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Reinforced Brick Masonry Used in Ohio Bridge

Substructure, railing and sidewalks utilize reinforced brickwork, while deck is of concrete T-beam construction

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A HIGHWAY BRIDGE of unusual type in that it made rather extensive use of reinforced brick masonry has recently been opened to traffic by the department of highways of Ohio. The structure is located on state route 39 at the east corporation line of the village of Sugar Creek, Tuscarawas County, and spans a small stream known as the South Fork of Sugar Creek. This small village is in the midst of the clay-manufacturing industry of eastern Ohio, and since two brick plants with many idle employees were located within a few hundred yards of the bridge site it was decided to design a structure that would make maximum use of the local labor. Accordingly, since the available foundation soil was unsuitable for brick-arch construction, a twin-span concrete T-beam superstructure, on a reinforced brick masonry substructure and with brick facing and railing, was chosen after preliminary estimates indicated this type to be economically justified.

The two spans, skewed 22 deg., are each 32 ft. clear, and accommodate a 24-ft. roadway and two 3-ft. refuge walks. The height from bottom of footings to top of curb varies somewhat for the different substructure units, but is approximately 20 ft., the footings in all cases consisting of concrete resting on timber piles. Above the footings all pier and abutment walls are made of reinforced brick masonry capped with concrete, to protect the vertical joints of the brickwork against entrance of water and to produce a more finished appearance.



REINFORCED BRICK MASONRY comprises the pier and abutments as well as the railing and sidewalks of this concrete girder bridge in Ohio.

In line with the general policy of the bureau of bridges, the abutments are designed with breast wall and wings in a straight line, to facilitate the future widening of the bridge.

Details for the structure were prepared for the use of the standard-size building brick, 2¼x3⅝x8 in. with permission to use any size of building or paving brick, if details showing variations in dimensions and patterns were presented by the contractor and approved by the bureau of bridges. Face brick was required to be smooth, dark red and hard-burned, meeting A. S. T. M. specification No. C-62-30 for hard or medium grade building brick. Backing brick was required to meet specification C-32-24 for Class A or B vitrified, or hard or medium-grade clay sewer brick. Face brick was also required to meet the absorption test for hard-grade sewer brick. The brick used was standard-size, dark red, building brick. Common bond was used, with every sixth course as headers, and joints were ½ in. thick. All joints were completely filled with mortar, and all exposed joints were struck, including those on the back of the abutment walls.

For experimental purposes, so as to determine relative efflorescence, workability, durability, etc., two types of mortars were used. The east abutment was built with 1:3 portland cement mortar to which was added hydrated lime, not to exceed 15 per cent by volume of the cement. The remainder of the brick masonry was built with 1:2½ mortar, using a commercial mortar cement. The latter mortar proved to be much more workable and easy to handle. Its crushing strength, although lower than the portland cement mortar, was sufficiently high to provide a reasonable factor of safety over the design stresses.

Waterproofing, consisting of two coats of hot asphalt, was applied to the back of all abutment brickwork below the ground line; total of 1 gal. per sq.yd. of surface was used. This, together with the concrete capping on all brickwork, was expected to reduce efflorescence to a minimum.

The sidewalks were built as reinforced brick slabs, spanning from curb to coping. Each slab was 3⅝ in. (one brick) thick and reinforced with a ⅜ in. round rod in each joint (2⅔ in. centers). This slab was precast or laid up as a 4 in. wall in sections about 2 ft. long, allowed to season, and then placed on a mortar bed at both ends. The sidewalks are so designed that they may be removed to facilitate widening of the roadway if required.

An H-15 design loading was used with the following unit working stress in the reinforced brick masonry walls, railing and sidewalk slab: compressive stress in brick masonry, 600 lb. per sq.in.; shear in brick masonry, 20 lb. per sq.in.; bond for deformed bars, 50 lb. per sq.in.; tensile stress in reinforcing steel, 14,000 lb. per sq.in.; and a ratio of modulus of elasticity of steel to brick masonry of 15.

The superstructure was not continuous, but both spans were anchored to the pier, with the abutment ends of each beam resting on two ½-in. rolled phosphor-bronze plates, separated by one layer of ⅛-in. sheet asbestos packing and flake graphite. An open joint 1½ in. wide was left between the sides of the superstructure and the abutment, and a waterproof expansion joint of folded copper and premolded expansion joint filler was provided at the ends of the roadway slab. To prevent lateral displacement of the superstructures incident to skewed construction, blocks of concrete cast monolithically with the bridge seats were placed between the central and adjacent beams. Brick facing on the outside beams was placed

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this same reduction with dowels, a spacing of approximately 18 in. would be necessary on a 10-in. slab and approximately 15 in. on a 6-in. slab.

This analysis assumes perfect dowel action. The dowels themselves are assumed to be so stiff that, for the reaction developed, no deflection of the dowel occurs. Further, it is assumed that the dowels seat perfectly in the slab, and complete shear resistance is developed. While it is our belief that the theory is sound and gives an excellent picture of the relation between dowel spacing and stress reduction, it is also believed that the theoretical stress reductions are considerably greater than are to be expected from dowel installations as they are found today.

