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Railroad-Highway Grade Crossings: Update

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Foreword

In January 1972, the Transportation Research Board Committee on Railroad-Highway Grade Crossings (A3A05) began preparation of an annotated bibliography on railroad-highway grade crossings. That effort culminated in the publication in 1976 of Bibliography 57, Railroad-Highway Grade Crossings. This publication represents the first update to Bibliography 57. It is designed to provide a comprehensive and convenient reference document for researchers, highway and traffic engineers, railroad signal and crossing engineers, and officials in public agencies and the private carrier industry.

This update contains 48 new entries; each provides complete source information, key words, and an annotation or abstract. Also listed are addenda to selected entries from Bibliography 57 (each addendum is keyed by number to the original entry in Bibliography 57; the numbering system is the same as that used in this update). The entries are arranged by year of publication and then alphabetically by author. With the exception of a few earlier studies, they encompass the period from 1976 through mid-1979. Most references were published in the United States.

A list of key words summarizes the subject areas covered and may be used to identify and locate entries that pertain to a specific topic. An author index is also provided.

Criteria for inclusion of documents in the bibliography were that they must be substantive and must have made a significant contribution to the state-of-the-art literature in the general area of railroad-highway grade crossings. Excluded were documents that contained opinion only, summaries or reviews of primary documents, periodic compilations of grade-crossing accident and inventory data, descriptions of specific safety improvement studies, and general-interest magazine articles.

Source material was originally compiled from searches of the Highway Research Information Service, the Railroad Research Information Service, bibliographies maintained by the National Highway Traffic Safety Administration, holdings in the U.S. Department of Transportation Library, the personal files of members of the Committee on Railroad-Highway Grade Crossings, and publications of other national committees on grade crossings.

The project was conducted under the direction of a subcommittee chaired by William D. Berg. Subcommittee members included Charles L. Amos, Louis T. Cerny, Bruce L. Gordon, and the late B. M. Stephens. Source material for the update was provided largely by members of Committee A3A05, either directly or by referral.

-Otto F. Sonefeld, chairman
Committee on Railroad-Highway
Grade Crossings

Contents

SELECTED REFERENCES

56-1 (addendum) See also: Stalder, H. I. and A. R. Lauer. EFFECTIVE USE OF REFLECTORIZED MATERIALS ON RAILROAD BOXCARS. Highway Research Board, Bulletin 89, 1954, pp. 70-75.

72-16 Messiter, G. F. CRASHES AT RAILWAY LEVEL CROSSINGS. New South Wales Department of Motor Transport, Australia, March 1972, 35 pp.

Key Words: accident characteristics, accident reports, highway traffic operations

The 486 accidents reported by Police to have occurred at railway level crossings in New South Wales in the four years 1966 to 1969 were studied. Less than half were collisions between a motor vehicle and a rail vehicle. The remainder were mostly collisions between motor vehicles and fixed objects such as the crossing gates, fences, signposts and so on. The distribution of reported motor vehicle speeds in the latter group approximated the normal distribution. However, the reported speeds of motor vehicles that collided with rail vehicles followed the negative exponential distribution. This implies that exposure time at the crossing has an influence on the incidence of accidents. Consequently, there is a possibility that a legal requirement that a vehicle stop at a crossing it is otherwise free to cross may increase rather than decrease its risk of collision by prolonging the time it will spend in the conflict area. At some crossings sight distances, the approach speeds of trains and the performance limits of motor vehicles will so combine that automatic train-actuated warning devices will be the only reliable protection against collision. Surveys of motor vehicle speeds at crossings having a variety of environmental conditions and methods for controlling road traffic showed that a crossing open to motor vehicles has little influence on the speed of them, and that the drivers traversed the crossings at speeds which were not significantly different from their speeds on adjacent road sections with similar geometry and other characteristics. The distribution of vehicle speeds traversing crossings approximated the normal distribution. The Spatial distribution of both groups of accidents (motor vehicle-rail vehicle collisions and motor vehicle/fixed object collisions) over the 2,790 level crossings in New South Wales followed a Poisson (random) distribution.

73-14 (addendum) See also: van Belle, G., D. Meeter, and W. Farr. INFLUENCING FACTORS FOR RAILROAD-HIGHWAY GRADE CROSSING ACCIDENTS IN FLORIDA. Accident Analysis and Prevention, Vol. 7, No. 2, June 1975, pp. 103-112; Lavette, R. A. DEVELOPMENT AND APPLICATION OF A RAILROAD-HIGHWAY ACCIDENT-PREVENTION EQUATION. Transportation Research Record 628, 1977, pp. 12-18.

74-4 (addendum) Federal Railroad Administration, U.S. Department of Transportation, Report FRA-OR&D-75-8; National Technical Information Service, Springfield, Virginia, PB 244 175.

74-12 (addendum) See also: Schulte, W. R. EFFECTIVENESS OF AUTOMATIC WARNING DEVICES IN REDUCING ACCIDENTS AT GRADE CROSSINGS. Transportation Research Record 611, 1976, pp. 49-57.

75-2 (addendum) National Technical Information Service, Springfield, Virginia, PB 244 532.

75-4 National Technical Information Service, Springfield, Virginia, PB 259 005.

(addendum)

75-5 (addendum) National Technical Information Service, Springfield, Virginia, PB 244 584.

75-6 (addendum) National Technical Information Service, Springfield, Virginia, PB 244 551.

75-12 (addendum) National Technical Information Service, Springfield, Virginia, PB 242 462.

75-13 (addendum) See also: St. Amant, A. POTENTIAL MEANS OF COST REDUCTION IN GRADE CROSSING AUTOMATIC GATE SYSTEMS. Volume I: Overview and Low Cost Railroad/Highway Grade Crossing Gate Systems, MB Associates, San Ramon, California, February 1977, 90 pp.; Federal Railroad Administration, U.S. Department of Transportation, Report No. FRA/ORD 77-06.I; National Technical Information Service, Springfield, Virginia, PB 265 724; and Hopkins, J. B. GRADE-CROSSING WARNING-SYSTEM TECHNOLOGY. Transportation Research Record 628, 1977, pp. 1-5.

75-15 Anderson, R. L. LOCOMOTIVE TO AUTOMOBILE BASELINE CRASH TESTS. Dynamic Science - Division of Ultra systems, Phoenix, Arizona, August 1975, 150 pp.; Federal Railroad Administration, U.S. Department of Transportation, Report FRA-OR&D-76-03; National Technical Information Service, Springfield, Virginia, PB 250 564.

Key Words: crash testing, on-train devices, vehicle dynamics

Four Locomotive to Automobile Crash tests were performed by the Dynamic Science Division of Ultrasystems at DOT's High Speed Gound Test Center under contract to the Transportation Systems Center, which is conducting the work for the Federal Railroad Administration. This report documents these four tests, which will provide baseline data for evaluation of future locomotive front structure modifications designed to attenuate the severity of the grade crossing accident. The automobiles were all 1973 standard size sedans of the same model with similar options. For each test, a 130-ton Alco locomotive impacted a stationary automobile at a nominal 50 mph. The first two tests contained no instrumentation on either the locomotive or automobile except for high-speed cameras. The last two tests were instrumented repeats of the first two tests which also involved a direct side impact and a side impact centered on the automobile front fender. The last two tests had an anthropomorphic dummy in the automobile and over 50 accelerometers installed in it. Each test had extensive high frame rate photographic coverage.

