

ample, the recently constructed Lorain Road Viaduct designed by the Bureau of Bridges in the Department of Highways, State of Ohio, for erection over the Rocky River Valley at the west edge of Cleveland, completed in 1935, was adjudged by the American Institute of Steel Construction as the most beautiful steel structure in its class erected in the United States during that year.

In closing I wish to congratulate Purdue University, the State Highway Department of Indiana, and those who are in attendance at this gathering on the co-operative development of this wonderful Road School, which has become so widely known among highway engineers of the midwest.

PROGRESS IN RAILWAY GRADE SEPARATION AND PROTECTION WORK IN INDIANA

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Grade separation and protection work in Indiana falls more or less naturally into three phases, both chronologically and in regard to the method of financing.

The first phase covers the work done in this state before the formation of a State Highway Department in 1919. This work was financed by the railroads and counties (or other political subdivision) either jointly, or wholly by one or the other.

The second phase covers the work done by the state under the 1916 Federal Aid Act, the 1919 State Law creating a Highway Department, and their subsequent amendments. In time, this period extends from 1919 to 1933.

The third phase extends from 1933 to the present time and represents that period during which large federal appropriations were made for carrying out this type of work. These appropriations differed from the normal Federal Aid appropriations in that they required no matching with state funds.

The first and second phases will be discussed in only enough detail to sketch in the background necessary for a proper conception of the development and progress that have been made in Indiana on railway grade separation and protection work. The third phase, because of its complexity and importance, will be more fully covered.

FIRST PHASE (PRIOR TO 1919)

The overhead structures built during the first phase are, in general, entirely inadequate when judged by modern requirements as to the design of the structure itself and as to the width of roadway, alignment, and grades on both the struc-

ture and its approaches. The subways constructed are reasonably adequate in respect to design strength because railway design loadings have not increased in the last few decades comparably to highway designs. However, in respect to width of roadway, alignment, and grades, the same criticism may in general be made of them as was made of the overpasses. In addition to these deficiencies, the overhead clearance frequently was considerably less than our modern requirement of at least fourteen feet; and the drainage system, if any, was often inadequate. The appearance of the majority of the structures indicates that little consideration was given to the question of esthetics in their design.

The flasher signals and other safety devices installed during this period were probably, in the majority of cases, paid for wholly by the railroads. Many of those installations are now obsolete and antiquated because of improvements made in design since that time. Some of these old signals have been replaced with modern types by the state with the federal funds recently allocated for the elimination of hazards at railway grade crossings.

SECOND PHASE (1919-1933)

An account of the progress in railway grade separation and protection work in Indiana during this second phase is primarily concerned with the activities of the state highway department in this field. However, some work was done during this period under the conditions described for the first phase.

This progress was, of course, intimately connected with the laws related to this work, both federal and state, enacted during this period. Following is a brief resumé of those laws citing their principal features affecting this type of work.

Under the system of federal aid, definite sums are allocated to the various states with the provisions that this money be matched dollar for dollar with state funds and expended on a limited mileage of roads or proposed roads which have been designated as the Federal Aid System. This money is spent under the supervision of the U. S. Bureau of Public Roads, which has promulgated detail regulations and set up certain standards of design and construction. These standards have been revised from time to time to keep pace with modern traffic requirements.

The original act under which this Federal Aid money was appropriated and entitled, "An Act to provide that the United States shall aid the states in the construction of Rural Post roads, and for other purposes," was approved July 11, 1916. It permitted no expenditure of federal funds within municipalities of 2,500 population or over except on that portion of the road from the corporation line inward where the average distance between houses exceeded 200 feet.

An amendment to this Act, approved May 21, 1928, provided that no federal funds should be expended for the construction of any bridge within, or partly within, any municipality having a population of more than 30,000.

One of the provisions of the original Federal Aid Act required that, before any of this federal money be made available to a state, the state should organize a highway department meeting the approval of the U. S. Bureau of Public Roads.

