

ASPHALT A CRITICAL COMPONENT OF ALL TRANSPORT INFRASTRUCTURE

It appears that Australia has survived the worst of the world economic crisis and has done so with less impact than in most other countries. Some of this has been due to the recognition by Australian Governments of the importance of transport infrastructure to the economy.

Transport infrastructure provides the essential links across our whole nation to allow for goods and materials to be freely moved and to ensure that our communities remain connected.

As well as providing corridors for commerce and communication, the construction and maintenance of infrastructure also provides a large number of direct and indirect jobs. Road construction and maintenance crews are just one part of the overall transport infrastructure work force.

In the road construction industry, we understandably usually focus on roads, but there are other parts of transport infrastructure that are also important. Rail is also a key part of our society and must to be developed and maintained alongside roads. Recognising this, the governments of Australia are currently supporting many significant rail projects, projects.

Like road development, railways must be maintained to a high standard to provide efficient, safe and reliable travel. This requires new railways to be built with appropriate cost effective and long life materials that can safely handle the increasing speed and mass of trains. Existing railways must also be maintained to ensure they are safe and reliable.

One way to improve the safety, efficiency and reliability of railways is to use asphalt in their manufacture and maintenance. This is highlighted in the following article prepared by Prof Jerry Rose from the University of Kentucky.

RAILS RIDING ON ASPHALT IN THE UNITED STATES AND ELSEWHERE

By Jerry G. Rose, P.E.

The continued growth in traffic volumes, revenue ton-miles, and wheel loadings on the United States freight railroads has prompted research to evaluate new technologies to provide higher quality and longer lasting track and support structures. Similar studies are on-going in several European and Asian countries.

To meet this challenge, the railroad companies and the asphalt paving industry have developed designs and applications for using hot mix asphalt (HMA) to replace a portion of the conventional granular material.

HMA is now being used in new mainline tracks, yards, and terminals. It is also being used for trackbed maintenance and as a solution for instability problems in existing trackbeds. These trackbed solutions include installing a layer of HMA during the rehabilitation of turnouts, railroad crossings, bridge approaches, defect detectors, hump tracks, tunnel floors and approaches, highway crossings, and loading facilities where conventional trackbed designs and support structures have not performed satisfactorily.

Two Designs

Two HMA designs are used to support the railway track structure. The most common design in the U.S. is known as HMA Underlayment, in which the HMA layer is placed directly on select subgrade or old roadbed. A layer of ballast is placed on the HMA layer on which the track is positioned. This design changes little from normal trackbed design, since the HMA layer merely replaces the granular subballast layer. The HMA layer is similar to a paved lane of a highway, except it is contained within the track structure to



A two per cent cross slope is specified.



Positioning a new track on the BNSF transcon project prior to adding the ballast and 'pulling the track up' to achieve the desired thickness of ballast.

form a structural hardpan layer between the ballast and the subgrade or existing roadbed.

Notable installations in the U.S. include the BNSF Railway's extensive use of the underlayment design on portions of their heavy traffic transcon line and coal-hauling lines in the mid-west section of the country. For many years the Italian State Railways has extensively used asphalt underlayment (known as "bituminous subballast") for new high-speed line railway construction. It is a standard for particular types of new rail lines. In addition, the Japanese Rail System recently adopted "performance-based design method" specifies asphalt roadbed with ballast for Rank II track designs and asphalt roadbed is an alternate for Rank I ballastless slab track design.

HMA Overlayment design involves placing the HMA layers in a similar manner, except no ballast is used between the HMA layer and the railroad ties. The ties are placed directly on the HMA surface. Cribbing aggregate is then placed between the ties and at the end of the ties to restrain track movement. This design is used primarily in Europe as a version of slab track with two-block concrete ties. The German Federal Railway Authority is a classic European specifier of the HMA Overlayment design. One particular system is known as the GETRAC Ballastless Track System on Asphalt.

The HMA Overlayment design is not as readily adaptable to current U.S. railroad construction and maintenance practices as is the HMA underlayment design. This article concentrates on the

more utilized HMA Underlayment applications.

Benefits of HMA Underlayment

The benefits of an HMA underlayment, as determined by research tests and observations over the past 25 years include:

- A strengthened track support layer below the ballast to uniformly distribute reduced pressures to the roadbed or subgrade.
- A waterproofing layer and confinement to the underlying roadbed to provide consistent load-carrying capability of track structures—even on roadbeds of marginal quality.
- An impermeable layer to divert water to side ditches, essentially eliminating roadbed moisture fluctuations, to consistently maintain adequate underlying support.
- A consistently high level of confinement for the ballast to provide high shear strength and uniform pressure distribution.
- A resilient layer between the ballast and roadbed to reduce the likelihood of subgrade pumping without substantially increasing track stiffness, and
- An all-weather, uniformly stable surface on which to place the ballast and track superstructure.

