PROGRESS REPORT ON THE EVALUATION OF VARIOUS TYPES OF RAILROAD CROSSINGS

MICHIGAN

RESEARCH LABORATORY SECTION

MICHIGAN DEPARTMENT OF
STATE HIGHWAYS AND TRANSPORTATION

PROGRESS REPORT ON THE EVALUATION OF VARIOUS TYPES OF RAILROAD CROSSINGS

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In April 1975 the Michigan Department of State Highways and 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 an 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. Initially, three types of materials were included in the study with three more added since the project began.

Although the experimental study concerns only the crossing material, the work involved at each crossing generally includes rebuilding of the entire crossing, installation of new and better warning devices, and changes in roadway alignment and surface to increase the safety of the crossing. The work is financed 90 percent 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.

The objectives of the study are:

1) To obtain information on construction procedures.

2) To evaluate the performance of new crossing materials with respect to durability and smoothness.

3) To determine the relative cost of each type of crossing.

Types of Materials

Prior to initiation of this study, approved crossing materials consisted of wood, bituminous material, concrete, and Goodyear rubber panels. The initially included materials are: T-Core, Fab-Ra-Cast, and Steel Plank, with Track-Span, Saf and Dri, and Gen-Trac added later. All of these materials are proprietary products. A brief description of each follows:

T-Core Crossing - 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.

Fab-Ra-Cast Crossing - 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 by use of 60-lb rails turned upside down except the rail adjacent to the roadway is right side up. Support for each slab is obtained by placing it on several plastic bags which were 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 smooth.

Steel Plank Crossing - 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 are coated with epoxy containing sand to increase surface friction. The interiors of the units are epoxy coated to resist corrosion.

Track-Span Crossing - 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 beginning pouring of 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 on the base course. The material is hand tamped as it 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.

Saf and Dri - This type of crossing consists of modular units made of structural steel tubes enclosed in an elastomer. The center units are 52-1/2 in. wide and 6 ft - 8 in. long. 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. The correct elevation is obtained by placing wooden shims on the ties. A thin neoprene pad is placed on each shim prior to installing the surface units. 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.

Gen-Track - 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. strain 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 unit is fastened with 8-3/4 in. washer-head drive spikes with a rubber washer placed under the spike heads. Four drive spikes with washers are used to fasten each side unit. Spike holes are sealed with a rubber plug. The required center-to-center tie dimension is 18 in.

Manufacturer's of the described products generally suggest the installation of new ties in the crossing area prior to placing the crossing surface. Also, rail splices in the crossing should be avoided.

Crossing Locations

To date 10 experimental crossings have been constructed. Table 1 summarizes information on each of these crossing sites. Four T-Core, two Fab-Ra-Cast, two Steel Plank, and two Track-Span crossings are in service. In addition two T-Core, one Steel Plank, and one Saf and Dri crossing are being processed for construction. Although no Gen-Track crossing location has yet been selected, the Department has approved the material for experimental crossings.

Construction Procedures

Construction of the crossings was the responsibility of the railroad and was done either by their own forces or by contract. Traffic control and roadway approach work were done by the roadway authority either with their own forces or by contract. The Department's Research Laboratory is charged with the responsibility of evaluating the various types of crossing material, and as part of the evaluation procedure the 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:

TABLE 1

SUMMARY OF DATA ON EXPERIMENTAL CROSSINGS IN SERVICE

Type of Crossing	Railroad	Type of Line	Crossing Length, ft	Route Location	Roadway Surface Type	No. of Lanes	Average Daily Traffic
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	32.5	Hurd Rd	Bituminous	2	1,200
Steel Plank	Detroit and Toledo Shoreline	Main	39	Nadeau Rd	Bituminous	2	2,000
Track-Span	Grand Trunk Western	Industrial	44	M 3, Mt. Clemens	Concrete	3	20,000
Track-Span	Chesapeake and Ohio	Industrial	52	M 46, St. Louis	Concrete	4	8,800

1) The most efficient procedure for replacing an existing crossing was when we were able to close the highway to traffic and a few hour gap in train traffic was available. The existing crossing, including the ballast, was removed by mechanical equipment. A pre-assembled 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, of course, necessary to replace half of the crossing at a time. The general procedure employed consisted of first replacing the ties and ballast on one half 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 welded 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 movements maintained, entailed a good deal of hand work. First, the old crossing surface was removed followed by removal of the ballast between the ties. The ties were unfastened from rails and a few ties at one end of the crossing were removed 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 welded 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.

