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BEER SHEVA FOOTBRIDGE, ROKACH-ASHKENAZI ENIGEERS

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Summary

The Beer Sheva Footbridge is a two-span lenticular truss bridge. The slender design and flexible piers cause several low frequencies in each of the three primary directions. In order to stiffen the bridge and still allow thermal expansion, a friction-based connection was designed which resists human induced vibration loads but slips under the large thermal loads. Stiffening the bridge in this way raised the frequency to 1.72Hz and lowered the participating mass to 24%. 6 TMD devices were designed for the bridge for vertical and horizontal vibrations.
On the eve of the 18th of June, all railway traffic was stopped and during a nightlong operation the southern span was lifted into place and welded to its supports. This span has a mass of 230 tons. The 430 ton northern span was lifted during a second operation and welded to its supports. Throughout the entire construction, the traffic was interrupted for less than 24 hours.

Keywords: footbridge; steel; architecture; truss; damping; vibration

Figure 1. Beer Sheva Footbridge, view from the Gav-Yam park - Amit Geron Photography

The bridge's total length reaches 200m. The bridge attains its length through two main spans, the longer of the two(northern span) is 100m in length, with the shorter(southern span) reaching 70m, which, together with the two end supports make up the 200m bridge deck.

The Beer Sheva Bridge has three simple static schemes in its three primary directions.

Vertically the bridge acts as two independent simply supported beams. Each span is supported by its end pier at the bridges extremities and by the central column where they meet. Despite the connections' physical continuity, each span works and behaves as would a single span with pinned end restraints (not bearing bending moment stresses). This approximation is made possible because of the flexibility of the cross section at the point of connection compared to the high rigidity of the span itself (due to the truss height), in addition to a sliding detail connecting the walkway to the central column but not allowing any coupling forces to develop between the walkway and the truss itself.

The bridge's axial static scheme is that of a cantilever, the bridges full rigidity stems from the central column and its resistance to bending as a cantilever. The truss ends' flexibility, the end piers' slenderness, and a hinged detail designed at the foundation, allow the piers to function (approximately) as a compression strut would and do not resist loads in the bridge's axial direction, allowing an approximately isostatic system. Axial forces are resisted solely by the central column as a cantilever.

Transversely, the bridge acts as a continuous beam across its entire length. In this direction it functions as a continuous beam supported by three supports. The end piers are able to restrain transverse movement due to their geometry and act as truss structures resisting movement. The central column again works as a cantilever.

Due to the flexible static scheme in the bridges axial direction, the theoretical axial frequency was calculated as 1.22Hz with a participating mass equal to 75% of the bridges total mass. This frequency is within the range of frequencies vulnerable to human induced vibrations and user discomfort. This mode would have to be damped artificially using a heavy, expensive TMD system. A stiffer scheme could raise the frequency above the above mentioned range. In order to stiffen the scheme without substantially increasing the column’s cross section dimensions, the bridge deck would have to be axially restrained. This restraint would lead to additional stresses due to thermal loading and would require certain changes in the bridges architecture(for example the addition of tension members connecting the end supports to the foundations and limiting their rotation). The eventual decision was to fix the escalator support beams at the north side. This raised the frequency to 1.72Hz and lowered the mass to 24%, improving the bridges characteristics and lowering the TMD systems cost. In order to solve the vibrations without adding thermal stresses, the solution had to restrain the axial direction under pedestrian loading but allow for thermal expansion. The initial proposal was to use viscous dampers as are used to on cable-stayed bridges to dampen cable vibrations, this type of damper is well suited to the axial restraint problem as they can be calibrated to lock up under rapid human induced vibrations and flow freely with slowly increasing changes in temperature. The eventual solution was a friction based detail which would resist the relatively low axial forces caused by vibrations yet slide with the large thermal forces. According to the theoretical model, in addition to the axial mode the bridge has slightly problematic vertical and transverse frequencies, albeit with low participating masses. The eventual design accounted for preparations for TMD systems in all three directions.

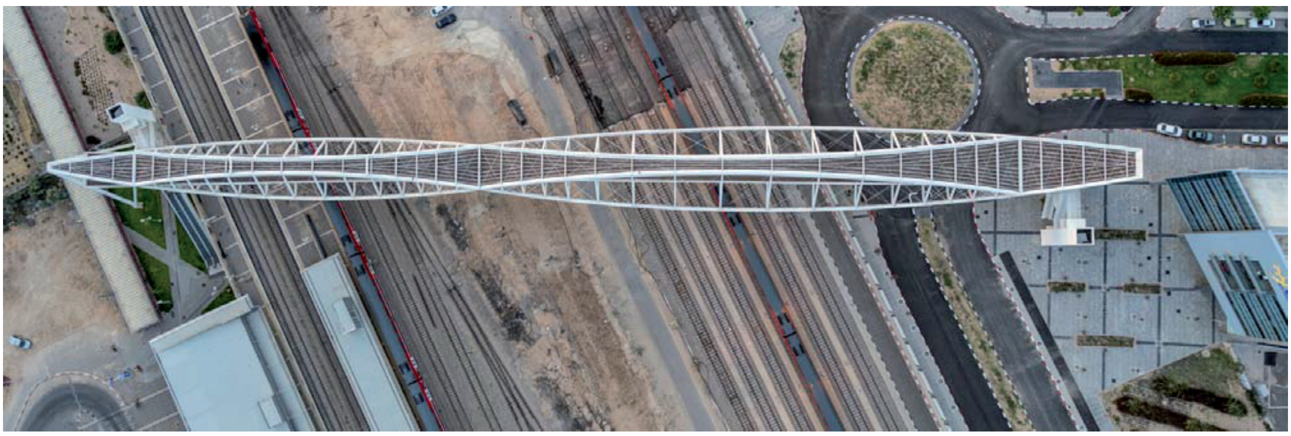

Figure 2. Plan View