FINAL REPORT ON EVALUATION OF A RUBBER PAD RAILROAD CROSSING

MICHIGAN
HIGHWAY
RESEARCH LABORATORY SECTION

MICHIGAN DEPARTMENT OF STATE HIGHWAYS

FINAL REPORT ON EVALUATION OF A RUBBER PAD RAILROAD CROSSING

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INTRODUCTION

This report completes the evaluation of rubber pads for railroad grade crossings. The study was undertaken by the Michigan Department of State Highways and Transportation in 1963 in cooperation with the Federal Highway Administration. Its objective was to provide information to determine whether the advantages of the rubber crossing would offset the cost difference between rubber and timber crossings. On the basis of these data, the FHWA could act on specifications and standard plans for this type of railroad crossing material.

The location, construction details, and initial evaluation results of a timber crossing and of the rubber pad crossing were covered in Research Report No. R-578 (April 1966). Evaluation data through 1968 were published in Research Report No. R-698 (April 1969). Pertinent portions of these reports are presented here in their entirety for the reader's convenience.

The Research Laboratory Section of the Testing and Research Division was assigned the responsibility of conducting materials tests, as well as performing field evaluation tests on the two types of crossings. A field test program was designed to evaluate each of the following four factors:

1) Durability -- Summer and winter inspections were made of each crossing to determine the extent of deterioration of the two materials; maintenance work was observed when performed and a cumulative record kept of maintenance expenditures. Annual Average Daily Traffic (ADT) volume for each year was obtained until the study was completed.

2) Riding Quality -- The surface roughness of each crossing was measured in the summer of each year with the Laboratory's profilometer; measurements were taken in each wheel track of all lanes.

3) Skid Resistance -- The coefficient of wet sliding friction of each type of material was measured in the summer of each year with the Laboratory's skidometer; measurements were taken in the wheel tracks in each lane.

4) Safety -- Observations and measurements made for the preceding three factors were studied to determine the safety characteristics of each crossing.

No special test program was established for the physical properties of the rubber pad material because the required test procedures were given in

