Comprehensive Review of Thin White Topping for Asphalt Road Enhancement

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Abstract

Maintaining and rehabilitating aging pavement infrastructure is a significant challenge faced by transportation agencies worldwide. Most bituminous pavements exhibit early signs of deterioration and need to be periodically maintained in order to remain strengthen. Traditional methods like bituminous overlays, while common, have limitations in terms of durability, maintenance requirements, and life cycle costs. Thin Whitetopping (TWT) emerges as a promising alternative, offering a robust, long-lasting, and ultimately more economical solution for pavement rehabilitation.

This research paper explores the advantages of TWT over bituminous overlays, delving into its superior performance characteristics, life cycle cost benefits, and environmental considerations. It also discusses key design considerations and construction practices for successful TWT implementation.

Keywords: Thin Whitetopping (TWT), road rehabilitation, pavement, cost-effective repair, environmental impact, infrastructure sustainability

Introduction

Roads deteriorate over time due to heavy traffic and environmental influences. It is essential to quickly fix them before it becomes worse. Nevertheless, in less developed nations, there is frequently a lack of funds to fully reconstruct roads to ensure their long-lasting strength, particularly due to the growing problem of traffic congestion. Engineers are seeking cost-effective methods to improve asphalt roads. An effective and cost-efficient solution is to use a thin layer of concrete known as "Whitetopping," which can prolong the lifespan of the pavement.

Whitetopping refers to the process of reinforcing asphalt pavement by adding a layer of Portland Cement Concrete (PCC) over the existing asphalt surface. Reported to have been used since the late 20th century, based on type of interfaces and thickness of overlay, whitetopping is classified into Conventional Whitetopping (CWT) and Thin Whitetopping (TWT). In Conventional Whitetopping, the thickness of overlay is 200mm or more, the bond between concrete overlay and existing bituminous surface is not considered, while in case of Thin Whitetopping, also known as paneled concrete, the thickness of overlay lies between 100-200mm and a solid bond between the concrete overlay, and the existing asphalt is desired. For thin whitetopping, strong concrete with embedded fibers is used. The concrete layer is also cut into small, square sections spaced about 1 to 1.5 meters apart. When compared to bituminous overlays, concrete overlays provide the possibility for longer durability, higher performance in terms of structure and functionality, less requirements for maintenance, and better return on investment.

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Advantages of Thin Whitetopping:

Thin white topping (TWT) offers several advantages over traditional asphalt pavements, enhancing their performance, durability, and overall lifespan. Some of the advantages are as explained below:

1. **Enhanced durability and longevity:** Whitetopping has resulted in increased service life due to their resistance to surface deterioration and superior load bearing capacity. Several whitetopping projects have shown superior and excellent results within their considered design life. Although some minor cracks have been observed after long run, it is more reliable and efficient than asphalt pavements.

2. **Reduced life cycle costs:** The Ohio Department of Transportation defines Life-cycle Cost Analysis (LCCA) as a method for assessing the economic value of a pavement section by considering both initial costs and discounted future expenses, including surface treatments, resurfacing, rehabilitation, and reconstruction, over a specified analysis period. LCCA suggests that thin whitetopping is more economical and beneficial compared to asphalt overlays. The percentage cost savings of thin whitetopping over bituminous overlays ranges in between 25% to 40%. Venugopalan K V (2024) suggest that thin whitetopping overlay offer a net saving of 25% over bituminous overlays. Ashok et al. (2017) suggest that thin whitetopping overlays' lifecycle cost is 38% lesser than that of bituminous overlays' (p.5).

3. **Utilization of industrial by-products:** Industrial byproducts, often referred as Supplementary cementitious materails (SCMs), such as ground granulated blast furnace slag, fly ash, silica fume, etc. can replace or supplement Portland cement to enhance its properties. Incorporating supplementary cementitious materials (SCMs) into cement and concrete reduces the CO2 footprint and prevents hazardous materials from ending up in landfills. Using SCMs in concrete pavement offers several environmental benefits. It avoids the additional use of virgin materials for cement production and reduces landfill waste by utilizing industrial by-products. Most importantly, replacing a portion of Portland cement with SCMs decreases greenhouse gas emissions and energy consumption, with CO2 and energy savings directly related to the percentage of SCMs in the concrete mix.

