Effect of Casting Temperature on Bond Stress of Reinforced Concrete Structure

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Abstract

This study investigates the influence of mixing and curing temperature on bond behavior of reinforced concrete. The properties examined were compressive strength, splitting tensile strength and bond stress between reinforcing bar and adjacent concrete at three different mixing and curing temperatures (150C, 300C and 450C). For measuring mechanical strength, cylindrical concrete specimens (100 mm dia. x 200 mm height) were prepared. Locally available materials were used to prepare these samples. Bond stress-slip relationship was observed to determine the mechanical properties of the interface between steel re-bars and concrete. Results of compression strength test shows that lower mixing and curing temperature exhibits higher early age strength and comparatively low long period strength in compare to high mixing and curing temperature. Interpretation of bond stress- slip relationship demonstrates that D15DC sample gives 27.4

Index terms— bond stress, mixing temperature; curing temperature; reinforced concrete; reinforcing bars.

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Reinforced Concrete Structure -This study investigates the influence of mixing and curing temperature on bond behavior of reinforced concrete. The properties examined were compressive strength, splitting tensile strength and bond stress between reinforcing bar and adjacent concrete at three different mixing and curing temperatures (15 0 C, 30 0 C and 45 0 C). For measuring mechanical strength, cylindrical concrete specimens (100 mm dia. x 200 mm height) were prepared. Locally available materials were used to prepare these samples. Bond stressslip relationship was observed to determine the mechanical properties of the interface between steel re-bars and concrete. Results of compression strength test shows that lower mixing and curing temperature exhibits higher early age strength and comparatively low long period strength in compare to high mixing and curing temperature. Interpretation of bond stressslip relationship demonstrates that D15DC sample gives 27.4% more bond strength than D45DC sample and P15DC sample gives 38.5% more bond stress than P45DC sample. Average bond stress of deform bars displays 36% more than plain re-bars. This study contributes mainly to explore the bond behavior for different mixing and curing temperature and enlighten the matter that hot environmental condition has great impact bond strength of reinforced concrete structure.

Keywords : bond stress, mixing temperature; curing temperature; reinforced concrete; reinforcing bars.

2 I. Introduction

einforced concrete is a common practice in Civil Engineering. It acts as a composite member when reinforcing bars and concrete residing together. Then they offer most stiffness and durability than others. It is almost depends on their bond behavior. Concrete is placed under many different atmospheric conditions. Sometimes it is placed at hot environment or cold environment. So, temperature has a great impact on reinforced concrete structure.

(Ordinary Portland Cement), crushed burned brick, sea bed sand and reinforcing bar.

3 R

Global Journal of Researches in Engineering XIII Issue v v II Version I hydration and this results in an increased rate of slump which leads to expedited setting and to a lower long term strength of concrete [2]. The effect of temperature on water demand is mainly brought about by its effect on the rate of cement hydration [3]. When water comes to the cement particle, hydration reaction starts. This hydration reaction is a heat generating reaction. When the ambient temperature is increased with atmosphere then the rate of chemical reaction is increased naturally. So, the ultimate degree of hydration increases with temperature [4]. As a result of the accelerated hydration, initial and final setting times are both reduced with the rise in temperature. A14°C rise in temperature from 10 to 24°C reduced the initial setting time by 8 h while the same rise in temperature from 24 to 38°C reduced the latter by 5 h only [5]. And hot weather conditions more water is required for a given mix to have the same slump, i.e. the same consistency. A 25mm decrease in slump is brought about by a 10 o C increase in concrete temperature [6]. The rate of reaction increases with temperature but so does the rate of evaporation from an exposed surface. The ultimate strength of concrete cured at low temperature is generally greater than that of concrete cured at a high temperature, but extremes of temperature generally have a negative effect [7].Concrete cast and cured at high temperature exhibits the expected increased earlyage strength, it later-age strength is adversely affected [8,9,10].A better understanding of effect of mixing and curing temperature on reinforced concrete would no doubt aid in the development of concrete structure under various environmental condition especially temperature to predict the bond strength of reinforced concrete structures. The objectives of this study are to investigate the bond strength of reinforced concrete under varying mixing and curing temperature.