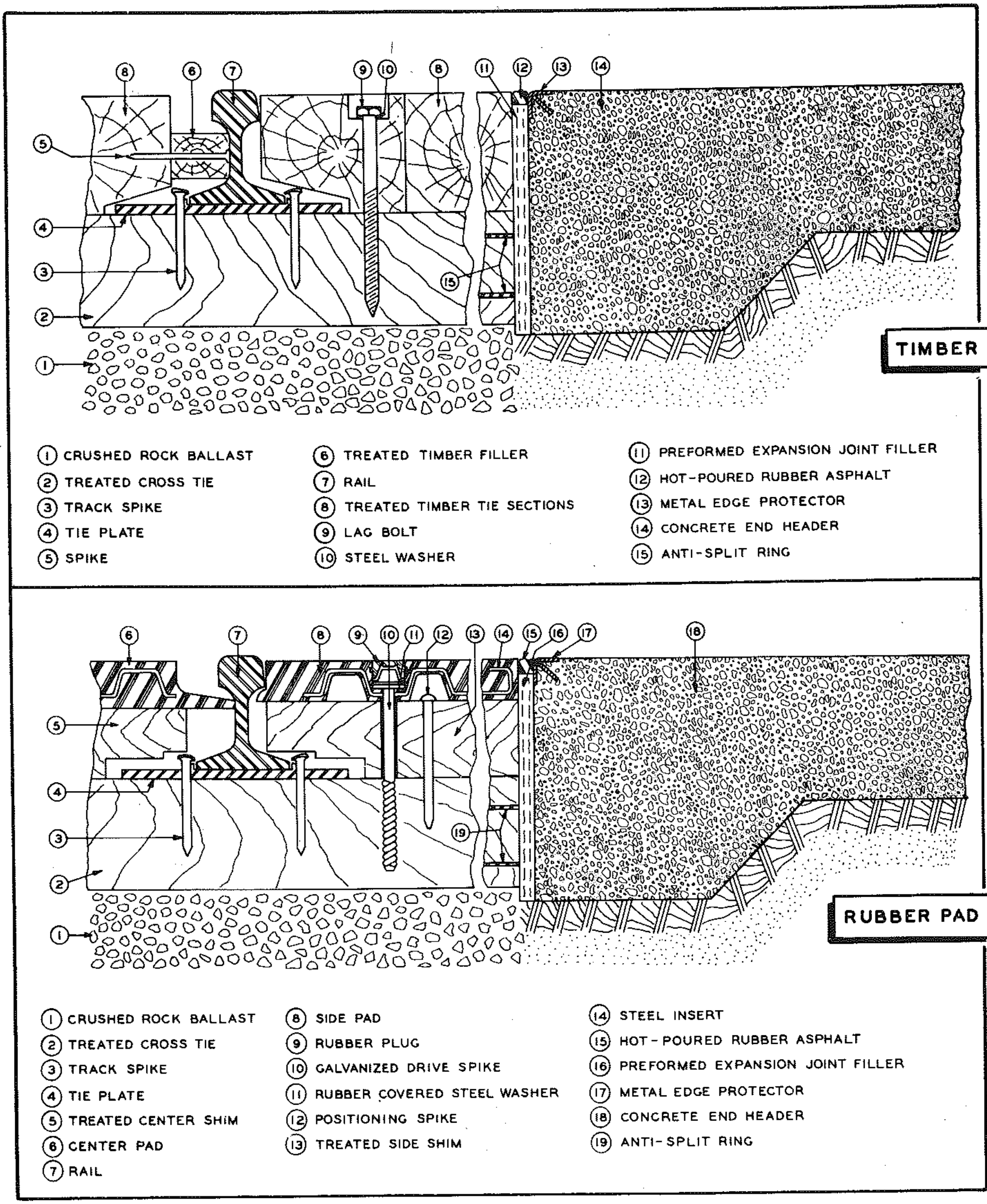

Figure 1. Cross-sectional detail drawings of railroad crossing components.

the ASTM Specifications referenced in the MDSHT supplemental specification. With respect to tests on the qualitative nature of the rubber, an arrangement was made with the FHWA Materials Research Division, Washington, D. C., whereby spectrophotometric tests would be conducted independently by each agency for comparative purposes.

Location and Description

Both crossings are single tracks and are the property of the Chesapeake and Ohio Railroad. The timber crossing is located approximately 160 ft south of Garey St on eastbound M 46 in the City of Saginaw. It consists of 58 ft - 4 in. of prefabricated treated timber ties, and crosses the roadway at a skew, the acute angle with respect to the roadway centerline being approximately 76°. The horizontal roadway alignment is straight, whereas the vertical is on a -0.67 percent grade. The roadway consists of a 9-in. reinforced concrete slab, four 12-ft lanes in width, with a 2-ft curb and gutter on each side. Present speed limit is 30 mph and the projected ADT for 1975 is 20,000.

The rubber pad crossing is located in the 1400 block of Davenport St on westbound M 58 (formerly M 81) in the City of Saginaw. It consists of 42 ft of steel reinforced rubber pads, and is very nearly perpendicular to the roadway centerline, which in the crossing area is on a tangent portion of the horizontal alignment. The centerline of the track coincides with the crest of a 300-ft vertical curve, the tangents having grades of +1.44 and -1.16 percent, respectively. The reinforced concrete slab is 9 in. thick and three 12-ft lanes in width, with a 2-ft curb and gutter on each side. Presently, the speed limit is 35 mph and the projected ADT for 1983 is 19,250.

Construction

The crossings were constructed by C&O Railway personnel on a force account basis, with coordination and inspection of the work the responsibility of the Department's District Office. The timber crossing was installed in July 1963 in accordance with Standard Plan for Track Crossings, E-4-A-22D, Detail 2. A sketch showing a cross-section of the crossing components is shown in Figure 1.

