What D. L. & W. Is Doing in Concrete Design

Long Precast Slab Spans are Used Successfully by Engineers of This Road

Part II

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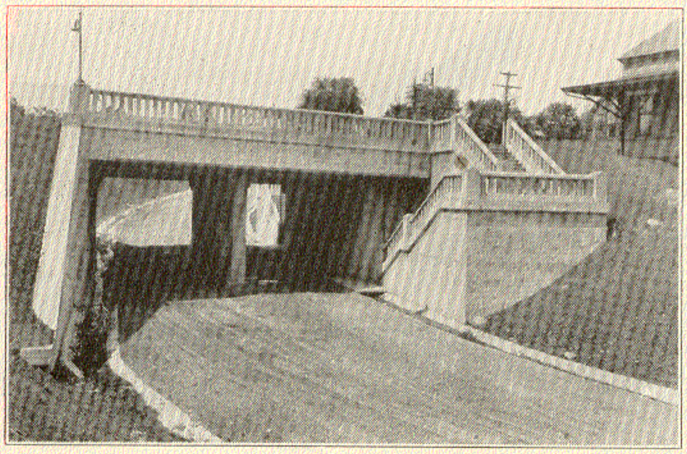
THE next step in the development of precast slab design on the Lackawanna consisted of a further reduction in the depth of the slab by making it continuous over two spans, and using compressive reinforcement as was done on the connecting line between Kingsland and Harrison, N. J.

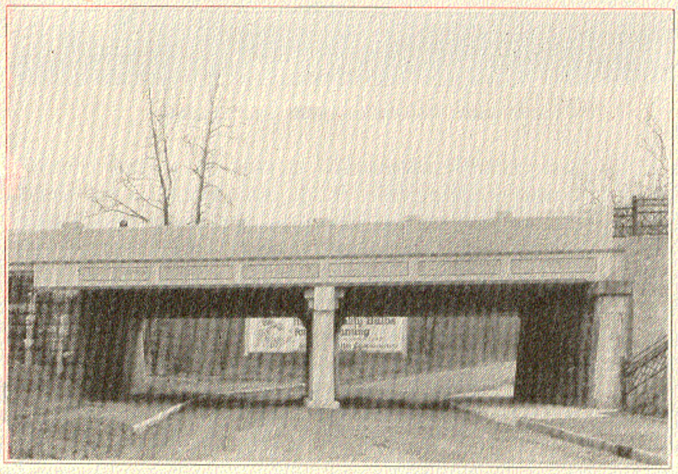
This type is, by far, the most interesting of the group. Probably it is the most unusual method of accomplishing the desired result, because, until recently, there has existed an inexplicable aversion to computing continuity in structures of any of the structural materials. Doubtless this aversion is due to the formidable appearance of the three-moment theorem formulæ, despite the fact that tables and influence line diagrams have been incorporated in text books, for the use of those who do not care to wade into the apparent intricacies of three moments. The writer has preferred to work out every case rather than use the predigested information supplied in the book, particularly since most of the cases with which he has had to deal have been of equal spans, although there have been some where the spans were unequal. Of the bridge slabs designed for continuity and precast, two have been selected for description, one because of its complexity, the other for its simplicity.

A Complex Problem

The first case is that of a bridge at Lackawanna place, Millburn, N. J., where it was necessary to replace a double track structural steel girder span by a bridge for three tracks. In this instance it was decided to construct a pier in the center of the street and use precast reinforced concrete slabs for the bridge floor. Because the original structure spanned Lackawanna place at a point where the width of street is only fifty feet, the abutments were placed along the street line fifty feet apart. North of the structure, however, the street widens to sixty feet. The condition is complicated further because there is a break in the street alignment under the extension for the third track. The break is along the line of the sixty foot street produced. This situation necessitated a break in the lines of the abutments and the center pier, and resulted in different span lengths in every one of the three units comprising the bridge floor for the third track extension. The six units over the existing supports and the new center pier, to accommodate the original two tracks, all are identical and cover two equal spans of 25 feet 11 inches from edge of abutment to center line of pier. This is the result of a twenty-five foot half width of street, modified by a skew of 15 degrees 10 minutes, because the angles of intersection between the center line of street and that of the two tracks of the railroad is 74 degrees 50 minutes. For the third track the skew was reduced to 2 degrees 55 minutes by the bend in the centerline of street so the slabs are nearly normal to the center pier, which is placed on this centerline of the street.



