Highlights

- SITE CAST, PRE-CAST PIER AND GIRDER SEGMENTS WITH HOUSED CASTING MACHINE.
- STRUCTURAL ELEMENTS DELIVERED ON BACKED-IN, TRACTOR TRAILER, LOWBOY.
- TOP-DOWN CONSTRUCTION EMPLOYED TO AVOID DAMAGE TO PRISTINE MOUNTAINSIDE.

SPANS

Hillsborough County Florida

Public Works Department
Bridge Team

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LINN COVE VIADUCT NARROWS GAP

The great Depression played havoc with the world economy and President Franklin Delano Roosevelt created programs to rectify the 25% unemployment rate here in the USA. He created meaningful, public works programs to put people back to work and improve the Country's infrastructure by building roads, bridges and dams on an unprecedented scale. The nearly 500 mile long Blue Ridge Parkway is one of these projects that were started in 1933 by the president. This Parkway is a part of the 2000 mile long Wilderness Trail that is in the Appalachian Mountain range that stretches from Maine to Alabama. The US Congress, in 1936, passed legislation that called for the establishment of recreational areas in the National Park System. The Blue Ridge Parkway was the first such area to come under this ruling and to this day it is administered by the National Parks Service. All but 5 miles of the Parkway were completed in the 50's and this gap was the result of local citizen's concern for the natural rock outcroppings (Figure: 1) of what is purportedly the oldest mountain range in the world.

This area is affectionately referred to as Grandfather Mountain and the Federal Highway Administration (FHWA) studied the five mile gap for 10 years before selecting the present roadway alignment on the picturesque, east mountain face. The bridge part of this 5 mile section of roadway known as the Linn Cove Viatuct, is 1243' long and functions to maximize the separation of roadway from the rock surface and consequently, minimizes intrusive roadway construction measures. This highly articulated superstructure forms an "S" in plan with radii of curvature as tight as 250' (Figure: 1). There are eight spans with a general north–south orientation between the two abutments. The spacing for the spans was not a purely engineering decision because the location for the seven columns were slightly moved from their mathematically determined position in order to conceal their foundations in

FIGURE 1: Elevated roadway hugs the east slope of Grandfather Mountain while sidestepping rock outcrops.

the recessed areas of the rock outcroppings (Figure: 1).

Jasper Construction Co., from Minneapolis, Minnesota, made the successful low bid at $7.9 million in September, 1978 for this 43,505 square foot structure. The Contractor's John Sutter, an eminently qualified and highly experienced construction man, selected the New York City, Minority Business Enterprise (MBE) firm, Contech Consultants Inc., to provide the Construction Engineering support for their technologically complex and environmentally constrained construction program.

The Contractor's only access to the bridge site was from the south on a narrow, temporary approach road which was extended 261.5' to the second pier location. These two spans were built from the ground but, the remaining 6 spans, totaling 981.5', were progressed with top down construction. Both the substructure (segmental box piers) and superstructure (segmental box girders) were site, pre-cast segments. The choice to pre-cast the segments was dictated by the harsh, mountain top winters and shortened construction season. The contractor chose to build an enclosed manufacturing facility which permitted him to produce concrete elements, unimpeded by the weather.

Transforming the virtual bridge depicted on paper into concrete and steel was achieved by the people who made the commitment and invested their sweat and energy to that end. Contech's involvement included: Boris Levintov who took the contractor's stiff-leg derrick and designed modifications that allowed it to perform the tasks unique to this construction sequence and Jee- Bong Louie who did a three dimensional analysis for the extremely complicated geometry control along with Lionel Bellevue. Lionel spent many nights in the office coordinating camber curves for the next day's segment erection with Jasper's Site Engineer, Laura Winter.