Construction of the rubber pad crossing began in July 1965 with work done on an intermittent basis until completion in September 1965. To realize the full advantage of this type of crossing, the materials must meet specified dimensions and the installation must be precisely performed. In both of these areas some difficulties were experienced. Twice it was necessary to reject installed ties, the first time because of undersize cross-sectional tie dimensions and the second because tie length was less than required. With the cooperation of railroad personnel, satisfactory ties were obtained by careful culling of the railroad's tie stock. With respect to installation of the pads, it was noted that in some cases the side shims split longitudinally when the lag bolts were installed. Moreover, it was extremely difficult to obtain the correct depth for the lag bolt heads below the rubber surface. Reaming the holes through the shims to the correct diameter and blowing out wood shavings collecting in the bottom of the drilled holes with compressed air, minimized the problems incurred when installing the lag bolts. The components of the rubber pad crossing are shown in a cross-sectional sketch in Figure 1.

The construction costs were as follows:

	Timber Crossing	Rubber Crossing
Material (including handling)	$ 794.24	$3,532.62
Labor	313.74	850.10
Total Cost	$1,107.98	$4,382.72

On a lineal foot basis, the timber crossing cost $19.00 and the rubber crossing $104.35. The cost per lineal foot of the rubber crossing was 5-1/2 times that of the timber crossing.

MATERIAL TESTS

Four rubber pads were selected from the delivered material (14 center pads and 28 side pads) at the railroad yard and taken to the laboratory for testing. The properties tested were hardness, tensile strength, and ultimate elongation, before and after oven aging for 96 hours at 158 F. A compression set test was performed on specimens oven aged for 22 hours at 158 F, and an infrared spectrophotometric analysis was conducted on samples of the rubber material as received. Five specimens were prepared for determination of hardness, tensile strength, and ultimate elongation, each pad material being represented at least once. For compression set tests, three specimens were used, each from a different pad. Samples for the spectrophotometric analysis included material from all four pads and duplicate samples were sent to the FHWA Materials Research Division for analysis as previously agreed.

The results as compared with specification requirements are as follows:

Property	Average Test Value	Specification Value
Sample as Received		
Hardness (Shore A2)	61	60 $\pm$ 5
Tensile Strength, psi	1,890	2,000 min
Ultimate Elongation, percent	465	400 min
Oven Aged		
Compression Set, percent	6	25 max
Hardness Change (Shore A2)	+1	+7 max
Tensile Strength Change, percent	+1.6	-25 max
Ultimate Elongation Change, percent	-3.7	-25 max

As can be seen, the average tensile strength is below the specified value. However, ASTM Specification D. 735 values apply to test specimens obtained from standard laboratory test slabs or blocks, and test results from finished products may vary from values given for standard test specimens. This variation may result from the method of processing or from difficulty in obtaining suitable test specimens from the finished product.

On the basis of infrared spectra of pyrolysates and pyrolysis-gas chromatography data, the elastomer was identified as GRS rubber by both FHWA and the Department. This result shows that the rubber conforms to the specified Type R compound.

FIELD EVALUATION

Durability

Timber Crossing -- The first inspection of the timber crossing was made in August 1964. It was noted that the south side of the crossing was from 1/2 to 1 in. low with respect to the pavement and that the north side was high by about the same amount. A 6 to 12-in. wide bituminous transition strip had been laid at the north side to provide a smoother crossing. The timbers were in good condition and neither they nor the rails were loose. The 1965, 66, and 67 inspections revealed no noticeable changes. During the March 1968 inspection it was noted that the crossing had settled. The south side was found to be about 2 in. lower than the pavement and the north side was nearly at the same elevation as the concrete slab. The 1968 summer inspection disclosed no further settlement. Inspection in 1969, 70, 71,

