FIG. 1—SPRING STREET VIADUCT, ATLANTA, GEORGIA

FIG. 2—AULON VIADUCT, MEMPHIS, TENN.

Protection of Steel Against Corrosion

Employment of Gunite for Protection of Steel Structures — Experiments Show That Gunite Encasement Increases Strength of Members — Method Employed on Spadina Avenue Bridge, Toronto—Method of Applying Gunite—The Pre-Shot Gunite Arch Slab

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FOR several years engineers have recognized the necessity of providing in their initial installation (especially of structures subject to such severe hazard as are steel bridges over railroad tracks) a method of corrosion prevention that will not penalize the structure with excessive dead load and will at the same time insure positive protection. It was for this reason that the engineers of the city of Toronto called for the use of "Gunite" protection of the steel members of the Spadina Avenue Viaduct over the tracks of the approaches to the new Toronto Union Station. Inasmuch as this type of protection is becoming so extended a study of proper methods will be of interest at this time.

"Gunite" is the name given to a mortar or concrete composed of sand and cement propelled against the surface to be covered by pneumatic pressure with a machine manufactured under the trade name "Cement-Gun," and it is on this quality

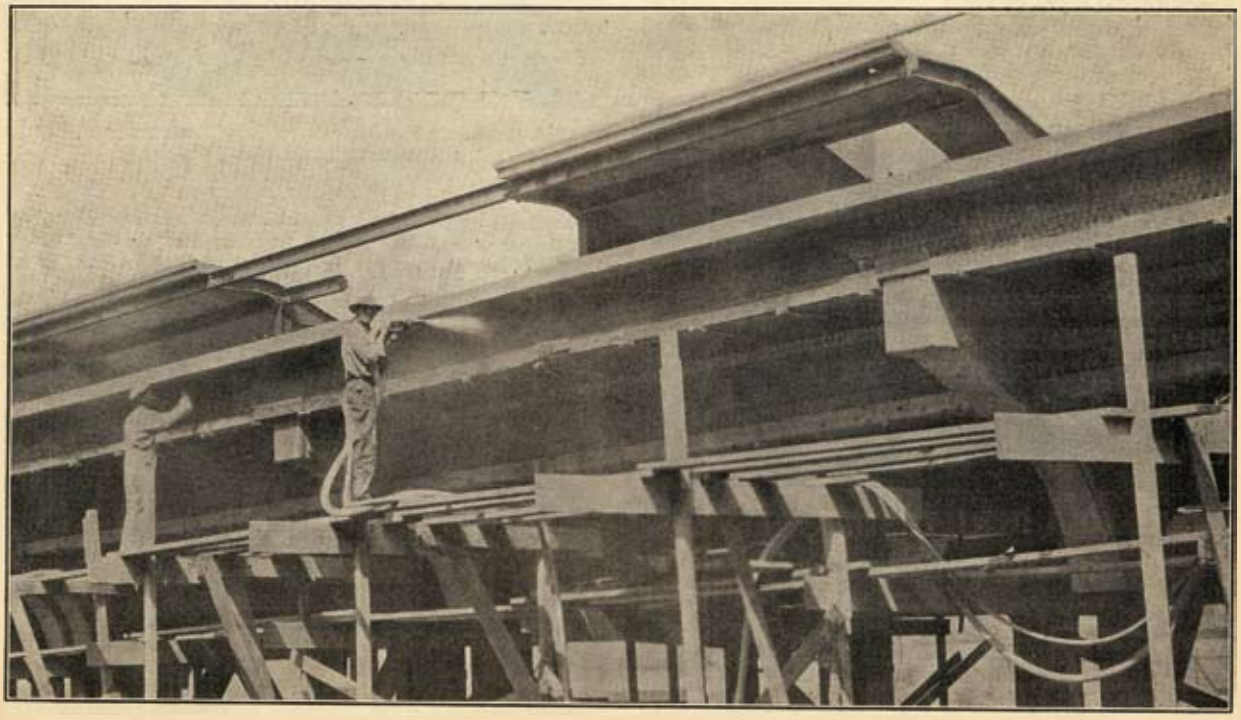

FIG. 3—LEHIGH VALLEY STATION AT EASTON, PA.
Showing L-Strips on Bottoms of Girders; Also Method of Building Cornice Below Deck; Also Gunite Umbrella Roof Over Platform.

Reprinted from "The Canadian Engineer," April 23, 1929

of high pressure and that of water for hydration being added at the point of application that success is dependent.

