EVALUATION OF VARIOUS TYPES OF RAILROAD CROSSINGS

Third Progress Report

TESTING AND RESEARCH DIVISION
RESEARCH LABORATORY SECTION

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Research Project 75 F-143
Research Report No. R-1113

Lansing, April 1979

INTRODUCTION

In April 1975, the Michigan Department of Transportation, with the approval of the Federal Highway Administration, initiated a Category 2 experimental study to evaluate the performance of various types of railroad grade crossing materials. The work plan covering the experimental project is of the open-ended type so that new materials can be added by a letter of request to the FHWA rather than submitting a separate work plan for each new type of material being developed. The objectives of the study are to obtain information on construction procedures, evaluate the performance of new crossing materials with respect to durability and smoothness, and determine the relative cost of each type of crossing.

Although the experimental study concerns only the crossing material, the work involved generally includes rebuilding the entire crossing, installing new and better warning devices, and changes in roadway alignment and surface to increase the safety of the crossing. The work is 90 percent financed by Federal funds, appropriated under the Highway Safety Act of 1973, and 10 percent by Road Authority funds, either State or local depending on the jurisdiction of the roadway.

This is the third progress report on the installation and performance of various types of railroad grade crossing materials. The first progress report (MDOT Research Report R-1027) was issued in November of 1976. The second progress report (MDOT Research Report R-1079) was issued in March 1978.

Materials

Prior to initiation of this study, approved crossing materials consisted of wood, bituminous material, concrete, and a proprietary (Goodyear) rubber panel installation. The materials included in the experimental program are: T-Core, Fab-Ra-Cast, Steel Plank, Track-Span, Gen-Trac, Saf and Dri, and Parkco. All of these materials are proprietary products.

Crossing Locations

During 1976, nine experimental crossings were built. Of these, four were T-Core, two were Fab-Ra-Cast, two were Steel Plank, and one was Track-Span. One each of T-Core, Steel Plank, and Saf and Dri were built in 1977. During 1978 11 crossings were reconstructed: four Gen-Trac, four Steel Plank, two Parkco, and one Saf and Dri. Table 1 summarizes information on each of the experimental crossings built to date.

CONSTRUCTION PROCEDURES

Construction of the crossings was the responsibility of the railroad agency and was done either by their own forces or by contract. The De-

TABLE 1

SUMMARY OF DATA ON EXPERIMENTAL CROSSINGS IN SERVICE

Year	Type of Crossing	Railroad	Type of Line	Crossing Length, ft	Route Location	Roadway Surface	No. of Lanes	Average Daily Traffic
1976	T-Core	Ann Arbor	Main	36	Kress Rd	Bituminous	2	1,800
	T-Core	Detroit and Mackinaw	Main	60	*US 23, Omer	Bituminous	4	7,800
	T-Core	Detroit and Mackinaw	Main	111	*M 65, Twining	Concrete	2	3,500
	T-Core	Detroit and Mackinaw	Industrial	69	*US 23, Alabaster	Bituminous	2	5,300
	Fab-Ra-Cast	Chesapeake and Ohio	Industrial	56	Wixom Rd	Concrete	4	11,500
	Fab-Ra-Cast	Chesapeake and Ohio	Main	56	Seven Mile Rd	Concrete	4	8,300
	Steel Plank	Detroit and Toledo Shoreline	Main	32	Hurd Rd	Bituminous	2	1,200
	Steel Plank	Detroit and Toledo Shoreline	Main	39	Nadeau Rd	Bituminous	2	2,000
	Track-Span	Chesapeake and Ohio	Industrial	52	M 46, St. Louis	Concrete	4	8,800
1977	T-Core	Grand Trunk Western	Main	48	34th St	Bituminous	2	400
	Saf and Dri	Conrail	Industrial	67	Oakland Ave	Concrete	5	25,000
	Steel Plank	Detroit and Toledo Shoreline	Industrial	110	M 50, Monroe	Bituminous	4	10,100
1978	Saf and Dri	Grand Trunk Western	Main	63	US 131, Schoolcraft	Concrete	4	11,100
	Steel Plank	Detroit and Mackinaw	Main	111	M 65, Twining	Concrete	2	3,500
	Steel Plank	Detroit and Mackinaw	Main	45	US 23, Rogers City	Concrete	2	1,750
	Steel Plank	Detroit and Mackinaw	Main	52	M 33, Aloha	Bituminous	2	1,400
	Steel Plank	Michigan Interstate Railway	Main	55	M 115, Cadillac	Bituminous	2	3,800
	Parkco	Detroit and Mackinaw	Main	48	US 23, Omer	Bituminous	4	7,800
	Parkco	Detroit and Mackinaw	Industrial	78	US 23, Alabaster	Bituminous	2	5,300
	Gen Trac	Detroit and Mackinaw	Main	52	US 23, Alpena	Bituminous	2	9,700
	Gen Trac	Detroit and Mackinaw	Industrial	60	US 23, Cheboygan	Concrete	4	7,900
	Gen Trac	Detroit and Mackinaw	Main	52	F 41, Oscoda	Bituminous	4	11,500
	Gen Trac	Grand Trunk Western	Main	30	Niagara St, Saginaw	Concrete	2	11,000

* The experimental surface material on these crossings was replaced in 1978.

partment's Research Laboratory is charged with the responsibility of evaluating the various types of crossing material and, as part of the evaluation procedure, construction of the experimental crossings was observed by research personnel. Installation of the crossing material was done in accordance with the manufacturer's recommended procedure and, generally, his representative was present during placement operations.

