Highlights

- World's first and only concrete swing span when opened in 1991
- Ranks, at 480' as one of the longest moveable spans on record.

Items

- Each 418' leaf weighs 7,500 tons
- Connects Harbor Island, a major shipping and ship building area, with Southwest industrial Seattle

SPANS

Hillsborough County Florida
Public Works Department
Bridge Team

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SWING LOW, SWEET CHARIOT...

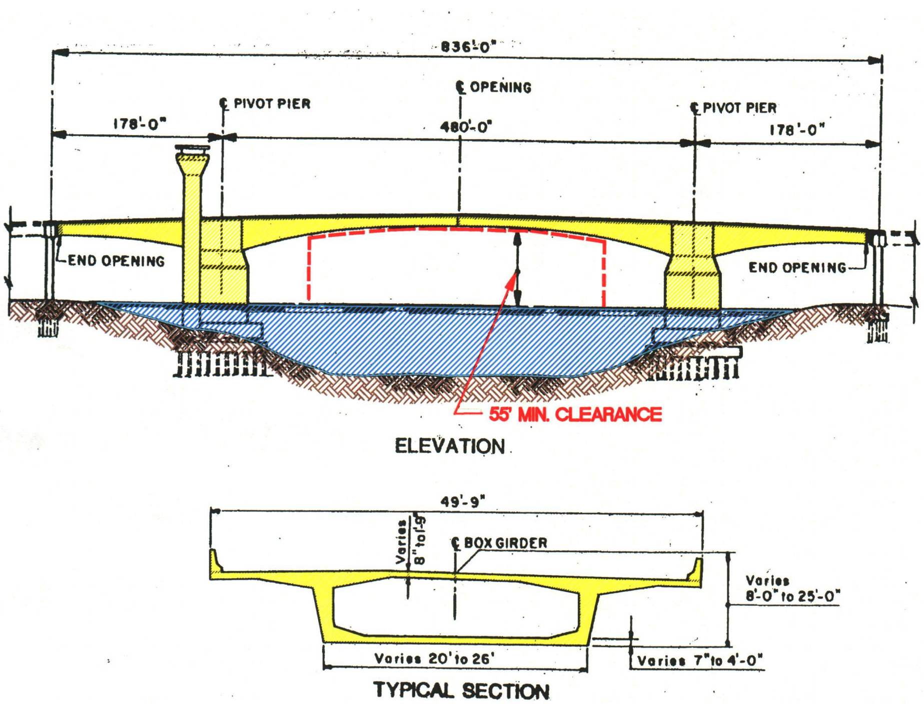

FIGURE 1: WEST SEATTLE SWING BRIDGE; CAST-IN-PLACE, POST TENSIONED, CONCRETE BOX GIRDER, MOVEABLE SPANS

The West Seattle Freeway, high-level bridge was completed in 1984. This modern, segmental, concrete box girder structure was built by Peter Kiewit Sons for the City of Seattle, Washington. The idea was to put the roadway high enough, on a fixed alignment, to avoid the necessity of a low level, moveable span. The previous moveable span was knocked out of service when struck by a freighter in 1978. With a main span of 590', all piers of the new bridge (WSB-1) were kept out of the water; consequently providing the option of widening the main channel of the traversed Duwamish River.

While the fixed, high level span (WSB-1) succeeded in providing the unimpeded movement of roadway traffic across the river, this solution included an unexpected drawback. Apparently, because of the additional travel distance to the south approach and the steep climb back, up and over the new fixed alignment by the cargo laden trucks, there was a significant increase in the amount of fuel (cost) expended. Consequently, the City of Seattle reconsidered the low level, moveable span (WSB-2); but under the light of today's technology, the chosen swing span was increased in length to avoid river piers.

The importance of not placing columns in the channel was demonstrated in 1978. The existing requirement of a minimum vertical clearance of 55 feet above MHW for the WSB-2 and having to stay within the existing right-of-way of the old moveable span were restrictions that narrowed the choices for the optimal bridge configuration. Additionally, the location of the pivot piers would require a main span approaching the upper limits for moveable span bridges and the tail-span would have an unbalanced length to shorten its' radius in order to allow it to swing past the existing bridge columns on the north side of the river.

The Bridge Engineer had to dig deep into his bag of solutions to find a superstructure that would fit into such a thin envelope as prescribed by this criteria. He came up with an unconventional answer but one that did address all of the issues confronted. The answer was a pre-stressed, segmental, concrete box girder bridge built by the balanced cantilever method. Yes, we are talking about a concrete, moveable span bridge (Figure: 1).

