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COOPERATIVE
RESEARCH

RAILROAD GRADE CROSSING ACCIDENTS
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RAILROAD GRADE CROSSING ACCIDENTS

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1. "AFO Circuits protect crossing", Ry Signaling & Communications 52: n 6, June 1959,p 19-22.

   Detroit, Toledo & Irontown has installed flashing light signals controlled by Audio Frequency Overlay track circuits at highway crossing on Dearborn branch that runs 13 mi from Flat Rock yard to Ford Motor Co Rouge Plant; use of AFO circuits avoided interference with existing track circuits and simplified approach that extends into interlocking maintained by another railroad; circuit diagram.

2. "A report to the Louisville Railroad Planning Commission on grade separations, railroad facilities and major trafficways", October 1950, plates, strip maps, exhibits. DeLeuw, Cather & Company, Engineers, Chicago.

   ...Our report proposes certain consolidations of freight houses, improvement in track connections and facilities, relocation of certain terminal facilities, and other projects which are largely of concern to the railroad companies themselves and only indirectly the concern of the City of Louisville. These recommendations, which have not been generally accepted by the railroad companies, were made in view of the obvious need for improvements in plant which would permit speeding up freight movements and deliveries in the Louisville area. A number of awkward and, in our opinion, unnecessarily slow freight movements which now exist could be eliminated through a relatively moderate capital outlay. This type of improvement, we believe, would result in checking the serious inroads on railroad freight traffic which the trucking industry has already accomplished...

3. Chubb, T.M., "Railroad crossing protection", Traffic Safety Research Rev 4: n 3, pp 12-21, September 1960.

   Presented is a plan which can be used to establish the best and most effective crossing protection wherever it is needed. This presentation is made through an orderly analysis of the factors which have been considered to improve public safety at railroad grade crossings in the City of Los Angeles.

   By following a program for crossing protection improvements it has been possible to reduce accidents at grade crossings in Los Angeles. A study involving the investigation of approximately 400 crossing years experience indicates that by the installation of No. 8 flashing light signals and the coordination of traffic signals with railroad operation, it has been possible to reduce accidents experienced by 76 percent and to reduce the fatalities more than 85 percent. Studies made by other agencies indicate similar public safety improvement by the installation of automatic crossing protection.

It might be helpful to summarize the various things that have been discussed to accomplish the improvement of crossing protection for the enhancement of public safety. First, a priority list should be developed by the use of a recognized formula to insure the orderly development of a plan for improvement crossing protection. This plan should be consistent with those of other jurisdictions.

Next, proposed installations of crossing protection should be made upon facts developed by field inspections of the individual crossings. The most important factors for consideration are conflict (train and vehicle movement), visibility, distractions, unusual physical conditions, and accidents. The other factors which have been indicated, such as special types of traffic, train speeds, activity of trains at the crossing, and the several other factors must also be considered and evaluated. Certain installations may be made based on one factor alone such as the requirement for automatic protection at a high-speed railroad line.

Lastly, coordination of traffic signals with railroad operation is also necessary when the railroad crossing is located close to or adjacent to a signalized street intersection.

4. "Efforts to reduce grade crossing accidents show results", American Highways XXXIV: n 4, October 1955, p 20.

Despite a steady increase in the number of motor vehicle registrations throughout the years, studies recently completed by the Association of American Railroads show that continued efforts to reduce highway-railroad grade crossing accidents have been highly successful, in spite of the fact that new highway crossings of railroads are being created about as rapidly as highway-railway grade separations are constructed. In the face of an all time high in motor vehicle registrations, aggregating 58.6 million in 1954, both fatal and non-fatal injuries in the past year were the lowest of record in the past twenty-seven years. Casualties (killed and injured) per 10,000 automobiles registered were 0.76 in 1954 compared with 0.90 in 1953, and 3.42 in 1928.

Since 1928 when the casualties for 10,000 automobiles registered was a high of 3.42, there has been an almost constant reduction in such casualties. In 1938, ten years later, the rate was 1.73. In 1940 the rate was 1.88 dropping again to 1.74 in 1943 and again reaching 1.86 in 1945. Since 1945 the drop has been constant and was the lowest on record in 1954, at a rate of 0.76.

There were 3,074 accidents in 19543 involving automobiles in which 1,151 persons were killed and 3,314 injured. Of these 3,074 accidents, 66 percent resulted from motor vehicles being struck by trains, while 34 per cent were the result of motor vehicles running into the side of trains. Fifty-five per cent occurred in daylight, while 45 per cent occurred after dark.

