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Study on Variation of Bond using Anti Corrosive Reagents on Reinforcing Steel Bar

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Abstract
Variation of bond stress with different anti corrosive reagent was determined. When bar is embedded in concrete it is corroded in course of time and corrosion products form pit or holes on the surface of reinforcing bar and reduce cross sectional area of steel and also reduce bond capacity. To protect corrosion, different anti corrosive reagent are available in the market. But the effect of bond, of reinforcing bar with surrounding concrete depending on product type is not known to users. A study are therefore felt important in this study. It is seen that if anti corrosive reagent is used to protect corrosion as the companies claim reduces bond stress from 13-37% depending on type of material (Brick aggregate or stone aggregate) and ratio (1:2:4 and 1:1.5:3). Development length of rebar for situation when anti corrosive reagent is used should be increase.

Keywords: *Moon star paint, berger paint, asian paints, aqua paint, khoa, sylhet*

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INTRODUCTION

General Concept

When a reinforcing bar is embedded in concrete, the concrete adheres to its surface and resists any force that tries to pull out or push the rod. This is called the bond between steel and concrete. The intensity of this adhesive force is called bond stress. Corrosion means the gradual destruction of metals and their alloys due to chemical or electrochemical action .The usual corrosion products are oxide, hydroxide, carbonate, sulfide etc. In most cases the corrosion products are insoluble in the environment and form a separate phase on the metal (reinforcing bar, pipes etc) surface. For steel embedded in concrete, corrosion also products pit or holes in the surface of reinforcing steel, reducing strength capacity as a result of the reduced cross-sectional area of the steel and finally reduce the bond stress. Corrosion of the embedded reinforcing steel is mainly the result of chloride contamination and carbonation of poorer quality concrete. Now a day a great amount of damages that happens in reinforced concrete structures is observed like Bangladesh. Many countries around the world are located in aggressive environments. Norway Coasts, the Arabian Gulf, Pakistan, India Australia and other countries along the seacoast face the same problem.

Present State of Art

Increasingly it is becoming apparent that the steel reinforced concrete infrastructure of North America and may other regions in the world is suffering large scale degradation and the economic implications of this problem are alarming. The principal cause of the degradation of structures such as bridges, parking garages, transit system, tunnels, piers and residential buildings are corrosion damage to the reinforcing steel (rebar), which is embedded in the concrete. In turn, this corrosion damage is largely related to the use of de-icing salts and chlorides found in marine environments, as well as carbonation of the concrete from carbon in the atmosphere. Inattention to corrosion control of as part of an overall maintenance program for infrastructure facilities has been reported to cost the US more than $250 billion annually [1]. The US Department of Transportation recently projected the rehabilitation costs of existing bridges at $155 billion [2]. In Canada, with the large-scale use of de-icing salts dictated by the cold climate, the situation is correspondingly serious. Canada's concrete infrastructure, of which a significant portion is near the end of its design life, has a replacement value of half a trillion dollars [3]. The ability to assess the severity of corrosion in existing concrete structures for maintenance and inspection schedule and the use of corrosion data for predicting the remaining service life is becoming increasingly important.

BACKGROUND

Nowadays corrosion of reinforcement is one of the most harmful damage that occurred in reinforced concrete structures. The corrosion of steel reinforcement was first observed in marine structures of California Bridge and chemical manufacturing plant. Concrete normally provides reinforcing steel with excellent corrosion protection. The high alkaline environment in concrete result in the formation of a tightly adhering film which passives the steel and protects it from corrosion. In addition concrete can be proportioned to have a low permeability, which minimizes the penetration of corrosion inducing substances. Low permeability also increases the electrical resistivity of concrete, which embeds the flow of electrochemical corrosion current. Corrosion of steel however can occur if the concrete is not of adequate quality, the structure was not properly designed for the service environment, or the environment was not anticipated or change during the service life of concrete. Chloride ions are considered to be the major cause of premature corrosion of steel reinforcement. Corrosion can occur in some circumstances in the absence of chloride ions, however. For example carbonation of concrete results in reduction of its alkalinity. There by permitting corrosion of embedded steel. Carbonation is a slow process, which has a low water cement ratio. The rate of corrosion of steel reinforcement in concrete is strongly influenced by environmental factors. Both oxygen and moisture is must be present if electrochemical reaction is to occur. Other factors are pH of the concrete pore water, carbonation of Portland cement paste, Mixture proportions, depth of cover over the steel and cracks of concrete etc.

OBJECTIVE OF THE STUDY

For study on variation of bond using anticorrosive reagent on bar the following objectives are considered:

- To determine the bond stress between concrete and reinforcing bars without any treatment.
- To determine the bond stress between concrete and reinforcing bars with different corrosion protective reagents.
- To determine the percentage reduction in bond stress due to different corrosion protective reagents.

SCOPE OF THE STYDY

This method of test is intended to provide a standard procedure (ASTM C234-91a) for determining the effects of variations in the properties of the concrete on the strength of the bond between concrete and reinforcing steel. Such determination may be made for any purpose from routine acceptance test to research testing, is so far as applicable to a particular project. The method is offered as our workable procedures, to be employed either in it's entirely or with modifications to meet specific conditions. This method is not intended for use in which the principal variable is the size, shape or type of reinforcing bar.

Also failure characteristics were investigated. Pull out tests was made on 60 cubes and compressive strength test were made from each batch of sample.