The bridge has a north-south alignment and spans the Duwamish River, flowing from the SE to the NW, on a forty-five degree angle with this alignment. The two main span piers are 480'

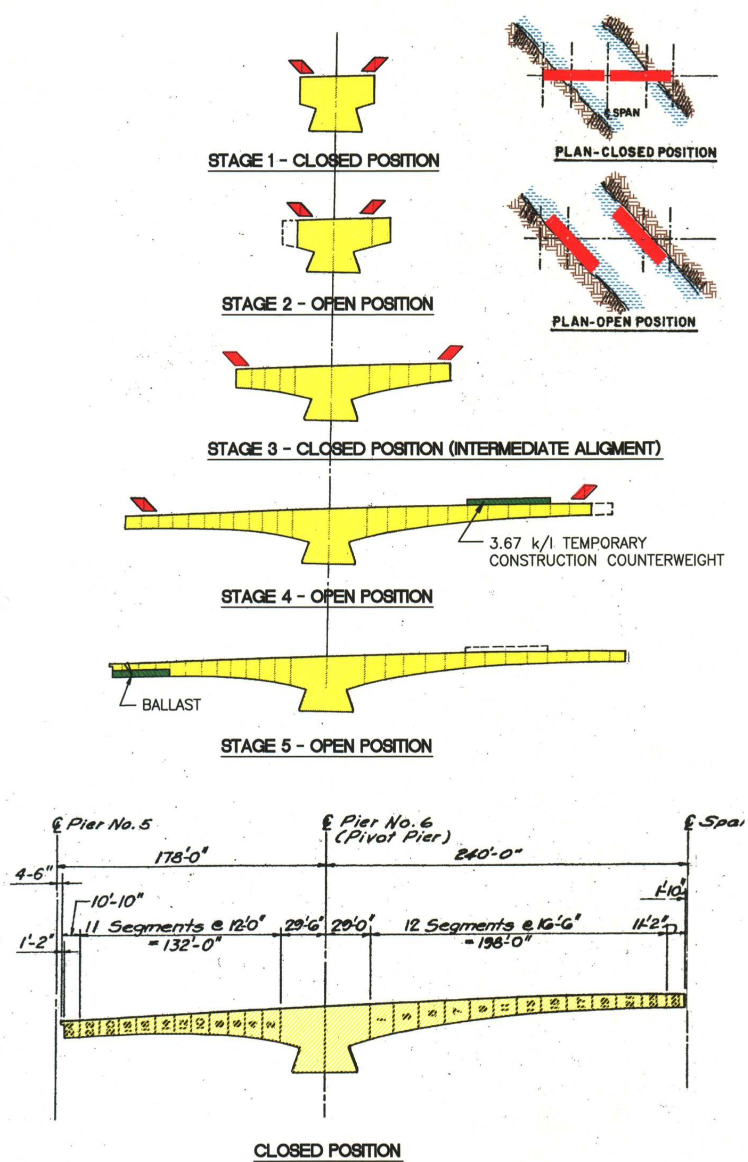

FIGURE 2: SUPERSTRUCTURE CONSTRUCTION SEQUENCE ABOUT SOUTH PIROT PIER (#6)

apart and are founded on piles in shallow water. The 49'-9" wide, winged, deck girders reach 240'-0" to the mid-span joint and they are balanced on their pivot points by their ballasted, 178'-0" back spans. Each of these 418'-0" long leafs weigh 7,500 tons; they are lifted off their bearings on pressurized, hydraulic fluid and are rotated to the open positions through a mechanical gear-train. Balance is the key to the mechanical efficiency of the operational aspects for this, first of its' kind, moveable, concrete span.

The construction sequencing is critical to the design for the optimum structural solution has been determined to be a pre-stressed, post-tensioned, cast-in-place, balanced cantilevered, segmental, concrete box-girder superstructure (Figure: 2). The Stage 1 superstructure construction includes the horizontal bearing surfaces between the fixed substructure and the moveable superstructure.

The hydraulic mechanism that floats the superstructure on the pressurized oil that lifts the superstructure off it's bearings and lubricates the turning motion is contained within this pier table. The form travelers are installed at each end of the pier table at this stage. All construction during Stage 1 is done with the pier table oriented in the closed position (virtual river span).

Stage 2 requires the pier table to be rotated clock-wise, 45 degrees, so that it is parallel to the river bank where segments 1 thru 21 are cast and stressed. Before segment construction continues the superstructure is rotated back to the virtual closed position. Stage 3 takes place with girder alignment and then is immediately returned to the open position where the temporary construction counterweight is applied to the deck of segments 11, 13, 15 and 17 according to the weight distribution of 3.67 kips/ft.

