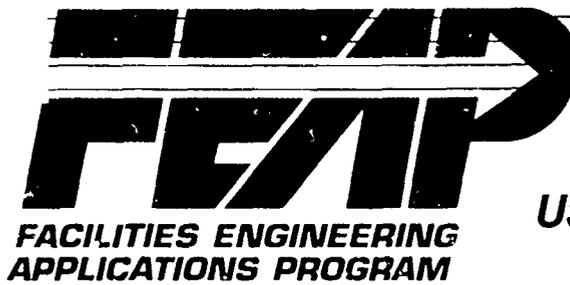


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USER'S GUIDE

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FEAP-UG-92/01

February 1992

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USER'S GUIDE: STRUCTURAL ENHANCEMENT OF RAILROAD TRACK



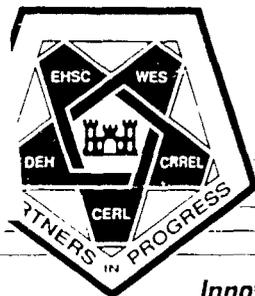
by

David M. Coleman
US Army Engineer Waterways Experiment Station
Vicksburg, MS 39180-6199

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Innovative Ideas for the Operation, Maintenance, & Repair of Army Facilities

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13. ABSTRACT (Maximum 200 words) Water intrusion into low strength and/or swelling subgrade soils under railroad track results in the need for almost continuous maintenance as well as operational problems for railroad traffic. In recent years many techniques for stabilizing unstable track structures have been developed. One of these techniques is the use of hot-mix asphaltic concrete as a structural layer in the track structure. The use of a hot-mix asphalt structural layer in the track structure combined with adequate drainage of water away from the track has been shown to reduce or eliminate water intrusion into the subgrade. The description, applicability, benefits, limitations, costs, recommended uses, and a demonstration of using hot-mix asphalt as a structural layer in a railroad at Red River Army Depot, Texarkana, TX are discussed.				
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**USER'S GUIDE
STRUCTURAL ENHANCEMENT OF RAILROAD TRACK**

PART I: EXECUTIVE SUMMARY

Description

Water intrusion into low-strength and/or swelling subgrade soils underlying railroad tracks can result in poor track conditions, operational problems for rail traffic, and a demand for continuous track maintenance. Using hot-mix asphalt concrete as a structural layer in the track system coupled with adequate drainage reduces or eliminates water intrusion into the subgrade. This in turn decreases track maintenance requirements while improving track and operating conditions. Structural enhancement of railroad track as described herein consists of the construction of a relatively thin layer of hot-mix asphalt immediately above the subgrade in a conventional ballasted railroad track. This is commonly referred to as an asphalt underlayment.

Application

The use of an asphalt underlayment in a railroad track structure is most applicable to relatively short sections of track having poor subgrade conditions or track experiencing severe pumping problems. Asphalt underlayment sections can be used to increase the track strength in the vicinity of turnouts, rail crossings, highway crossings, and bridge approaches.

Benefits

The asphalt underlayment serves several functions in the track structure that makes it an excellent method for enhancing the strength of railroad track over poor subgrade soils. These include waterproofing the subgrade and spreading the applied

loads. An asphalt underlayment decreases the stresses applied to the subgrade which helps to prevent vertical displacement of the track. The underlayment also prevents mixing of the ballast and subgrade materials and provides increased track support and load-carrying capability. An asphalt underlayment performs these functions in such a manner as to produce track that has longer lasting track geometry, reduced maintenance requirements, and improved operating conditions.

Limitations

The only real limitations to using an asphalt underlayment is the need to completely remove the existing track to place the underlayment, the track time that is lost during construction, and the fact that construction equipment may have to be moved into remote or difficult to reach sections of track to place the underlayment.

Costs

The initial cost of track reconstruction using an asphalt underlayment is approximately 17 percent greater than the cost of reconstruction without the underlayment. If geotextiles, subballast, or subgrade stabilization is required in the conventional reconstruction, there is little difference in the cost for the two methods. Because the initial cost of the underlayment is greater, its economic viability depends upon a longer life and a lower life-cycle cost. The functional life required to offset this increased initial cost with annual maintenance savings is dependent on site conditions. In general, an asphalt underlayment will be cost effective in track locations having problem subgrade soils. Specifically high maintenance areas such as turnouts, track crossings, and grade crossings will produce the best return-on-investment.

Recommendation for Use

Structural enhancement of railroad track using hot-mix asphalt underlayment is recommended for use in the construction, reconstruction, or rehabilitation of railroads where poor subgrade soils or poor drainage conditions result in operational problems or intensive track maintenance requirements. Specific locations where underlayments have proven effective are at turnouts, rail crossings, road crossings, and bridge approaches where the subgrade soils and drainage conditions are poor. Additionally, sections of track over swelling or low-strength soils can benefit from this enhancement technique.

