EVALUATION OF VARIOUS TYPES OF RAILROAD CROSSINGS

Seventh Progress Report

TESTING AND RESEARCH DIVISION
RESEARCH LABORATORY SECTION

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Testing and Research Division
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SUMMARY

This project was initiated by the Department as an HPR "Category 2" Experimental Features Project nine years ago. During this time numerous experimental grade crossing surface materials have been evaluated. Some of these materials failed shortly after installation and were replaced, others are now showing failures which will require expensive repairs or perhaps replacement. In addition, the manufacturers have been modifying their original designs to improve their product. As a result, many of the experimental crossings currently being evaluated have not been in service long enough to warrant approval without restriction. Therefore, rather than wait for conclusive results on which unconditional approval can be given, it is recommended that a conditional "Qualified Products List" be established. It is also recommended that experimental crossing materials approved for installation by the Department's New Materials Committee be limited to four evaluation sites. Crossing materials that have been evaluated and either failed or provided inferior performance will be dropped from further consideration. Repairs of failed crossings will be monitored to evaluate their effectiveness. Increased efforts to obtain quality installation and consideration of more effective maintenance procedures are suggested.

The results, conclusions, and recommendations given in this report are in basic agreement with those determined on a similar study conducted by Louisiana Highway Research personnel and reported in Interim Report No. 6, "Evaluation of Experimental Railroad-Highway Grade Crossings in Louisiana," by Steve G. Bokum and Alfred F. Moore (August 1983).

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 changing 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 upon the jurisdiction of the roadway.

TABLE 1
SUMMARY OF DATA ON EXPERIMENTAL CROSSINGS IN SERVICE
(All crossings single tracks except as noted)

Year	Type of Crossing	Railroad	Type of Line	Crossing Length ft	Route Location	Roadway Surface	No. of Lanes	ADT[1]
79	Steelplank	D&TS.L.	Main	52	Northline Rd. Wyandotte	Bit.	4	9,000
80	Steelplank	D&TS.L.	Main	45	Pennsylvania Rd. Wyandotte	Bit.	2	9,600
80	Steelplank[2]	D&TS.L.	Main	52	East Elm St. Monroe	Bit.	2	2,000
82	Steelplank	D&M R.R.	Main	70	M-13 Pinconning	Bit.	4	10,000
80	Parkco	D&M R.R.	Main	42	M-72 Grayling	Bit.	2	9,000
81	Parkco	Con Rail	Main	42	M-89 Plainwell	Bit.	2	2,500
81	Parkco	L.C. R.R.	Main	90	M-52 Adrian	Conc.	4	6,900
81	Parkco	L.C. R.R.	Main	72	US-223 Palmyra	Bit.	2	6,800
81	Parkco	C&O R.R.	Main	162	M-46 Merrill	Bit.	2	5,100
81	Parkco	M.I.R.	Main	66	M-71 S. Wash. Ave. Owosso	Bit.	4	16,000
81	Parkco	M.I.R.	Main	60	M-71 E. Coruna Owosso	Bit.	4	12,500
82	Parkco[2]	D.T.&I. R.R.	Main	54	M-85 Trenton	Conc.	2	27,500
83	Parkco[3]	C&O R.R.	Main	60	North St. Lansing	Bit.	2	13,800
83	Parkco[2]	C&O R.R.	Main	220	M-46 Breckenridge	Bit.	2	5,200
80	Cobra X[2]	G.T.W. R.R.	Main	54	M-40 Marcellus	Bit.	2	2,500
80	Cobra X[3]	G.T.W. R.R.	Main	93	M-216 Marcellus	Bit.	4	2,300
81	Cobra X	C&O R.R.	Main	42	M-15 Vassar	Bit.	2	4,600
81	Cobra X	Con Rail	Industrial	72	M-89 Plainwell	Bit.	2	2,500
83	Cobra X	G.T.W. R.R.	Industrial	105	M-50 Charlotte	Bit.	2	3,900
83	Cobra X	T&SB	Main	46	M-83 N. of Gera	Bit.	2	2,000
83	Cobra X	T&SB	Main	40	M-36 5 Mi. E of Pinckney	Bit.	2	5,100
77	*Saf and Dri	Con Rail	Industrial	67	M-43 Oakland Ave. Lansing	Conc.	5	25,000
78	*Saf and Dri	G.T.W. R.R.	Main	63	US-131 Schoolcraft	Conc.	4	11,100
79	*Saf and Dri	G.T.W. R.R.	Main	66	M-21 Owosso	Bit.	4	17,900
79	*Saf and Dri	C&O R.R.	Industrial	80	US-10 Ludington	Bit.	5	14,000
80	*Saf and Dri	C&O R.R.	Main	72	M-57 Clio	Bit.	2	10,000
80	*Saf and Dri	C&O R.R.	Main	40	M-83 Gera	Bit.	2	5,000
81	*Saf and Dri	C&O R.R.	Main	48	M-15 Arthur	Bit.	2	3,400
81	**Saf and Dri[2]	C&O R.R.	Main	108	M-54BR Saginaw Rd. Flint	Bit.	4	
82	**Saf and Dri	L.C. R.R.	Main	222	M-34 Adrian	Bit.	3	8,700
83	Strail	C&O R.R.	Industrial	54	M-46 St. Louis	Bit.	4	5,200

