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**Railroad HMA Project Review**  
**October 15, 1999**  
**Pueblo, CO**  
**M. J. Hensley, P.E. , Chief Engineer**

Transportation Technology Center, Inc. (TTCI) conducted the first project review consisting of four hours classroom presentations followed by a project tour October 15, 1999. Those in attendance with organization identification were:

**TTC/AAR:** Pueblo, CO  
Dr. Dingqing Li, Sr. Engr.  
Dave Davis, Principal Engr.  
Rayn McWilliams, Engr.  
Satya Singh, Sr. Engr.  
Semih Kalay, Chief Technical Officer

**Asphalt Institute:** Lexington KY  
Steve Mueller, District Engr. (Littleton, CO)  
M. J. Hensley, Chief Engr. (Little Rock, AR)

**University of Kentucky:** (Lexington, KY)  
Prof. Jerry Rose  
Prof. David Bentler  
Prof. David Zeng  
Graduate Students: Dan Durrett, Paul Orsburn, Brad Long and Xiao-Guang Zhong

**Koch Materials Company:** (Wichita, KS)  
Gayle King, Technical Services  
David Rowlett, Manager, Research and Development

**Consolidated Oil and Transportation Company:** (Denver, CO)  
Charles Reilly, Director of North American Supply and Distribution

**University of Nottingham:** (England)  
Prof. Steve Brown

**CTL/Thompson:** (Denver)  
Scott Sounart, Materials Laboratory Manager

TTCI staff presented an overview of the track layout and the related research to the heavy load, soft subgrade study. The research consists of three phases. The HMA sections are included in the third phase. Test sections are located in Section 29 (soft subgrade) and in Section 40, which is a normal subgrade with heavy diamond loads. The diamond loads are expected to be as much as four times the regular track load because of cross traffic. The test train consists of seventy (70) cars loaded at 125 tons each. Axle loads testing with both static and dynamic testing are being performed with axle loads of 10, 20, 30 and 39 tons. It was reported that the most economical axle load is 36 tons. The track is testing the new carloads, which go up to 325,000 pounds. It was reported that as much as 50% of the current traffic on revenue lines are hauling approximately 286,000 pounds. This is up from 268,000 pounds a few years back. The standard carload that most tracks were designed for is 100 tons. When the current traffic exceeds the typical loads of 100 tons, the track maintenance is reported to be much higher by approximately 30%. (Note: this trend toward increased track loading may result in the need for more widespread use of HMA underlayments to lower track maintenance and reduce slow orders.)

Three classifications of revenue track are now posted for accumulated million gross tons (MGT) as, 1) Standard-limited to 160 MGT, 2) Standard Premium-limited to 300 MGT, and 3) Improved Track- limited to 425 MGT. It was reported that not many lines exist that can handle the 425 MGT.

Material variables included in the research are HMA, PCC, Geoweb, and the native subgrade. Conventional ballast is used in conjunction with all these materials. Track geometry, (vertical & horizontal alignment) ballast wear, number of MGTs before resurfacing is required. Track modulus and subgrade strains are measured on all the materials at variable axle loads.

Section 40 has a short section of 50-feet, which was placed to measure the load response of a diamond crossing. This section was designed for an 8-inch HMA and 8-inches of ballast, over the normal subgrade.

AI presentation by CE Hensley gave a brief background of the thirty years research by the AI and the reported findings. The mix design and in-place properties of the HMA sections were presented to the group. CE Hensley presented a list of expected results of the test sections that could confirm some of the research findings observed over the years by specific site installations by AI and UK. Some of the results that may be confirmed by the testing schedule are listed below:

- Provides uniform sub-ballast.
- Water proofs the subgrade and stabilizes the in-place moisture content.
- Provides a uniform track modulus for the track system.
- Helps maintain uniform track geometry.
- Minimizes annual temperature swings of the underlayment.
- Increases the modulus of ballast by it's keying into the plastic mixture.
- Reduces ballast wear and fouling.
- Provides a self-cleaning system by allowing water to flow through the ballast.
- Minimizes the effect of track modulus by inclement weather.

The job mix formula (JMF), in-place gradation, and mixture properties are shown in the following Tables I - III. The JMF was developed in accordance with ASTM 1559, Marshall Mix Design Procedures.

**Table I Grading Limits and Specifications**

Sieve	1 ½	1	¾	½	3/8	#4	#8	#16	#30	#50	#100	#200
Specs	100	--	70-98	---	44-76	30-58	21-45	14-35	8-25	5-20	3-10	2-6
JMF	100	97	76	66	52	41	30	23	17	11	7	4.5
Test <sup>1</sup>	100	95.5	78.6	64.6	60.1	48.2	36.8	27.1	19.0	11.8	7.5	4.5

<sup>1</sup>Average values

**Table II 50-Blow Marshall Design**

Asphalt Content %	6.4
Voids %	2.0
Voids Filled Asphalt %	86
Dust to Asphalt Ratio	0.8
Compacted Density (pcf)	147.8
Maximum Density (pcf)	150.6
Marshall Stability (lbs.)	1729
Flow (0.01 in.)	24

**Table III In-Place Mixture Properties**

Section	29	29	40
Thickness inches	4 (5.3) <sup>2</sup>	8 (8.7) <sup>2</sup>	8 (10.4) <sup>2</sup>
Ballast inches	12	8	8
Voids	0.85%	1.2%	1.2%
VMA	14.9%	15.2%	15.3%
VFA	94.4%	91.9%	91.6%
%AC <sup>1</sup>	6.14%	6.14%	6.14%
M <sub>r</sub> 25° C @ 1Hz <sup>3</sup>			
M <sub>r</sub> 5° C @ 1Hz <sup>3</sup>			

