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To Analyze Bond Strength between Dowel Bar and Blended Pavement Quality Concrete

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ABSTRACT

This present paper discusses bond strength between Reinforced steel dowel bars, tie bars, and three types of pavement quality concrete. The first type of concrete is base on the conventional concrete method used in regular practice. Second and third types of concrete are prepare - the second type with a blending of two preset mixes of the same grade of concrete mix type term known as selfing concrete. The third type with a mixing of two preset of the blends is of different concrete mix types term known as a crossing. Time lag considers from the time of mixing of preset concrete. Bond strength was measured using the pull-out test. The results of an experimental study deformed dowel of 25mm, 32mm diameter with concrete strength of 40MPa & 50 MPa. Usually, crossing method of remixing is considering to have a better bond with steel in comparison with conventional method concrete. The relationship between remix concrete and steel is tough to evaluate. Applying crossing technique to the existing partially set concrete at various time lags, the tremendous increase in bond strength as compared to Selfing. The result is essential not only for the evaluation of bond strength between steel and concrete of pavement but also for the development of selfed and crossed mix concrete theory. Applying crossing technique to the existing partially set concrete at various time lags, the tremendous increase in Bond strength as compared to Selfing.

1. Introduction

The design of the reinforced concrete pavement joints is base on the fundamental assumption that exists adequate bond strength between pavement quality concrete & deformed steel bars (Dowel & Tiebar). When the pavement is in loaded by wheel load, the behaviour and the strength capacity of reinforced concrete pavement panel's joints depend upon bond strength between PQC and steel bond. The primary objective of this study was to experimentally investigate the dynamic interaction (bond strength) of reinforcement with concrete and gain a better understanding of the parameters that control this interaction. Specifically, the effects of concrete confinement, bar deformation and bar diameter on the bond slip, and the influence of loading rates static to impact on these effects were investigated. Additionally, the selfing & crossing concept was introduced to overcome the reduced bond strength due to delay in placing of partially hardened concrete. Consider time lag 30min, 60min, 90min, 120min, in concrete placed over a preset concrete or partially set concrete. The providing pre stiffened mixes in the composite mass under observation have different mix proportion (M40, M50, M40+M50 grades of concrete was used), blend ratio (r = Old concrete/Fresh Concrete), and time lags (t in minute) due to avoidable reasons.

The observations were made on evolving bond strength, reducing bond slip by considering two grades of cement concrete M40 & M50 with water to cement ratios of 0.40 and 0.35 respectively and cured for 28 days(Alnki et al.,2014). The concept of strength variation of composite mixes has been studied by (Bairagi and Jhaveri., 1977). The pre-stiffened mixes in the composite mass under observation have different mix proportions, water-cement ratios, and time lags as variables. The corresponding theoretical strength values have been predicted using selfing theory and its generalized version the time lag strength variation of the strain along the length of the steel bar and strain transfer to the concrete were investigated. A simplified analytical model to simulate bond-slip between longitudinal bars and surrounding concrete. The proposed model provides a tensile stress-slip relationship for both straight and hooked longitudinal bars, including steel deformation and slip (Kunnath et al., 2009). The Direct tensile pull-out bond test (DTP-BT) was designed by (Tastani, and Pantazopoulou., 2002).

1.1 Research Significance

Every day a variety of field problem concerned with concreting are met with when the casting of concrete is not just at the site of mixing but for some distance far off. The preparation of concrete and transport the same to the particular site takes a considerable amount of time. The delay of dumping the concrete into the formwork always causes loss of some strength. Concrete mass thus obtained by laying one "fresh" concrete mass over relatively "older" preset mass of concrete (be of the same or different mix types) at a particular time lag of casting, is often practised at construction sites, and maybe termed as layered concretes or "Spread Concretes"(Goyal., 1990)

In the event of spread concreting, mainly speaking for the case of casting with a preset mass at time lag t ; (ti<t < tf) over the existing concrete cast. The

standard interface surface of the two concrete layers of the time-lag castings is prone to be weaker (Tapkire and Parihar, 2014). The bond between concrete to concrete and concrete to steel plays a vital role in holding together two such preset layers of concrete to behave as integrated mass. The monolithic ness of two such layers of time-lag castings depends significantly on the bond developed at this interface. (Bairagi, 1978; Bairagi et al.1995)
The problems concerning preset concretes, viz., determination of their strengths either of the individual mix at time lag t, or of the blended mass formed of the two preset concretes in blending in a certain weight ratio in terms of the strengths of the constituent mixes, their reuse etc., can be efficiently handled with the help of a very strong and reliable mathematical tool known as "Selfing Concept in Concrete "(Bairagi, N.K, et al., 1995)
Selfing is a term attributed to the blending of two preset mixes of the same mix type but considered at different time lags. A large number of studies have been carrying out on the various aspects of two preset combinations in blending for observation of multiple strengths using the concept of Selfing. The said concept has also been extended to the more generalized form viz., Crossing (Bairagi and Jhaveri,1977; Bairagi et al., 1990; Bairagi et al., 1989).

2. Materials and Methodology

Present In this study, the laboratory work includes testing on concrete cube & cylinder specimen under tension by using a Universal testing machine of 100-tonne capacity. One end of the dowel bar is free to slide, and the other end is entirely restricted. The concrete blocks form a cold joint at 75mm and inserted dowel & tie bars under bending moment and shear load to derive the stiffness of dowel bars & tie bar embedded in the slab. Both ends of the tie bar restricted to the concrete blocks, in this case. Testing will also be done on concrete blocks with aggregate interlock joints under shear load to derive their stiffness. The axial stiffness of joints sealants between the concrete blocks under axial loading calculated.

