Innovative and Economical rehabilitation solutions for concrete pavement infrastructure

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Abstract: The use of concrete overlays for pavement and bridge deck maintenance and rehabilitation has been in existence for several decades, both un-bonded and bonded overlays have been used in rehabilitation and maintenance of deteriorating road pavements. For both BCO and UTW overlays, characteristics of the overlay concrete have important implications for early age behavior and long-term performance. The process of strengthening involves the assessment of the residual life of the pavement, the expected traffic and the design of the overlay thickness. While the assessment processes are outside the scope of manual. In this paper M60 grade of concrete with use of GGBS as cement replacement and addition 5% Dramix fiber as studied for workability, Compressive strength, Flexural strength, split tensile strength & Water permeability to fulfil the requirement of the specified parameter of case study.

Key words: Admixtures, Concrete Pavement, fibre, steel fibre GGBS, High performance concrete, Permeability.

INTRODUCTION

There is a wide perception that concrete pavements "cost too much," "take too long," or "are too difficult to repair." However, to the contrary, although the initial cost of concrete may be higher than for asphalt pavement, however concrete costs less during the pavement's life cycle. Roads can be opened faster than ever and can be repaired easily with the proper equipment, materials, processes and or procedures. Also concrete pavement restoration can return a pavement to a near-new condition at a lesser cost to the road user if measurers to decrease delay time are put in place.

Research has shown that concrete overlays over asphalt often bond to the asphalt, and that some reduction of concrete flexural stresses may be expected from this effect

Bond strength and resistance to cracking are important for overlay performance. In many cases these overlays are constructed on heavily traveled pavements, making early opening to traffic important. Therefore, early strength development without compromising durability is necessary. Satisfactory performance will only occur if the overlay is of sufficient thickness and is well bonded to the original pavement. The design assumption is that if the overlay bonds perfectly with the original pavement, it produces a monolithic structure. Without bond, there is very little structural benefit from an overlay, and the overlay may break apart rapidly under heavy traffic.

LITERATURE REVIEW

Deteriorating asphalt and concrete pavement infrastructure worldwide demands innovative and economical rehabilitation solutions. A properly designed and constructed bonded overlay can add considerable life to an existing pavement, by taking advantage of the remaining structural capacity of the original pavement. (Delatte, 2001).

Concrete overlays bonded to existing concrete pavements are called Bonded Concrete Overlays (BCO) or Thin Bonded Concrete Overlays (TBCO). In this report, the term BCO will be used because it includes TBCO. These overlays have been constructed for several decades (McGhee, 1994), although their use has mostly been localized to Iowa and Texas. Texas BCO projects have been particularly well documented (Delat te, 1996, Delatte et al., 1996b, Delatte et al., 1997, Huddleston et al., 1995, Lundy et al., 1989, Lundy etal., 1991, Wade et al., 1995, Whitney et al., 1992). Considerable research experience has been developed in this technology, particularly in these states (Delatte and Laird, 1999). Some results were obtained by the Strategic Highway Research Program (SHRP) (Smith and Tayabji, 1998).

Dar Hao Chen; Tom Scullion; and John Bilyeu has presented Reflective cracking through jointed concrete pavement overlays has been a persistent problem. Several different rehabilitation strategies have been used in Texas. This paper is a summary of the performance of strategies used in the past 10 years. The writers believe the small openings in the crack-retarding grid and the lack of an effective bond may be the causes of the layer separation

The use of a lower water-cement ratio and a high percentage of normal cement was used in attaining early strength. It was concluded in this research that high strength concrete was appropriate for opening overlay to traffic in 24 hours or less, but normal strength may be used if traffic loading can be delayed for 48 or 72 hours. Under the sponsorship of the New Jersey Department of Transportation a unique concrete mix was developed. This concrete mix attained a significant strength of 3,000 psi – 3,500 psi (21 to 24.5 MPa) in a period of six to nine hours for use on pavement repair in high-traffic areas [FHWA NJ 2001-015].

The Maryland State Highway Administration (MDSHA) currently requires use of a 12-hour concrete mix for patching in heavily trafficked roadways in urban areas. This mix is required in order to achieve 2,500 psi (17.5MPa) compressive strength in 12 hours. The objective of the project is to test proper concrete materials mixes both designed in the lab and in the field, for composite pavements that will allow the repaired sections to be opened to traffic after four hours of concrete placement in the patch.