Professors Peter Gillespie and P. J. Culliton, of Toronto University, in an extensive report dated October 28th, 1924, call attention to the fact that Portland cement is a positive protection for steel against corrosion, but that in order to assure this protection it is necessary for the surface to be free from rust, scale, grease or paint; and that all air shall

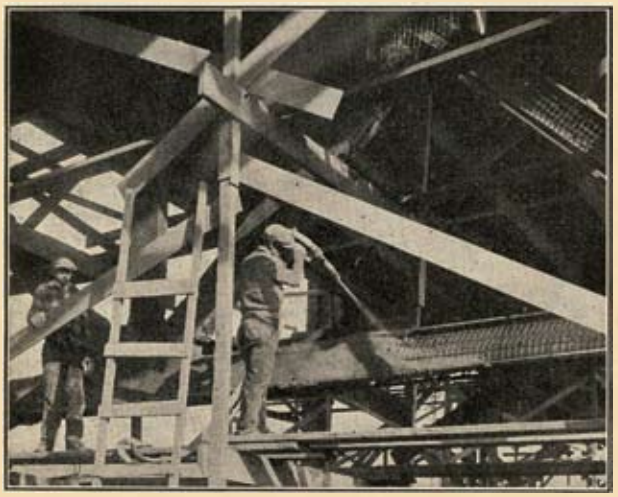

FIG. 4—SHOWING METHOD OF WIRING AND PLACING SINGLE PLANK STRIPPING, ALSO SHOWING GUNITE BEING APPLIED

be eliminated from contact with the surface. A number of other authorities have called attention to the fact that the methods of placing a covering of hand-applied mortar, or of concrete, instead of eliminating these air pockets, augment their existence. On the other hand, Professors Gillespie and Culliton draw attention to their entire elimination when "Gunite" is used, due to the velocity of the impelled material driving the air ahead of it.

Very extended experiments made by Professors McKay, Gillespie and Leluau for the Dominion Bridge Co., showed that the strength of steel members encased in concrete or

FIG. 5—SETTING PRE-SHOT GUNITE ARCH SLAB ON P.R.R. BRIDGE

"Gunite" was materially increased, but, as pointed out by Professor McKay in a paper read before the American Institute of Steel Construction, the analysis of these tests was dependent on the T-beam section of the deck slab, and to be assured that in a simple encasement an increase of strength could be obtained a very exhaustive series of tests were carried on at Ohio State University under Professors Clyde T. Morris and J. R. Shank (described in report dated 1928) which conclusively proved that the ordinary encasement of reinforced "Gunite" largely increased the strength of the member, and it is therefore common practice to consider such encasement at least without a penalty of added dead load.

Architectural appearance so often affects the decision as to the type and character of a structure that a description of some of the methods being employed in "Gunite" encasement of steel to obtain proper lines will be of interest and benefit.

Fig 1 shows a bridge over the tracks of the Southern Railway at Spring Street, Atlanta, Georgia. The panel effect shown is obtained by trowelling or floating the surface of the flange and stiffener encasement, with the finish in the panels merely that of the natural surface of untreated "Gunite." This panel effect is both economical and effective.

Fig. 2 shows a finish of somewhat different type obtained on a structure in Memphis, Tennessee. This texture is obtained by "brushing" with a whitewash brush wetted with clean water.

One of the most recent and interesting illustrations of proper methods to be employed to obtain true lines in "Gunite" encasement was in the work done by the Cement Gun Co. Inc. in encasing the steel members of the overhead structures being built by the New Jersey State Highway Department in connection with the new appoaches to the Holland Tunnel. The specifications for these structures call for an encasement of reinforced "Gunite" 1½ in. thick on all webs with a 2-in. encasement over the edges and bottoms of all flanges and further call for the placing of "shooting strips"

