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SEISMIC RETROFITTING AND INCREASING BEARING CAPACITY OF STEEL TRUSS RAILWAY BRIDGE'S DECK IN IRAN

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ABSTRACT

Iran is located in the seismic zone of the world which many earthquakes have occurred in recent years in many cities of it and caused a lot of damage to buildings and bridges. Therefore rehabilitation and retrofitting of bridges is very important in this country. Bridges are important part of railways, especially after earthquakes. In this paper an old truss railway bridge in Iran is evaluated by FHWA code and after that all parts of its deck have been analyzed. Finally retrofit method for this bridge has been proposed. Results show that many parts of this bridge have not sufficient strength for increasing applied load and satiability during earthquake.

Introduction

Railway bridges are playing important rule in Iran's transportation, for example the traffic in rail ways in Isfahan province was 3844913 ton in year 2003. Many of bridges in the Iran's railway network have been constructed many years ago and have not designed for enduring seismic loads or they have designed with old seismic codes, therefore retrofitting of railway bridges has significant importance and many of bridges need to be retrofitted. For finding the priority of retrofitting of bridges, there are some methods which explained in the some codes and manuals like FHWA (1995). This reference introduced a method which can quantify the priority index for selecting bridges which should be retrofitted before other bridges. Also in this reference there are some details for seismic retrofitting of bridges, but there is no detailed method for calculating forces and deflections. For this reason some design codes such as AASHTO (1996), Iranian Code of Practice for the Earthquake Resistant Design of Road and Railroad Bridge (1996) and etc can be used. It is important to calculate seismic loads and analyze it by more accurate method like response-spectrum or nonlinear analysis if it is required.

Other part of retrofitting of a bridge before starting analysis stage is screening. In this stage the whole structure of a bridge should be inspected by the engineer. Gathering information about quality of each part of bridge, seismic details which used in construction of bridge, any deficiency in the bridge's members should be screened in this stage. All parts of bridges should be inspected

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accurately by the engineer for finding any probable crack or deformation in the members. In some cases it is needed to increase the bearing capacity of a bridge. This is because of different reasons. One reason is that some bridges are designed to endure only trains which carrying passengers and they have not designed to endure the load of freight trains. For example in Iranian Instruction of Bridge Loading (2007) the load of any vehicle of passenger car is 20 ton, which for freight car, it is equal to 25 ton. Therefore if it is needed to change the usage of bridge and passing trains, the whole structure should be analyzed again and retrofit process should be done for it. The other reason is the importance of railway bridges after earthquake. After accruing an earthquake it is needed to immediately send items to help the people in the damaged region. One of the best ways is using railway networks. But if one of the bridges in the network can not be used, because of failing of its members, the helping process will stop.

In this paper the process of retrofitting a railway bridge is explained. The methodology of gathering information and analyzing the structure of the truss span has been presented. Finally it is tried to give a retrofitting procedure for increasing the bearing capacity of truss bridge. Also some details are presented for seismic retrofitting of truss and other spans.

Methodology

The first step for seismic retrofitting of structure is to create detailed drawing of any part of the bridge. If there are any maps for the structure of the bridge, it is enough to check all part of the map with existing bridge; otherwise detailed drawings should be prepared by the engineer. In this bridge, there were some maps, but these maps were drawings which created at the design stage, and there was no as-built map for this bridge. Therefore all parts of the bridge checked with existing maps and any inconsistency has been corrected. Also any decay in the members inspected by the engineer. After preparing maps, the numerical model of the bridge is created by SAP 2000 software (2005). Finally after derivation of results, some details for increasing the bearing capacity of the bridge have been proposed. Also some details for local decays have been presented.

Specification of Bridge

Studied bridge, has 5 spans which the middle span is a truss span, and others span are girder spans. Length of the truss span is 40 meters and the length of other spans equal to 20 meters. Height of bridge is nearly 6 meters. This bridge's location is near to Isfahan. Fig 1 & 2 show all spans and truss span of the bridge respectively.

All spans are single spans and there is a gap over any pier. In Fig 3 one of the gaps has been shown.

