Chapter 3
The Prestressed Concrete Girder Bridge

3.1. Introduction

This chapter presents the analysis of a prestressed concrete girder bridge, which is located in Midlothian, a southern suburb of Richmond, Virginia. This bridge was analyzed to investigate if it could endure the maximum considered earthquake, which had a 3% probability of exceedance in 75 years. This bridge was 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 bridge was held to the highest standard, which means it would perform well during the worst possible earthquake and be operational immediately after the earthquake.

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

3.2. Material Properties

The properties of the materials used in the bridge model are presented in Appendix I. It is important to note that two kinds of concrete are used in the bridge model. The prestressed concrete girders have a specified f_c' = 55 MPa, while the pier cap beam and columns have f_c' = 25 MPa as specified in the construction drawings [Maday, 2002]. The superstructure slab has a specified f_c' = 30 MPa, but it is transformed into the concrete used for the prestressed concrete girder in the section properties calculation. This was required because the superstructure, which consists of the slab and the prestressed concrete girders, is modeled as one member.

The RISA 3D bridge model also used a link 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.

3.3. Section Properties

The section properties of the superstructure, pier cap beam and columns are provided in Appendix II.

The superstructure cross section is shown in Figure 3.1. However, to simplify the section properties calculation, the superstructure cross section is assumed to look like that shown in Figure 3.2. In calculating the section properties for the superstructure, the slab properties are transformed into the prestressed concrete girder properties because of the difference in the f_c' values of the slab and the prestressed concrete girders. The important section properties of the superstructure are as follows:

$A = 8.66 \times 10^6$ mm^2
$I_{xx} = 4.47 \times 10^{12}$ mm^4
$I_{yy} = 4.69 \times 10^{14}$ mm^4

The pier cap beam doesn't have a constant cross section, because its top surface has a slight slope. The pier is shown in Figure 3.3. However, for the purpose of calculating the section properties, the average pier cap beam height was used. The pier cap beam and column cross sections are shown in Figures 3.4 and 3.5.

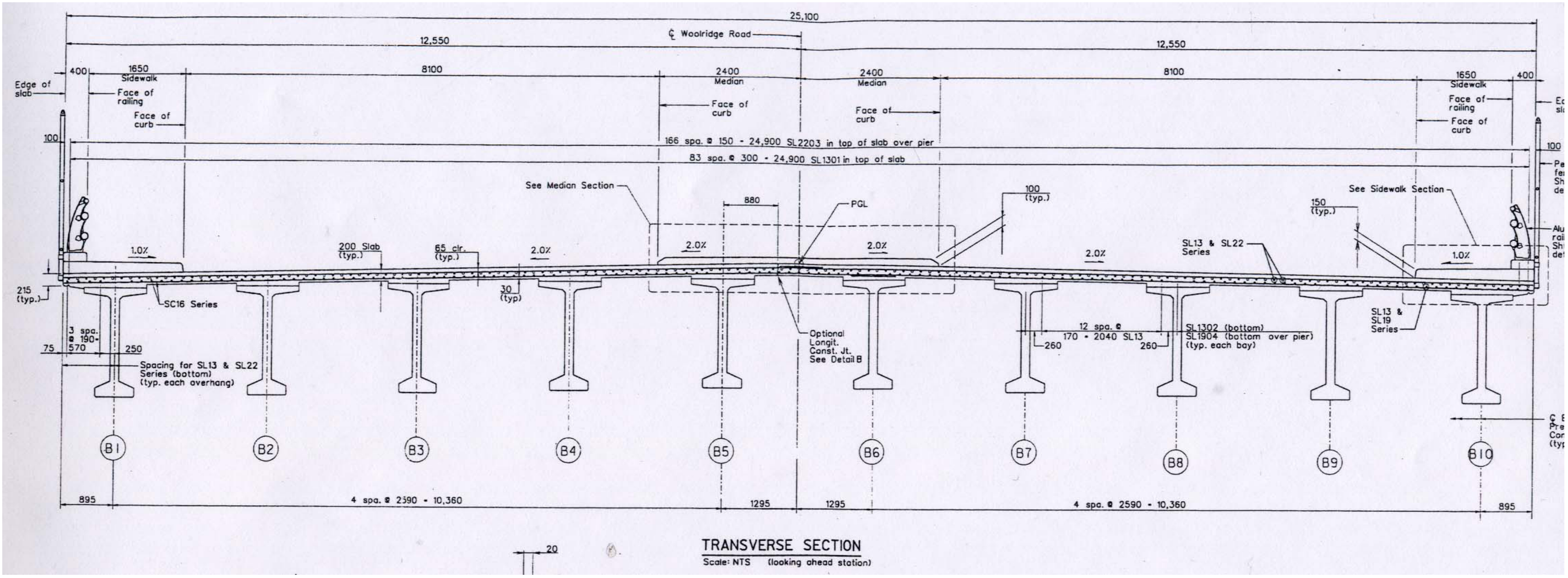

Figure 3.1. The cross section of the prestressed concrete bridge superstructure [Maday, 2002]. All dimensions are in mm.

