Introduction

Recent increase of railcar weight limits from 263,000 lb to 286,000 lb raised additional concerns for the passenger rail systems since the bridges in the passenger rail system were not designed based on the increased railcar weight. Therefore, typical rail bridges on various New Jersey lines will be reviewed to investigate the impact of the increased railcar weight on the bridges. In this study, dynamic impact of the heavier railcar on the bridges was investigated.

Selected Bridges

Bridge I: Steel plate girders with floorbeams and ballast concrete deck, 3 spans, 74 ft.
Bridge II: Steel plate through girder and deck girder with floorbeams supporting a ballasted steel deck through 7 spans, 344 ft.
Bridge III: One truss steel bascule span, one steel through truss tower span with 15 approach steel plate through girders, open deck, 17 spans, 1005 ft.
Bridge IV: Steel plate through girders, open hearth steel, 4 spans, 163 ft.
Bridge V: Steel truss swing span flanked by 28 steel deck girder spans, 30 spans, 2891 ft.

2-D Dynamic Model and Validation

- The wheel sets of each vehicle are assumed to be kept in full contact with the rail/bridge at all times.
- The simple-span bridge is modeled as a linear elastic Bernoulli-Euler beam.
- Each rail car is composed of one car body, two identical bogies, and four identical wheel sets. The car body and two bogies are assigned two DOFs each.

Parametric Study and Discussion

In this study, the impact factor is defined based on the maximum value of the dynamic and static deflections at the mid-span of the bridge which is expected to be larger than those based on other responses such as acceleration data. The following parameters were considered:

- The effect of train speed
- The effect of girder stiffness
- The effect of damping ratio
- The effect of railcar type
- The effect of track roughness

Dynamic assessment with AREMA Specifications

- In the American Railway Engineering and Main tenance-of-way Association (AREMA) Specifications, for steel railway bridge, following equation was proposed to account for the vertical effect of the dynamic effect:
  \[ \text{IF} = \frac{40 \cdot (\frac{S}{L})^2 + 40 \cdot (\frac{S}{L})^2}{(S/L) = 90, \ 90 > L \geq 80, \ B = 24m} \]
  \[ (S/L) = 60, \ 60 > L \geq 80, \ B = 24m} \]
- For train speed below 80 mph, for all spans carrying equipment without hammer below, and for all spans other than truss spans carrying equipment with hammer below, the values of the vertical effects of the impact equation shall be multiplied by the following factor:
  \[ 1 - 0.015 \cdot (60 - S) \cdot (S < 40) \]

Conclusions

- The axle spacing is an important factor that affects the critical speed and impact factor.
- The variation of the impact factor with train speed is the same regardless of different girder stiffness. However, when the stiffness was larger, the maximum impact factor occurred at a higher speed. This can be attributed to the change in the stiffness which will in turn affect the natural frequency of the bridge.
- When the train runs at speeds different than the resonant speeds, the effect of damping ratio on the impact factor is negligible. However, when bridge resonance occurs, the impact factor decreases sharply as the damping ratio increases.
- There is a small difference in the impact response for each bridge regardless of the track roughness which can be attributed to the small force added due to roughness being equal to 3.4% of the axle load.
- The passenger train has the highest impact factor within 120 mph followed by 286-kips freight car, while the 263-kips freight car has the lowest impact factor.
- The present AREMA code has a tendency to overestimate the impact factor for these type of steel through-girder bridges that exhibited high first natural frequencies.