Concrete Pier Repair - A Case Study

How do you repair a 1,300 foot long concrete pier that has been struck by a large tanker causing severe damage and major disruption? William J Castle, President. The Castle Group, USA, explains how to tackle the problem.

The pier in question was built in 1968 and is located along the Delaware River just south of the Ben Franklin Bridge. Large vessels, including US Navy ships, are known to dock on the east side of the structure along the Delaware River. A marina is located on the west side of the curved pier structure. The pier is constructed of approximately 62 concrete bents running east-west spaced at 25'-0" c-c supported on 18" square concrete piles. Each pile bent consists of 4, 6 or 8 piles with a concrete pile cap. Following the collision W.J. Castle, P.E. & Associates, P.C. performed the emergency inspection (including underwater) of the pier and found that the area around Pile Bent 49 sustained the primary force of the collision. Bent 49 was constructed of eight piles; 4 piles on the east end (river) and 4 piles on the west end (marina). The concrete seawall on the river side was crushed inward exposing the bent and broken reinforcing bars. Approximately 15 timber fender piles on the east end were damaged and/or broken in this area. One of the concrete piles on the east end had completely broken off and was found on the channel bottom. Two additional piles on the east end were cracked and/or broken approximately mid height and were shifted off centre and no longer completely bearing on the pile cap. This left only one pile supporting the damaged area at the east end. Areas of extensive spalling and cracking were found around the pile cap on Bent 49 and five additional bents around it. It was WJ Castle's recommendation that the pier was unsafe and should be closed to all usage, including vessel dockage, until repairs were made. Delaware River Waterfront Corporation (DRWC), the owner concurred with the recommendations and the pier was subsequently closed.

Repair design

DRWC considered various repair designs including removal and replacement of the existing superstructure prior to any repairs implemented. W J Castle developed a design that would repair the pier structure without complete replacement. The proposed repair would save the DRWC USD 625,000-$1,125,000. No design calculations or complete as-built drawings of the pier structure were available, therefore the analysis for the capacity of the existing bearing piles, concrete cap beams, etc. was based upon the only drawings available and engineering judgment. Due to the precarious conditions and the potential of partial collapse of the damaged area, a temporary support was required for the area prior to any work done on the underside of the pier. Entrance for working on the underside of deck would require cutting away a section of the concrete seawall which would create excess vibration. Additionally, drilling or coring into the concrete before it was stabilised may also have caused a potential disaster.

Phase I - temporary stabilisation

A temporary system was developed to prevent any movement or further deterioration of the pier using a system of hydraulic jacks. A 50'-0" long W33x201 support beam was placed on the east end extending to the bents on either side of Bent 49. The beam was supported on a hydraulic jack on each end which rested on 12" tube sections. Four 1 1/2"diameter cables were attached to the outside of the concrete cap beam on the river side and on the top of the deck on the marina side with a WT bracket anchored with Hilti adhesive anchors. A steel guide for the cables was fabricated and installed on top of the W33 beam. The hydraulic jacks were slowly engaged until the cables were sufficiently tensioned to ensure the structure would not collapse.

Phase II - temporary repair

After the cable pulley system was in place, Phase II could be implemented. A W33x263 beam supported on tube posts on either end was installed approximately 11'-0" from the east end. A total of eight 1"Ø anchor rods were used to clamp the W33 beam on the top of the deck and the two sets of back-to-back channels on the underside of the pile cap. The channels ran perpendicular to the pile cap. For the installation of this system some of the asphalt and pavers were removed as required. 2" diameter holes were drilled in the concrete for the installation of the anchor rods. Once the "clamp" system was in place the Phase I sections including the beam and cables were removed. The Phase II repairs could not be made prior to the pulley system due to dangers of working below deck. The pier had to be deemed safe before any work was performed on the underside.

Phase III - permanent repair

Phase III was postponed due to insurance issues. Due to the limited carrying capacity of the pier, the permanent repairs had to be