Bond Behavior

It is required to cast Cube & Cylinder specimen embedded with steel in a single stretch dimension of b*h & Ø*h respectively at a single stretch. But after casting with M1 concrete (b*a1h) in the cube, work stops, due to unavoidable reasons. Wait up to time lag t, then the work starts. Instead of fresh concrete M1, the top layer [b*(1-a1) h] is cast on the partially set mass M2 to complete the work (Gilbergues et al., 1993), diagrammatically shown in fig 1 & 2.
Cube & Cylinder specimen cast in two layers at a time lag t
a1=0, full M2 (it is as good as M1)
a1=1, F=full M1 (it is genuinely wanted)
Vary M1 of different grades of partially set mass identified by time lag t1 -- $(0\text{-}ti) \leq t1 \leq tf$.
& vary M2 of different grades of partially set mass identified by time lag t2--- $(0\text{-}ti) \leq t2 \leq tf$.
Select interface - if M1=M2 (same)
Crossed interface - if M1 $\neq$M2 (different)

For obvious reason, the top layer M2 to be compatible to that of M1(bottom layer) to have the strength developed at the interface same as that for the case of full section (b*h) at the homogenous body at that level at (a1h) height, the strength of M2 (which is at time lag t) be of higher value.

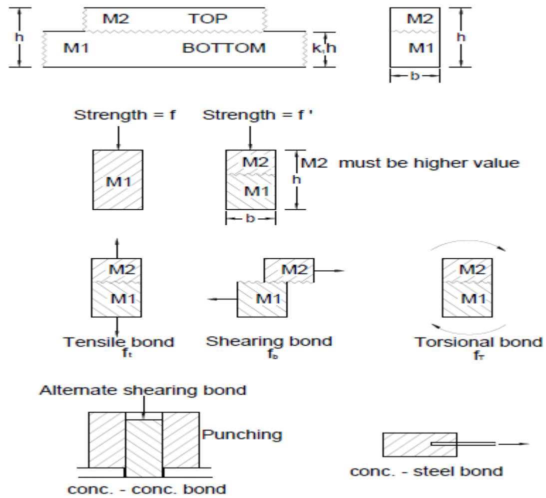

Fig. 1 *Methodology of Selfing & Crossing method*

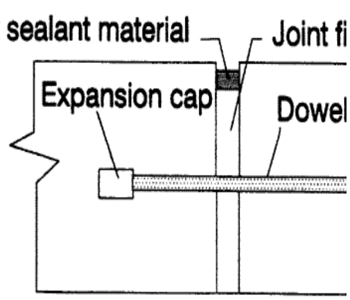

Fig. 2 *Dowel Bar Position in pavement slab*

3. Material

Cement: Cement is a binding material used in construction. It has property setting and hardening when mixed with water to attain strength cement is always used in the form of either grout or mortar or concrete, so we use cement of OPC 53 grade for concreting.

The initial and final setting time of cement have been observed, through standard Vicat needle apparatus as per IS:4031- 1968 (Method of physical tests tor hydraulic cement) and are as follows:

Initial setting time of cement =40 minute

Final setting time of cement= 280minute

The compressive strength values of the cement used observed at 3, 7 and 28 days-of complete water curing

Dowel Bar & Tie Bar:

Length of Dowel bars & ties bars

The joint function significantly related to dowel bars & tie bars. Mostly the concrete pavement damaged due to load cannot bear & distribute by dowels bar. Too short a dowel bar will restrict the loading transfer capability across joint. In all contraction joint to installed with dowel bars for heavy volume road shown in fig 3 & fig 4 (Chichun et al. 2016)

The dowel bar size and spacing suggested by Portland cement Concrete Pavement Association (JTG D40–2002) listed in table 1

Table: 1 *Dowel bar size*

Slab thickness (cm)	Dowel Diameter (cm)	Dowel embedment length (cm)	Dowel length (cm)
12.5	1.6	12.5	30
15	1.9	15	35
20	2.2	15	35
20	2.5	15	35
22.5	2.8	17.5	40
25	3.1	18.8	45
27.5	3.5	20	45
30	3.8	22.5	50

Specimen Details

Casting of Cube, Cylinder, & Beam specimens of M-40& M50 grades of concretes at different time laps intervals find out bond stresses between different concrete grade combinations at joint intervals. Specimen details are shown in table 2.

Table: 2 *pull out Test Specimen Details*

Sr. No.	**Specimens**	**Conventional Method**	**Selfing Method**	**Crossing Method**
Providing Time lag (t-hr) 0,30,60,90 & 120 Minutes				
1	Cube(150mm x150mm) with tie bars	30	30	15
2	Cylinder (ϕ 150 mm) with dowel bars.	30	30	15

Concrete Mix proportion of M40 & M50 Grade shown in table 3.

Table: 3 *Trial Mix Ratio by using IS 10262-2009*

Grade	**W/C**	**Cement**	**Fine Aggregate**	**Coarse Aggregate**
M 40	0.40	1	1.82	3.09
M 50	0.35	1	1.43	2.42

2.3 Casting of Cubes and Cylinders for Pull out Test

The primary objective of this study was to experimentally investigate the dynamic interaction (bond-slip) of reinforcement with concrete and gain a better understanding of the parameters that control this interaction. Specifically, the effects of concrete confinement, bar deformation and bar diameter on the bond-slip, and the influence of loading rates static to impact on these effects investigated. Additionally, the variation of the strain along the length of the steel bar and strain transfer to the concrete investigated. Finite element analyses performed using the experimental parameters to determine the value of the chemical adhesion and to compare the experimental results with the analytical values.