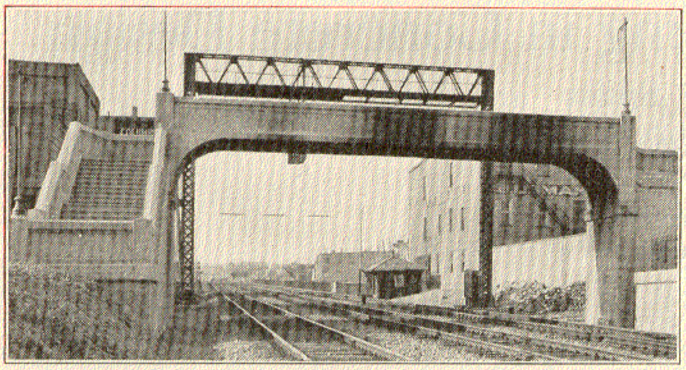
Taylortown Road, Montville, N. J.



Subway at Lackawanna Place, Millburn, N. J.

The slabs vary in length (out to out) from 57 ft. for the original two tracks to 60 ft. 3½ in. for the outside of the third track. To maintain the fifteen foot track centers which obtained before replacement, three units five feet wide were selected for every track, and upon this the design was based. The depth available for the slabs was 2 ft. 4 in. over the center pier. The allowance of two inches for drainage to either end gave a depth of 2 ft. 2 in. at the ends. This aided the design, since the maximum (negative) moment is over the center support.

The main reinforcement of the largest slab consists of six 1¼ in. square bars and nine 1-⅛ in. round rods in the lower plane. Seven of the 1-⅛ in. round bars are bent up from one span, and six from the other, for negative moment over the support. Ten 1¼ in. square bars are placed in the upper plane for compressive reinforcement at the center of span, as well as for additional tensile reinforcement over the support. Two additional bars are provided for compressive resistance at that point. Short bars are provided also at the abutments for anchorage to resist bond stresses, while forty-four 7/8 in. round stirrups are bent around the main reinforcement for shearing resistance and fifty-nine ½ in. square bars act as transverse reinforcement. The drawing shows these details. These units also were cast in the yards adjoining the car shops at Kingsland, N. J. When cured they were set in place, and waterproofing completed.



A Precast Footbridge, 14th St., Newark.

The other example mentioned is part of a grade crossing elimination at Montville, N. J., incidental to the third and fourth tracking of the Boonton line upon which this station is situated. Taylortown road (the crossing in question) was made a forty foot road. The bridge consists of two 19 ft. clear openings and a center-pier two feet wide. The angle of crossings 72 degrees 15 minutes, and the skew spans are 19 ft. 11½ in. For a slab depth of 2 ft. 5 in. which was available no additional compressive reinforcement was required since, at the point of maximum moment (negative) over the support, the straight bars supplied all the additional compressive resistance required.

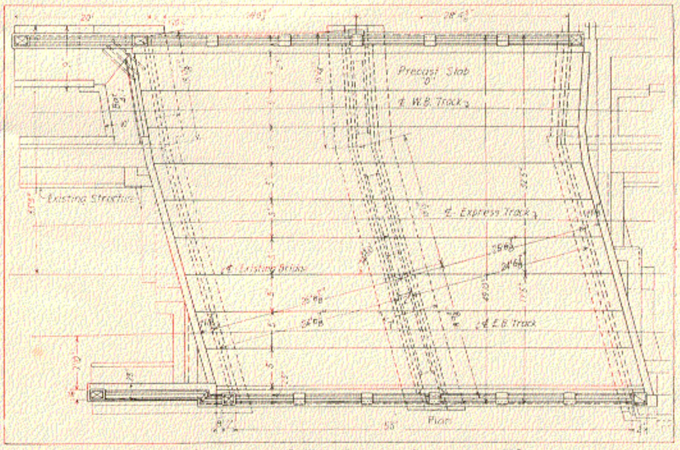
The reinforcement consists of sixteen one inch square bars, of which ten bars are continuous over both spans, and six are bent up from each side over the supports for negative moment. Short bars are placed in the upper plane to correspond to the straight bars in the lower plane; stirrups are added to assist in taking the shear; transverse bars are installed to distribute the stresses over the 6 ft. 9 in. widths of slabs used for track centers of fifteen feet for center tracks, and thirteen feet for outside tracks, with outer slabs supporting platforms.