The structure's geometry, shown on the contract plans, depicts the completed bridge, as it should be, in its final state, carrying only designed-for traffic loads along a roadway in its completed, closed configuration. To reach this end the Contractor had to negotiate a number of high risk considerations to carry these segmental elements through a process from their manufacture (casting), storage, transportation and installation into their final, designed-for matrix. Lionel developed the equations to convert the global coordinates from the contract plans into local coordinates to generate the casting curves for each segment in the superstructure. Jee-Bong Louie checked his computations with a vector equation analysis. The tools the Contractor resorted to were his derrick, his casting machine and his casting curves. The casting curves include the dimensions for the final grade and alignment. These curves anticipate the deflections before and after the segment installation. The construction engineering required repeated analysis of the structure as it evolved from its weakest condition through to the sought after depiction on the contract drawings while being subjected to the greatest loading, from the construction equipment and their loads, that the bridge would ever be subjected to.

FIGURE 2: Superstructure segments delivered to and advanced from roadway deck.

The pier segments were simple in that they were purely prismatic in shape and their joints were parallel in orientation (no curves). Conversely, the superstructure was highly convoluted with horizontal curves, vertical curves and superelevated decks. The best geometry control for the segmented, superstructure elements was determined to be the short-line, match casting method.

When employing this methodology, a controlled, articulated, casting face forms one end of the typically 8.12' long segments and the trailing face is cast against the previously poured segment. The internal forms are extended into the casting machine from the controlled, articulated side of the forming machine and ride with, while responding to, the geometry adjustments introduced into the segment by the casting machine and forms the hollow core of the box girder segment.

The casting machine had to tilt (for vertical curve control), rotate (for horizontal curve control) and warp (for super-elevations) the forms. All of these controls were applied to each of the 153, individual, 8.12' long segments and provided the maximum number of corrections per lineal foot of span. An alternative method of correcting girder alignment is to place shims into the joints of matching segments during erection in order to make remedial, field adjustments. A testament to the quality of construction engineering for this job was that no shimming was required on the Linn Cove Viaduct.

Twenty foot diameter and five feet deep concrete footings (designed by the FHWA) were cast and locked to the rock with drilled and grouted, 9" diameter pencil piles. The spans were, from each cast-in-place concrete abutment out, 98.5' and 163' with four 180' intermediate spans. Temporary, intermediate steel bents were located midway within the last six spans to shorten the overreaching, progressively cantilevering, superstructure by halving the construction spans. The segments were trucked across the top of the finished deck to the back side

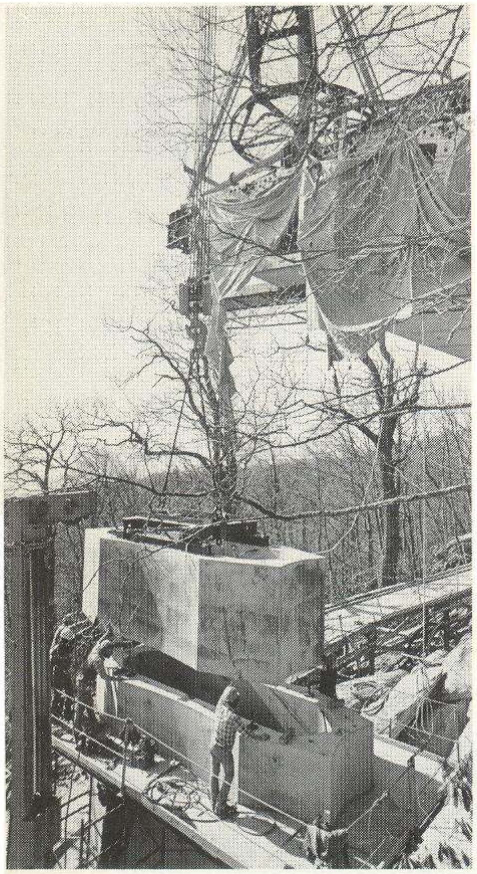

FIGURE 3: Pier segments stacked from progressing superstructure.

of the derrick which was typically located two segments behind the leading edge of the progressing, cantilevering superstructure.

The derrick would hoist the 50 ton, pre-cast superstructure segments off the flatbed (low-boy) truck trailer that was, coincidently, expertly backed up the road and out across the newly completed deck by the truck driver. The derrick would then lift it off the delivery vehicle and swing it around to the front side of the superstructure (Figure:2) in order to be attached to and incrementally extend the superstructure. The derrick was unlocked from the deck, after each segment was attached, and moved forward on steel rollers to its next position and reattached to the progressing, concrete girder to remain two segments behind the next segment programmed for installation.