To accomplish the research objectives, the number of pull-out tests performed. The test specimens were subjected to quasi-static, dynamic and impact loadings, to investigate the influence of rebar size and shape, confinement and loading rate on pull-out resistance and failure mode.The loading rates varied from static loadings to dynamic loadings, with rising times of approximately 5 msec to include the full spectrum of strain rates. Deformed #25 & #32 tie bar & dowel bar used to determine the effects of bar diameter on the failure mode. Cube mould of 150mm x150mm x150mm & cylinder mould diameters of 150mm & 300 mm height used to determine the effects of increased concrete confinement on these failures.

The cubes and cylinders filled by M40 and M50 grade of concrete embedded with 25mm dia tie bar in 3 no. of cubes up to 150mm embedment length (Le) & 32mm dowel bar embedded in 3 no. of the cylinder up to 190mm embedment length (Le) were maintain in all the tests.

Methods of Casting of specimens.

Conventional Method

The cube & cylinders 50% volume fill by fresh concrete of M40 grade and the remaining 50% volume fille by the same new concrete of same grade concrete with a time lag of 0 minutes.

The 03 no. of cubes and 03 no. of cylinders ere filled by 50% of fresh concrete of M50 grade and remaining 50% of volume filled by same grade fresh concrete of time lag of 0 minutes.

Selfing Method

The cubes (03 No.) and cylinders (03No.) filled by 50% of fresh concrete of M40 grade and remaining 50% of volume filled by mixing of 25% Old & 25% fresh concrete of M40 grade with a time lag of 30 minutes.

The cubes (03No.) and cylinders (03No.) filled by 50% of fresh concrete of M40 grade and remaining 50% of volume filled by mixing of 25% Old & 25% fresh concrete of M40 grade with time lag of 60 minutes.

The 03 no. of cubes and 03 no. of cylinders were filled by 50% of fresh concrete of M40 grade and remaining 50% of volume filled by mixing of 25% Old & 25% fresh concrete of M40 grade with time lag of 90 minutes.

The 03 no. of cubes and 03 no. of cylinders were filled by 50% of fresh concrete of M40 grade and remaining 50% of volume filled by mixing of 25% Old & 25% fresh concrete of M40 grade with time lag of 120 minutes.

The 03 no. of cubes and 03 no. of cylinders were filled by 50% of fresh concrete of M50 grade and remaining 50% of volume filled by mixing of 25% Old & 25% fresh concrete of M50 grade with time lag of 30 minutes.

The 03 no. of cubes and 03 no. of cylinders were filled by 50% of fresh concrete of M50 grade and remaining 50% of volume filled by mixing of 25% Old & 25% fresh concrete of M50 grade with time lag of 60 minutes.

The 03 no. of cubes and 03 no. of cylinders were filled by 50% of fresh concrete of M50 grade and remaining 50% of volume filled by mixing of 25% Old & 25% fresh concrete of M50 grade with time lag of 90 minutes.

The 03 no. of cubes and 03 no. of cylinders were filled by 50% of fresh concrete of M50 grade and remaining 50% of volume filled by mixing of 25% Old & 25% fresh concrete of M50 grade with time lag of 120 minutes.

Crossing Method

The 03 no. of cubes and 03 no. of cylinders were filled by 50% of fresh concrete of M40 grade and remaining 50% of volume filled by 50% of fresh concrete of M50 grade mix with time lag of 0 minutes.

The 03 no. of cubes and 03 no. of cylinders were filled by 50% of fresh concrete of M40 grade and remaining 50% of volume filled by mixing of 25% old concrete of M40 Grade & 25% fresh concrete of M50 grade with time lag of 30 minutes.

The 03 no. of cubes and 03 no. of cylinders were filled by 50% of fresh concrete of M40 grade and remaining 50% of volume filled by mixing of 25% old concrete of M40 Grade & 25% fresh concrete of M50 grade with time lag of 60 minutes.

The 03 no. of cubes and 03 no. of cylinders were filled by 50% of fresh concrete of M40 grade and remaining 50% of volume filled by mixing of 25% old concrete of M40 Grade & 25% fresh concrete of M50 grade with time lag of 90 minutes.

The 03 no. of cubes and 03 no. of cylinders were filled by 50% of fresh concrete of M40 grade and remaining 50% of volume filled by mixing of 25% old concrete of M40 Grade & 25% fresh concrete of M50 grade with time lag of 120 minutes.

Testing of Pull-Out Specimens

The test conducted as per IS 2770 Part 1:1996 using a universal testing machine of 1000kN capacity. The specimen installed to pull the bar axially. Pull applied end must be at the top of the cube.

The test framework set up shows in the figure. Strain gauges used to measure the displacement of the bar. Two gauges fixed, one at the loaded end and other at the free end of the bar for measuring the slip of the bar to concrete. The gauges at the free end placed such that the pointed tip of gauge touches the exposed end of rebar on the back end of the specimen to record bar slip. The load was applied to the reinforcing bars monotonically at a rate not greater than 22.5 kN/min. The loading continued until the specimen failed. Assuming a uniform bond stress distribution over the embedment length in concrete, the average bond stress between the reinforcing bar and the surrounding concrete τb calculated as:

$\tau b = P/(\pi\ db\ Ib)$

Where τb is the bond stress in (MPa)

P is the applied load (N)

db is the diameter of bar (mm)

Ib is the embedded length of bar (mm)

Behaviors of Cube after Pull-Out Test

Bond Stress.

