Launch of the new span

TAKING THE STAGE

A complex operation to replace a bascule bridge with a vertical lifting span demanded staged analysis as part of the construction engineering

A 75-year old single leaf bascule bridge over the Chelsea Creek between Boston and Chelsea in the USA has been replaced by a much larger vertical lifting bridge in a project funded by the Massachussetts Department of Transportation. The old six-span bridge had a total length of 136m and a main span consisting of a 43m-long heel-trunnion Strauss bascule with 20m and 13m spans on the east side, and three 20m-long spans on the west side. The bascule span itself was across a 30m-wide channel, restricting shipping, and hence had to be replaced as it was a hazard to navigation.

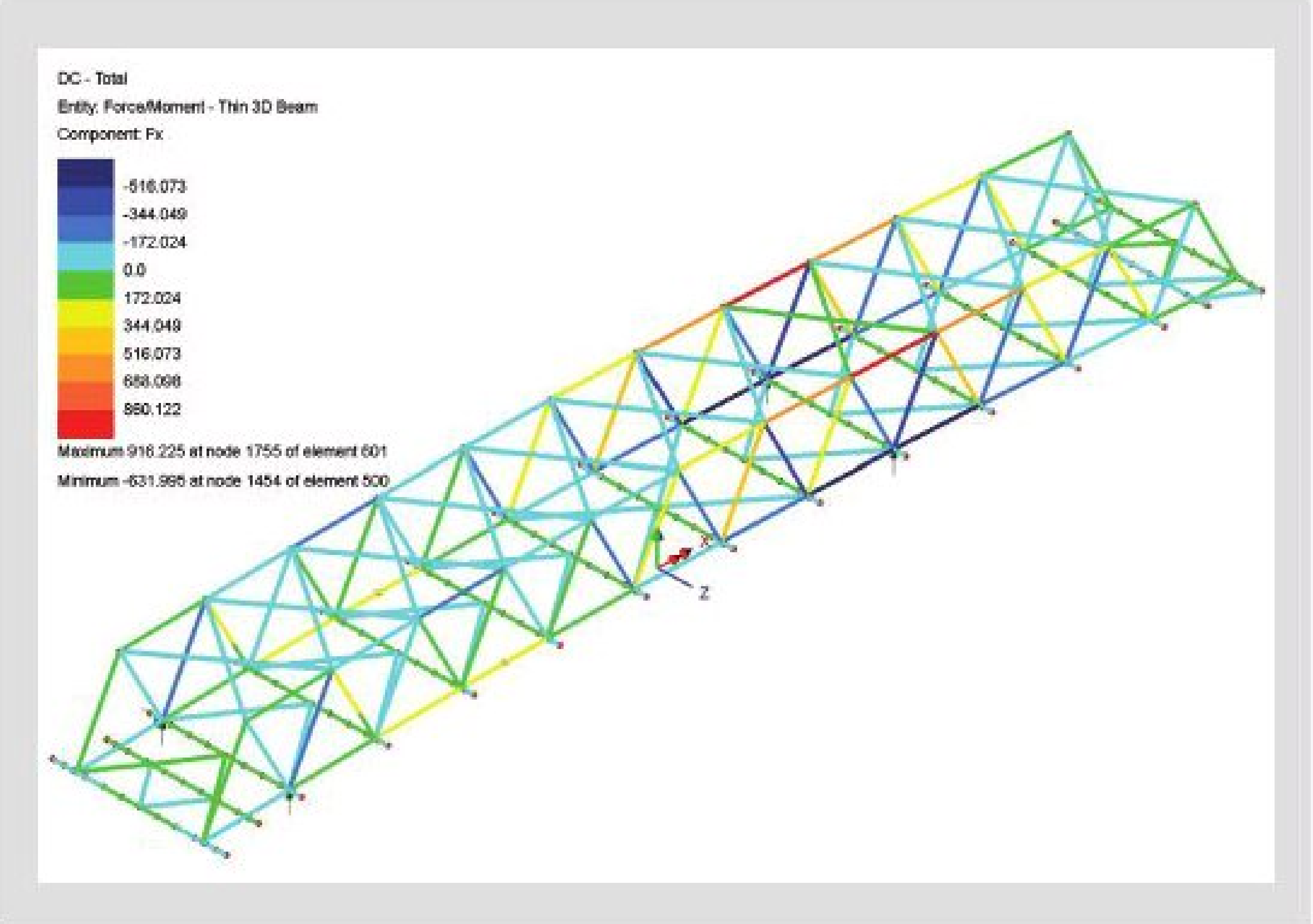
The new replacement structure, designed by HNTB Corporation, is a massive constant-height Warren-type steel truss that spans 137m between two, 65m-high towers, and when raised provides 53m of vertical clearance for shipping. It matches the footprint of the previous bridge and its approach structures and carries four lanes of traffic, two in each direction, along with two pedestrian footways.