All of piers are reinforced concrete piers, also foundation and piles have been used as the substructures of the bridge. All piers are wall piers and are connected to the foundation which has 7 meters length piles.

Material Properties

This bridge does not have any concrete deck; therefore all parts of the deck have been made by steel. Because there is no data about the type of the steel which used in the bridge, 3 samples of bridge are selected to sending to the laboratory. The results show all members have been made by ST-52 steel with yield stress of 3600 kg/cm2 and ultimate stress of 5200 kg/cm2.

Figure 1. All spans of the bridge

Figure 2. Truss spans of the bridge

Bridge Decays

Before analyzing the bridge with new loading it is needed to specify any decays in the bridge. One of the important problems in this bridge is some cracks in the longitudinal beam over the transverse girders as shown in Fig 4. in Fig 5 the detail of the connection of the longitudinal beam to transverse girders of truss span has been shown.

The main reason of this crack is type of the longitudinal beam's connection. Because all longitudinal beams have been considered to have single span, the rotation of end of these beams can not endure by such a connection and it caused the propagation of a crack in the bottom flange of the longitudinal beams.

Figure 3. Gap over the pier

Figure 4. Crack in the connection between longitudinal beam and transverse girder

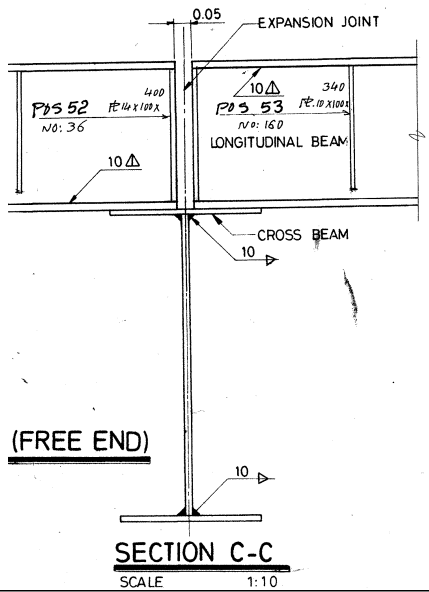

Figure 5. Detail of the connection of transverse and longitudinal beams

The other problem in this bridge is the type of stiffeners under the longitudinal beams in the transverse girder. Because longitudinal beams have been seated on the top flange of transverse girders, the concentrated loads are applying to the transverse girders in the place of connection between transverse and longitudinal beams. Under the concentrated loads compressive stiffener is needed because of concentrated loads. This kind of stiffeners should be continued to bottom flange of the transverse girder, but, as shown in Fig 6, stiffeners are normal and have not been continued to bottom flange.

Figure 6. Stiffeners in the transverse girders (other plates have been added later)

As it shown in the next section of paper, transverse girders do not have enough strength after increasing applied load and section modulus of the transverse girders should be increased. Finally some details are needed to ensure that none of the spans will drop during the earthquake.

Analyzing of Bridge

For analyzing of bridge a computer model has been created in SAP 2000 computer software (2005). Although propose of this paper is only studding on increasing the bearing capacity of the truss span of this bridge, also other spans is modeled and analyzed, but there is no insufficiencies in bearing capacity of other spans has been observed.

Loading

For loading of the bridges Iranian Instruction of Bridge Loading (2007) has been used. For seismic loads, Iranian Code of Practice for the Earthquake Resistant Design of Road and Railroad Bridge (1996) has been used.

Live Loads

Applied live load is presented in Fig 7. This loading is 25% more than live loads which bridge has been designed using it.

