The Reconstruction of the Cast Iron Railway Station from 1865

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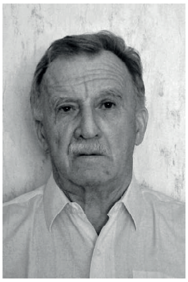

Milan Vašek, born 1941, received his civil engineering degree from the CTU in Prague, Czech Republic. He worked and became a Professor there and attended as a visiting professor Yugoslavia, Japan, and USA (Pittsburgh University), His research is related to the structural non-linearity.

Summary

The oldest steam railway station in Prague (Czech Republic) was built between 1844 - 1865. Structural repairs were made over several decades. The necessary complex reconstruction of the bearing cast iron and timber structure of the main hall is described. The design of the reconstruction had to be done within the highest professional level, using the most relevant technologies [1]. The obvious stability analysis of columns according to EN codes did not give satisfactory results [2]. Non-linear FE analysis and contact analysis 3D models were used to represent the cast iron hollow columns. The results were verified by laboratory testing to ensure the correct function of the main station hall. The welding of broken columns was introduced and a combination of steel tubes and cast iron columns were used. The deteriorated timber roof members were supplied by glued members.

Keywords: Cast iron, cast iron welding, computer model, contact elements, finite elements, non-linear behaviour, laboratory testing, strengthening, stability, timber

1. Introduction

The first steam railway was built in the Czech region around 1838 replacing the existing horse operated railway. Prague was in that time enclosed by city walls that were removed in1874. The erection of the station began in 1844 and on the 1st September 1845 it became operational. The hall was covered by a glazed timber roof system supported by cast iron columns. The hall was built circa 1862. In that time this railway station was one of the biggest in Europe (Fig.1). According to the last official surveys the hall of the station should be left and its bearing structure kept as original possible. All design and physical building works were conducted by the investor's company. The company for the realisation was chosen by the competition.

2. Description of the structure and designated malfunctions

Fig. 1 The hall of the Masaryk's station

The hall has a rectangular plane view 28,45 x 67,7m designed as a three-bay sytem (11,67 m – 5,01 m – 11,8 m) (Fig.1). The longitudinal spacing of the main structural frameworks is from 3,81 m to 4,73 m. Every second frame is supported by hollow cylindrical cast iron columns. These columns have served as rainpipes for about 146 years without substantial damage due to a corrossion. The timber roof system is formed by three hinged trusses.with wrought iron draw bars. The longitudinal stiffness is ensured by doubled rafters with struts and wrought iron draw bars. The trusses are embeded in cast iron shoes. Some iron draw bars were removed during the existence of the structure and therefore malfunction of some connections occured due to the extra tension. A brief list of failures and malfunctions follows: a) cracked sandrock foundation blocks of columns and destroyed rainpipe system, b) longitudinal cracks (2,5 m) of four cast iron columns due to the frozen rain water, c) 2 columns transversally broken, d) cracks on majority cast iron

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shoes at the roof, e) overloaded and cracked timber members and bilogical corrossion some of them, f) some timber purlins were not satisfying today eurocode, g) demaged connections of longitudinal double rafters, h) roof wooden board sheet deteoriated by rot, insect and due to the high temperature.

3. Realisation of the reconstruction and forensic report

The structural survey and the project of the reconstruction were executed in 2010 whilst the railway continued to operate. The stability of the columns according to Euro codes showed very unsatisfactory results. The forensic report started in May 2011.

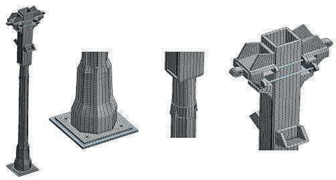

Fig. 1: Model of the column for the FEA

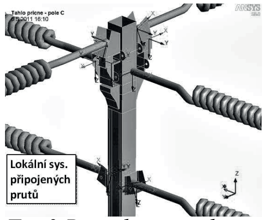

Fig.3 Boundary condition for the non-linear analysis

The main purpose of the report was to define a technique of how to preserve the original cast iron columns which are almost twenty five years older than the Eiffel tower. The stability analysis according to EN based on the code's material properties of cast iron showed very unsatisfactory results. One column truncated for the testing machine shows carrying capacity far better than the code analysis, tested material properties were also about one third better than the code. A 3D non-linear and contact finite element analysis of the representative hollow cast iron column (Fig.2), (Fig.3) was conducted. Results correspond to the testing and the carrying capacity of the column was sufficiently larger, than the acting forces. About 23 327 elements were used and 30 steps each needing 15 minutes. Cracked columns were welded and an inner steel tube was supplied for the column function. Cracked cast iron shoes and roof timbers were mainly replaced with new parts.

4. Discussion and Conclusion

The detail survey of the structure was not done at the time of the project because of the unclearness of the station development and heavy train service. The most important information about the cast iron members was gained within the restoration work and from results of the forensic report. The restoration of some historical buildings should be always checked in detail [1]. Structural analysis based on the routine code's calculation is sometimes too conservative and FE analysis together with the experimental test gives significantly better results.

5. Acknowledgements

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