Points of Contact

Points of contact regarding this technology are:

Technical:

Director

US Army Engineer Waterways Experiment Station

ATTN: CEWES-GP-N (Mr. Richard Grau)

3909 Halls Ferry Road

Vicksburg, MS 39180-6199

Telephone: (601) 634-2223

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Commander

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Fort Belvoir, VA 22060-5516

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Demonstration Site (1985)

Commander

Red River Army Depot

ATTN: SDSRR-OE (Mr. Jerry Stewart)

Texarkana, TX 75507-5000

Telephone: (903) 334-4035

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PART II: PREACQUISITION

Description of Asphalt Underlayment

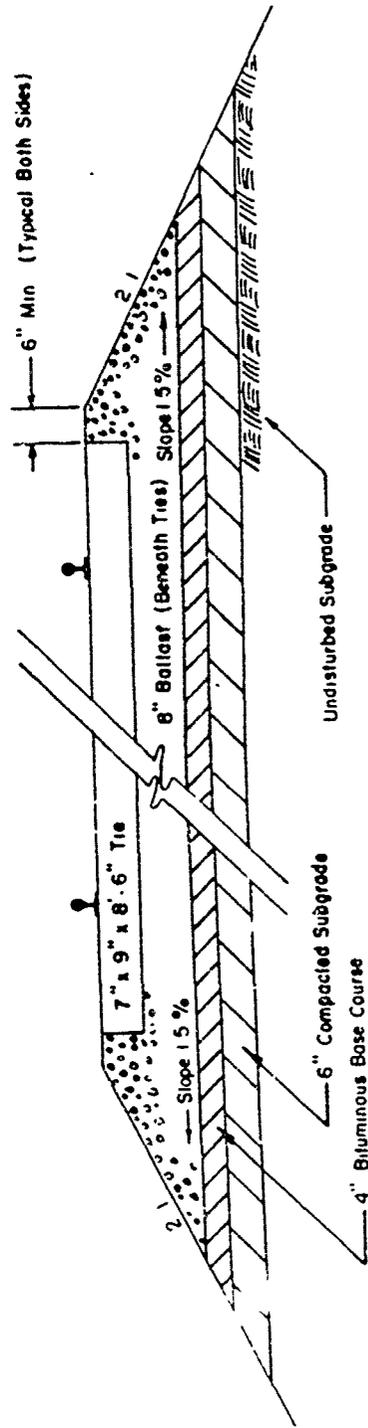
An asphalt underlayment in railroad track consists of a relatively thin layer of hot-mix asphaltic concrete that acts as a subballast beneath a conventional ballasted track. In most installations the track will consist of a prepared subgrade, 4 to 8 in. of asphaltic concrete, and a conventional track with 8 to 12 in. of ballast beneath the tie. Figure 1 presents a typical cross section of a track having an asphalt underlayment.

Asphalt underlayment sections can be installed during track construction or rehabilitation using conventional paving and railroad construction equipment and methods. In most cases installation will require the removal of the entire track, although some commercial railroads have experimented with equipment that can place the asphalt behind an undercutting operation.

The asphalt underlayment serves several functions in the track structure that makes it an excellent method for enhancing the strength of railroad track over poor subgrade soils. These include waterproofing the subgrade, spreading the applied loads, decreasing the stresses applied to the subgrade, preventing vertical displacement of the track and mixing of the ballast and subgrade materials, and providing increased track support and load-carrying capability. An asphalt underlayment preforms these functions in such a manner as to produce track that has longer lasting track geometry, reduced maintenance requirements, and improved operating conditions.

Application

The use of a hot-mix asphalt layer in a railroad track structure is most applicable to relatively short sections of track having poor subgrade conditions or track experiencing severe pumping problems. Asphalt underlayment sections can be used to increase the track strength in the vicinity of turnouts,



NOTE: Where More Than One Track Is Involved In The Cross Section Of The Track Structure Bituminous Base Course Shall Extend Continuously Under All Tracks At Indicated Slope A Minimum Of 6'-6" Outside The ϵ Of The Outside Track Each Way

NOT TO SCALE

Figure 1. Typical section of asphalt underlayment

rail crossings, highway crossings, and bridge approaches, as well as areas exhibiting poor subgrade conditions. The most likely application will be in locations with subgrade soils of clay or highly plastic silt that classifies as CH, MH, or CL in the Unified Soil Classification System.

To determine if an asphalt underlayment is appropriate for a particular situation, the user must consider the following:

- a. Location of problem area (turnout, road crossing, adjacent buildings, open track, etc.)
- b. Frequency, extent, and cost of track maintenance now required to maintain traffic at the desired level.
- c. Length/size of problem area (track-feet).
- d. Subgrade type and strength.
- e. Conventional approaches that are applicable to the problem and the cost to repair them (underdrains, geotextiles, subgrade stabilization).

The user should look at all possible options, select the two or three most promising and then perform a detailed cost analysis. In most cases the cost will be comparable to, if not lower than, other methods of permanent repair.