At all crossing sites the existing rails, ties, and ballast were removed and replaced for about 30 ft beyond each crossing end. The procedures used to replace these materials depended on the requirements for maintaining both rail and highway traffic at the crossing. Basically, the following three methods were employed.

1) The most efficient procedure for replacing an existing crossing was when the highway could be closed to traffic and a few hours gap in train traffic existed. The existing crossing, including the ballast, was removed by mechanical equipment. A preassembled track section was positioned on the grade. The joints between new and old rails were bolted and new ballast added and compacted under the ties. Train movements could now be resumed if necessary, and final adjustment of rail height, compaction of the ballast, and installation of the surface material was done under normal train traffic.

2) Where traffic on the highway was maintained during reconstruction of a crossing, it was necessary to replace half of the crossing at a time. The general procedure employed consisted of first replacing the ties and ballast on half of the crossing and installing a temporary wood crossing. Road traffic was then routed over on the temporary crossing while the other half was replaced. Once the new ballast and ties were in place on the entire crossing, the old rails were removed and new rail sections were placed. Road traffic was stopped during replacement of the rails. The crossing material was installed on half of the crossing, traffic switched over on the completed side, the temporary wood crossing removed, and installation of the new surface material was completed.

3) The procedure for replacing a crossing where the road traffic was detoured but high speed frequent train movement prevailed, entailed a good deal of handwork. First, the old crossing surface was removed followed by removal of the ballast between the ties. The ties were then unfastened from under the rails. The ties, up to the center of the crossing, were slid and twisted out and new ties were inserted under the rails. New ballast was placed and compacted and the existing rails spiked to the ties to allow train traffic over the crossing. The ties in the other half of the crossing were replaced in the same manner. The new rail sections were placed and fastened into position and raised to proper elevation by adding and compacting the ballast. The crossing surface was installed during periods between train movements.

Once the ballast, ties, and rails had been replaced, the installation of the crossing surface generally was completed in a matter of hours. The actual time involved in installing the various types of crossing materials depends upon the equipment, hand tools, and number and experience of the personnel. The installation of all seven experimental crossing types used to date is fairly simple, but precision work is necessary.

In cases where the experimental surface has failed and replacement was made, the new surface material was placed on the existing ties and no rework of the ballast was done, except in one case the existing tie spacing was adjusted to accommodate the new material.

PERFORMANCE EVALUATION

The performance of the experimental crossings is checked semi-annually. The inspections consist of visual observation of the following performance factors:

1) Surface Wear - the wearing away of the material's surface as a result of tire contact.

2) Surface Damage - cracking, fracturing, or tearing of the surface resulting from either train or vehicular traffic or from snow clearing equipment.

3) Alignment of Units - the ability of the individual units to maintain both vertical and horizontal position while in service.

4) Fastening of Units - the ability of units to remain securely fastened in position during the life of the crossing material.

5) Fastening of Rails - the securing of the rails to the ties. Loose rails may indicate that settlement of the crossing has occurred.

6) Pavement/Crossing Joint - the distance between the pavement and the crossing edge. The width of the joint may vary considerably from one crossing to another and in bituminous pavement the joint is eliminated entirely. In concrete pavements, the joint is generally filled with bituminous material.

7) Crossing Smoothness - a measure of the discomfort felt by vehicle occupants while passing over the crossing. Generally, most drivers will adjust their speed to hold the discomfort to a tolerable level and on this basis the smoothness of the crossings is rated as Good, Fair, and Poor, (Good - basically no slowdown in traffic; Fair - some slowdown in traffic; and, Poor - considerable slowdown in traffic).

In addition, the elevation of the rails, the surface materials, and the pavement—at 5-ft intervals along the curbline or pavement edge—for 25 ft each side of the crossing centerline are measured.

T-Core (74 NM-400)

The material is identified as expanded linear high density polyethylene. It is fabricated in 2-in. thick pads with the center pads measuring 52 in. in width and 3 ft in length. The side pads are 17 in. wide and 3 ft long. The pads are supported on modules fabricated from the same material as the pads. These support modules run perpendicular to the railroad ties with four supports used under each center pad and one under each side pad. A tie spacing of 18 in. on centers is required. The pads are bolted to the ties with lag bolts, 12 in each center pad and 6 in each side pad. A rubber and a steel washer are used under each bolt head. The surface consists of a 1/16-in. raised diamond pattern.

The installation of the pads began in the center of the crossing and proceeded toward the edges. The pads were placed by hand. The center pads were positioned equidistant from the ball of each rail; whereas, the side pads were positioned by placing a wood 2 x 4 between the rail and the pad. The pads were fastened by first bolting through the center row of holes in each pad followed by bolting through the end rows of holes. Installation of the 3/4-in. diameter lag bolts was preceded by drilling 11/16-in. holes into the ties. Before placing bituminous material against the crossing edge, a 2 x 4 or 1 x 8 was installed against the side pads to prevent the material from infiltrating under the crossing surface.

The three-year old Kress Rd and the two-year old 34th St T-Core crossings have performed satisfactorily to date and their smoothness is rated 'Good.' Both of these crossings are subjected to only relatively low traffic volumes (1,800 and 400 ADT for Kress Rd and 34th St, respectively) and commercial traffic is negligible at both locations.

At the Omer, Twining, and Alabaster crossings cracks developed in the surface pads shortly after installation. Eventually the cracked pads fractured and replacement was necessary. Because of the poor performance of these crossings the use of T-Core material was suspended in 1977. The Omer and Alabaster crossings were replaced with Parkco material in 1978 and the Twining crossing was replaced with Steel Plank material also in 1978.