Correspondingly, the pre-cast, pier segments were transported across the deck to the derrick which was able to lift the element, swing it around the derrick and boom the lighter pier segments ahead two segment locations and lower it into position at the next pier location (Figure:3). The pier segments were stacked, each temporarily post–tensioned to the other with steel bars and, consequently, raised to the proper elevation.

The top segment, being a closed, capping element, provides the bearing for the oncoming, superstructure segments. With the cap in place, strand tendons were threaded down through the stacked segments to the footing and all the stacked elements were locked into one structural element by post tensioning strand tendons which were anchored in the footing and grouted.

The 153 superstructure segments (Figure:4), each unique in volumetric dimensions, were designed with greater overall depths (9'-0"), thicker webs (18") and deeper bottom slabs than typically required for these spans in order to accommodate the extreme, temporary cantilevering with construction loading and the high torsional loads from the tight curves.

Moreover, intermediate diaphragms were added in order to install temporary, negative moment post-tensioning over the temporary, intermediate, steel bents. The construction post-tensioning, at the intermediate steel piers, was accomplished using all threaded, pre-stressing steel bars that were passed through the holes in the intermediate diaphragms, spliced with couplers and post tensioned. These bars were retrieved and reused at other locations with great care taken not to use any steel that had been fatigued.

All pre-cast, concrete segments, vertical and horizontal, were assembled with temporary wood blocking providing a 6" space between elements which allowed workers room to apply epoxy glue to the previously installed segment before the next placed segment was brought forward and seated in this bed. This material was hand applied and served, coincidentally, to level the interfacing concrete surfaces and to lubricate the two elements during fine adjustments in alignment as they were joined together. Additionally, though, the main purpose of the sealer was to prevent the intrusion of water. The joints were heated and insulated in cold weather to assure proper curing of the epoxy resin.

All pre-cast concrete had a 28 day, specified strength of 6,000 psi and the superstructure segments were locked into their final positions with strand tendons in both their longitudinal and transverse directions. The roadway deck had a waterproof membrane under a 2" topping of asphalt.

The engineers who prepared the contract documents were Figg & Muller Inc of Tallahassee, Florida. Their work received a great deal of acclaim with a number of prized awards for design.

The bridge was completed in 1983 and narrowed the Gap; however, the balance of the five miles of roadway was not completed until 1987, which then closed the Gap.

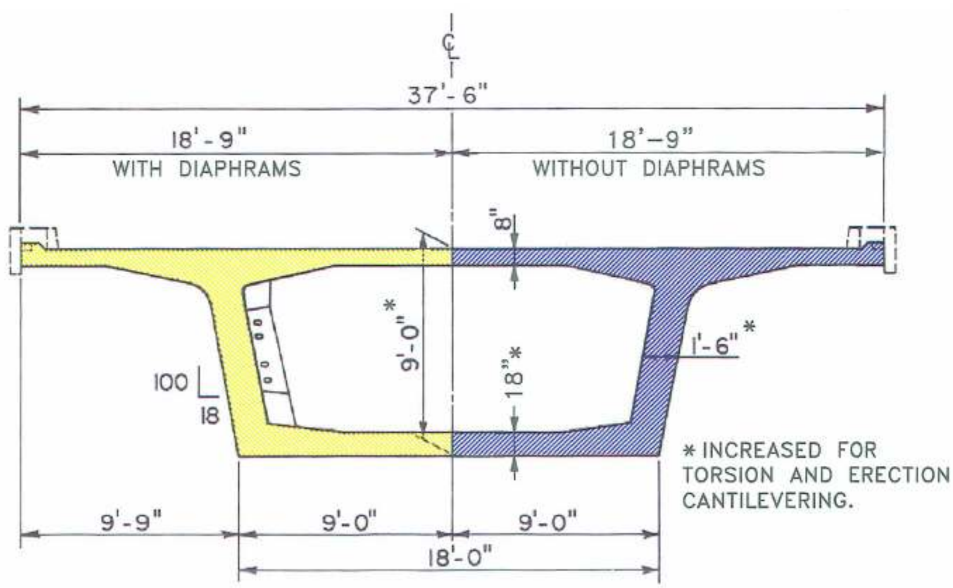

FIGURE 4: Depths, webs and bottom slabs increased to accommodate high torsion and temporary construction loads (*)