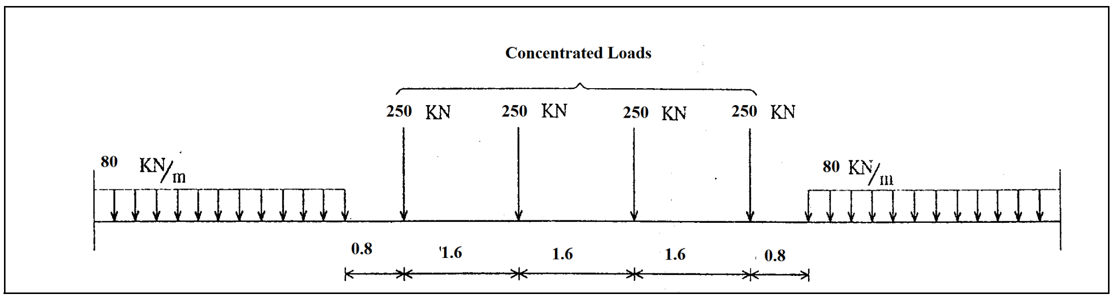

Figure 7. Applied live load based on Iranian Instruction of Bridge Loading (2007)

Seismic Loads

For calculating seismic loads, PGAH and PGAV which are horizontal pick ground acceleration and vertical pick ground acceleration respectively, are calculated by probabilistic seismic hazard analysis process (Ghodrati Amiri et al., 2009). Results have been shown in Table 1.

Table 1. Probabilistic seismic hazard analysis results (Ghodrati Amiri et al., 2009)

PGAH (g) 475 years RP	**PGAV (g) 475 years RP**	**PGAH (g) 2475 years RP**	**PGAV (g) 2475 years RP**
0.19	0.09	0.29	0.13

Vertical and horizontal response spectrum analysis has been done for calculating amount of seismic loads in this span.

Modeling

The model of the truss span has been shown in Fig 8. For modeling of transverse girders, the shell element is used. Other parts of the span have been modeled by frame element.

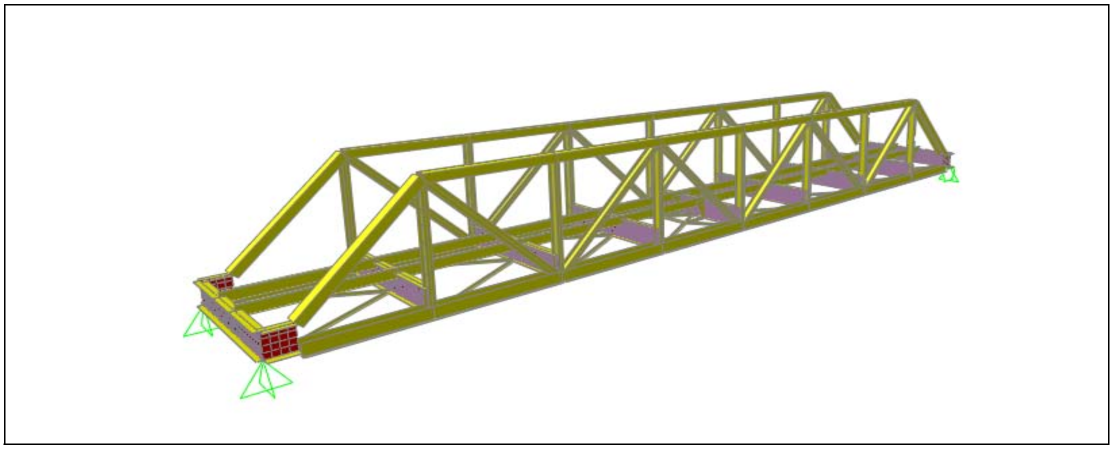

Figure 8. Truss span model

For buckling analysis of the compressive member of the truss span, separate models have been created. Buckling analysis has been done and results showed that the critical buckling load is more than twice of the existing load in compressive members.