4. **Heavy vehicle fuel saving:** Fuel consumption of a vehicle partly depends on the extent to which a pavement bends under the weight of heavy vehicles passing over it. Studies indicate that heavy-vehicle wheels experience more deflection on asphalt pavements compared to concrete pavements. Thus, thin whitetopping saves fuel as less fuel is required to move heavy vehicles compared to bituminous overlays.

5. **Reduction in maintenance and repair cost:** Compared to asphalt pavements, thin whitetopping, a cement concrete pavement construction, requires less upkeep. Asphalt pavements often show signs of wear and tear, rutting, and surface cracking very fast. Additionally, they are more vulnerable to weather conditions and wheel loads damaging them. Conversely, because of their slab action and stiff construction, concrete overlays are less likely to deteriorate in this way. According to the Indian Cement Review, concrete pavements only need minor repairs to surface textures and joints, but asphalt roads require maintenance every two to four years and resurfacing every eight to ten years. Because of this, over an extended length of time and with smooth traffic flow, the maintenance cost of asphalt overlays is eight to ten times greater than that of concrete overlays.

6. **Additional benefits:** Thin whitetopping has a number of advantages over bituminous overlays in addition to the ones already discussed. When compared to asphalt pavements, thin whitetopping uses two to five times less energy over its lifetime. This results in a smaller embodied primary energy footprint. Because of its increased solar reflectance, it helps mitigate the effects of the urban heat island effect, resulting in lower outside temperatures and less energy needed for cooling. Additionally,

concrete surfaces save lighting energy needs by up to 33% and enhance nighttime visibility, which adds up to big financial savings.

Steps of construction of thin whitetopping:

The construction steps for thin whitetopping according to IRC:SP:76-2015 are briefly summarized as below:

1. **Milling of existing asphalt pavement:** The old asphalt pavement is milled to smooth out any ruts and provide a rough surface so that the new concrete layer adheres to the old pavement more readily. The milling depth, which ranges from 25 to 50 mm, is determined by the extent of the asphalt damage, particularly by the thickness of the asphalt layer and the depth of ruts. Hand tools like grinders or chisels may be used to roughen up the surface in tricky areas. In the absence of milling machines, the unevenness can be patched up with a new asphalt layer, at least 50mm thick, on top of the existing one. A sticky layer or tack coat between the old and new asphalt is put first which ensures a total asphalt thickness of at least 75 mm according to specifications of Ministry of Road Transport and Highway, India.

2. **Repair to existing pavement:** Any cracks in the milled asphalt surface are fixed carefully, if present. If there are lots of cracks, it might indicate the failure of the subgrade. In this case, pavement shall be replaced and the subgrade will also be re-compacted. Existing bituminous layer after milling should be in good condition to minimize reflection cracks or sympathetic cracks. If any cracks, weak spots, or other problems are found in the asphalt, they are patched up with a special, strong asphalt mix. Once everything is fixed, the entire milled surface, including repairs, needs to be perfectly flat and even. Before adding the new concrete layer (PCC), any cracks present are first filled with hot asphalt and then any loose bits are blown away with compressed air or a vacuum to make sure that the surface is clean. Finally, the asphalt surface is rinsed with water for a final clean before the overlay is applied.

3. **Cleaning:** To ensure that the new concrete layer sticks properly with the milled surface, the top surface is cleaned after milling the asphalt or adding a new layer to even things out. Methods such as air blasting/vacuum cleaner, power brooming, water blasting, sand blasting, chiseling, etc. may be used to remove foreign particles (Indian Roads Congress, 2015).

4. **Laying, Finishing, Texturing and Curing the New Pavement with Common Practices and Materials:** Once the asphalt surface is prepared by milling or adding a leveling course, steel channels or girders are used to set up the formwork, ensuring its stability. A thin layer of cement paste may be applied before pouring the concrete. Standard procedures and materials are then used to pour, smooth, and harden the concrete. After laying the PCC, a runner beam is placed simultaneously to avoid any vibration or disturbance to the freshly laid thin whitetopping. Using curbs as formwork is avoided. Depending on the project size and equipment availability, a semi-automatic machine or fixed formwork may be used to pour the concrete. Because thin whitetopping is thin and loses moisture quickly, a curing compound or water is applied at double the normal rate. The surface is textured for grip at a specific time when the concrete is no longer shiny but not yet fully hardened. For slower roads in towns or cities, a simple drag with burlap, turf, or a coarse broom is enough. For faster highways, tining is done to create a long lasting textured surface.