In the tests now being made at Arlington the transverse joints containing dowels were constructed with joint openings of ½ and ¾ in., dowel spacings of 18, 27 and 36 in., and dowel diameter of ¾ in. in all cases; pains were taken to see that the dowels were installed properly. The tests indicate that the joints of this type with dowels 18 in. or more apart are not very effective in reducing the critical stress caused by a load placed near the joint, the efficiency of the joint construction being generally below 50 per cent. The deflection curves of the slab ends adjacent to the joint show that corresponding points on the two abutting edges do not deflect the same amount. This is probably due primarily to dowel deflection, and perhaps in part to some slight looseness of the dowel in its socket. Whatever the cause, the actual dowel behavior of these carefully installed ¾-in. dowels falls considerably short of the ideal action upon which the Westergaard analysis is predicated. To secure appreciable stress reduction in doweled joints, as actually constructed, it seems to be quite definitely indicated that a dowel spacing of the general order of 12 in. is necessary.

Many of the objections against the use of dowels would be overcome if the shape of the dowels were changed to secure greater stiffness without sacrificing bearing value. This may be accomplished by installing bearing plates in the concrete in which the clearance between the dowel and its bearing is reduced to an absolute minimum, so that the dowel is brought into play without excessive deflection of the slab ends. This may be the ultimate solution, as the amount of steel may conceivably be less than is now used for round dowels, and much greater ease of installation and efficiency would be secured.

Accurate dowel installation

The principal objection to the use of dowels for load transfer is the time and difficulty of securing proper installation. Where the mixer is located on the subgrade, this is of prime importance, as the time lost in installing joint devices necessarily cuts down production. Where the mixer is not located on the subgrade this consideration is not so important, as joint devices may be placed well in advance of the concrete.

Where dowels are used it is absolutely essential that they be accurately spaced parallel to the axis of the pavement, that they be painted and well oiled with a good grade of heavy oil to break bond. Dowels across expansion joints must be provided with metal caps to give sufficient air space for their movement in the slab. If the dowels are out of position, the movement of the slabs creates a funneling action in the concrete which destroys their effectiveness. Dowel bars for load transfer are subject to shearing and bending stresses. It is essential, therefore, that they have continuous close contact with the concrete. Any clearance between the dowel and the concrete permits a corresponding deflection of the pavement slab before the dowel bars become effective. Dowel-bar sleeves or sockets covering one-half the length of the dowel bars should not be used

With the dowel-bar spacing of 12 in. for load transfer, it is an almost hopeless task to secure proper installation of dowels by using individual dowel-bar supports, or pins on each dowel. Unsatisfactory results with dowel bars have been largely due to the abuse of their use. If they are not properly installed, they had better be omitted. Our specifications must provide for continuous dowel support in such a way that the joint, whether contraction or expansion, regardless of type of expansion device employed, be assembled alongside the work and lifted into place and supported in position as a unit.

Cost of various joints

The cost of installing transverse expansion joints with adequate provision for load transfer will vary according to the type of joint used. The cheapest type is a poured or preformed asphalt filler with dowel bars. On the basis of a 20-ft. width the joint filler of this type may be expected to cost about $2.50 per joint and dowels about $5 per joint, making a total of approximately $7.50 per joint, or $450 per mile for a 90-ft. spacing. If preformed rubber or cork is used for the joint filler, the cost of the filler will be about doubled, while the cost of the dowels will remain the same, making the cost for a 90-ft. spacing approximately $600 per mile. All metallic air-chamber joints with copper seal will range in cost from 45c. to 65c. per foot, exclusive of the dowels for load transfer. Where other means than dowels are used for load transfer with these types of joints, prices range somewhere between these figures.

The cheapest installation for contraction or crack control is the dummy joint or plane of weakness. The cost of forming the weakened plane is almost negligible, the principal item of cost being the dowels for load transfer. A complete installation for expansion and crack control consisting of expansion joints at 90-ft. intervals, with contraction joints or planes of weakness spaced so that the distance between contraction joints or expansion joints is 30 feet. with resilient joint fillers and load transfer across all joints, will cost about $1,100 per mile. This cost may be as much as $2,000 per mile when all-metallic copper-sealed air chamber expansion joints and copper-sealed metal lic contraction joints are used.

One principal objection to the use of resilient joint fillers is a belief that the resilient properties will be lost in a few years. No definite answer can be made to this. It may be that joint installations of this type will be developed in which the resilient filler will occupy only the joint space above the dowels so that the joint opening may be cleaned and the filler renewed when it has lost its resilient properties. The sub-grade seal type of joint used in Minnesota has this interesting possibility. Cotton-seed hulls and sawdust packed in joint openings and impregnated with asphalt have been used for some time, but the extent to which they will be effective over long periods is not known.

Experience has rather definitely indicated that metal seals for expansion joints must be of malleable material. Copper is undoubtedly the best material; unless punctured or destroyed by direct application of load, it should be effective for long periods. Hard metal seals have a tendency to split rather easily when subjected to the maximum movement possible in joint construction. Some difference of opinion exists concerning whether premolded bituminous caps or poured bituminous material should be used for the protection of copper seals. Both have been used to a considerable extent. Probably a sticky bituminous material will give better service in the long run.

At the present time we are passing through a transition period of joint development. Definite conclusions regarding the life expectancy or proper functioning of the different devices now being used cannot yet be drawn. As more information is developed from research supplemented by the behavior of these devices under service conditions, it is natural to expect that joint design and installation will become standardized to the same degree as exists with respect to other features of concrete-pavement design such as the design of the concrete mix and the cross-section.

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