75-16 Dommasch, I. N., R. L. Hollinger, and E. F. Reilly. PASSIVE CONTROL AT RAIL-HIGHWAY GRADE CROSSINGS. Bureau of Operations Research, Division of Research and Development, New Jersey Department of Transportation, Trenton, New Jersey, December 1975; pp. See also: I. N. Dommasch, R. L. Hollinger, and E. F. Reilly. PASSIVE CONTROL AT RAILROAD-HIGHWAY GRADE CROSsings. Transportation Research Record 611, 1976, pp. 58-59.

Key Words: conspicuity, crossbucks, driver behavior, highway traffic operations, innovative systems, passive warning devices

Improved designs for passive grade crossing control were evaluated on the basis of spot speeds, head movements of motorists, brake light applications, and motorist interviews. Two combinations of experimental advance warning and crossbuck signs were studied by making before and after comparisons of two control changes: (a) as is conventional to upgraded conventional and (b) upgraded conventional to experimental. The before and after studies were compared, and an increase of motorists awareness was noticed at all sites where experimental signs were used. Differences among experimental signs were noticed when the signs were considered together (advance and crossbuck) and in combination with other changes. It was found that the experimental signs using brilliant yellow-green scotchlite were more noticeable than yellow experimental signs. Other changes included a reduction in the variance of spot speeds at nine out of ten sites and an increase in the percentage of motorists observed applying brakes at seven out of seven sites.

75-17 Holmstrom, F. R. LIGHTNING AND ITS EFFECTS ON RAILROAD SIGNAL CIRCUITS. Lowell Technology Institute Research Foundation; Lowell, Massachusetts, December 1975, 106 pp.; Federal Railroad Administration, U.S. Department of Transportation, Report FRA-OR&D-76-129; National Technical Information Service, Springfield, Virginia, PB 250 621. See Also: Hopkins, J. B. GRADE-CROSSING WARNING-SYSTEM TECHNOLOGY. Transportation Research Record 628, 1977, pp. 1-5.

Key Words: active warning devices, signal components, signal control systems

This study discusses the occurrence of lightning, its effects on railroad signal equipment, and protection of such equipment from lightning damage, with special attention to known protective techniques which are employed in a variety of situations in the power, communications, and railroad industries. A brief review is offered of the causes of lightning and other surges, followed by an extensive treatment of the means by which lightning and power-line transients induce surges and over-voltages in signalling circuits. Specific topics include the effects of the direct stroke current, the collapsing electric field when the stroke occurs, inductive coupling, and the effects of ground currents in the earth. A survey of protective devices and techniques currently in use for specific types of equipment is presented, including categorization of arrestors by type and application. Preferred lightning protection practices in railroad signalling are examined and related to practices in other fields. The problem of lightning protection is addressed from an overall systems viewpoint, encompassing development and testing of protective systems and design of systems, so that they can more easily be protected. Recommendations for future research are made.

75-18 Newton, T. M., R. L. Lytton, and R. M. Olson. STRUCTURAL AND GEOMETRIC CHARACTERISTICS OF HIGHWAY-RAILROAD GRADE CROSSINGS. Texas Transportation Institute, Texas A&M University, College Station, Texas, Research Report No. 164-1, August 1975, 113 pp.

Key Words: crossing surfaces, grade crossing characteristics

This report is the first in a series dealing with structural and geometric characteristics of highway-railroad grade corssings. The seven chapters cover distribution and geometric characteristics of crossings, appraisals of some existing crossings, surface and subsurface drainage systems, crossing evaluations, computer simulation of dynamic loads at crossings, subgrade stabilization fabrics, and structural details.

76-2 Ahmad, A. and R. L. Lytton. COMPUTATION OF DYNAMIC LOADS AT GRADE CROSSINGS; A USER'S MANUAL OF THE COMPUTER PROGRAM. Texas Transportation Institute, Texas A&M University, College Station, Texas, Research Report 164-2, January 1976, 65 pp.

Key Words: crossing surfaces

This report gives the theoretical background and a description of a computer program, DYMOL, along with its revisions. This program was originally written to calculate the dynamic forces applied normal to a rigid surface by moving traffic. Revisions are made in the program to include the flexibility (stiffness, damping and inertia effect) of the riding surface, and a special subroutine is added to generate typical grade crossing profiles. Input formats, program listing and a glossary of variables are given for the use of the program. Also included with the report are the descriptions of the program's subroutines and functions and method of calculation of dynamic loads along with Maysmeter readings.

76-3 Ahmad, A., R. L. Lytton, and R. M. Olson. AN ANALYSIS AND DESIGN PROCEDURE FOR HIGHWAY-RAILROAD GRADE CROSSING FOUNDATIONS. Texas Transportation Institute, College Station, Texas, Report 164-4F, November 1976, 104 pp.

Key Words: crossing surfaces

In this study a design system for a grade crossing is developed. A unique design criterion of permanent differential deformation between railroad track and adjacent highway pavements is established. This criterion is related to other existing criteria, available in pavement design literature, which are related to the rideability. Polynomial stress equations are developed separately for railroad and highway pavements under their typical design wheel loads to predict stresses at different depths. Characteristic properties of all materials involved, such as resilient modulus and permanent deformation under repeated loading, are considered. The influence of environmental factors such as temperature and moisture balance on subgrade material characteristics is also included. A computer program is developed to calculate the differential deformation (the design criterion) for the purpose of the design of a grade crossing.

76-4 Coleman, J., and G. R. Stewart. INVESTIGATION OF ACCIDENT DATA FOR RAILROAD-HIGHWAY GRADE CROSSINGS. Transportation Research Record 611, 1976, pp. 60-67.

Key Words: accident prediction, hazard evaluation criteria, priority ratings, warrants

This paper discusses some of the results of investigations of railroad-highway accidents and accident-related inventory information that was collected from 15 states and three railroad companies. Statistical techniques were applied to tabulated data to obtain prediction equations for accident frequency and severity of various grade-crossing situations. The results of the analysis and the uses of prediction equations for the development of warrants for safety improvements are also discussed.

76-5 COORDINATION OF TRAFFIC SIGNALS WITH RAILROAD GRADE CROSSING PROTECTION. Transportation Engineering, Vol. 46, No. 12, December 1976, pp. 44-47.

Key Words: active warning devices, interconnection, traffic signals

Preemption sequences for various geometric conditions are presented in figures, and criteria for adequate grade crossing preemption and coordination are listed. The preemption sequences illustrated cover signalized intersection of 4-lane undivided roadways - 2 phase operation; signalized intersection of 4-lane undivided roadways with railroad bisecting intersection - 2 phase operation; signalized intersection of 2-lane roadways with railroad bisecting intersection - 2 phase operation; and signalized intersection of 2-lane roadways with a railroad crossing on two approaches - 2 phase operation. The recommendations presented were developed after evaluation of information from a literature review and from contacts with engineers from states, counties, and major cities.

