Heavy Movable Structures, Inc.

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Lake Buena Vista, Florida

"Suez Canal Swing Bridge"

by

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Quade and Douglas, Inc.

SUEZ CANAL SWING BRIDGE

by

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This paper is about a bridge design that was developed in 1995 in response to requests for design-build proposals from the Egyptian National Railways for a new movable bridge across the Suez Canal. As the design was not selected, it never got beyond the preliminary design. But as the proposed design would have been the longest movable bridge in the world and would have carried rail traffic, it presented a number of design challenges that may be of some interest to other designers of movable bridges.

The design was developed by Parsons Brinckerhoff Quade & Douglas, Inc. for the consortium of American Bridge, Pittsburgh and DSD, Saarlouis, Germany, a German steel supplier, with Dr. Charles Birnstiel and Steward Machine as design consultant on the bridge machinery

The background of the project can be traced to a rail line built by the British. The Benha-Port Said line crosses the Suez Canal at El Ferdan and the type of bridge originally constructed was not known. However, at least two swing spans have been built on the site. The first one having an approximately 76 meter span, pivot to pivot, to cross a 70 meter wide canal, and the second, a 168 meter double swing span, pivot to pivot, that was built, probably in the 1950's, by Krupp Steel, a German steel fabricator. Until it was destroyed in the 1967 Six-Day War, the bridge was listed in the Guinness Book of World Records as the longest swing span in the world. Figure 1 shows the location of the canal and the earlier bridge foundations on the west bank. The foundations on the east bank had been removed when the canal was widened.

However, as ship sizes were increasing, plans are underway to enlarge the Suez Canal to 316m wide and 27m deep. Currently the only canal crossing in the area is by ferry, and the Egyptian government had decided to rebuild this line, including the bridge. This led to the 1995 request for design-build proposals for a new single track bridge, that would also serve as a two lane highway.

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The planned use of the bridge was based on the fact that the canal operates in one direction only, so that first northbound ships use the canal, the canal is allowed to clear, then southbound ships use the canal, it is allowed to clear, and then the northbound traffic proceeds. Therefore, during the periods between the passage of northbound and southbound shipping, the canal does not carry marine traffic and the bridge can be closed, thus allowing both train and vehicular traffic to cross the canal. When the bridge is open, trains and vehicles are marshaled on either side of the canal awaiting for the time when the canal will again clear.

In order to meet the new canal clearances, two swing spans were required, and the general configuration proposed is shown in Figures 2 and 3. As these spans are well beyond any movable span previously built it presented a challenge, particularly for the heavy rail loading, prescribed by the ENR, see Figure 4. The greatest challenge was how to control deflections. The ENR Design Specifications are very similar to AREA and limit live load deflections to L/900, for live load without impact. To further complicate the problem a mid-span joint was required, a feature that is never used in movable railway bridges due to problems with the deflection of the joint.

Two alternative designs were proposed. The first was a conventional through truss as shown in Figure 2, and the second was a cable-stayed alternative, see Figures 5 and 6. At the time of the preliminary design submittal we were not able to develop a suitable design for the stays that would meet the deflection criteria. However, the writer is confident that this could be resolved. The problem being that a cable-stayed design typically uses the dead weight of the span to induce sufficient tension into the stays so that under live load their behavior is almost linear. In this case the dead load of the swing spans was relatively low when compared to the live load so normal stays would not be stiff enough to be essentially linear under live loads.

Other features of the design were typical for those found in other large swing bridges. For the pivot, a rim bearing arrangement was proposed, see Figure 7, driven by 8 electric motors/reducers, see Figure 8. A ten minute opening time was specified. At the abutments wedges were proposed and they were to be detailed to resist uplift as well as downward forces.

The bridge was required to be able to be opened manually, and Figure 7 shows a typical capstan. However, this would be unlikely as a large number of laborers would have been required and they would have taken several hours to open or close each span.

In order to resolve the joint deflections problems, an offset truss joint was proposed as shown in Figure 9. This type of configuration is not new but is seldom used. Dr. Birnstiel was able to find a reference in an old German text and the writer is aware of its use on the Jose Leon de Carranza Bascule Bridge in Cadiz, Spain, which is a double leaf highway bridge, 96.8 meters between trunnions.

For the foundations, high capacity drilled shafts were proposed. It was proposed that their capacity be improved with injection grouting. An alternative of a caisson for the pivot piers was also proposed, as this was a requirement of the request for proposals.

