Use of Concrete Wearing Surfaces On Bridge Structures

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Three types of bridge pavements are used in New York State: the wearing surface constructed integrally with the carrying slab, the concrete pavement placed separately from the carrying slab, and the asphaltic concrete wearing surface.

Asphaltic concrete is easily placed, but is sometimes slippery in cold weather and is permeable to water. The integral wearing surface, which is simple to construct but requires considerable care by the contractor and engineer to secure a smooth riding surface, is usually satisfactory on major structures, but many times is unsatifactory on short span structures. Due to the fact that the riding surface must be finished when the slab is placed, and also due to the fact that the camber does not always come out of the steel as designed, the finished grade of the structure does not always conform to the planned grade.

Many New York State bridges are built with a separate concrete wearing surface. By placing the pavement as a last operation, a greater proportion of the concrete dead load can be applied to the superstructure steel before the pavement is constructed to the planned grade.

• NEW YORK is one of the few states that generally uses a separate wearing surface on its bridge structures. Three types of bridge pavements are used to some extent, including the wearing surface of concrete poured integrally with the carrying slab; the concrete pavement poured separately from the carrying slab; and asphaltic concrete, which of course is placed after the carrying slab has been completed.

ASPHALTIC CONCRETE

Asphaltic concrete is the least used in New York State. When used as a wearing surface on structures, the top of the slab is thoroughly cleaned by brooming, then given a coating of medium liquid asphalt applied at the rate of ¼ gal. per square yard. The asphaltic concrete is placed in two courses to a thickness of 2½ in. in a manner similar to that used on highway pavements. For this type of pavement on structures a stone-filled sheet asphalt hot mix is used. The principal disadvantages of asphaltic concrete are its tendency to become slippery in cold weather, and its being permeable to water.

INTEGRAL CONCRETE WEARING SURFACE

In constructing the wearing surface integrally with the carrying slab 3 in. of concrete are added to the designed depth of the slab. This procedure is the easiest for the contractor, because all of the concrete deck is placed in one operation. When the slab and wearing surface are constructed integrally, a steel screeding strip is attached to the structural steel in such a way that its elevation can be changed by threaded pipes attached to the underside of the screeding strip. The screeding strip can then be changed in elevation to conform to the planned grade of the bridge as the camber comes out of the carrying beams.

This method is generally satisfactory

on extensive structures, where the bridge slab is a major item of the contract. However, it is not as satisfactory on short span structures where a bridge is a minor part of a contract. For economy either spiral bar or stud shear connectors are used. These devices, plus the fact that the concrete on a particular span is placed in one operation, often prevents the camber from coming out of the carrying beams in accordance with the design computations. This will result in a poorly riding bridge surface.

SEPARATE CONCRETE WEARING SURFACE

A large proportion of New York State bridges is built with separate concrete wearing surfaces. The sequence of operations is first to construct the carrying slab, then the pavement or wearing surface, and finally the sidewalks and curbs. This permits placing about three-fourths of the dead load on the structure when the carrying slab is poured. The thickness of the pavement can then be varied slightly so as to establish a smooth riding surface over the entire structure. The curbs and sidewalks can then be constructed to proper grades, so that when the railing is added it will be parallel to the sidewalk and pavement. The railing and curbs in a structure are clearly visible to the user; if they are poorly graded and aligned the result is definitely unsatisfactory.

The widths of pavement slabs on structures conform to the lane widths on the adjoining highway, and the slab length is usually the structural span, except on long span structures, where the slabs are about 100 ft in length. The pavement slab is reinforced with 6-gage wire mesh fabricated at 6-in. centers in both directions.

The mix of the pavement slab is proportioned as 1 part of air entrained cement, 1¾ parts of fine aggregate, and 3½ parts of coarse aggregate. The coarse aggregate is composed of numbers one and two sizes. Curing is by the use of quilted covers, which are kept wetted for four days during the summer months.