The report by the Construction Technology Laboratories

(CTL) was submitted to the Maryland State Highway Administration in April 2003. Based on the performances of mixes during the initial trials and, considering modifications for local materials, the VES mix, the GADOT mix in Georgia, and the VES mix and the ODOT mix in Ohio were selected as the four trial mixes to be evaluated further as part of a laboratory study. Also included as one of the trial mix designs, was a 12- hour concrete mix design currently used in Maryland for fast- track paving, and designated as the control Mix.

PROBLEM DEFINITION

Any construction project of road needs to be maintained for the efficient flow of traffic. The road before work was asphalt road. As it is flexible one the road gets damaged as that is not suitable for heavy traffic. The heavy traffic causes problems like cracks, patch damaging, pot hole etc. To remedy that rigid pavement road is proposed i.e. Concrete road. In this concrete road M40-M60 concrete is used for PQC. M40 for stretch roads and M60 at junctions to get early high strength so that no traffic problems to be occur. To get high early strength for M60 grade, admixtures and fibres are added in RMC plant at a time of batching.

EXPERIEMENTAL STUDY

The materials used in this research and their sources are summarized.
1. Cement: OPC 53 grade. Conforming IS 12269 (1987)
2. Sand : fine aggregate conforming to zone II of IS 383 -1970
3. Aggregate : coarse aggregate of maximum size 20mm and 10mm.
4. GGBS
5. Dramix fibres :
6. Admixture used : Fosroc Auramix 400
Details of Materials & their sources shown in Table 2

Following testing conducted on Concrete

a) Workability – Slump cone
b) Compressive Strength
c) Flexural Strength
d) Split tensile strength
e) Water permeability

Mix design parameters : Mix design for M 60 grade concrete
Proposed Mix Proportions : shown in Table 1 (all weights in kg/cum)

	Control Mix	Mix with Dramix fibre
Cement	400	400
GGBS	200	200
Natural Sand	747	747
10 mm aggt.	263	263
20 mm aggt.	736	736
Water	150	150
Admixture	3600ml	3600ml
Dramix Fibre	-	30

Table 1: Mix Proportions Kg/cum

Water cement ratio = 0.25

Admixture used = Fosroc Auramix 400

Materials	Type /Manufacturer	Vendor	MSHA Approval
Cement	Type I	Ind. Products Co.	Approved
	Type III	Ind. Products Co.	Approved
Fine Agg	Mortar sand	Aggregate Industries	Approved
Coarse Agg	¾" Quarry Gravel	Aggregates Industries	Approved

Table 2 : Concrete Materials details

RESULTS AND DISCUSSION

Mix Proportions: The mix proportions were made for a control mix of final slump (60min) 75 ± 10 mm for M60 grade of concrete for w/c ratio of 0.25 by using IS-10262-2009 method of mix design.

Test Set-up: The 6 in.(150 mm) cubes with a set of 3 cubes, each were cast for compressive strength .and split strength at 3, 7, 28, days time. Beam moulds of size 6in x 6in x 27.56in i.e.(150x150x700mm) for flexure strength and 6 in.(100 mm) cubes for water permeability test for 28 days time respectively. After the cast, all the test specimens were put into the water tank for curing maintaining temperature of 89.6±35 oF (27±2 ºC) as per IS requirements. The concrete was tested for slump cone test as per the IS-1199 –Methods of sampling and analysis of concrete, for each mix of concrete. The results obtained from the laboratory tests of the cement test specimens in tabular format in Table no 3

Test Particulars	Unit	Result
Standard Consistency	%	29
Initial Setting Time	Minutes	123
Final Setting Time	Minutes	288
Density	g/cm^3	3.11
Fineness By Blain's Air Permeability Method	m^2/kg	329
Soundness by Le-Chateliers apparatus	Mm	1.0
72 ± 1 hr (3 Days) Compressive Strength	N/mm^2	36
168 ± 2 hr (7 Days) Compressive Strength	N/mm^2	45
672 ± 4 hr (28 Days) Compressive Strength	N/mm^2	58