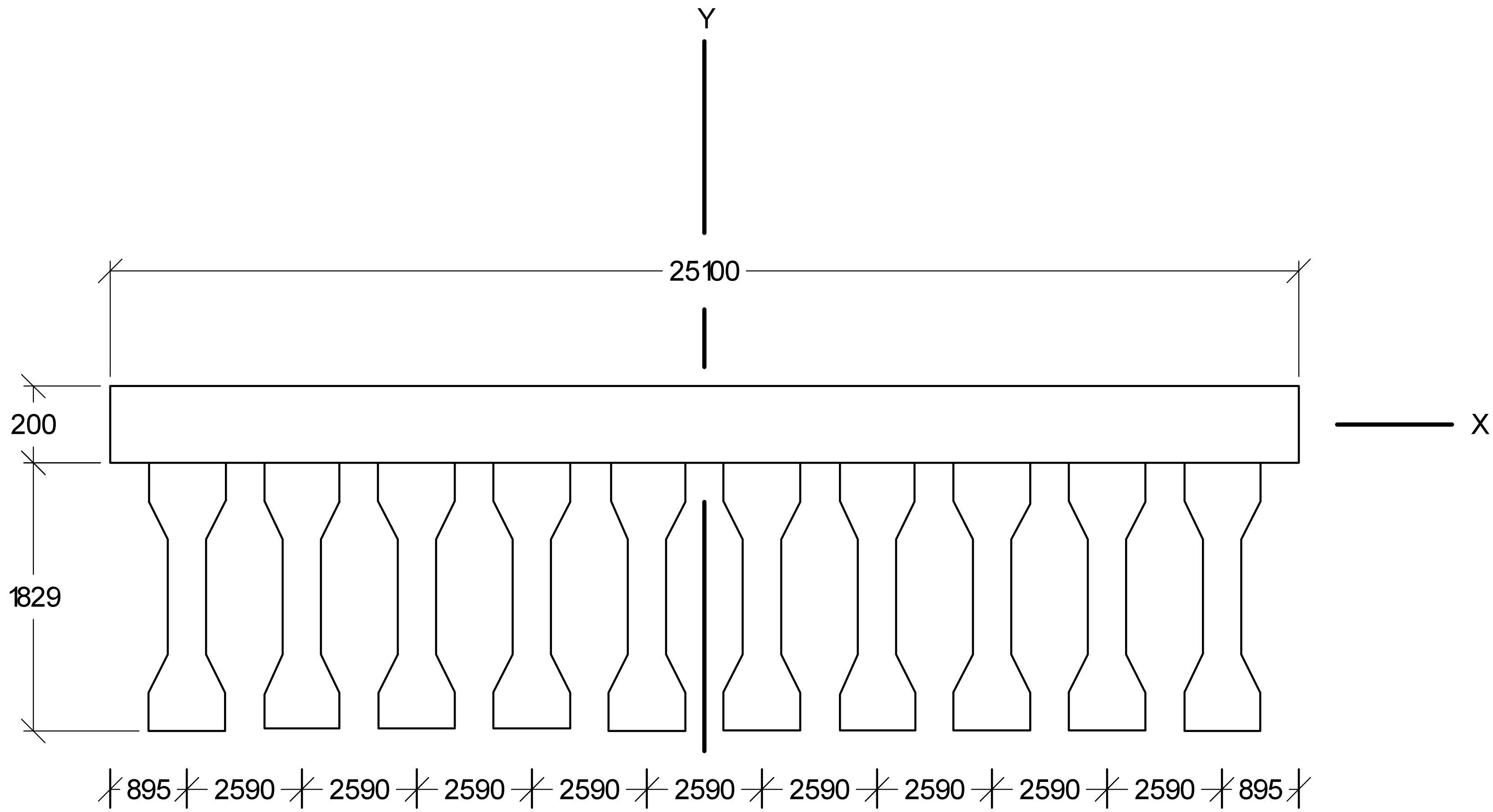

Figure 3.2. The simplified cross section of the prestressed concrete bridge superstructure. This figure was not drawn to scale. All dimensions are in mm.