In both instances the slabs were waterproofed and protected with special Hastings paving blocks in the casting yard before they were set in place on the bridge, to expedite setting of tracks.

Overhead Highway Bridges

In replacing this type of bridge by means of precast units, it is possible to maintain traffic both on the railroad and the highway except for a short time necessary to set the units on the abutments. At the same time the use of falsework is unnecessary.

Some years ago it became necessary to replace a series of overhead timber bridges in the vicinity of Port Murray, Netcong, and Hackettstown, N. J., where the masonry abutments were in good condition while the timber superstructure had deteriorated to the point where they would no longer serve. It was decided to replace all these bridges with precast reinforced concrete units as most suitable, economical, and effective. The units were constructed in the slab yard adjacent to the Kingsland shop, allowed to cure and then transported to the site of the bridge for erection. Most of these are farm crossings where the owner's property is on both sides of the tracks so it was necessary to provide a twelve foot clear driveway only; the remainder are public roads which required a twenty foot clear roadway. With a few exceptions all of these bridges were designed of T-beam units. The width of the T-sections was fixed uniformly at four feet, but the depth varied from 2 ft. 6 in. for a clear length of 30 ft. 8½ in. to 2 ft. 8 in. for a clear span of 35 ft. 6 in. The main reinforcement for the smaller spans consists of four one inch and two 1¼ in. square bars, of which three of the one inch square bars are bent up; for the longer span the reinforcement is three one inch and three 1¼ in. square bars. In every instance ¾ in. square bar stirrups aid in taking the shear, while transverse distributing bars and lifting loops for handling

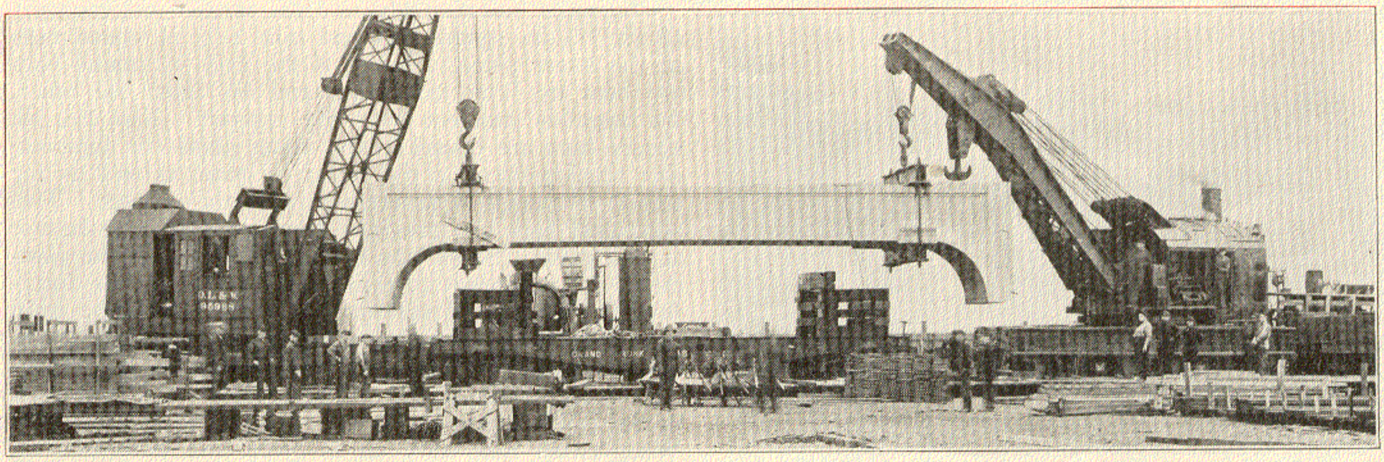


Plan of Piers and Tracks, Lackawanna Place.