Limitations/Disadvantages

The major disadvantages of using an asphalt underlayment is the need to completely remove the existing track to place the underlayment and the track time that is lost during construction. However, this disadvantage is negated if the underlayment is placed during initial track construction (new construction) or when the track is to be rebuilt entirely during major rehabilitation. Another disadvantage is the fact that construction equipment may have to be moved into remote or difficult to reach sections of track. These limitations can be offset by using alternative construction techniques such as placing the underlayment behind an undercutter or dumping and spreading the asphalt with a dozer or motor grader. Time is generally not a problem, as the underlayment can be placed rapidly once the track is removed.

FEAP Demonstrations/Implementation Sites

In 1985 a demonstration project was conducted at Red River Army Depot (RRAD), Texarkana, TX. In this demonstration three tracks leading into the engine maintenance facility and a section of the main lead track into the area were removed and the tracks reconstructed with an underlayment. A total of 1,375 ft of track was reconstructed along with three turnouts. The existing track materials were removed, and the rail, joint bars, and turnout materials were stockpiled for reuse. The old ballast was removed and the top 6 in. of subgrade compacted and shaped. Conventional asphalt paving equipment and procedures were used to place 4 in. of hot-mix asphalt in two lifts. The asphalt was compacted using a Dynapac CC14 steel-wheeled vibratory roller and a small 1-ton steel-wheeled roller. Upon completion of the asphalt placement, approximately 4 in. of ballast was placed and leveled with a small bulldozer. The track was reconstructed on this first layer of ballast using new ties. The remaining ballast was then placed in the track and the track raised to provide a total of 8 in. between the bottom of the tie and the asphalt layer. Final surface and lining were accomplished with a tamper liner and the ballast section dressed with a ballast regulator. As part of the repair project, the shoulders and drainage ditches adjacent to the project area were graded to provide positive drainage away from the track.

Upon completion of construction, track deflection measurements were taken. The postconstruction track modulus indicated an average 48 percent increase in track strength (as defined by track modulus) over the preconstruction tests. A site visit in 1989 (4 years after completion) indicated no track surface deviations, and discussions with RRAD personnel indicated that the section was performing well although no maintenance had been performed on it. Telephone conversations with personnel from RRAD in 1991 (6 years after construction) indicated that the section was still exhibiting excellent performance with no maintenance.

Life-Cycle Costs and Benefits

The initial cost of track reconstruction using an asphalt underlayment is approximately 17 percent greater than the cost of reconstruction without the underlayment and without geotextiles, soil stabilization, and other remedial measures. Recent cost data (Rose and Hensley 1991)* indicate that an asphalt underlayment can actually be less costly than conventional track construction where a heavy-duty geotextile and subballast section was used. In the 1985 demonstration project at RRAD a section of track having severe pumping problems was reconstructed using an asphalt underlayment and the existing rail and joint bars but with new ties, ballast, spikes, and bolts. Track reconstruction with the underlayment cost \$78.43 per track foot. Another track at the demonstration site was reconstructed in a similar manner but without the underlayment at a cost of \$67.23 per track foot. Table 1 presents a cost comparison for these two construction methods. If the conventional track construction included subgrade stabilization and the use of a heavy-duty geotextile, the cost would have increased to approximately \$79.00 per track foot. This would make the asphalt underlayment comparable with conventional construction.

Because the initial cost of the underlayment is greater, its economic viability depends upon a lower life-cycle cost. To be cost effective, the decrease in maintenance cost resulting from the improved functional life must offset the greater initial cost. The functional life required to offset this increased initial cost with annual maintenance savings is dependent on site conditions. For the demonstration site, it was expected that the underlayment would result in a savings in maintenance cost of \$1.50 per track foot per year. At this level of savings, a functional life of at least 8 years with no major maintenance is required to offset the initial cost. At this time the demonstration project has been completed (and subjected to daily rail

* References (cited and uncited) are given in Appendix A.

Table 1
Comparison of Construction Cost Underlayment Versus
Conventional Out-of-Face Rehabilitation*

Item	Cost per 1,000 Track Feet		
	Underlayment	Conventional	Difference**
Remove Old Track	8,800	8,800	-0-
Subgrade Preparation	7,112	7,112	-0-
Bituminous Prime Coat†	1,387	-0-	+ 1,387
Hot-Mix Asphalt Underlayment†	21,784	-0-	+21,784
Ballast††	10,000	21,970	-11,970
Ties	12,126	12,126	-0-
Spikes, Bolts, Anchors, and Other Track Materials	2,621	2,621	-0-
Replace Track (Reused Rail)	9,650	9,650	-0-
Line, Surface, and Dress	3,000	3,000	-0-
Clean Ditches	<u>1,950</u>	<u>1,950</u>	<u>-0-</u>
Total	\$78,430	67,229	+11,201

* Cost is normalized to indicate cost for rehabilitation of 1,000 ft of single track. The roadbed is assumed to be 16 ft wide.

** Difference is the cost of underlayment versus the cost of conventional track construction.

† Prime coat and underlayment are assumed to be 14 ft wide.

†† Ballast thickness for underlayment is 8 in. below bottom of tie; ballast thickness for conventional rehabilitation is 18 in. below bottom of tie.

traffic) for 6 years with no expenditure of maintenance funds other than for routine joint and turnout maintenance. The performance to date indicates that the underlayment section may not require major maintenance for another 10 to 15 years, thus improving the life-cycle cost of the project.