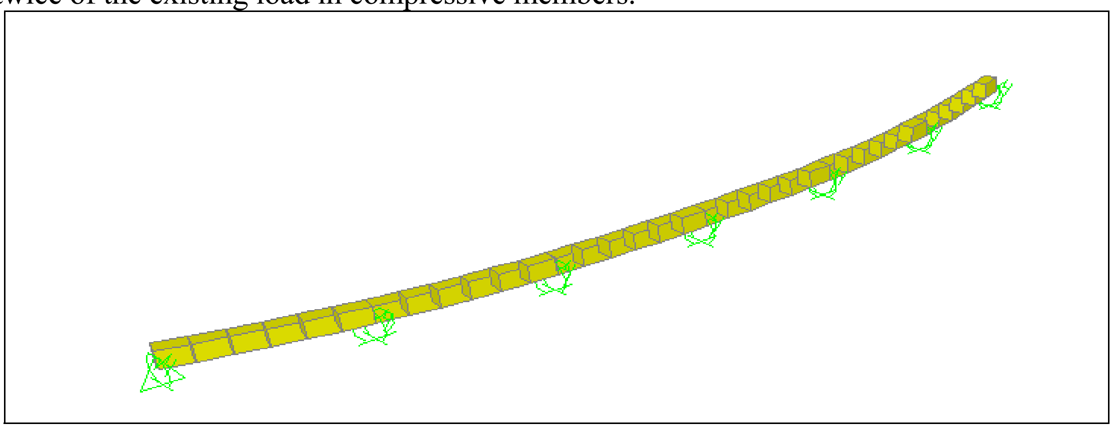

Figure 9. Model for buckling analysis

Results

An example of results of analysis is shown in Fig 10 combination of vertical and lateral loads have been used for checking of the bridge members. In the next section details of strengthening any part of bridge is presented.

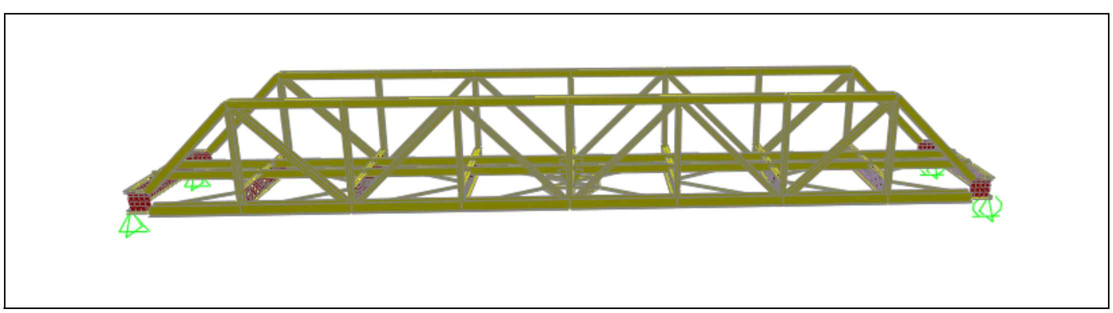

Figure 10. An example of results

Details for Retrofitting

In this section details for retrofitting of bridge is presented. In Fig 11 corrections of the longitudinal beams connections is presented.