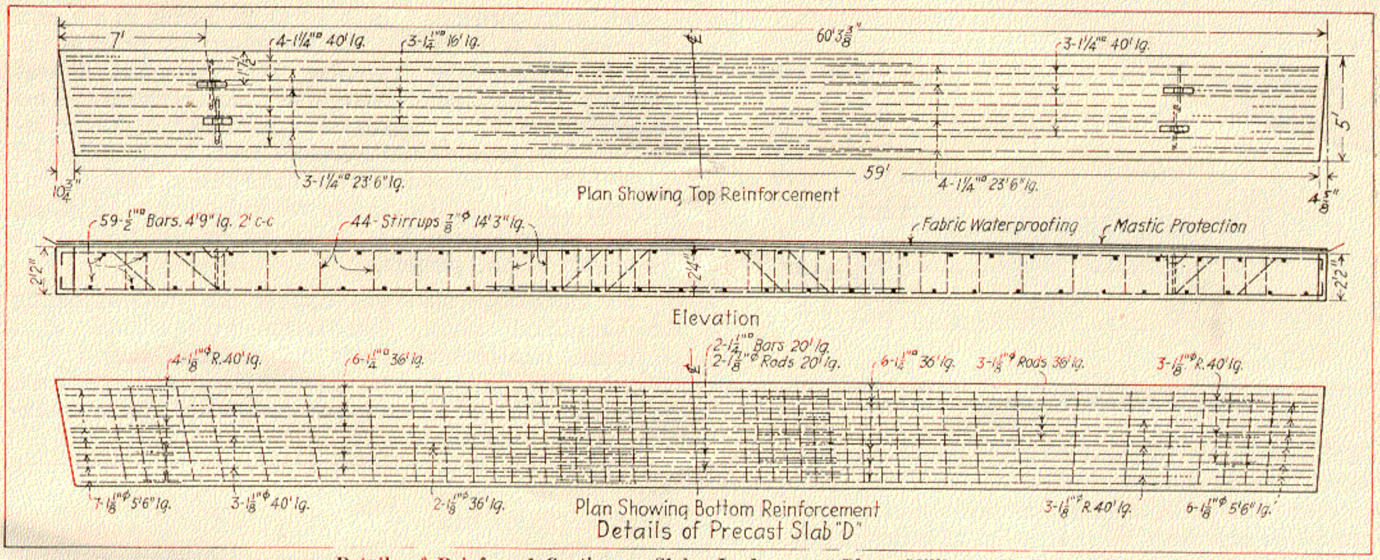
are provided. The bridge seats and girder railings were also precast.

Those bridges which were not made of T-beam design were ordinary slab construction, because the spans were short. This allowed use of simple slabs between piers which were capped with precast concrete cross girders and which supported the slabs forming the spans between the piers and abutments. As will be noted the piers were simple columns supporting the cross girders.

For the bridge west of Netcong, N. J., the slab units at the center were 4 ft. 6 in. wide and were cast to the curve of the camber caused by the vertical curve



Method of Handling a Precast Footbridge of Forty-Seven Foot Span.



Details of Reinforced Continuous Slabs, Lackawanna Place, Millburn, N. J.

on the bridge, the soffit of the slabs following this curve. The thickness of slab was sixteen inches. The reinforcement consisted of nine 7|8 in. square bars in every unit. Three are bent up over the supports to take shearing stress which are resisted also by stirrups.

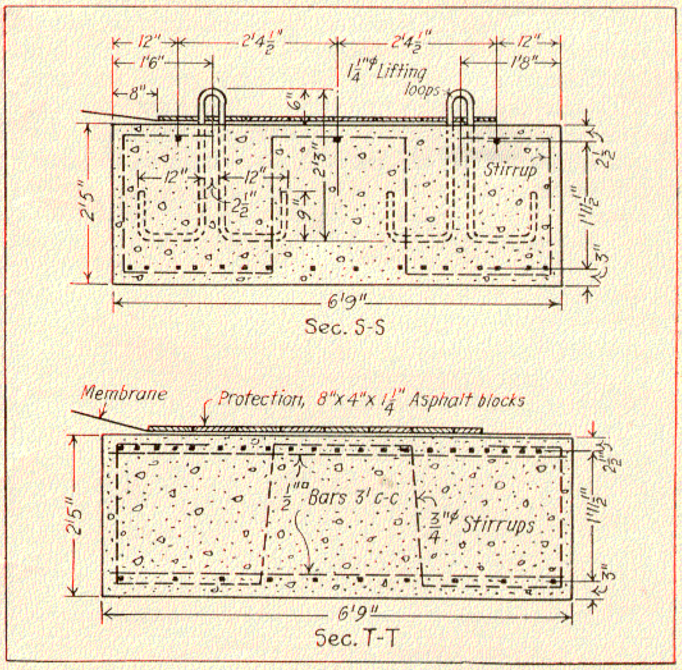
Foot Bridges

Perhaps the most interesting example of all the precast bridge work is that of the foot bridges, cast completely in one operation and, when cured, placed on the abutments ready for service. The first precast footbridge on the Lackawanna was designed to replace one of structural steel in connection with the East Orange improvement, completed in the autumn of 1922.