Life-cycle cost data available from commercial railroad installations of asphalt underlayments cannot be extrapolated to the railroads on military bases. However, major decreases in maintenance costs, which involved reductions in life-cycle cost, have been realized. The potential rate-of-return for constructing an asphalt underlayment on installation's track must be determined based on specific conditions. Considerations in determining the life-cycle cost are:

- a. The location of the problem area (site access and working room).
- b. Frequency, extent, and cost of track maintenance presently required to maintain traffic at the desired level.
- c. Length of problem area.
- d. Construction cost including cost of the asphaltic concrete mix, underlayment placement, site access, and amount of hand work necessary.
- e. Thicknesses of asphaltic concrete and ballast required.
- f. Cost for conventional methods (geotextiles, soil stabilization, etc.) that may solve the problem.
- g. Drainage improvements required.
- h. Expected future (20 to 25 years) maintenance cost with the possible repair methods.

Advantages/Benefits

An asphalt underlayment helps to improve track support and operating conditions while reducing track maintenance costs. Specific advantages of using an asphalt underlayment in a railroad track include:

- a. Provision of a nearly impermeable layer over the subgrade that minimizes changes in subgrade moisture content due to intrusion of surface water.
- b. Increased track support and load-carrying capacity.

- c. Prevention of subgrade intrusion into the ballast, commonly known as "ballast fouling."
- d. Longer lasting track geometry and improved operating conditions.
- e. Reduced track maintenance requirements and an increase in required maintenance cycles that result in long-term cost savings.
- f. Improved operating conditions that translate into improved safety and fuel savings.

PART III: ACQUISITION/PROCUREMENT

Potential Funding Sources

Typically, installations fund the implementation of pavements and railroads technologies out of their annual budgets. However, the annual budget is always underfunded, and normally railroad projects do not compete with the higher visibility/higher interest projects. As a result, when a project merits action, it is recommended that funds from outside sources be sought. Listed below are some sources commonly used to fund this type of work. All of the sources listed below may not apply to asphalt underlayment, but are included for consideration on other projects.

- a. Productivity program. See AR 5-4, Department of the Army Productivity Improvement Program for guidance to determine if the project qualifies for this type of funding (Normally will not apply to asphalt underlayment).
- b. Facilities Engineering Applications Program (FEAP). In the past, a number of pavement and railroad maintenance projects located at various installations were funded with FEAP demonstration funds. At that time, emphasis was placed on demonstrating new technologies to the Directorate of Engineering and Housing (DEH) community. Now that these technologies have been demonstrated, the installations will be responsible for funding their projects through other sources. However, emphasis concerning the direction of FEAP may change in the future; therefore, don't rule out FEAP as a source of funding.
- c. Special programs. Examples of these are as follows:
 - (1) FORSCOM program to provide facility repairs to support mobilization which may include rehabilitation of railroads and rehabilitation or enlargement of parking areas and the reinforcement of bridges.
 - (2) Safety program which may include the repair of unsafe/deteriorated railroad/highway grade crossings and in ammunition storage areas.

- (3) Security upgrade which may include the repair or enlargement of fencing (may apply where railroads through gates or sully ports are being reconstructed).
- d. Reimbursable customer. Examples of this source are roads to special function areas such as family housing or schools and airfield pavements required to support logistical operations.
- e. Special requests from MACOMS.
- f. Year end funds. This type funding should be coordinated with the MACOMS to ensure that the funds will not be lost after a contract is advertised.
- g. Operations and Maintenance Army. These are the normal funds used for funding pavement and railroad projects.

Technology Components and Sources

Components of this technology which must be procured for track construction/rehabilitation using an asphalt underlayment are section design, plans, and specifications (may be in-house or contracted out), railroad construction contractor to perform track removal and reconstruction, necessary railroad track materials, hot-mix asphalt concrete (standard state Department of Transportation mixes will generally work well), and a paving contractor for subgrade preparation and asphalt placement work.

All of the items used in the installation of an asphalt underlayment are conventional materials and procedures that are normally used in the construction/rehabilitation of railroads and in highway pavement construction. No special materials or procedures are required. However, care must be taken in the contracting process to ensure that there is proper coordination between the railroad contractor and the paving contractor or subcontractor so that installation of the underlayment will not delay the track construction. In some situations special contract considerations may be required regarding site access and work locations.

Procurement Documents

Track construction/reconstruction using an asphalt underlay-
ment is a site specific activity, and a standard specification or
guide specification is not available. In the demonstration pro-
ject regular Corps of Engineers Guide Specifications including
CEGS 02230 "Excavation, Embankment, and Preparation of Subgrade;"
CEGS 2450 "Railroads;" and CEGS 02551 "Bituminous Paving for
Roads, Streets, and Open Storage Areas" were modified to form the
project specifications. In the case of the demonstration project
the asphalt mix design specified in the CEGS was changed to allow
the use of a Texas Department of Transportation surface course
mix that was readily available from local asphalt plants. The
railroad construction section of the specifications had to be
modified to include the installation of the asphalt layer as the
subballast. Appendix B presents the general specification for
the asphalt underlayment used in the demonstration project. This
specification can be used as an example. Additional information
is available from the University of Kentucky and The Asphalt
Institute.*

Procurement Scheduling

There are no long lead time items that must be procured for
construction of the underlayment. The time required and methods
used to prepare project plans and specifications are similar to
that required for conventional repair projects.