[1]Total traffic in both directions
[2]Two tracks
[3]Three tracks
* Model "S"
**Model "C"

This is the seventh evaluation report concerning the performance of railroad grade crossing surface materials. Previous reports were issued in 1976, 1978, 1979, 1980, 1982 and 1983.

Materials

All materials are proprietary products and to date 12 have been installed for evaluation purposes. The name and brief description of each of these materials follows:

T-Core - High-density linear polyethylene structural foam.
Fab-Ra-Cast (Old Design) - Precast concrete panels.
Steelplank (Old Design) - Modular steel units.
Steelplank (New Design) - Modular steel units with redesigned supports and fasteners.
Saf and Dri (Model S) - Structural steel tubes enclosed in an elastomer.
Saf and Dri (Model C) - Corrugated steel plates enclosed in an elastomer.
Gen-Trac (I) - Structural steel arches enclosed in an elastomer.
Track-Span - Mixture of ground automobile tires and flexible epoxy cast-in-place.
Parkco (Old Design) - Arched steel plates enclosed in an elastomer.
Parkco (New Design) - Arched steel plates reinforced with a steel bar and enclosed in an elastomer.
Cobra X - High-density linear polyethylene structural foam.
Strail - Ethylene-propylene rubber.

The Goodyear (Super Cushion) crossing material was evaluated and found to perform satisfactorily during an earlier Departmental study.

Of these materials T-Core, Fab-Ra-Cast (old design), and Track-Span have previously been deleted from this study because of unsatisfactory service or because the manufacturer withdrew the material from the market. Performance problems have been slowly developing with the Steelplank (old design), Parkco (old design), and Gen-Trac (I). Their performance problems (discussed in detail in the Evaluation section) were found to have increased in magnitude during the 1983 survey and these materials will be deleted from further evaluation because of unsatisfactory performance.

Crossing Locations

Table 1 lists the locations and gives summary information for each of the materials included for further evaluation. As can be seen a total of 41 single track crossings are involved. There are 7 Saf and Dri (Model S), 3 Saf and Dri (Model C), 14 Parkco (new design), 6 Steelplank (new design), 10 Cobra X and 1 Strail crossings included.

CONSTRUCTION PROCEDURES

Construction of the crossings is the responsibility of the railroad agency and is done either by their own forces or by contract. As part of the evaluation procedure, construction of the experimental crossings is observed by research personnel as time permits. Installation of the crossing material is to be done in accordance with the manufacturer's recommended procedure and, generally, their representative is present during placement operations of the first few crossings.

At all crossing sites the existing rails, ties, and ballast are removed and replaced for at least 10 ft beyond each crossing end. The procedures used to replace these materials depend on the requirements for maintaining both rail and highway traffic at the crossing. Basically, the following three methods are employed.

1) The most efficient procedure for replacing an existing crossing is when both the highway and railroad are closed to traffic or where at least a two-hour gap in train traffic exists. The existing crossing, including the ballast, is removed by mechanical equipment. A preassembled track section is positioned on the grade or the crossing is assembled in place. The joints between new and old rails are bolted and new ballast added and compacted under the ties. Final adjustment of rail height, compaction of the ballast, and installation of the surface material is done under normal train traffic or completed before train traffic is resumed.