Thirty-six per cent of these accidents were at crossings protected by gates, lights, bells or watchmen.

The types of trains involved in these accidents were 54 per cent freight trains, 29 per cent passenger trains and 17 per cent yard or work trains. Sixty-two per cent of the accidents involved trains moving at 29 miles per hour or less, or standing still.

5. Hays, Joseph H., "Can government curb grade-crossing accidents?" Traffic Safety 64: n 4, April 1964, p 16-18.

There is beginning to emerge from the recent invetigation conducted by the Interstate Commerce Commission a better understanding of the role which should be played by government in grade-crossing safety. The proceedings have broughtto light a number of important concepts, some of which are new and some of which are partly so. While collisions between trains and motor vehicles are, numerically, a small part of the over-all highway safety problem, the severity of these accidents and their frightening fatalities, injuries and property loss are so great as to justify special effort to prevent them.

From a review of the problem in all of its aspects, it is evident that prospects for improvement lie in two broad fields: first, better enforcement of laws and regulations applying to the drivers of motor vehicles at railway-highway crossings; and, second, the installation of more grade separation structures and automatic protective devices.

It is obvious that there would be no collisions between trains and motor vehicles if there were no intersections at common grade between highways and railroad tracks. However, as of Jan 1, 1960, there were 224,547 such intersections in the continental United States. A fair estimate of the cost of separating all these crossings is $86,119,119,000. This is more than three times the total capital investment in all the railroad plant. Separation of all such crossings would not only be prohibitive in cost but clearly unnecessary.

6. Herman, Robert and George Weiss, "Comments on the highway-crossing problem", Operations Research 9: n 6, pp 828-840, November-December 1961.

A discussion is given of the gap acceptance problem confronting a driver at a stop sign who is attempting to cross a single lane of traffic. This problem is discussed in the light of a gap acceptance probability that is taken in the form: $\alpha(t) = 0$ when $t < T$ and $1 - \alpha(t) = \exp[-\lambda(t-T)]$ when $t > T$, rather than a step function as has been considered in the past. Some experimental information is discussed concerning the values of the parameters λ and T in such situations. This information coupled with theoretical considerations allows one to estimate quantities such as mean delay time, probability of zero delay, and highway transparency. Comments are made concerning the influence of car performance on road crossing and on entering highways.

7. Jorlett, J.S., "Merit of various types of highway-railway grade crossing protection", American Railway Engineering Association Bul 61: n 553, pp 271-272, November 1959.

In 1957 the Armour Research Foundation, under an arrangement with the Association of American Railroads, processed the data of the characteristics of 2291 Chicago, Rock Island & Pacific highway--railway grade crossings in Iowa and the 1395 accidents that had occurred over the 16-yr period, January 1, 1941, to December 31, 1956. The date, tabulated on IBM cards, were processed on the Foundation's 650 digital computer. In the 1958 Proceedings, Vol. 59, p 1162, is a detailed report of this project presented by G.M. Magee, director of engineering research, AAR. He cited the prediction equation that was evolved and made suggestions for further investigation. The prediction equation produced contredictory results, which was attributed either to inconsistent and insufficient data or unknown factors that interacted with known crossing characteristics.

It was felt that additional information should be obtained on more crossings with improved and upgraded protection, and the State of Ohio was contacted in regard to a survey that had been made of the physical characteristics of railroad crossings in Ohio. This state has 10,852 highway-railway grade crossings, ranking 5th in the nation. Of these, 2,725 have some type of protection other than fixed crossbuck signs. Ohio ranks 4th in the number of auto-train accidents and also rates quite high in the number of fatalities, although the number has been declining steadily over the past 2 decades.

The State of Ohio has recognized the importance of determining the potential hazard of a crossing and for many years has used the Bureau of Public Roads' formula, the study of Wm. J. Hedley, chief engineer of the Wabash Railroad, and also some of its own ratings. However, it is desirous of determining a formula suitable to Ohio's crossings and has formulated the physical characteristics of each of its crossings on duplicate IBM cards and furnished them to the AAR for this study at no cost. Early in 1959 it was agreed by the State of Ohio, the director of engineering research for the AAR, and the Area Committee that the highway-railway grade crossing accident records over a 10-yr period of the 14 largest railroads operating in Ohio would be more representative of crossing conditions for the continued grade crossing hazard rating survey than those on the Rock Island in Iowa. These 14 railroads in Ohio have furnished their accident records for the 10-yr period from 1948 to 1958 at nominal cost to cover the preparation of their summary reports. The Armour Research Foundation is classifying the data, preparing summary tables for the investigation of correlation between accidents and grade crossings.