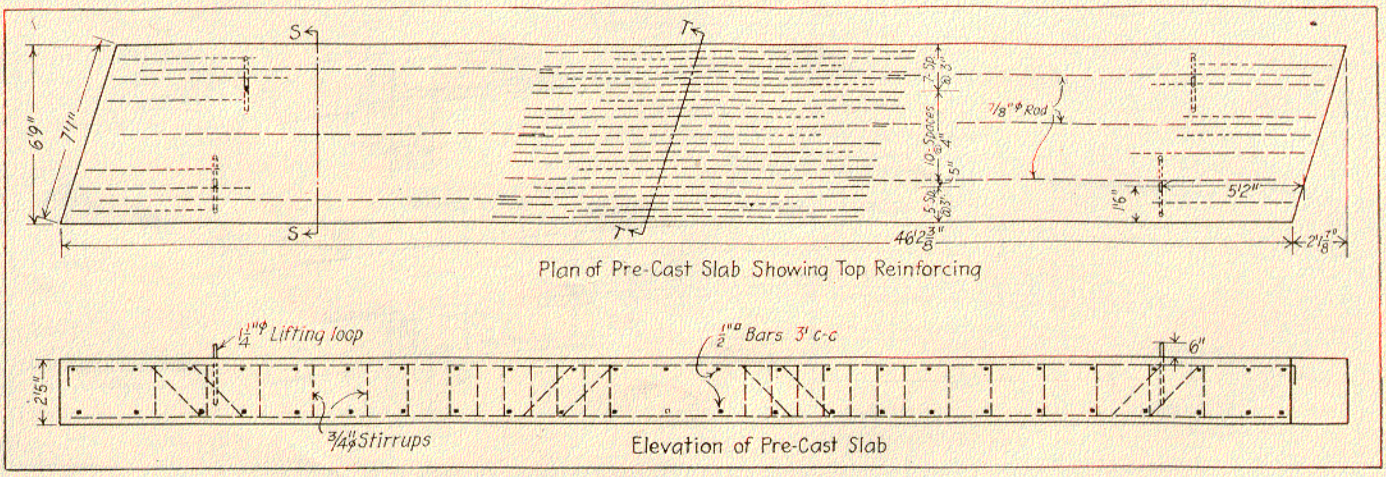
This bridge has piers cast in place on top of the continuous retaining walls which were built in connection with the depression at this point. The girders, together with the slab between them, constitute the precast section. The stairways leading from the bridge at either end, like the piers, were built in place.

The piers carrying the footbridge are supported on the retaining walls and held in place by means of five one inch square bars imbedded 3 ft. 6 in. both in the walls and piers, or about forty diameters. The piers are 1 ft. 9 in. thick and somewhat more than eight feet high above the walls. They were completed more than a month before the footbridge was placed.

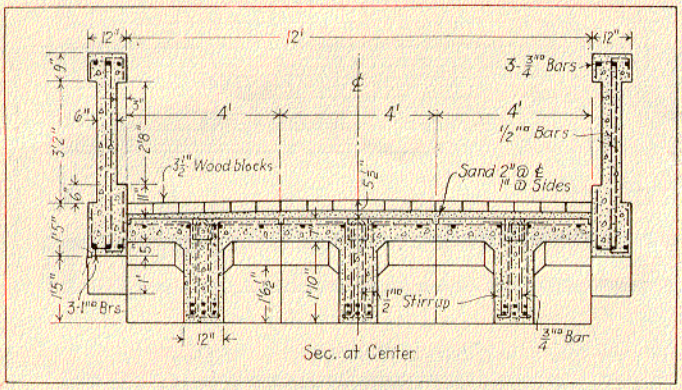
The interesting part of the work, of course, is the precast section, which the writer believes to be the first instance of a complete reinforced concrete bridge precast and erected on previously prepared piers. This footbridge has a single span of 46 ft. 8 in. over three tracks. The center lines of bridge and tracks made an angle of 84 degrees 59 minutes with each other, or very nearly a right crossing. It is of the slab and girder type. The slab is supported at the bottom flanges of the girders,



Sections of Slabs, Tarrytown Road.

