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Experimental Investigation of Bonded Specimen with Epoxy Between Steel and Concrete Using Slant Shear Test

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***Abstract* - We know that use, of Concrete is at construction industry is one of important part and comes at first number due to its compressive test, strength and durability. It has capacity to act as a binding material and high capacity to take strength and some other properties. There are many research were going on respective bond of concrete, fatigue, and creep on active level. Another part is as the times goes the strength of concrete will be reduced and may leads to damage and deteriorate it is one of the drawback of the concrete after we should have the need to repair the concrete to increase a structural strength and make a stiffness property improved which leads to safe structure. Our day by day infrastructure has been developed and have facing some problem for bonding between old to new structure and with composite structure are main issue so we need to repair that and make a proper strength to the corresponding structure. A bond which is good helps the engineer to consider monolithic behavior and it also helps in preventing de-icing salts and water to transmit along the interface. The strength and efficiency of a structure Increases with monolithic behavior of the structure. Main concept is the repair is to be done in such a way that bond will acts a it is originally designed. Making bond strength capable to transfer load and forces such as compression, tension, shear will be properly and safely. In concrete patch repairs application we have seen that the repair material plays a vital importance for concrete on Good Adhesion. For determining the bond strength between material and substrate there are several test. Bond strength under combines shear and compressive stresses, bond strength under shear stresses, under tension stresses respectively are the tests. Combine state of stress that combines compression and shear fall under slant shear tests. . In slant shear test we use a cylindrical or a square prism sample made of two identical parts which are bond at an angle of 30° and under axial compression they are tested. Some experimental work is done in this thesis using concrete steel composite material using epoxy based bonding agent and performing slant shear test and finding out bonding strength and durability of the bond.**

Keywords: Concrete, Fatigue, Cohesion, Adhesion, Bond Strength, Monolithic, Repair Material, Slant Shear Test, Safety Standards, Epoxy, composite bond.

I. INTRODUCTION

"Twice as much concrete is used in construction around the world than the total of all other building materials including wood, steel, plastic and aluminum" stated by **world business council for sustainable development 2015**. Another part is as the times goes the strength of concrete will be reduced and may leads to damage and deteriorate it is one of the drawback of the concrete after we should have the need to repair the concrete to increase a structural strength and make a stiffness property improved which leads to safe structure.

Simple and straightforward standard tests exist to measure the compressive and tensile strengths of bonds but when it comes to shear, few methods have been formalized into standard tests. (Helmick *et al.*). For this reason, engineers need an effective method to experimentally determine the strength in shear at the interface bonded between old and new concrete for purpose of conducting repairs or applying overlays. Structural interfaces are crucial for: i) repairing/strengthening of existing concrete structures; and ii) Composite precast members of concrete with parts of cast-in-place. In these composite structures, the bond strength of the interface has to be higher than acting shear forces in order to achieve a monolithic behavior. In today time, there are different experimental methods available to check the behavior of old concrete to fresh concrete bonding.

Those methods could be differentiated based to the state of stresses at the bonding surface in the following groups: i) shear stress; ii) bending stres; and iii) tension. In the table below the tests available for stresses of the referred groups are listed.

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	Tests	Standards	Research
Tension	Pull off	(EN 1542, 2000) (ASTM C1583, 2004) (BS 1881: Part 207, 1992)	
	Direct Tension	(ASTM C1404, 2003) (CAN/CSA A23.2 6B, 1990)	
	Split Tensile	(EN 12390-6, 2004) (ASTM C496, 2004)	
Bending		EN 12189, 2000 EN 12636, 2001	(Wall et al, 1986) (Abu-Tair et al, 1996)
			(Kunieda et al, 2000) (Kamada et al, 2000)
Shear	Direct Shear Test		
	Bi surface Shear Test		(Li et al, 1997) (Chen et al, 1995)
	SST	ASTM C882 2015	(Momayez et al, 2005)
	Push off		
			Hofbeck et al, 1969) (Mattock, 1974) (Crane, 2010)

1.1 Common Bond Strength Test

The most common tests performed on bonded concrete is the pull-off test, formally standardized as ASTM C1583, where a pure tensile force acts on a bond.

A core is drilled through an overlay and at least 1 inch or half the core diameter into the substrate. With the use of an epoxy, a steel puck is attached to the overlay. Once the epoxy has set, the testing apparatus is attached to the puck and an upward force is applied until failure occurs (ASTM C1583 2015). Other than a failure of the epoxy connection, there are three possible outcomes and each will indicate something regarding the tensile strength of the bond. This test can be done in the field and is very straightforward and easy to perform, hence its popularity. However, there are not very many situations in the real world that will apply this type of force alone to a bond so other tests are necessary to truly check the strength in shear at the interface which is bonded. In studies related to concrete the tests based on direct shear has not done regularly in previous researches due to the reason of difficulties which are technical.

Because of the clamping action and the angle at which the load is being applied relative to the interface surface, this is not a good test to evaluate strength in direct shear. Based on order to appraise strength of bond in the shear, the Arizona Slant Test, has a broad spread use due to: i) The simplicity of the experimental set-up ii) The fact that the bonded surface is subjected to a combined compressive and shear stress state, similarly to what happens in real structures (Clímaco and Regan,).