8. McLaughlin, W.A., "Highway-railway grade crossing treatments", <u>Canadian Good Roads Association Technical Pub</u> No. 13, October 1960, 84pp.

The problem of highway-railway crossings at grade, as related to the safety and convenience of the public,had its origin with the first railway built. It has been greatly magnified by the increase in mileages of roads and the vastly increased amount of travel on them.

There are two solutions to the proble:

1. Provide improvements to the crossings by installing or effecting better protective measures.

2. Eliminate grade crossings by railway or highway relocations or by the construction of grade separations.

To provide these solutions at all crossings is economically impossible in a short period of time. Therefore, sound policies must be developed to find the most adequate and economical solution to the problem.

The basis of demand for railway-highway grade crossing improvements or elimination is still one of inherent hazard. This basis is correct for crossing improvements up to the maximum protective device short of a separation.

The maximum protective device (short of a separation) is the automatic short arm gate with flashing lights and bells. This device provides maximum protection to all but the foolhardy or mentally defective driver.

Delay and inconvenience to the highway user is replacing inherent hazard as the demand for separations.

The gross number of crossing accidents is increasing but at a much slower rate than other highway accidents. The crossing accidents, on a rate basis, are declining. Crossing accidents (involving death and injury) account for less than 1 percent of all highway accidents (involving death and injury).

Before a crossing improvement is undertaken it must be justified economically. That is, the benefits from the incremental improvements to the crossing must equal or exceed the incremental costs occasioned by these improvements. Further the excess gains over costs must be equal to or greater than the excess of gains over costs to be derived by an expenditure of like funds on some other segment of the highway plant.

For improvements short of separations, only the provincial or municipal and railway contributions need be considered in an economic analysis.

A general numerical warrant based upon economic considerations may be developed for improvements short of separations.

9. "Plastic markings for railroad crossings", Public Works 92: n 3, p 132, March 1961.

A major program of marking dangerous railroad grade crossings in Ohio with permanent-type white, reflectorized Plastix "RR" legends and "Stop" bars has been inaugurated by the Department of Highways following successful test applications of thenew legends at two crossings.

Initial attention will be concentrated on installing the Plastix legends at 110 grade crossings with bad accident histories.

The special railroad crossing legends are applied directly to the pavement, in the right lane. Distance from legend to railroad tracks is determined by a special formula, as is the placement of a "Stop" bar, also of Plastix, located between the legend and the tracks.

The survey also pointed out that the greatest returns in increased safety for dollar volume of investment could be realized in the fields of warning devices and improved sight distances.

Use of the permanent-type Plastix for legends and stop bars has been recommended in view of the long life of the material, which stands up under traffic and weather for years. Coated with a special adhesive, the Plastix adheres immediately to the surface of the highway, and under traffic quickly becomes almost an integral part of the pavement, with little wear under cinders, salt and even snow plows.

10. "Rail-highway grade crossing accidents, 1935-1954", Interstate Commerce Commission, Bureau of Transport Economics and Statistics, U.S. Department of Commerce, Statement No. 5521, 123pp.

A partial summary of thefindings of this study shows that:

In the 20 years, 1935-1954, there were 78,036 accidents at railroad-highway grade crossings, or 3,902 per year. Persons killed numbered 33,558, or 1,768 per year, and persons injured 86,278, or 4,314 per year.

While it cannot be definitely concluded that a downtrend in crossing accidetns has set in during recent years, accidents, deaths, and injuries average 5.4, 10.8 and 12.7 per cent fewer in 1950-1954 than in 1935-1939.

About 90 percent of crossing accidents in 1950-1954 involved motor vehicles. The reduction in this group of accidents, 1950-1954 compared with 1935-1939, was 2.07 per cent, or considerably less than the reduction in all crossing accidents.

The severity of accidents, measured by the ratio of the number of deaths or injuries to the number of accidents, has tended to decrease irregularly.

There was a net reduction from 234, 231 grade crossings in 1935 to 226,522 in 1954, or about 3.3 percent, with a year-to-year decline in crossings without special protection and an increase in crossings with special protection. There is about one crossing per mile of line, but some crossings have very limited use. The average number of crossings eliminated by separation of grade was 258 per year in 1935-1942 and 44 per year in 1943-1954.

Rail-motor vehicle accidents at specially protected crossings, 1941-1954, were about 36 percent of all crossing accidents which involved motor vehicles; crossings with special protection constituted 14 percent of all crossings in 1941 and 17 percent in 1954. Special protection is provided at the most hazardous and heavily traveled crossings. The number of accidents per 100 crossings in the specially protected group decreased about 31 percent, 1954 compared with 1941; the reduction was about 18 percent for crossings which had no sign or signal indicating train approach. No data are at hand as to the number of passages over crossings of the various types.