An asphalt underlayment must be placed during the normal
construction season for asphalt paving in your area. Therefore,
the procurement planning and scheduling should be timed for this
limitation.

In most cases the asphalt underlayment will be placed by a
paving contractor working under subcontract to a railroad

* Dr. Jerry Ruse, The University of Kentucky, Department of
Civil Engineering, Telephone (606) 257-4278.
Mr. M. J. Hensley, The Asphalt Institute, Telephone
(501) 758-0484.

construction/maintenance contractor. Another alternative is for the trackwork to be performed with in-house labor with the underlayment placement contracted to a paving contractor.

PART IV: POST ACQUISITION

Initial Implementation

Equipment

No special equipment is required to construct the asphalt underlayment. Conventional railroad construction equipment is used to remove and replace the track and to obtain final track grade, line, and surface. Conventional highway construction equipment and procedures are used to prepare the subgrade and place the hot-mix asphalt concrete.

Material

The asphaltic concrete recommended for use in an underlayment is a conventional, dense-graded, highway intermediate course mix, slightly modified to contain more mineral fines (minus No. 200 material) and slightly more asphalt cement. These increases in fines and asphalt content result in a mix with lower air voids. The aggregate gradation recommended for use in the underlayment is given in Table 2. The asphalt content of the asphalt mix may vary from 3 to 9 percent by weight; however, the actual asphalt content to be used must be determined from a laboratory mix design. It is recommended that the asphalt content be increased above the optimum to provide air void contents in the compacted mix of 1 to 3 percent. If a mix having the exact gradation specified above is not available at a competitive price, a mix with a similar gradation may be substituted with no adverse effect. However, care must be taken to ensure that the asphalt content of the mix is increased to obtain the lower void content desired.

The thickness of the asphalt underlayment and required ballast thickness will vary depending on the subgrade strength and condition, drainage characteristics, train traffic, and wheel loads. For most applications of an underlayment on military railroad track, a 4-in. asphalt underlayment combined with 8 to 12 in. of crushed stone ballast will provide an adequate track section. Table 3 presents a design chart for determining the

Table 2
Recommended Asphalt Gradation for Use in Asphalt Underlayment

<u>Sieve Size</u>	<u>Amount Finer, Weight %*</u>
1.5 in. (37.5 mm)	100
1.0 in. (25.0 mm)	90-100
0.5 in. (12.5 mm)	56-80
No. 4	29-59
No. 8	19-45
No. 50	5-17
No. 200	1-7**
Asphalt Cement (weight as a percentage of total mixture)	3-9**

* ASTM D 3515 for medium traffic conditions.

** Selected to provide 1 percent to 3 percent air void content in the compacted mix and a minimum VMA (Voids in Mineral Aggregate) of 12 percent.

Table 3
Asphalt Underlayment Thickness Design For Freight Railroads with Less than 8 MGT/Year

<u>Subgrade Support</u>	<u>Subgrade Strength</u>		<u>Asphalt Thickness</u>	<u>Ballast Thickness</u>
	<u>CBR %</u>	<u>Resilient Modulus psi</u>	<u>in.</u>	<u>in.</u>
Excellent	20	30,000	3*	6*
Good	10	15,000	4	6*
Fair	5	7,500	4	6*
Poor	2	3,000	6	17

Notes: Criteria developed by the University of Kentucky. Adapted with the permission of Dr. Jerry Rose.

* Minimum recommended asphalt thickness for underlayment is 3 in.; minimum ballast thickness is 6 in.

required depths of asphalt and ballast in an underlayment section. Table 4 is a chart to aid in estimating the quantity of hot mix required in the underlayment.

Table 4
Hot-Mix Asphalt Quantity Determinations

Mat Thickness (in.)	Tons of Mix*	
	Per Track Foot	Per Square Yard
3	0.21	0.16
4	0.28	0.21
5	0.35	0.26
6	0.42	0.32
7	0.49	0.37
8	0.56	0.42

* Based on a HMA compacted density of 140 lb/ft³ (2240 kg/m³) and a mat width of 12 ft (3.6 m).
 1 ton/track foot = 3.61 metton/track meter.
 1 ton/ft² = 11.84 metton/m².
 Developed by University of Kentucky. Used with the permission of Dr. Jerry Rose.

Conventional railroad ballast and other track materials are used in the reconstruction of the track over the asphalt underlayment.