For maintaining composite action requires a transfer of load between the concrete and steel, this load transfer referred to as a bond. It is idealized as a continuous stress field that develops in the vicinity of the steel-concrete interface. The value of bond stress at a slip of 0.025mm and 0.25mm which is the requirement in IS 2270 Part 1:1967 and the ultimate load and ultimate bond stress of all the specimens which failed due to pull-out of reinforcement bars shown in bellows tables. For all the specimens, very little slip noted till reached the ultimate load. Only at the time of failure of specimens, there was a considerable slip. Tables results show that if the ultimate stress increase specimen may lead to breaking.

Bond Stress-Slip Behavior.

Generally, the bond stress slip relationship represents the bond behaviour in reinforced concrete members. Adhesion of bar to concrete is the principal component that describes the bond performance of the bar at an initial loading stage. Once adhesion between bar and concrete breaks, the bar starts to slip, and friction between the outer layer of the bar and concrete control the bond mechanism.

The load versus slip recorded for all type of specimens during testing and the values plotted in the graph. All curves show a first ascending branch up to maximum τmax.

It also showed a falling branch or softening branch, after the maximum bond stress attained. The portion of the curve characterize by a significant decrease in the bond stress accomplished by an increase in the slip.

4. Result and discussion

The test result of bond Stress cube specimens using conventional, selfing & crossing method at blend ration r = 0.33 & t = 30, 60, 90, 120……. □ (infinity) minute are listed in table 4, table 5 & table 6. In table 7 shows the summarized result of all three methods at blend ratio r = 0.33, dia of bar 25mm & Length 150mm for cube specimen. In Table 8 the result shows that the addition of a higher grade of concrete in old concrete has a determinate effect on bond stress as compared with the conventional method and selfing method at blend ratio r = 1, dia of bar 25mm & Length 150mm for cube specimen. Table 9 the result shows that the addition of a higher grade of concrete in old concrete has a determinate effect on bond stress as compared with the conventional method and selfing method at blend ratio r = 3, dia of bar 25mm & Length 150mm for cube specimen.

Similarly table 10,11 & 13 shows bond stress of cylinder specimens using conventional, selfing & crossing method at blend ration r = 0.33 & t = 30, 60, 90, 120……. □ (infinity) minute.In table 14 shows the summarized result of all three methods at blend ratio r = 0.33, dia of bar 32mm & Length 190mm for cylinder specimens.

In Table 15 the result shows that the addition of a higher grade of concrete in old concrete has a determinate effect on bond stress as compared with the conventional method and selfing method at blend ratio r = 1, dia of bar 32mm & Length 190mm for cylinder specimen. Table 16 the result shows that the addition of a higher grade of concrete in old concrete has a determinate effect on bond stress as compared with the conventional method and selfing method at blend ratio r = 3, dia of bar 32mm & Length 190mm for cylinder specimens.

In Conventional Method observed that bond stress reduced gradually after time lag started shown in fig 3, 4, 5& 6. In selfing method observed that bond stress reduced gradually after time lag started. Still, the bond stress value is on the higher side as compared with the conventional method. The result of bond stress of concrete and reinforced bar by using the crossing method observed that bond stress is improved.

Table 4. *Bond stress of concrete and dowel bar of cube specimen by the conventional method*

C	Method	d_t (mm)	L_e (mm)	Sample Mix	t_l (Min)	Load (N)	Slip (mm)	σ_b (Mpa)	Remark
1	Conventional Method (M40, r = 0.33)	25	150	M40 Conventional Method	0	67598	5.15	5.74	Concrete Split & Bar Fail
2					30	65644	5.7	5.57	Concrete Split
3					60	64173	5.98	5.45	Concrete Split
4					90	63337	6.35	5.38	Concrete Split
5					120	61750	6.95	5.24	Concrete Split
6	Conventional Method (M50 , r = 0.33)	25	150	M50 Conventional Method	0	70440	4.82	5.98	Concrete Split & Bar Fail
7					30	68460	5.12	5.81	Concrete Split & Bar Fail
8					60	65170	5.9	5.53	Concrete Split
9					90	63825	6.05	5.42	Concrete Split
10					120	62940	6.35	5.35	Concrete Split

Table 5 *Bond stress of concrete and dowel bar of cube specimen by selfing method*

Sr. No.	Method	d_t (mm)	L_e (mm)	Sample Mix	t_l (Min)	Load (N)	Slip (mm)	σ_b (Mpa)	Remark
1	**Selfing Method (M40, r = 0.33)**	25	150	M40 old + M40 fresh	0	67600	4.15	5.74	Concrete Split
2					30	70420	3.75	5.98	Concrete Split
3					60	71890	3.42	6.11	Concrete Split & Bar Fail
4					90	74160	3.5	6.30	Concrete Split
5					120	66220	5.5	5.62	Concrete Split
6	**Selfing Method (M50, r = 0.33)**	25	150	M50 old + M50 fresh	0	70450	4.05	5.98	Concrete Split
7					30	75375	3.92	6.40	Concrete Split & Bar Fail
8					60	80120	3.64	6.80	Concrete Split & Bar Fail
9					90	82290	3.82	6.99	Concrete Split & Bar Fail
10					120	65500	4.15	5.56	Concrete Split

Table 6 *Bond stress of concrete and dowel bar of cube specimen by crossing method*

