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Guidelines for the Design and Construction of Ultra Thin White Topping

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Abstract

The highway construction industry has made rapid strides in the field of new technology upgradation and adaptation. Newer materials have been tried in the field applications with a lot of emphasis on optimizing life cycle cost and minimizing rutting/abrasion. One of the solution for rutting asphalt pavement is white topping, which means, the placement of a concrete overlay on top of asphalt pavement. Salient features of white topping are: milling is generally not required, a leveling layer of dry lean concrete or bituminous material is required, and joints are at normal spacing with dowel at each contraction joints for high volume roads.

Keywords-*asphalt pavement, mix proportioning, white topping*

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I. Introduction

With the advent of new fast track concrete pavement technologies that allow the opening of a concrete pavement within short duration of initial paving, white topping technology is advancing. Since its inception in 1991, ultra thin white topping has increased throughout the world including India. As per U.S. Department of Transportation Federal Highway Administration, Ultra-thin whitetopping is the placement of a thin plain cement concrete (PCC) pavement over an existing hot mix asphalt pavement (HMA) as shown in Figure 1

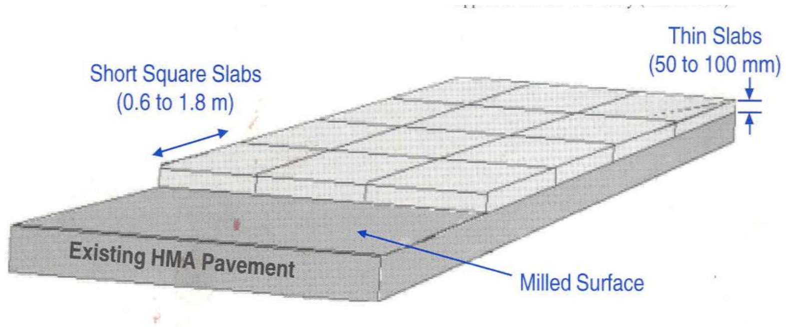

Figure 1: Cross Section View of UTWT

If heating of bitumen is not allowed at any nearby location and if bituminous mix is brought from longer distances, it becomes so cold that it is difficult to be properly compacted. Different high performance fibre reinforced concrete mixes, which may also be used for making UTWT were tried in the laboratory as well as in the field using polyester, polypropylenes and steel fibres at many research institutions in India. The basic purpose of UTWT is to improve the riding quality, load carrying capacity besides improving the subgrade/ sub base quality.

II. Salient Features Of Ultra Thin Whitetopping

The development of an effective bond between the Plain Cement Concrete (PCC) overlay and the existing HMA pavement is critical to the performance of these rehabilitation techniques because of the existing HMA pavement is being relied upon to carry part of the traffic load. UTWT is differentiated from conventional white topping by following aspects:

- The use of thin Plain Cement Concrete (PCC) surfacings between 50 and 102 mm in case of UTWT. In case of very heavy traffic roads UTWT thickness of 150 mm may also be used.
- The need for extensive surface preparation to promote significant bonding between the PCC overlay and the HMA pavement.
- The use of short joint spacings (generally between 0.6 and 1.8 m)
- In many cases use of high-strength PCC mixtures to provide early opening times and the inclusion of synthetic fibres (commonly steel, polypropylene and polyolefin) to help control plastic shrinkage cracking and enhance post-cracking behaviour.

III. Materials

As per FHA, USA, UTWT is defined as a concrete product reinforced with synthetic fibres that rehabs deteriorated asphalt pavement that has sufficient structure, but a poor or rutted surface. Therefore, ultra thin white topping may involves the use fly ash grade I (as per IS 3812-2003), granulated blast furnace slag (as per IS: 12089) and silica fume (as per IS: 15388-2003), which are byproducts of thermal power plants, iron industries and Ferro-silicon industries respectively. Application of these three mineral admixtures in concrete is specified in IS: 456-2000. By using these mineral admixtures, total heat of hydration is reduced. When these mineral admixtures used together, they improve the density of concrete due to particle packing theory. To improve the ductility of high performance high strength concrete, polymeric or steel fibres may be added in the concrete. As ultra thin white topping requires very high strength concrete, so it is made up of high performance fibre reinforced concrete or ultra high performance concrete, using special polymeric fibres upto 0.2 %/steel fibres as per IRC: SP-49, additives, admixtures, very hard and smaller size aggregates (maximum 20mm) etc. By using above mentioned materials in the concrete, there is improvement in toughness, long term mechanical properties, early high strength, ease of placement and consolidation, volume stability, longer life, less abrasion, least permeability, improvement in the interlocking of aggregate at the joints and bond between aggregate - cement mortar and existing bituminous layers etc. These properties are required for construction UTWT based on Indian Climatic conditions.

