Study on Concrete Mix Design for Ultra Thin Whitetopping

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Abstract - *Ultra-thin whitetopping (UTW) is an overlay for pavement rehabilitation option to asphalt concrete overlays. UTW is typically a concrete overlay less than 4 inches thick on an existing distressed asphalt pavement. In this study we prepared concrete with various mixes by using IS code and IRC recommendations on quantity of cement and chemical admixture which are suitable for pavement construction. UTW design methods and develop new recommendations for improved UTW performance. As part of this project, a laboratory study conducted on various concrete mixtes effects on Ultra Thin Whitetopping performance. Seven mixture designs containing various water to cementitious materials (w/cm) ratios, cementitious content*

Key Words: **Ultra Thin Whitetopping, Hot Mix Asphalt, Concrete Mix Design, W/C ratio, Compression Strength, Flexural Strength**.

1.INTRODUCTION

In Constructions of pavements the construction of long-term performing pavement, since pavements are the costliest structures. In India most of the pavements are bituminous pavements with thin binder course. Bituminous pavements are showing early sign of distresses worldwide, due to increasing loads, intensity of traffic high tyre pressure etc. The distresses like rutting, cracking and ageing etc are commonly seen. Another distress in bituminous overlay is Reflective cracking. These distresses get more indicated in hot climatic regions like India, since bitumen is very highly sensitive to high temperature. Performance of bituminous pavements in hot climatic regions is thus becoming somewhat doubtful. Concrete on the other hand is known to be relatively stiffer material and less sensitive to high temperature. Accordingly, concrete pavements are being increasingly adopted as an alternative to traditional bituminous pavements. Even in terms of rehabilitation and repair the use of concrete overlay is replacing traditional bituminous overlay because of better performance against rutting and cracking (Sinha et al.2007).

Whitetopping refers to laying a thin concrete overlay directly on top of an existing distressed Hot Mix Asphalt (HMA) pavement (Julie 2002). Whitetopping is thus PCC resurfacing (overlay) as a rehabilitation or structural strengthening alternative on bituminous pavement is a real problem in hot climate like India, with heavy truck loads, operating under frequent start/stop conditions. It is commonly applied where rutting of bituminous pavement is a recurring problem. Concrete overlays offer the potential for extended service life, increased structural capacity, reduced maintenance requirements, and bituminous overlay alternative (IRC SP 76, 2008).

In comparison to bituminous overlays, bonded Concrete overlays provide significantly more structural improvement per inch of thickness. This means that it requires 6 to 7 in. of bituminous overlay to produce the same edge load stress induced under a 3 in. bonded overlay. Bonded concrete overlays are more structurally efficient per inch of material (Kamal.2001).

1.1 Ultra-Thin whitetopping

The term, “ultra-thin whitetopping” or UTW refers to the resurfacing of existing asphalt pavements with thin concrete overlays 4 in. (100 mm) or less in thickness. The development of UTW technique started in the early 1990’s. Experimental test sections have been built and research efforts have been expended in the last decade to evaluate the applicability of the UTW as a pavement rehabilitation alternative.
The first UTW experimental project was constructed on an access road to waste disposal landfill in Louisville, Kentucky, in September 1991(Cole 1993, Brown 1995, and Rissser.1993). The Louisville, Kentucky UTW performed well and carried more traffic than anticipated. Following the promising results of the Louisville experiment, many states, including Colorado, Georagia, lowa, Kansas, Kentucky, Minnesita, Missouri, New jersey, North Carolina, Pennsylvania and Tennessee, have experimented with UTW for asphalt pavements rehabilitation. (Mang Tia et al.2002)
The ultra-thin whitetopping looks and acts like regular concrete pavement overlays. The only noticeable difference being noticeable is that joint spacing’s (2 to 6 ft. panels) which are closer than the regular concrete overlays.

Rutted asphalt is a prime candidate for UTW, provided the asphalt does not have an underlying base failure. Severely mapped or alligatored asphalt is not a suitable choice for UTW. Pavement sections with underground conduits and drainage pipes are also not suitable for using UTW (Kamal. 2001)
The brief information of ultra thin whitetopping is given in annexure A, which consists of general information on UTW,

advantages and disadvantages of UTW and Comparison of UTW with conventional whitetopping, HMA Rehabilitation, Pre-overlay repairs, Materials, Construction procedure and Thickness design.