Table 3 : Results of Cement testing

Test results of workability compared with Dramix fiber mix shown in Figure 1

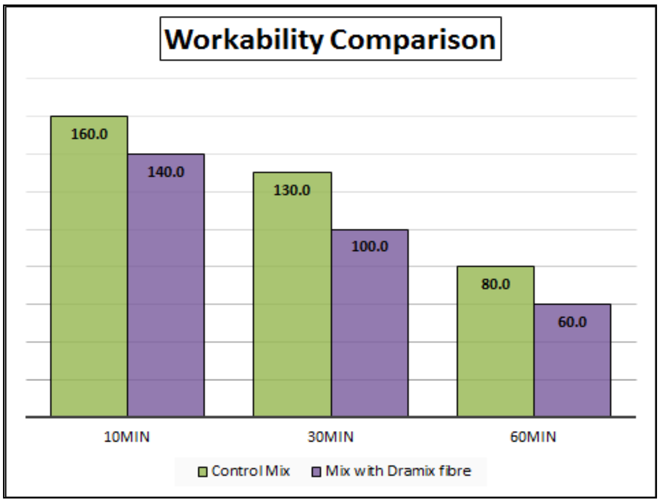

Figure 1 : Comparison of Workability in mm

Test results of Compressive strength compared with Dramix fiber mix shown in Figure 2

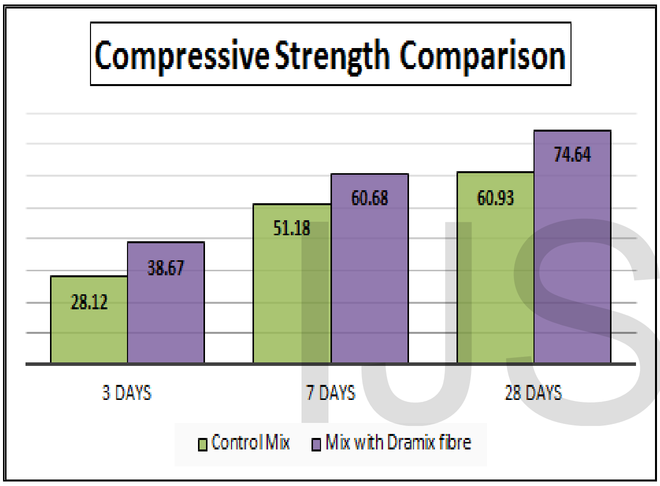

Figure 2 : Comparison of Compressive Strength (MPa)

Test results of Flexural strength compared with Dramix fiber mix shown in Figure 3

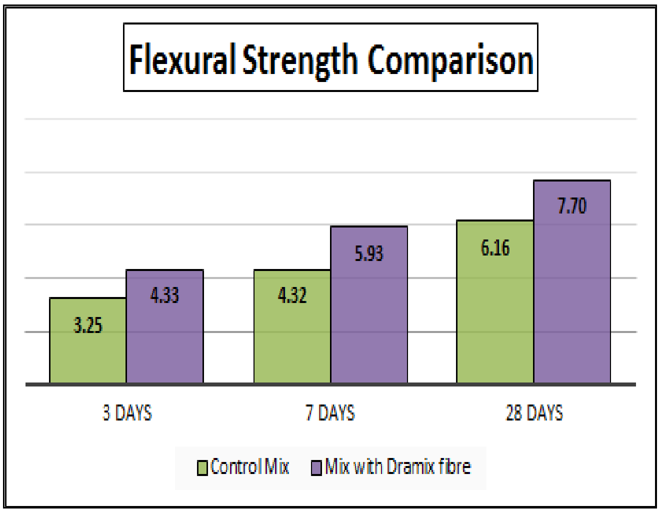

Figure 3 : Comparison of Flexural Strength (MPa)

Test results of Split tensile strength compared with Dramix fiber mix shown in Figure 4