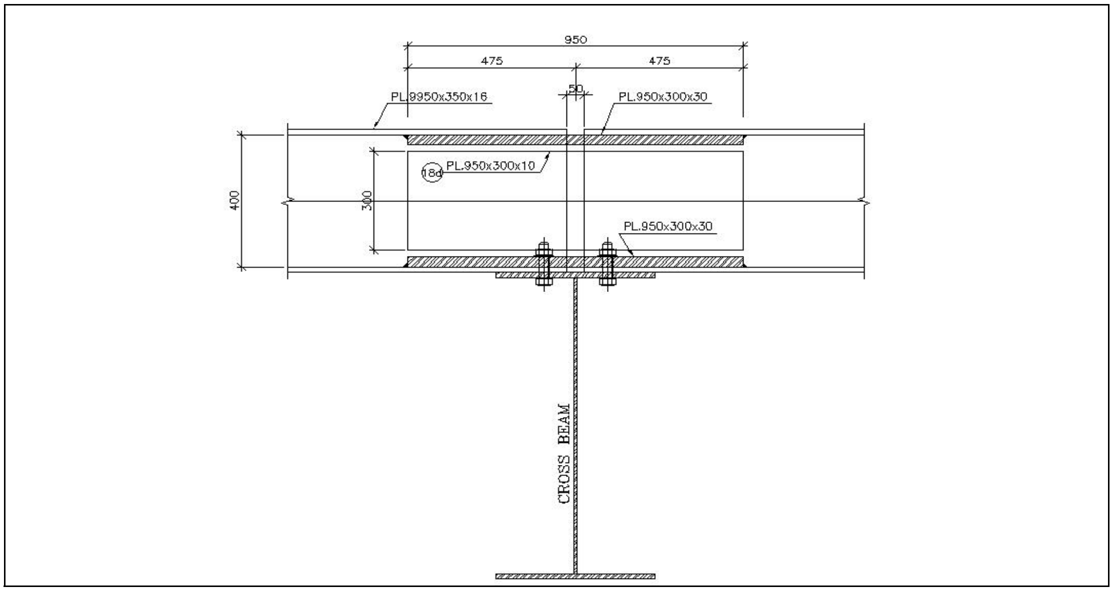

Figure 11. Correction of connection of longitudinal beams

For overcoming the lack of modulus of elasticity of transverse girders the detail which has been shown in Fig 12 is used. Note that because of fatigue issue, it was not possible to use welding connection in the regions that have maximum stress.

In Fig 13 the detail which used for preventing the drop of deck has been shown. In Fig 14 the correction of stiffeners has been shown.