The first highway law passed in Indiana that successfully accomplished this purpose was enacted in 1919. This law provided, among other things, that state funds could be expended on grade separation work but only on projects located outside incorporated cities and towns. This law further provided that the state should co-operate with the federal government, under any federal law, in any manner necessary, to secure for the state its share of any federal appropriation that might be made in the future.

An amendment to this law passed in 1931 permitted the expenditure of state funds for highway construction within corporations of less than 3,500 population. At the same time, it brought the grade separation provisions into consistency with the highway sections by permitting the state to do grade separation work on any highway project which it was authorized to construct.

During this period the state law stipulated that the cost of a grade separation project should be borne equally by the state and the railroad or railroads involved. Fifty-one crossings at a total cost of almost \$2,000,000 were eliminated by separation of grades—36 of these structures were overheads and 15 were subways. The design of the structure and its approaches, including width of roadway, clearances, alignment, and grades was in strict accordance with the then-accepted standards of good construction.

That some of these structures fall somewhat below the present-day requirements, in some respects, is no reflection on the ability and judgment of those who were in responsible charge at that time. Any such criticism of our Indiana bridges would apply with equal force to those of practically every state in the Union. The design specifications followed were substantially those recommended by the American Association of State Highway Officials. The construction specifications, the testing of materials, field inspection and supervision were such that, except for the limitations mentioned above, these structures are giving and will, for many years to come, continue to give, excellent service.

Extensive consideration was given to the esthetics of design of the structures built during this period with the emphasis placed on lines and proportions rather than ornamentation.

THIRD PHASE (1933 TO DATE)

In this phase, the bulk of the work done on railway grade separation and protection projects in Indiana was prosecuted with federal funds which required no matching with state funds. However, some work of this nature has been and is being done with state funds and with state funds matching normal Federal Aid appropriations.

The 1933 Highway Act changed the basis of payment on grade separation and protection work. When an existing structure was replaced, or when a new structure eliminated an existing grade crossing, the state was to pay 80% and the railroad or railroads 20% of the cost of the project. When no existing structure was replaced, nor an existing grade crossing eliminated, the state was required to pay the entire cost of the project. Two separations of this latter class were constructed by the state in 1933.

Under Title II of the National Industrial Recovery Act as passed by Congress and approved by the President on June 16, 1933, \$400,000,000 was granted to the several state highway departments to provide for emergency construction of public highways and related projects. The funds were to be expended in accordance with the 1921 Federal Highway Act except that the states were not required to match the federal funds granted. Other important provisions of the grant were:

1. The funds were available for grade separation and protection work.
2. Seven-eighths of the grant was to be divided among the states in accordance with the 1921 Federal Highway Act, one third each on the basis of their relative area, miles of rural delivery routes, and population, and one eighth on the basis of their relative populations.
3. The entire cost of projects could be financed from these funds except that no federal funds were to be used for land, right-of-way, or easement in connection with any railroad grade separation project.
4. Each state highway department was to predetermine the wages for skilled and unskilled labor on the projects in that state and incorporate these provisions in the contract for the work.
5. A maximum of human labor was to be used in lieu of machinery whenever practicable and consistent with sound economy and public advantage.

This program, originally called the N.R. Program, is now frequently designated as the first N.R. Program or the 1934 N.R. Program to distinguish it from another N.R. Program the funds for which were made available about a year later. Under the 1934 N.R. program, various types of work, highway and bridge work on the Federal Aid System outside

municipalities (N.R.H. Projects), work on the Federal Aid System within municipalities (N.R.M. Projects), work which was a combination of the two previous types (N.R.H.M. Projects), and highway and bridge work on secondary or feeder roads (N.R.S. Projects), were carried out.

The Indiana allotment for the 1934 N.R. Program was a little over ten million dollars, of which amount about \$940,000 was expended for grade separations. Thirteen structures involving 7 different railroads were built in 10 counties. Of these 13 structures, 8 were overheads and 5 were underpasses. Included in this program was the Western Avenue subway in South Bend, designed and built in conjunction with the New York Central Railroad Company and costing about \$370,000.

Under the so-called "Public Works" section of this act, funds were allocated to projects on a grant-loan basis. Indiana built one separation under this arrangement, an overhead carrying S. R. 67 over the Pennsylvania Railroad, at Redkey, on which the state paid 70% and the federal government 30% of the cost.