1.2 Brief History of the Slant Shear Test

To find out the strength of the bond based on a epoxy based resin in shear using SST Kriegh in 1976 proposed a specimen which is cylindrical in shape originally. Later in 1978 Tabor adopted a prismatic version in spite of cylindrical section to studying the concrete to concrete interfaces the strength of bond. Following are sizes of specimen for SST given below.

Table 1.2: Standards Code sizes for the SST specimen

Code	Dimension of specimen	Height of specimen (H)	Angle (α)
BS EN 12615, 1999	100 × 100 mm^2	400 mm	30°
	40 × 40 mm^2	160 mm	30°
Italian standard (reported in Clímaco and Regan, 2001)	70 × 70 mm^2	200 mm	17°
NFP18-872 (reported in Clímaco and Regan, 2001)	100 × 100 mm^2	300 mm	30°
ASTM C882, 1999	75 mm diameter	150 mm	30°

II. LITERATURE REVIEW

Prashant, Pankaj Kumar and AbhilashShukla (2020) 'Performance Assessment of Steel-Concrete Composite Bonded Specimen Under Slant Shear', International Journal of Current Advanced Research, 09(05), pp. 22341 22344.

Austin et.al (1) performs testing in bond of concrete repairing in shear. He said in application and performance of repair in concrete good adhesion between the material to be repaired and the concrete is required. He compares different methods and gets results of test of strength of bond that also include a tensile slant shear test. He find the failure of bond for repairs of concrete based on many tests such as pull off,

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Arizona slant shear etc test which shows stresses in compression and also state of pure tension.

Saldanha et.al (2) to enforce adhesive failure he has done a modified slant shear test. He performed various test after bonded the old concrete with new one and gave rest up to 7 days providing the same conditions to the specimen such that of monolithic sample. He provides the results he obtained each for the SST sample as well as for Modified-SST sample, in respect of strength, also gives out the mean value, divergence as well as COV. For each test three numbers of samples were. By checking the failure type of samples, it was concluded that samples of SST test were find having failure of cohesive type, whereas M-SST samples have adhesive type failures. He also finds out that the COV in the samples of the Modified-SST samples which have appreciably lower as compare to the samples of SST.

Naderi et.al (3) Naderi has done the analysis of slant shear test. He said that the SST test which concern with the interface between two semi-prisms bonded samples of fresh material and material to repair in a state of shear or compression single and combine is affirm to constitute the condition of stress of structures, also there are few major disadvantages in this test. The effects of adhesion, orientations, angle etc in a semi prisms samples or structures at the time of the making of samples and interlocking mechanically as well as the along the interface friction of repair in concrete are dispense. Also in the analysis which is done theoretically the factors which responsible for failure and a comparison of the practical results which comes from test performed with the outcome specify the existent of a critical angle at joint.

Diab et.al (4) diab has find bond strength using slant shear between old type concrete material and self-compacting type concrete. He takes out a cylindrical specimen of 150mm dia and300 mm height having minimum COV. He find out that the roughness of the substrate having a notable effects on the strength of bond and also on specimen of prism which shows more reliability in bond strength. In these study first parts shows reasons that affect bond strength in old type and new type of concrete and effect of, roughness in old type of concrete, effect of bonding agent and effect of providing polyprepene fiber also latex to SCC. In the second half slant-shear tests study is carried out.

Clímaco and Regan (9), a Mohr-Coulomb failure model was received in choosing a basic point by selecting a critical angle to check adhesive failure. A 223 no of tests were done by embrace three types of different angles of 0°, 20°, and 26.7°. Despite a fact that 20°angle was characterized for always get an adhesive type of failure, cohesive type failure was also revealed. Furthermore, even when the angle is the lowest possible (0°), cohesive failures were still observed.

III. RESULTS AND DISCUSSIONS

Load Vs Deformation Curve for Different Grade of Concrete and Steel bonded Specimen

(a) Before Sulphate attack to the sample

(b) After Sulphate attack to the sample

Table 3: Compressive and slant shear bond strength

Sr.No.	Grade of concrete	Compressive Strength (N/mm^2)	Apparent Bond Strength (N/mm^2)	Type of failure
1.	M30	33.1	19.95	Cohesive
		32.6	19.64	Cohesive
		32.86	19.8	Cohesive
2.	M40	43.31	26.09	Cohesive
		42.8	25.7	Cohesive
		42.54	25.6	Cohesive

IV. CONCLUSION

1) Bond strength affecting many factors such as curing conditions, cleanness at the specimen interface, cracks are present or absents, type of bonding agent etc are some factors which are considered major factor etc.
2) The bond strength of the specimen has Different surface preparation techniques have different effect.
3) Bond I have obtained is cohesive type of failure it means that the concrete sample fails first and the bond did not break.
4) The type of failure is cohesive, so the bond strength obtain is not true bond strength. It is apparent bond strength between concrete and steel specimen.
5) The durability of sample is checked and finds out that the strength of sample is decrease but not that much, so durability of sample is good.
6) Compressive strength of bonded specimen is more than the concrete cube alone strength.

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