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Investigation of a Steel Pony Truss Bridge

Figure 1. The Main Street Bridge, circa 1995.

In 1977, Rubin M. Zallen Associates (a predecessor of Zallen Engineering) was retained to investigate bridges in Framingham, Massachusetts to determine their load capacity and condition, as part of a state-wide program to rate the load capacity of all existing bridges in the State. A few of the bridges that were investigated were very old and posed interesting problems.

The investigation of one of these bridges, the Main Street Bridge over the Sudbury River is described in this issue.

Figures 1 shows the Main Street Bridge as it existed in 1995. This bridge is an example of an early steel bridge probably built between 1890 and 1900. It has a 71 foot span with the main members being what is commonly called *half through trusses* or *pony trusses*. It was originally built with a timber deck supported by timber stringers (longitudinal beams), both of which were replaced in 1946 by an open steel grate deck and steel I-beam stringers.

No plans of the bridge could be found, except for the steel stringers and open steel grate deck. Therefore detailed field observations and measurements of the bridge were undertaken in order to make a structural analysis and to evaluate its condition. Figures 2, 3, and 4 *(on page 2)* show a plan, longitudinal cross-section, and transverse cross-section of the bridge. Figure 5 is a photograph of the bottom of the bridge.

The arch shaped top chords of the trusses are in compression and thus have a tendency to buckle transverse to the planes of the trusses, i.e. displace laterally. (They also have a tendency to buckle vertically but this effect is readily resisted by the other members of the trusses which are connected to the top chords). The transverse buckling is resisted by *sway frames* which can be seen in Figure 1 and which are shown on Figures 3 and 4. Referring to the bridge cross-section on Figure 4, if the top chords try to buckle transverse to their own planes, this tendency would be resisted by the bending resistance of the sway frames, acting as vertical cantilevers (in the plane of Figure 4). The sway frames are at-

Continued on page 3

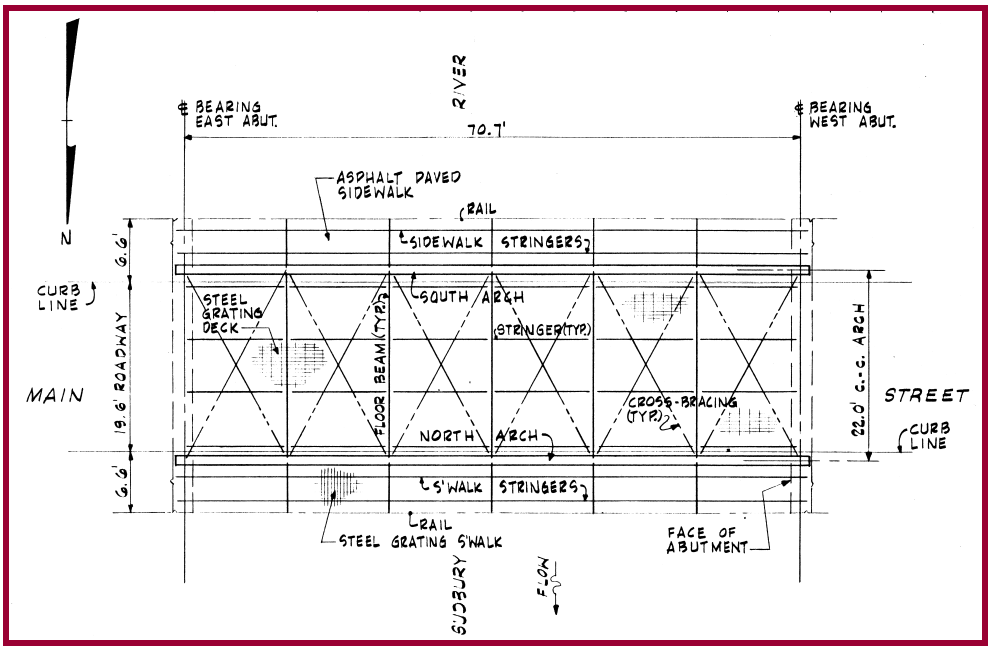

Figure 2. Plan of Main Street Bridge.