2.Literature review

2.1 Materials and Mix Design for UTW

The same PCC mixes used for new construction are generally used for Whitetopping. For projects in congested urban areas, however, extended lane closures due to pavement rehabilitation may be highly undesirable. For those projects, the use of fast-track paving may minimize traffic disruptions. Numerous fast-track PCC mixes are available that can provide the strength required for opening to traffic in 12-14 hours, and the techniques for fast-track paving are well established (FHA 1994,ACPA 1994,ACI 2001) (Chunhua 2005).

The concrete mix for a particular UTW projects is often selected based on requirements for opening to traffic. A normal mix design includes cement, coarse and fine aggregates, air-entraining agent, admixtures, and a lower water-cement ratio. Fibers have been used in many UTW projects (Mang Tia et al. 2002).

UTWT/TWT projects are generally constructed with concrete of mix, having lower water / cement ratio, less than 0.40. It is, however, preferable to have water / cement ratio around 0.28 to 0.30. The workability / slump requirement (25-50 mm) may be conveniently achieved by the use of high mixes may have high cement content (but not greater than 540 kg/m3). Extra precautions are required while using very high cement content with regard to the heat of hydration. Since, high cement content will lead to extra heat and hydration and cracking, the cement content in the international context is usually 350 kg/m3. The higher strength is derived not by increasing the cement content but by reduced water content. (IRC SP 76, 2008).

Compared to aggregate used for thicker concrete aggregates for UTW is reduced. Materials and mix proportions selected for the first experimental project in Louisville, Kentucky are shown in Table 2.1.

Table 2.2. Concrete Mix Proportions Used to Leawood, Kansas (Dumitru et al.2002)

Constituents	**Quantity**
Cement (ASTM C 150 Type I)	611 lb/cy (363 kg/m^3)
Coarse aggregate SSD (Crushed Limestone)	1730 lb/cy (1027 kg/m^3)
Fine Aggregate SSD (Natural Sand)	1345 lb/cy (798 kg/m^3)
Total Water	225 lb/cy (134kg/m^3)
Pave air	5 oz/cy (0.19kg/m^3)
Pozzutec	65 oz/cy(2.51kg/m^3)
Rheobuild	43 oz/cy(1.66kg/m^3)

The Concrete mixes used are so proportioned that the mix generally produces concrete of minimum characteristic compressive strength M40 or more than M40 at 28 days. High performance concrete of compressive strength M50 is normally preferred. The minimum flexure strength of the concrete shall be 4.5 N/mm^2 for responding to the minimum grade of concrete i.e. M40 at 28 days .It is, however, preferred to have a flexure strength of 5 to 6 N/mm^2 (Third point loading) (IRC SP 76.2008).

3.1 Results and Discussions

3.1.1 Cement

Cement used in this project is Birla Super 53 Grade. Properties of cement were tested in the laboratory and the results are shown in Table 3.1.

Table 3.1. Physical Properties of Cement

Sl. No	Properties	Obtained Value
1	Specific Gravity	3.15
2	Normal Consistency	32 %
3	Initial Setting Time	82 Mins
4	Final Setting Time	600 Mins

3.1.2 Fine Aggregate for Concrete

The fine aggregate for Cement concrete used is natural sand and it fulfills the gradation requirements of Zone II. The specific gravity of the material tested is found to be 2.60.

3.1.3 Coarse Aggregate

Table 3.2. Physical Properties of Coarse Aggregate for Concrete Mix

Sl. No.	**Properties**	**MORTH Specifications for**		**Obtained values**
		DBM	**Cement Concrete**	
1	Impact Value, %	Max 30	Max 27	24
2	Crushing Value, %	Max 30	-	25
3	Abrasion Value, %	Max 35	Max 35	32
4	Specific Gravity			2.70
5	Water Absorption,%	Max 2	Max 2	1.2
6	Flakiness and Elongation index, %	Max 30	Max 30	21
7	Density, kg/m^3 Loose Density Roded Density			 1460 1600

3.1.4 Admixture

For this study super plasticizer Sp-430 is used as admixture. The main objective of using the admixture is to increase the workability at low water content to gain the required concrete strength.