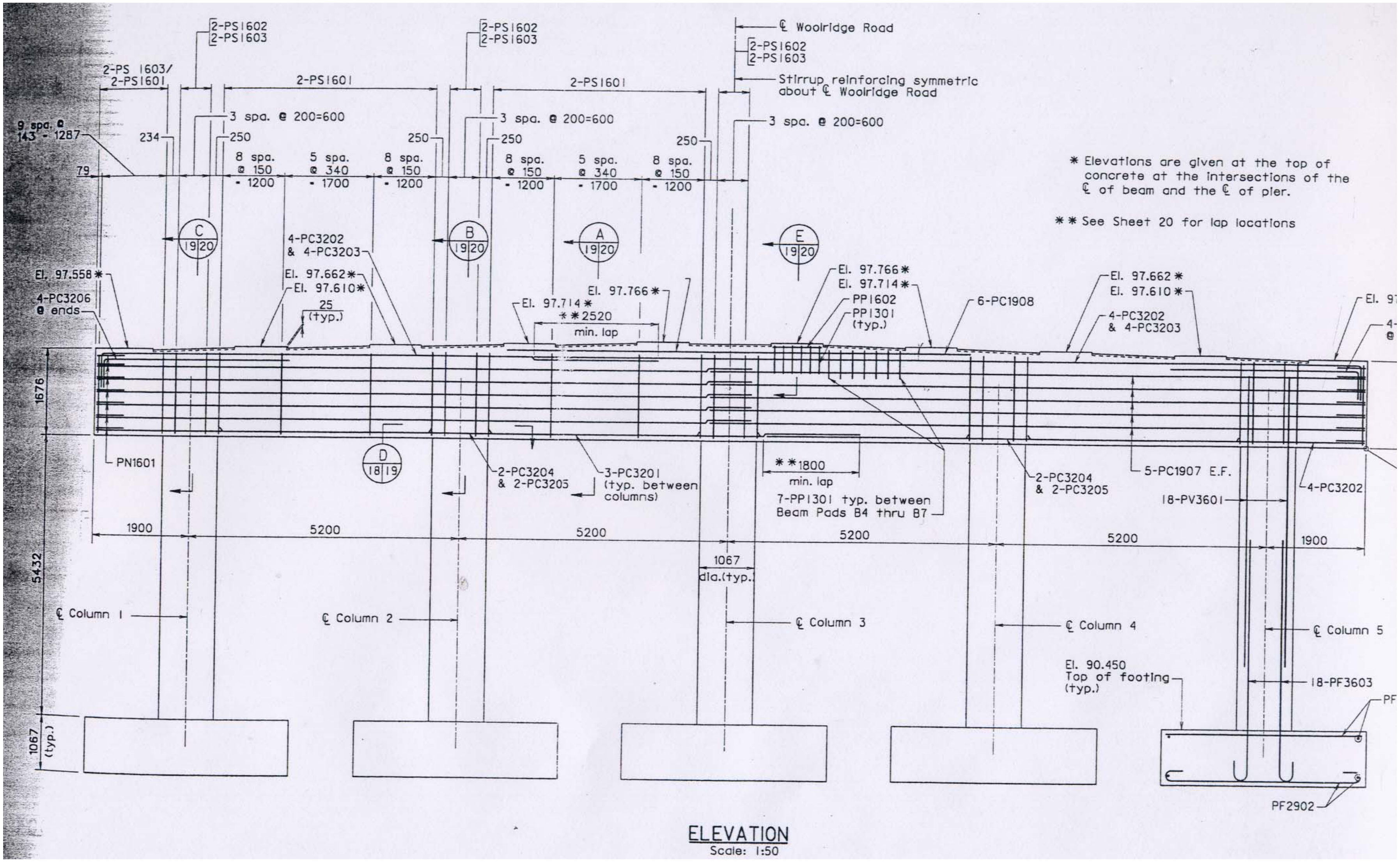

Figure 3.3. The Pier Elevation [Maday, 2002]. All dimensions are in mm, and the 1:50 scale is no longer correct.