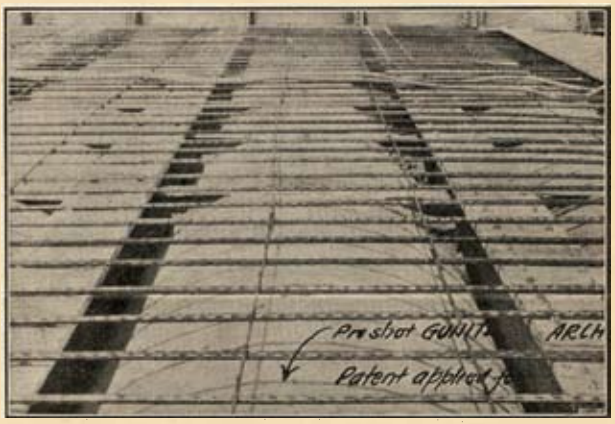

FIG. 6—SHOWING PRE-SHOT ARCH SLAB CONSTRUCTION BEFORE CONCRETE DECK WAS POURED

which will insure the proper thickness of encasement as well as proper alingment. Before applying the "shooting strips" the mesh must be properly fastened in place so that it will be held uniformly at about the centre of the slab and shall not come into contact with the steel especially at the flange edges. To obtain this effect rods were tied along each side of the webs through holes previously punched in the steel as near the fillets as possible, and over these rods the mesh was stretched and tied. Care was taken to prevent contact of the mesh with the edges of the lower flanges by bending the mesh over templets at least 1 in. wider than the flanges.

It will be noted from the accompanying cuts that different types and shapes of "shooting strips" were used to obtain the proper results with different members. Fig. 3 shows the use of an L-shaped strip at each edge of the lower flange of the horizontal members. For these strips it was customary to use two pieces of 1-in. plank 4-in. wide nailed together to form the L. This longitudinal strip was held in place by wiring to the rods or by other methods. The proper spacing from the faces and edges was obtained by blocking with nails or other satisfactory means. Fig. 4 shows how that for vertical and diagonal members the practice was to use single boards with the outer edges set to proper alignment. This enabled the operators to finish between these surfaces with trowels or screeds.