From observation of the reconstruction work, it was noted that the ballast, especially at mainline crossings, had been contaminated from pumping in the crossing area. Since pumping cannot take place without the presence of water, the need for better drainage facilities at some railroad crossings is evident. At crossings located in a concrete pavement, permanent increase in slab length had narrowed the original width of the crossings and in some cases pressure was being exerted on the ties. This makes it more difficult to remove the old crossing ties and removal of several inches of

Figure 1. Installing T-Core side pads.

Figure 2. Fastening pads to ties with 3/4-in. lag bolts.

Figure 3. Two-by-four installed against side pads before bituminous material is placed next to the crossing.

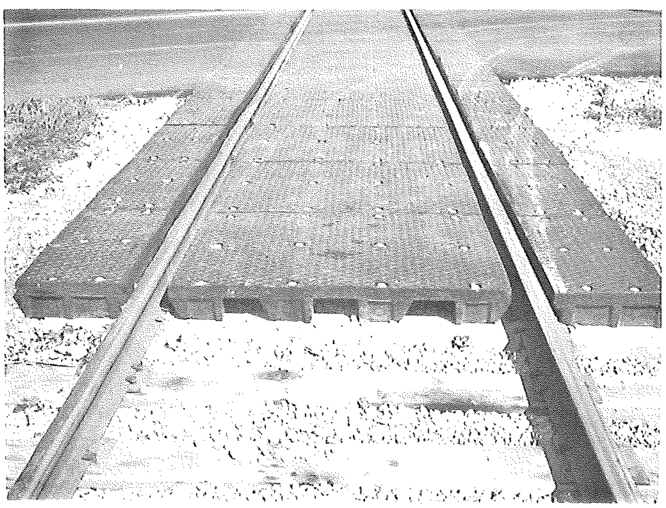


Figure 4. Completed T-Core crossing.

Figure 5. Low angle view of T-Core crossing showing wavy surface.

Figure 6. Positioning steel plank units in crossing area.

pavement on each side of the crossings may be required to provide space for installation of the new ties and surface material.

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 type of crossing materials depends on the equipment, hand tools, personnel available, and their experience. The installation of all four experimental crossing types used to date is fairly simple, but precision work is necessary. A brief account and illustrations of the installation process of each material follows:

T-Core - 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 using a 2-by-4 as shown in Figure 1. 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 (Fig. 2). Installation of the 3/4-in. diameter lag bolts was preceeded by drilling 11/16 in. holes into the ties. Before placing bituminous material against the crossing edge a 2-by-4 was installed against the side pads to prevent the material from infiltrating under the crossing surface (Fig. 3). A completed T-Core crossing is shown in Figure 4.

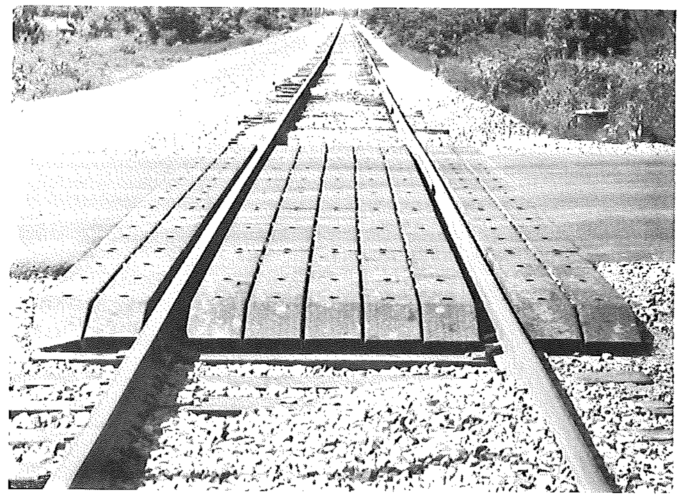
During installation of the T-Core crossings it was noted that the finished crossing surface had a wavy appearance (Fig. 5). The supplier explained that this is caused by the pads being slightly thinner at the edges than at their center. The manufacturer is aware of the problem and corrections are being made so that on future installations the thickness of surface pads should be more uniform.

