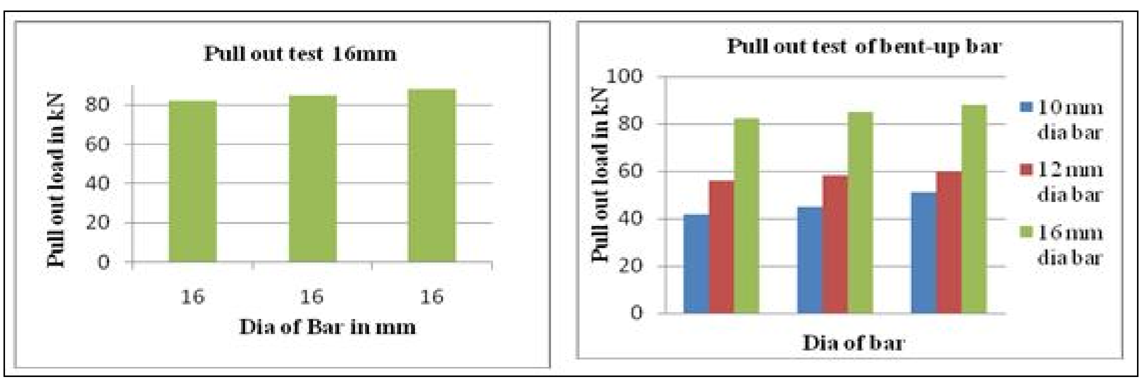
In above graph of headed bar in different bar size and same garde of concrete M30.10mm bar size the maximum bond strength is 69kN. and same as 12mm bar size the bond stregth is 88kN.



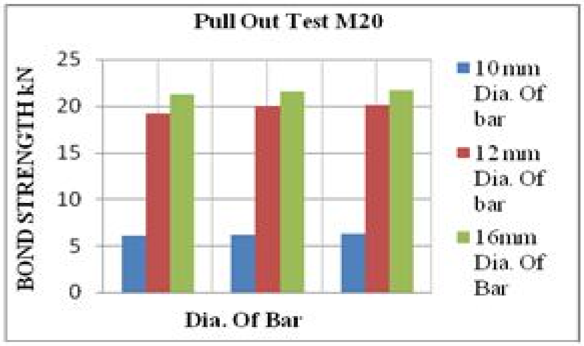
In above graph of headed bar in different bar size and same garde of concrete is M30. 16mm bar size the maximum bond strength is 130kN. and the combine graph of all different bar size. in final the headed bar result in M30grade of concrete 16mm dar size is takes a maximum bond strength.

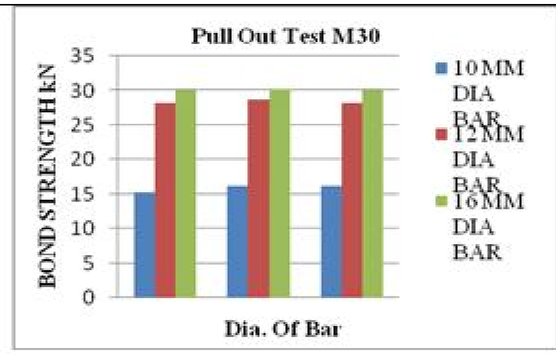


In above graph of bent-up bar in different bar size and same garde of concrete M30.10mm bar size the maximum bond strength is 51kN. and same as 12mm bar size the bond stregth is 60kN.

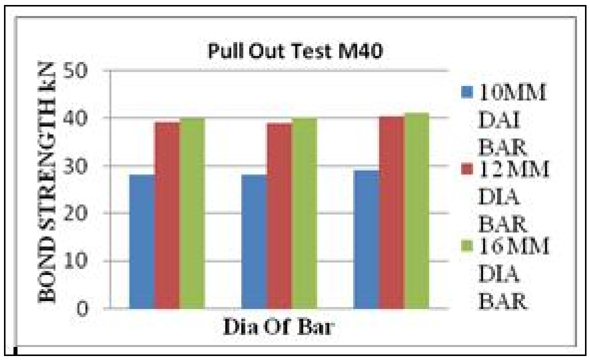


In above graph of bent-up bar in different bar size and same garde of concrete is M30. 16mm bar size the maximum bond strength is 88kN. and the combine graph of all different bar size. in final the bent-up bar result in M30grade of concrete 16mm dar size is takes amaximum bond strength.