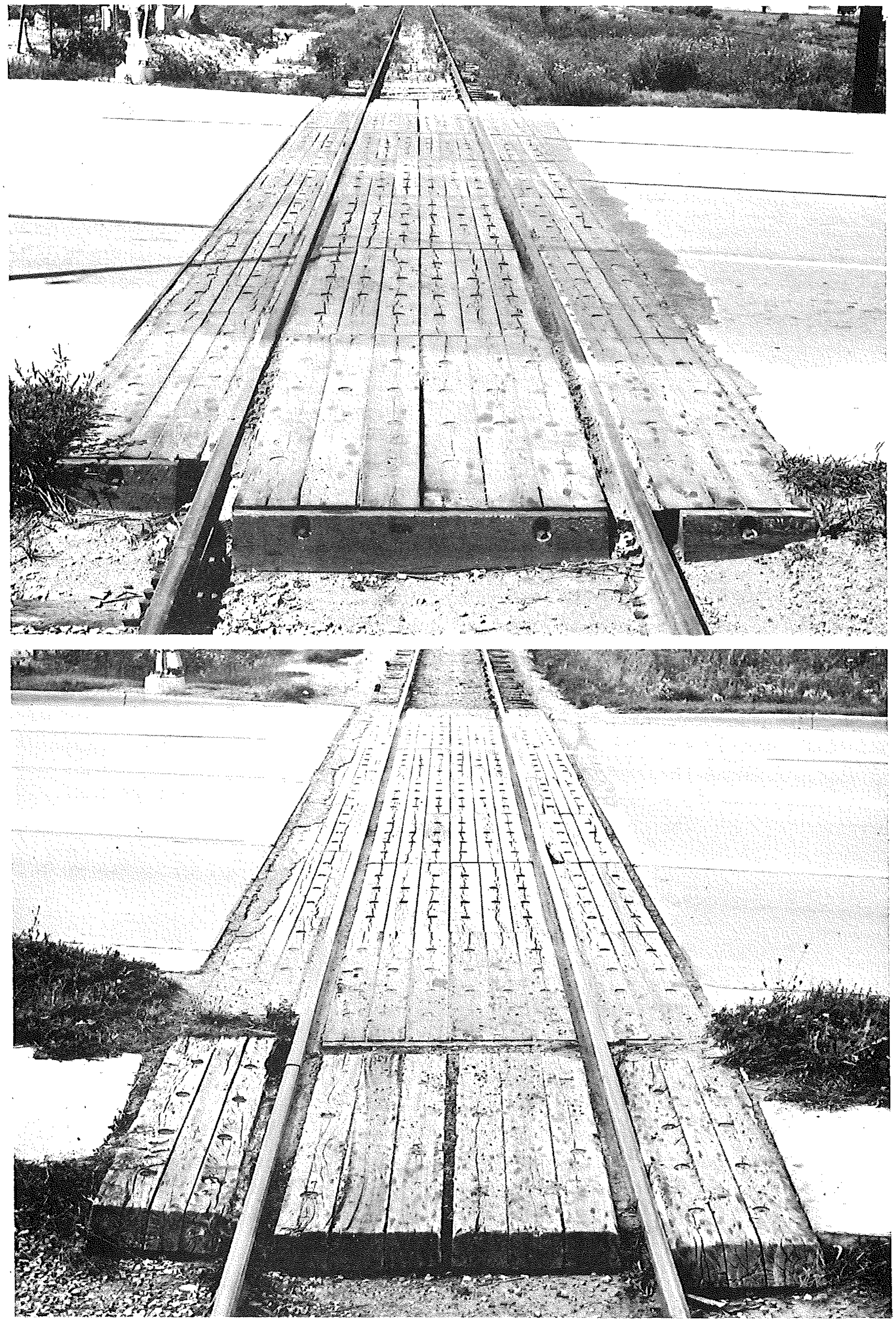

Figure 2. Views of timber crossing one year after installation (top), and 10 years after installation (bottom).