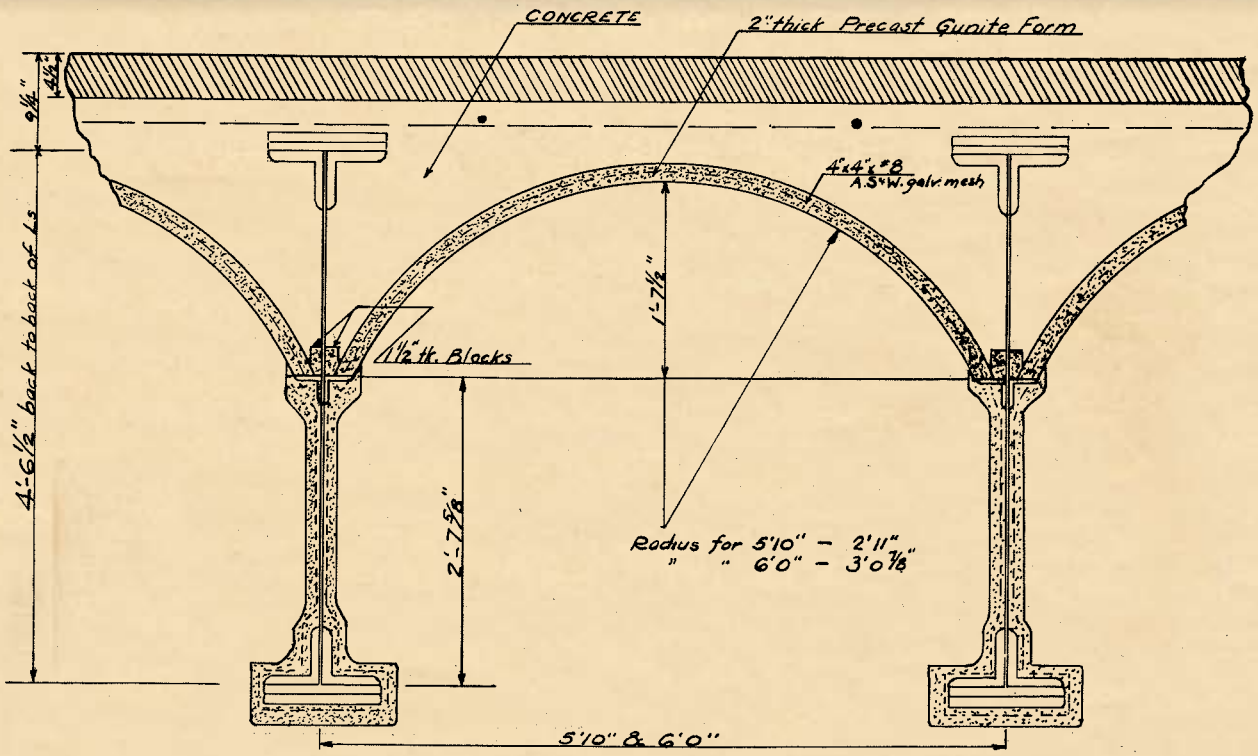

FIG. 7—DETAIL OF GUNITE ENCASEMENT USED BY P.R.R. FOR BRIDGES AT OVERBROOK AND PHILADELPHIA

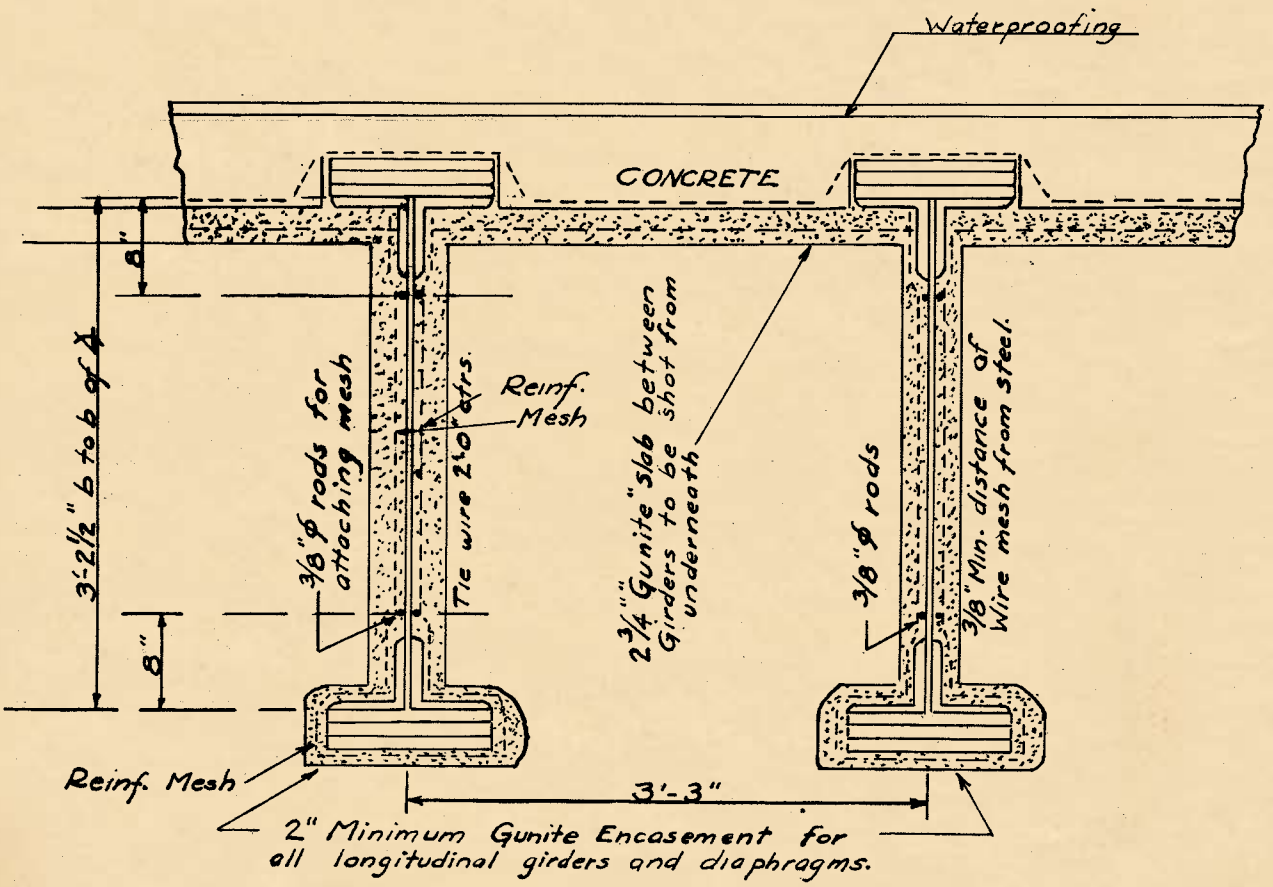

FIG. 8—DETAILS OF GUNITE ENCASEMENT USED BY P.R.R. FOR BRIDGE AT CLEVELAND

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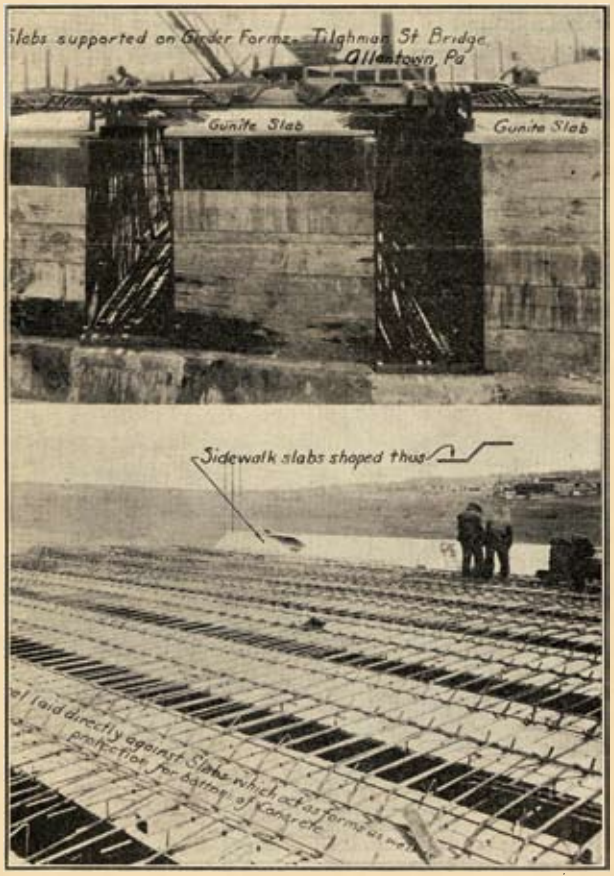
In placing "Gunite" it is necessary that the material be impelled, as nearly as practicable, normal to the surfaces being covered, and therefore the method of "shooting" was to first fill the L strips or between the straight planks, and subsequently after the cement had obtained its set, the strips were removed and the spaces between the finished lines were filled. This was especially necessary in the horizontal beams to insure the density and imperviousness of the "Gunite."

No forms were necessary for the webs except that for the outer face of the stiffeners. A straight plank 4 in. wide was used to denote the line and grade of the stiffener. Careful "shooting" by expert nozzlemen secured a surface of the webs that demanded nothing more than a finish obtainable by brushing with a whitewash brush. This same finish was used for the surfaces where the strips had been used.

An essential element for proper workmanship in "Gunite" encasement has been found to be the use of experienced nozzlemen and consequently the specifications of the New Jersey State Highway Commission provide that no man could be employed as nozzleman unless he could show actual experience of having handled the nozzle on at least three previous similar jobs.

The "Gunite" method of steel protection has been extended to include its use for protecting the bottoms of floor slabs, and the two methods of slab protection shown in Figs. 5 and 6 as employed in the construction of bridges over the Pennsylvania Railroad are of interest. In Fig. 5 is illustrated the construction of a preshot "Gunite" arch slab which is subsequently placed in position supported on the flanges or on shelf angles of the girders. The concrete deck slab is poured over these arches as forms. The joints between the