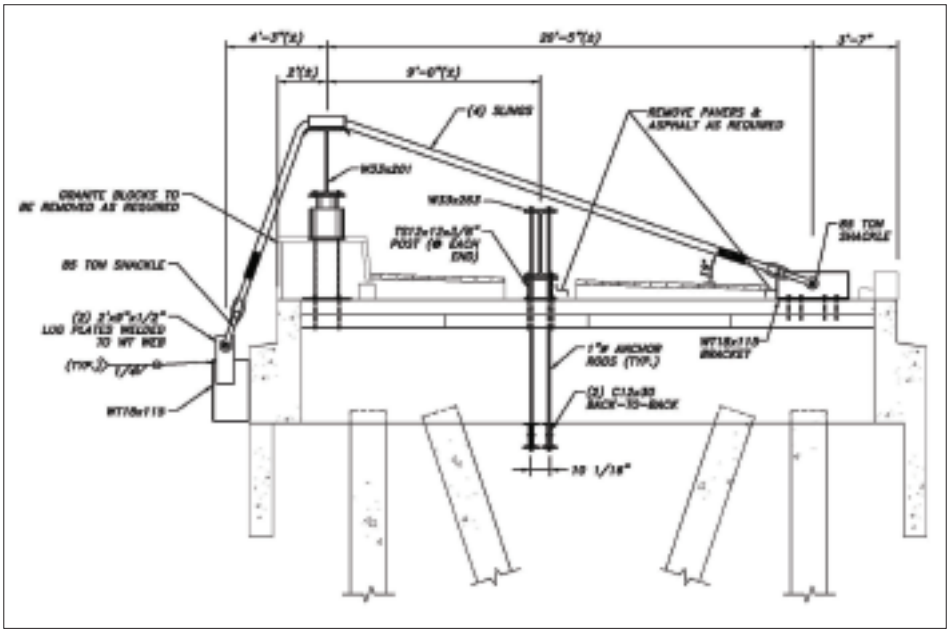

Figure 1: Phase I Typical Section

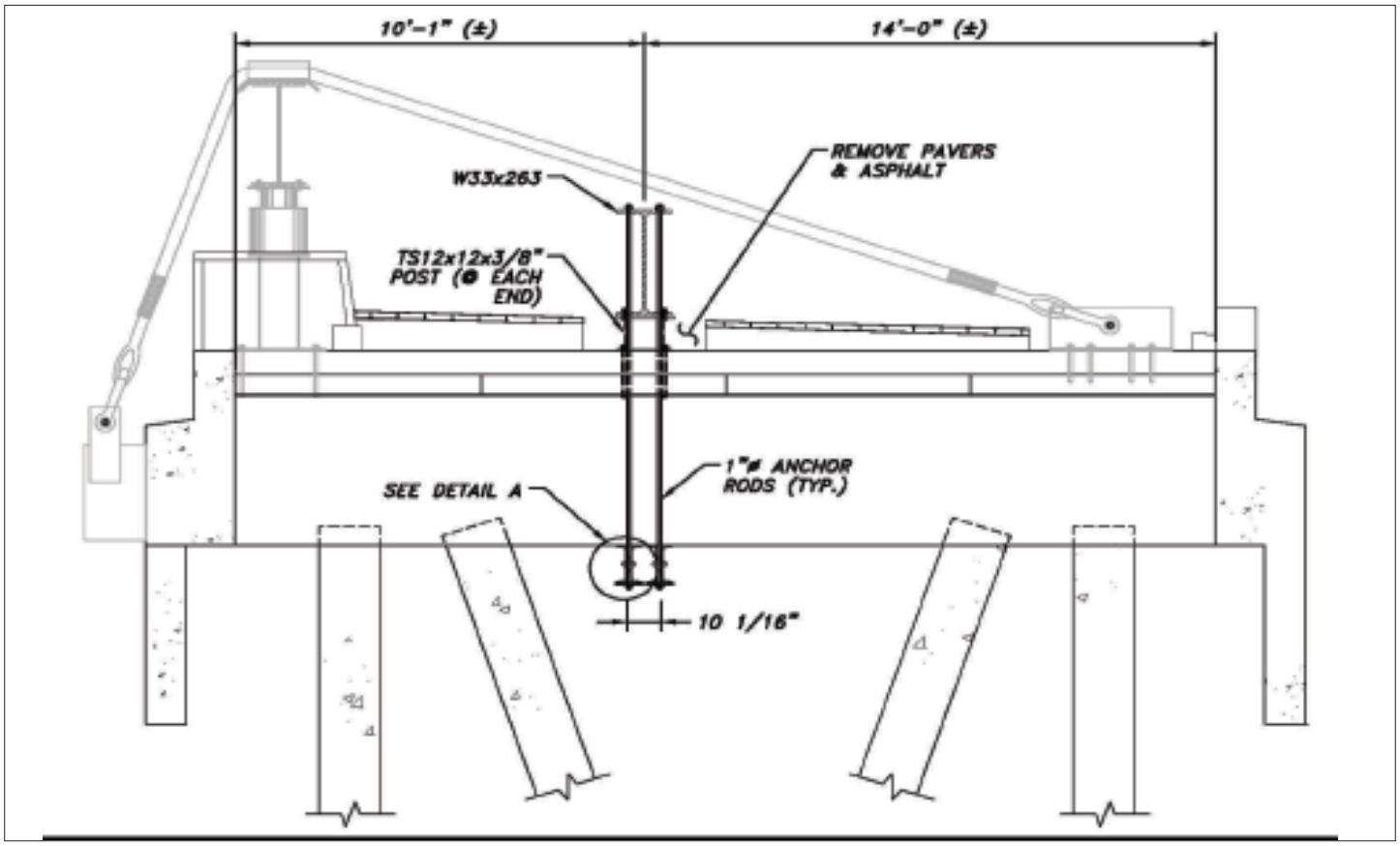

Figure 2: Phase II Temporary Support

completed from a barge on the Delaware River side. Holes were drilled in the concrete deck superstructure for the installation of new 14" diameter steel pipe piles. The piles were 80 feet long and driven from the topside. The new piles were driven on either side of the existing concrete cap beam. They were cut off below the cap beam and then filled with reinforcing steel and concrete. A new pile cap for the piles was made using W14 beams placed under the existing cap beam and attached to the pipes. The W14 beams were anchored in the concrete cap beam using epoxy anchor bolts. Additional channel bracing was installed between the new piles on each side. Once the Phase III repairs were completed, the Phase II temporary repairs were removed. A 20'-0" section of concrete seawall was