Fab-Ra-Cast (75 NM-433)

This crossing consists of precast reinforced concrete slabs. The center slabs are 51-1/2 in. wide by 8 ft long. The side slabs are 18 in. wide and 8 ft long. The slabs are either 5 or 6 in. thick depending on rail height.

The sides of the slabs are formed and armored with 60-lb rails inverted on the track side and right side up on the roadway side. Support for each slab is obtained by placing it on several plastic bags which are filled with quick-setting grout and positioned on the ties. Temporary support, while the grout is setting, is provided by wood shims. The slabs are held in position by specially designed steel fastening devices which attach to the rails; no special tie spacing is required. The slab's surface is treated with epoxy and sand to increase the surface friction.

Unlike other prefabricated crossing materials, which are fastened to the ties, the Fab-Ra-Cast slabs are fastened to the rails. Tie spacing, therefore, is not critical. A set of fastening hardware consists of an angle, three bolts (two with a clip and nut for attaching to the rail), an angle bracket, shock absorbing washer, and nut for each bolt for fastening the slab in position. An insulator was placed between the hardware and rail to prevent interference with the signal circuit. Four sets of hardware were used for each 8-ft length of crossing. Once the hardware was fastened to the rails, wood shims were placed on the ties and the slab temporarily positioned on the shims to ensure correct elevation and bearing. Grout-filled plastic bags were placed on the ties and the slab again lowered into position by a crane. The weight of the slab flattens the grout bags until the weight is carried by the shims. When the mortar has hardened the slab is supported on both the mortar bags and the shims. Once the slabs were in correct position, they were fastened by tightening the bolts passing through the angle brackets.

The original crossings installed in 1975 were replaced at no cost to the Department in 1976 because of concrete deterioration which the manufacturer attributed to problems during slab casting. The new crossing panels developed spalling and deterioration at the joints after one year of service. Six anchor bolts were noted to have broken at the 1976 winter survey, but replacements had been made before the summer inspection was made.

Deterioration of the slabs was found to be extensive during the 1978 summer survey. At the Wixom crossing one center slab was breaking apart and at the Seven Mile Rd crossing, one of the side slabs was severely tilted and loose.

On the basis of the poor performance, the Department's Committee on New Materials recommended that further use of the Fab-Ra-Cast crossing, of the type described herein, be discontinued. Both crossings are currently being processed for replacement of the surface material.

Steel Plank (75 NM-404)

The steel crossing consists of modular units fabricated from No. 3 gage hot-rolled steel. The center units are 50-1/2 in. wide and 6 ft 6 in.

long and are fastened to the ties with 15 lag bolts. The side units are 20 in. wide and 6 ft 6 in. long, with six lag bolts used to fasten each unit to the ties. A tie spacing of 19-1/2 in. on centers is required. A steel washer and a rubber washer are used under the head of each lag bolt. The top surface of the units is coated with epoxy containing sand to increase surface friction, and the interiors of the units are epoxy coated to resist corrosion.

The Steel Plank units were placed mechanically with final positioning done by hand using breaking bars. Once the units were in position, holes for lag bolts were drilled in each corner of a unit and lag bolts were installed. After all the units were fastened in this manner, the remaining holes were drilled and the lag bolts installed.

Four new Steel Plank crossings were installed during the 1978 construction season. These crossings were inspected shortly after installation and all were found to be performing satisfactorily. At the Aloha crossing on M 33 the final approach feathering had not been done at the time of inspection and the temporary feathering was quite rough.

During replacement of the T-Core crossing at Twining, it was discovered that 86 percent of the existing ties were shorter than the required 8 ft 6 in. for a Steel Plank surface. Since tie replacement was not included in the work the bolt hole spacing was decreased in the side panels placed on short ties to ensure that the outside bolts could be tightened satisfactorily.

The surface coating on the M 50 crossing is wearing off in the wheelpaths. A derailed car has been dragged over the crossing, but only minor damage was done. The smoothness of the crossing was rated 'Good.'

The remaining two Steel Plank crossings on Hurd and Nadeau Rds were also damaged from a derailed car being dragged over the crossings. The damage was somewhat more severe than on the M 50 crossing, but as of the 1978 summer survey no repairs had been required. On both crossings the surface coating is wearing off in the wheelpaths. Because of roughness increase from the derailed car damage some slowdown in traffic was noted and, therefore, the crossings were rated 'Fair' with respect to smoothness.

Track-Span (74 NM-416)

This crossing utilizes flexible epoxy and ground automobile tires and is cast-in-place. The rails, ties, and pavement edges are coated with epoxy prior to pouring the crossing. A base layer of flexible epoxy containing ground tire casings is placed first. Then a wearing surface about 2-1/2 in. thick consisting of flexible epoxy with rubber buffings is placed and the surface is finished by tamping. A flange-way is formed on the inside of each rail. Approximately four hours of curing time is needed and installation is limited to dry weather and temperatures above 35 F. No special tie spacing is required.

The surface shows no wear after two years of service. Cracking in the surface layer in the westbound lanes developed during the first year after installation and repairs were begun in the fall of 1977. However, because of cold weather, temporary repair with bituminous material was necessary and permanent repair with epoxy mixed with ground tires was not completed before the early summer of 1978. The repair work was done by the manufacturer at his expense. With respect to smoothness, the crossing is rated 'Good.'

Saf and Dri (75 NM-428)

This type of crossing consists of modular units made of structural steel tubes enclosed in an elastomer. To increase the rigidity of the tubes they are filled with grout. The center units are 26 in. wide and 6 ft 8 in. long and two units are used to span the distance between rails. The side units are of the same length and are 20-7/8 in. wide. The surface pattern consists of 1/4-in. wide by 5/16-in. deep grooves spaced 1 in. apart and running perpendicular to the rails. A tie spacing of 20 in. on centers is required. Twelve 3/4-in. drive spikes with shock absorbing rubber washers are used to fasten each center unit, and four are used to fasten each side unit. The spike holes can be closed with a rubber plug, if desired.