REVIEW LITERATURE

From Previous Undergraduate Thesis:
Monayem, A and Islam, R made study on "Comparison between the Rate of Evaporation and Evapotranspiration" and on "Effect of Painting on the Bond Strength of M. S. Bar" in 1989–90. They investigated an experimental study on effect of bond strength of Mild Steel bars due to painting. They selected ½", ¾" and 1" diameter Mild steel bars for this experiment. Four cylinders (6 inch diameter x 12 inch height) for each size of bars were made. Two of these cylinders were provided with painted bars whereas the other two were provided without paint. Red oxide was used for painting the bars. The bars were penetrated 6" and 4" inside the cylinders for painted and unpainted bars respectively. After 21 days of

curing they made pull out Test and observed that due to the application of paint the average bond strength of Mild steel bar was reduced by 60 %.

From Internet

1. Wang J Janson, Weiss W, Yoon S , Shah,P made study on Combined Effect of Corrosion and Stresses In Reinforced Concrete Beams in 2000.

The beam dimension was 100 mm (width) x150 mm (height) x1170 mm (length) and reinforced with a standard #6(19 mm in diameter) Grade 60 reinforcing steel bar. The cover of the reinforcing steel was 30mm.The weight proportion of the concrete mixture was 1(cement) : 2(coarse aggregate, MSA=9mm) :2(fine aggregate) : 0.5(water). After being cast and de-molded, the concrete specimens were moist cured for 28 days in a 95 % relative humidity room at 22 ^{0}C.

They observed that Corrosion initiated faster in the beams subjected to a previous load than it did in a pristine (undamaged) beam. With increased loading levels, the time for corrosion initiation was reduced and the rate of corrosion propagation was increased. At a given loading level, a beam exposed to sustained loading exhibited an increased corrosion rate and a lower residual strength when compared with a preloaded beam.

As the degree of reinforcing steel corrosion increased, the failure mode of the reinforced concrete beams shifted from a shear failure to bond splitting, which resulted in the slip and pullout of the reinforcing bar. The combination of a high level of a sustained load and extensive corrosion might result in a sudden creep or corrosion failure in the reinforced concrete beam.

The results of this investigation imply that influence of service load on structure performance needs to be considered in combination with environmental conditions and proportions to obtain a rational service-life prediction.

2. Zuo J , Drawin D made study on Splice Strength of Conventional and High Relative Rib Area Bars in Normal and High-Strength Concrete.

The effect of concrete strength coarse aggregate quality and type and reinforcing bar geometry was investigated in this study. Results for 64 splice specimens with reinforcing bars with relative rib areas ranging from 0.069 to 0.141, concrete strength ranging from 4250 psi to 15650 psi and quantities of lime stone and basalt coarse aggregate ranging from 1586 to 1908 lb/yd^3 (941 to 1132 kg/m^3) are reported.

For splices not confined by traverse reinforcement, the ¼ power of compressive strength $fc^{/}$ best characteristics the effect of concrete strength on splice strength. $f_c^{' \, 3/4}$ characterizes the effect of concrete strength on the additional splice strength provided by traverse reinforcement. The splice strength of bars confined by traverse reinforcement increases with an increase in relative rib area and bar diameter. The use of stronger coarse aggregate results in an increase in splice strength for bars both with and without confining reinforcement. For splices confined by transverse reinforcement the higher the quality of coarse aggregate, the greater the contribution of traverse reinforcement to splice strength. The expressions characterizing the splice strength of reinforcing bars accurately represent the development/splice strength of bottom-cast uncoated bars as a function of member geometry, concrete strength relative rib area, bar size, and confinement, provided by both concrete and traverse reinforcement.

3. Fowler N, Hanson J, Mitchell E made study on Effect of Temperature on the Effective Reinforcement Value of Flexural Grid.

Three different grid sizes C3000, C5500 and C1100 were used as panels.

The grid number represents the strength of grid in lb/ft of length of the primary direction. Grid is made in a continuous process, meaning that it is one long roll rather than individual sheets.

Testing procedure consisted of making the concrete panels and than testing their strength under a range of temperature. They observed that the panels became weaker as temperature increased but they did not lose all strength and four types of failure among them. First, fiber fracture occurred at room temperature. Second, pullout failure was caused by the epoxy melting at high temperature. Third type of failure is splitting bond failure. This failure type occurred when the high temperature caused the moisture in the concrete to create a vapor pressure. The fourth type of failure observed was a gradual fiber failure caused as the epoxy resin heated beyond the glass transition temperature. The glass transition temperature is the point where a plastic material changes from being hard and brittle to soft and ductile.

METHOD FOR DETERMINING BOND STRESS

Bond Pullout Test

Permissible bond stresses were formerly established largely from pull out tests with some beam tests as confirmation. A bar was embedded in a cylinder or rectangular block of concrete and the force required to pull it out or make it slip excessively was measured. Figure 1 Shows such a test schematically, omitting details such as bearing plates. Slip of the bar relative to the concrete is measured at the bottom (loaded end) and top (free end). Even a very small load cause some slip and develops a high bond stress near the loaded end, but leaves the upper part of the bar totally unstressed, as shown in fig. As more loads are applied, the slip at the loaded end increases, and both the high bond stress and slip extend deeper into the specimen. The maximum bond is somewhat idealized in these sketches; its distribution depends on the type of bar and probably varies along the bar more than shown.

When the unloaded end slips, the maximum resistance has nearly been reached. Failure will usually occur (1) by longitudinal splitting of the concrete in the case of deformed bars, or (2) by pulling the bar through the concrete in the case of a very small bar or very lightweight aggregate, or (3) by breaking the bar, if the embedment is long enough.

The average bond resistance U is calculated assuming uniform bond over the bar embedment length. Friction on the base restraints splitting of the specimen. Many tests include spirals to avoid splitting collapse. The test appears useful chiefly were relative rather than real bond resistance is acceptable, as in comparing various lug size and patterns. The principal problem of splitting is not realistically handled.