4 II. Experimental Program

The experimental work was carried out to the effect of mixing and curing temperature on bond stress of reinforced concrete. The variable parameters studied and materials and methods involved were as follows:

5 a) Materials

The experimental program consists of main four types of materials. These are mainly Cement Type I this is placed at hot temperature, leads to rapid The properties of fine and coarse aggregates that were used are summarized in Table (2). Sea bed sand was used as a fine aggregate and crushed burned brick was used as a coarse aggregate. The maximum size of coarse aggregate was 19 mm. Six groups of pullout specimens consisting of 100mm (4 in.) x 200mm (8in.) concrete cylinders rebar embedded axisymmetrically were tested. Deform rebar used in three groups and plain rebar used in another three group. Every group contained four specimens. Rebar was casted vertically from the top of the cylinder. Fig. 1 shows the pullout test specimen dimension. Type of specimens and rebar, rebar diameter, embedded length, compressive strength and splitting tensile strength are provided in Table (3). For compressive strength test, same size of concrete cylinder was tested for 3 days, 7 days, 28 days and 90 days sample.

6 c) Concrete Mix Design

The concrete mix for every specimen was based on the mix design. The weight proportion of the concrete of the mixture was 1 (cement) : 1.4 (coarse aggregate) : 2.5 (fine aggregate): 0.5 (water), giving a water to cement ratio (W/C) of 0.5. The concrete was mixed by following the hand mixing method. The concrete mix consisted of 147kg/m 3 water, 295 kg/m 3 cement, 445 kg/m 3 sea bed sand, 500 kg/m 3 burned crushed brick.

7 Results and Discussion

In compressive strength test, measurements of compressive load were taken from compressive strength testing machine. Compressive strength was calculated as compressive loads were divided by cross sectional area of concrete cylinder. Measurements of compressive strength were observed for three mixing and curing temperature such as 15 o C, 30 o C, 45 o C and for several four days (3, 7,28 and 90 days).

The results of compressive strength are plotted in fig. 3 for different temperature for several days. The fig. 3 is illustrated that mixing and curing temperature has the direct effect on compressive strength. It shows that at beginning stage of strength gaining process, 45 0 C casting temperature sample has the higher value of strength than 15 0 C mixing temperature sample. But 28 days and 90 days strength shows that reverse of 7 days strength value. Due to the high temperature, rate of hydration of cement has increased and initial setting time has decreased. In Pullout test, measurement of bond load and corresponding slip were taken from the pullout test setup arrangement. Bond stress was calculated as the maximum bond load was divided by the embedded steel surface perimeter. It was observed for deform and plain reinforcing bar as well as different mixing and curing temperature. Table (4) shows that bond stress slip relationship between deform and plain reinforcing bar for different mixing and curing temperature. The pick point of bond stress-slip relationship is indentified as a maximum bond load and corresponding bond slip. The average calculated maximum nominal bond stress, bond load, failure slip and calculated maximum bond stress are shown in Table (4). The fig. 5 shows that bond stress of deform rebars are always greater than plain bars. Deform rebars show initially more incresing bond nature with respect to slip value than plain rebars. But after maximum bond load these give more slip value than plain rebars.Due to adition and friction defrom rebars give better bond stress than plain rebar. Friction can contribute up to 35%of the ultimate strength governed by the splitting of the concrete cover [11]. For deformed bars, bond stress depends on the mechanical interlocking betwwen ribs and concrete keys. The ultimate bonstrength is reached , shear crack begin to form the concrete between the robs as interlocking forces induce large bearing stress around ribs and large slip occure [12]. It is clear in fig. 5 that mixing and curing temperature have a great impact on bond stress. D15DC gives more bond stress and slip value than D30DC and D45DC and P15DC sample gives better bond strength thanP30Dc and P45DC. According to the fig. 3, low temperature has great impact on long term strength of reinforced concretea and it illustrates that 15 o C mixing and curing temperature sample shows 21% more compressive for 28 days than 45 o C sample. Compressive strength is considered to be a significant parameter in bond behavior because the force between steel and concrete is transferred mainly by bearing and bond [13]. It has been found that the bond of high strength concrete is proportional to the compressive strength of concrete [14]. The fig. 6 explains the variation of normalized bond stress for deformed and pain reinforcing bars. It shows that D15DC sample gives 27.4% more bond stress than D45DC sample and P15DC sample shows 38.5% more bond stress than P45DC sample. Again average of D15DC, D30DC and D45DC samples gives nearly 36% more bond stress than P15DC,P30Dc and P45DC samples.