76-6 Edris, E. V. Jr. and R. L. Lytton. DYNAMIC PROPERTIES OF SUBGRADE SOILS, INCLUDING ENVIRONMENTAL EFFECTS. Texas Transportation Institute, Texas A&M University, College Station, Texas, Report 164-3, 157 pp.

Key Words: crossing surfaces

Three fine-grained soils, varying in clay content between 20% and 70%, were tested in a unique repetitive loading apparatus to determine how soil suction, temperature, and stress state affect the resilient modulus and residual strains expected under highway and railroad loadings. In developing equations to predict these dynamic properties, three values of soil suction, stress intensity, and temperature were used in tests of each of the three soils in a statistically designed experiment. A fundamental change in the behavior of the tested soils from "effectively saturated" to effectively unsaturated" occurs at a soil suction corresponding to two percent dry of the optimum moisture content. The critical soil suction is directly related to the clay content of the soils. This relation has important implications for the climatic design and stablization of highway pavements and railroad grade crossings.

76-7 Herbert, A. J., and N. M. H. Smith. ANALYSING RAILWAY CROSSING ACCIDENT DATA. Australian Road Research, Vol. 6, No. 3, September 1976, pp. 24-33.

Key Words: accident prediction, hazard evaluation criteria

This paper discusses the application of maximum likelihood analysis to the prediction of long-term accident rates at rail-highway grade crossings. Theoretical concepts of the method are developed, including significance testing, and it is shown that traditional regression techniques are not usually applicable to sparse data of this type since accidents cannot be assumed normally distributed. Various model forms are developed and discussed from both a theoretical and practical viewpoint. Finally, the application of maximum likelihood methods to a fairly large set of accident data is described and some general conclusions given.

76-8 Holmstrom, F. R. STANDBY POWER FOR RAILROAD-HIGHWAY GRADE CROSSING WARNING SYSTEMS. University of Lowell Research Foundation, Lowell, Massachusetts, September 1976, 26 pp.; Federal Railroad Administration, U.S. Department of Transportation, Report No. FRA-OR&D-76-286; National Technical Information Service, Springfield, Virginia, PB 263 592. See also: Hopkins, J. B. GRADE-CROSSING WARNING-SYSTEM TECHNOLOGY, Transportation Research Record 628, 1977, pp. 1-5.

Key Words: active warning devices, innovative systems, signal components

The requirements for standby power at railroad-highway grade crossings, as established by the states, the Association of American Railroads, and the individual railroads, are described. Standard means of satisfying these requirements, using 115 vac primary power and storage batteries for standby, are compared with a number of new techniques, now passing from experimental to operational use, that incorporate solar cells or thermoelectric generators. In addition, other even more innovative techniques are examined. The conclusion of this survey is that for most railroad grade crossing applications, the existing standard techniques (reliance on ac primary power and standby storage batteries) will continue to be the preferred choice. In a number of circumstances in which the provision of ac primary power is very expensive, the combination of solar cells or thermoelectric generators as the primary source, with storage batteries as standby, will be optimal.

76-9 STUDY OF PUBLIC PEDESTRIAN CROSSINGS. Proceedings, American Railway Engineering Association, Vol. 77, 1976, 266-271 pp. See also: AREA Proceedings, Vol. 78, 1977, p. 249.

Key Words: active warning devices, passive warning devices, pedestrians

This informational report presents unique signs and automatic warning devices for pedestrian

and bicycle crossings which have been developed in three states. These signs and devices closely follow the pattern of standards found in the Manual on Uniform Traffic Control Devices.

77-1 Duttera, J., and M. Friedland. POTENTIAL MEANS OF COST REDUCTION IN GRADE CROSSING AUTOMATIC GATE SYSTEMS. Volume II: Improved Gate Arm Concepts for Railroad/Highway Grade Crossings, Gulf and Western AD&E Center, Swarthmore, Pennsylvania, February 1977, 66 pp.; Federal Railroad Administration, U.S. Department of Transportation, Report No. FRA/ORD 77-06 II; National Technical Information Service, Springfield, Virginia, PB 265 725. See also: Hopkins, J. B. GRADE-CROSSING WARNING-SYSTEM TECHNOLOGY. Transportation Research Record 628, 1977, pp. 1-5.

Key Words: gates, innovative systems, signal control systems

The results of a recent study of railroad-highway grade crossing warning system technology are presented. Emphasis in the investigation was placed on the determination of the potential for significant reduction in equipment, installation and maintenance costs through improvements sought within a framework of the basic (track circuit) system concepts now prevalent. This study comprises a comprehensive survey of current practices and hardware, an analysis of all major cost elements, and a consideration of potentially beneficial technical changes. The effort is concentrated on the equipment involved in train detection and the activation of warning devices. Special attention is given to European practices. The applicability of European signal relays and of mercury-wetted reed relays to the North American situation is analysed.

77-2 DuVivier, C. L., L. M. Rodgers, W. Scheffeld, and H. J. Foster. POTENTIAL MEANS OF COST REDUCTION IN GRADE CROSSING MOTORIST-WARNING CONTROL EQUIPMENT. Vol. I: Overview, Technology Survey and Relay Alternatives, Storch Engineers, Chestnut Hill, Massachusetts, December 1977, 190 pp., Federal Railroad Administration, U.S. Department of Transportation, Report FRA/ORD-77/45.I; National Technical Information Service, Springfield, Virginia, PB 277 946. See also: Hopkins, J. B. GRADE-CROSSING WARNING-SYSTEM TECHNOLOGY. Transportation Research Record 628, 1977, pp. 1-5.

Key Words: active warning devices, innovative systems, maintenance, signal components, signal control systems

This report, Volume II of a two-volume study, examines the potential for reduction of the cost of installing and maintaining automatic gates at railroad-highway grade crossings. It includes a review of current practices, equipment, and standards; consideration of modification of existing specifications to permit use of alternative technologies: generation of design concepts for new gate systems or subsystems intended to offer significant economic benefits; analysis and comparative evaluation of the more promising concepts; and conclusions concerning further design, development, and test activities. Concepts found to be particularly promising include a pneumatic gate-drive mechanism and a swing-away, gravity-resetting arm support intended to reduce the incidence of gate breakage; and a gate arm utilizing new materials to obtain resistance to breakage.

77-3 Hitz, J. S. SUMMARY STATISTICS OF THE NATIONAL RAILROAD-HIGHWAY CROSSING INVENTORY FOR PUBLIC AT-GRADE CROSSINGS. Transportation Systems Center, U.S. Department of Transportation, Cambridge, Massachusetts, Report DOT-TSC-FRA-77-10, June 1977, 160 pp.: Federal Railroad Administration, U.S. Department of Transportation, Report FRA-OPPD-77-8; National Technical Information Service, Springfield, Virginia, PB 271 334. See Also: Federal Railroad Administration, U.S. Department of Transportation, Report FRA-OPPD-78-20; September 1978, 156 pp.; National Technical Information Service, Springfield, Virginia, PB 293 070.