Sr. No.	Method	d_t (mm)	L_e (mm)	Sample Mix	t_l (Min)	Load (N)	Slip (mm)	σ_b (Mpa)	Remark
1	Crossing Method (M40 + M50, & r = 0.33)	25	150	40 old + M50 fresh	0	73830	4.05	6.27	Concrete Split
2					30	81390	3.65	6.91	Concrete Split & Bar Fail
3					60	85410	3.55	7.25	Concrete Split & Bar Fail
4					90	87180	3.72	7.40	Concrete Split & Bar Fail
5					120	66150	3.9	5.62	Concrete Split

Table 7. *Analysis of joints by conventional method & find out bond stress r = 0.33*

Sr. No.	d_t (mm)	L_e (mm)	t_l (Min)	Method	σ_b (Mpa)	Remark	Method	σ_b (Mpa)	Remark	Method	σ_b (Mpa)	Remark
1	25	150	0	Conventional Method (M40, r = 0.33)	5.74	Concrete Split & Bar Fail	Selfing Method (M40, r = 0.33)	5.74	Concrete Split	Crossing Method (M40 + 50, & r = 0.33)	6.27	Concrete Split
2			30		5.57	Concrete Split		5.98	Concrete Split		6.91	Concrete Split & Bar Fail
3			60		5.45	Concrete Split		6.11	Concrete Split & Bar Fail		7.25	Concrete Split & Bar Fail
4			90		5.38	Concrete Split		6.30	Concrete Split		7.40	Concrete Split & Bar Fail
5			120		5.24	Concrete Split		5.62	Concrete Split		5.62	Concrete Split
6	25	150	0	Conventional Method (M50 , r = 0.33)	5.98	Concrete Split & Bar Fail	Selfing Method (M50, r = 0.33)	5.98	Concrete Split	Blend Ratio (r): r = (Quanitity of old or preset concrete ÷ Quantity of fresh concrete).. r = 25 ÷ 75 = 0.33 r = 0.33 (Time lag t = 30, 60, 90,120,……...□ (Minute)		
7			30		5.81	Concrete Split & Bar Fail		6.40	Concrete Split & Bar Fail			
8			60		5.53	Concrete Split		6.80	Concrete Split & Bar Fail			
9			90		5.42	Concrete Split		6.99	Concrete Split & Bar Fail			
10			120		5.35	Concrete Split		5.56	Concrete Split			

Table 8. *Analysis of joints by conventional method & find out bond stress r = 1*

Sr. No.	dt (mm)	Le (mm)	tl (Min)	Method	σb (Mpa)	Remark	Method	σb (Mpa))	Remark	Method	σb (Mpa)	Remark
1	25	150	0	Conventional Method (M40, r = 1)	5.74	Concrete Split & Bar Fail	Selfing Method (M40, r = 1)	5.74	Concrete Split	Crossing Method (M40 + M50, & r = 1)	6.01	Concrete Split
2			30		5.38	Concrete Split		5.85	Concrete Split		6.11	Concrete Split & Bar Fail
3			60		4.87	Concrete Split		5.99	Concrete Split & Bar Fail		6.46	Concrete Split & Bar Fail
4			90		4.76	Concrete Split		6.18	Concrete Split		6.59	Concrete Split & Bar Fail
5			120		4.63	Concrete Split		5.01	Concrete Split		5.09	Concrete Split

6	25	150	0	Conventional Method (M50 , r = 1)	5.98	Concrete Split & Bar Fail	Selfing Method (M50, r = 1)	5.98	Concrete Split	Blend Ratio (r) = (Quanitity of old or preset concrete ÷ Quantity of fresh concrete). r = 50 ÷ 50 = 1 r = 1 (Time lag t = 30, 60, 90, 120,……..□ (Minute)
7			30		5.63	Concrete Split & Bar Fail		6.05	Concrete Split & Bar Fail	
8			60		4.86	Concrete Split		6.32	Concrete Split & Bar Fail	
9			90		4.76	Concrete Split		6.48	Concrete Split & Bar Fail	
10			120		4.68	Concrete Split		4.85	Concrete Split	

Table 9. *Analysis of joints by conventional method & find out bond stress r = 3*

Sr. No	**dt (mm)**	**Le (mm)**	**tl (Min)**	**Method**	**σb (Mpa)**	**Remark**	**Method**	**σb (Mpa)**	**Remark**	**Method**	**σb (Mpa)**	**Remark**
1	25	150	0	Conventional Method (M40, r = 3)	5.74	Concrete Split & Bar Fail	Selfing Method (M40, r = 3)	5.74	Concrete Split	Crossing Method (M40 + M50, & r = 3)	5.98	Concrete Split
2			30		4.62	Concrete Split		5.82	Concrete Split		6.05	Concrete Split & Bar Fail
3			60		4.26	Concrete Split		5.92	Concrete Split & Bar Fail		6.24	Concrete Split & Bar Fail
4			90		4.21	Concrete Split		6.04	Concrete Split		6.42	Concrete Split & Bar Fail
5			120		4.1	Concrete Split		4.94	Concrete Split		5	Concrete Split
6	25	150	0	Conventional Method (M50 , r = 3)	5.9	Concrete Split & Bar Fail	Selfing Method (M50, r = 3)	5.9	Concrete Split	Blend Ratio (r): r = (Quanitity of old or preset concrete ÷ Quantity of fresh concrete). r = 75 ÷ 25 = 3 r = 3 (time lag t = 30, 60, 90,120,…………...□ (Minute)		
7			30		4.99	Concrete Split & Bar Fail		6.01	Concrete Split & Bar Fail			
8			60		4.37	Concrete Split		6.12	Concrete Split & Bar Fail			
9			90		4.28	Concrete Split		6.32	Concrete Split & Bar Fail			
10			120		4.22	Concrete Split		4.79	Concrete Split			