Steel Plank - The steel plank units were placed mechanically with final positioning done by hand using breaking bars (Fig. 6). Once the units were in position, holes for lag bolts were drilled in each corner of a unit and lag bolts were installed (Fig. 7). After all the units were fastened in this manner the remaining holes were drilled and the lag bolts installed. A completed crossing is shown in Figure 8.

Fab-Ra-Cast - 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 (Fig. 9), 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

Figure 7. Installing lag bolts.

Figure 8. Complete Steel Plank crossing.



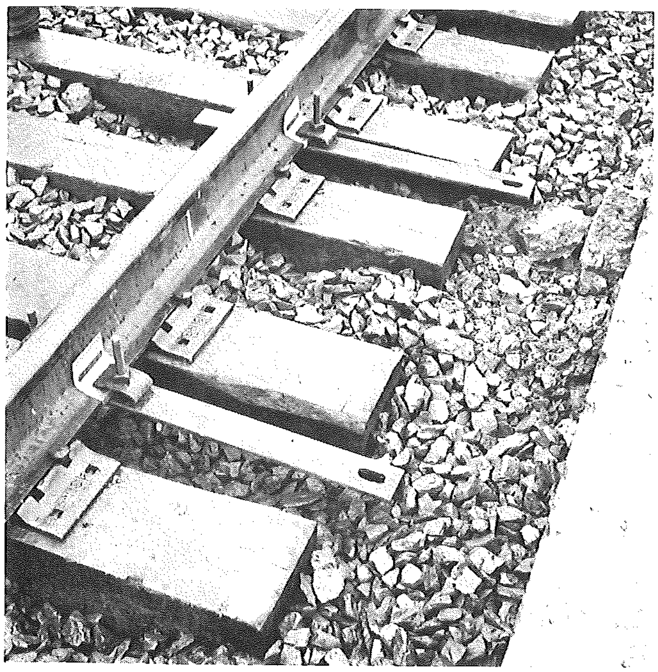
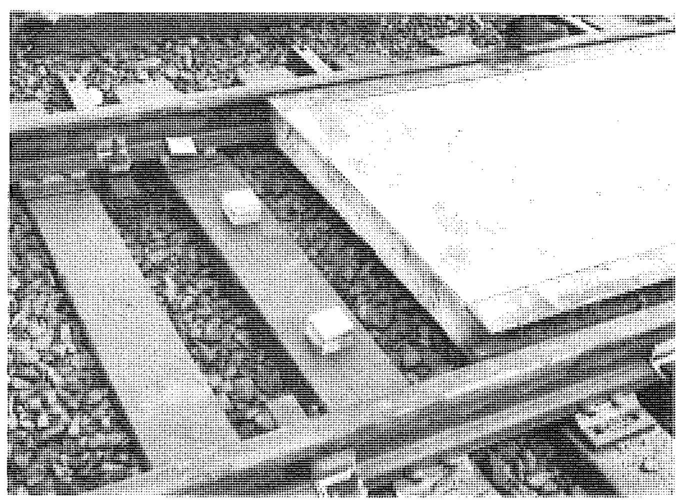


Figure 9. Fastening hardware in place on rail. Note insulator placed under fastening clip.

Figure 10. Wood shims placed on ties and slab temporarily in place to ensure correct elevation and bearing.