In addition to the bridge proper, the design included approach roads, tracks, truck scales, and housing and offices for the bridge staff. These are shown in Figure 10.

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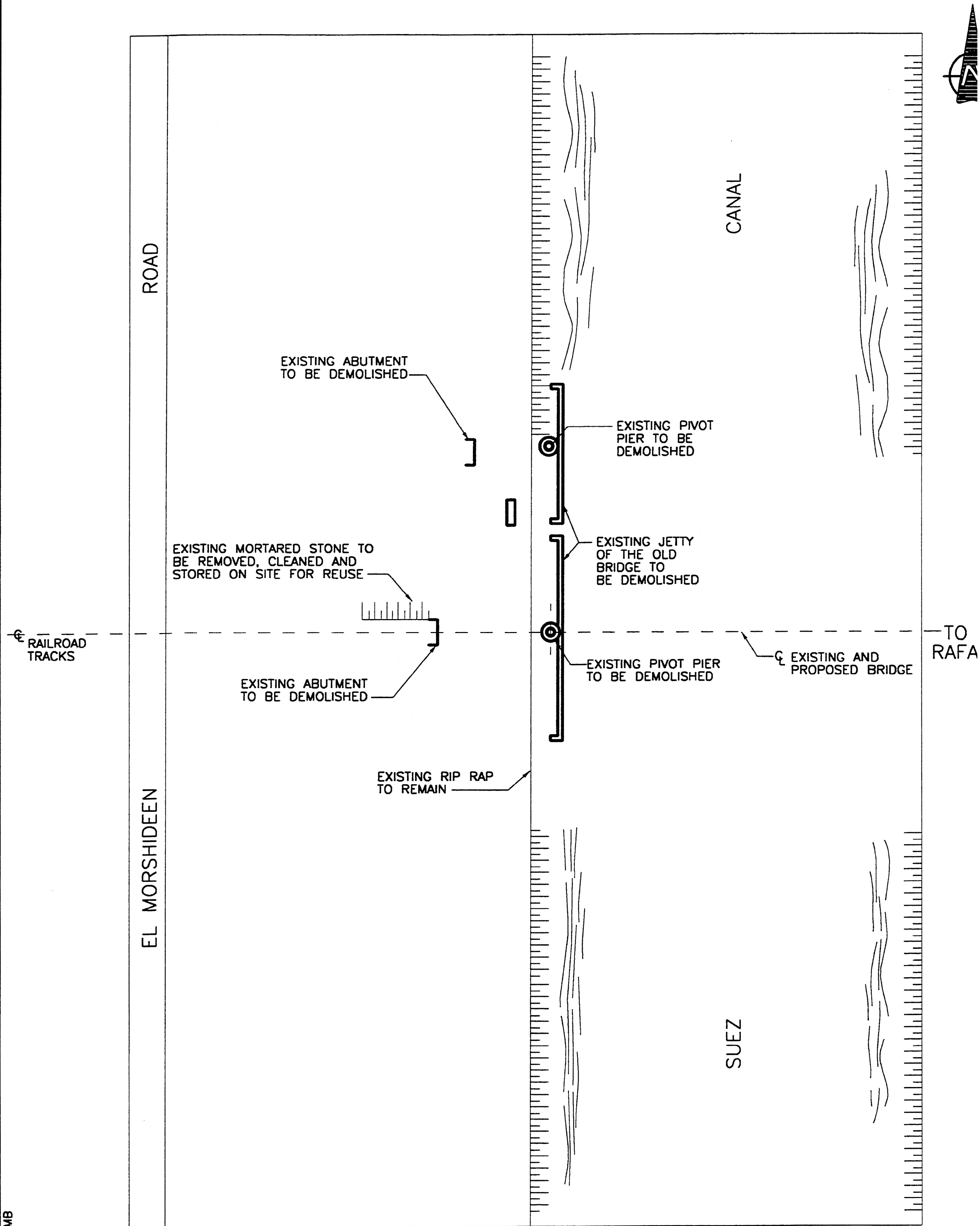