5. **Drainage:** When resurfacing with thin whitetopping, any existing drains, inlets, and manholes need to be lifted to the same level as the new pavement to maintain proper drainage. Drainage pipes, if present, should be located underneath the drainage layer for optimal functionality. Additionally, it's recommended to use reinforced concrete slabs (RCC) around the manholes for increased strength. These slabs should be made with standard steel bars (10mm diameter) spaced at 150mm center-to-center placed along the neutral axis of the concrete for better reinforcement.

6. **Additional considerations:** Laying thin whitetopping in urban areas requires extra planning due to the unique challenges these environments present. This includes strategically placing additional steel corners near manholes for reinforcement, incorporating paver block surfaces along the edges to allow for future utility access, and installing pipes at regular intervals for potential future services. Since the overlay raises the road level, it's crucial to consider potential adjustments to the storm water drainage system or even slightly tilting the road down (reverse camber) at entry points like driveways to avoid water pooling issues.

Applications of Thin Whitetopping

Thin Whitetopping (TWT) is a flexible and durable pavement rehabilitation method suitable for a variety of settings:

1. **High-Traffic Roads and Intersections:** TWT is highly effective for roads that endure heavy traffic, such as highways, city streets, and busy intersections. Its design is robust enough to manage significant traffic loads, enhancing the longevity and performance of these high-use areas.

2. **Airports and Taxiways:** The exceptional strength and durability of TWT make it ideal for airport pavements. Airports require surfaces that can withstand the heavy loads imposed by aircraft, and TWT provides a reliable solution that meets these demanding conditions.

3. **Bridges:** For bridge deck rehabilitation, TWT offers a cost-efficient and durable alternative. It extends the lifespan of bridge decks while minimizing the need for frequent repairs, making it a practical choice for bridge maintenance projects.

4. **Parking Lots and Industrial Areas:** TWT is well-suited for parking lots and industrial zones due to its resistance to heavy wear and tear. These areas often experience continuous heavy use, and TWT can maintain its integrity and functionality over time, reducing maintenance costs.

Design Considerations for Thin Whitetopping

To achieve successful TWT implementation, several critical design factors must be carefully evaluated:

1. **Traffic Volume and Load:** The design and thickness of the TWT layer should be determined based on the expected traffic volume and the weight of the vehicles. Heavier traffic and larger vehicles necessitate a thicker and more durable TWT layer to ensure long-term performance.

2. **Subgrade Strength:** The condition of the subgrade, or the soil beneath the pavement, is crucial. If the subgrade is weak, additional measures such as a thicker TWT layer or a cement-treated base may be required to provide adequate support and stability.

3. **Existing Pavement Condition:** The existing asphalt pavement must be thoroughly assessed before applying the TWT overlay. Any existing cracks, potholes, or other defects should be repaired or milled to create a smooth and stable base for the new concrete layer.

4. **Bond Strength:** For the TWT to be successful, the concrete overlay must have a strong enough bond with the existing asphalt. Proper surface preparation, including cleaning and possibly milling the old pavement, is essential. Applying a tack coat can further enhance the adhesion, ensuring that the concrete and asphalt layers act as a cohesive unit.

5. **Additional Considerations:** Adherence to regional design guidelines and standards is crucial for TWT projects. Regulations may vary, so consulting with qualified engineers is essential to ensure compliance and optimal design. Engineers can offer customized recommendations based on the unique conditions of the project site.

Thorough planning and assessment are also important to identify potential challenges. For example, proper drainage design is essential to prevent water-related damage to the pavement. By addressing these considerations, TWT can be effectively utilized in various applications, providing a durable, cost-effective, and sustainable solution for pavement rehabilitation and construction.