Personnel

Regular highway and railroad construction personnel are used in the underlayment and track construction. In the demonstration project, a railroad construction/maintenance contractor performed all of the construction on this project, except for the asphalt placement which was subcontracted to a local paving company. Installation personnel provided project inspection and contract administration. Quality control testing was performed by a local laboratory under contract to the installation. This type of track rehabilitation can be performed in-house if experienced railroad maintenance and road construction personnel are available.

Procedure

Given the need for track rehabilitation, the procedure has three major steps: (1) establish the cost-effectiveness of using an asphalt underlayment, (2) if cost-effective, design the underlayment and drainage to fit the site conditions, and (3) reconstruct the track according to the design.

Because of the higher initial cost of track rehabilitation using an asphalt underlayment, the use of this method of rehabilitation on military track may be limited. In order to establish the cost-effectiveness of using an asphalt underlayment for track rehabilitation, a thorough benefit-cost analysis should be conducted. This analysis should consider the initial cost of constructing the underlayment versus the cost of conventional track rehabilitation techniques, as well as the long-term maintenance costs of both types of track.

If cost-effective, the design of the underlayment and adjacent drainage facilities are prepared. While general information on required design thicknesses are give in Table 3, the technical point of contact listed herein should be contacted to assist in determining thickness requirements for specific subgrade conditions and traffic levels and in the overall design of the track rehabilitation. The design must include provisions for adequate drainage of surface water away from the track, as well as a transition from the underlayment section to the conventional track structure. For large projects, an asphalt mix design must be performed to determine the proper aggregate gradation and asphalt content for use in the underlayment.

Once the design, plans, and specifications have been completed and any contracts awarded, the steps in the construction of the underlayment section are:

- a. Remove the old track structure down to the subgrade. Materials that are to be reused should be stockpiled outside of the work area.
- b. If the subgrade is wet and/or soft, the top 6 to 8 in. should be dried and adequate compaction obtained to support the construction equipment that will be placing the asphalt. To facilitate drainage away from the track, the subgrade should be crowned at the track

centerline with a 1.5 to 2 percent slope to both sides. Because the asphalt underlayment acts as a structural layer in the track, it is generally not necessary to obtain subgrade compaction at great depths or to remove and replace wet subgrade material.

- c. Place the hot-mix asphalt using conventional paving equipment and procedures. Underlayments will typically be 12 to 15 ft wide, depending on the depth of ballast. In any event, the underlayment should extend out at least 4 ft past the rail or 6.5 ft past the centerline of the track. In general, the asphalt is placed in two or more lifts depending on the design thickness.
- d. Conventional asphalt placement compaction techniques are used to place and compact the underlayment. In some situations the asphalt densities obtained may not be as high as would be expected in normal highway construction. This is due to the richer asphalt mix and the fact that extremely good subgrade compaction was not obtained.
- e. Upon completion of the paving a layer of ballast is placed on the underlayment. This layer of ballast acts as a platform for reconstruction of the track.
- f. The track is rebuilt using standard track construction techniques, and the remaining ballast is dumped in the track. Automated equipment (a tamper liner) is used to raise the track to the desired elevation, provide proper alignment, tamp the ballast under the ties, and surface the track. A ballast regulator is then used to final dress the track.

An alternate method of underlayment construction is to remove the track in panels using a crane, construct the underlayment, replace the track panels on the underlayment, ballast the track, and surface and align the track.

Operation and Maintenance

Operations over and maintenance of railroad track constructed with an asphalt underlayment are no different than conventional ballasted track.

Past experience with this technology on commercial railroads has indicated that the track maintenance surfacing cycle (time between surfacings) is lengthened and that less maintenance is required to maintain a desired level of track condition.

Asphalt underlayments have been used in the United States since the early 1960's with good results. There are numerous sections in heavy traffic commercial railroads that have been in place for 10 to 15 years with excellent results. With the low traffic volumes normally found on military bases a life expectancy of 20 to 25 years may be reasonable.

Service and Support Requirements

No special services or support is required to implement or maintain this technology.

Performance Monitoring

Installation personnel can monitor and measure the performance of an asphalt underlayment by keeping records of the track maintenance requirements for the underlayment section versus a similar section of track (same subgrade condition, traffic levels, and age) constructed without the underlayment. Pertinent data that should be collected include date of maintenance activity, type of maintenance performed, man-hours expended, and maintenance cost (broken down as to material, equipment, and labor cost).

The asphalt underlayment section is performing well if the track maintains its track geometry, particularly surface, under several years of traffic without needing major maintenance to correct problems with profile (dips), crosslevel, or settlement.

APPENDIX A
REFERENCES

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APPENDIX B
TYPICAL UNDERLAYMENT SPECIFICATION

Subgrade

1. Laboratory tests indicate that the subgrade is a CH soil, liquid limit of 51, plastic limit of 16, and plasticity index of 35. At the CE-55 compaction effort, the maximum dry density, $\gamma_{d_{max}}$, is 113.4 pcf at an optimum moisture content of 15.3 percent.