PLAN

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FIGURE 1

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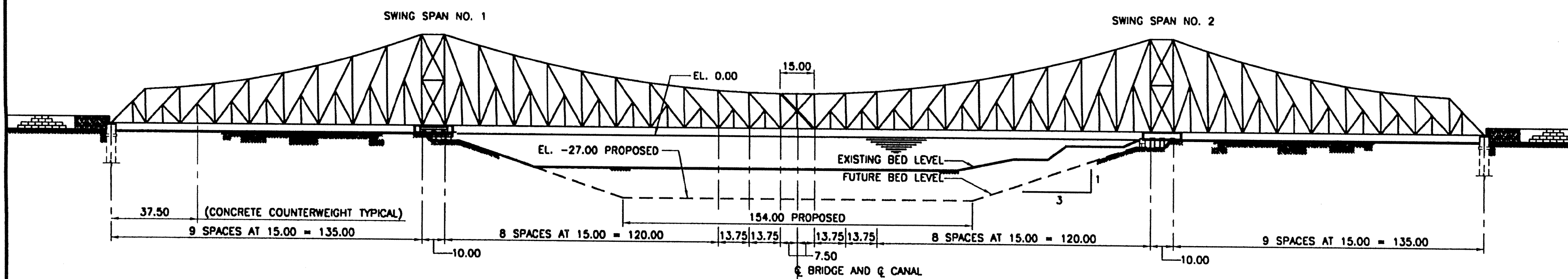
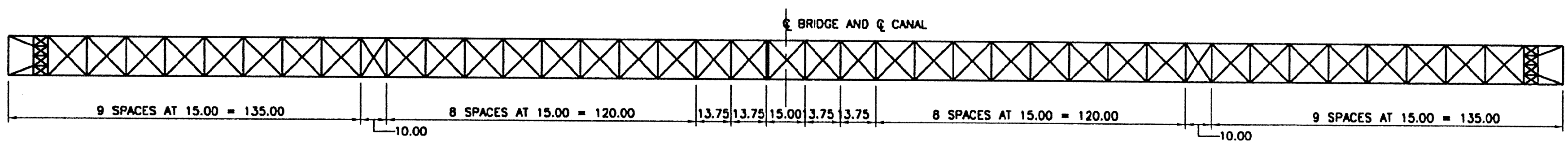
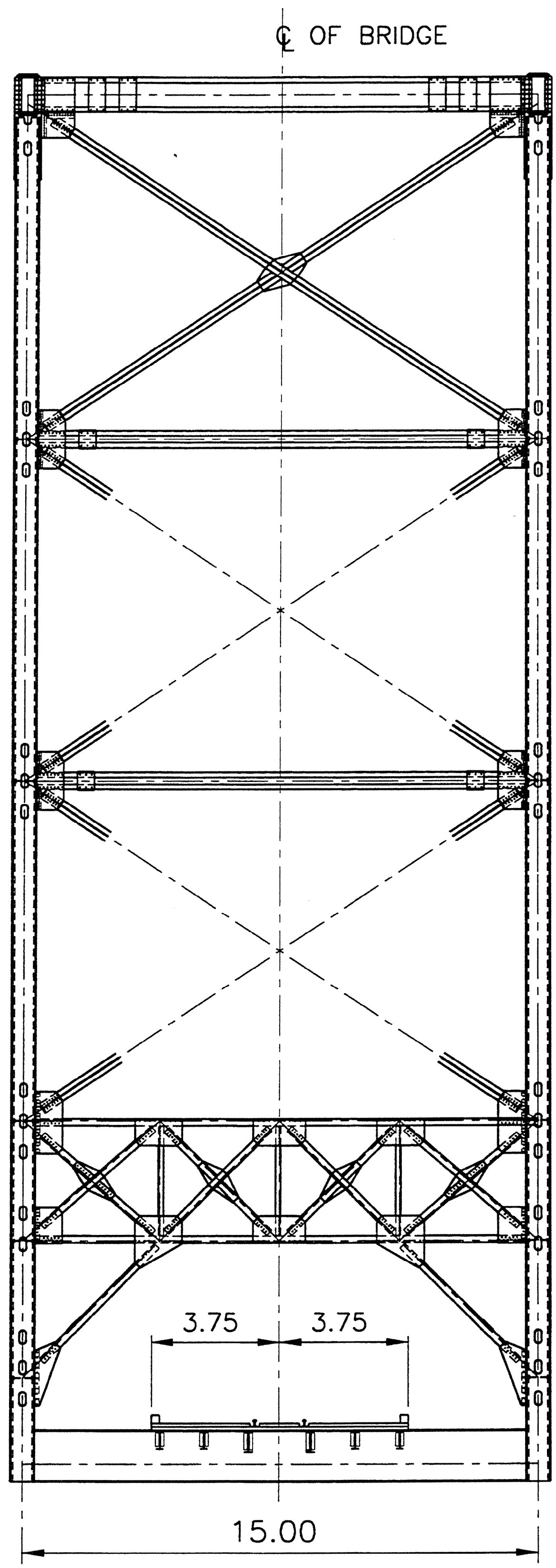


