Chapter 4
The Steel Girder Bridge

4.1. Introduction

This chapter presents the analysis of a pair of steel girder bridges, West Bound and East Bound, which are located in the Tazewell County, 70 miles northeast of Bristol, in the southwestern part of Virginia. They were built at the same time in 1993. These bridges are parallel and next to each other. The West Bound bridge has two lanes, and the East Bound bridge has three lanes [Brown, 1993].

These bridges were analyzed to investigate if they could endure the maximum considered earthquake, which had a 3% probability of exceedance in 75 years. These two bridges were also analyzed to examine if it would satisfy the operational performance level. The maximum considered earthquake and the operational performance level were chosen to ensure that the bridges were held to the highest standard, which means they would perform well during the worst possible earthquake and be operational immediately after the earthquake.

The bridges were modeled in RISA 3D to determine the fundamental period of vibration. Then based on the spectral accelerations for the Bristol area, the equivalent seismic loads were determined. These loads were applied to the RISA model to determine earthquake elastic force effects in the structures. After applying the appropriate R factors, the seismic force effects were combined with the dead and live load force effects. Finally the structures were evaluated for compliance with the appropriate Seismic Design Requirement. US Customary units were used for all the calculations for this pair of bridges because US Customary units were used in the construction drawings.

4.2. Material Properties

The properties of the materials used in the bridge model are presented in Appendix XII. It is important to note that there are two kinds of concrete used in the bridge model. The superstructure has a specified f_c' = 4000 psi, while the pier cap beam and columns have a specified f_c' = 3000 psi. There are also two kinds of steel used for the bridge, 50 ksi and 36 ksi. The 50-ksi steel is used for the plate girder webs and flanges, while the 36-ksi steel is used for all other structural steel, including diaphragms, stiffeners, connector plates, and bearings [Brown, 1993]. Therefore the calculation of the section properties of the superstructure, which combines the plate girder and the slab, uses only the 50-ksi steel.

The RISA 3D model of the bridges also used a link for each bridge to connect the superstructure and the pier cap beam. This link was created to account for the fact that the superstructure rests on the pier cap beam, and therefore the centroid of the superstructure was above that of the pier cap beam. The link was made rigid so that it would not be flexible enough to influence the deflections of the other members that it connected. Therefore steel material properties were used for the link to reflect its rigidity, except that the density of the link was set to zero, so that it would not impose any unrealistic load on the pier cap beam and columns.

4.3. Section Properties

The section properties of the superstructure, pier cap beam and columns are provided in Appendix XIII. The actual superstructure cross sections for the West Bound and East Bound bridges are shown in Figures 4.1 and 4.2, respectively. But in order to simplify the section properties calculation, the superstructure cross sections are assumed to look like those shown in Figure 4.3 and 4.4. In calculating the section properties for the superstructure, the slab properties are transformed into the steel girder properties because of the difference in the E values of the concrete slab and the steel girders. The important section properties of the superstructure are as follows:

West Bound:

A = 899 in^2

I_{xx} = 373,000 in^4

I_{yy} = 25,600,000 in^4

East Bound:

A = 1114 in^2

I_{xx} = 521,000 in^4

I_{yy} = 50,500,000 in^4

4.4. Soil Site Class

After the section properties were calculated, the next step was to determine the site class of the soil underneath the bridges. The classification of the soil under the bridges had to be determined using the site class definitions in the new LRFD Specifications, which depend on the shear wave velocity ($\overline{v_s}$), blow count ($\overline{N}$), or undrained shear strength ($\overline{s_u}$) in the upper 30 m (100 ft) of site profile. The site class definitions in the new LRFD Specifications were presented in Section 3.4. After analyzing the boring results, the soil underneath the two bridges was classified as class B [Dove, 2002].