installed to replace the damaged portion and doweled into the existing concrete. Timber walers and timber fender piles in that 20'-0" section were replaced in kind. The spalling and cracking in the underside of deck, pile caps, and piles were patched using epoxy concrete or equal.

Conclusions

Implementing the repairs described instead of demolishing portions of the pier and rebuilding as was first discussed, enabled the client to save a significant amount of money. WJ.Castle designed the temporary and permanent repairs, acquired the pertinent permits, and performed the construction management for the installation of the support system. Hydro-Marine Construction Co, Inc. an affiliate construction company assisted in performing the emergency underwater repairs required to stabilise the pier. The project was completed for a total cost of USD 875,000.00.

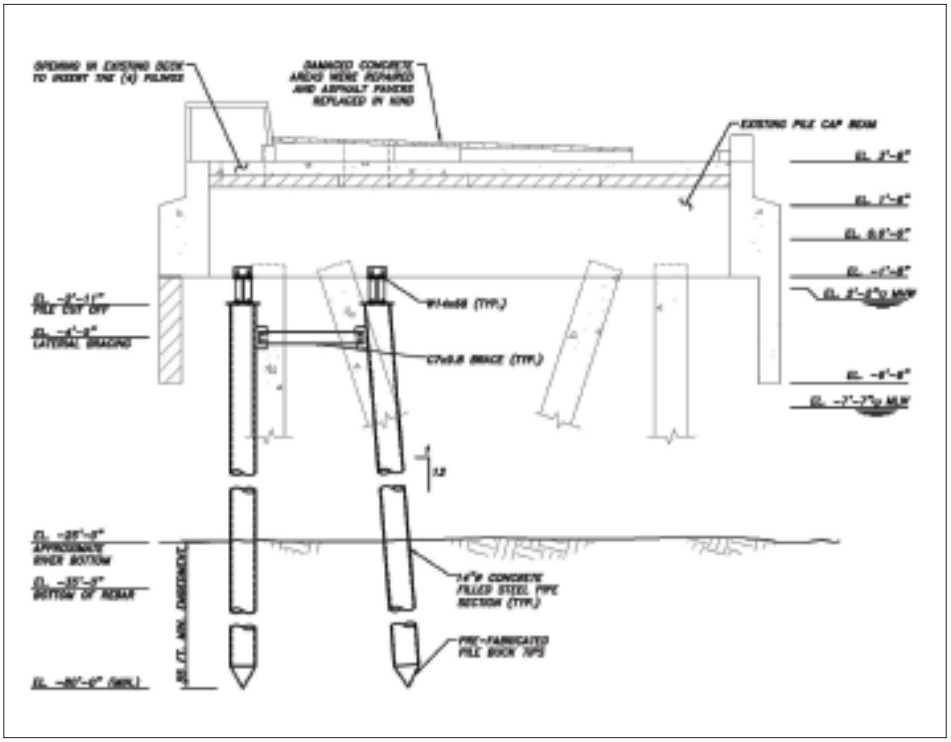

Figure 3: Phase III Permanent Repairs