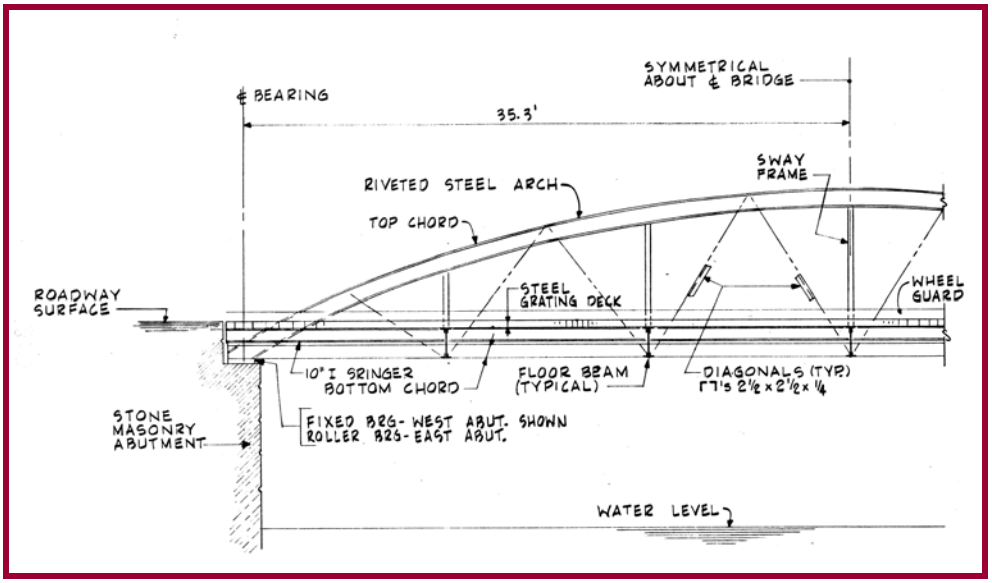

Figure 3. Longitudinal section through Main Street Bridge.

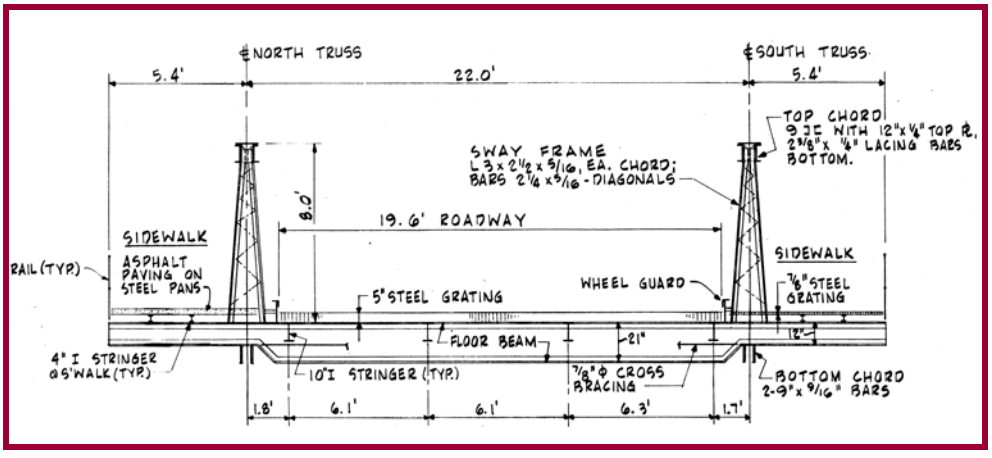

Figure 4. Transverse section through Main Street Bridge.

tached rigidly to the floor beam which in turn resists the bending of the sway frames. The buckling can only occur if the sway frame/transverse beam system does not have sufficient stiffness;[1,2] the required stiffness depends on the magnitude of the axial compression forces in the top chord.

Figure 5 shows the angle seats on the floor beams that supported the original timber stringers (up to 1946). The horizontal rod cross-bracing near the bottom of the transverse floor beams can also be seen.

During the investigation, we observed extensive rusting at connections between members, at splices, and at the bearings, which reduced their load capacity.

Figure 5. View of bottom of Main Street Bridge, circa 1978, showing seats on the floor beams for the original timber stringers.

The bridge capacity was determined to be 2½ tons for Type H and Type 3 trucks in accordance with the AASHTO guidelines.[3] The "weak link" for load capacity turned out to be the bottom chords. These chords (see Figure 4) are tension members made out of two flat bars.

In 1977, this bridge would have had to be replaced if it were on a busy thoroughfare, due to its low load rating and its need for repair. However, the section of Main Street serviced by the bridge is a lightly traveled thoroughfare, and the load on the bridge was limited. In 2008, the bridge is closed for repairs.

- Principal Rubin M. Zallen lead the investigation of this bridge.

Forensic Engineering in Construction® is published by Zallen Engineering, 1101 Worcester Road, Framingham, MA 01701. Comments are welcome. Please direct comments to Rubin M. Zallen, P.E., by telephone at 508-875-1360 or by e-mail at rmzallen@zallenegineering.com.

End Notes

1. The notes explain structural engineering jargon to non-engineers.

2. Stiffness is *not* strength; it is defined as the force (e.g., in pounds) required at a point in a structural system to cause a unit (e.g. an inch) displacement of that point in the direction of interest.

3. *AASHTO* is the American Association of State Highway and Transportation Officials. Three rating vehicles were used: a Type H truck which has a single rear axle and a 14 foot wheelbase; a Type 3 truck which has two rear axles spaced at 4 feet on center, and a spacing between the front axle and 1st rear axle of 15 feet; and a Type 3S2 truck which is a semi-trailer truck with double axles at the rear of the tractor and at the rear of the trailer.