ELEVATION



PLAN



SECTION AT PIVOT PIER

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FIGURE 3

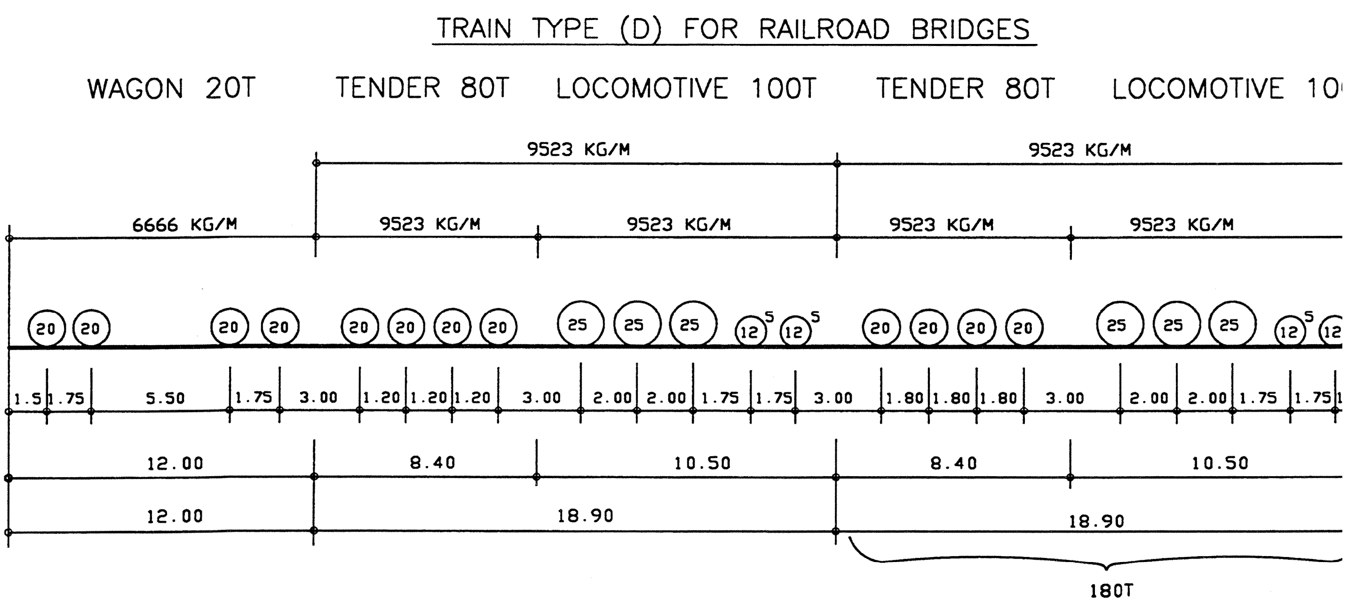

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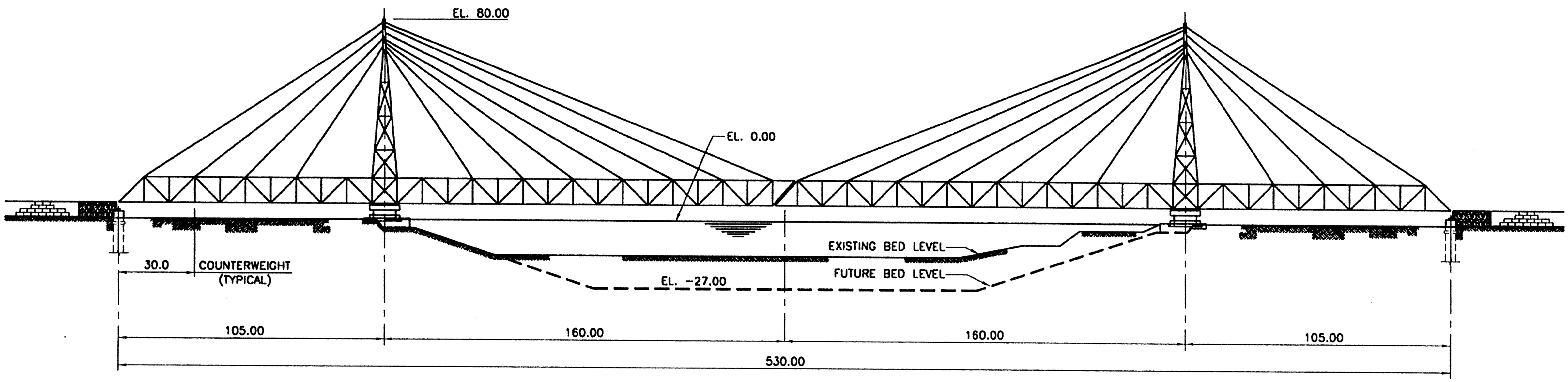
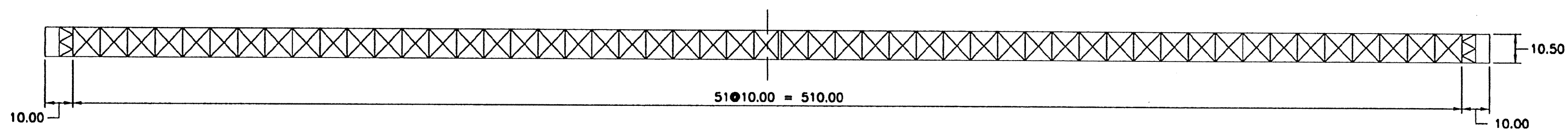
FIGURE 4

