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EVALUATING TECHNIQUES TO STRENGTHEN BONDING BETWEEN OLD AND FRESH CONCRETE

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ABSTRACT: *Concrete is the most widely used construction material around the world because of its high strength and low cost as compared to alternatives. However, concrete structures tend to deteriorate over time due to various factors which include sulphate attack, severe weather conditions etc. and that is why concrete structures require repairing works after a certain span of time. The problem that arises is that the bonding between old and fresh concrete is poor and most of the times structures do fail at the interface. Commonly, mechanical methods are used which normally involves roughening of surface of old concrete before the addition of fresh concrete but in modern market, number of chemicals are available in market that can contribute to the bonding strength at the interface.*

This research covers both type of methods for bonding which includes roughening of surface as mechanical method and addition of locally available bonding agent in different compositions as chemical method. Also concrete that was added on top of old surface was of different types to check whether that would have any effect on the bonding at the interface. It was found out that the bonding agent did improve the bond strength at the interface by 20 percent although it did not have any effect on the compressive strength of concrete.

1. INTRODUCTION

Concrete as a structural component can be seen in buildings and bridges in various forms. For the development of an overall efficient and safe structure, it is fundamental to understand the response of these components during different loading conditions [1]. Concrete is one of the most widely used, versatile and economical material in the today's construction industry and is cast by mixing cement, water, coarse and fine aggregate. The use of concrete is more than any other man-made material in the world; about 7.5 cubic kilometres of concrete is made each year. Concrete has specific properties which can be altered by external factors. Addition of additives, reinforcement or prestressing can change its properties to meet the desired requirement. Efforts have been made to strengthen concrete, some of which are proved successful.

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This research covers both type of methods for bonding which includes roughening of surface as mechanical method and addition of locally available bonding agent in different compositions as chemical method. Also concrete that was added on top of old surface was of different types, high strength concrete and Glass fiber reinforced concrete, to check whether that would have any effect on the bonding at the interface. The research was done as part of a project in University of Engineering and Technology, Taxila. Fresh concrete was added on top of already casted hollow core slabs.

2. EXPERIMENTAL SETUP

2.1 Concrete Materials

a. Ordinary Portland cement manufactured by a local cement factory using indigenous raw material was used.

b. Well-graded fine and coarse aggregates were used. Specific gravity of fine aggregate (sand) is 2.68. According BS-882: 1973[2], its grading lies in zone 4. Gradation of coarse aggregate full fills the ASTM C 33-78[3] grading requirement.

c. SBR Latex bonding agent was used to treat surface under different mix ratios in order to check how bond behavior will change between old and fresh concrete.

Table 1 shows the properties of bonding agent used.

Table 1 Properties of Bonding agent SBR Latex

Property	Value
Tensile strength (MPa)	19
Elongation at tear (%)	635
Mooney viscosity (100 °C)	51.5
Glass transition temperature (°C)	-50
Polydispersity	4.5

d. AR-D (Alkali resistant-water dispersed) Glass fibers chopped strand obtained from China Beihai Fiberglass were used. These fibers have a sizing system which is water dispersible, allowing its well dispersion into individual filament's in water in 10 seconds. These fibers disperse fast and dosage amount required is low. It is typically used in a small amount to prevent cracking and to improve the performance of ready mix concrete, gypsum or other special mortar mixes .The details of glass fibers are shown in Table 3.4. Fig 3.11 shows the image of glass fibers used in the research.After a careful study of the previous research done by other researchers, the percentage of glass fibre used was decided to be 1.5% of the mass of cement used in the mix. Table 2 shows technical characteristics of glass fibers

Table 2 Technical characteristics of glass fibers

Tex of strands (Tex)	Filament diameter (μm)	Chop length (mm)	Moisture content (%)	Sizing content (%)	ZrO_2 content
98±10 JC/T572-2002	15	12	≤0.6 JC/T572-2002	1.0±0.2 JC/T572-2002	14.5%

2.2 Mixing Of Concrete

Concrete was mixed in steel pan available in lab. First coarse aggregates and fine aggregates and then cement was added and mixed well until it looks homogenous. Then water was added to dry mixture and mixed well for 3-4 minutes until it became homogenous mixture.

In case of Glass fiber reinforced concrete, glass fibers were added before addition of water and mixed until the mixture looked homogeneous.