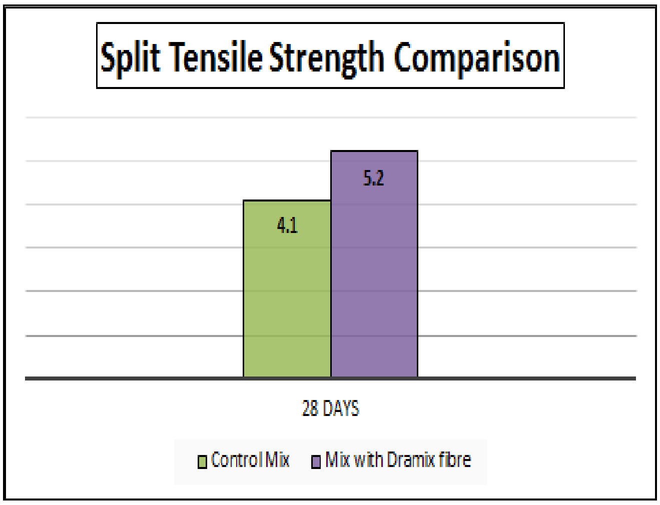

Figure 4 : Comparison of Split tensile Strength (MPa)

Test results of water permeability compared with Dramix fiber mix shown in Figure 5

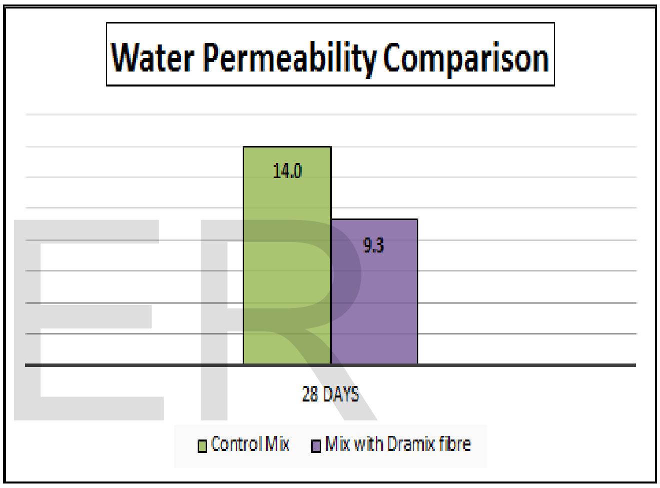

Figure 5: Comparison of Water Permeability test.(mm)

SUMMARY AND CONCLUSION

The primary conclusion expected from this research was to determine if all the mixes researched into, fell into the category of High Performance concrete and thus was either Very early strength (VES), High early strength (HES) or not an Early strength mix. It was finally expected to recommend which mixes based on the strength and durability requirements of High strength concrete were the best.
Based on the results of this investigation, the following conclusions can be drawn.

1) The use of sustainable materials such as dramix fibres, admixture and GGBS has proved beneficial in imparting additional strength to the concrete.
2) High strength concrete can be produced with a variety of mix options including the use of;
   a) Type III Portland cement and
   b) Type I or Type III Portland cement with a low water-cement ratios by using admixture and sustainable materials to achieve moderate to high consistencies.

3) By using sustainable materials dramix fibres the setting of the concrete decreases by 8 hours as it is opened to traffic after 4 hours of concrete placement.
4) It is observed that by using GGBS and dramix fibres with admixture it good as HPC because the setting time, strength of concrete durability of concrete is improved.
5) It is suggested that the mixture of GGBS, dramix fibres and admixture is very well can be used as a counter measure for existing patch damaging and safety of operators.
6) As the patch is found to be durable the labour cost is save to a great extent.
7) Although the water cement ratio plays an important role in attaining early strength for concrete to be poured and consolidated the water cement ratio is been improved.
8) The compressive strength of concrete is found to be 61N/mm2 in 28 days by using GGBS were as 74.64 N/mm2 is found by using GGBS, dramix fibres and admixture i.e. approx 22.5% higher than control mix.
9) The flexural strength of concrete is found to be 6.2N/mm2 in 28 days by using GGBS were as 9 N/mm2 is found by using GGBS, dramix fibres and admixture i.e. around 46% higher.
10) The Split tensile strength of concrete is found to be 4.1N/mm2 in 28 days by using GGBS were as 5.2 N/mm2 is found by using GGBS, dramix fibres and admixture i.e. approx 27% higher than control mix.
11) The water permeability is found to better in mix by using GGBS, dramix fibres and admixture i.e. 9mm penetration compared with 14mm penetration in 28 days by using GGBS.
12) The geometry of dramix fibres helps in better bonding of concrete, it also helps the fibres to act more efficiently as a bridge in reducing the fracture of concrete. It also helps us in attaining fibres free surface.

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