Key Words: grade crossing characteristics, inventory, statistics

In response to the Federal Railroad Safety Act of 1970, a joint government/industry effort to compile a national inventory of railroad-highway crossings was initiated in 1972 and completed in 1976. The inventory contains data on the physical and operational characteristics of all 402,000 railroad-highways crossings in the United States of which 219,000 are public at-grade, 142,000 are private, 37,500 are public grade separated and 3,500 are pedestrian. This series of reports presents periodic comprehensive statistical summaries of the characteristics for all public at-grade crossings reported in the inventory. This information will be useful at the Federal, state, and local levels for determining effective allocation of crossing improvement funds and developing R&D, legislative, information and education programs aimed at improving safety at crossings.

77-4 Holmstrom, F. R. POTENTIAL MEANS OF COST REDUCTION IN GRADE CROSSING MOTORISTS-WARNING CONTROL EQUIPMENT. Volume II: Comparison of Solid State and Relay Devices and Techniques, University of Lowell Research Foundation, Lowell, Massachusetts, December 1977, 50 pp., Federal Railroad Administration, U.S. Department of Transportation, Report FRA/ORD-77/45.II; National Technical Information Service, Springfield, Virginia, PB 277 947. See also: Hopkins, J. B. GRADE-CROSSING WARNING-SYSTEM TECHNOLOGY. Transportation Research Record 628, 1977, pp. 1-5.

Key Words: active warning devices, innovative systems, maintenance, signal components, signal control systems

Consideration is given to the properties of solid-state circuits, miniature relays and large gravity-operated relays when applied to control systems for grade crossings equipped with train-activated motorist warnings. Factors discussed include original cost and service-life cost, vulnerability to environment, reliability and fail-safety, power requirements, maintainability, complexity of tasks to be performed and economic scale.

77-5 Hopkins, J. B. GRADE-CROSSING WARNING-SYSTEM TECHNOLOGY. Transportation Research Record 628, 1977, pp. 1-5.

Key Words: active warning devices, conspicuity, innovative systems, signal components, signal control systems

This paper reviews the objectives, content, and results of a large number of research projects sponsored by the Federal Railroad Administration and related to possible improvement concepts associated with motorist-warning systems at railroad-highway grade crossings. The benefits sought included increased effectiveness, reduced cost, and elimination of institutional constraints. The subjects that were investigated include the application of modularization concepts and alternative components in warning-control logic systems, cost reduction in automatic gate equipment, flashing lights using xenon flashlamp technology, functional requirements and the relevant equipment for lightning protection and standby power, and studies of alternative or novel warning system concepts. The potential for meaningful advances is found to be limited and is severely constrained by the technically challenging nature of the functional and safety requirements.

77-6 Hopkins, J. B. and E. White. IMPROVEMENT OF THE EFFECTIVENESS OF MOTORISTS WARNINGS AT RAILROAD-HIGHWAY GRADE CROSSINGS. Transportation Systems Center, U.S. Department of Transportation, Cambridge, Massachusetts, Report DOT-TSC-FRA-76-25, February 1977, 96 pp.; Federal Railroad Administration, U.S. Department of Transportation, Report FRA/ORD-77/07; National Technical Information Service, Springfield, Virginia, PB 266 784. See also: Hopkins, J. B., and F. R. Holmstrom. TOWARD MORE EFFECTIVE GRADE-CROSSING FLASHING LIGHTS. Transportation Research Record 562, 1976, pp. 1-14; Hopkins, J. B. GRADE-CROSSING WARNING-SYSTEM TECHNOLOGY. Transportation Research Record 628, 1977, pp. 1-5.

Key Words: conspicuity, flashing light signals, innovative systems, signal components, signal control systems, traffic signals

Flashing red incandescent lamps have formed the primary motorist warning device at grade crossings for several decades, in spite of technical constraints that inherently limit the overall effectiveness possible. Tightly focused beams, necessary to obtain high intensity at low power consumption, make perceived brightness highly dependent on precise alinement, which is difficult to achieve and expensive to maintain. In this report an examination of appropriate literature and existing standards reveals preliminary requirements of function and desirable qualities for such motorist warnings. A consideration of relevant lighting technology shows that significant improvement is possible through the use of xenon flashlamps in standard crossing mountings. The quick flash of the xenon unit appears to be more effective, with little deviation from the applicable standards, what motorists are used to, and conventional equipment. This study includes a discussion of optimal specifications, relevant technology, field tests, and related topics including system credibility and the use of highway traffic signals.

77-7 Konecny, M. F., H. P. Johri, and E. W. Eastman. THE GOVERNMENT'S ROLE IN IMPROVING SAFETY ON RAILWAY-HIGHWAY CROSSINGS: A CANADIAN PERSPECTIVE. Proceedings 1977 National Conference on Railroad-Highway Crossing Safety, University of Utah, August 23-25, 1977, U.S. Department of Transportation, pp. 53-60; National Technical Information Service, Springfield, Virginia, PB 293 071.

Key Words: accident characteristics, cost allocation, economic analysis, grade crossing characteristics, program planning, regulations

Through the development of a conceptual framework, the role of a regulatory agency with respect to the risk at rail-highway grade crossings is examined. The level of risk acceptable to society is discussed in the context of physical, economic, and value systems. Alternative regulatory policy options are then examined. These include enforcement of standards, subsidization of safety projects, and taxation programs.

77-8 Koziol. J., and P. Mengert. RAILROAD GRADE CROSSING PASSIVE SIGNING STUDY. Transportation Systems Center, U.S. Department of Transportation, Cambridge, Massachusetts, January 1977, 126 pp.; Federal Highway Administration, U.S. Department of Transportation, Report DOT-TSC-FHWA-76-1; National Technical Information Service, Springfield, Virginia, PB 264 749. See also: Coleman, J., J. S. Koziol, and P. H. Mengert. RAILROAD GRADE CROSSING PASSIVE SIGNING STUDY.

Transportation Engineering, Vol. 47, No. 11, November 1977, pp. 15-18; Coleman, J., J. S. Koziol, and P. H. Mengert. RAILROAD GRADE CROSSING PASSIVE SIGNING STUDY. Public Roads, Vol. 40, No. 4, March 1977, pp. 141-144.

Key Words: advance warning systems, conspicuity, driver behavior, innovative systems, passive warning devices

More than three-fourths of the 219,000 public railroad grade crossings nationwide are equipped with passive warning signs only. A two-phase study is now underway to develop improved passive signing for use at these grade crossings. This study is a pool-funded effort involving 25 states, the Federal Railroad Administration and the Federal Highway Administration. This report describes seven signing configurations (at-crossing sign and advance warning signs) tested in two states during Phase I of the study, the test sites, the types of data collected, the experimental variables, the analysis procedure, and the results of Phase I. Upon completion of Phase II, which involves nationwide testing, a final report will be written making recommendations on what signs should be adopted for driver warning at railroad grade crossings.