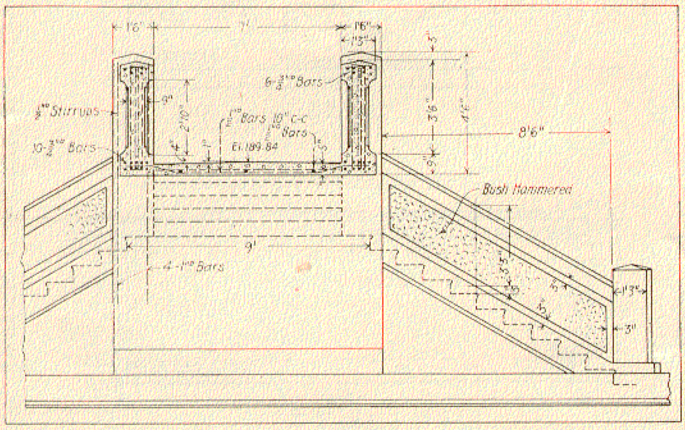


Top Reinforcing, Continuous Slabs, Tarrytown Road, Montville, N. J.



Section Through Precast Farm Bridge.

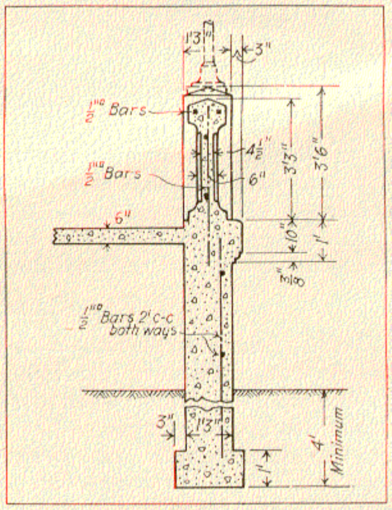
which are at the respective fascias, and somewhat ornamented for architectural effect. The clear passageway is seven feet wide, making an out-to-out width of ten feet at the end posts of 9 ft. 6 in. at other points. The fascia girders act as balustrades or railings, and have a width of 1 ft. 3 in. both at top and bottom flangers. The web between these flangers is only nine inches thick except for the 1½ in. panel indentations. The floor slab is six inches thick along the center line or crown with a pitch of one inch to either side for drainage. Drainage is facilitated further by a two inch camber which gives a pitch toward the stairs at either end. Side clearances for the tracks below were sufficient to permit curving the soffit of the slab to a 4 ft. 10 in. radius at the junction with the supports. This gives a curved corbel and allows the introduction of the stair construction several feet before the supports are reached. The precast section, therefore, includes five risers of the stairway at either end.



Section Through Maple Ave. Footbridge.

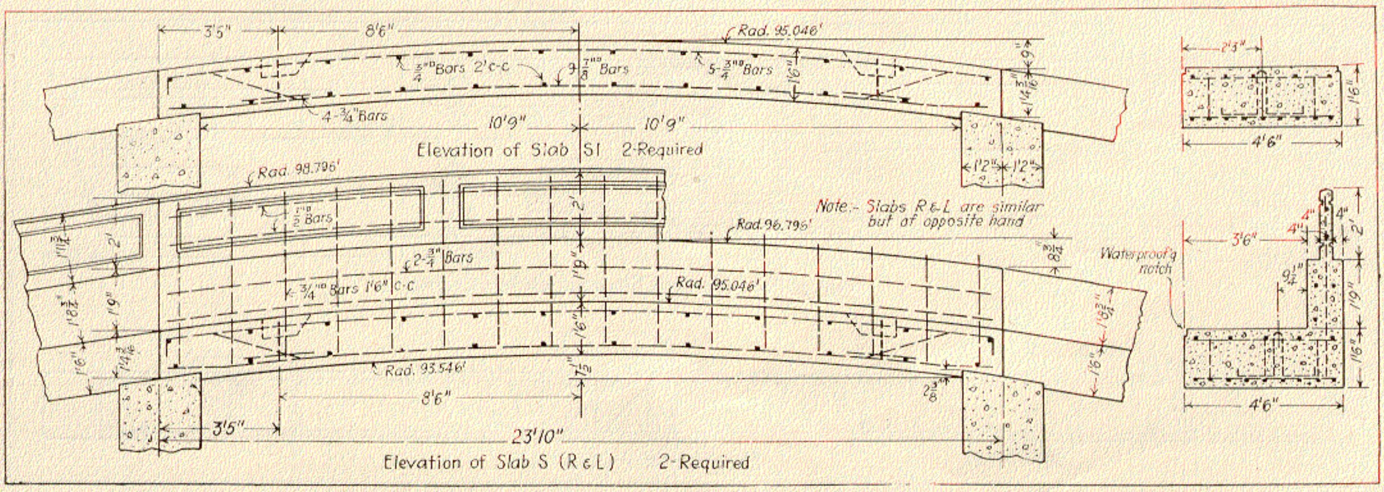
The fascia girders, 4 ft. 3 in. high, result in a depth of railing of 3 ft. 9 in. As this does not provide the required compressive resistance for the span, it was necessary to use compressive steel reinforcement. This consists of six ¾ in. square bars as shown in the cross-section. The tensile reinforcement consists of ten ¾ in. square bars, two of which are bent to resist diagonal tension and are in addition to the vertical stirrups of ½ in. square section spaced 2 ft. 6 in. on centers throughout the length of the girders.