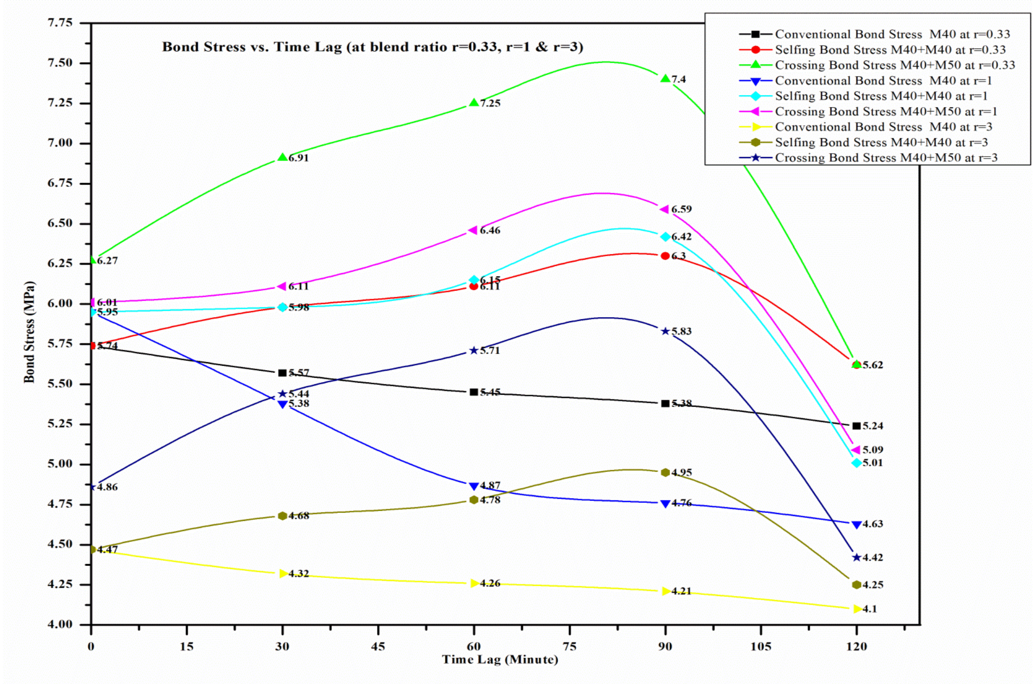

Fig 3 *Bond Stress vs. Time Lag at Blend ratio (r=0.33, 1, & 3) at M40 grade concrete*
of cube specimen

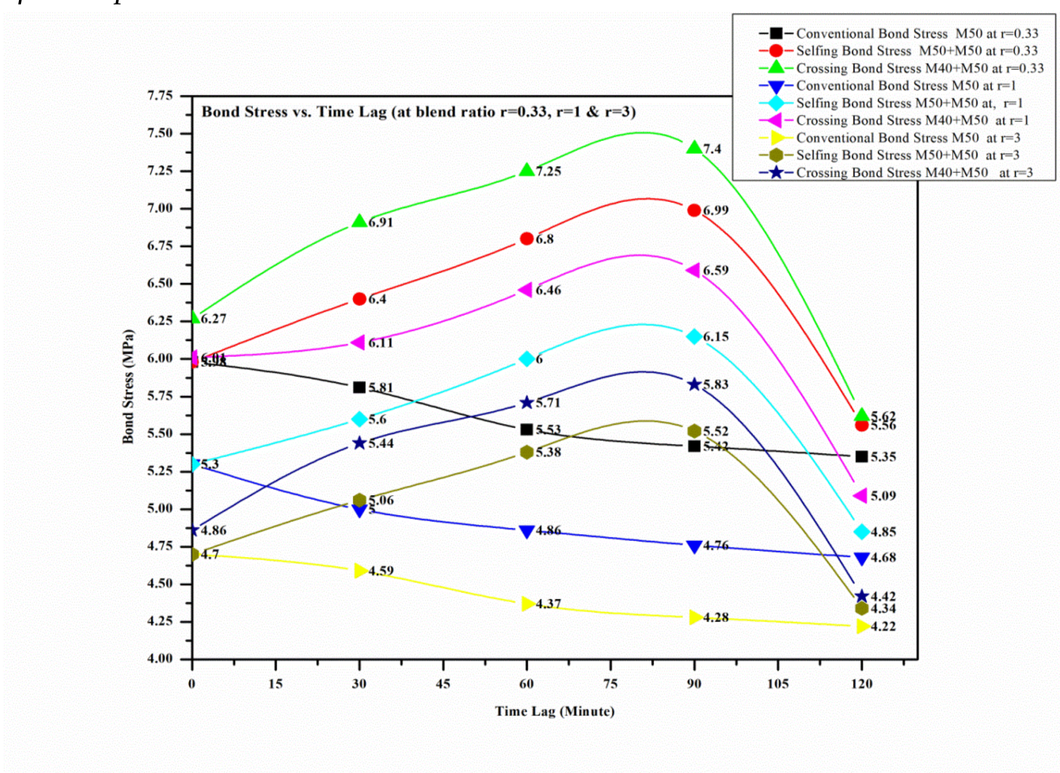

Fig 4 *Bond Stress vs. Time Lag at Blend ratio (r=0.33, 1, & 3) at M50 grade concrete of cube specimen*