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

A variation of this procedure where train traffic does not need to be maintained is to place a preassembled track section on the ballast in half the crossing, retamp the ballast and then install the new surface material. Road traffic is then rerouted onto the new surface and the other side of the crossing is rebuilt. Using this procedure, the rails are welded in place while road traffic is maintained.

3) The procedure for replacing a crossing where the road traffic is detoured but high-speed frequent train movement prevails, entails a good deal of handwork. First, the old crossing surface is removed followed by removal of the ballast between the ties. The ties are then unfastened from under the rails. The ties, up to the center of the crossing, are slid

and twisted out and new ties are inserted under the rails. New ballast is 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 are replaced in the same manner. The new rail sections are placed and fastened into position and raised to proper elevation by adding and compacting the ballast. The crossing surface is installed during periods between train movements.

Once the ballast, ties, and rails are replaced, the installation of the crossing surface generally is 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 12 experimental crossing types used to date was fairly simple, but careful work was necessary.

PERFORMANCE EVALUATION

Evaluation of the crossing materials is based on yearly visual observations 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 end of 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 crossing is rated as 'Good, Fair, and Poor,' (Good - basically no slowdown in traffic; Fair - some slowdown in traffic; and, Poor - considerable slowdown in traffic).

TABLE 2
1983 SUMMARY OF CROSSING PERFORMANCE

Crossing Type and Total No. of Crossings	Number of Crossings With and Without Problems in Each Performance Factor Category														
	Surface Wear		Surface Damage		Poor Alignment		Loose Panels		Loose Rails		Joint Problem		Crossing Smoothness		
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Good	Fair	Poor
Saf and Dri (7) (Model S)	0	7	6	1	1	6	2	5	3	4	3	4	7	0	0
Saf and Dri (3) (Model C)	0	3	2	1	0	3	0	3	0	3	1	2	3	0	0
Steelplank (6) (New Design)	4*	2	0	6	0	6	0	6	0	6	0	6	6	0	0
Parkco (14) (New Design)	0	14	2	12	0	14	-	-	0	14	3	11	14	0	0
Cobra X (10)	0	10	1	9	0	10	2	8	3	7	3	7	10	0	0
Strail (1)	0	1	0	1	0	1	-	-	0	1	0	1	1	0	0

*Epoxy coating only

On the basis of the 1983 performance inspection as well as the previous inspections, the surface materials have been separated into two groups: those with satisfactory and those with unsatisfactory performance. The performance of the satisfactory crossings is summarized in Table 2 and results shown for each performance factor are briefly discussed as follows:

Surface Wear - Except for four Steelplank crossings no surface wear was observed. As noted in the table, the Steelplank surface wear was confined to wearing-off of the epoxy coating.

Surface Damage - The surface damage observed on the "rubber" crossings consists of nicks and gouges caused by snow plows and is only of minor extent. The damage at the one Cobra X crossing consists of minor fractures caused by the rail wheel flanges along the rail in nine field-side units (field-side units are those on the outside of the rails, gauge-side being those between the rails).

Panel Alignment - The only alignment problem observed was at one six-year old Saf and Dri (Model S) crossing and was confined to two low field-side panels on the approach side of the crossing. The slight settling of these panels appeared to have been caused by a base support failure.

Loose Panels - Two Saf and Dri (Model S) crossings were found to have loose field-side panels. Three panels were loose on a six-year old crossing and four panels were loose on a seven-year old crossing. Rocking of the panels apparently has caused the bolts to pull out somewhat. Eight loose panels were noted on a four-year old Cobra X crossing and 12 on a three-year old crossing. The panels were estimated to rock about 1/4 in. It is suspected that tie wear under the panel support area may have caused the panels to rock.

Loose Rails - Loose rails were observed at six crossings. This problem indicates base settlement which adversely affects the performance of the surface material.

Joint Problems - At 10 crossings, fracturing and cracking had occurred in the bituminous road surfacing. This type of failure is the result of induced deflections as trains pass over the crossing. Periodic maintenance of the joints and adjacent pavement should be done to maintain the smoothness of the joint area.