Environmental Impact Considerations of Thin Whitetopping

Thin Whitetopping (TWT) offers a compelling alternative to traditional bituminous overlays from an environmental perspective. Let's explore these benefits in detail:

1. **Resource Conservation and Reduced Waste Generation:**
   a. **Reduced Use of Virgin Materials:** Compared to bituminous overlays that require new asphalt production, TWT utilizes the existing pavement structure. This significantly reduces the demand for virgin materials like aggregates and asphalt binder, which have environmental impacts associated with extraction, processing, and transportation.

   b. **Minimized Construction Waste:** The rehabilitation process with TWT generates less waste compared to complete pavement reconstruction or multiple bituminous overlays. By salvaging the existing pavement structure, TWT minimizes the need for disposal of old asphalt layers, reducing landfill burdens.

2. **Lower Maintenance Needs and Reduced Environmental Footprint:**
   a. **Reduced Frequency of Rehabilitation:** The extended lifespan of TWT pavements translates to fewer rehabilitation projects over time. This translates to a significant reduction in the environmental impact associated with future construction activities, such as energy consumption for equipment operation and emissions from materials transportation.

   b. **Reduced Maintenance Materials:** Due to its superior durability, TWT requires less frequent maintenance compared to bituminous overlays. This translates to a decrease in the use of materials like patching asphalt and sealants, minimizing the environmental footprint associated with their production and application.

Challenges and Considerations for TWT Implementation

While TWT offers numerous advantages, implementing it successfully requires careful consideration of some potential challenges:

1. **Higher Upfront Costs:** The initial cost of installing a TWT pavement can be slightly higher compared to a simple bituminous overlay. This is due to factors like the use of concrete materials, potentially thicker pavement sections, and specialized construction techniques.

2. **Design Complexity:** Designing a successful TWT project requires careful consideration of factors like traffic volume, subgrade strength, and existing pavement condition. Qualified engineers with expertise in TWT applications are crucial for designing a cost-effective and durable pavement solution.

3. **Thorough Site Evaluation:** A thorough assessment of the existing pavement condition, subgrade strength, and drainage patterns is essential for successful TWT implementation. This upfront planning helps identify any potential challenges and ensures the project is tailored to the specific site conditions.

4. **Long-Term Planning:** TWT is a long-term solution, and planning should consider future traffic projections and potential changes in usage patterns. This ensures the chosen TWT design remains adequate for the pavement's anticipated lifespan.

Conclusion

Thin Whitetopping (TWT) emerges as a game-changer for road rehabilitation in developing nations grappling with resource limitations and rising traffic congestion. Traditional asphalt pavements, with their frequent maintenance needs, strain already stretched budgets. TWT offers a transformative solution. Its superior durability translates to a significantly extended lifespan, requiring fewer rehabilitation projects over time. This translates to substantial long-term cost savings, particularly when considering the environmental impact of construction activities associated with traditional methods. Furthermore, TWT boasts reduced maintenance needs compared to asphalt, minimizing the use of materials like patching asphalt and sealants, further reducing its environmental footprint.

Beyond immediate economic benefits, TWT offers significant environmental advantages. By utilizing the existing asphalt pavement structure, TWT minimizes the need for virgin materials like aggregates and asphalt binder, which have substantial environmental impacts associated with extraction, processing, and transportation. Reduced dependency on virgin materials also translates to lower energy consumption and a smaller carbon footprint. Additionally, the extended lifespan of TWT pavements translates to fewer rehabilitation projects over time, further reducing the overall environmental impact associated with construction activities. Furthermore, TWT construction generates less waste compared to complete pavement reconstruction or multiple bituminous overlays, minimizing landfill burdens.

The potential for TWT in developing nations extends beyond its economic and environmental benefits. Heavy-vehicle fuel consumption is lower on concrete pavements compared to asphalt due to reduced deflection under load. In developing countries with limited fuel resources, this translates to cost savings on fuel imports and transportation. Additionally, concrete surfaces have a higher solar reflectance compared to asphalt, contributing to a reduced urban heat island effect. This translates to lower ambient temperatures, potentially reducing energy demands for cooling buildings, particularly in hot climates prevalent in many developing countries. While TWT offers numerous advantages, implementing it successfully requires careful consideration of some potential challenges. The initial cost of TWT installation can be slightly higher compared to a simple bituminous overlay. However, these upfront costs are often offset by significant long-term savings in maintenance and rehabilitation.