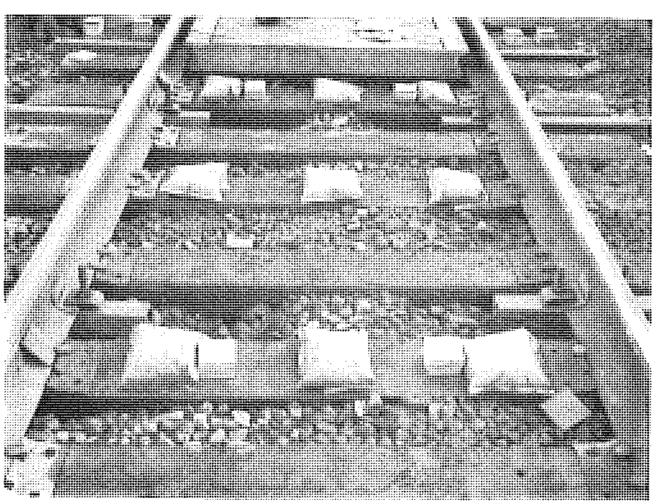


Figure 11. Grout-filled bags in position of ties.

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 (Fig. 10). Grout-filled plastic bags were placed on the ties as shown in Figure 11 and the slab again lowered into position by a crane (Fig. 12). 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. The angle bracket, washer, and nut used to fasten the slabs to the rails are shown in Figure 13, and a completed crossing is shown in Figure 14.

Track-Span - This type of crossing is poured-in-place and therefore, as in the case of the Fab-Ra-Cast crossing, tie spacing is not critical. However, the material is not recommended for placement when the temperature is below 35 F or during wet weather. Prior to pouring the epoxy mix the rails, ties, and pavement edges were coated with epoxy. Then epoxy mixed with ground rubber tire casings was placed to within about 2-1/2 in. of the crossing surface as shown in Figure 15. The wearing surface, consisting of epoxy mixed with rubber buffings, was placed and finished by hand tamping (Fig. 16). A flangeway was formed on the inside of each rail by using a shaped wood piece. Figure 17 shows a completed crossing. Approximately four hours of curing time is required before the crossing can be opened to traffic.

Cost of Material

The average unit bid price for each of the four types of crossing material, including fastening hardware, is as follows:

T-Core	$103 per track ft
Fab-Ra-Cast*	$ 98 per track ft
Steel Plank	$105 per track ft
Track-Span*	$212 per track ft

Performance Evaluation

A visual inspection of the performance of the crossings is made semiannually. Information on any damage or wear of the surface is recorded. The crossing units and the rails are checked to ensure they are securely fastened. The condition of the joints between the pavement and the crossing

* Cost based on one crossing only.

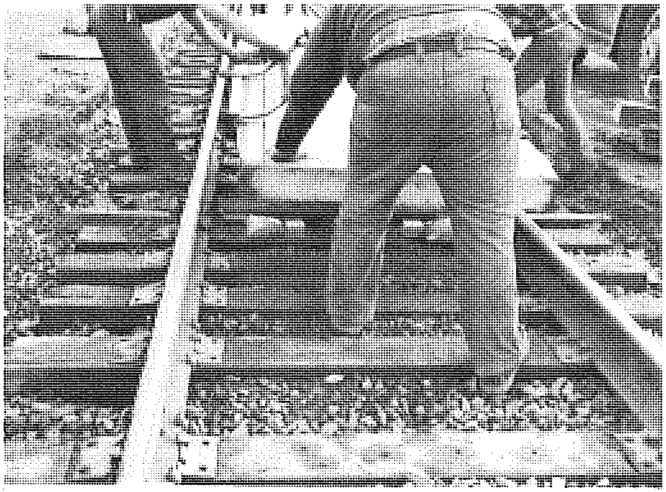


Figure 12. Slab lowered into final position on grout-filled bags.