IV. Mix Proportioning and Strength of Concrete

PCC mixtures used in UTWT are often high strength and high performance concrete. Considerations regarding the existing HMA pavement shall be evaluated by examining pavement deficiencies and the causes of deterioration prior to the selection of the mix, grade of concrete and thickness of UTWT.

UTWT projects are generally constructed with concrete of mix having lower water cement ratio (<0.4). The slump requirement (75 – 100mm) for construction and placing and flow are achieved conveniently by the use of high range water reducers. The mixes may have high cement content (but not greater than 540 kg/m^3). A typical mix proportion given in Table 1 may be tried to achieve characteristic minimum compressive strength of M 50.

Table 1: Typical mix proportions for UTWT

Sl No.	Ingredients or Property	
1	Cement 43 or 53 Grade	440.32
2	Coarse Aggregate	947.38
3	Fine Aggregate (Natural Sand)	596.3
4	Total Air Content	0.5%
5	Polypropylene/polyester Fibres	0.88
6	Water/Cement Ratio	0.28
7	Water	170
8	Fly ash/granulated blast furnace slag	88.0
9	Silica fume	58.69
10	Admixture	1.5%

V. Construction Of Utwt

Ultra thin white topping is used where the minimum thickness of sound asphalt layer is more than 75 mm, which is the basic requirement of its design as composite pavement. The thicker asphalt pavement section improves the load carrying capacity of the system because it creates a thicker final ultra thin white topping structure. Ultra thin white topping improves the riding quality along with the load carrying capacity. Some of its salient features are:

- Joints spacing is normally kept at less than 120 cm,
- More transfer of wheel load to the underlying due the bond between the top and the existing bituminous layer, and
- Additional durability due to high performance fibre reinforced concrete.

Existing bituminous layer after milling shall be in good condition to minimize or avoid reflection cracks or sympathetic cracks. These cracks, if left, after milling shall be repaired first with either bituminous or cement concrete or any other suitable material and the surface is broomed by compressed air to remove debris prior to placing of concrete. Sometimes, the surface of the asphalt is flushed with water to aid in cleaning before overlay is applied. In case of non-availability of milling machine, UTWT may also be laid directly over the asphalt after properly repairing the minor distress or relaying with a fresh layer of 40 mm DBM over the distressed asphalt pavement.

The joints, which are 3 mm wide and are upto a depth of $1/3^{rd}$ to $1/4^{th}$ of UTWT, are not generally sealed because the compactness of the slabs minimizes joint movement. However, sealing of joints as per IRC: 15-2002 may also be carried in case of rainfall more than 1000mm per year. Fibre in the UTWT concrete minimizes shrinkage cracking and aid in aggregate-interlock load transfer by holding joints tightly together. After bonding, (which is the secret of UTWT) with (hot mix asphalt (HMA), it works as concrete pavement.

In case of transition slab, joining UTWT with existing asphalt pavement, the technique as shown in Fig 2 may be adopted. It indicates that thickened edges are provided at the transition point as the stress developed at this type of joint are more than the normal contraction or construction joint. Alternatively, the transition UTWT slabs may be reinforced in one row of panels.

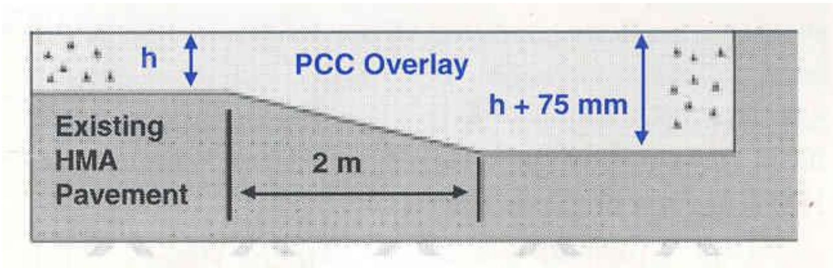

Figure 2 : Cross Section View of the Transition Slab adjoining Asphalt Pavement

STEPS OF CONSTRUCTION

i) Repair: Repair of the distresses is required in the existing HMA pavement before UTWT is applied.