During Stage 4, casting and stressing of segments 22 thru 25 is completed. Stage 5 includes the removal of the 120 ton form travelers, first from the tail span followed by the removal from the main span. The barrier and deck overlay is then placed on the main span from the pier table up to the temporary deck counter-weight. Then the temporary deck counterweight is removed.

With the counterweight gone, all other work including the installation of the ballast for the tail span was completed. Permanent ballast is cast into segments from 25, back toward the pivot bearing, to and including segment number 18, in six lifts separated by ¼" asphalt sheets (Figure: 3). Recognizing that eccentricities will occur throughout the life of the bridge, but will be more pronounced during construction, a "do not exceed" allowance is specified at 53,000 ft-kips for this condition. This allowance is about 10% of the maximum design moment.

San Lin Lok, P.E. was the Structural Design Engineer for the WSB-2 and was employed by Contech Consultants Inc, a Seattle based MBE firm. The WSB-2 Design Team was composed of Anderson-Bjornstad-Kane-Jacobs Inc. (ABKJ), Parsons Brinkerhoff Quade and Douglas, Inc. (PBQ&D) and Tudor Engineering Company with Contech Consultants employed as a sub-consultant. San Lin completed his design work in June of 1985.

Both structures, WSB-1 and WSB-2, were designed and built utilizing the balanced cantilever method of construction. Conceptually, they were identical up to the point where they reached their maximum cantilever. The top tendon distribution in both bridges, at this point of maximum cantilever, is maximum across the top of the pier segment and

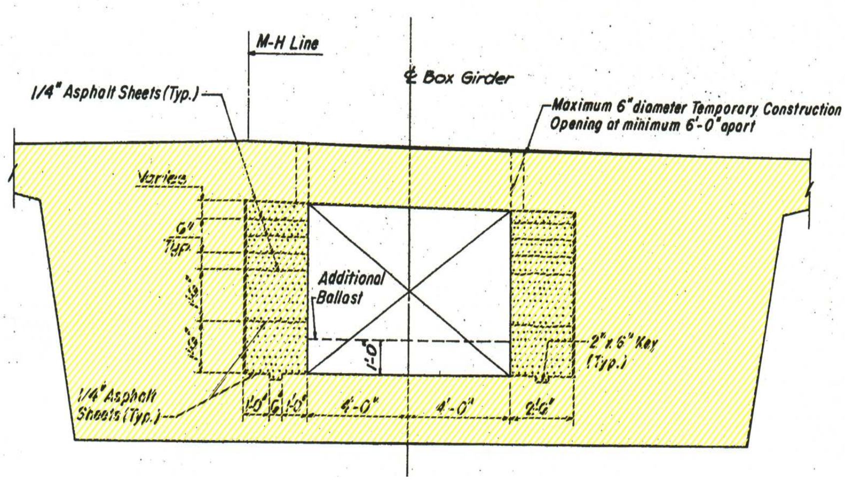

FIGURE 3: BALLAST PLACEMENT DETAIL BETWEEN SEGMENTS 18 AND 24

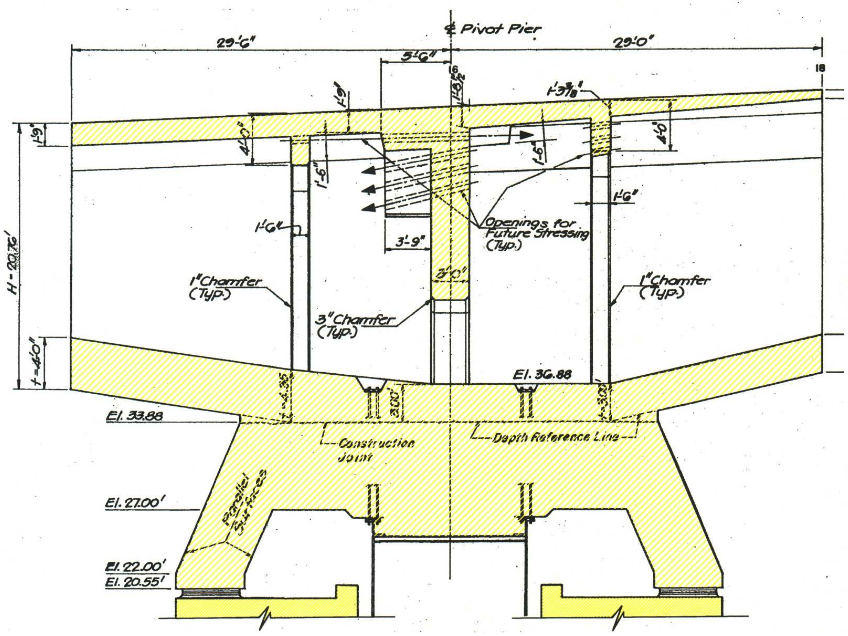

FIGURE 4: LONGITUDINAL SECTION THROUGH PIROT PIER

sequentially decreases in number as segments are added to the arms of this growing tee frame. The WSB-2 has unequal lengths for its' arms because the river span has to be maximized to remove all piers from the channel and the tail span shortened to clear the existing WSB-1 piers when it swings to the open position.