Table 10 *Bond stress of concrete and dowel bar of cylinder specimen by the conventional method*

Sr. No.	Method	d_t (mm)	L_e (mm)	Sample Mix	t_l (Min)	Load (N)	Slip (mm)	σ_b (Mpa)	Failure
1	**Conventional Method (M40, r = 0.33)**	32	190	M40 Conventional Method	0	**108900**	7.02	5.70	Concrete Split
2					30	105308	7.6	5.52	Concrete Split
3					60	103125	7.85	5.40	Concrete Split & Bar Fail
4					90	101720	8.05	5.33	Concrete Split
5					120	100000	8.24	5.24	Concrete Split
6	**Conventional Method (M50 , r = 0.33)**	32	190	M50 Conventional Method	0	113165	8.5	5.93	Concrete Split & Bar Fail
7					30	110019	8.64	5.76	Concrete Split
8					60	104575	8.95	5.48	Concrete Split & Bar Fail
9					90	102380	9.14	5.36	Concrete Split
10					120	101100	9.33	5.30	Concrete Split

Table 12 *Bond stress of concrete and dowel bar of cylinder specimen by Selfing Method*

Sr. No.	Method	d_t (mm)	L_e (mm)	Sample Mix	t_l (Min)	Load (N)	Slip (mm)	σ_b (Mpa)	Failure
1	**Conventional Method (M40, r = 0.33)**	32	190	M40 old + M40 fresh	0	**108900**	7.02	5.70	Concrete Split
2					30	113170	7.6	5.93	Concrete Split & Bar Fail
3					60	115690	7.85	6.06	Concrete Split & Bar Fail
4					90	119900	8.05	6.28	Concrete Split
5					120	106300	8.24	5.57	Concrete Split
6	**Conventional Method (M50 , r = 0.33)**	32	190	M50 old + M50 fresh	0	113165	8.5	5.93	Concrete Split & Bar Fail
7					30	121110	8.64	6.34	Concrete Split
8					60	128750	8.95	6.74	Concrete Split
9					90	132380	9.14	6.93	Concrete Split & Bar Fail
10					120	105100	9.33	5.51	Concrete Split

Table 13 *Bond stress of concrete and dowel bar of cylinder specimen by Crossing Method*

Sr. No.	Method	d_t (mm)	L_e (mm)	Sample Mix	t_l (Min)	Load (N)	Slip (mm)	σ_b (Mpa)	Failure
1	Conventional (M40, r = 0.33) Method	32	190	M40 grade & M40 old + M50 fresh	0	118610	7.02	6.21	Concrete Split
2					30	130900	7.6	6.86	Concrete Split & Bar Fail
3					60	137410	7.85	7.20	Concrete Split & Bar Fail
4					90	140900	8.05	7.38	Concrete Split
5					120	106300	8.24	5.57	Concrete Split

Table 14 *Analysis of joints by conventional method & find out bond stress r = 0.33*

Sr. No.	d_t (mm)	L_e (mm)	t_l (Min)	Blended Concrete Type	σ_b (Mpa)	Remark	Blended Concrete Type	σ_b (Mpa	Remark	Blended Concrete Type	σ_b (Mpa	Remark
1	32	190	**0**	**Conventional Method (M40, r = 0.33)**	5.70	Split & Fail	**Selfing Method (M40, r = 0.33)**	5.70	Split	**Crossing (M40, M50, & r = 0.33) Method**	6.21	Split & Fail
2			**30**		5.52	Split		5.93	Split		6.86	Split & Fail
3			**60**		5.40	Split		6.06	Split & Fail		7.20	Split & Fail
4			**90**		5.33	Split		6.28	Split		7.38	Split
5			**120**		5.24	Split		5.57	Split		5.57	Split
6	32	190	**0**	**Conventional Method (M50 , r = 0.33)**	5.93	Split & Fail	**Selfing Method (M50, r = 0.33)**	5.93	Split			
7			**30**		5.76	Split & Fail		6.34	Split & Fail			
8			**60**		5.48	Split		6.74	Split & Fail			
9			**90**		5.36	Split		6.93	Split & Fail			
10			**120**		5.30	Split		5.51	Split			

Table 15 *Analysis of joints by conventional method & find out bond stress r = 1*

Sr. No.	d_t (mm)	L_e (mm)	t_l (Min)	Blended Concrete Type	σ_b (Mpa)	Remark	Blended Concrete Type	σ_b (Mpa	Remark	Blended Concrete Type	σ_b (Mpa	Remark
1	32	190	0	Conventional Method (M40, r = 1)	5.74	Split	Selfing Method (M40, r = 1)	5.74	Split	Crossing Method (M40, M50, & r = 1)	6.01	Split
2			30		5.38	Split		5.85	Split		6.11	Split
3			60		4.87	Split & Fail		5.99	Split & Fail		6.46	Split & Fail
4			90		4.76	Split & Fail		6.18	Split & Fail		6.59	Split
5			120		4.63	Split & Fail		5.01	Split & Fail		5.09	Split & Fail
6	32	190	0	Conventional Method (M50 , r = 1)	5.98	Split	Selfing Method (M50, r = 1)	5.98	Split			
7			30		5.63	Split		6.05	Split & Fail			
8			60		4.86	Split & Fail		6.32	Split & Fail			
9			90		4.76	Split & Fail		6.48	Split			
10			120		4.68	Split		4.85	Split			