Before placing the modular units, wood shims were placed on each tie and nailed in place using two 3/8 by 10-in. spikes in each shim. The units were placed mechanically with final positioning done by hand. The transverse joints were tightened by jacking from both crossing ends. The bolt holes are recessed 4-1/4 in. and a 1-3/4-in. diameter by 2-1/4-in. long shock absorbing rubber washer was placed under each spike head. The drive spikes used to fasten the pads to the ties were 3/4-in. diameter by 12 in. long. Driving of the spikes was preceded by drilling 5/8-in. diameter pilot holes through the shims and ties. The spike holes were not plugged.

The first Saf and Dri crossing was installed on Oakland Ave in Lansing in November 1976. The crossing has given excellent service for two years and its smoothness was rated 'Good.' A fractured tube in one of the side panels was discovered during the 1978 summer survey. The manufacturer was notified of the problem and it was learned that failures of this type had occurred on some of their earlier crossings where the steel tubes were hollow. Rather than replace the fractured section the manufacturer replaced the entire crossing with panels having grout filled tubes. The replacement was done in February 1979.

The crossing on US 131 was installed in June 1978 and was in excellent condition when surveyed shortly after installation.

Gen-Trac (76 NM-489)

The modular units for this crossing consist of a 1/4-in. structural steel arch enclosed in an elastomer. The arch is prevented from spreading at its springing line by 1/2-in. bolts installed perpendicular to the arch. The center units are 52 in. wide and 1 ft 6 in. long. The side units are 23 in. wide and 1 ft 6 in. long. The surface pattern consists of grooves 1/8-in. deep by 1/2-in. wide, spaced 1/2 in. apart, and running perpendicular to the rails. The units are supported directly on the ties. Each center and each side unit is fastened by four 3/4-in. washer-head drive spikes with a rubber washer placed under the spike heads. Spike holes are sealed with a rubber plug. The required center-to-center tie dimension is 18 in.

The units were placed directly on the ties by hand. Normally the crossing center units were placed and secured first. Then installation proceeded toward the crossing ends. Jacks were used to ensure the joint between units was tight. Pilot holes were drilled into the ties before fastening with the drive spikes. All bolt holes were plugged.

Four Gen-Trac crossings were installed during the last half of 1978, and all were in excellent condition when the initial survey was conducted.

Parkco (77 NM-537)

This crossing material is described by the manufacturer as molded rubber modules reinforced with steel flex plates. The slab units are placed on wood shims spiked to the ties. The slab joints are of the tongue and groove type and longitudinal channels are cast within the units. The slabs are fastened by tensioning cables passing through the longitudinal channels and through holes in steel plates bolted to the end ties of the crossing. A steel plate protects the fastening rods and plates at each crossing end. The center units are 6 ft long, 29-1/2 in. wide, and 3-1/2 in. thick and two units, placed side by side, are used between the rails. The side units are 6 ft long, 18 in. wide, and 3-1/2 in. thick. A wood header is used to prevent material from entering under the crossing surface. A tie spacing of 18 in. is required. The surface consists of a 1/2-in. raised circle pattern to divert moisture away from the contact area of the tires of crossing vehicles.

The two Parkco crossings installed in June 1978 replaced two experimental crossings that had failed. Since these crossings were rebuilt a relatively short time ago, no work was done to the ties, rails, or ballast before installing the Parkco surface material.

After the wood shims were fastened to the ties the surface units were placed by hand. The center units of the crossing were placed first and held in position by nailing stabilizer clips to the shims. Installation then proceeded toward the crossing ends. Each pad placed was jacked against the preceding one to ensure a tight joint. Once the unit was in place the stabilizer clips were installed. Before installing the last units at each crossing end the steel plate was bolted to the last crossing tie. Then when the last units were in place, eight cables (four in the center units and two in each side unit) were inserted through holes in the steel end plates and through the channels cast into the surface units. The units were then fastened by tightening the cables and fastening them to the end steel plates.

Both crossings were in excellent condition when inspected a few months after construction.

The performance of the various crossing types is illustrated photographically in the Appendix.

A characteristic of nearly all crossings with bituminous material adjacent to the crossing surface is the formation of cracks in the bituminous layer. These cracks result from vertical changes in elevation of the crossing and the pavement. On the basis of elevation measurements made at the 12 crossings installed in 1976 and 1977 the amount of elevation change of the crossings from the time of construction to the 1978 summer measurement ranged from 0 to 1 in. settlement with an average of 3/8 in. settlement. For the same time period the pavement elevation change at the crossing edge averaged 1/8 in. settlement with a range of 1/8 in. rise to 3/4 in. settlement.