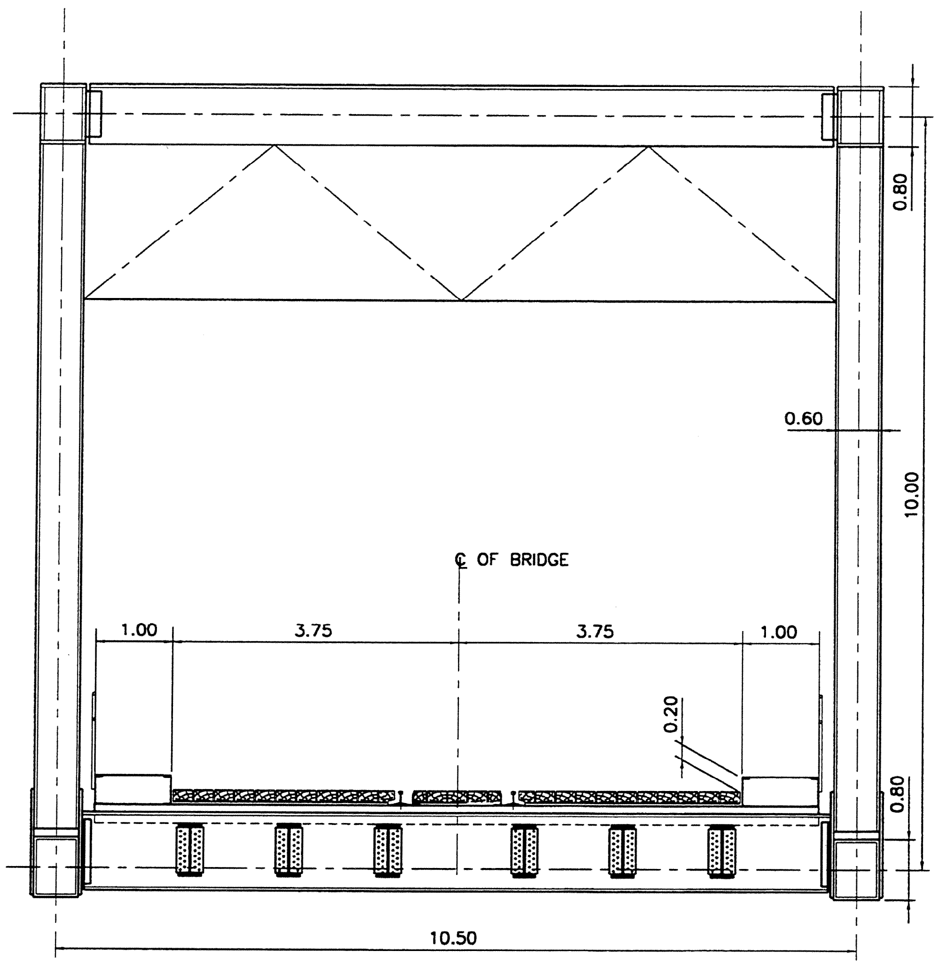
ELF-SK05.DWG 14 OCT98JMB



ELEVATION



PLAN OF TOP BRACING



SECTION

FIGURE 6

