The rehabilitation of long span truss bridge

Tomasz W. SIWOWSKI
Professor
Rzeszow University of Technology
Rzeszow, Poland
siwowski@prz.edu.pl

Tomasz Siwowski, born 1961, received his civil engineering degree from the Rzeszow University of Technology, Poland. He has established and worked for Promost Consulting, Poland, before becoming Professor at the Rzeszow University of Technology. One of his main area of research is related to steel bridges design and assessment.

Summary

The rehabilitation works on the five span continuous Warren type steel truss bridge built in 1961 have been presented in the paper. Because of steel structure deterioration and huge live loads growth during recent years, the bridge has been selected for the comprehensive rehabilitation with a main goal to increase its load carrying capacity. Apart from the strengthening of truss girders (f.e. member sections enlargement, external prestressing, rivet replacement, etc.), the rehabilitation also included deck grid extension, redecking of deteriorated concrete slab and upgrading of supports. The repair program for existing steel structure contained among others the replacement of two diagonals deformed by impact of vehicles. The rehabilitation procedure has been presented in the paper as well as the proof load test results, which proved rehabilitation efficiency.

Keywords: steel truss bridge, rehabilitation, strengthening, external prestressing, redecking, member replacement.

1. Introduction

The bridge over Vistula river in Nagnajow is five span continuous Warren type steel truss with RC deck slab (Fig.1). The spans of steel truss are 72+3x90+72 m long. The bridge has been selected for the comprehensive rehabilitation with a main goal to increase its load carrying capacity. Before the design work has begun, the comprehensive assessment of the bridge state of repair along with load carrying capacity evaluation (with the proof test) were undertaken in order to find the most relevant methods for bridge rehabilitation. The most severe faults discovered during assessment were mechanical damages (plastic deformations) due to vehicle collision with bridge diagonals, cracks in one floor beam over a support and loss of member sections due to intensive corrosion after 50 years of service.

Fig. 1: The truss bridge before rehabilitation

The assessment of actual bridge condition and evaluation of load carrying capacity let to established the scope of required rehabilitation works, which were necessary to fulfill road administration expectations. The scope of works (limited in this paper to bridge superstructure) included: repair, strengthening and replacement of relevant members of truss girders; strengthening of riveted connections; repair and strengthening of deck grid steel beams along with RC deck slab replacement and execution of new bridge deck equipment. The rehabilitation works mentioned above have been described in the following chapters of the paper.

https://doi.org/10.2749/222137813808627028

2. The rehabilitation works description

Two direct strengthening methods of truss members have been employed in the rehabilitation: member section enlargement with additional welded plates and external prestressing. Strengthening of relevant riveted joints was executed by replacing rivets with HSFG bolts with additional use of epoxy glue. During joint strengthening the existing connection was partially dismantled by removing of 50% rivets. The remaining rivets ensured the relevant load carrying capacity required for dead and technological load on the bridge.

Two deformed members (tension, compression) had to be replaced. Post tensioning steel bars were selected to relieve tension member and stabilize the truss girder during the replacement procedure. The tension force in the bars was strictly controlled during tightening. Replacing compression member was much more complicated procedure than replacing tension member. The difficulties was mainly caused by a necessity of relieving compression member and stabilizing the truss girder geometry during the replacement procedure. The option was chosen to build a temporary support under truss girder. Hydraulic jack was used to push the truss node up to the level, when the axial force in compression member was completely reduced and thus the member was relieved. After relieving the deformed member was removed and replaced with new element.

After old deck slab demolition the existing floor beams were strengthened with steel plates bolted to lower flanges with HSFG bolts. The deck grid strengthening procedure comprised also the assembly of three additional stringers in order to relieve two existing ones. On the top flanges of floor beams and stringers shear studs were installed to connect the new RC slab in composite action with steel grid. Special sequence of slab concreting was established to reduce rheological effects (creep, shrinkage). Finally the insulation layer and two pavement courses were placed on the slab following anticorrosion works undertaken on the whole steelwork. The new steel sidewalk brackets were also mounted out of truss girders with the prefabricated concrete slabs laying on them.

3. Monitoring and proof test

A temporary structural monitoring system was deployed to assist in operation of replacement of deformed members. The structural monitoring system allowed for continuous control of replacement operation and on-site decision making. Comparison of recorded and expected values before and after operation allowed to check the safety of replacement operation and to verify whether the bridge structure has been repaired properly. The proof test carried out after bridge rehabilitation had two main goals: to check the strengthening efficiency of the applied methods by a comparison of the same parameters (displacements, strains, accelerations, etc.), measured before and after strengthening works and thus to prove the increased load carrying capacity of the bridge. The tables (in the full paper) showed truss girders displacements, strains in truss members and dynamic coefficients before and after rehabilitation. The proof test results revealed the high effectiveness of all strengthening and repair methods used on the bridge. Its load carrying capacity and stiffness were considerably enhanced and the dynamic behaviour did not change.

4. Conclusions

The global safety factors estimated on the strain measurement basis were quite high and amount about 5 for chords, 8 for diagonals and 10 for steel deck members. All these values revealed, that rehabilitation works carried out on the bridge allowed to gain expected level of strengthening and reliability. The present load carrying capacity fulfils requirements of the road administration for bridges located on international road network in Poland.

However, a year after rehabilitated bridge was open to traffic the heavy truck hit the portal end post of the truss girder causing extensive deformation of steelwork. Several riveted joints were also influenced by this struck. The detailed inspection just after accident discovered several cracks under the gusset plates of riveted joints. Some fatigue calculations based on the European methodology proved that the remaining fatigue life of the bridge is very short. Therefore it was decided to implement structural health monitoring system. The lesson learnt from the case of Nagnajow bridge is that even very efficient rehabilitation methods used for old steel riveted bridges do not restore the required level of safety without structural health monitoring. Therefore SHM implementation should be one of the most important part in rehabilitation strategy for such kind of bridges.