A plastiment or set retarder is used in all structural concrete and bridge pavements. By gradually reducing the quantity of retarder used during the working day, an entire pour of concrete can be controlled so that the set takes place at the same time. Use of this material controls the action of the dead load on the concrete relative to camber reduction in the structural steel in a more accurate manner, especially when shear connectors are used.

Various thicknesses have been experimented with on bridge pavements. The original procedure was to build the carrying slab level transversely and crown the pavement from the outside edge to the bridge centerline. This resulted in a pavement which varied in thickness from 3 in. at the edge to 4½ in. at the center for a two-lane structure. On four-lane bridges, the thickness of the pavement slab at the center increased to 6 in., and on a six-lane structure to 7½ in. This pavement thickness at the center of the structure was costly and unnecessarily increased the dead load on the structure. Now the carrying slab is constructed to conform to the crown of the pavement by haunching the concrete over the steel carrying beams, or by setting the steel to conform to the crown of the pavement, building a carrying slab of uniform thickness, and then constructing the pavement slab to a uniform 4-in. depth.

It is essential that the top of the carrying slabs be waterproofed, due to the action of salts. This was originally accomplished by applying a coat of bituminous material, but the unprotected coating was found to be of little value as a waterproofing agent. Then a three-ply membrane waterproofing with four applications of asphalt was tried. This satisfactorily waterproofed the slab, but acted as a cushion when heavy loads were applied to the roadway and caused considerable cracking in the pavement. An oil distillate also was tried. Currently in use is a water-soluble silicone solution which seems to be a satisfactory waterproofing agent.

There are, of course, certain disadvantages in the construction of a separate concrete wearing surface. An added 3 in.

of concrete are included for a wearing surface when integral slabs are constructed, and a 4-in. pavement is added for a separate wearing surface. This adds slightly less than 4 cu yd of concrete for each 100 ft of a 12-ft traffic lane. There is also the cost of waterproofing the carrying slab.

On structures subject to heavy truck traffic there has been some cracking of the pavement in the outside or truck lanes. These breaks are generally quarter-circle corner cracks and transverse cracks 2 to 4 ft from a transverse joint. By the use of Ames dials supported independently from the pavement, it has been found that during the period of warm days and cool nights, the pavement slab curled up at the ends a maximum of 3/16 in. This had no ill effects on the slab when light vehicles were using the highway. However, heavily loaded vehicles caused the breaks previously described. Hook dowels now are required between the carrying slab and the pavement to keep them in contact. Additional reinforcing probably would not stop pavement curling caused by temperature changes.

There are, of course, advantages in the separate wearing course. A richer mix of concrete can easily be used if desired. In New York State, due to climatic conditions, salts must be used to a considerable degree during the winter months. In some instances this solution causes a scaling or disintegration of the concrete pavement. A separate wearing surface on the bridge structure can be removed and replaced with little difficulty. This is much more of a problem if the pavement is an integral part of the bridge slab. The main reason for using a separate wearing surface is to obtain a smooth riding surface on the entire structure. The construction procedure permits application of three-quarters of the dead load to the structural members before the final grade is established. Due to the fact that shear connectors are used to connect the concrete slab to the structural steel members, and that this slab load has had its effect in reducing the camber in the carrying beams, the applied dead load of the pavement and sidewalk slabs has little effect in a further reduction of camber.

Maintenance of the separate pavement slabs on bridge structures is not a serious problem. The records indicate that in the past 30 years only two bridge pavements have been removed and replaced. One of these failures was due to the use of a fine aggregate, which was subsequently rejected for use in concrete; the second failed due to inadequate protection late in the construction season.

Quite a number of the bridge pavements have been resurfaced due to a surface disintegration, probably caused by the use of salts. The procedure is to thoroughly clean the pavement of all loose material, apply a surface treatment of bituminous material to act as a bond, and then apply a 1-in. armor coat of mixed macadam as a riding surface.