77-9 MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES: PART VIII-TRAFFIC CONTROL SYSTEMS FOR RAILROAD-HIGHWAY GRADE CROSSINGS. Federal Highway Administration, U.S. Department of Transportation, FHWA Bulletin, April 1, 1977, 38 pp.

Key Words: active warning devices, advance warning systems, passive warning devices, standards, traffic signals

The purpose of this publication was to notify all Federal Highway Administration elements and State highway and transportation departments of the addition of a new part, Part VIII - Traffic Control Systems for Railroad-Highway Grade Crossings to the Manual on Uniform Traffic Control Devices (MUTCD) and to transmit copies of the approved change in the MUTCD. This new Part VIII replaced Bulletin No. 7 "Railroad-Highway Grade Crossing Warning Systems - Recommended Practices" published by the Association of American Railroads. The new Part VIII should be used by all persons engaged in the planning, design, and construction of traffic control systems for railroad-highway grade crossings as the basic reference source.

77-10 More, J. R., and B. B. Viser. THE URBAN RAILROAD SITUATION. Transportation Engineering, Vol. 47, No. 6, June 1977, pp. 29-33.

Key Words: case study, program planning, rail corridors, urban railroad relocation, vehicle delay

This paper explores the impact of railroads on urban development in terms of delay at grade crossings, incompatible land uses, safety at grade crossings, and noise, air and visual quality. Examples of different levels of improvement are discussed using case study cities. The examples include major rail relocation on new alignment, major relocation and consolidation on new alignment, and operational changes and consolidation on exisiting alignment(s). Factors influencing the success of the improvements include the need for cooperative planning and reliable sources of financing.

77-11 Morag, D. AT-GRADE CROSSINGS OF LIGHT RAIL TRANSIT. Transportation Research Record, No. 627, 1977, pp. 7-10.

Key Words: gates, highway traffic operations, inter-connection, traffic signals, train operations, vehicle delay

A methodology is provided for analyzing and estimating the effect of semiexclusive light rail transit lines on motor-vehicle traffic. Typical estimates of traffic flow through at-grade crossings, and light rail service frequencies are presented. This information may be useful in the definition of minimum grade separation requirements, as well as in setting policies for traffic movement restriction on crossing approaches.

77-12 Palmer, H. C. APPLICATION OF RAIL-HIGHWAY GRADE CROSSING EQUIPMENT. Proceedings 1977 National Conference on Railroad-Highway Crossing Safety, University of Utah, August 23-25, 1977, U.S. Department of Transportation, pp. 102-108; National Technical Information Service, Springfield, Virginia, PB 293 071.

Key Words: active warning devices, highway traffic operations, signal control systems, train operations, warrants

The use and application of various forms and combinations of active warning devices is described. Emphasis is placed on the rail and highway operating characteristics and other factors which would influence the selection of a particular warning system. Consideration is given to both warning devices and control equipment such as track circuits, motion-sensing devices, and constant warning time devices.

77-13 Paterson, D. D. and D. S. Boyer. INNOVATIVE CONCEPTS AND TECHNOLOGY FOR RAILROAD-HIGHWAY GRADE CROSSING MOTORISTS WARNING SYSTEMS. Vol. II: The Generation and Analysis of Alternative Concepts, Tracor-Jitco, Inc., Rockville, Maryland, September 1977, 96 pp.; Federal Railroad Administration, U.S. Department of Transportation, Report FRA/ORD-77/36.II; National Technical Information Service, Springfield, Virginia, PB 273 355. See also: Hopkins, J. B. GRADE-CROSSING WARNING-SYSTEM TECHNOLOGY. Transportation Research Record 628, 1977, pp. 1-5.

Key Words: active warning devices, innovative systems, signal control systems, traffic signals

This report describes the results of a study directed toward the generation, analysis and evaluation of innovative conceptual and technical approaches to train-activated motorist warning systems for use at railroad-highway grade crossings. Particular attention is given to the use of the track as a transmission line in a guided reflection (radar-like) technique operating at audio frequencies. Attention is also given to improved special road surfaces in advance of the crossing, and to optically programmed traffic lights.

77-14 Peckover, F. L. EFFECT OF WINTER CONDITIONS ON THE SAFETY OF HIGH SPEED TRAINS ON THE MONTREAL-QUEBEC LINE. Transport Canada Research and Development Centre, Technology Branch, Montreal, Quebec, Canada, June 1977, 46 pp.

Key Words: gates, maintenance, private crossings, train operations

The Montreal-Quebec portion of the Quebec-Windsor corridor, on which high speed passenger train service is planned, is unique in having winter conditions more severe than on any other route on which similar service is being planned or operated in the world. As a result, the potential effects of these conditions on the safety of trains is substantial. Some of the problems involved can be handled by present technology and extension of current practices. Examples are the control of frost heaving of track, reduced snow drifting, and maintenance of level crossings. Due to the difficulty of detecting the approach of high speed trains in blowing snow conditions, it is proposed that all protected crossings be equipped with barrier gates and all unprotected crossings and farm crossings be closed in winter. Special studies are required to reach decisions on the best means of reducing danger to trains from hitting either heavy windblown drifts or ridges of hard snow left across the track by road plows at level crossings.

77-15 PROCEEDINGS 1977 NATIONAL CONFERENCE ON RAILROAD-HIGHWAY CROSSING SAFETY. University of Utah, August 23-25, 1977, U.S. Department of Transportation, 126 pp.; National Technical Information Service, Springfield, Virginia, PB 293 071.

Key Words: active warning devices, conference proceedings, crossing surfaces, driver education, grade crossing characteristics, hazard evaluation criteria, program planning

The purpose of this conference was to promote implementation of grade crossing safety improvement projects authorized by Federal, state, and railroad industry programs. Major subject areas included: perspective of crossing needs as seen from the viewpoint of the various involved sectors; evaluation of strengths and weaknesses of current grade crossing safety programs; labor, media, and education roles in crossing programs; program planning and administration; current research; and crossing warning systems and surfaces.

77-16 Raab, F. H., M. C. Brooker, T. E. Ryan, and J. R. Waechter, INNOVATIVE CONCEPTS AND TECHNOLOGY FOR RAILROAD-HIGHWAY GRADE CROSSING MOTORISTS WARNING SYSTEMS. Vol. I: Overview and Concept Generation and Analysis, Transportation Systems Center, U.S. Department of Transportation, Cambridge, Massachusetts, September 1977, 210 pp.; Federal Railroad Administration, U.S. Department of Transportation, Report FRA/ORD-77/37.I; National Technical Information Service, Springfield, Virginia, PB 273 354. See also: Hopkins, J. B. GRADE-CROSSING WARNING-SYSTEM TECHNOLOGY. Transportation Research Record 628, 1977, pp. 1-5.