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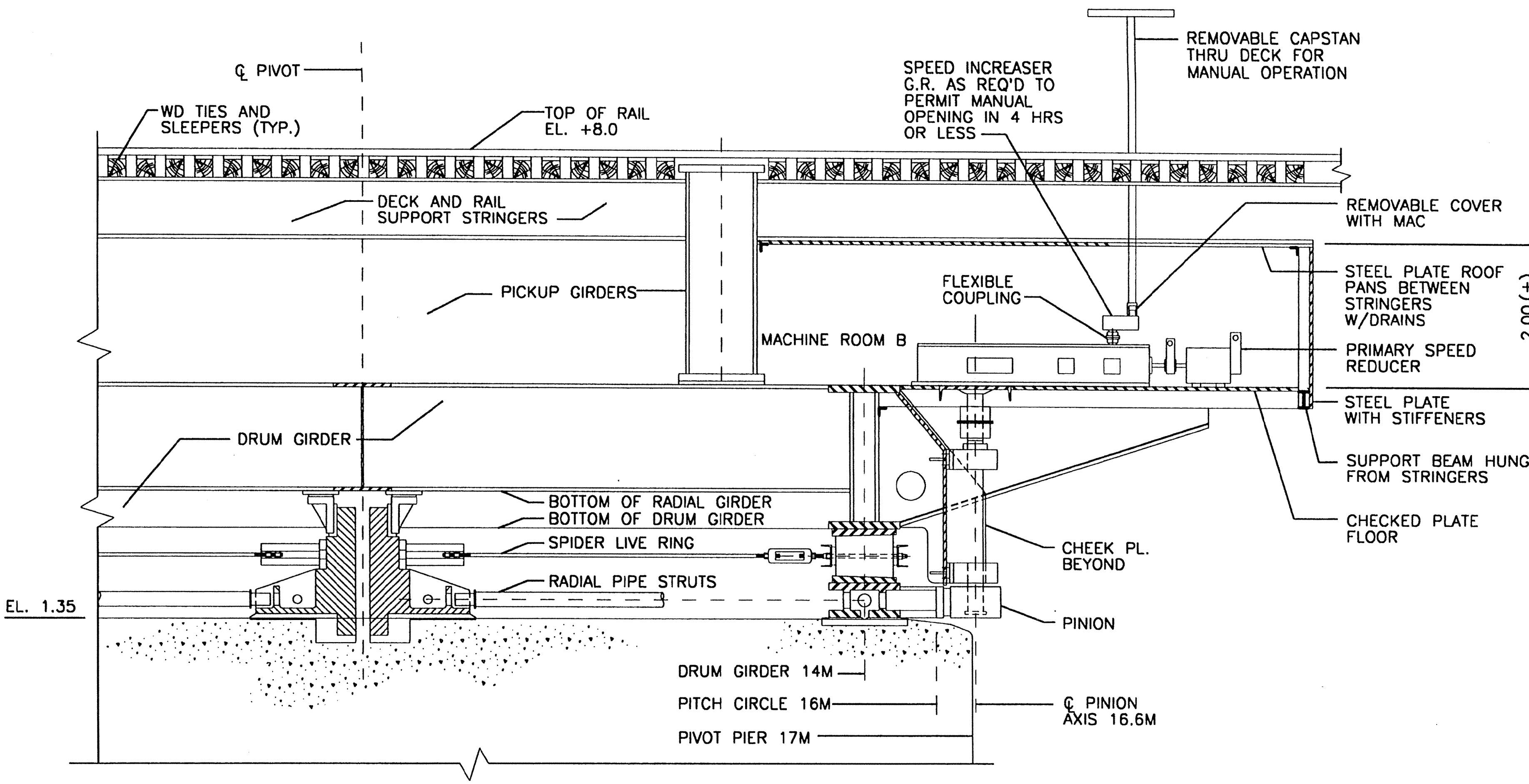
ELF-SK08.DWG 14 OCT98JMB