ii) Milling: The milling of the existing HMA pavement provide removal of rutting, a roughened surface to enhance the bonding between the new PCC overlay and the existing HMA. The depth of milling depends upon the types and severity of distress especially the depth of rutting or other surface distortions and the available thickness of HMA.

iii) Cleaning: After milling the existing HMA pavement upto specified depth, the top surface is cleaned to ensure bonding between the existing HMA and the new PCC overlay. The different methods of cleaning to remove slurry or foreign particles are given as:

- Air blasting
- Power brooming
- Water blasting
- Sand blasting
- Chiseling by hammer

Iv) Place, Finish and Curing using Conventional Paving Techniques and Materials:

After the milling operation, form work using steel channels or girder are fixed and stability of these is ensured simultaneously. Concrete is placed, finished and cured using conventional paving techniques and materials.

v) Joint Cutting

Early joint cutting prevent cracking to reduced curling and warping stresses. The joint width may be 3 mm and depth ¼ of the UTWT. The sealing of joint may be desirable.

vi) Open to Traffic: The traffic can be opened when the UTWT attained the desired strength depending on the traffic loading condition. Usually after 7 days traffic may be opened as per the prevailing conditions in India.

VI. Selection Of Pcc Overlays Alternatives

The selection of overlay types means identifying technically feasible rehabilitation alternatives and then evaluating the option in terms of costs and performance benefits. The option may also consider service life, performance, duration of construction, and local experience.

UTWT is generally not recommended for HMA which have significant structural deterioration, inadequate base/sub base support, poor drainage conditions. Falling weight deflectometer (FWD) in major projects may be used to study the structural adequacy of existing HMA pavement to ensure that load carrying capacity of the existing HMA is not too low. FWD results can help to find the local weak spots requiring strengthening. UTWT usually are applied where a substantial thickness of HMA exists (greater than 76 after any surface preparation/milling). Taking core from the existing HMA may ensure the thickness.

Repair of certain distresses in the existing HMA pavement (potholes, moderate to severe alligator cracking, rutting etc) is required in order to achieve the desired level of performance, since HMA is relied upon to carry part of the traffic loading. The rough surface preparation by milling of the existing HMA is carried to increase the load carrying capacity of the pavement system by enabling it to behave a monolithic structure. Milling is generally carried after the existing HMA pavement has been patched.

VII. Design Of Utwt

The basic requirement for the design of UTWT is the bond between the HMA and the PCC which allows the concrete and asphalt to perform as a composite section and causes the layers to act monolithically and share the load with each other and also with the other lower layers. With bonding, the neutral axis in the concrete shifts from the middle to the concrete down towards the bottom of the concrete and brings the stresses into a range the concrete can withstand.

For low traffic minimum thickness of existing HMA may be 75 mm and for very heavy traffic, for heavy traffic minimum thickness of HMA may be considered as 100 mm. On certain locations, where some spots of exposed base and sub base course are visible, the same shall be adequately re-compacted and proper HMA may be re-laid over it. The goal is to provide durable HMA to act as part of composite structure. With UTWT, short joint spacings are used so that the energy is absorbed by deflection rather than by bending.

Joint spacing for UTWT overlays are very short in order to reduce the magnitude of curling and bending stresses. Joint spacing shall be 12 to 15 times the slab thickness. The slabs for UTWT shall be square shaped. The steel tie bars, dowel bars is generally not recommended as the load transfer is expected from stiff support of the underlying HMA pavement and aggregate interlock. Following Table 2 may be adopted for the design of UTWT:

Table2. Typical Design of UTWT

Sl No.	Traffic Classification	HMA thickness mm (minimum)	UTWT Thickness (minimum), mm	Minimum Grade of Concrete
1	0-10 msa (light),	75 mm	75	M40, HPC
2	10-50 msa (Moderate)	75 mm	100	M- 45, HPFRC
3	50-100 msa (Heavy)	100 mm	125	M –50, HPFRC
4	More than 100 msa (Very Heavy)	150 mm	150	M-55, Reinforced

				cement concrete (RCC) using HPFRC

HPC – High Performance Concrete containing silica fume 5% by weight of cement, with other mineral admixtures optional.