8 IV.

9 Conclusion

Based on the results of this research work, the following conclusions can be drawn with respect to different mixing and curing temperature of concrete. Lower mixing and curing temperature leads to increase initial setting time of concrete that increase 21% compressive strength for 28 days than higher mixing and curing temperature samples. It increases 27% -38.5% more bond stress than higher mixing and curing temperature sample. Deform reinforcing bars give 36% more bond stress than plain reinforcing bars due the adhesion, friction and mechanical interlocking of deform rebar's. Finally, lower mixing and curing temperature presents better results than higher mixing and curing temperature. [1] [2]

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Figure 1: Figure 1 :

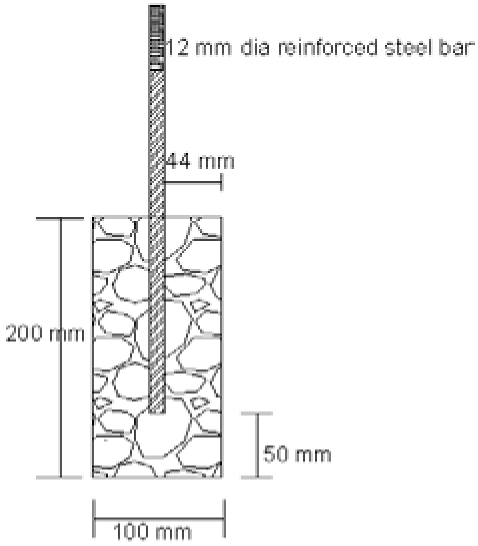
2 

Figure 2: Figure 2 :

3 

Figure 3: Figure 3 :

4

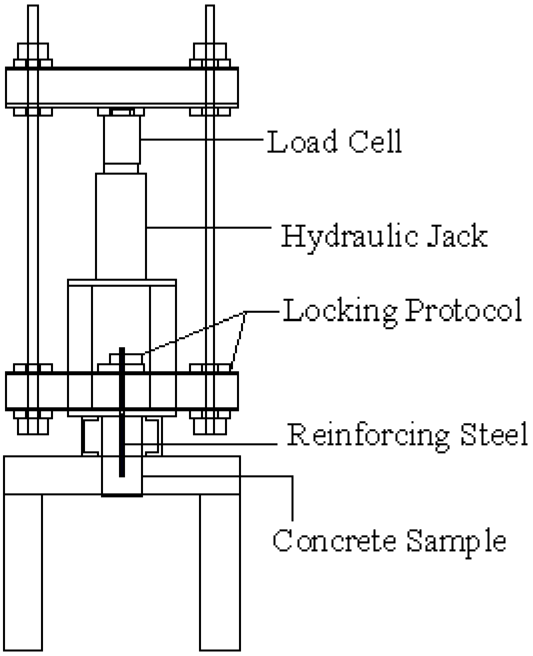


Figure 4: Figure 4 :E

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Oxide Composition	Ordinary Portland Cement
CaO	62.75
SiO_2	20.83
Al_2O_3	5.29
Fe_2O_3	3.50
MgO	0.52
SO_3	2.44
Na_2O	0.23
Total	95.56
Ignition loss	2.65
i. Cement	
Cement Type-I,	

Figure 5: Table 1 :

2

Properties	Aggregate Coarse aggregate (Crushed Burned Brick)	Fine aggregate (Sea Bed Sand)
Maximum aggregate size, (mm)	19.0	2.38
Unit weight(Kg/m 3)	861.02	1555.58
Specific gravity	2.04	2.64
Fineness modulus	-	2.72
Absorption, (%)	18.25	3.19
b) Test Specimens		

Figure 6: Table 2 :

4

Specimen	Maximum Load (kN)	Maximum Nominal Steel Stress (MPa)	Failure Slip (mm)	Maximum Bond Stress (MPa)
D15DC	49.35	436.35	0.75	8.59
D30DC	42.98	380.03	1.10	7.48
D45DC	35.78	316.36	0.85	6.23
P15DC	34.01	300.71	0.88	5.92
P30DC	27.46	242.78	0.77	4.78
P45DC	21.37	188.95	0.35	3.72

Figure 7: Table 4 :

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