Crossing Smoothness - All crossings, ranging in age from a few months (Strail) to seven years (Saf and Dri, Model S) were rated in the "Good" category with respect to smoothness.

The crossing materials in the unsatisfactory performance group are: Steelplank (Old Design), Parkco (Old Design), and Gen-Trac (I). These materials are a "first generation design" and have not been installed on Michigan Trunkline crossings since they were redesigned. The problems

which developed during their evaluation period and the proposed or utilized maintenance repairs are as follows:

Steelplank (old design) - The primary problem is that the side panel bolts loosen and consequently the panels rock under traffic. Fractures have occurred in some support brackets and resulted in the collapse of the panel.

To date, three crossings have been replaced with bituminous material, one has had two side panels replaced with a bituminous mix, and one crossing has been repaired by installing panels of the new design.

Parkco (old design) - Impending failures are characterized by a downward bend in the surface. Removal of bent panels revealed that the steel "flex" plate was broken. Also, the hold-down cables had fractured at the panel joints. The panel failures appear to occur where support loss, either from a broken shim or tie settlement, has developed. The cable fractures result from a combination of corrosion and wear at the panel intersections.

Panel fractures have developed at three crossings. Of these, two have been replaced with the "new design" Parkco panels and one is scheduled for replacement with a bituminous crossing. At another crossing, "new design" side panels and cables have been installed.

Gen-Trac (I) - The failures occur in the ties under the support area of the side panels. The tie wear apparently is caused by sand infiltrating between the tie and the panel, and when the panel rocks under traffic the abrading action of the sand wears the tie. The tie wear has been observed to be 3/4 in. deep on some ties but a 1/8 to 1/2 in. range is more normally observed. The wear problem is nearly always confined to the wheel tracks of the roadway.

Of the 16 Gen-Trac crossings on trunklines, only two are free of the tie wear problem. On the remaining 14 crossings there are an estimated total of 250 side panels that are rocking because of tie wear.

On one crossing, some of the side panels have been removed and timbers installed, and on another crossing three pads were removed and replaced with bituminous material. Currently, total replacement is under consideration for some of the high traffic volume crossings. An epoxy repair system, proposed by the manufacturer, is being considered for some crossings exhibiting a relatively small number of tie wear failures.

MATERIAL COST

Typical bid prices for each of the six types of experimental crossing materials, including fastening hardware, are as follows:

Crossing Type	Cost per Track-Foot						
	1977	1978	1979	1980	1981	1982	1983
Steelplank	--	--	$135	$115	--	$244	--
Saf and Dri-S	$210	$230	$230	$225	--	--	--
Saf and Dri-C	--	--	--	--	$265	$260	--
Parkco	--	--	--	$220	$253	$250	$232
Cobra X	--	--	--	$160	$200	--	$175
Strail	--	--	--	--	--	--	$210

The price per track-foot of the previously evaluated Goodyear crossing material was in the $280-$290 range during 1983.

CONCLUSIONS AND RECOMMENDATIONS

As previously mentioned, 12 types of railroad grade crossing surface materials have been included in this field testing program to date. Of these, two (T-Core and Track-Span) failed to perform satisfactorily and were taken off the market by the manufacturers. One, [Fab-Ra-Cast (old design)] failed shortly after installation in 1976 and was deleted from the evaluation. A new Fab-Ra-Cast design is now available but to date this design has not been installed for evaluation on Michigan trunklines. The first generation design of Parkco, Steelplank, and Gen-Trac (I) failed to perform satisfactorily and all have been redesigned to improve their performance.

Because of complete failure, or redesign, of the first-generation crossings, the units currently being evaluated have only been in service from one to seven years. Therefore, the performance information obtained to date is insufficient with respect to accepting the materials for unlimited use. However, based on this year's and previous inspections the following general conclusions are made:

1) The following materials have shown satisfactory performance to date to continue to be included in the program for further evaluation: Steelplank (new design), Parkco (new design), Saf and Dri (Model S and Model C), Cobra X, and Strail.

2) Parkco (old design), Steelplank (old design), and Gen-Trac (I) have experienced failures requiring considerable maintenance work and consequently are classified as unsatisfactory materials.