various sections are filled with "Gunite" at the same time that the flanges and exposed steel are being protected. This method is of interest in creating a jack arch section; in protecting the concrete; and at the same time eliminating the use of forms. The method shown in Fig. 6 is employed in cases where the grade problem demands the use of shallower beams spaced more closely. Similarly the use of expensive forms is eliminated by shooting the "Gunite" slab between beams from below against a movable panel laid on the top of the girders. After the "Gunite" slab is completed the steel for the deck is laid directly against this slab and the concrete poured to the proper thickness.

In other cases plain, flat, preshot slabs, which have been designed to be of sufficient strength to bear the dead load of the concrete without deflection, have been used with great success, especially in cases where the problem of form construction is serious, but the particular added value of this construction is the elimination of the danger of honeycombed concrete below the plane of the reinforcing and the assured protection against corrosion. This has been found of such great advantage that a number of engineers have specified such construction in building reinforced concrete bridges when subjected to the hazard of salt water or locomotive gases. In these cases the preshot slabs are rested on the walls of the girder forms; the steel rods for the girders are placed directly against the forms; and subsequently after the concrete is set and the forms removed the sides and bottoms of all girders are covered with "Gunite."



REINFORCED CONCRETE BRIDGE OVER L. & N.E.R.R.

Showing method of using pre-shot flat slabs for forms and bottom protection of concrete slabs in reinforced concrete bridge built over tracks of L. & N.E.R.R. at Allentown, Penna. The girder steel is placed directly against the wooden forms and the girders subsequently encased with reinforced GUNITE as described in the last paragraph above. This bridge designed by J. B. Long, Norristown, Penna.

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