Cost of Material

The average unit bid prices for each of the five types of crossing material, including fastening hardware, are as follows:

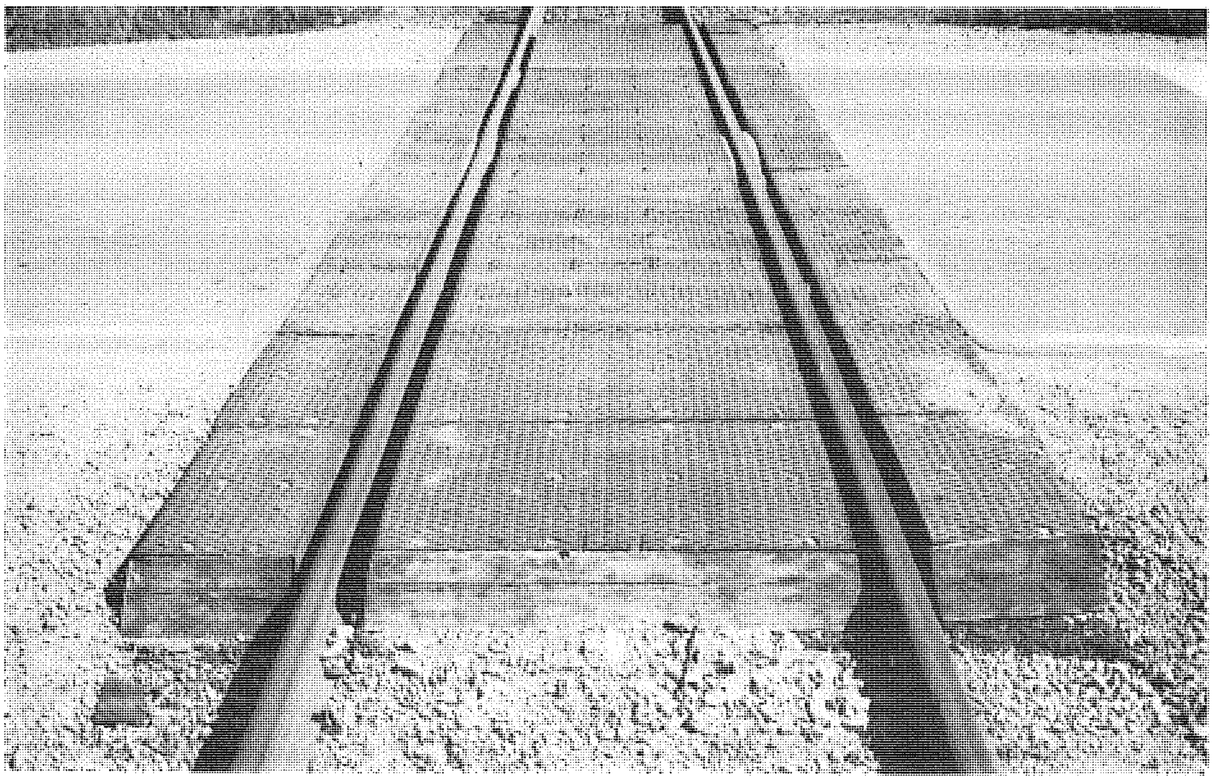
Crossing Type	Cost per Track-Foot		
	1976	1977	1978
T-Core	$103	$ 98	--
Fab-Ra-Cast	$ 98	--	--
Steel Plank	$105	$120	$130
Track-Span	$212	--	--
Saf and Dri	--	$210	$230
Parkco	--	--	$220
Gen-Trac	--	--	$240

Conclusions

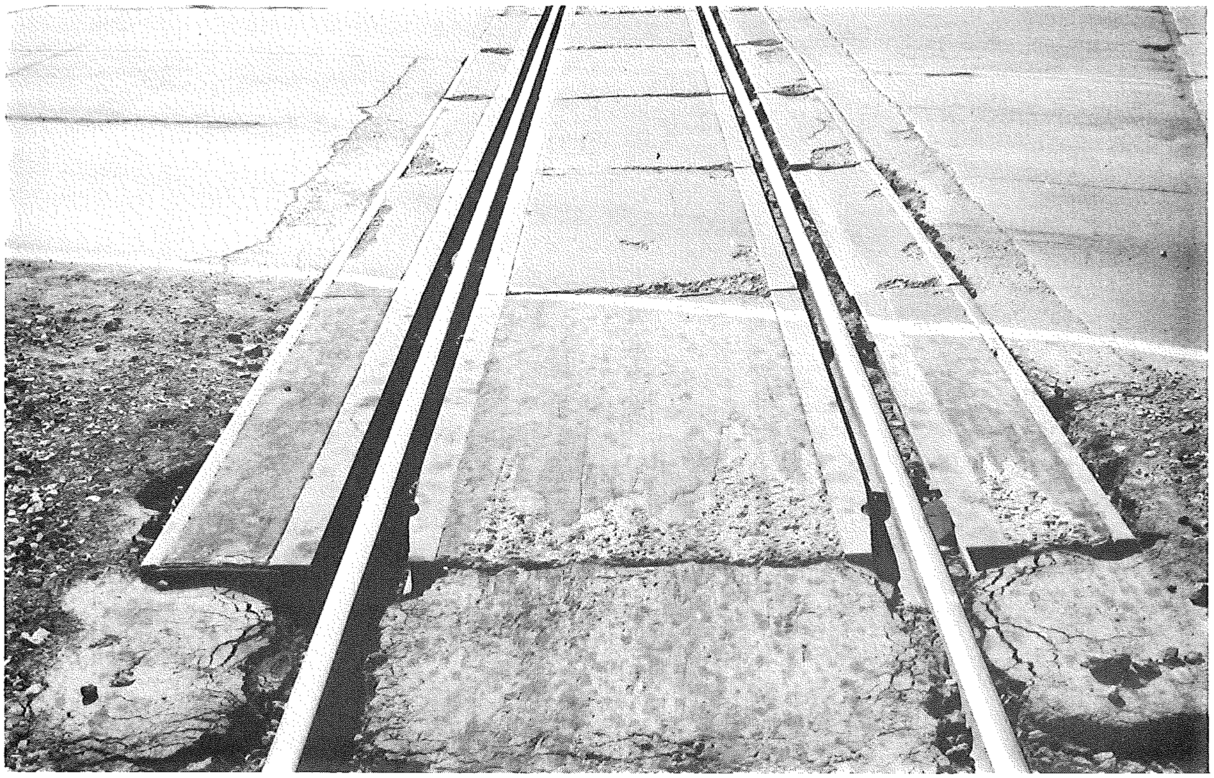
On the basis of observations of the performance of the experimental crossings it has been concluded that T-Core and Fab-Ra-Cast crossings of the type described herein are not suitable for use at crossings having traffic volumes of the magnitude experienced at Omer, Twining, and Alabaster (T-Core), and at Wixom and Seven Mile Rd (Fab-Ra-Cast). Consequently, the Department has suspended the use of these crossing types.