Modification of this test, called the tensile pullout specimen, has also been used (Figure 1) to eliminate compression on the concrete.

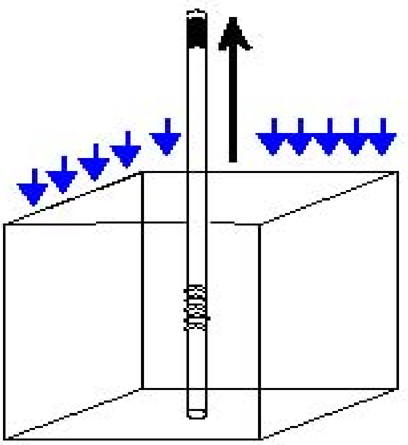


Fig. 1: *Bond Pull out Test.*

NATURE AND MAGNITUDE OF BOND STRESS

When a reinforcing rod is embedded in concrete, the concrete adheres to its surface, resisting any force that tends to pull or push the rod. This is called the bond between the concrete and the steel .the intensity of this adhesive force is called the bond stress, or bond unit stress, in reality, this bond stress is a resistance to shearing between the surface of the steel and the concrete away from the surface of the steel in a direction parallel to the surface and lengthwise of the bar.

The function of board in a reinforced concrete member is somewhat analogous to that of rivets in structural steel work. If the force that holds the two materials together so as to develop their simultaneous and mutually helpful action. If the rods have no change of stress and therefore no change of length as a result of the application of a load on the member, then there will be no bond stress set up by it, but as soon as flexural action cause, the steel to stretch or to compress, the bond stresses must come into action in order to cause these change.

When the rod stretched, the elongation in the embedded length is greatest at the point where the steel enters the bottoms of the concrete block. If then decreases to zero at or some where below the top and of the rod. A little reflection will show that the intensities of the bond stresses along the rod must vary somewhat in proportions to the stretching of the rod inside the concrete block unless the bond is broken. Probably the bond stresses are very high (Probably to the point the local failure) at the cracks. The distribution of bond stresses is very uncertain, Yet for analysis and design, it is generally considered to be uniform over some length that is necessary to develop the strength of bar. However, one must realize that the bond will develop the rod as quickly as possible so that a part of the rod which is a long way from the point of entry of the rod may have no stresses at all; in other worlds, anchorage far from the point where the rod is needed may not be bought into action if the bond can develop the required resistance before tensile stresses can reach the anchor.

An expression for the magnitude of the average bond stress can be found readily-
Let,
D= Diameter of the rod.
L_a = The length of embedment
U= the average bond unit stress.
Bond stress, U=(P÷∏ΔΛa)

THEORITICAL CONSIDERATION

General Remarks

A reinforced concrete structure is designed to have a long service life typically in excess of 50 years. Unfortunately, may structure falls short of this goal, requiring expensive repair and protection work in the future. A major cause for the premature deterioration of our reinforced concrete infrastructure is Corrosion of the Reinforced Concrete.

Steel in concrete is usually protected against corrosion by passivation of the steel arising from the high alkalinity of the pore solution with the concrete. A stable oxide layer is formed on the steel surface, which prevents the anodic dissolution of iron. Loss of durability in reinforced concrete only occurs if this stable oxide layer is rendered unstable (if depassivation occurs) due to the ingress of chlorides to the steel /concrete interface or carbonation of the concrete reducing alkaline of the pore solution at the steel/ concrete interface. Durable reinforced concrete must be designed to resist carbonation and to exclude chlorides from any source. Reinforcing steel should be embedded in concrete specified in accordance with current standards. In particular the mix design and minimum cover must be observed and suited to corrosivity of environment. In many cases this will provides sufficient corrosion protection to the reinforcing steel, provided that the concrete is correctly placed, compacted and cured.

METHODS OF CORROSION PREVENTION

Since the 1960's many methods toward corrosion prevention have been investigated, with mixed success. Following are a few of the more popular or more successful methods that have been employed.

Steel Surface Treatment

In the 1970's the coating steel with epoxy was established as the primary means for corrosion deterrence. Recent studies of bridges and structures that incorporated epoxy coated steels built during that time suggested that epoxy coating may not provider the75-year service life that was predicted. Another method of steel surface treatment is galvanizing, or zinc coating. However, this treatment has shown mixed results in concrete and may be inadequate for desired service life performance in many environments.

Epoxy Coating

Epoxy coating is one of the most widely used techniques for protecting reinforcing bars against corrosion inside the concrete there are two types of epoxy –coating: liquid and power coatings. Because of better corrosion protection efficiency electrostatic spraying of epoxy power to the straight of rebar currently accounts for the majority of coated rebar After cleaning the steel by abrasive blasting in electrostatic spraying the electrically charged powder particles are sprayed onto a preheated steel surface (230 ^{0}c) where they melt to form an even and uniform power film. After a heat catalyzed irreversible reaction the power starts to get. After the film is solidified the coated bars are cooled in water or air.

Alternative Materials

Alternative materials for reinforcing steel have been considered and tested. However many of these materials are generally disqualified based on costs or safety requirements. Stainless steels provide a corrosion resistant alternative to conventional steel, but at considerable expense other structural materials, including fiber-polymer composites, are generally considered undesirable for use, as concrete reinforcement since they are brittle and do not passes the yield characteristics of steel. Overstressing or fatigue of brittle materials may present a potential for catastrophic failure, without the visible warning afforded by ductile steels.