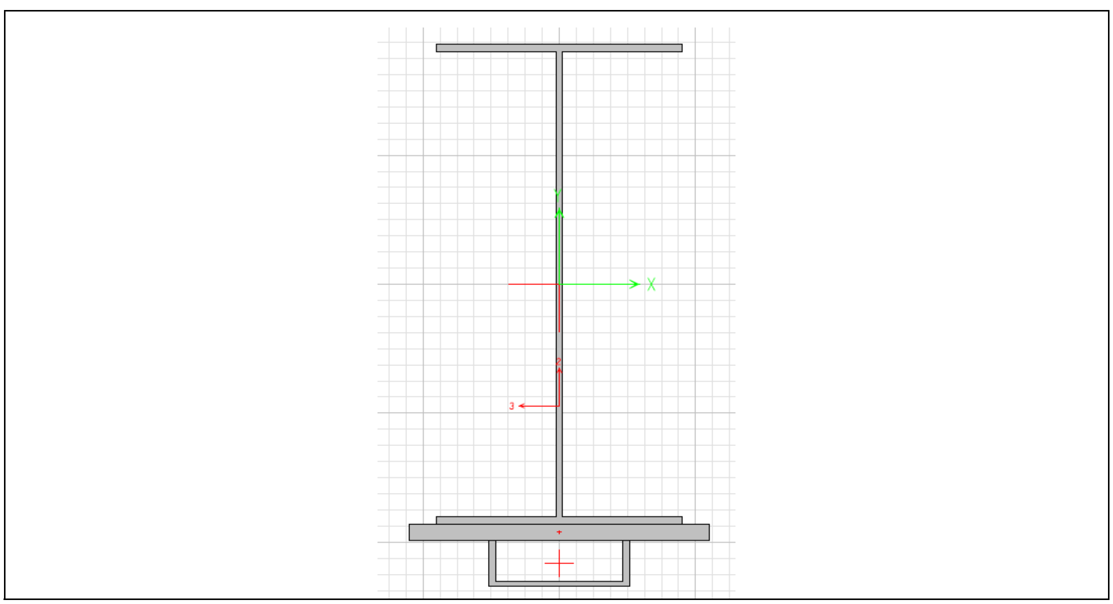

Figure 12. Increasing section modulus of transverse girders

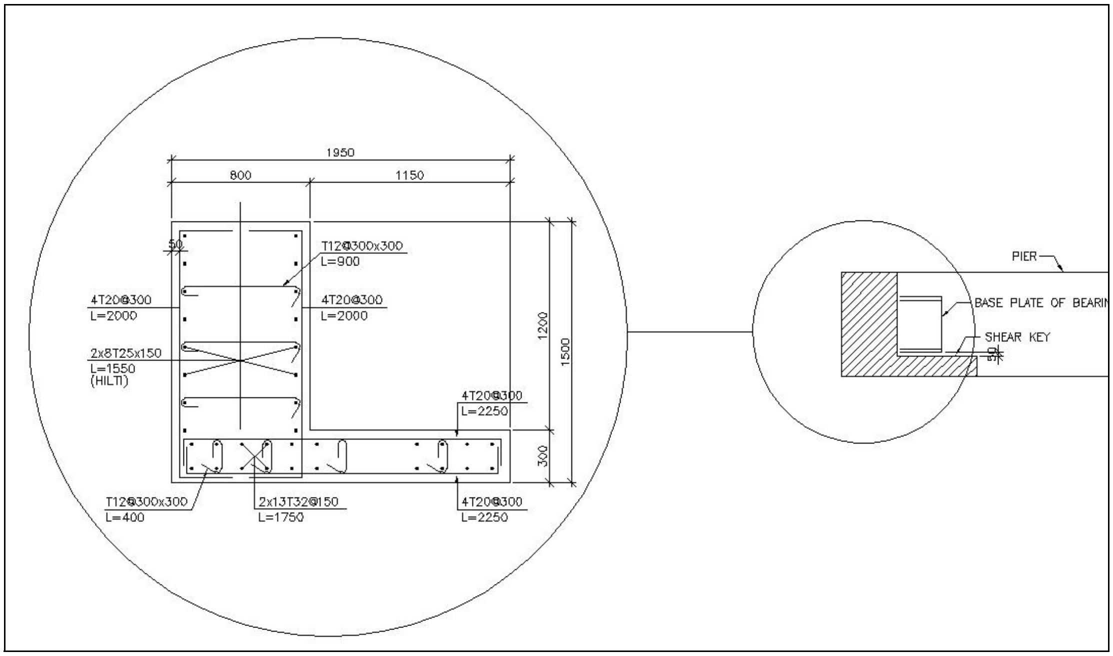

Figure 13. Shear key for truss span

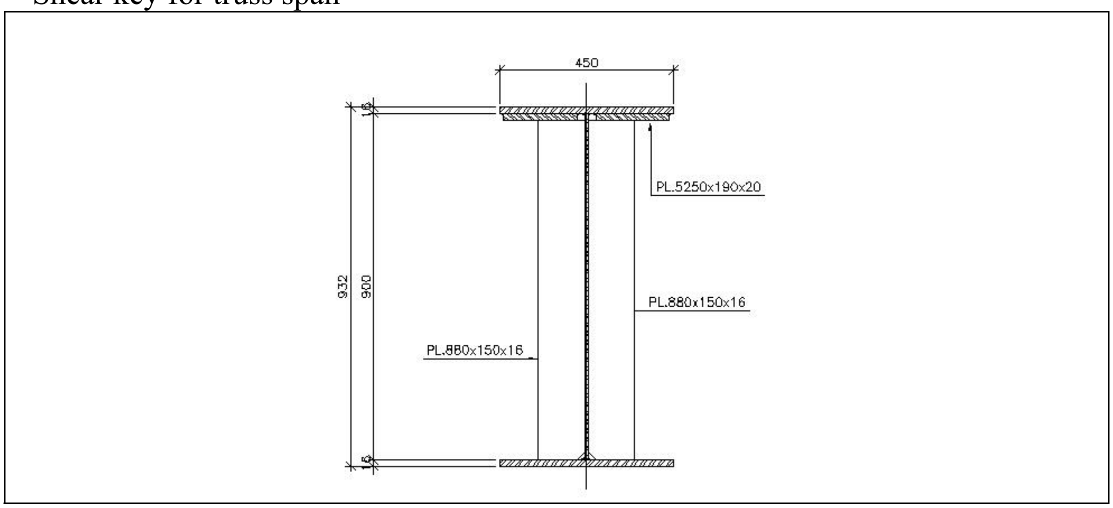

Figure 14. Correction of compressive stiffeners

Conclusion

In this paper process of retrofitting of truss span bridge has been presented. This bridge had some decays for increasing applied load; therefore it was needed to strengthening some members of the bridge. Also some details are required for seismically retrofitting of this span. Finally details for retrofitting of the span proposed.

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