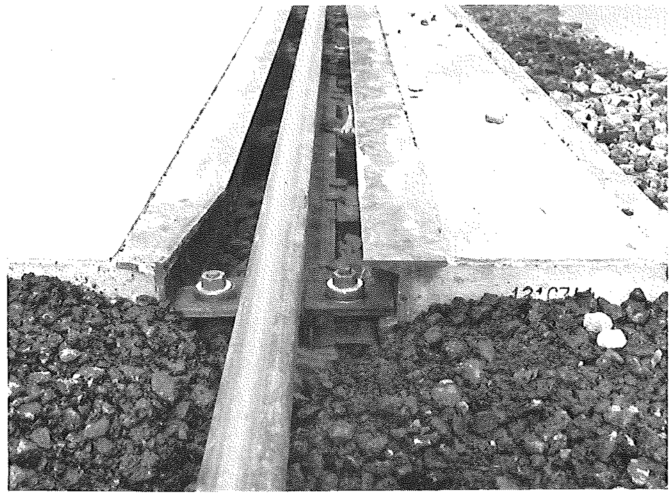


Figure 13. View of angle bracket used to hold slabs in position.

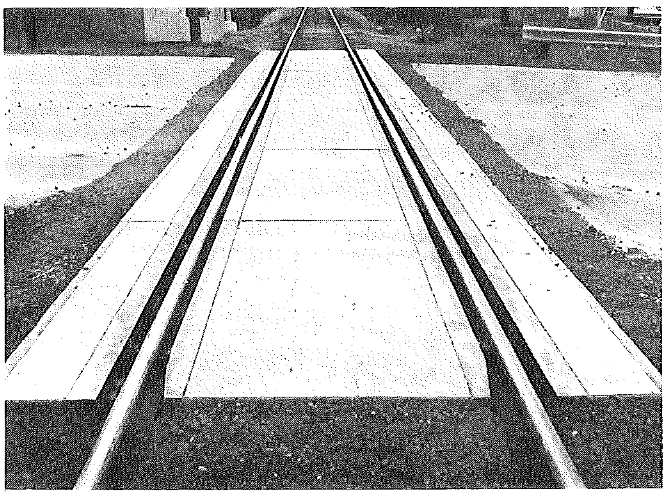


Figure 14. A completed Fab-Ra-Cast crossing.

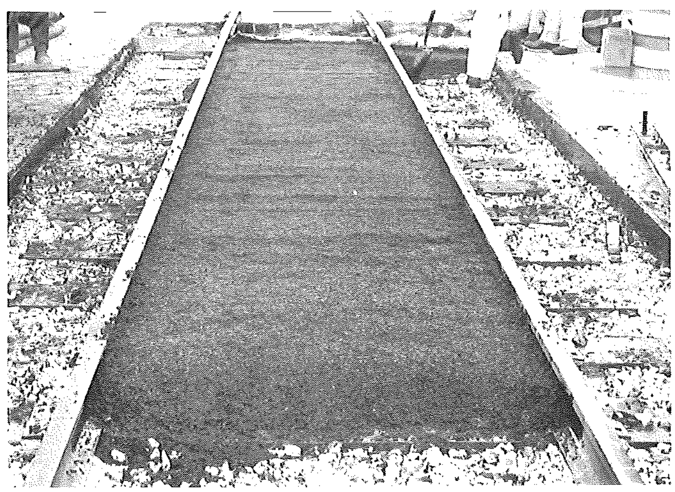


Figure 15. Placing bottom layer of epoxy mixed with ground rubber tire casings.

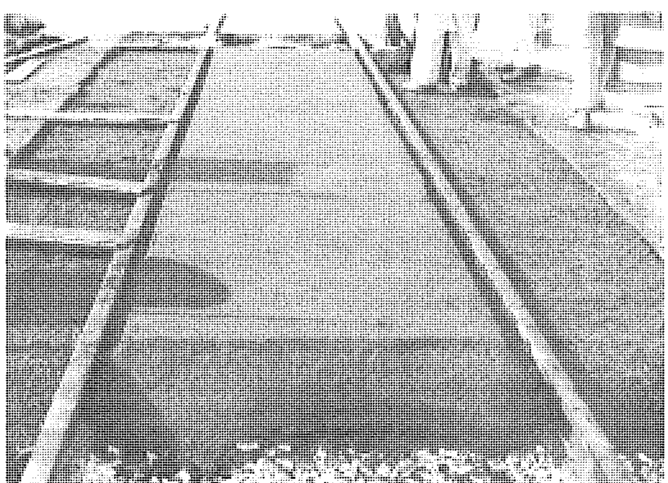


Figure 16. Placing wearing surface consisting of epoxy mixed with rubber buffings.