Table 16 *Analysis of joints by conventional method & find out bond stress r = 3*

Sr. No.	d_t (mm)	L_e (mm)	t_l (Min)	Blended Concrete Type	σ_b (Mpa)	Remark	Blended Concrete Type	σ_b (Mpa	Remark	Blended Concrete Type	σ_b (Mpa	Remark
1	32	190	0	Conventional Method (M40, r = 3)	5.74	Split	Selfing Method (M40, r = 3)	5.74	Split	Crossing Method (M40, M50, & r = 3)	5.98	Split
2			30		4.62	Split		5.82	Split		6.05	Split
3			60		4.26	Split & Fail		5.92	Split & Fail		6.24	Split & Fail
4			90		4.21	Split & Fail		6.04	Split & Fail		6.42	Split
5			120		4.1	Split & Fail		4.94	Split & Fail		5	Split & Fail
6	32	190	0	Conventional Method (M50 , r = 3)	5.9	Split	Selfing Method (M50, r = 3)	5.9	Split			
7			30		4.99	Split		6.01	Split & Fail			
8			60		4.37	Split & Fail		6.12	Split & Fail			
9			90		4.28	Split & Fail		6.32	Split			
10			120		4.22	Split		4.79	Split			

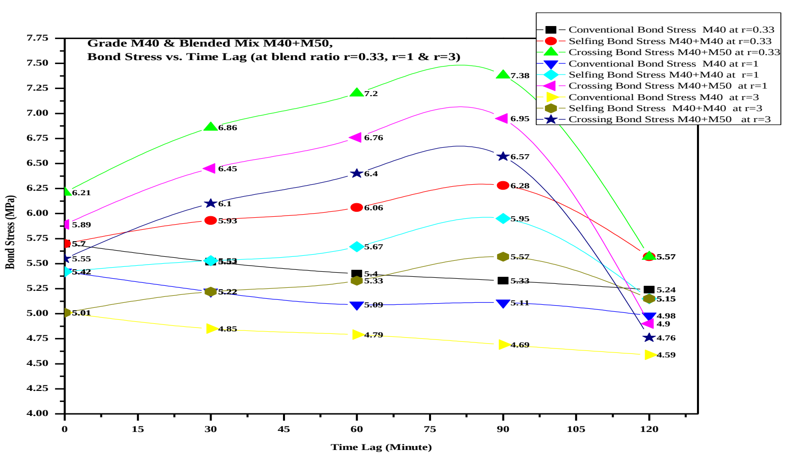

Fig 5 *Bond Stress vs. Time Lag at Blend ratio (r=0.33, 1, & 3) at M40 grade*

concrete of cylinder specimen

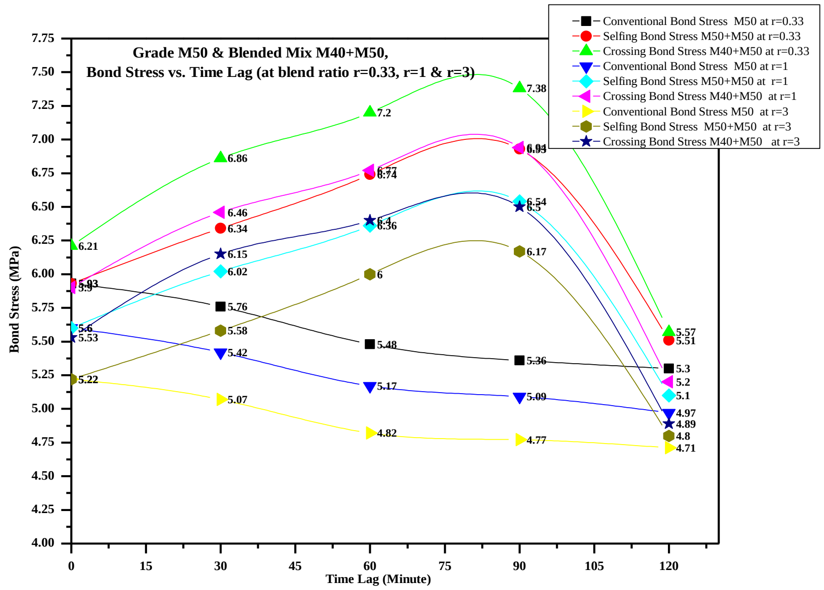

Fig 6 *Bond Stress vs. Time Lag at Blend ratio (r=0.33, 1, & 3) at M50 grade concrete of cylinder specimen*

5. Conclusions

After applying Selfing technique (M40 Old + M40 New) to the existing partially set concrete at various time lags, it has been observing that there is a small increment in bond strength of the above newly formed concrete as compared to conventional concrete. By adding a higher grade of fresh concrete, i.e. (M50 Grade) to the old partially set concrete (M40 Old), Tremendous increase in Bond strength as compared to an addition of the same grade of fresh concrete (New M40) to the old partially set concrete. It has been observing that during the experimental work, the Bond Stress strength obtained to the concrete for the time lag 60 minutes is greater than the strength obtained for the time lag 90 minutes. The mean strength of concrete prepared after time lag = 30 minutes is less as compared to the same concrete after time t = 30 minutes selfed with a fresh concrete of the same grade.

Selfing and Crossing of concrete provides a wide scope in preventing the wastage of partially set concrete materials and which is not suitable for good quality of construction work. The trend of bond-slip relation was found independent of the bar diameter. The Crossing Method is most beneficial to gives more efficient results as compared to selfing technique.

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