SECTION THRU MACHINE ROOM SCHEME A

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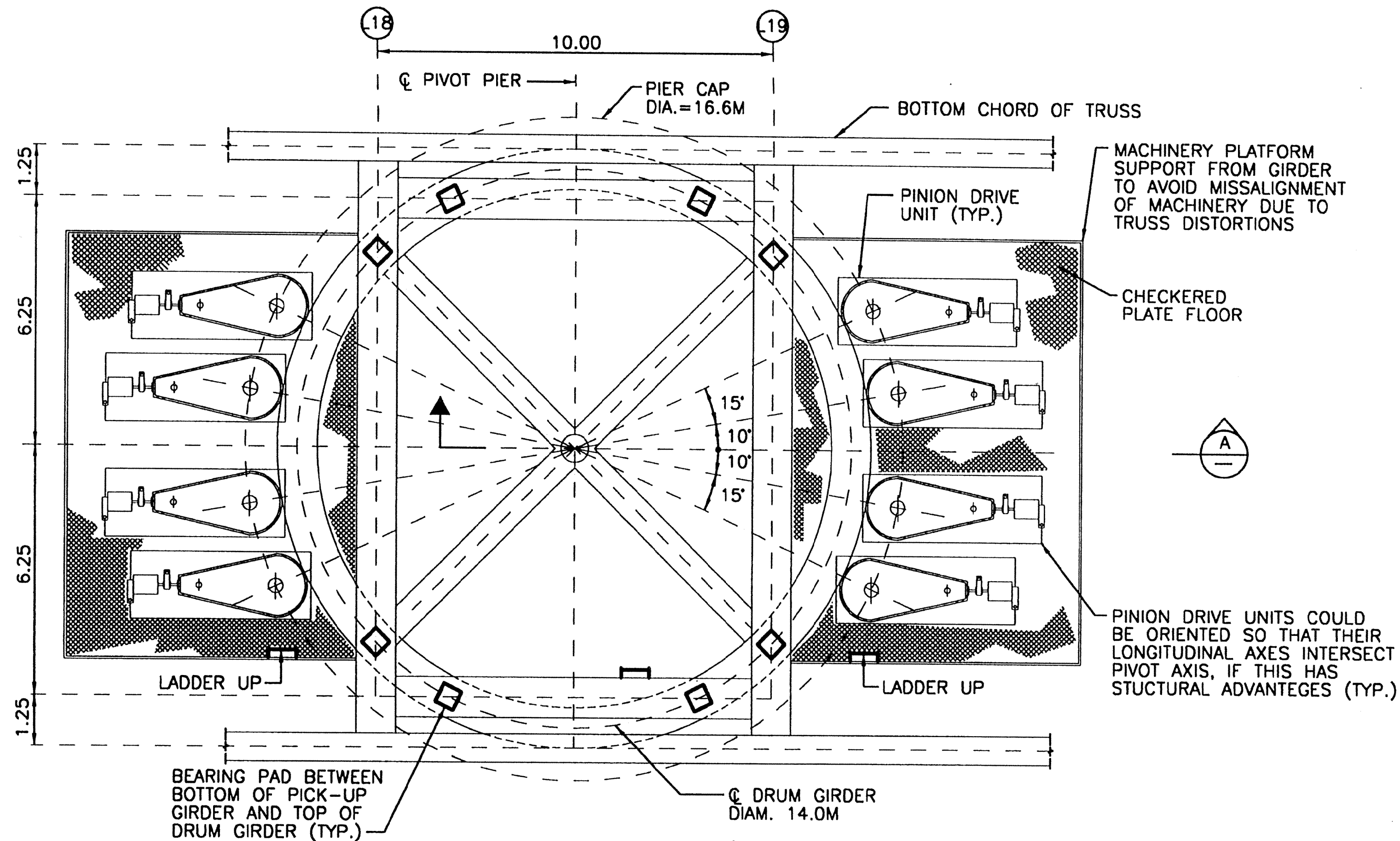
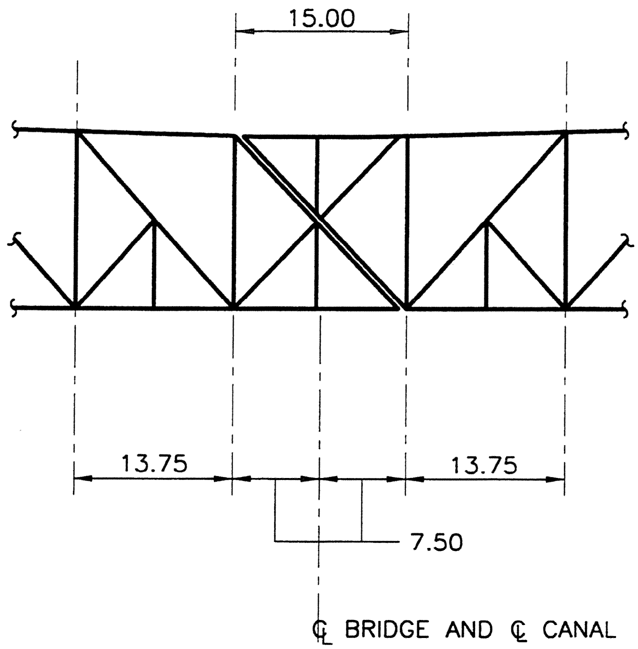