3.1.5 Concrete Mix Design

Concrete Mix Design has performed as per IS10262-1982, in total seven different trial mixes was prepared to achieve the target mean compressive strength is 48.25 N/mm² at 28 days. The details of mix proportions for all the trial mixes are shown in Table 3.4 and detailed information on the mix design is provided in Annexure-B. Properties of fresh cement concrete such as slump and Vee-Bee, and properties of harden cement concrete such as average compressive strength and average flexure strength of all the mixes tested are shown in the Fig. 3.1, 3.2 & 3.3 respectively. The Mix-6 (M6) is chosen for preparing the composite specimens of UTW out of seven different trial mixes, because it meets the requirements of the fresh and hardened concrete properties as laid by IS with low cement content among the seven mixes.

The compressive strength is 49 N/mm² it is greater than the 48.25N/mm². Flexure strength is 7.25 N/mm² where for UTW the flexure strength is required 5 to 6 N/mm² (IRC SP 76, 2008).

Table 3.2. Details of Concrete Mixes

Sl no	Type of Mix	Proportion	W/c	Cement in kg/m³	Admixture (SP430)
1	M1	1:1.19:2.87	0.34	450	1.25%
2	M2	1:1.11:2.69	0.32	475	1.25%
3	M3	1:1.13:2.73	0.30	475	1.25%
4	M4	1:1.10:2.66	0.34	475	1.25%
5	M5	1:1.58:2.46	0.34	450	1.25%
6	M6	1:0.99:3.08	0.34	450	1.25%
7	M7	1:0.98:3.04	0.36	450	1.25%

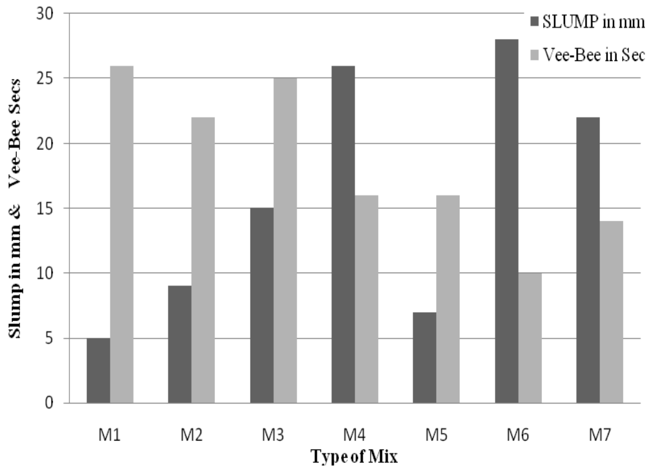

Fig-3.1: Slump and Vee-Bee of Concrete mixes

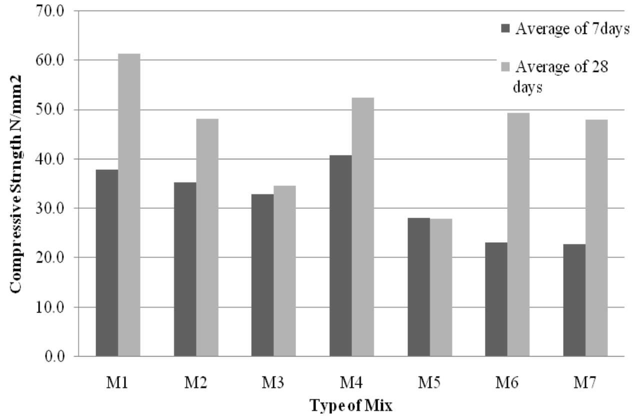

Fig- 3.2: Average Compressive Strength

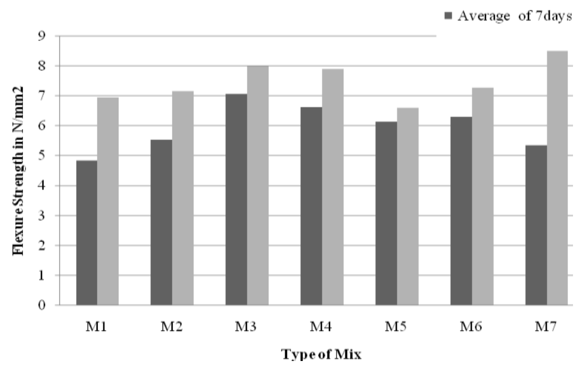

Fig- 3.3: Average Flexure Strength

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