Heavy Freight and High Speed

Railways that most benefit from HMA underlayment are those having heavy freight traffic or high speed passenger traffic, where one or more of the following conditions exist or are anticipated:

- Difficulty in establishing and maintaining a sufficiently strong and stable roadbed (hardpan) to adequately support the ballast and track.
- Difficulty in establishing and maintaining proper surface drainage to convey surface water away from the track structure.
- Difficulty in preventing ground water from weakening the track structure, and
- Abnormally high impact stresses at joints, bridge and tunnel approaches, other special track works, or open track where track stiffness varies abruptly.

Areas where these conditions exist are likely to show rapid track contamination, excessive wear of track components, and below standard track geometric parameters. Maintenance costs become too expensive to continue safe line speed operations so "slow orders" must be imposed, which reduce operating efficiency.

Trackbed Design

Recommended HMA specifications, trackbed section designs, and application practices have evolved over the years. Slight variations from the initial mix designs and construction techniques are typical and have not affected trackbed performance.

The HMA mix that has the best properties for the track structure is a low to medium modulus (plastic) mix, having design air voids of 1 to 3 percent. The mix will easily compact to less than 5 percent air voids in place. A local dense-graded highway base mix with a minimum aggregate size of 25 to 37 mm

(1.0 to 1.5 inches) is typically specified.

Ideally, the asphalt binder content can be increased by about 0.5 percent above optimum for highway applications because rutting and bleeding are not concerns in the insulated trackbed environment. This is similar to the bottom, or fatigue resistant, asphalt layer of the perpetual pavement system being promoted for highway pavements in the U.S.

Stiff but Resilient

Long-term monitoring and testing of in-service trackbeds indicate that this low voids, impermeable mix, undergoes minimal oxidation from the effects of air and water. The mix is also isolated from extreme temperature fluctuation within the insulated trackbed environment.

The mix provides a layer with reasonably consistent stiffness in hot weather but is slightly resilient in cold weather. Furthermore, the tendencies for the mix to rut and bleed in hot weather and crack in cold weather are significantly reduced, thus ensuring a long fatigue life for the mix.

Tests on subgrade/roadbed samples, obtained directly under the HMA layer, indicate that the in-situ moisture contents are very close to optimum values for maximum density of the materials. For structural design analyses, it is reasonable to base bearing capacity values at optimum conditions for the material under the HMA layer.

Width and Thickness

The predominate HMA layer width is 3.7 to 4.3 m (12 to 14 feet) for open track, but the width is wider under special trackwork, such as turnouts, to provide support under the longer ties.

The thickness of the HMA layer varies depending on the quality of the roadbed (subgrade) support and traffic loadings. A 125- to 150-mm (5- to 6-inch) thick layer is normally used for average conditions. For unusually poor roadbed support conditions, and high impact areas, a minimum of 20 mm (8 inches) is used. Ballast thickness normally ranges from 200 to 300 mm (8 to 12 inches). A 150 mm (6-inch)



Placing asphalt underlayment on the Wichita, KS elevated track section for the mainlines of the BNSF and UP railways.

HMA thick layer that is 3.6 m (12 feet) wide requires 1.25 metric tons per track meter (0.42 tons per track foot).

The HMA layer should extend a reasonable length beyond the ends of special trackwork so that subsequent track surfacing operations and any impact from track stiffness changes will not infringe on the area.

The roadbed should be reasonably well-compacted, well-drained, and capable of accommodating the hauling and spreading equipment without excessive rutting or deformation. A slight crown on side slope is desirable. The need for sub-surface drainage or roadbed support improvements, prior to placing the HMA, depends on site specific conditions.⁸

KENTRACK

The structural design of railway trackbeds containing HMA underlayment can be performed using KENTRACK, a finite element computer program. The primary governing factor is limiting the vertical compressive stresses, or permanent deformation, on the subgrade.

For the HMA layer, the tensile strains at the bottom of the HMA layer control its service life. Damage analyses are conducted and used to predict the service life of the trackbed components for various combinations of traffic, tonnages, subgrade support, and component layer compositions and thicknesses.

Installation Practices

The construction of new rail lines and extensions, classification yards, and intermodal terminals are ideal conditions for HMA underlayments. These are normally large paving projects with exposed subgrades that are readily accessible to conventional asphalt paving equipment for placing the HMA layer prior to placing the ballast and track. Typical highway paving technology can be used.

New intermodal yards use HMA for all or portions of the new track construction. A particular advantage is the waterproofing characteristics of the HMA layer and the positive drainage system that can be used in the design of the loading area.

Maintenance and Rehabilitation

Maintenance and rehabilitation of existing rail lines, using current technology, requires that the track must be removed and the underlying material excavated to the desired grade. The existing roadbed material should be reasonably compact and capable of providing adequate support.

The HMA is hauled by dump trucks. For short track sections, it is common to dump the mix and spread it to the desired configuration. Paving machines can be used for longer sections where manoeuvrability permits. Conventional compaction equipment is used. Placing and compacting the ballast and positioning the tracks completes the process. It is not necessary for the HMA to cool prior to placing the ballast.

HMA underlayment provides excellent support for heavy freight rail traffic and high speed passenger traffic on subgrade that cannot adequately sustain heavy weights and high speeds. HMA continues to be the working solution of choice to counter railway trackbed instability.

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