72 and in the summer of 1973 revealed no significant change in elevation between pavement and crossing. The timber ties are beginning to show wear (estimated to be about 1/8 in.) and one of the ties next to the rail in the center lane is split and a piece broken off. The crossing elements are still securely fastened and no deflection of the crossing is noticeable when vehicles pass over it. Figure 2 shows the condition of the crossing after one year and 10 years of service.

Rubber Crossing -- The rubber crossing was inspected for the first time in the winter of 1966 and was found to be in excellent condition. The 1966 summer inspection revealed that seven bolt-hole rubber caps had been lost, presumably due to snow removal operations. These caps have never been replaced. No change in condition was noted at the 1967 winter inspection, but a slight deflection of the approach side of the crossing in the right hand lane was noted during the summer inspection when vehicles passed over the crossing.

By the time of the 1968 summer inspection this small deflection at the approach edge was evident in all three lanes. However, during the following five years until now there has been no further increase in amount of give and the smoothness of the crossing has not been impaired by it.

The sealant along the crossing edges showed signs of adhesion failure in 1968, and has now failed for the entire length. The pads have shown excellent resistance to wear and after nine years of service the amount of wear is minute. The pads, shims, and rails are securely fastened to the ties, and the crossing has remained smooth since installation. Figure 3 shows the crossing condition when installed and its condition after eight years of service.

Traffic Volumes -- The ADT counts at each of the crossings are given below.

Year	Timber Crossing	Rubber Crossing
1964	5,000	
1965	5,700	
1966	6,000	11,500
1967	7,400	12,000
1968	8,400	12,500
1969	6,300	15,000
1970	7,600	15,000
1971	8,800	15,500
1972	8,200	15,500