The remaining five crossing types: Steel Plank, Track-Span, Saf and Dri, Parkco, and Gen-Trac continue to perform satisfactorily.

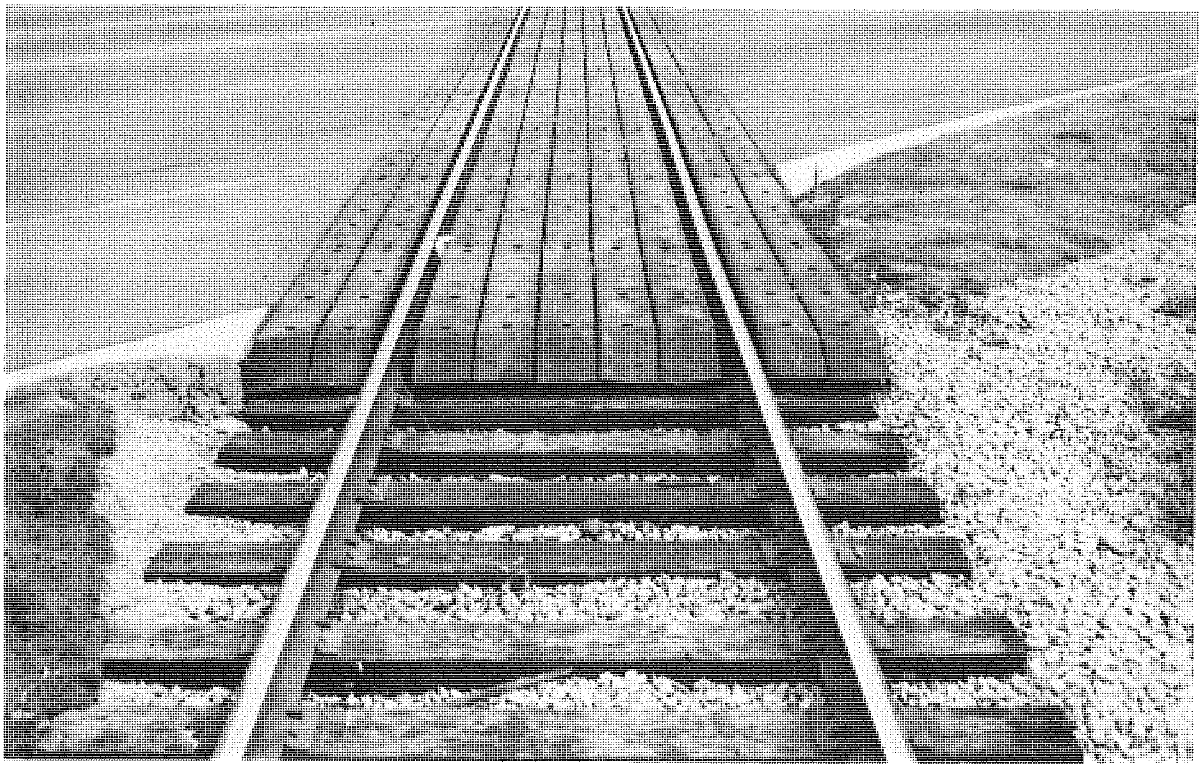
APPENDIX



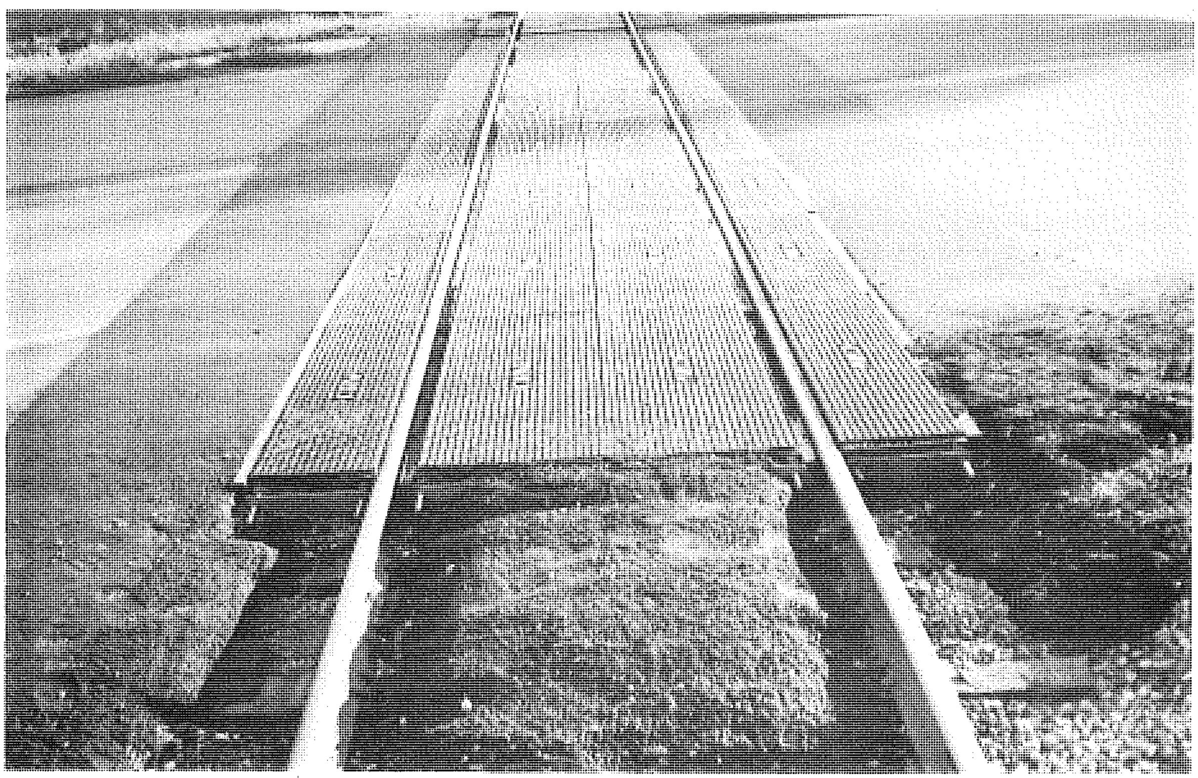
Condition of three-year old T-Core crossing on Kress Rd.