Key Words: active warning devices, innovative systems, on-train devices, signal control systems

This document includes a general review of innovative conceptual and technical approaches to train-activated motorist warning systems for use at railroad-highway grade crossings, and also contains a specific report describing a study directed toward the generation, analysis and evaluation of innovative concepts. The review includes a discussion of communication-link systems, radar train detection, locomotive-mounted transmitters and several other concepts. The basic application constraints of safety, reliability, resistance to serve environments and low cost are used as the basis for evaluating the merits of the alternative concepts. The special study reported here explores the communication-link concept in detail, with particular emphasis on train-detection techniques. The use of microprocessor technology is advocated, along with substantial changes in motorist warnings.

77-17 Rawat, S. K., H. P. Johri, and M. F. Konecny. AN OVERVIEW OF RAILWAY-HIGHWAY CROSSING SAFETY RESEARCH IN CANADA. Proceedings 1977 National Conference on Railroad-Highway Crossing Safety, University of Utah, August 23-25, 1977, U.S. Department of Transportation, pp. 77-87; National Technical Information Service, Springfield, Virginia, PB 293 071.

Key Words: accident characteristics, accident predicition, hazard evaluation criteria, warrants

Major issues affecting grade crossing safety research are discussed. These include: level of acceptable risk; identifying the most hazardous crossings; the trade-off between risk and convenience (or delay); the development of cost-effective safety improvement programs; and the allocation of program costs. The development and application of a hazard index model is then discussed.

77-18 Remaley, D. F. WAYSIDE AND CONTROL EQUIPMENT FOR RAIL-HIGHWAY GRADE CROSSING WARNING SYSTMES. Proceedings 1977 National Conference on Railroad-Highway Crossing Safety, University of Utah, August 23-25, 1977, U.S. Department of Transportation, pp. 97-102; National Technical Information Service, Springfield, Virginia, PB 293 071.

Key Words: active warning devices, audio frequency overlay, signal components, signal control systems

The types, characteristics, and function of grade crossing warning and control equipment are described in detail. Warning equipment includes signs, bells, flashing light signals, gate assembles, and cantilevers. Control equipment includes DC track circuits, AC-DC track circuits, audio frequency overlay circuits, motion-sensing devices, constant warning time devices, and standby power facilities.

77-19 Ruden, R. J., and C. F. Wasser. MOTORISTS' REQUIREMENTS FOR ACTIVE GRADE CROSSING WARNING DEVICES. MB Associates, San Ramon, California, October 1977, 270 pp.; Federal Highway Administration, U.S. Department of Transportation, Report FHWA-RD-77-167; National Technical Information Service, Springfield, Virginia, PB 296 183/AS. See also: Ruden, R. J., and J. Coleman GRADE CROSSING ACTIVE WARNING DEVICES. ITE Journal, Vol. 49, No. 3, March 1979, pp. 23-25.

Key Words: active warning devices, conspicuity driver behavior, human factors, innovative systems, signal components

This report describes a two-year study of some of the basic problems involved in improving the design of active warning devices intended to make motorists more aware of grade crossing hazards. Emphasis was placed upon improvement of the attention-getting aspect (conspicuity) of active crossing warning devices which was presumed to positively correlate with improvements in grade crossing safety. An indoor laboratory test was conducted in the FAA Low Visibility Research Facility located at the University of California. In excess of 150 subjects gave over 20,000 responses to flashing light displays. Results were analyzed to determine effects of color, flash rate, brightness, size and placement under daylight, darkness and daytime fog conditions. The laboratory tests resulted in development of two improved devices which were field tested on actual grade crossings. The first device consisted of an array of three eight-inch white (clear) strobe lights added to a standard flashing warning system at a high accident rate urban crossing in Richmond, CA. The second was a gate arm add-on device consisting of three small strobes, red, white (clear) and blue in color installed at a rural highway grade crossing with high speed truck and automobile traffic. Due to project constraints, no long term safety improvement analysis could be conducted. Because there was no evidence of driver confusion during the conduct of these field tests, it was concluded that colored lights other than red can be used in moderation as add-on to existing active crossing warning devices to increase the attention getting property of the warning system. The high composite (not from a single source) flash rate devices that were installed did not result in any erratic driving behavior on the part of approaching motorists.

77-20 Sanford, J. L. CRITERIA USED BY STATE HIGHWAY AGENCIES TO DETERMINE WARRANTS AND PRIORITIES FOR WARNING DEVICES AT RAIL-HIGHWAY CROSSINGS. Research Report No. 8, Highway Traffic Safety Center, University of Illinois, Urbana, Illinois, April 1977, 115 pp.

Key Words: active warning devices, grade separations, hazard evaluation criteria, hazard ratings, priority ratings, warrants

The objectives of this research were to determine state highway agency warrants and priorities for rail-highway crossing improvements, and to prepare a summary of national trends from this data. Survey questionnaires were distributed to state highway agencies and requested information on rail-highway crossing hazard index formulae and warrants for grade crossing imporvements. The responses are tabulated by states for the methods used for determining improvements, and by frequency for criteria used in hazard index formulae and warrants for active traffic control devices at rail-highway crossings. The analysis revealed that the number of state highway agencies using hazard index formulae to determine railroad-highway improvements

has increased about 300 percent during the past 30 years, but the most frequently reported criteria continues to be traffic and train exposure. Many state highway agencies use accident records and diagnostic studies of crossings to adjust priority lists of crossing improvement needs developed from hazard index formulae. State highway agency responses were adequate for analyzing hazard index formulae criteria but no significant conslusions could be drawn about minimum train-traffic exposure factors warranting active traffic control devices at rail-highway crossings. The results of the research illustrate the flexibility afforded by crossing improvement priority lists, developed from hazard index formulae, for changing funds and safety programs.

77-21 Schnablegger J., and S. Teply. TRAFFIC-CONTROL MEASURES AT HIGHWAY-RAILWAY GRADE CROSSINGS WITH PROVISIONS FOR LIGHT RAIL TRANSIT. Transportation Research Record 628, 1977, pp. 6-11.

Key Words: case study, highway traffic operations, interconnection, signal control systems, traffic signals, train operations

Railway rights-of-way in cities are attractive alternatives for transit corridors, but, for modes that are not fully grade-separated, such as light rail transit systems, there may be problems with combined railway and transit crossings of arterial streets. This situation has been studied in Edmonton, Alberta, where a light rail transit line is under construction. The surface portion of this line is along the railway right-of-way, and as a result, the operation of its eight grade crossings is regulated by railway authorities. The short headways of light rail transit could cause frequent disturbances to the road traffic that operates at saturation during peak hours. This paper illustrates the method used for the analysis of the problem and discusses the surveys conducted. The basic principles governing the solutions to the grade-crossing problem are (a) the coordination of adjacent signalized intersections in such a way that the impact of the crossing closure is minimized and the system recovers shortly after the closure, (b) the integration of light rail transit scheduling and control with traffic control, i.e., restricting the closures to the periods of minimum impact on road traffic, and (c) the use of special features to increase safety.