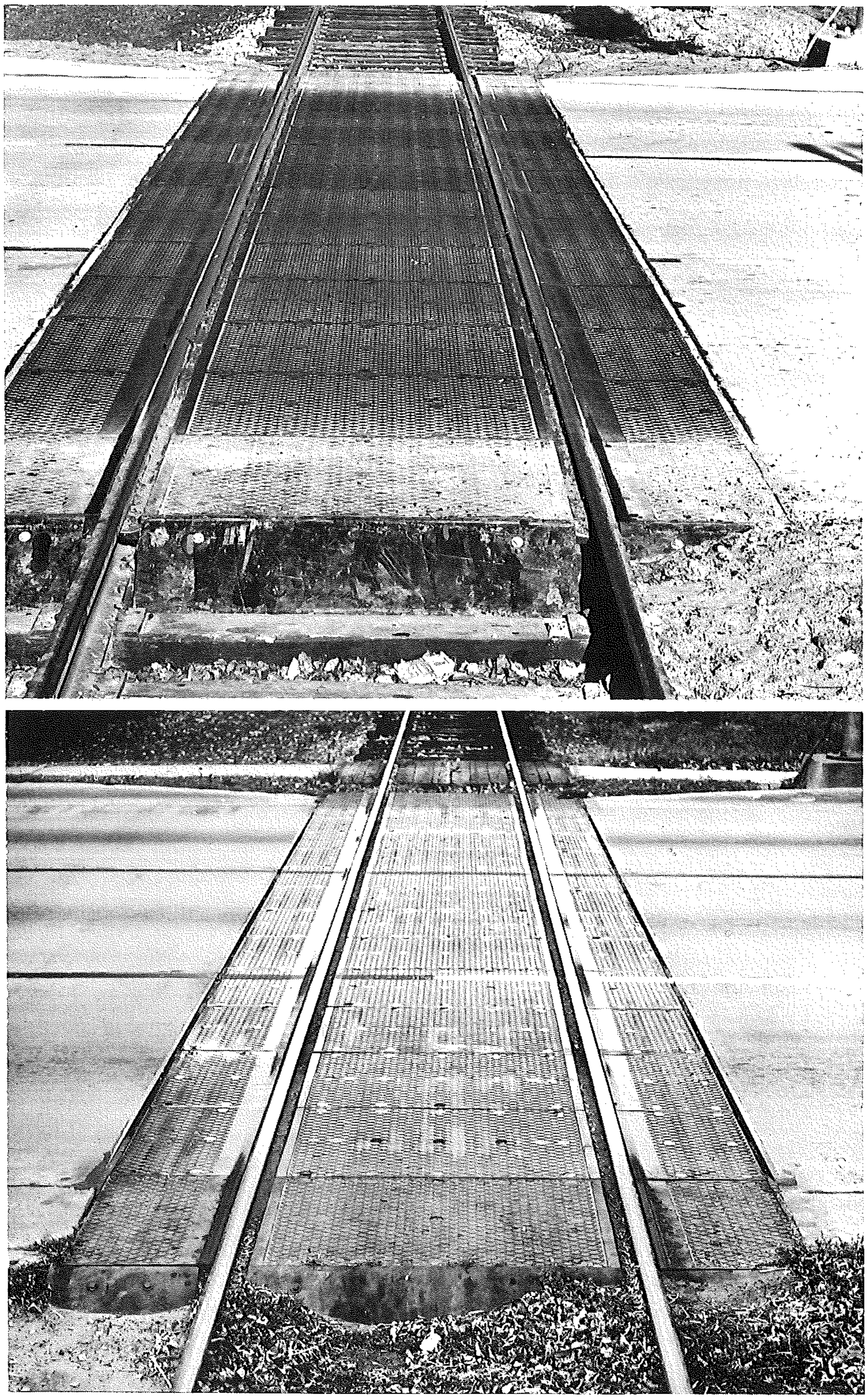

Figure 3. Views of rubber pad crossing. As constructed (top), and eight years after construction (bottom).

Maintenance Costs -- As of this date there have been no maintenance charges to either crossing.

Roughness

The area evaluated at each crossing consists of a 25-ft approach slab, the edge-to-edge width of the crossing, and a 25-ft leaving slab. Profilometer readings were taken in the inner and outer wheel paths in each lane at each crossing. The wheel path values were averaged to obtain a roughness index for the approach slab, crossing, and leaving slab. These values in turn were weighted according to length, and averaged for roughness of the total area evaluated. The test results from 1964 through 1971 are as follows:

Material	Survey Date	Roughness, incles per mile			
		Approach Slab	Crossing	Leaving Slab	Weighted Average for Area Evaluated
Timber	8-19-64	179	1,248	283	389
	8-30-65	193	1,218	282	390
	8-19-66	253	1,334	370	470
	9-12-67	317	1,421	198	446
	9-13-68	222	1,657	229	456
	8-26-69	222	1,788	256	488
	9-9-70	208	1,806	281	496
	8-24-71	187	1,751	251	466
Rubber	12-1-65	95	552	93	163
	8-19-66	124	630	120	197
	9-12-67	140	587	140	206
	9-13-68	94	592	86	166
	8-26-69	182	647	162	244
	9-9-70	180	621	154	236
	8-24-71	196	657	189	262

As can be seen the roughness of the crossings has shown a general tendency to increase from year to year. Most notable is the increase of 500 inches per mile in the roughness of the wood crossing compared to an increase of 100 inches per mile for the rubber pad crossing during the evaluation span.

Skid Resistance

The widths of the crossing were too short for measurements of the coefficient of wet sliding friction at normal pavement test speeds (20 or 40 mph). Consequently, skid tests were conducted by positioning the trailer wheel just past the first rail, locking the wheels and then pulling the trailer across the wetted surface between the rails. The friction coefficients for crossings, therefore, cannot be directly compared to coefficients for pavement, but reflect the friction characteristics of the two materials when tested as described. The tests have produced the following results for the two crossings, with each value representing the average of three tests and the lanes numbered from left to right with respect to traffic direction.