In conclusion, Thin Whitetopping presents a compelling and sustainable solution for developing nations facing the dual challenges of resource constraints and increasing traffic congestion. Its superior durability, reduced maintenance needs, and significant environmental benefits make it a cost-effective and environmentally sound approach to road rehabilitation. By overcoming the initial investment hurdle and implementing TWT with proper planning and knowledge sharing, developing nations can unlock long-term economic and environmental benefits for their infrastructure projects. The potential for long-term cost savings, improved road performance, and a reduced environmental footprint offers a glimpse into a future with more sustainable and resilient transportation networks in developing countries.

References

Alapure, A. P., Ganjale, S. S., Kulkarni, S. S., Ingle, U. B., Gore, Y. Y., Dahatonde, Y. B., & Student, U. G. (2007). *Pavement Rehabilitation Using Thin White Topping*. 5(5).

Ashok, S. P., Patil, A. R., & Pataskar, S. V. (2017). *Life Cycle Cost Analysis of Bituminous Pavements and Concrete Pavements in Urban Areas*. 3(7).

Garoma, S., & Garoma, U. (2023). *Fiber Reinforced White Topping as a Rehabilitation Alternative over Flexible Pavement: An Experimental Study on Awash-Mille Road*. https://doi.org/10.21203/rs.3.rs-3248224/v1

Gowda, S. (2022). *Experimental Investigation on Performance Of White Topping Over Flexible Pavements*. 9, 1602–1607.

Indian Roads Congress. (2015). IRC SP 076: *Guidelines for Conventional and Thin Whitetopping* (First Revision). http://archive.org/details/gov.in.irc.sp.076.2015

Li, X., & Wen, H. (2011). Performance Evaluation of Whitetopping and Ultra-thin Whitetopping Pavements. *Transportation Research Record Journal of the Transportation Research Board*, 2205, 247–253. https://doi.org/10.3141/2205-31

Mishra, B. (n.d.). *A Study On Thin White Topping: An Alternate For Pavement Treatment*.

Nooruddin, M. S. A., Mr. Samiullah, & Safiuddin, M. M. (2019). Design and Execution of Thin White Topping Road. *International Journal of Civil Engineering*, Volume 4. https://doi.org/10.14445/23488352/IJCE-V4I4P102

Patil, R. Y., & Ranadive, M. S. (2022). Design and development of methodology for construction of thin white topping for rural roads in India. *Innovative Infrastructure Solutions*, 7(4), 245. https://doi.org/10.1007/s41062-022-00762-7

Qureshi, A. (2020). *Experimental Analysis of White Topping & Bitumen Roads In Sagar*.

Satishkumar, C., & Uppuluri, S. (2017). Ultra-thinwhite topping concrete mix with sustainable concrete materials – a literature review. *International Journal of Pavement Engineering*, 20, 1–7. https://doi.org/10.1080/10298436.2016.1274598

Sehgal, A. K., & Sachdeva, S. N. (2015). *A Review of Using Thin White Topping Overlays For Rehabilitation of Asphalt Pavements. 2(3).*

Thakar, V. V. (n.d.). *Performance of Thin White Topping (TWT) Overlay for NH-848.* Retrieved May 18, 2024, from https://www.nbmcw.com/article-report/infrastructure-construction/roads-and-pavements/performance-of-thin-white-topping-twt-overlay-for-nh-848.html

Vandenbossche, J., Dufalla, N., & Li, Z. (2016). Bonded concrete overlay of asphalt mechanical-empirical design procedure. *International Journal of Pavement Engineering,* 18, 1–12. https://doi.org/10.1080/10298436.2016.1141410

Vandenbossche, J. M., & Fagerness, A. J. (2002). Performance, Analysis, and Repair of Ultrathin and Thin Whitetopping at Minnesota Road Research Facility. *Transportation Research Record: Journal of the Transportation Research Board*, 1809(1), 191–198. https://doi.org/10.3141/1809-21

Venugopalan K V. (2024). *White Topping Revolution for Cost-Effective and Long-Lasting Treatment over the Existing Bituminous Roads.* https://doi.org/10.5281/ZENODO.10453305

White Topping Concrete: A Solution To Potholed Roads | UltraTech. (n.d.). Retrieved May 18, 2024, from https://www.ultratechcement.com/for-infrastructure/infrastructure-solution/white-topping-concrete-