Concrete Surface Treatments

The use of surface coatings for concrete member, including polymer membranes, penetrating sealers, and modified cementations or acrylic coatings, has open been used to supplement existing corrosion prevention strategies. Indeed, quality surface treatments may prevent the ingress of aggressive species, including chlorides, as well as the diffusion of reactants necessary to sustain corrosion. However, such coatings are often maintenance intensive. Surface coatings are inadequate to prevent corrosion once the aggressive species have penetrated the concrete, since there is generally sufficient moisture within concrete to sustain corrosion for an extended period of time. A properly selected and applied coating may reduce the rate of ingress of oxygen, other by slowing the rate of reaction, but by no means eliminates the occurrence of corrosion.

Historical Study of Bond

The first scientific investigation of bond between steel and concrete was made by M.O. willey in 1906-1907, followed by the test of Duff. A, A brams reported in 1913 in which discredited the use of the small angle the bearing faces made with the axis of the bar. He recommended a bar with the bearing lugs, as nearly as possible the circumference about one- tenth of the diameter is height and one-half a diameter point.

IN 1937 George Werrish established that threaded bars had bound resistance as much as 50% higher than the commercial deformed bars he used. In 1983 H.Y.Gilky showed that then the ultimate strength, that bond is proportional to the total embedment of the bar, but after some 24 diameters drops off special anchorage a bar stressed to full working capacity would in a length of 15 in elongate an amount equal to the so called “initial bond failure” Carl menzef in 1939 investigated specially the effect of various position of the bar and orientation of the deformations, and find that a bar rigidly held on a horizontal position, with considerable concrete below it ,would have a reduced bond because of the shrinkage of the concrete during hardening which would particularly affect the bond up ends of truss bars .Menzefs studies resulted with the first new type of bond to be marked

TEST SPECIMEN, EQUIPMENT AND PROCEDURE

General Remarks

In this study, we used 60 grade #6 deform bars, anti corrosive reagents, sylhet sand, stone chips, brick khoa and ordinary Portland cement. Sylhet sand, stone chips and brick khoa were collected from engineering section of KUET. Deform bars, anti corrosive reagent and ordinary Portland cement were bought from shop [4, 5].

MATERIAL USED

1. 60 grade #6 deform bar.
2. Anti corrosive reagent (four companies)
3. Coarse aggregate (Stone chips and Brick khoa)
4. Fine aggregate (sylhet sand)
5. Ordinary Portland cement (Holcim cement)
6. Water (Rain water)

INSTRUMENT USED

7. Universal Testing Machine
8. Mixture Machine
9. Slump cone (top diameter 5/8”, length 24”)
10. 6-inch steel mold
11. Trowel

Test Specimen

Specimen shall consist of concrete cubes 6” or 150 mm on each edge with a single reinforcing bar embedded vertically along a central axis in each specimen. T bar shall project downward from the bottom face of the cubes as cast a distance of about 3/8” (10 mm) and shall project upward from the top face whatever distance is necessary to provide sufficient length of bar to extend through the bearing blocks and the support of the testing machine and to provide an adequate length to be gripped for application of load.

Reinforcing Bar
The reinforcing bars shall be 60 grade #6 deformed bars. Care shall be taken that all bars used in a given series of test are of the same type and have the same size, shape and pattern of deformations. The length of the individual bars shall be such as to meet the requirements of the test specimens.

Mixing of Concrete
Correct quantities of cement, aggregate and water are placed in electrically operated mixing machine. Then mix it properly that the surface of the entire aggregate particle with cement paste.

Casting the Specimen
Prior to casting the test specimen, coat the inside surface of the molds with a thin film of mineral oil (Mobile). Clean the reinforcing bar of loose and coat it anticorrosive reagent with appropriate percentage of thinner for individual company. Hardened it for 18 hours. Place the concrete in two layers of approximately equal thickness and rod each layer 25 times with the 5/8” (16 mm) diameter-tamping rod. After the top layer has been consolidated strike off the surface with a trowel. Make at three standard 6 by 6 in cube from each batch of concrete for determining compressive strength of concrete [4].

Slump Test
The mould for the slump test is a frustum of a cone.305 mm (12 in.) high. The base of 203mm (4 in.) diameter is placed on a smooth surface with the smaller opening of 102 mm (4 in.) diameter at the top, and the container is filled with concrete in three layers. Each layer is tamped 25 times with a standard 16 mm (5/8 in.) diameter steel rod, rounded at the end, and the top surface is struck off by means of a screeding and rolling motion of the tamping rod. The mould must be firmly held against its base during the entire operation; this is facilitated by handles or foot-rests brazed to the mould [4, 6].

Immediately after filling, the cone is slowly lifted, and the unsupported concrete will now slump-hence the name of the test. The decrease in the height of the center of the slumped concrete is called slump, and is measured to the nearest 5 mm (1/4 in.).

If instead of slumping evenly all round as in a true slump (Figure 2), one half of the cone slides down an inclined plane a shear slump is said to have taken place. The slump indicates the lack of cohesion of the mix. Sometimes instead of true slump or shear slump, the concrete may collapse and the resulting slump due to collapse is termed as thick. Only true slumps indicate the workability of the concrete. Instead of true slump, if shear or collapse slump is found to take place, the test should be repeated.

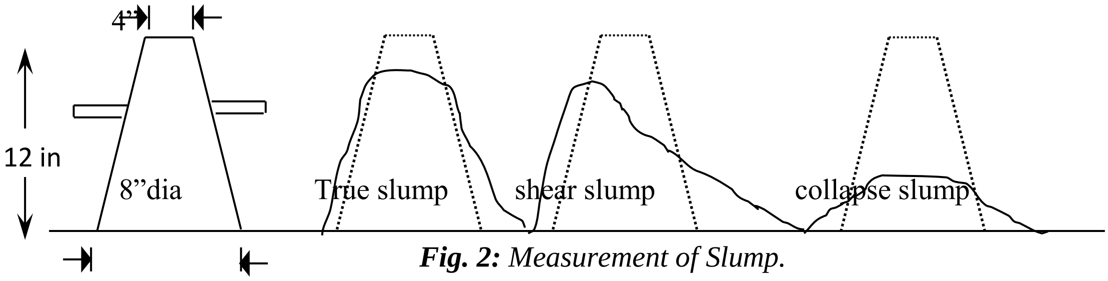


Fig. 2: *Measurement of Slump.*

Curing the Specimen
Remove the molds from the specimens after 24 hour after casting. Take extreme care to prevent striking or otherwise disturbing the reinforcing bars. Immediately after removing the molds, cure the specimens in a water basin. Test the specimen at an age of 28 days.