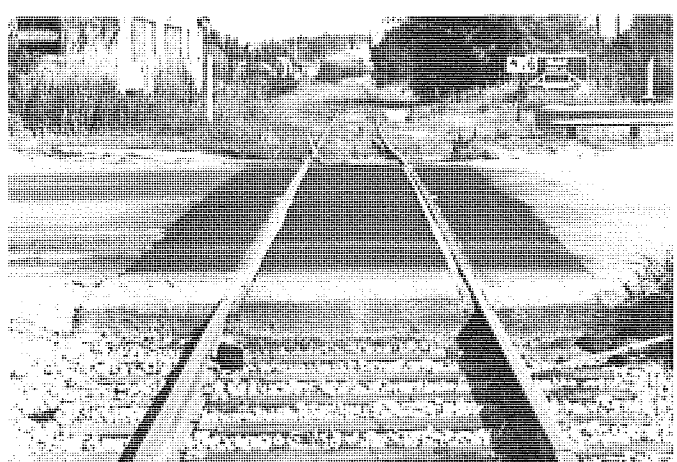


Figure 17. A completed Track-Span crossing.

is inspected and the smoothness of the crossing is noted. The elevation of the rails, the crossing material, and of the pavement at 5-ft intervals along each curbline for 25 ft each side of the crossing is also measured. In addition, the surface profile in each lane is measured with the Department's profilometer in the summer and winter of each year.

Since the experimental crossings have only been in service a few months, it is too early to make any conclusions regarding their performance. Inspections to date have revealed the following:

1) The Steel Plank and Track-Span crossings have performed without any distress.

2) At the M 65 T-Core crossing, the corner of one end pad has been broken as shown in Figure 18 and a crack has formed in an interior pad from the bolt to the pad edge (Fig. 19). It is suspected that the damage has been caused by the flange of a wheel hitting the pad edge. Cracks have also developed in the two interior pads located in the wheel tracks of the southbound lane. The Kress Rd crossing was installed before extensive construction work was done to the approach pavement. It appears that construction equipment caused a fracture to occur at a corner of a side pad (Fig. 20). Gravel has completely filled the flangeway and has worked its way in between the pads and their support.

At the Omer-US 23 crossing one side pad and its support fractured to the extent that replacement was necessary. Another side pad (Fig. 21) and its support have cracked and replacement will be necessary. Several other pads exhibit cracks in the surface.

The remaining T-Core crossing on US 23 is in good condition. However, because of the cracking problem at two of the crossings the Research Laboratory has suggested that the use of T-Core crossings be held in abeyance until the cause of the fractures has been found.

3) Shortly after the Fab-Ra-Cast crossings were installed, it was noted that the slabs' surfaces were full of hairline cracks and crumbling at the joints has developed (Fig. 22). It was learned that the concrete had taken a flash set during slab fabrication which caused the surface to deteriorate once the slabs were in service. Problems with maintaining secure fastening of the slabs also developed. Apparently, vibrations from traffic caused the bolts to loosen and the slabs would rock under traffic which may have contributed to the surface adjacent to the side slabs breaking up (Fig. 23). Some problems with short circuiting in the signal installation were experienced in the early service life of the crossings.

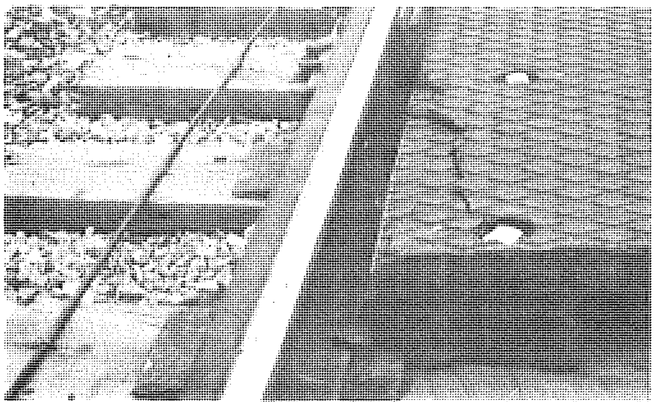


Figure 18. Broken corner of end pad on M 65 T-Core crossing.