3) The performance of crossing materials is linked to the ADT volumes using the crossing. Therefore, limitations appear justified based on ADT volumes for which the materials will satisfactorily serve.

4) Failure to follow the manufacturers' recommended installation procedures with respect to subbase reconstruction and use of properly dimensioned ties, and correct spacing, can cause premature failure of the crossing surface.

5) An important factor in prolonging the performance of the crossing is timely scheduled maintenance by both the roadway and railroad agency.

Recommendations

The following recommendations concerning the establishment of a Qualified Products List, limitation on number of experimental crossings to be permitted, and repair of failed crossings, have been discussed with, and agreed upon, by personnel from the Department's Railroad and Municipal Section:

1) Qualified Products List - It is recommended that the attached Qualified Products List containing the surface materials currently considered to be of sufficient quality to provide satisfactory performance for the traffic volume ranges specified be approved.

Note that qualification of a product for a particular ADT does not mean a blanket approval for unlimited use. Any product may be removed from the Qualified Products List as dictated by subsequent performance evaluation.

Based on previous experience and judgement, the Goodyear crossing has been included as an acceptable alternate for an ADT "over 2000" and a premium grade and an industrial grade timber crossing have been included as acceptable alternates for ADT's "up to 5000" and "up to 2000," respectively.

Installation procedures will be as specified by the product manufacturer who will be responsible for informing the railroad personnel about the required installation techniques.

The Department will be responsible for ensuring that the product to be used at a certain crossing meets the ADT volume requirements.

The Qualified Products List will be reviewed periodically for updating to reflect any changes that may occur in the performance of any crossing material.

2) Experimental Materials - Experimental crossing materials will continue to be processed through the Department's New Materials Committee. The information submitted to the committee by a manufacturer

will be subject to an initial review which may result in, a) rejection, b) recommendation for experimental use, or c) inclusion on the Qualified Products List. A material recommended for experimental use will be subject to a minimum five-year evaluation period. However, after two years of satisfactory service the material may be placed on the Qualified Products List with appropriate limitations, as required.

Experimental materials will be installed as recommended by the manufacturer who will be responsible for informing the railroad personnel concerning the installation techniques.

Experimental crossings will be limited to a total of four, one each at crossings with the following ADT volumes: up to 2,000, 2,000 to 5,000, 5,000 to 10,000, and over 10,000.

The proprietary products currently qualified for experimental installations are:

Fab-Ra-Cast (new design)
Greenhart Timber
Strail
Gen-Trac (II)

3) Failed Crossings - Crossings surfaced with Steelplank (old design), Parkco (old design), and Gen-Trac (I) have experienced failures and they will be deleted from further evaluation.

Crossings containing these materials will need to be maintained or replaced. The manufacturers of the Parkco and Steelplank crossings have in some cases furnished replacement panels for the failed ones. The Gen-Trac manufacturer is recommending repair of the worn ties by using a filled epoxy and then reinstalling the same panels. Repair systems recommended by a manufacturer will be evaluated for their effectiveness.

4) Additional effort should be made to ensure that the materials are properly installed and a quality base material, thoroughly compacted, should be used to minimize crossing settlement. The best quality ties of the proper dimension, and installed at the required spacing, is needed to ensure proper fastening of bolted surfacings.

5) Finally, it is recommended that a preventive maintenance program by both the roadway and railroad agency be considered. A few occasional minutes spent to tighten a bolt or a few hours to smooth the pavement/crossing joints should prevent premature, costly and inconvenient closures for major repairs or reconstruction.

Michigan Trunkline
Railroad Grade Crossings
Qualified Products List

Product	Range in ADT Volume
Goodyear (Super Cushion)	
Saf and Dri (Model C and Model S)	2,000 and over
Red Hawk	
Parkco (new design)	
Steelplank (new design)	up to 5,000
Cobra X	
Timber (premium grade)	
Bituminous	up to 2,000
Timber (industrial grade)	

Disqualification

Any product may be removed from the Qualified Product List should any problem develop during installation and/or performance evaluation. The Department must be notified in writing of any change in design or product formulation. Specific changes may require re-evaluation of the product.