PLAN BELOW TRACK / ROADWAY - SCHEME A



ELEVATION

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FIGURE 9

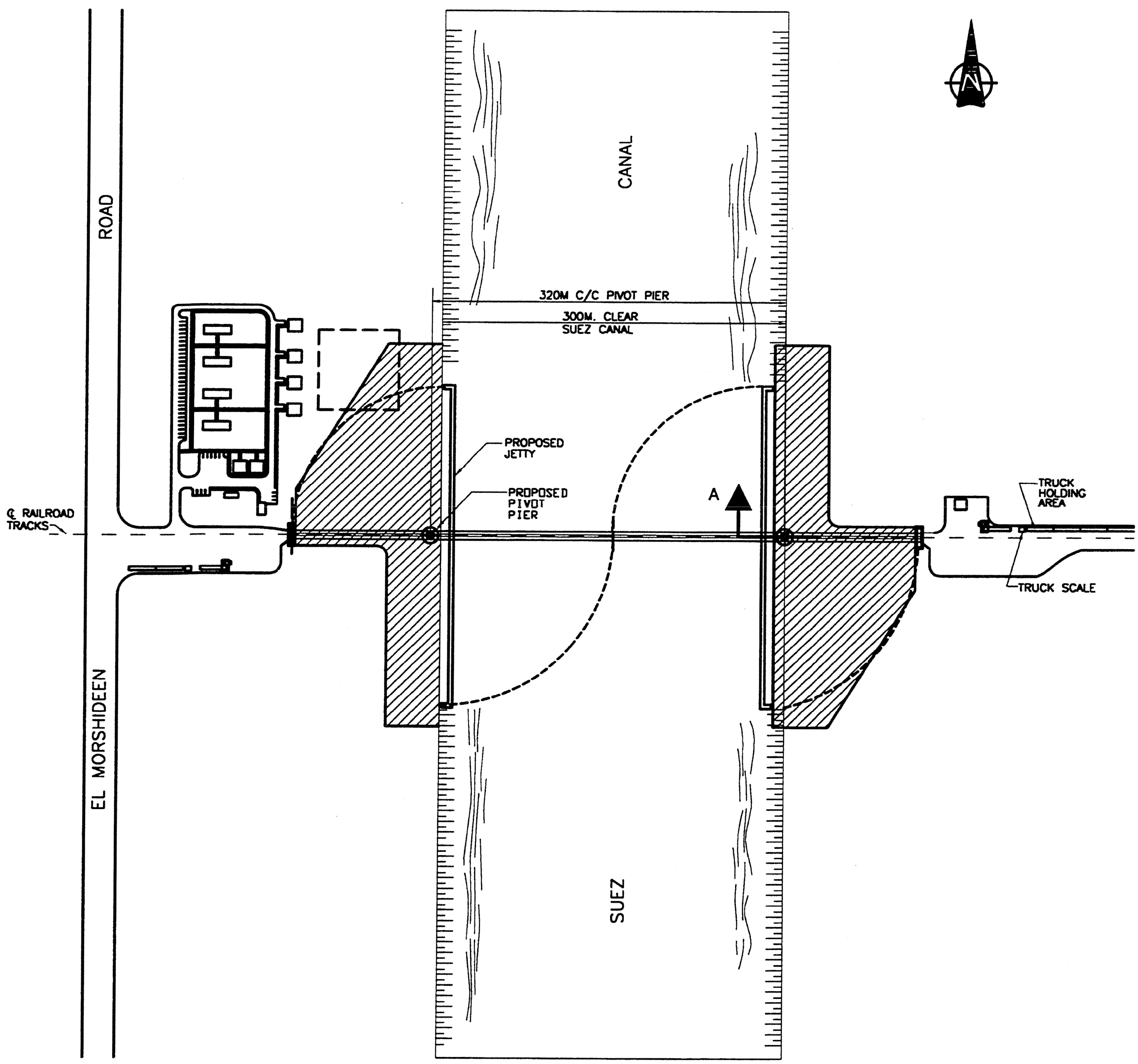

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FIGURE 10