Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte

Band: 79 (1998)

Artikel: Heat straightening: an unpopular method of repair of steel bridges

Autor: Zobel, Henryk / Alkhafaji, Thakaa / Golubinska, Agnieszka

DOI: https://doi.org/10.5169/seals-59891

Heat Straightening - an Unpopular Method of Repair of Steel Bridges

Henryk ZOBEL
Assoc. Prof.
Warsaw Univ. of Technology
Warsaw, Poland

Thakaa ALKHAFAJI
Dr Eng.
Warsaw Univ. of Technology
Warsaw, Poland

Agnieszka GOLUBINSKA
Civil Eng.
Warsaw Univ. of Technology
Warsaw, Poland

Henryk Zobel, born 1950, received his civil engineering degree from Warsaw Univ. of Techn. in 1972 and Ph.D. in 1978.

Thakaa Alkhafaji, born 1957, received her civil engineering degree from Moscow Autom. & Road Constr. Inst. in 1987, Ph.D. from Warsaw Univ. of Techn. in 1994.

Agnieszka Golubinska, born 1966, received her civil engineering degree from Warsaw Univ. of Technology in 1991.

Summary

Deformations of steel bridges relatively frequently result from the impact of oversized vehicle, fire or earthquake. These deformations are removed using various methods. One of them is heat straightening, sometimes combined with mechanical action. The paper presents application of this method for repair of plate girder and truss members. Although conclusions are not fully satisfied, this is the next step for more wide understanding of phenomena occuring during heating and cooling of steel members.

1. Introduction

Heat straightening is usually the most economical and practical method of field repair for a various type of damage. Unfortunately, even experienced personnel in steel fabrication industry, construction companies or maintenance services mostly do not know, what parameters of heating are adequate for a given kind of deformation. This knowledge is obtained from experience, which is not often shared. Unwillingness for application of heat for repair of steel structures is caused by limited knowledge related to work of structure in elevated temperature and impact of heating for steel properties. The fear of negative impact of heating for durability of bridges is also common. Most of mentioned above problems are myths which exist among bridge and structural engineers and technicians. The results of not numerous investigations and experience of a few only firms applying heat straightening confirm usefulness of this method. It should be emphasized that each case needs the individual design and choice of repair method .

2. Idea of Heat Straightening

The flame of the torch applied to the steel element causes its expansion. But this process is limited by cool part of this element. If the temperature is sufficiently high plastic deformations will generate and remain after cooling. The basic problem is to select proper pattern and parameters of heating to obtain required values and desired direction of deformations, which remain in the structure. Although heating alone may be used to straighten a deformed member, external load may also be applied to increase the efficiency of the process.

3. Damage Classifications

Generally, there are two categories of damage: overall and local. First one consists of three types i.e. bending about „strong" axis, bending about „weak" axis and asymmetrical bending that results in torsion about the longitudinal axis of the member. The second group are bulges, crimps, buckles etc. One of the most common damage of plate girder is deformation of bottom flange often combined with the twist of the web against „weak" axis. In the case of truss, this is hitting the portal bracing at the approach of the truss. In some situations, the vehicle may travel partially through the truss span, striking intermediate sway frame bracing. The end post may be pulled inward enough to be bent beyond the elastic limit. Striking the sway frames may result in pulling the vertical truss members inward. In cases where the inward displacement is large enough, the top and the bottom chord members can be pulled down or up, respectively.

4. Heating Patterns

Two kinds of heat pattern are used: concentrated and continuous. The first are spot, strip and Vee; the second line and edge heats. They can be used individually or as a combination, depending on the structural configuration and damage pattern.

5. Factors Influenced the Heat Straightening Process

A lot of factors is necessary to take into account in design and repair of bridge structure. They can be put into 5 groups: technological parameters, geometry of the steel member, geometry of heated areas, change of steel properties in elevated temperatures, „accelerators" and „retardants" of the process. The large number of factors and their mutual coupling causes that problem is still, from mathematical and physical point of view, not sufficiently solved. It still remains more art than science.

6. Research and Practice

The main aim of computer analysis and experiments on heated and simultaneously compressed or tensioned truss members and plate girders was to determine the proper parameters of heating like its pattern, dimensions, location, number and spacing in dependence on size and location of damage in the bridge structure. The efficiency of single Vee or three Vee's combined with or without strip, line or edge heat patterns was investigated. The comparison of relations determining steel properties in chosen countries was also done. Authors of the paper realized successfully a repair of one bridge in Poland and also observed such process done in the U.S. The results of thermal-plastic analysis are comparable with practice in many cases but not always. To find better convergence it is necessary to improve thermal load model, to define more precisely change of steel properties in elevated temperatures, to use more correct statical scheme of bridge structures and to determine carefully boundary conditions. The investigation of about 15 bridges heat straightened in last 20 years proved that this method does not affect durability of steel bridges. No signs of damages related to heating were observed.