HPFRC- High Performance Fibre Reinforced Concrete containing polymeric/steel fibres and silica fume 5% with other mineral admixtures optional.

Certain locations, such as urban intersections, may present specific constraints on available lane closure times. In these cases, use of paving, lane by lane may be considered for the UTWT to minimize lane closure times.

Controlled cracking results in improved ductility, energy absorption and resistance to impact, shock and thermal loading of the composite. The ability to control the size and amounts of cracks will also lead to improved durability by the use of high performance fibre reinforced concrete in UTWT. The advantages of UTWT are viz i) longer design life than HMA, ii) elimination of rutting and shoving problems and iii) conservation of materials. However there are certain disadvantages viz.) de-bonding can lead to premature failure, ii) require a thicker HMA pavement with adequate structural capacity, iii) longer duration of construction, and iv) high Initial cost.

Refrences

[1]. Shahin,M.Y. and J.A. Walther, 1990, Pavement Maintenance Management for Roads and Streets using paver System, USA CERL TR M-90/05, US Army Corps of Engineers, Construction Engineering Research Laboratory, Champaign, Illinois, 1990

[2]. Cole, L.W. and J.P. Moshen, Ultra-thin Concrete Overlays on Asphalt, 1993, Transportation Association Annual Conference, American Concrete Pavement Association, Skokie, 1993

[3]. Ultra-Thin Whitetopping Guide Part of Product No. SP 126P, American Concrete Pavement Association, Skokie, 1996

[4]. Wu, C.L., S.M. Tarr, T. M. Refai, M. A. Nagi and M. J. Sheehan, 1997, Development of Ultra Thin White topping Design Procedure, PCA Research and Developments Serial No. 2124, Portland Cement Association, Skokie IL.

[5]. Cole, L.W. 1997, " Pavement Condition Surveys of Ultra Thin White topping Projects." Proceedings Sixth International Purdue Conference on Concrete, Pavement Design and Materials for High Performance Indianpolis, IN.

[6]. Mack, J.W., L. D. Haw baker, and L.W. Cole. 1998 " Ultra Thin White topping: State-of-the-Practice for Thin concrete Overlays of Asphalt." Transportation Research Record 1610, Transportation Research Board, Washington, DC.

[7]. American Concrete Pavement Association (ACPA), 1998 White topping- State of the Practice, Engineering Bulletin EB210P. American Concrete Pavement Association, Skokie, IL

[8]. Sprinkel, M.M. 2000. Thin Bonded and Surface Lamination Projects for Pavements, Final Report, Federal Highway Administration, Washington, DC.

[9]. Grogg, M. G., K. D. Smith, S. B. Seeds. T.E. Hoerner, D. G. Peshkin and H.T. Yu 2001. HMA Pavement Evaluation and Rehabilitation, Manual NHI Course 131062, National Highway Institute, Arlington, VA

[10]. Hall, K. T. C. E. Correa, S.H., Carpenter, and R.P.Elliot, 2001, " Rehabilitation Strategies for Highways Pavements:, NCHRP Web Document No. 35 Transportation Board, Washington, DC

[11]. U. S. Department of Transportation Federal Highway Administration, 2002, Technical Brief Ultra- Thin White topping, Publication No. FHWA-IF-03-007, May 2002

[12]. U. S. Department of Transportation Federal Highway Administration, 2002, Technical Brief Conventional White topping Overlays, Publication No. FHWA-IF-03-008, May 2002

[13]. Vandenbossche, J. M. and J. A. Fagerness. 2002, " Performance and Repair of Ultra Thin White topping: The Minnesota Experience." Paper NO. 81st Annual Meeting of the Transportation Research Board, Washington, D.C.

[14]. U. S. Department of Transportation Federal Highway Administration, 2002, Technical Brief Bonded Cement Concrete Overlays, Publication No. FHWA-IF-02-009, May 2002

[15]. U. S. Department of Transportation Federal Highway Administration, 2002, Technical Brief Selection of PCC Overlays Alternatives, Publication No. FHWA-IF-03-005, May 2002