- a. After the desired grade has been obtained, the subgrade should be compacted to at least 95 percent of the CE-55 compaction effort. Compaction should be accomplished at, or slightly wet of, optimum moisture content.
- b. The compacted subgrade should extend 1 ft beyond the proposed edge of the asphalt mat.
- c. A 25-ft-long transition section of compacted subgrade should be provided at the ends of the underlayment section. This will provide a gradual transition from soft subgrade to firm underlayment.
- d. Grading and Slopes:
 - (1) The compacted subgrade must be graded and sloped to provide positive drainage away from the track structure.
 - (2) Recommended crown and slopes are:

Sta 0+95 to 1+80:

No crown.

Constant slope to east to provide positive drainage away from Buildings 166 and 168.

Sta 1+80 to 6+25:

Crowned.

Approximately 1.5 percent slope from center line to edge.

Transition Sections:

Crowned.

Sta 4+75 to 5+00 on Track 5: Approximately 1.5 percent slope from sta 6+00 to 6+25 on Track 3, centerline to edge.

Underlayment

Asphalt thickness

2. Constant 4 in. placed directly on compacted subgrade so that the asphalt surface will have the same slope as the compacted subgrade.

Dimensions

3. Asphalt should extend out 4 ft from the center of the outside rails or 6-1/2 ft from the centerline of the outside tracks.

Turnout to Track E

4. Underlayment should extend up Track E to sta 4+75. The end of the asphalt mat should be perpendicular to the track.

Transitions

5. The first 10 ft of asphalt underlayment should provide a transition to the full asphalt depth. On Track 3 the asphalt mat will be the full 4-in. design depth at sta 6+00 thinning to 2 in. at sta 6+25. On Track 5 the transition will begin at sta 5+00 with the full 4-in. design thickness and end at sta 4+75 with 2 in. of asphalt. This will allow a gradual change from the soft subgrade to the firm compacted subgrade to the firmer underlayment section.

Mix design

6. The asphalt mix design should be based on ASTM 3515, Dense Graded Highway Base Mix. The recommended gradations are:

<u>Sieve Size</u>	<u>Amount Finer, Weight %*</u>
1 1/2 in.	100
1 in.	90 - 100
1/2 in.	56 - 80
No. 4	29 - 59
No. 8	19 - 45
No. 50	5 - 17

(Continued)

* ASTM D3515 for medium traffic conditions.

<u>Sieve Size</u>	<u>Amount Finer, Weight %**</u>
No. 200	1 - 7**
Asphalt Cement, Weight % of Total Mixture	3 - 9**

** Selected to provide less than 3 percent air void contents in the compacted mix and a minimum (voids in mineral aggregate) VMA of 13 percent.

7. It is recommended that the percentage passing the No. 200 sieve be kept in the 5 to 7 percent range and that the asphalt content be approximately one half of a percent above optimum.

Ballast

8. The minimum ballast depth below the bottom of the tie will be 6 in. The thickness may be increased to achieve required track elevations.