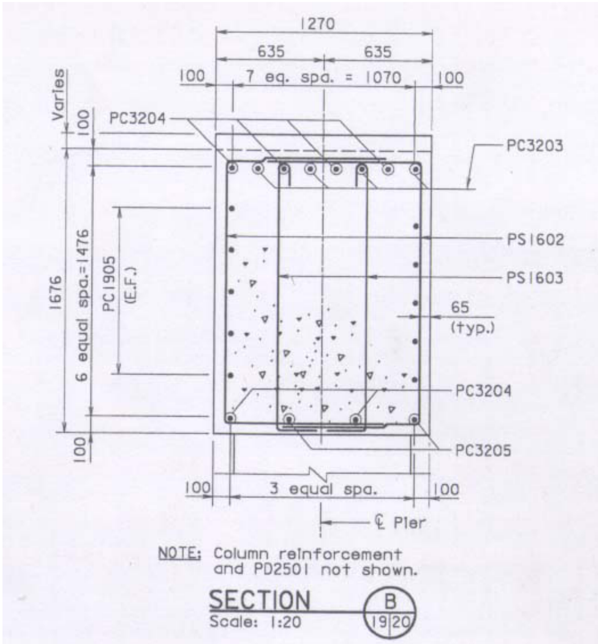

Figure 3.4. The pier cap beam cross section [Maday, 2002]. All dimensions are in mm, and the 1:20 scale is no longer correct.

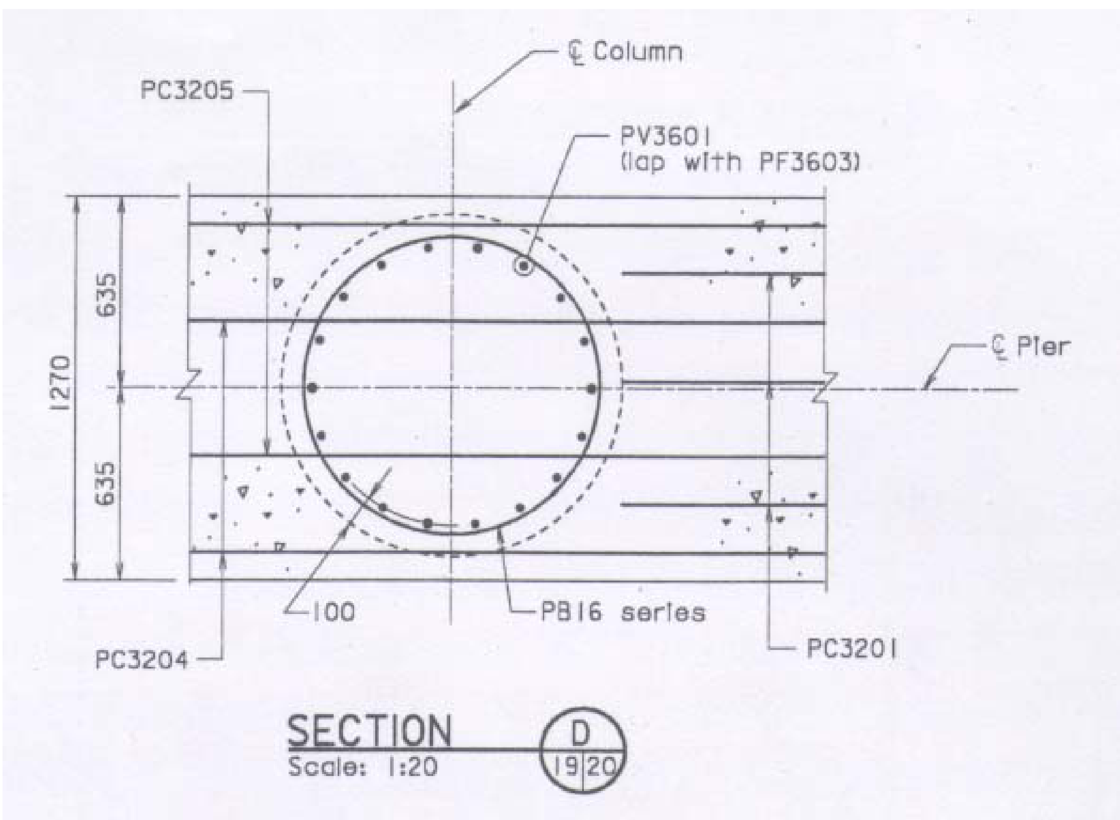

Figure 3.5. The column cross section [Maday, 2002]. All dimensions are in mm, and the 1:20 scale is no longer correct.