Guest Commentary

"Steeling a Mountain View"

By: Larry R. Watts

I have been asked by the editor of ***SPANS***, to be a guest commentator. He called and said "Larry would you write something about bridges for this issue, ***anything***, from your favorite bridge or bridge experience. I will begin by commenting on one of my favorite bridges and then following-up by describing how he and I are involved with maintaining Hillsborough County's bridges.

The picture above is of the New River Gorge Bridge in Fayette County, West Virginia. This is one of my favorite bridges. It opened on October 22, 1977. The bridge was designed by Michael Baker, Jr., Inc. and American Bridge Division of U.S. Steel constructed the bridge. American Bridge had many construction challenges with the extreme height and the steep sloping sides of the gorge. To make construction easier they used a helicopter to hoist a 5000 foot by half inch diameter cable across the gorge. Then they added cables until they had a three inch diameter cable connected between the four 300 foot towers used for construction.

The bridge was built using Cor-Ten steel which is erected and put into service, unpainted. When weathered it has a rust-like appearance but forms a protective barrier to minimize deterioration. The steel also has a 50 ksi yield strength which is stronger than the ordinary 36 ksi bridge steel. The New River Gorge Bridge is the world's longest, steel, single arch span with a length of 3030 feet. Its arch length and rise are 1700 feet and 360 feet, respectively. At a height of 876 feet above the New River it is the second tallest bridge in the United States. The final cost of construction was $37,000,000. In addition to changing the drive time across the New River from more than 45 minutes to less than one minute it is the site of a wide array of outdoor activities.

There is white water rafting below the bridge, and on each end there are hiking and biking trails through the woods. Each year on the third Saturday of October a "Bridge Day" is celebrated. On this day the bridge is closed to vehicular traffic but is open to pedestrians. Crowds of up to 250,000 people participate in events including parachuting, rappelling and organized walks, all serviced by a variety of vendors. On a personal note, I have experienced the white water rafting and hiking offered there and it was awesome. I have not tried the parachuting or rappelling. I love the land and water and I think I'll stick close to those things I love.

As for our work in Hillsborough County, I will start by explaining how the editor and I know one another. We both started with Hillsborough County on the same day. We both work for the Public Works Department in the Engineering Division. He works at the County Center, downtown, in the Design and Engineering Support Section and I work at the Countywide Construction Unit in the Northeast part of the County. We have worked together on many projects. As part of my duties, I manage the bridge maintenance team. There are more than 250 bridges in Hillsborough County, which means we have plenty of work to do, all the time. All bridges (steel, concrete and timber) are inspected by the State as part of the Federal Government's requirements and the deficiencies are identified. They are then ranked and prioritized. A majority of the bridges in the County are concrete "beam bridges" varying from short, single spans to long, continuous spans. A good portion of our time is spent maintaining these bridges.

Countywide Construction starts by cleaning the bridge superstructure, substructure and approaches. This work includes pressure washing, sand blasting, clearing and grubbing. After the structure is exposed, the work request is reviewed to confirm that the original scope is adequate. Many of our repairs revolve around approach expansion joint failure, which leads to abutment problems. Also, the concrete bridge deck topping delaminating, caused by excessive deflection associated with over loading, is a major concern. One repair technique used is to check the dead load capacity of the existing bridge deck before adding a layer of structural course asphalt. If necessary, the topping is replaced which can help to redistribute the load. The added mass also reduces the impact load to the bridge and improves the ride-ability. We often perform work on the guardrail systems to improve safety and visibility at or near the bridges.

The editor and I work together with a dedicated team of people to help keep our bridges within compliance and offer the citizens of Hillsborough County a safe way to travel. Thanks to all that are a part of this valuable team.

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