The main span part is 240 feet in length and is counterbalanced by the 178 foot tail span. When compensating for the unequal arms of the WSB-2 the tail span segments are made shorter and heavier than those for the main span in order to maintain a balanced condition. Despite this dimensional variance both bridges remain the same in concept up to this point.

The difference in concept for the two bridges is that of a fixed and moveable span. The WSB-1 is a fixed span so the free ends are cast continuous with the abutting span making the superstructure continuous. Conversely, the WSB-2 is a moveable span and the tee-frame arms are left to ride free of the abutting structure.

For the first case, even though there are zero moments at the girder ends before closure, provisions are made for adding bottom, post-tensioning steel at the mid-span segments to accommodate future positive moments. This eventuality is the result of concrete creep that will cause a growth in the mid-span, positive moments and a consequent decrease in the negative moments at the pier segments.

Alternatively, in the second case, the ends will remain permanently free allowing the superstructure to lift and rotate. However, creep will still be a factor and to accommodate the resulting tendency of the cantilever to droop, the structural configuration at the top of the box girder is designed for future top tendons to be added and augment the resisting cantilever moment (Figure 4). Moreover, a three inch camber is built into the main span and a half inch into the tail span all referenced to the rigid support location at the piers intended to mitigate drooping.

Further deviations between the two concepts are evident as we persue the design for the WSB-2. The dynamic forces introduced with the opening and closing process (Figure 5), allowing passage of ocean-going freighters, requires extensive three dimensional post-tensioning to assure resiliency of the concrete structure.

This first of a kind, moveable, concrete bridge has been operational for 15 years and was a product of some very specific site requirements. The bridge cross section has two 17' wide traffic lanes and a 12' wide pedestrian and bicycle lane on the east shoulder of the WSB-2. A control tower to observe all bridge and waterway traffic is located between the two bridges on the south shore.

This bridge has brought to the Seattle Department of Transportation, the bridge owner, a number of prestigious awards including the *1992 Outstanding Engineering Achievement Award by the American Society of Civil Engineers.*

FIGURE 5: NORTH LEAF (LEFT) CLOSED, SOUTH LEAF(RIGHT)FULLY OPENED THROUGH A 45 DEGREE ARC, PARALLEL WITH THE DUWAMISH RIVER

Guest Commentary

Bridging Memory Lane

By: Rose Titone

My family and I have lived at the foot of the Columbus Drive Bridge, here in Tampa, since April of 1956. The first time that we heard the sirens warning motorists that the bridge would be opening, we thought we were being invaded.

We used to have a boatyard and marine dock at the corner of Riverside Drive and Ridgewood Avenue, but the only way a boat could get there was by opening the bridge. The bridge had full-time attendants who would open and close the bridge; now-a-days, its' computerized.

One of the last attendants was Joe; he worked from around 8:30 AM to 6:00 PM. His job was not only to open and close the bridge but to keep the bridge clean and the grass cut on both banks of the river. Among his many jobs he also kept an eye on the neighborhood, always watching for suspicious characters. During the summer months we kept him supplied with ice, which was the least we could do for always keeping an eye on us.

Fishing from the bridge and crabbing under the bridge were some of my fondest past times. I even remember taking the children fishing, setting their playpen up under the oak tree on the river bank in front of my house while the older children fished. Good times, great memories.

Thirty years ago the river bank resembled the beach but, in fact, you were just walking across the street to the river. During these times the beach had not been washed away, gators would crawl up onto the banks to sun themselves and one even came up to the street.

ROSE TITONE FACING CAMERA, TAMPA SKYLINE BEYOND. OVER THE HILLSBOROUGH RIVER.

Fishing never grew old, even when the temperature dropped fishermen would park their cars along the river and get ready for a night of snook fishing.

Another part of these memories has been the car accidents. They would jump the curb, crash through the concrete balustrade and carry their passengers into the river. After multiple accidents a short concrete wall was built next to the side walks. This wall prevented cars from going into the river.

There are so many stories, so many memories.

Coming Issues:

- **Glebe Island cable-stayed bridge in Sydney, Australia**
- **Marketing bridge engineering services**
- **The Acosta Bridge over the St. Johns River, Jacksonville, Florida**
- **The Tallmadge Bridge over the Savannah River, Savannah Georgia**

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Rose Titone a longtime resident with a great deal of interest in this 80 year old, historic swing span, pony truss.

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