On June 18, 1934, a further appropriation for emergency highway construction was authorized by Congress in the Hayden-Cartwright Act. Under this Act, from which developed the 1935 N.R. Program, not less than 25% of the apportionment to any state was to be expended on the secondary or feeder roads in that state. In this bill was also an appropriation of normal Federal Aid funds in the sum of \$125,000,000 for each of the fiscal years of 1936 and 1937.

The same classes of work were done under the 1935 N.R. Program as had been done under the 1934 N.R. Program (N.R.H., N.R.M., N.R.H.M., and N.R.S.). Indiana's allotment was a little over five million dollars, out of which about \$642,000 was expended on grade separation structures and \$118,000 on flasher signal installations. Five overheads and two subways were constructed and 50 flasher signal installations were made. At the same time, the state handled separately two additional flasher signal installations. These N. R. Programs of grade separation structures and flasher signal installations were gotten up by the state with the assistance and advice of the railroads involved.

The Emergency Relief Act authorizing an appropriation of up to \$800,000,000 for highways, roads, streets, and grade crossing eliminations was approved on April 8, 1935.

Under this Act, \$200,000,000 was allotted to the states for the "elimination of existing hazards to life at railroad grade crossings". The principal provisions of the Act governing this allotment were as follows:

1. One half of this money was apportioned to the several states according to their relative populations: one fourth according to their relative mileage of Federal Aid Routes; and one fourth according to their relative mileage of railroads.

2. It was not necessary to match these funds with state funds.

3. Detailed rules and regulations were to be formulated later by the federal government and issued for guidance in the expenditure of these funds.

These "Rules and Regulations," soon issued thru the U. S. Bureau of Public Roads, contained the following principal stipulations:

1. Projects within municipalities were to be designated as W.P.G.M. Projects; and those outside of municipalities but on the Federal Aid System, as W.P.G.H. Projects; and those on secondary or feeder roads outside of municipalities, as W.P.G.S. Projects.

2. Not less than 25% of the funds was to be expended on secondary or feeder roads.

3. For any state, these funds were to be apportioned within practical limits to the individually operated Class I railroads in the proportion that their mileage bears to the total mileage of such railroads in the State.

4. The entire cost of projects could be paid from these funds except any charges for rights-of-way or property damage.

5. Funds for any project were to be limited to those actually required for necessary work within 1,500 feet on each side of the nearest track.

6. In regard to grade crossing eliminated by highway relocation, the amount of these funds available were to be limited to:

(a) The estimated cost of providing grade separation structures and approaches thereto for the crossings eliminated on the existing route; or

(b) The estimated cost of providing on the relocation an improvement to modern standards with a surfacing type comparable to that existing on the portion of the route so relocated.

7. Funds were not available for the separation of grades on a newly established highway which was not essentially a relocation of an existing route.

8. Each state was required to submit, in tabular form, a proposed program listing individual elimination, separation, and protection projects by classification (W.P.G.M., W.P.G.H., and W.P.G.S.) and by individual railroads. The following information was also to be shown for each individual project—project number, county, location, proposed character of work, estimated man-hours of employment, estimated quantity and cost of the principal kinds of material involved, estimated total cost of the project, and the amount of W.P.G. funds requested.

9. There were many other regulations, such as those regarding advertising and the awarding of contracts, wages,

employment, and hours of labor, accounting, etc., which, because of lack of space, will not be discussed in detail.

Under this program, Indiana has completed, or has under construction, 40 projects located in 27 counties and involving 14 different railroads. Of these projects 27 are overheads, 10 are underpasses, and 3 are road relocations eliminating 8 existing grade crossings on State Roads.

Also under this program Indiana has completed, or is working on, 161 flasher signal installations, located in 60 counties and involving 16 of the 18 Class I steam railroads in the state and one electric line.