Specimen Preparation for Testing

Align the reinforcing bar vertically by use of a carpenter's level. Placing the specimens on the base of the mold will facilitate the use of shims generally required to align bars. Oil the 3/4" (19 mm) drilled steel plate used in the pullout operation and use as the capping plate. After a sufficient quantity of capping material has been placed on the specimen, slip the plate over the reinforcing bar and press firmly on the capping material until extrudes at all edges of the plate as shown in Figure 3. Level the plate with a carpenter's level. Removal of material that excludes through the drilled hole in the plate before it hardens will aid in removing the plate without damage to the cap.

Fig. 3: *Prepared specimens for Testing.*

LABORATORY INVESTIGATION

General Remarks

In our study we performed our test in Strength of Material laboratory in Civil Engineering Department, Khulna University of Engineering and Technology (KUET).

TEST PROCEDURE

- Mount the specimen in the testing machine so that the surface of the cube from which the long end of the bar projects is in contact with the bearing block assembly as shown in Figure 4.

Fig. 4: *Testing procedure.*

- Clamp the sample in UTM and then fixed.
- Load is started to apply.
- The bond failure loads are recorded from dial gauge reading.
- Cracking pattern of the specimen is also identified as in Figure 5.

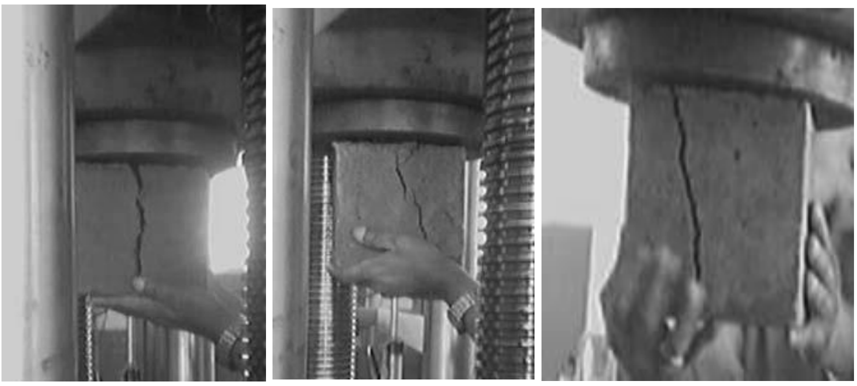


Fig. 5: *Cracking pattern of Specimen.*

CALCULATION

Bond Stress

When a reinforcing bar is embedded in concrete, the concrete adheres to its surface and resists any force that tries to cause slippage of the bar relative to its surrounding concrete. This is achieved by the development of shear stress at the surface of the bar and concrete and is known as bond stress. It is the force per unit of nominal surface area of a reinforcing bar acting on the interface between the bar and the surrounding concrete [6].

Bond Stress= Load on the bar as recorded from UTM (in pound)÷ Nominal surface area of the entire embedded length of the bar (sq. inch).

$\Rightarrow \sigma=(P \div A)$

For #6 bar Bond stress, $\sigma=(P\div\prod\Delta\Lambda)$

$=[\{P \div \prod\times(6\div8)\times6\}]$ Psi

$=(P \div 14.14)$ psi

Compressive Strength

Place the plain lower bearing block, with its hardened face up, on the table or platen of the testing machine directly up under the spherically seated (upper) bearing block. Wipe clean the bearing face of the upper and lower bearing blocks and of the test specimen and place [5,6].

Compressive Strength of cube specimen= Load÷Area

$=\{P \text{ (in lb)} \div 36\}$ P

Test Results

Shown in (Tables 1–4) and (Graphs 1–6).

Table 1: *STONE CHIPS (Mix ratio: Cement: Sand: Stone Chips=1:1.5:3).*

Name of paint condition	Failure load (KN)	Failure load (lb)	Bond stress (Psi)	Average bond stress (Psi)	% Reduction in bond stress	Cube crushing strength (psi)	Average cube strength (Psi)
Without painted bar (Dummy)	51	11469	811	795	---------	3222	3240
	51	11469	811				
	48	10795	763				
Robbialac red oxide primer (Berger)	43	9670	683	688	13.5		
	45	10120	715				
	42	9445	667			3305	
Anti corrosive primer ro (Asian)	42	9445	667	667	16.1		
	40	8995	636				
	44	9895	699				
Aqua anti corrosive red oxide primer (Aqua)	42	9445	667	656	17.5		
	42	9445	667			3194	
	40	8995	636				
Anti corrosive red oxide primer (Moon star)	37	8321	588	588	26.0		
	43	9670	683				
	31	6971	493				