78-1 Cherchas, D. B., W. S. McLaren, G. W. English, L. Brockhoven, and N. Ritchie. A COMPUTER SIMULATION OF RAIL VEHICLE DERAILMENT DURING GRADE CROSSING COLLISIONS. The Eighties: A New Rail Era - Proceedings of the Biennial CIGGT Seminar on Railway Research, Canadian Institute of Guided Ground Transport, Queen's University at Kingston, Ontario, Canada, CIGGT Report 78-5, April 1978, pp. 237-257.

Key Words: crash testing, train operations, vehicle dynamics

A mathematical model and digital computer simulation are developed to analyze the dynamics of railway and road vehicles during grade crossing collisions. The main objective of the simulation is to relate the probability of derailment to railway vehicle speed; however, a variety of other response characteristics such as railway and road vehicle structure deformation and road vehicle dynamic response can be examined. The criterion for derailment is based on the derailment coefficient, i.e. ratio of wheel flange/railhead lateral force to vertical wheel load. Experimental results obtained from extensive Japan National Railways tests are used to relate the probability of derailment of a wheel and railway vehicle to the analytically determined derailment coefficients in the computer simulation. Results indicating the probability of derailment as a function of train speed for a range of initial conditions and a specific configuration are given.

78-2 FEASIBILITY OF SPECIAL STRUCTURAL DESIGN OF LOCOMOTIVES AND RAILCARS TO IMPROVE COLLISION SAFETY AT LEVEL CROSSINGS. Dilworth, Secord, Meagher and Associates, Ltd., Toronto, Canada, Report 789/920, June 1978, 54 pp.; Transport Canada Research and Development Centre, Montreal, Quebec, Canada.

Key Words: crash testing, on-train devices, train operations

This report examines the potential of using structural techniques to reduce fatalities in railway/road vehicle collisions. A review of the state-of-the-art of crossing problems concludes that the preferred solution - grade separation - is very expensive. This approach could cost Canada at least $18 billion, if all crossings were grade separated. The problem is therefore of the cost benefit type. The available data examined included statistics, other studies, road safety work, and results of impact tests. Based on these limited available data, an acceleration factor at the point of impact was selected and gross concept sizes for various conditions were defined. Further work is required to reconcile the very limited test data with actual experience. However, the potential for improvement by structural design is good. One test of a system was located. Additional work is required on alternate approaches and to minimize railroad operational constraints.

78-3 Gertler, J. B. A STUDY OF STATE PROGRAMS FOR RAIL-HIGHWAY GRADE CROSSING IMPROVEMENTS. Transportation Systems Center, U.S. Department of Transportation, Cambridge, Massachusetts, Report DOT-TSC-FRA-78-3, February 1978, 174 pp.; Federal Railroad Administration, U.S. Department of

Transportation, Report FRA-OPPD-78-7; National Technical Information Service, Springfield, Virginia, PB 279 774.

Key Words: case study, legislation, program planning, regulations

In response to a DOT study of rail-highway grade crossing safety in the United States, the Congress passed the Highway Safety Act of 1973 which earmarked funds specifically for grade crossing improvements. Law requires the states to establish programs for identifying and implementing crossing improvement projects. This report examines the experiences of five states in establishing programs. The programs are discussed in terms of program initiation, project processing procedures, sources of funds, role of the regulatory agency, and maintenance of improved crossings. Descriptions of each state encompass grade crossing activity prior to 1973, the state's procedures, and types of improvements. The report also suggests some modifications to the current federal program which might enhance its effectiveness.

78-4 Korve, H. W. TRAFFIC ENGINEERING FOR LIGHT-RAIL TRANSIT. Transportation Research Board, Special Report 182, 1978, pp. 107-115.

Key Words: highway traffic operations, interconnection, signal control systems, traffic signals, train operations, vehicle delay

The development of safe and operationally effective designs for at-grade intersections and crossings for light-rail transit (LRT) is an issue central to the future deployment of the mode. This paper describes a design approach based on the performance characteristics of light-rail vehicles (LRVs) and the application of conventional traffic engineering hardware and design practice. At-grade operation of LRT introduces potential conflicts with motor vehicles and pedestrians at intersections, in streets between intersections, and at mid-block crossings. These conflicts are a source of delay and accidents for LRVs. Application of the appropriate conflict-control techniques must consider that modern LRVs have performance characteristics essentially similar to those of transit buses. There are four strategies available to the traffic engineer to eliminate or control points of conflict among LRVs, motor vehicles, and pedestrians: at-grade separation of traffic flows in space, vertical separation of traffic flows in space, separation of traffic flows in time, and reduction in the number of traffic approaches.

78-5 Koziol, J. S., and P. H. Mengert. RAILROAD GRADE CROSSING PASSIVE SIGNING STUDY FINAL REPORT. Transportation Systems Center, U. S. Department of Transportation, Cambridge, Massachusetts, August 1978, 66 pp.; Federal Highway Administration, U.S. Department of Transportation, Report FHWA-RD-78-34; National Technical Information Service, Springfield, Virginia, PB 286 528/AS. See Also: Coleman J., J. S. Koziol, and P. H. Mengert. RAILROAD GRADE CROSSING PASSIVE SIGNING STUDY-PHASE 2. Public Roads, Vol. 42, No. 4, March 1979, pp. 128-135.

Key Words: advance warning systems, conspicuity, driver behavior, innovative systems, passive warning devices

This report describes the Phase II results of a study to determine the effectiveness of new passive signing configurations in warning drivers of the potential hazards at railroad grade crossings. Experiments were conducted in two phases over a two-year period. The first phase was begun in March 1975 and evaluated seven sign configurations at five test sites in Ohio and one site in Maine. The purpose of Phase I was to determine at a few crossings whether any of the new signs showed promise of being more effective than the existing sign configuration and to evaluate a variety of experimental variables. The result was to test and verify at a national level (18 sites in 14 states) the most effective signs as determined from Phase I and to concentrate on and refine, if necessary, the most important variables. In each phase, before-and-after data were collected at each site so that relative improvements provided by the new signs could be determined. The results of Phase II confirmed the findings of Phase I in that drivers showed more awarness (that is, as increased percentage of headmovements or looking for trains) with the new signs at the crossings tested.

78-6 Priest, W. C., and K. Knoblauch. ANALYSIS OF NPRM STROBE LIGHTS ON LOCOMOTIVES. IOCS, Inc., Waltham, Massachusetts, May 1978, 71 pp., Federal Railroad Administration, U.S. Department of Transportation, Report RP-41; National Technical Information Service, Sprinfield, Virginia, PB 293 483.

