Chapter 6
Conclusions

6.1. Design Effort

The amount of time to check a bridge, previously designed, for compliance with the new LRFD Guidelines is approximately two weeks of workdays (80 hours) if performed by one person. The analyses require a 3D frame analysis software, which was used to do all the analyses in this study.

The two-week approximate required time is much longer than the required time to perform a check on a bridge using the old AASHTO Specifications. Most bridges in Virginia belong to category A in the old AASHTO Specifications, which requires that the bridge be checked for its bearing length, and the connections at the abutments and piers be checked that they can handle at least 20% of the tributary weight. For bridges that belong to category B, a check using the earthquake force method, which is similar to the uniform load method explained in Chapters 3 and 4, is required [*Standard*, 1996].

Thus the old AASHTO Specifications only require a few hours to perform a check on most Virginia bridges, compared to approximately two weeks using the new LRFD Guidelines.

6.2. Longitudinal Column Reinforcement

As Chapters 3 and 4 revealed, if the longitudinal (x-direction) supports are not released, the bridges are adequate to sustain the design dead, live and earthquake loads. But if the longitudinal (x-direction) supports are released as in the parametric study, in high seismic risk regions such as Bristol where S_a is more than 40%, bridges with long spans and short columns will not be able to sustain the design dead, live and earthquake loads, as currently designed. This is due to the fact that short-column and long-span bridges have shorter periods of vibration, which means higher spectral accelerations, and therefore larger equivalent earthquake forces. Furthermore, long-span bridges have more dead load from the weight of their long superstructures. In order to make the deficient bridges adequate, the column reinforcement ratio has to be increased.

6.3. Detailing Requirements

Besides the column longitudinal reinforcement, there were other detailing requirements that were not met by the two bridges analyzed in this study. Those requirements include:

- Column shear reinforcement in potential plastic hinge zones
- Transverse reinforcement for confinement at plastic hinges
- Spiral spacing
- Moment resisting connection between members (column/beam and column/footing joints)
- Minimum required horizontal joint shear reinforcement
- Lap splices at the bottom of the column, which are not permitted
- Column joint spiral reinforcement to be carried into the pier cap beam
- Transverse reinforcement in cap beam-to-column joints

6.4. Increased Construction Costs

The additional construction costs to bring the bridges into compliance with the new LRFD Guidelines will be insignificant. For the prestressed concrete girder bridge and the steel girder bridges, the increase of construction cost would be 0.2% and 1.0%, respectively.

6.5. Recommendations for Further Research

In performing the analyses of the two bridges and parametric study, several assumptions were made, which could be verified through field testing. The assumptions and subjects for further research included:

1. Using a rigid link to connect the superstructure and the substructure for the purpose of obtaining the load that the superstructure imposes on the substructure.
2. Using the average height of the pier cap beam in calculating its section properties, i.e. assuming the pier cap beam is not tapered like shown on the drawings.
3. Fixity of the connection between the superstructure and the abutment.
4. Using a stiff superstructure and a flexible substructure instead of a stiff substructure and a flexible superstructure.
5. Using shear deformation for the analysis.