2.3 Workability Test

After all the ingredients have been mixed thoroughly, slump test was performed for each batch according to British as well as American standards.

3. RESULTS AND DISCUSSION

SBR latex bonding agent was used for checking the effect of using bonding agent on the flexural capacity of the hollow core slab units with topping. SBR was used in 3 different forms which included two water diluted forms of ratio 1:1 and 1:4 with dilution of 50% and 20% respectfully. The other method used was the addition of bonding agent to cement slurry in ratio of 1:1:4. The solution was applied to the surface of the slabs and the fresh concrete was poured on top while the solution was still wet. Wet-on-wet application method was adopted for all the slabs.

In order to check the bond strength at the interface, two types of tests were performed. In total 12 cores were cut from different slabs with different type of topping type used. 6 of the cores were used for tensile test and the other 6 were tested in compression. In the 6 cores selected each core had a different type of topping and with use of the bonding agent in different ways. The table below shows the nomenclature for the different cores with its topping type and the form in which SBR Latex was used as a bonding agent. Table 3 shows the nomenclature of cores with their topping type involved and which type SBR form was used at the time of application of topping.

Table 3 Nomenclature of the cores

Specimen	Topping Type	SBR form
H.S	High Strength	Not used
G.F	Glass Fibre reinforced	Not used
H.S 1:4	High Strength	Diluted
G.F 1:1	Glass Fibre reinforced	Diluted
G.F 1:1:4	Glass Fibre reinforced	Cement slurry
H.S 1:1:4	High Strength	Cement slurry

According to Silfwerbrand, the tensile bond strength varies between 1 to 2 Mpa for normal strength concrete but in this case the concrete used was high-strength, so at the time of tensile testing all the failures took place at the interface because that part is the weakest spot because no aggregate particles penetrate the surface. The tensile strength of the concrete topping itself was calculated as a ratio of its compressive strength which is normally taken as 1:10. For the tensile strength values of high strength concrete and glass fibre reinforced concrete, their compressive strength values were used to calculate the tensile strength values which came out to be 736.5 psi (5 MPa) and 559.3 psi (3.8 MPa).

The tensile test was performed using the Universal Testing Machine (Figure 1). Cores were cut from the slab, placed in the universal testing machine and tensile load was applied until the failure was seen. For the other 6 cores, compression test was performed and the maximum load taken by each core was noted. The table 4 below shows the tensile and compression values obtained from the cores. Figure 2 shows the interface failures of the specimens used.

Table 4 Strength of cores

Specimen	Tensile strength (MPa)	Compressive strength(Psi)
H.S	2.10	1170
G.F	2.15	1170
H.S 1:4	2.02	950
G.F 1:1	2.30	750
G.F 1:1:4	2.45	1253
H.S 1:1:4	2.50	1167