Table 2: *STONE CHIPS (Mix ratio: Cement: Sand: Stone Chips= 1:2:4).*

Name of paint condition	Failure load (KN)	Failure load (lb)	Bond stress (Psi)	Average bond stress (Psi)	% Reduction in bond stress	Cube crushing strength (psi)	Average cube strength (Psi)
Without painted bar (Dummy)	51	11469	811	694	----------	2771	2849
	40	8995	636				
	40	8995	636				
Robbialac red oxide primer (Berger)	30	6746	477	524.5	24.5		
	32.5	7309	517				
	36.5	8208	580			2916	
Anti corrosive primer ro (Asian)	33	7421	524	513.5	26.0		
	33	7421	524				
	31	6971	493				
Aqua anti corrosive red oxide primer (Aqua)	29	6522	461	477	31.3		
	31	6971	493			2861	
	30	6746	477				
Anti corrosive red oxide primer (Moon star)	25.5	5734	405	434	37.5		
	31	6971	493				
	25.5	5734	405				

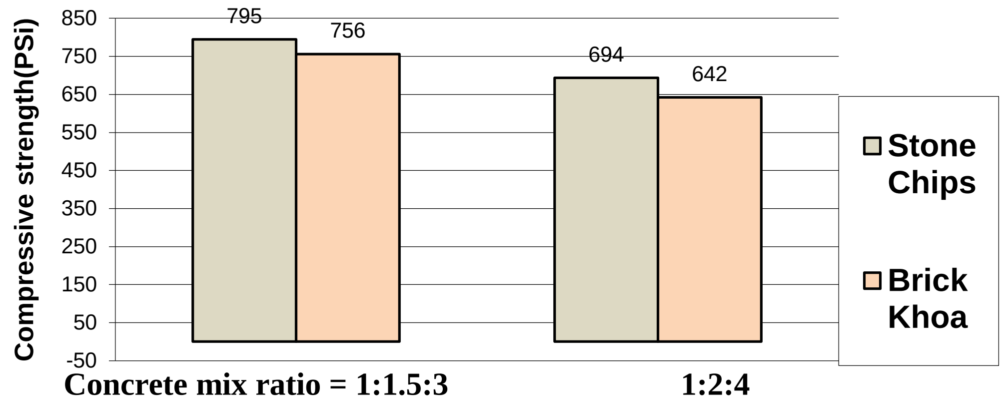
Table 3: *BRICK KHOA (Mix ratio: Cement: Sand: BRICK KHOA =1:1.5:3).*

Name of paint condition	Failure load (KN)	Failure load (lb)	Bond stress (Psi)	Average bond stress (Psi)	% Reduction in bond stress	Cube crushing strength (psi)	Average cube strength (Psi)
Without painted bar (Dummy)	50	11244	795	756	----------	3194	3110
	46	10345	732				
	47	10570	741				
Robbialac red oxide primer (Berger)	40	8995	636	647	14.5		
	40	8995	636				
	42	9445	668			3222	
Anti corrosive primer ro (Asian)	36	8096	572	551	27.2		
	36	8096	572				
	32	7196	509				
Aqua anti corrosive red oxide primer (Aqua)	28	6297	445	546	27.8		
	40	8995	636			2916	
	35	7871	557				
Anti corrosive red oxide primer (Moon star)	30	6747	477	520	31.2		
	31	6972	493				
	37	8321	588				

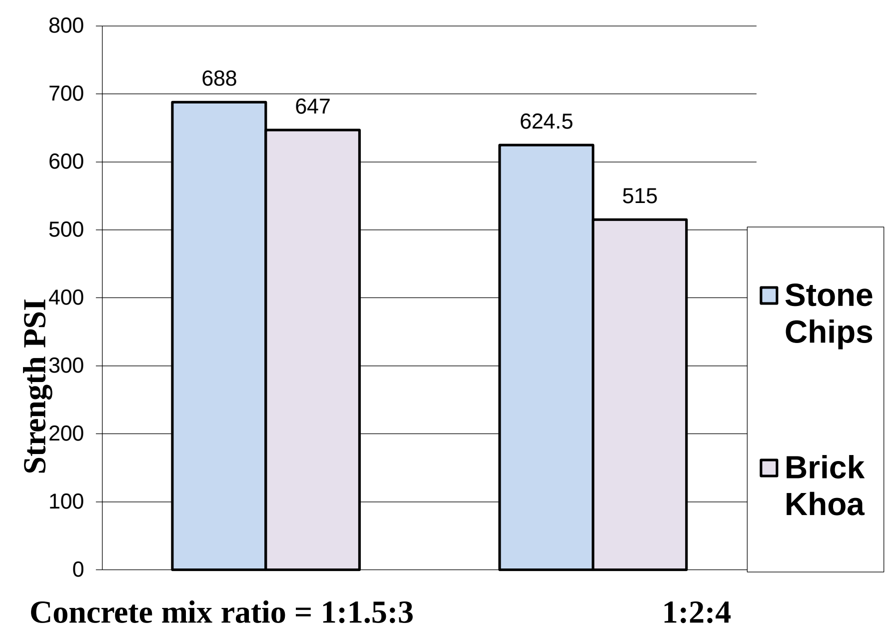
Table 4: *BRICK KHOA (Mix ratio: Cement: Sand: BRICK KHOA =1:2:4).*

Name of paint condition	Failure load (KN)	Failure load (lb)	Bond stress (Psi)	Average bond stress (Psi)	% Reduction in bond stress	Cube crushing strength (psi)	Average cube strength (Psi)
Without painted bar (Dummy)	43	9671	684	642	----------	2777	2814
	40	8996	636				
	38	8546	605				
Robbialac red oxide primer (Berger)	30	6746	477	515	20		
	35	7871	557				
	32	7197	509			2861	
Anti corrosive primer ro (Asian)	35	7871	557	504	21.5		
	30	6746	477				
	30	6746	477				
Aqua anti corrosive red oxide primer (Aqua)	25	5622	398	472	26.5		
	32	7197	509			2805	
	32	7197	509				
Anti corrosive red oxide primer (Moon star)	25	5622	398	435	32		
	30	6746	477				
	27	6072	430				

