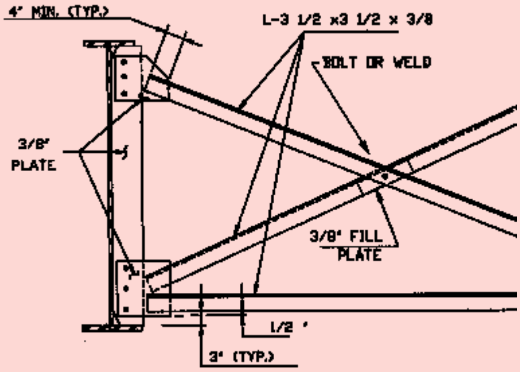

BRIDGE CROSSINGS

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Practical Information For The Bridge Industry

This weathering steel bridge at State Route 385 over Pleasant Ridge Road in Memphis utilizes integral abutments to overcome vertical clearance restrictions while avoiding extreme skews.

Integral Post-Tensioned Concrete Bent Caps

By Edward P. Wasserman, P.E.

Though available for nearly two decades, many steel bridge designers are still unaware of the many benefits of integral, cast-in-place, post-tensioned concrete bent caps. The innovative technique, which allows steel girders to pass directly through the pier's cap, rather than over the top of the cap in the traditional manner, overcomes vertical clearance restrictions while avoiding extreme skews.

The technique, which many believe was developed by structural engineers at Wilbur Smith and Associates of Columbia, SC, working under the leadership of Chief Engineer Ray Whitaker, utilizes caps that are either conventionally reinforced or prestressed. The caps are designed to be of the same depth as the steel girders, or it may be partially dropped below them, depending on vertical or horizontal clearance requirements or aesthetic preference.

The first application for the Tennessee Department of Transportation, in 1978, was for the construction of the I-75/I-640 Interchange in Knoxville (a full study of this project was presented in a USS Bridge Report, "Interstate Highway Interchanges, Knoxville, TN," May 1982). Four bridges were built between 1978 and 1982 in Knoxville, three with integral hammer head pier configurations and the fourth with two free standing columns supporting a simple span integral concrete cap to form an outrigger bent. All have proved serviceable with no cracking after 14 years of service.

The Division of Structures, Tennessee Department of Transportation, has designed other similar integral caps since the concept was introduced. State Route 385 over Pleasant Ridge Road in Memphis, a controlled access highway built to Interstate Standards, is typical of current practice, both with respect to design and detailing, as well as to circumstances of selection. The crossing is at an intersection angle of 25° 28'-21". Seismic rock acceleration values for the site are 0.22g, in accordance with the *AASHTO Standard Specification for Highway Bridges*, 16th Edition. Adjusted for Soil Modification Factors at the site, the design acceleration is 0.26g.

Utilizing a 90-degree crossing, integral bent caps and integral abutments produced a very efficient seismic design free of joints. And the right angle piers eliminated the detrimental effects of skewed piers. Integral caps maximized column efficiency by halving the column design moments and shears compared to conventional cantilever columns. Additionally, using integral abutments significantly reduced seismic loading on the piers, while eliminating the possibility of bearing seat loss at the ends of the bridge.

Importantly, elimination of the typical drop-cap construction coupled with a single round column shaft allowed the use of a right angle structure without unnecessarily increasing roadway fill heights. The lighter weight of the composite steel and concrete superstructure also significantly reduced gravity loads and seismic load on the columns. These features combine to reduce project costs.

As in all similar structures constructed in Tennessee, the columns are constructed to the elevation of the bottom of the cap. Girders are then erected with temporary supports placed at the column locations. The temporary supports are braced against the column for stability and girder ends rest on either permanent or temporary bearings at the abutments. Next, mild reinforcing for shear and any needed longitudinal bonded reinforcement and temperature steel is placed, along with ductwork. The cap is then poured to the bottom of the deck elevation. After cap form work is removed, the post-tensioned steel is placed and stressed.

Staging of construction beyond the pouring of the integral caps has varied, depending on designer choice and force demands. The original bridges constructed in Knoxville employed two-staged post-tensioning. The first phase used multiple rows of deflected bars capable of carrying the full dead load of the cap, the girders, the slab and superimposed dead loads as well as a portion of the live load. After pouring the slab, a second stage of post-

tensioning was applied utilizing transverse bars placed in the deck. The post tensioning was distributed over an effective slab width, considered to act with the cap, to insure compression—from the top of the slab to the bottom of the cap-under all loadings.

Subsequent designs have utilized straight post-tensioned bar paths providing reistance for all loads within the depth of the cap below the top slab, tensioned prior to any slab pours. Tension, less than $7.5\ (f'ci)^{1/2}$ for initial conditions and $6\ (f'c)^{1/2}$ for final conditions has been allowed in the extreme fibers of the bottom of the cap under all appropriate loads. Mild reinforcement in the bottom of the cap also is used. These modifications simplify construction procedures and eliminate potential difficulties that arise from curved trajectories of post-tensioning systems.

It is recommended that when the center of gravity of post-tensioning is above or near mid-depth of the exterior girders a modest amount of post-tensioning be added near the bottom of the cap and girder. This addition will prevent the web from curling outward as the cap concrete creeps under compression. This lower post-tensioning need not be stressed to the allowable limits but only a sufficient amount to anchor the girder firmly to the lower cap force.

The integral post-tensioned concrete bent cap offers an additional dimension to bridge aesthetics and a useful tool in designing efficiently using steel beams and girders.

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The mission of The National Steel Bridge Alliance (NSBA), which was formed in 1995, is to enhance the art and science of the design and construction of steel bridges. Its activities include organizing meetings, conferences and national symposia, conducting the Prize Bridge Awards competition, supporting research, developing design aids, and providing assistance to bridge owners and designers. The NSBA membership includes representatives from all aspects of the steel bridge industry.