Key Words: accident characteristics, conspicuity, economic analysis, human factors, innovative systems, on-train devices

This study includes an evaluation of the effectiveness of strobe lights, an analysis of the benefits and an estimation of the costs of the proposed regulation, and a measure of the economic impact of the regulation on the railroad industry. The benefits of strobe lights are measured against the accident information for 1975 and 1976 contained in the Rail-Highway Grade-Crossing Accident/Incident data base. A methodology was developed, utilizing fault tree analysis, modeling, and human factors analysis, to postulate the expected value of benefits

associated with the use of strobe lights on locomotives. Fault tree analysis indicated those accidents which would be affected by the presence of strobe lights. Modeling and human factors analysis were then utilized to develop multipliers which estimated the reduction in the number accidents for each applicable accident circumstance of the fault tree analysis

78-7 RAIL CROSSING SAFETY--AT WHAT PRICE? Report to the Congress of the United States by the Comptroller General, U.S. General Accounting Office, April 1978, 50 pp.

Key Words: accident characteristics, economic analysis, hazard evaluation criteria, legislation, program planning, standards

This report discusses the cost-effectiveness and funding of the Federal grade crossing safety improvement program. The need for uniform safety standards and categorical funding of safety programs are discussed. It is recommended that a nationwide standard for an acceptable level of grade crossing safety be established, and that safety improvement projects be selected on the basis of relative cost-effectiveness.

78-8 RAILROAD-HIGHWAY GRADE CROSSING HANDBOOK. Federal Highway Administration, U.S. Department of Transportation, Report TS-78-214, August 1978, 241 pp.

Key Words: active warning devices, crossing surfaces, grade crossing characteristics, hazard evaluation criteria, passive warning devices, priority ratings, program planning, signal control systems

This handbook provides a summary of past accomplishments, existing techniques, and a compendium of applicable concepts, technology, and practice in the area of grade corssing improvements. It is aimed primarily at providing railroad, state and municipal personnel with information which can help them in their cooperative efforts to improve conditions at grade crossings. Major topics which are treated include: grade crossing components; program administration; program development, definition, and implementation; site improvements; crossing surfaces; traffic control devices; and research and development.

78-9 REPORT ON LEVEL CROSSING PROTECTION. Department of Transport, London, England, Her Majesty's Stationery Office, 1978, 68 pp.

Key Words: accident characteristics, active warning devices, hazard evaluation criteria, innovative systems, program planning

This report presents the findings and recommendations of a British study which examined ways in which the utilization of automatic grade crossing warning devices could be expanded. The study reviews current British and European practice as a means of formulating a program for upgrading automatic warning devices. A variety of recommendations are offered in the areas of safety practices, design and use of automatic warning devices, and roadway design and traffic control standards.

78-10 Sanders, J. H., H. W. McGee, and C. S. Yoo. SAFETY FEATURES OF STOP SIGNS AT RAIL-HIGHWAY GRADE CROSSINGS. Biotechnology, Inc., Falls Church, Virginia; Federal Highway Administration, U.S. Department of Transportation, Vol. I Executive Summary, Report FHWA-RD-78-40, April 1978, 17 pp., and Vol. II Technical Report, Report FHWA-RD-78-41, March 1978, 167 pp.; National Technical Information Service, Springfield, Virginia, PB 295 422/AS and PB 295 423/AS.

Key Words: accident characteristics, driver behavior, passive warning devices, stop signs, warrants

The study objectives of this research project were to determine the advantages and disadvantages of selective use of highway stop signs as safety improvements at rail-highway grade crossings and to develop guidelines for their appropriate use or non-use. The study results indicated that stop signs are used more frequently in urban areas and crossings having stop signs tend to have higher train volumes. Accident analysis results indicated that rates for stop sign crossings are lower than rates for crossbuck-only crossings for higher vehicle-train exposure values. Field studies showed that stop signs, when properly used, result in improved driver behavior adequate for the detection and avoidance of trains. The study conclusions suggest that stop signs should be applied selectively only at hazardous passive grade crossings and should not be used indiscriminately at all passive grade crossings. Requirements for effective use of stop signs at grade crossings are listed in the report.

78-11 STUDY TO DEFINE THE REQUIREMENTS FOR RAILWAY LEVEL CROSSING PROTECTION ACCEPTABLE FOR TRAIN OPERATION AT SPEEDS UP TO 200 KM/H. Canalog Logistics Limited, Montreal, Quebec, Canada, August 1978, 375 pp.; Transport Canada Research and Development Centre, Montreal, Quebec, Canada, Report TP 1996.

Key Words: accident charcteristics, active warning devices, grade crossing charateristics, hazard evaluation criteria, train operations

The report analyzes accident reports from both railway and highway department records to identify causal factors in grade crossing accidents, classified in relation to possible countermeasures designed to prevent the consequential train/highway-vehicle collision. New conditions created by train speeds up to 200 km/h over grade crossings, are identified, and protective systems are proposed to achieve appropriate standards of accident prevention.

79-1 DRAINAGE AND FOUNDATIONS FOR HIGHWAY-RAILWAY GRADE CROSSINGS. Proceedings, American Railway Engineering Association, Vol. 80, 1979, pp. 205-208.

Key Words: crossing surfaces

Information is presented on the availability and use of filter fabrics for drainage and foundation structure applications at grade crossings. Interim guide specifications for filter fabrics are also described.

79-2 Kearney, E. F. DRIVER'S DUTIES AT RAILROAD GRADE CROSSINGS. Traffic Laws Commentary, National Committee on Uniform Traffic Laws and Ordinances, Vol. 8, No. 1, January 1979, 79 pp.; National Highway Traffic Safety Administration, U.S. Department of Transportation, Report DOT-HS-803-813.

Key Words: driver behavior, enforcement, exempt crossings, jurisdiction, legislation, regulation

This study reviews state motor vehicle and traffic laws applicable to railroad grade crossings. It is limited to provisions appearing in state vehicle codes and does not include laws appearing in state codes relating to highways nor railroads. Every attempt has been made to reflect laws that were in effect on January 1, 1978. Major topics include: stopping when a train is near or when signaled to stop, stopping for stop signs, stops by school buses and vehicles at grade crossings, required safe speed, passing restrictions, and numerous miscellaneous provisions. The report concludes with a summary of the more important findings, and suggestions for adoption of certain Uniform Vehicle Code requirements by several states.

79-3 Ruden, R., and S. Hulbert. PHOTOMETRIC AND HUMAN FACTORS ANALYSIS OF RAILROAD FLASHING WARNING LIGHTS. JGM Associates, Inc., Palo Alto, California, February 1979, 44 pp.; Rail Rate and Sevice Division, Public Utility Commissioner of Oregon, Salem, Oregon.

Key Words: conspicuity, flashing light signals, human factors, signal components

This study was an investigation of the photometric and the appearance values of six 12-inch railroad crossing signal lights conducted for the Oregon Public Utilities Commission. The results of the study indicated that it was not possible to determine that any of the six lights were consistently superior. The restricted shape of the light beam from all six lights was critical relative to the appearance of the signal light and made effective alignment difficult to achieve and maintain in field. The alighnment difficulties were concluded to be a principal source of large variation in the appearance of the lights. There was little correlation between the photometric light readings and the appearance of the light's size and brightness due to the fact that the railroad light is a non-uniform brightness target as seen by the viewer, i.e., the viewer sees primarily the hot spots (brighter areas) of the surface.

Key Word Index

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