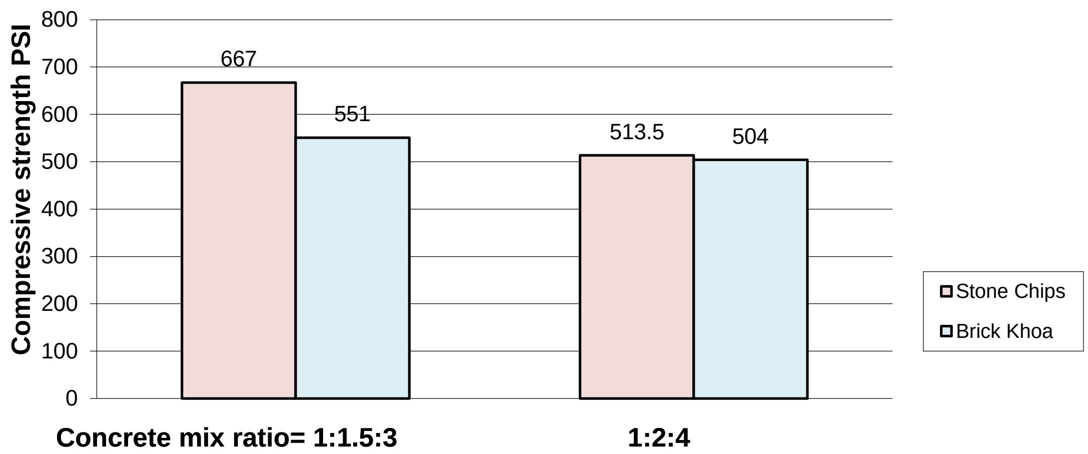
Laboratory Bond Stress Test Results Graphical Presentations



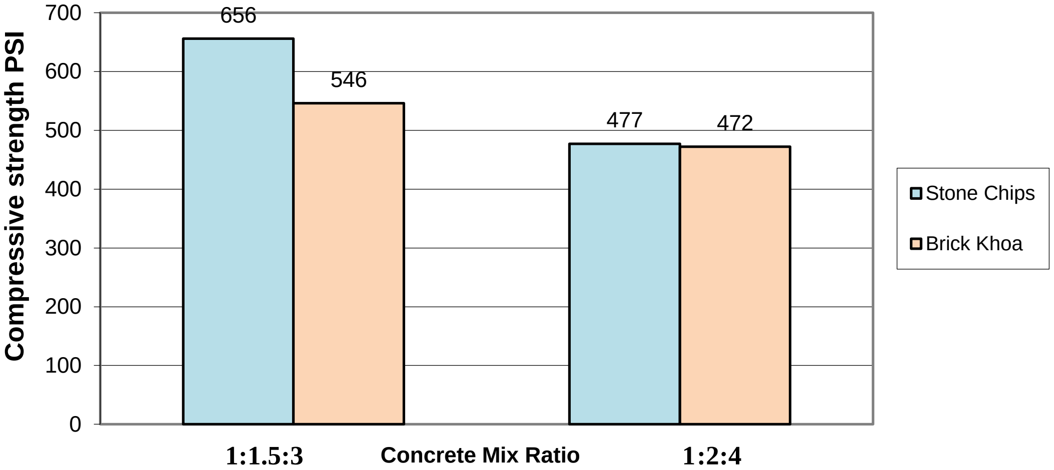
Graph 1: Strength vs. Concrete mix ratio for without painted bar (Dummy bar)



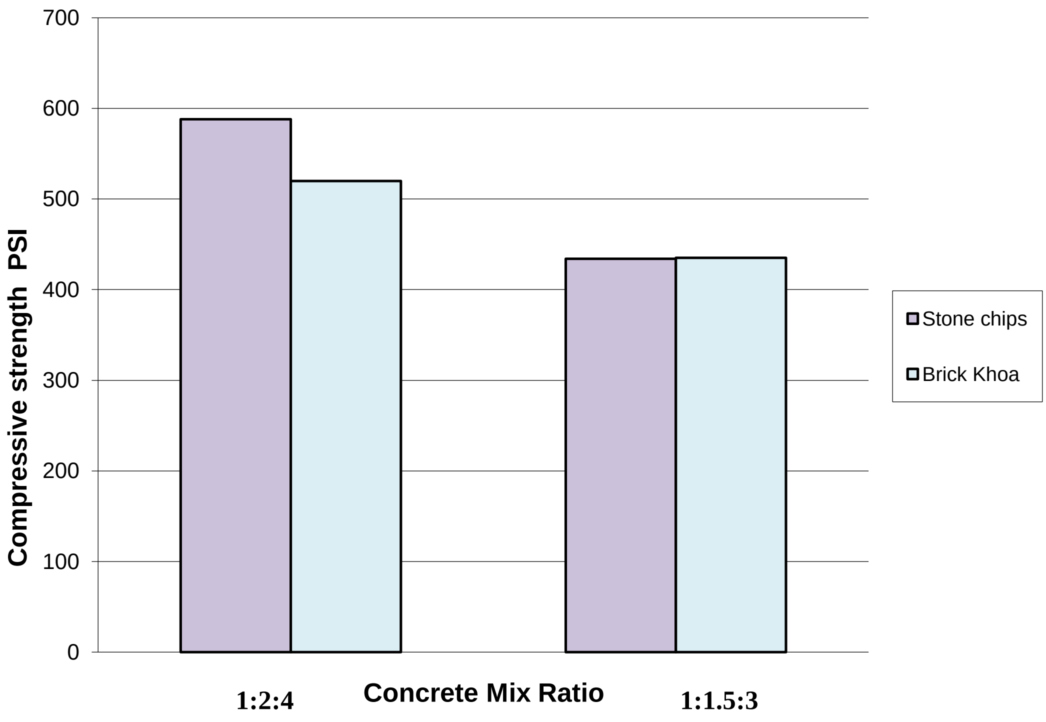
Graph 2: Strength Vs Concrete mix ratio for Robbialac Red Oxide Primer(Berger)