As part of its appointment to provide pre-bid and construction engineering services to JF White Contracting Company for the Chelsea Street Bridge replacement project, Finley Engineering Group developed an erection scheme for the bridge. A lack of clearance for larger vessels meant that it would have been difficult to float the truss in on barges as would commonly be done for bridges of this type. Finley's solution was to launch a fully-assembled truss 43m across the navigation channel using launching girders supported on the existing bridge piers. Finley used Lusas Bridge analysis software to assist with this task and also to analyse the stresses on temporary steel bracing as a result of pouring of concrete into the steel-plated counterweights.

The lower halves of each steel tower were assembled member by member up to mid-height. Then ready-assembled upper leg sections, 34m long and weighing 200t, were lifted and fixed into place before each tower was topped with machine houses measuring 23m by 7.6m, which would provide housing for the lifting machinery.

Tower plumbness tolerances demanded verticality along the project baseline within 25mm over the 65m height and within 13mm orthogonally to the project baseline. Adjustments were made to the base of each tower, with reference to a network of survey stations, to achieve this. The 770t counterweights in the towers assist the lifting motors and reduce the deadweight; they are essentially steel-plated containers filled with a high-density concrete that was poured in stages to prescribed depths. During the concrete pours, temporary bracing of the counterweight top flange is required to control the stresses induced in the steel container. After casting, strand jacks were used to raise the counterweights to their location below the control room at the top of each tower. A staged analysis of the concrete pours for the counterweights was required to check the effects on the steel bracing. Using Lusas, a finite element model of the counterweight was developed using shell elements to model the outer and inner steel plates and thick beam elements to represent the lateral bracing members. The concrete pours were modelled individually as hydrostatic loads, with lifts of 1.5m, 1.5m and 1.2m to comply with Finley's balancing plan.

The massive 1,200t truss and deck system consists of of built-up steel members



Forces in the members shown in Lusas

connected to one other by gusset plates. On site, the component parts of the truss were assembled in a yard next to the bridge to create two truss units. Each was then launched into position from the side, joined together, and then jacked progressively along the launching girders until the truss system was eventually fully-cantilevered across the navigation channel before touching down on the opposite side. Project specifications dictated that the main river channel couldn't be closed for more than 60 hours. So once the truss breached the channel clearance, it had to be launched, installed, and lifted to its maximum open position within the allotted closure period.

For the launch of the truss, Finley designed specialised launching equipment, launching girders, temporary supports and launching geometry. The existing bridge piers had been recently retrofitted and a field inspection/condition survey and subsequent evaluation for launching loads confirmed they had sufficient capacity to be used for the launch.

The main purpose of the launching analysis, which was carried out using Lusas, was to ensure that member stresses and truss displacements during launching of the truss would remain within tolerable limits. All truss members were modelled using thick beam elements placed at member centroids. Section properties for each member were calculated using the section property generator within Lusas. All loads and stages in the launching process were modelled and analysed in Lusas with envelopes of worst effects being obtained. The fully-cantilevered condition was the most demanding, causing the highest jack reactions and forces in the members. JF White Contracting Company project manager Jack Pecora says: "Finley's use of Lusas provided us with updated support point reactions once the final launch load and sequence was engineered. This was most critical through the launch phases as the truss model was used to confirm observed reactions from the field."

After the truss was launched across the shipping channel at the end of last year, final fitting-out work of the deck system and removal of all existing temporary works and mid-channel piers was carried out. The shipping channel was then dredged and widened to allow the passage of larger vessels. After additional unforeseen work that required the removal of an abandoned sewer line beneath the channel, the US$125 million bridge was officially opened in May.

Jerry Pfuntner at Finley adds: "The use of Lusas helped us prove our erection design and early communication between the client Massachusetts DOT, the contractor JF White and Finley created a construction solution that took the contractor's strengths into account. It maximised the use of existing support structures to create a reliable and efficient erection plan."■