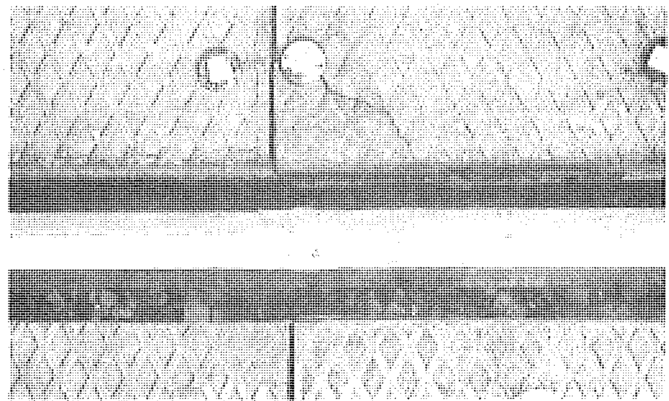


Figure 19. Crack at interior corner of a pad on the M 65 T-Core crossing.

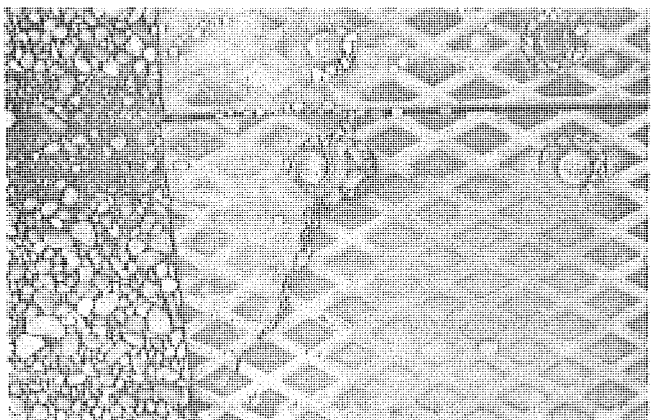


Figure 20. Corner damage to side pad at the Kress Rd T-Core crossing.

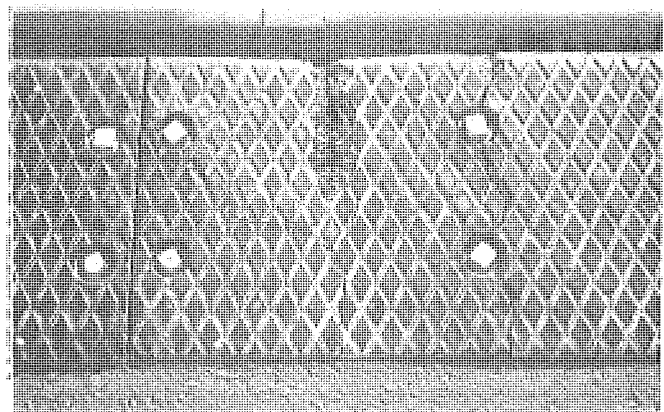


Figure 21. Fractured side pad at the Omer-US 23 T-Core crossing.

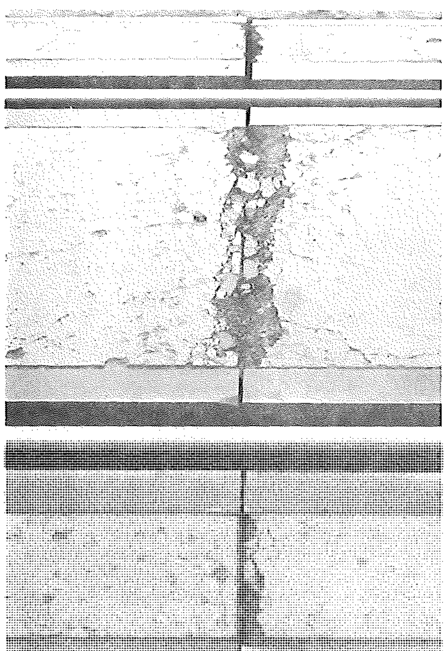


Figure 22. Surface condition of Fab-Ra-Cast slabs.