Drainage

9. Adequate drainage of surface water away from the track structure is critical to the success of the underlayment.

10. All pipes, culverts, and other drainage structures should be opened to allow unobstructed runoff.

11. Ditches should be opened and sloped for positive drainage.

12. The natural ground should be sloped away from the track structure to provide adequate drainage away from the track.

13. A shallow ditch or swell ditch should be provided between Tracks 3 and 4 and sta 3+30 and 4+35.

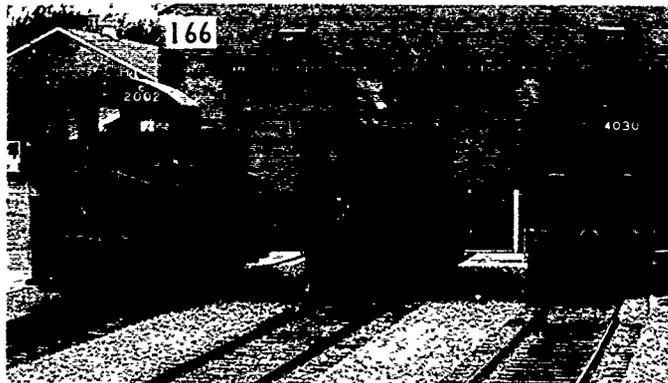
APPENDIX C
FEAP AD-FLIER

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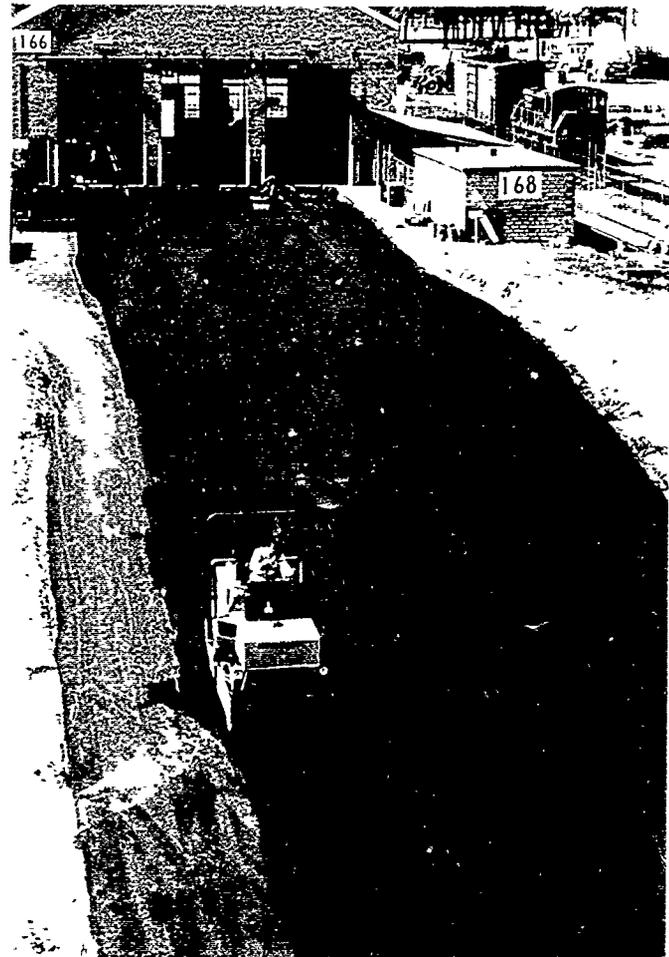
FACILITIES ENGINEERING
APPLICATIONS PROGRAM

*Innovative
Ideas for the
Operation,
Maintenance,
& Repair of
Army Facilities*

Asphalt Stabilization of Railroad Track



Top. Bulldozers and other equipment cut the subgrade for aeration and work the soil to reduce the moisture content.
Bottom. The completed asphalt underlayment will greatly decrease maintenance requirements and costs while extending the track's life



A conventional steel-wheeled vibratory roller compacts the asphalt to 90 - 92 percent of its maximum density.

- PROBLEM:** Water seepage into weak and/or swelling subgrade soils can result in costly maintenance of railroad track and operational problems for railroad traffic.
- TECHNOLOGY:** Construction of an asphalt underlayment section over a compacted subgrade acts as a subballast layer under the conventional track structure.
- DEMO SITE:** Red River Army Depot, TX FY85
- BENEFITS:** At the demo site, track maintenance savings of approximately \$7,000 per mile per year are anticipated.

Description of Technology. Water intrusion into low-strength and/or swelling subgrade soils can result in the need for almost continuous maintenance of railroad track while creating operational problems for rail traffic. Such unstable track can be stabilized by using hot mix asphalt concrete as a structural layer in the track. This involves the construction of an asphalt underlayment section over a compacted subgrade to act as a subballast layer for the track. Combined with adequate drainage, this type of underlayment can eliminate or greatly reduce water intrusion into the subgrade, thus reducing maintenance requirements and costs while improving operating conditions. No special equipment is required to place an asphalt underlayment since conventional highway construction equipment and procedures are used to prepare the subgrade and place the asphalt.

Details of Demonstration. An area of track with three spurs leading into the locomotive maintenance shop at the Red River Army Depot was selected for rehabilitation.

Work began with removal of 1,400 feet of track and the old fouled ballast. A bulldozer cut the subgrade 18 inches deep for aeration. The soil was worked in place until the moisture content was reduced from 26 percent to 12 percent. The soil was replaced and compacted first with a sheep-foot roller and then with a pneumatic roller. The top 6 inches of the subgrade were compacted to 90-95 percent maximum dry density. A motor grader provided the finished grades for asphalt placement.

Four inches of asphalt were placed in two 2-inch layers with standard construction techniques and equipment. A steel-wheeled vibratory roller compacted the asphalt to 90-92 percent of maximum laboratory density.

Four inches of new crushed stone ballast, American Railroad Engineering Association No. 4 gradation, were then placed on the asphalt mat. The track was rebuilt over this using new ties and the old rail that had been removed. Another 4 inches of ballast were added prior to obtaining the final surface.

Benefits of Technology. Benefits of the asphalt underlayment include extension of the required track surfacing cycle; decreased need for ballast cleaning and replacement; and reduced wear on rails, tieplates, and ties, which leads to longer track life. These benefits are long term. Some underlayment sections have been in place on commercial railroads for up to 18 years and are still performing well.

The initial cost of an asphalt underlayment is higher than conventional construction. At the Red River Army Depot the asphalt underlayment cost \$78,000 compared to a conventional construction estimate of \$67,000. However, the maintenance savings are substantial. A three-man crew using automated equipment to maintain tracks costs about \$8,000 per mile per year. The asphalt underlayment section, under the current traffic levels at Red River, should only require major maintenance every 8 to 10 years at an average annual cost of \$800 to \$1,000 per mile per year. This results in a savings at Red River of about \$7,000 per mile per year.

The asphalt underlayment also reduces ballast thickness. At Red River, 8 inches of ballast were placed over the 4-inch underlayment instead of the usual 15 inches. The underlayment also prevents migration of soil into the ballast, commonly known as "ballast fouling." This decreases the need for periodic reballasting.

Procurement Information. Because conventional highway construction equipment and procedures are used to prepare the subgrade and place the asphalt, this technology can be implemented by any local road contractor.

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