One of the recent federal reports shows that Indiana has an unobligated balance of only \$6 of these W.P.G. funds out of the original allotment of \$5,111,096. The flasher installation program will amount to about \$415,000 and the balance (except \$51,000 set aside to help finance the work of the Highway Survey Commission), amounting to over \$4,600,000, is being spent on grade separation structures and grade crossing eliminations by road relocations.

During this third phase of railway grade separation and protection work in Indiana, the standards of design and construction were raised to a new high plane—partly to conform with the new general policies of the U. S. Bureau of Public Roads but largely because the state itself recognized the vital need for such steps. Among the most important tendencies and trends in this direction as emphasized by the construction during this period, might be listed the following:

1. Wider roadways on both structure and approaches. (Figs. 1 and 2.)



Fig. 1. (See Fig. 2.) E. J. & E. R. R. subway, in west part of Gary near East Chicago Corporation Line, on U. S. 12. Traffic reaches 8,000 vehicles per day. Note two-lane pavement, columns, and no sidewalks. Widening of highway to four lanes (42') necessitated reconstruction of subway.



Fig. 2. (See Fig. 1.) Old columns removed, new steel superstructure designed and erected, and abutments remodeled. Pedestrian sidewalk tunnels provided. Clear width, curb to curb, 42'. Note scaffolding and tarpaulins during painting. Entire design and handling of contract by state. W.P.G.M. Project. Cost—\$51,000.

2. Wider shoulders on the approaches with flatter side slopes and guard rail protection where needed.

3. Sidewalks, or at least safety walks, on practically all overheads—the widths depending on the present and estimated future needs. Sidewalks through subways where there is a present or expected future need.

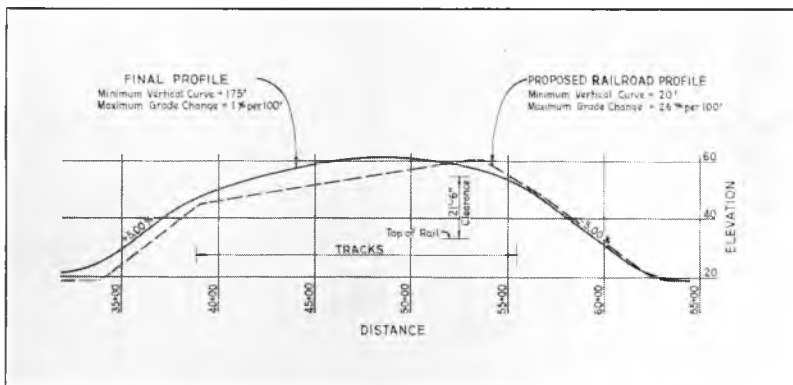


Fig. 3. Bridge at this site (see Fig. 4) first conceived by City of East Chicago. Railroad prepared some preliminary plans which were later turned over to state but were not used.

This sketch shows one reason. Dotted line is profile prepared by railroad—very short sharp V.C.'s with a sight distance of less than 100'. Solid line shows profile actually used. V.C. over structure is a continuous compound V.C.—compounded five times. Height of piers was kept as low as possible and at same time provided a smooth riding-surface. Sight distance 850 feet.

By a rearrangement of the truss spans to gain the maximum possible duplication in shop work, by substituting curved top chords for horizontal, and by the omission of granite protection, which was proposed for the floor system of some of the truss spans in the railroad design, this project was let for almost \$300,000 less than the estimate for the design proposed by the railroad.

4. Modern specifications for both design and construction with increasing emphasis on rigorous testing of materials and field supervision of the work.

5. Much better alignment and grades than were formerly considered necessary, with a corresponding increase in the sight distance provided. (Figs. 3, 4 and 5).



Fig. 4. This is a side elevation of the largest and most expensive grade separation structure ever built by the State Highway Commission, in fact the largest bridge ever built by the state where the state handled the entire project—the design and preparation of the detail plans, the letting of the contract, and the inspection and supervision of the construction. (See Fig. 3.) In Hammond near East Chicago corporation line. Structure proper consists of 9 through truss spans, all skewed one panel and varying in length from 170 feet to 245 feet, and 8 R.C.G. spans at 42 feet each.