Notes: <sup>1</sup>Average values <sup>2</sup>Average Core Thickness <sup>3</sup>Tests Incomplete

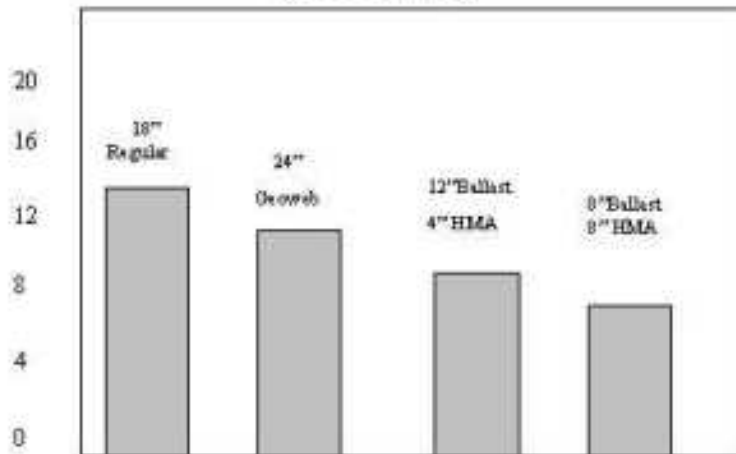


**Completed Test Section Graphic  
Figure 1**



**Pueblo Test Train Graphic**

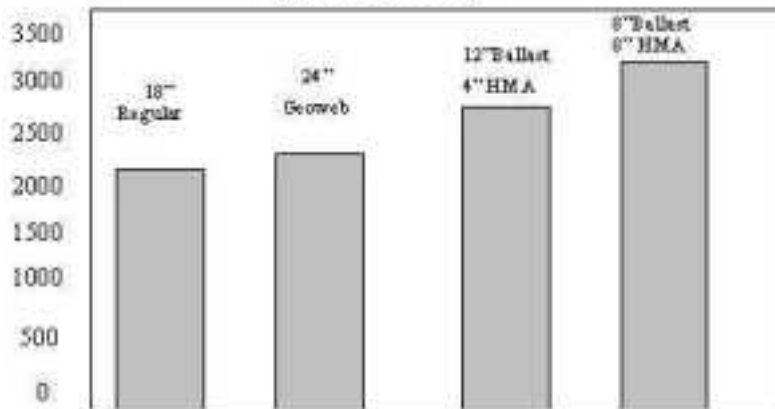
## Average Subgrade Stress (lbs/in/in)



**Figure 2**

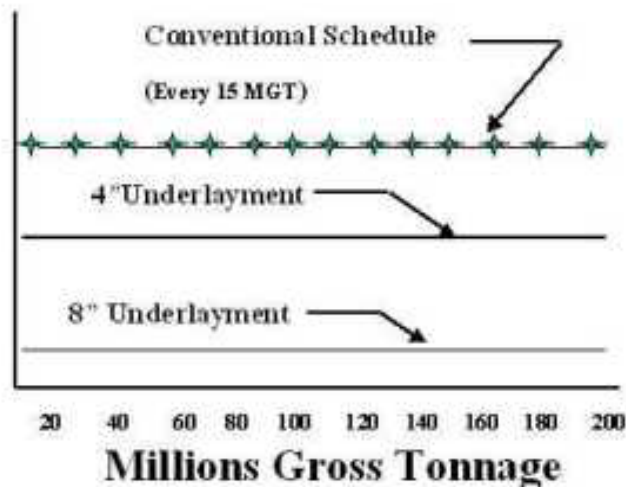
**Figure 3** - Average Subgrade Stress Chart

## Average Track Modulus (lbs/in/in)



**Figure 4** - Average Track Modulus

## Ballast Resurfacing Surfacing



**Figure 5** - Ballast Resurfacing Surfacing

The preliminary data shown in Figures 1-5 from the HMA sections in Phase III is compared to designs of the native subgrade and an 8-inch Geoweb with 16 inches of ballast in phase II. The numbers shown for the HMA are preliminary and are subject to change. The data was collected after an initial run of 5 MGT. Figure 5 shows the resurfacing schedule of the conventional ballast. To be an economical design the resurfacing must not occur in such short intervals. It is anticipated the HMA will do much better than this. A tamping will be done after the initial settlement is completed around 15-25 MGT. When the track has reached this stage receptive resurfacing could be stretched to 30 or more MGTs before resurfacing is required. Using the heavy loads of 125 tons and the soft subgrade introduces variables that have not been tested before. In actual construction these types of subgrade are normally corrected or stabilized before the track is placed.

Professor Jerry Rose and the UK group reported on the current research that is being done at UK. The subgrade moisture content under the underlayment was reported to be within 2% of optima after twenty years or more of service. These finding could lead to improved trackbed design values resulting in reduced requirements for underlayment thickness. Additional studies are underway to determine more about the vibration attenuation in the track foundations. This could lead to 1) improved ride comfort, 2) reduced damage to track-wear, and 3) satisfactory environmental noise.

TTCI officials expressed an interest in future research with AI that will involve transitions to bridge ends for reduced impact at the bridge ends. It is proposed that a section of a least 100 feet of HMA be installed in year the 2000 to research the damping that will result from the HMA transition. Vibration attenuation is achieved by energy absorption of material in the foundation. The capability of energy absorption of a material is measured by its damping ratio. HMA appears to have such characteristics, which could be achieved by varying the voids of the mixture.

Professor Steve Brown presented the research that has been done by the University of Nottingham and the state of the art of track design in England. It appears that the USA is out in front by a large margin.

October 29, 1999