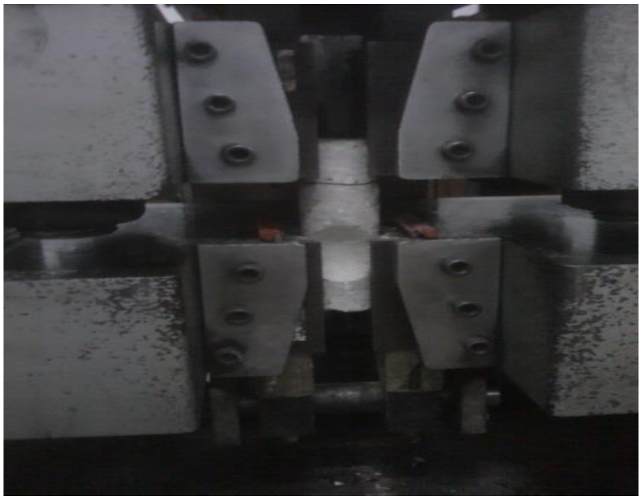

Figure 1 Tensile test on the cores

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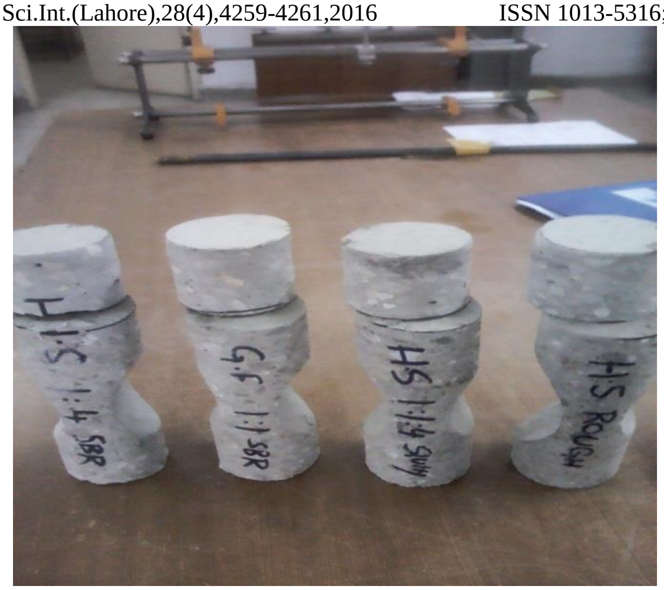

Figure 2 Failure of the cores in tensile test

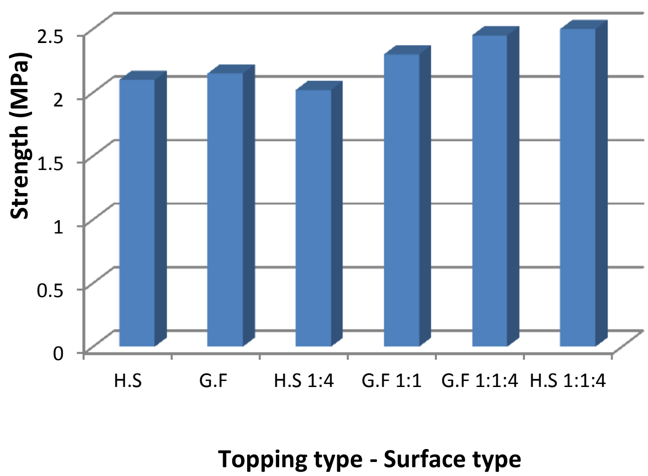

Figure 3 Tensile strength of cores

It can be seen from the graph (Figure 3) that the most effective way of getting a good old to fresh concrete bond is to use SBR Latex as part of cement slurry. The bond strength at the interface was achieved maximum when the bonding agent was used in form of cement slurry which was 2.5 MPa in case of high strength concrete topping with use of cement slurry as compared to 2.1 when no bonding agent was used. Another aspect that can be noted is that the bonding agent acted with more effect when no fibres were used in the concrete although the change was not much.

A slight fall in the tensile strength was noted with the use of the diluted bonding agent which can be regarded as an abnormal value. This might have been due to the poor workmanship or unclean surface at the time of the application.

The use of bonding agent did not affect much the compressive strength of the concrete. For the cores tested in compression the L/D ratio selected was 1.25 in accordance with the ASTM C-42 standard and the correction factor of 0.93 was applied. It was noted that two of the cores showed much less values compared to the rest. This might have been due to the fact during the cutting of the cores the concrete lost its strength. Figure 4 shows the compressive strength achieved by the cores.

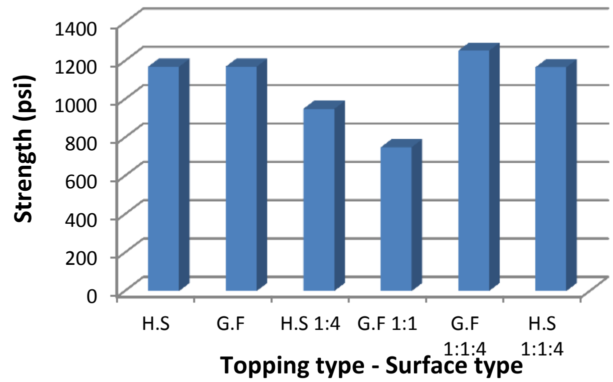

Figure 4 Compressive strength of cores

4. CONCLUSIONS

Based on the results following conclusions can be made.

- The use of bonding agent used in form of cement slurry that is in 1:1:4 mix did improve the bond strength at the interface the most among all the other techniques used.
- The least effective bond was with roughened surface when no bonding agent was used.
- The bonding agent acted with more effect when no fibres were used in the concrete although the change was not much.
- The use of bonding agent did not affect much the compressive strength of the concrete.

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