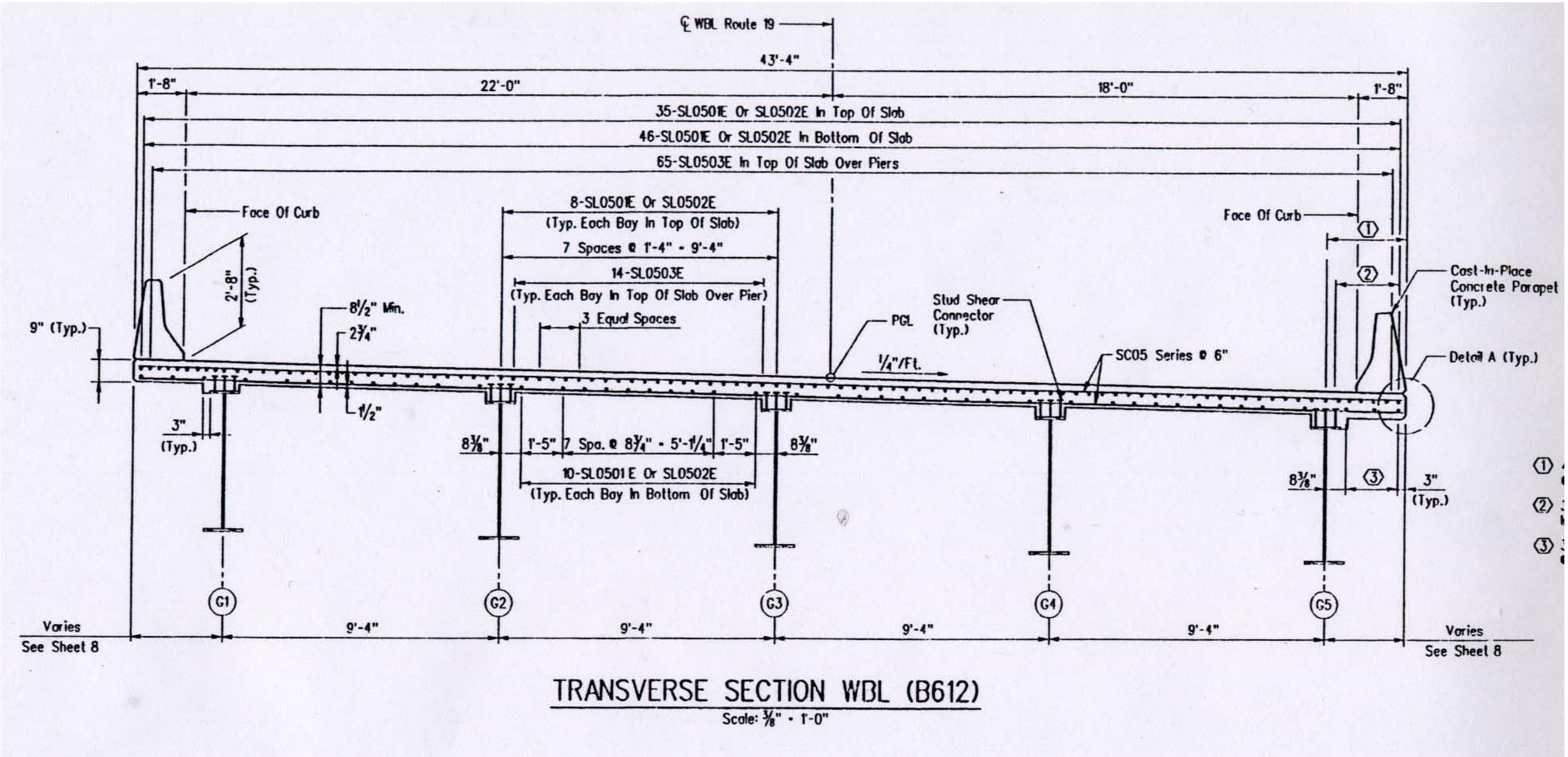

Figure 4.1. The actual cross section of the West Bound bridge superstructure [Brown, 1993]. The 3/8" = 1'-0" scale is no longer correct.

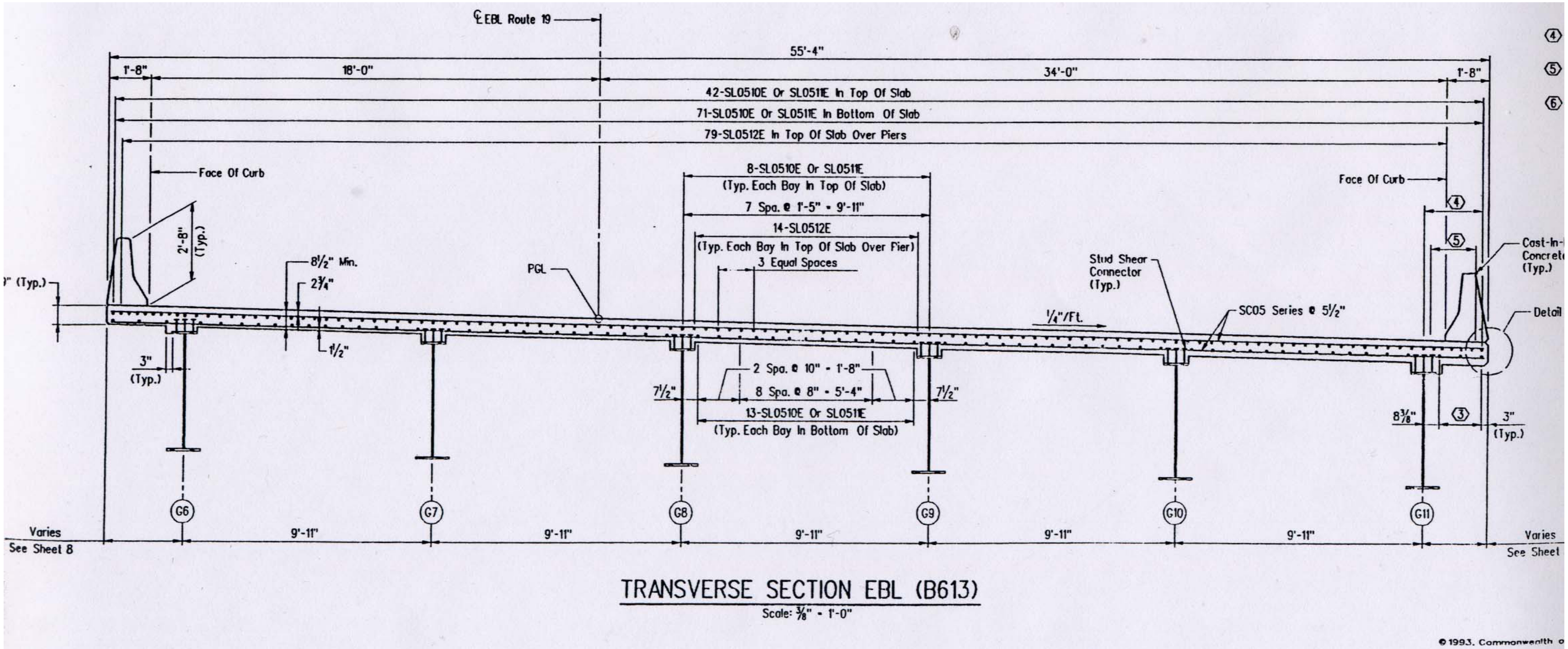

Figure 4.2. The actual cross section of the East Bound bridge superstructure [Brown, 1993]. The 3/8” = 1’-0” scale is no longer correct.