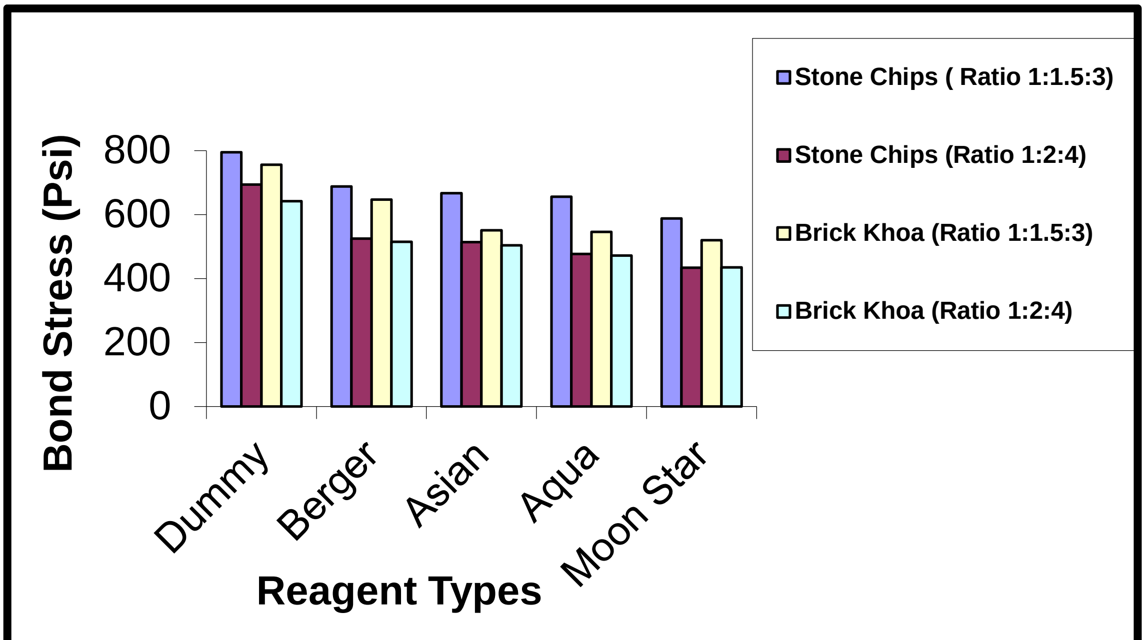
Graph-3: Strength Vs Concrete mix ratio for Anti corrosive primerro(Asian paint)



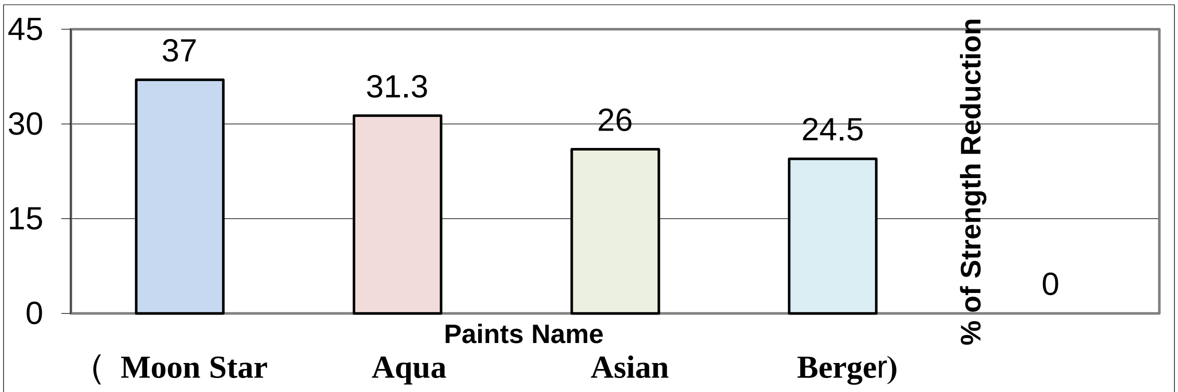
Graph 4: Strength Vs Concrete mix ratio for Aqua anti corrosive red oxide Primer (Aqua paints)



Graph 5: Strength Vs Concrete mix ratio for Anti corrosive red oxide primer(Moon Star paint)



Graph 6: Combined Graph of Stress.



Graph 7: Strength reduction Vs various painted concrete mix of ratio 1:2:4 for stone Chips.

RESULTS AND DISCUSSIONS

In this project, four different types of paint used as anticorrosive reagent on deformed bars. To obtain accurate results, more cubes of same size were cast for each batch of anticorrosive reagent. Painted and paint free bars were penetrated into concrete and after 28 days of curing the bond stresses were calculated. It was observed that the bond stresses reduced 13 to 37 % due to application of paint as anti corrosive reagent.

CONCLUSION

If paint is applied on the surface of M.S bars for protection against rusting due to salinity, the bond stress of the bars reduced 13 to 37 %.

RECOMMENDATION

1. A wide-scale investigation the efficiency of paints as a protective measure against salinity may be performed.
2. Effect of paints, other than red oxide, on the bond stress of M.S bar may be studied.
3. A comparative economic study of the application of paints as a protective measure against salinity may also be done.
4. Development length of rebar for situation when anti corrosive reagent is used should be increase.

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