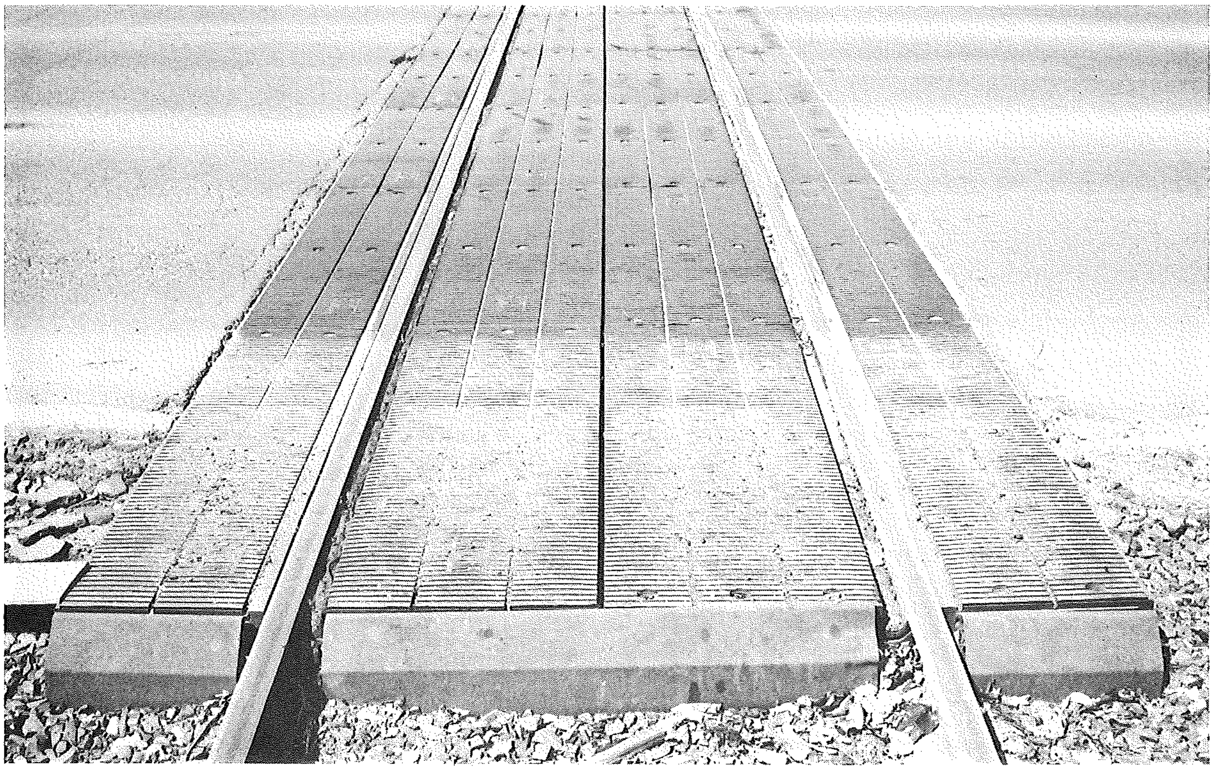
Condition of two-year old Fab-Ra-Cast crossing on Seven Mile Rd.