Figure 23. Condition of road surface along side slabs of Fab-Ra-Cast crossing.

The producer-supplier of the crossing slabs has been most accommodating in dealing with problems that have developed. Because of the deterioration of the slabs he has replaced and installed new slabs at both crossings. To solve the fastening and short circuiting problems a better insulator, a new type of shock absorbing washer, and a lock-nut were used. The surfaces of the new slabs were treated with epoxy and sand to increase the friction of the slab surface.

General Problems Involving Railroad Crossings

In addition to the crossing material itself there are several other factors that affect the smoothness and performance of a railroad crossing. Some of the more important factors that contribute to early failure of crossings are discussed in the following. The suggested solutions to the various problems may not entirely eliminate the problems, but, hopefully, will minimize their undesirable effects.

Maintaining Traffic - The reconstruction of a railroad crossing can best be done in a safe, effective, and efficient manner when the road is closed and sufficient gap in train traffic will allow for replacement of the entire crossing at one time. Therefore, it is suggested that the possibility of closing the road and changes in train scheduling be thoroughly investigated by the roadway agency and the railroad involved.

At crossings where traffic must be maintained and no rail joints are allowed within the crossing area, it is necessary to stop traffic for several minutes while installing the rails. This aspect should be checked prior to letting the contract to ensure that the road can be closed for a few minutes without creating serious traffic problems. If short closures of the road cannot be tolerated, rail joints should be allowed in the crossing area. In this case it is necessary to check the type of crossing material specified to ensure that it will accommodate rail joints.

Drainage - At some crossings it is evident that drainage problems exist. Therefore, consideration should be given to install drainage pipes to improve the performance of the base of both the roadway and the railroad. Several fabric materials are available for controlling the movement of moisture and fines within the base material. Such fabrics could possibly be used in troublesome areas provided the reconstruction procedure would allow their use.

Joints - Probably the most damage inflicted to a crossing surface results when a difference in elevation exists across the joints between the pavement surface and the crossing surface. Unfortunately, there is no solution to the problems of vertical offset developing between crossing and roadway. Its occurrence can, however, be minimized by constructing a good drainable base through the crossing site.

In general, manufacturers of crossing material recognize that the edges of the crossing abutting the pavement need to be closed to infiltration of pavement materials. Either the material has a closed edge for the depth of the crossing surface or else a treated timber plank is required to close the gap between ties and surface material.

On the experimental crossings, whether the road surface was concrete or bituminous, bituminous material was placed against the crossing edge or wood plank without any special joint being installed. In most cases, cracks have formed next to crossings as a result of vertical movement between crossing and roadway.

The Department is currently reviewing its plans concerning concrete pavement encroachment and joint problems at railroad crossings in both concrete and bituminous pavements.

Railroad Ties - One of the most important factors in the installation of prefabricated crossing materials (that are fastened to the ties) is the use of properly sized ties. The ties should be of full cross-section throughout their length and have square cut ends. They should be of uniform length and installed so that they extend an equal distance beyond each rail. The length should be as recommended by the crossing material manufacturer and the ties should be spaced as required for a particular material type. As previously mentioned, some crossing materials need a timber plank installed at the crossing edges. The dimensions of such planks are generally given in the manufacturer's installation information.

To avoid problems caused by the ties, it is suggested that once the type of crossing material to be used has been decided, the tie requirements be discussed with the railroad.

If the material requires a plank for closing the edge, this should also be discussed to ensure that such material will be on hand when needed at the crossing site.

Approach Pavement - At nearly all reconstructed crossings it has been necessary to feather the approach pavement to match the crossing elevation. Although the crossing may be smooth just after rebuilding, periodic checks should be made by the road maintenance agency to ensure the elevation of the crossing and the approach pavement match each other. The use of good maintenance procedures to maintain the pavement-crossing elevation should be beneficial in providing both smooth riding crossings and longer lasting ones.