This footbridge also was cast in the yard adjoining the Kingsland shops. The forms were erected on a platform, reinforcement was set in place and 1:2:4 concrete, made with broken stone as the coarse aggregate, was used. The whole unit was completed in one operation (the volume amounting to less than 30 cu. yd.). After the forms had been removed and the concrete hardened sufficiently the panels formed by the indentations were bush-hammered. The bridge was ready then for transportation to the site of the work.

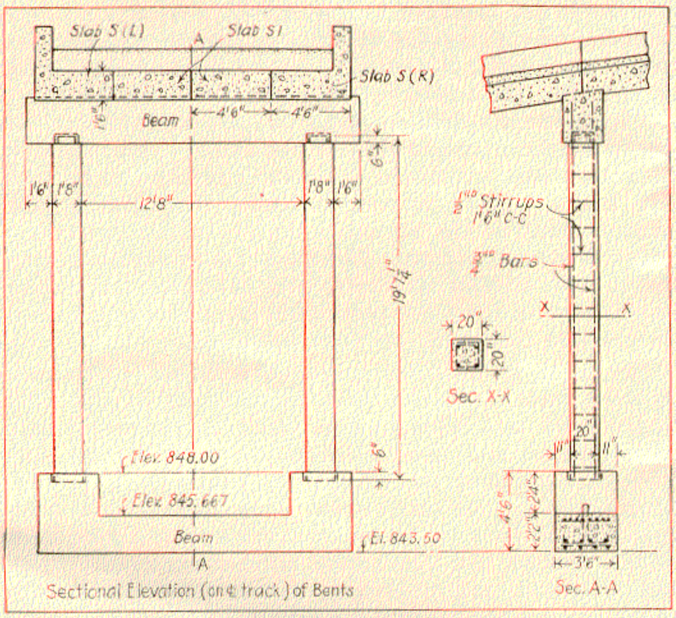


A Detail of Footbridge.

To insure against damage to the bridge, in the various operations incident to final erection, and to facilitate handling, a combination of spreader and cradle was devised to encircle the structure at points adjacent to the curved sections near each end. Each of the cradles consisted of a pair of 15-in. I-beams side by side, both under the soffit of the slab and above the tops of the girders. They projected beyond the structure sufficiently to permit bolting them together at both top and bottom angers by plates one inch thick and 15 in. square at each end. At the center of this spreader there was a pin, 3¾ in. in diameter, held in place at the underside of the I-beams by means of a one-inch plate bent to the radius of the pin; the flat parts of the plates were bolted securely to the two I-beams. This pin was connected with a 3-in. eyebolt ending in a loop to engage the hook of the crane.



Cambered Slabs on Overhead Highway Crossings.



Details of Bents, Overhead Crossings.

