NATIONAL AWARD

SPECIAL PURPOSE

Liberty Bridge over the Reedy River

Greenville, SC

Rosales Gottemoeller & Associates, Inc.

The new Liberty Pedestrian Bridge over the Reedy River in Greenville, SC has become one of the defining landmarks of the city's downtown. The 340'-long bridge is unique in its use of a single suspension cable attached to only one side of a curved alignment plan. Its discrete cable pattern allows unhindered views of a park and waterfall.

Greenville's downtown is divided by a wooded valley that contains numerous trails and recreational areas. Until recently, a high-level vehicular bridge crossed over the river, obscuring the beauty of the waterfall to motorists and pedestrians. The city decided to demolish the existing bridge and replace it with this unique pedestrian bridge.

One of the main constraints on the site was the location of the falls in relation to the entrances into the park. The new bridge is curved in plan to establish the link between the two side entrances. The curved alignment relates better to the river, paths, and hills, which are also curvilinear in nature so that the bridge fits into the landscape. Also, the curved alignment made it possible to have an unusual and visually unique cable configuration.

Owner
City of Greenville, SC

Architect and Engineers of Record
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Engineering Software
SOFiSTiK

Detailer and Fabricator
Dave Steel Company, Inc., Asheville, NC, AISC member

General Contractor
Taylor & Murphy Construction Co., Inc., Asheville, NC

Aesthetic Considerations

The circular bridge is supported by a single suspension cable along the outer side of the curve, with two inclined towers. Locating the cable supports on the outer edge of the curvature created an amphitheater effect oriented toward the falls. The towers that support the main suspension cable are also located on the outer side and angled in profile to further emphasize the directionality of the views. The inner side of the curvature does not have visible means of support. The views along the bridge constantly change due to the curvature and the 3.5% slope of the bridge.

The clear span between the towers over the river and falls is approximately 200'. Thirty-two thin suspender cables attach to the outer ends of 32 radial light steel transverse frames, 4' in depth, which in turn support the 12'-wide, 7"-deep concrete deck.

The slender towers are approximately 100' high and are stabilized with single sloped backstay cables. In order to resolve the torsion forces created by the one-sided suspension of the deck frames, a series of ring cables connect all the steel frames below deck level.

Structural Considerations

The bridge's alignment in plan allowed for the use of a structural system that required only a single-sided cable supported structure. The bridge has a ring girder supported at the outside edge, with compression occurring at the top of the section and tension at the bottom.

Cables easily support the tension at the bottom of the girder, while the deck slab supports the compression force at the top of the girder. Observing the ring forces in plan provided the best overview of the principle of the ring girder. The tension force at the underside of the girder produces a component force directed towards the center of the curvature, while the compression force produces an outwardly directed force component. The resulting pair of forces $u \times h$ with $u = C/R$ is in equilibrium with the pair of forces $P \times w/2$, with $P + p \times w$ and p = loading of the bridge.

The deck needed a vertical support to be in equilibrium. This vertical support was formed by the hanger cables. Because of the geometry of the cable structure, there are also horizontal forces due to the inclination of the hangers. The horizontal forces cause a transverse bending moment that has no relation to the behavior previously explained. To provide the deck with additional stiffness for non-uniform distributed loads, a truss girder was formed in the plane between the hanger connections and the ring cables.

Bridge Construction

In the initial construction phase, the main steel components were installed and the deck slab was constructed on site while being supported by temporary scaffolding. Prefabricated steel components were laid out in the required geometry and welded together. The bridge ribs consisted of steel plates at each cable axis supporting the diagonals of the truss


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and the corner profiles at the edges. After completion of the structural steel components, formwork was placed between the ribs, reinforcement was installed, and concrete was poured, forming the deck. At the same time, the two towers were constructed, installed, and stabilized using temporary stays.

After reaching the necessary strength in the concrete slab, cable installation began, which was broken down into two steps. In the first step, the ring cables were connected to the girder and stressed. The ring cables were supplied at a shorter length to take into account the deformation due to pre-stressing. The geometry of the ring cable prior to tensioning did not match the geometry of the structural steel work. A two-piece connection of the ring cable to the structural steel was conceived, which allowed radial displacements between the girder and cable until the final position. The ring cable was laid out in an arc of larger radius at the inside of the girder and then pushed outward and connected to the girder. This radial deformation caused the necessary pre-tensioning force in the cable. During the tensioning of the ring cable, the bridge deck was pulled inward. The deck developed a light upward tilt because the hanger cables were not yet installed. The horizontal components of the cables would later counteract this deformation.

In the second step, construction began of the main suspension cable, hanger cables, and the backstay cables. The hanger cables were installed without jacking by lengthening the backstays, causing the towers to tilt in the direction of the deck. Using this method, the relatively slack suspension cables could be installed easily. The backstay cables were then stressed to their necessary pre-stressing force, pulling the towers away from the bridge.

During pre-stressing of the cable structure, the hanger cables became the support for the bridge by lifting the deck from the scaffolding. The horizontal component of the hanger cable force counteracted the tilt of the bridge deck, bringing the bridge into the desired geometry and marking the end of construction.

Detailing

Detailing of the bridge's main elements was carefully designed to achieve a high level of visual appeal. Cast steel components were used in order to have visually clean, highly accurate connectors and anchors. Other important details included cable clamps connecting the hanger cables to the main cables. A cast steel element was chosen to allow an efficient member to carry the loads from the hanger cables to the main cables by the means of friction between the clamps and the cable.

The bridge railing is visually transparent and has a series of thin horizontal cables and slender vertical supports that are coordinated in plan and elevation with both the hanger cables and steel struts. ★