Material	Lane No.	Avg. Coefficient of Wet Sliding Friction (at speeds less than 2 mph)			
		8-64	10-65	9-66	9-67
Timber	1	0.52	0.74	0.58	0.75
	2	0.52	0.78	0.63	0.81
	3	0.55	0.78	0.64	0.99
	4	0.55	0.78	0.60	0.94
Rubber	1	----	0.77	0.91	0.95
	2	----	0.77	0.84	0.81
	3	----	0.76	0.93	0.88

Skid resistance tests on concrete pavement conducted in the manner described here and reported in Part II of the First International Skid Prevention Conference (August 1959) indicate that at low speeds a small change in speed can cause considerable variation in the coefficient of friction. Assuming this to be true also for timber and rubber, the variations in the measured coefficients from year to year and from lane to lane are believed to be caused by testing under slightly different speeds rather than changes in the surface smoothness of the materials. Because of this difficulty any firm conclusions as to which material has the better skid resistance, would be meaningless.

The skid coefficients reported here were recorded continuously on a direct writing oscillograph for manual reduction. In 1967 the oscillograph method was exchanged for a completely digital system. One step of the programmed operation of this system involves integration which cannot be sufficiently slowed to permit operation at the speeds used on the crossings. In view of the uncertain accuracy of the measured coefficients and the considerable amount of work involved in changing the skidometer back to the old recording method, skid tests were discontinued in 1968.

Safety

There has been no reported accident at either crossing during the evaluation period. The timber crossing ties are beginning to show surface wear to a greater extent than the rubber pad crossing. The crossing components at both locations are securely fastened, except at the wood crossing one of the ties has split and part of it has broken off. The latest measurements of skid resistance show almost identical coefficient of friction for the two materials. With respect to roughness the rideability of the wood crossing has decreased more than that of the rubber crossing. This roughness is regarded as the cause of a noticeable slowdown of the traffic as it approaches the wood crossing. Although the roughness measurements indicate some increase in roughness of the rubber crossing, the smoothness is still excellent after several years of service and the traffic does not appear to slow when approaching this crossing.

CONCLUSIONS

On the basis of observations and measurements of the performance of the two crossing materials the following conclusions are made:

1. The durability of the rubber pads exceeds that of the timber ties. The wear of the ties is estimated to be about 1/8 in. in some areas whereas the wear of the rubber pads is insignificant in spite of this crossing carrying about twice as much traffic.

2. The riding quality of the rubber crossing is superior to that of the wood crossing. Roughness measurements indicate that the roughness in inches per mile of the timber crossing was 2.2 times more than that of the rubber crossing in 1965. In 1971 this roughness difference had increased to 2.7.

3. The skid coefficients obtained in 1967 indicate that the two materials have nearly identical coefficients. As mentioned in the text these results may not be reliable because of difficulties in measuring skid properties of materials in short distances, such as the width of a single track rail crossing.

4. The rubber pads provide a safe crossing. The smoothness of the crossing has all but eliminated the slowdown of traffic as it approaches the crossing which has caused rear end collisions at other crossings. It provides a comfortable ride for vehicle occupants and should drastically reduce vehicle damage.

5. The following steps should be taken to insure a satisfactory rubber pad crossing:

a) The railroad ballast must be of such quality and compacted in such a manner that settlement is limited to the least possible amount in order to minimize rework of the foundation after the crossing is in service.

b) The ties and shims must meet dimensions specified and installation of all components must be done accurately.

c) The vertical alignment of the highway and railroad must be compatible. Poor alignment appears to be the greatest cause of roughness and deterioration of any railroad crossing.

d) The joints between the crossing and the roadway should be constructed to a width of 1 in. and the seal should be maintained to limit the amount of moisture entering the foundation.

RECOMMENDATION

Since neither crossing has required any maintenance during the evaluation period the study failed to determine if the additional first cost of the rubber crossing can be justified by reduced maintenance cost. However, the excellent durability and smoothness exhibited by the rubber crossing should be sufficient evidence to justify paying the extra cost for this type of railroad crossing material. Therefore, it is recommended that the rubber railroad crossing be included as an alternate in the specifications and plans for railroad grade crossings.