In preparation for setting the bridge on the flat car used to transport it, a timber grillage was built near each end, high enough to keep the curved ends off the floor of the car. Two cranes, one at each end of the bridge, engaged a lifting loop, raised the bridge from its platform and set it on the flat car in proper position. The train including the cranes then moved to East Orange and passed partly through the Bergen Hill tunnel at Jersey City. The bridge was set on its supports by two cranes, in the same way it was loaded on the cars in the hour between 1:00 and 2:00 a.m., after the last westward suburban train had passed. The weight of the precast bridge is fifty-seven tons.

A footbridge almost identical with the bridge at Maple avenue was built the following year at Fourteenth street, Newark, the only difference in procedure being that of casting the bridge alongside the site of the structure where there was space available for that purpose. It was a simple matter to lift and swing the bridge into place.

This really completes the story of precast concrete bridge construction except to note that many minor members such as concrete balustrades, fence posts, transmission poles, signal boxes and, recently, ties have been cast and placed successfully.

G. J. Ray, chief engineer of the Lackawanna system since 1909, always has looked with favor upon and encouraged, this type of construction, because of its great value in eliminating disturbance of traffic during construction.

Railway Fire Protection Meeting

The Railway Fire Protection Association held its Thirteenth annual meeting at the St. Charles hotel, New Orleans, La., October 12, 13 and 14, with president C. C. Michie, assistant secretary of the Chesapeake & Ohio Ry., presiding over an attendance of about 200. Besides the address of the president, L. C. Bentley, general safety agent, Chesapeake & Ohio Ry., addressed the meeting on Spending Money to Make Men. Charles N. Rambo, manager of the Railroad Insurance Association, spoke on How a Railroad Can Make Use of the Services of its Fire Underwriters. Robert Scott, director, department of insurance and safety, Atlantic Coast Line R. R., made an address on The Human Element in Fire Prevention.

Among the committee reports, that of the committee on motor transportation made recommendations on hazards relative to housing, servicing and making repairs on automotive vehicles, the recommendation probably being the first made by any association affecting motor buses.

Motor Vehicle Rule

The committee reported that it had sent questionnaires to 85 member roads and that 65 had replied. From these questionnaires it was found that 28 roads are operating 186 rail motor cars with the largest number on any one road being 24 and 8 roads are operating 244 highway motor coaches, the largest number operated by one road being 141. The committee found in its investigation that gasoline vapor causes many and may be responsible for spreading almost every fire that occurs in this type of vehicle and should be treated as the most serious hazard. Fuel tanks should be constructed substantially and accessibly situated to permit frequent inspection. They should be so placed as to prevent possible injury from collision or overturning. Fuel filling openings should be accessibly located where not subject to mechanical injury and should be protected with some approved device that will prevent flames from entering the tank or the possibility of the gasoline vapor becoming ignited when the cap is off.

The committee felt that the vacuum system is the only type that it cares to recommend as a standard fuel feed system. The exhaust from the engine should be protected by a properly designed muffler and so placed as to insure against injury, while, at the same time it should allow the proper dissipation of possible unburned gasoline vapor away from the car. It was found that in all the highway motor coaches and many of the earlier rail motor cars, a by-pass from the exhaust line has been used to heat the interior of the car. This line is usually extended under a metal grill along the floor and the inner section of the side wall. Several fires have been reported as having been caused by a pyroxylin umbrella tip, paper, etc., coming in contact with the hot pipe.

The committee recommended that all wiring and electrical equipment should conform to the National Electrical Code and the National Electric Safety Code and at the same time to the regulations of the National Board of Fire Underwriters relative to electric cars insofar as they apply. Wires should be code rubber covered and run in such a manner that they will not be exposed to mechanical injury, especially vibration or to the absorption of oil or damage by heat. Emergency electric lighting equipment should be provided with advantageously located receptacles into which portable lamps on leader cords can be plugged.

In considering rail motor cars, the committee recommended that fuel tanks should be placed below the floor and, on cars where coal or other open flame heaters are installed, should be situated as far as possible from the heaters. Filling openings should not be located near the outside doors leading to baggage compartments and doors should be kept closed during the filling operations. The filling of fuel tanks should be performed only at approved filling stations. The motor should be shut down during the process of receiving fuel supply. The rules governing electric wiring in motor buses were recommended for rail motor cars.

Exhaust line heaters for rail motor cars were found to be unsatisfactory as they are only effective when the engine is running and are unsafe from a fire protection standpoint as it is practically impossible to provide sufficient clearance from inflammables and to keep such material from coming in contact with the hot pipe. As