- Total length of structure proper, 2,165 feet.
- Total length including approaches, about 3,100 feet.
- Roadway width over structure 40 feet, over approaches 40 feet.
- Two 6-foot sidewalks, with ornamental steel handrail, bracketed on outside of trusses.
- All-metal stairway 5 feet wide from one of sidewalks down to the railroad yard level.
- Bridge spans about 60 tracks of the Gibson Yard of N.Y.C. Railroad Co., with provisions for many more tracks.
- Over 3,000 tons of structural steel used.
- Complete set of plans consisted of over 200 24"x36" sheets.
- Took about 8 men working 9 months to design and prepare detail plans—complete shop details made of structural steel as is done on all our steel jobs.
- Total cost—over \$600,000 of W.P.G.S. funds.



Fig. 5. View through trusses of Fig. 4. Notice heavy vehicular guard rail just above lower chord.

6. Adequate vertical and horizontal clearances. (Figs. 6 and 7.)



Fig. 6. (See Fig. 7.) S. R. 29 (U. S. 35) and Pennsylvania R. R. and U. S. 30 north of Knox in Starke County. Note short distance from R. R. to U. S. 30 and difference in elevation. Very dangerous when traffic was heavy.



Fig. 7. (See Fig. 6.) Six-span continuous steel beams crossing U. S. 30 on right, county road on left, and railroad in center. Note interchange connection on extreme right. Considered a subway at this point—gave it up because of drainage problem—general ground water level only a foot or so below top of ground. Note water on right. Beams only have been erected. W.P.G.H. Project. Cost—\$117,000.

7. Very careful study of the drainage problems, especially at underpasses.

8. Careful consideration of esthetics of design. (Figs. 8, 9 and 10.)

Two features of the design may be noted as being first introduced during this phase. One is the sodding of all slopes. This was done primarily to improve their appearance, but may



Fig. 8. S. R. 43 over Big Four and Nickel Plate Railroads, south of Lafayette. Three-span steel beams on concrete bents and bridge built on horizontal curve.
Note curved lines. Structure also on a vertical curve. 1935 N R. Project. Cost—\$31,000.

turn out to be an actual economy due to reduced maintenance charges. The other is the extensive use of continuous steel beam designs for the overhead structures, which frequently reduces the height of the approach fills because of the use of beams of shallower depth.



Fig. 9. Before. (See Fig. 10.) S. R. 58 over C. M. St. P. & P. R. R. east of Burns City in Martin County. Old structure weak, flimsy handrail. Poor profile on approaches and a hump over structure. Only $14\frac{1}{2}'$ clear roadway.



Fig. 10. After. (See Fig. 9.) Three-span steel-beam continuous—concrete bents. Grade, straight 2%. Note splices in center span. One of earlier continuous designs—had to discontinue placing splice at these points on account of cambering difficulties—moved splice back to directly over piers on later designs.

As a matter of interest—we camber all steel spans, whether simple or continuous, so that under full dead load of superstructure, including handrails, they deflect to the exact theoretical profile whether on a straight grade or a vertical curve. W.P.G.S. Project. Cost—\$18,000.

CONCLUSION

Many grade crossings have been eliminated by road relocations, more than 100 crossings have been eliminated by grade separation structures, and over 200 flasher signal installations (Fig. 11) have been made by the State Highway



Fig. 11. Modern flasher signal. Notice reflectorized signs.

Department since its formation in 1919, in addition to the work of this nature done before that date. In spite of all this work and while we may all be proud of our progress in Indiana, bear in mind that there are still several thousand unprotected grade crossings in the state, several hundred of which are located on our State Highway System.

Normal Federal Aid funds for the fiscal years of 1937, 1938, and 1939 and additional appropriations for the fiscal years of 1938 and 1939, to be used exclusively on this type of work and to require no matching with state funds, assure us that this work will be carried on in the near future. However, it will be many, many years before the need and desirability of this kind of work ceases to exist, if it ever does.

ESTABLISHING AND PRESERVING SECTION CORNER STONES

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It is a well-known fact, as established by courts, that, in all deeds of conveyance of lands, lots, or parcels of land, cor-