Statistics used in this study do not enable evaluations of the relative merits of different types of crossing protection, but shifts in types of protection provided, described in the study, can be assumed to reflect experiences with different types.

The number of crossing accidents occurring in daylight somewhat exceeds the number occurring after dark, but in terms of relative vehicle travel in daylight and after dark, accidents were about twice as frequent after dark.

The study brings out other aspects of the record of grade-crossing accidents and the problems they present to railroads and public authorities.

11. "Railroad crossings surveyed for traffic delays", Cook County Highways 4: n 11, pp 4-5, 6, 7, April 1957.

The Cook County Highway Department recently conducted a study to determine the amount of vehicular delay at grade level railroad crossings. Three hundred and eleven crossings in the county outside of Chicago were surveyed between the hours of 7 a.m. and 1 p.m.

This was done by measuring each length of time the crossing was closed and counting the number of vehicles delayed by each respective closing of the crossing. The average vehicle delay for a particular closing of the crossing was taken to be t/2, where t is equal to the time in minutes that the crossing was closed. Then it follows that the total minutes of vehicular delay for a particular closing of the crossing is the number of delayed vehicles multiplied by the average delay, t/2, per vehicle. The total minutes of vehicular delay, vmd, for all closings of a crossing is the sum of the delays of the individual closings.

It seemed desirable to develop a formula for estimating vehicle minutes of delay by use of which a reduction can be achieved in the man-hours required per crossing. Two such formulas were developed and are presented here.

The simplest formula is the first one which expresses vmd only in terms of (1) the per minute traffic volume across the tracks and (2) the length of time the gates are down. This formula is basically the one used in the preparation of the rank order list. It is felt that for ranking purposes this formula does an adequate job with a minimum of field and computational labor.

The second formula takes driver reaction time into consideration and allows for an additional deceleration-acceleration factor.

Main objective of the study was the compilation of a rank order list intended to serve as a guide to a priority system for the construction of grade separations.

Each crossing is ranked by its total hours of vehicle delay. The crossing with the greatest amount of delay is ranked number one, that with the second greatest amount number two, etc.

A list of the 200 highest ranking crossings, withthe number of vehicles crossing the tracks in the six-hour period and the total delay at each, is given.

12. "Santa Fe tests AF track circuits", Ry Signaling & Communications 51: n 11, Nov 1958, p 32-6.

Test of audio frequency track circuits for control of highway crossing protection at Pauline, Kan, on single track main line from Kansas City to Emporia via Topeka; frequencies in range of 1.0 to 2.0 kc per sec can be connected to rail to feed definite distances; with this equipment, approach circuits to give 20 sec warning in advance of train traveling 136 mph may be operated; circuit diagram.

13. "Speed with safety at railroad crossings", Research for Industry, Stanford Research Institute (Menlo Park, Calif) 15: n 1, pp 14-15, Jan 1963.

A research project sponsored by Southern Pacific in SRI's Control Systems Laboratory has now resulted in development of a new device, an electronic "Grade Crossing Predictor," that represents a simplification and improvement over present protection controls.

The methods in standard use for closing barrier gates at crossings are based on a modified block system. When a train enters a zone near a road crossing, a warning signal is transmitted to put the gate, flashing lights, and bell into operation. In the basic zone system, it makes no difference how fast or slow the train is moving or even if it stops--the gates remain down until the train leaves the zone.

Southern Pacific wanted a system that would minimize delays to highway cross-traffic by taking into account the speed and position of approaching trains at all times and activate the advance warning signals in synchronization with train speeds.

A system was devised which treats the rails as a transmission line, and does not require multiple cuts in the rail or associated signal relays. The rails are energized by an alternating-current source, and a train on the tracks acts as a short circuit. The a-c reactance is related to the distance to the short, and the rate of change of reactance tells how fast the train is approaching. Thus, the predictor "looks" down the tracks, detects the distance to an approaching train and the train's speed, then calculates when the train will arrive at the crossing and lowers the gate atthe safe time. Fail-safe features are incorporated into the system to insure against breakdown.

Southern Pacific has conducted long-term field experiments to test the system's reliability. SRI's experimental predictor was installed two years ago in an area where a great deal of switching takes place. Although it did not actually operate the gate--a conventional signal system was used--it recorded warning time given by the predictor and allowed comparison of the two systems.