In the above combine graph of Straight bar in different grade of concrete, bar size and same emebeded length. in all over result maximum result in M20 and M30 maximum bond strength 21.69kN and 30.25kN.



In above graph of Straight bar of bond stress in M40 and different bar size. the maximum bond strength is in 41.23kN.

5. Conclusion

In this experimental work the compression between Straight bar, bent-up bar and headed bar. In Straight bar bond strength is less as compare to two other bar .i.e. bent-up and headed bar. In Straight bar experimental work 40 kN. Bond strength is achieved.

In bent-up bar, the bar is bent in 90 degree and performing the direct pull out test. The bent –up bar normally use in construction field. But in bent-up bar as a hook type mechanism , that hook fix in the concrete block and pull the bar but in pull out test that bent – up bar is open and so reduce the pull strength. In this experiment the only change the bar size and only same the grade of concrete. In 10mm bar size pull out strength is 51kN; 12mm bar size pull out strength is 60kN and last is 16mm bar size pull out strength is 88 kN.

The headed bar gives the more strength as compare to bent-up bar. The headed bar strength is depend on the size of headed, shape of head and also fixing of head to the rod. In headed bar bonding strength is very high related to bent-up bar and the grade of concrete and grade steel also depend on the bond strength. In the above result grade of concrete is safe, effective cover is same but only change the bar diameter. In an experiment the maximum bond stress in 10mm bar size 69 kN. , same as 12mm bar size 88 kN and last 16mm bar size takes bond strength 130kN.

6. References

1. Direct Tension Pullout Bond Test: Experimental Results S. P. Tastani1 and S. J. Pantazopoulou, M.ASCE2 Bonacci J., Marquez J. (1994) “Tests of Yielding Anchorages under Monotonic Loadings”,
2. Journal of Structural Engineering, Vol. 120, No. 3, March, pp. 987-997. Cairns J. (1979) “An Analysis of the Ultimate Strength of Lapped Joints of Compression
3. Reinforcement”, Magazine of Concrete Research, Vol. 31, No. 106, March, pp.19-27. Chana, P. (1990) “A Test Method to Establish a Realistic Bond Stress”, Magazine of Concrete
4. Research, Vol. 24, No. 151, June 1990. pp. 83-90. Cosenza E., Manfredi G., Pecce M., Realfonzo R. (1999) “Bond between Glass Fiber Reinforced
5. Plastic Reinforcing Bars and Concrete – Experimental Analysis”, Proceedings of 4th International Symposium of Fiber Reinforced Polymer Reinforcement for Reinforced
6. Concrete Structures (SP188), Editors Dolan C., Rizkalla S., Nanni A.88. Gambarova P.G., Rosati G.P., Zasso B. (1989) “Steel-to-Concrete Bond after Concrete Splitting:
7. Test Results”, Materials and Structures, Vol. 22, pp. 35-47. Larrard F., Schaller I., Fuchs J. (1993) “Effect of Bar Diameter on the Bond Strength of Passive
8. Reinforcement in High-Strength Concrete”, ACI Materials Journal, Vol. 90, No. 4, August, pp. 333-339.

9. Malvar L.J. (1992) “Bond of Reinforcement under Controlled Confinement”, ACI Materials Journal, Vol. 89, No. 6, November – December, pp. 593-601.
10. Tastani S. P., Pantazopoulou S. J. (2001) “Experimental Investigation of GFRP-bar Anchorages in Concrete”, proceedings of CCC2001-Composites in Construction International Conference, Porto – Portugal, October, pp. 193-199.
11. Tastani S. and Pantazopoulou S.J. (2002) “Experimental and Analytical Investigation of Corroded Bar Anchorages”, invited paper, accepted for publication in the Volume compiled by the “Institut für Werkstoffe im Bauwesen” of the University of Stuttgart, in honor of Prof. R. Eligehausen.
12. Tepfers R. (1979) “Cracking of Concrete Cover along Anchored Deformed Reinforcing Bars” Magazine of Concrete Research, Vol. 31, No. 106, March, pp.3-12.
13. Vecchio F.J., DeRoo A. (1995) “Smeared-Crack Modeling of Concrete Tension Splitting”, ASCE Journal of Engineering Mechanics, Vol. 121, No. 6, June, pp. 702-708