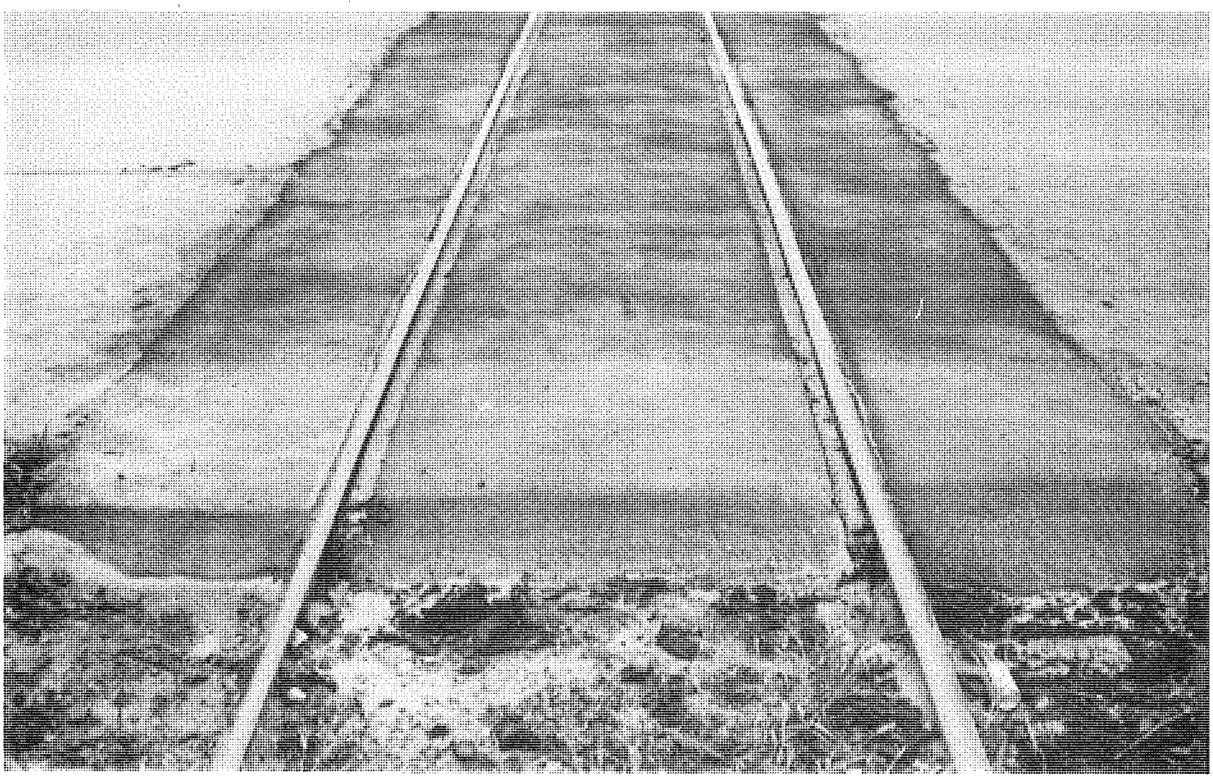
Condition of one-year old Steel Plank crossing on M 50.



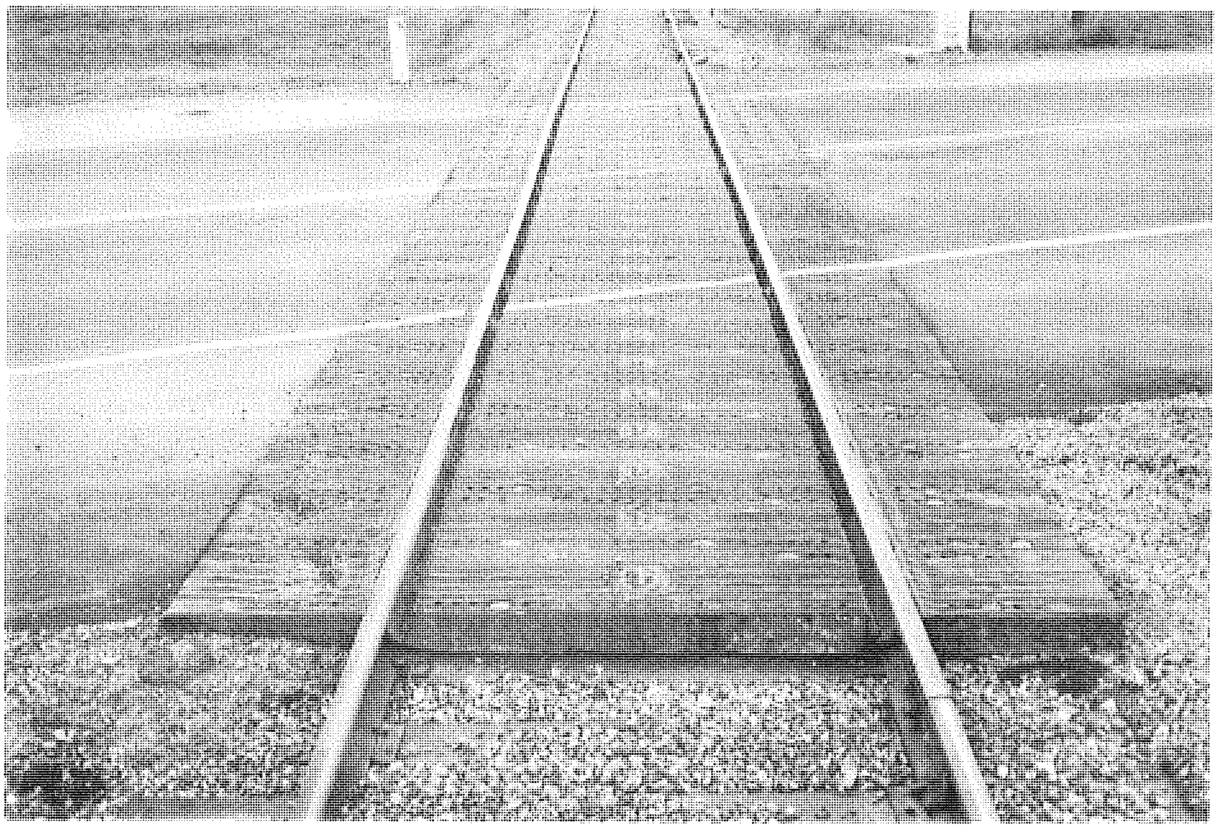
Condition of recently installed Parkco crossing on US 23 in Omer.



Condition of two-year old Saf and Dri crossing on Oakland Ave.



Condition of two-year old Track-Span crossing on M 46.



Condition of recently installed Gen-Trac crossing on US 23 in Alpena.