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Rehabilitation of Ancient Steel Structures

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Abstract

The first iron bridge in Europe was constructed in Coalbroockdale (England) in 1776. The span of its structural arches was 32 m. Twenty years after the first bridge construction, another one of similar structure was built in the town Lazany (Laasan) that now belongs to Poland and those days was in Germany. Lazany is not far from Wroclaw. Arches of that bridge was of 11.2 m span. Structural iron members have begun to be used in industrial buildings as early as in the first half of 19th century. It was common to construct cast iron columns supporting suspended slabs. Sometimes, also cast iron beams have been used into the slab structure. Many of bridges, buildings and tanks constructed in that time, have been using, till now.

Beginning from the half of the 19th century, iron materials like puddled steel, cast steel and cast iron have been used more and more in industrial structures. Due to the simple production technology of iron materials, their chemical heterogeneity was high. Also, the dispersion of their mechanical properties was big. Puddled steel and cast steel have low impact resistance and welding of those materials was impossible. Bolted and riveted connections were commonly used.

On the turn of the 19th century puddled steel was replaced by cast steel, manufactured in Bessemer converters (1855), Thomas converters (1880) and Siemens-Martin furnaces (1864). The new technologies secured high quality of cast steel and its high homogeneity. Technical properties of the historical iron/steel materials are presented in the paper.

The paper presents case studies of several iron/steel structures, constructed in the 19th century and beginning of the 20th century, that are still in use. All of the presented structures were renovated, strengthened or rebuild. The examples of interesting rehabilitation processes of old iron structures are presented in the paper. The rehabilitation processes are unique for each structure. They were designed with a big precise. Some interesting case studies are presented in the paper.

All cases show mainly strengthening of floor slabs in old buildings. For example, there is a steel structure of the building constructed in 1834. The main floor of the beams were strengthened by supporting them at mid span by means of the steel tension members 2ϕ30, running longitudinally. Partial interaction between the reinforced concrete slab and the floor beams (composite structure)

has been taken into account. Composite action together with strengthening by tension members allowed for the service load p = 2500 N/m^2. Load capacity of cast iron columns of tube section was suitable for the new level of loads and was not increased.

In other, cast steel building constructed in 1897, increase of the load capacity of floor beams was needed. Overloaded I 130 beams have been unweighted by additional system of steel beams supporting of I 130 beams at their mid spans. Additional I 240 beams were supported on new transverse beams fixed to existing main floor beams (2 I 280) near the columns. In this way, the bending moment in main beams (2 I 280) has been increased of small value, while the beams have been not overloaded. New beams were connected with the old ones by bolts. There was no need to strengthen of the cast steel columns, supporting the floor and the roof.

Unique, multistory shopping center steel building was constructed in Wroclaw, in 1928. Ten years ago, service loads had to have been increased up to the level 5000–6000 N/m^2. In such a case, it was necessary to strengthen of the main beams (I 600) and secondary beams (I 220, I 360, I 380). Only the steel built-up columns with brick walling, had sufficient margin of capacity. In order to strengthen of the floors, the additional RC slab has been constructed. The slab has been connected with floor beams I220, I 360 and I 380 in such a way that composite action was developed. The increased weight of the floor has been compensated by considerable increase of load capacity of floor beams. Main floor beams were supported as simple beams. Increase of load capacity of that beams have been developed by making spring connections between beams and columns. Angles between I 600 beam flanges and columns gave the spring action. Moreover, special reinforcing of the additional RC slab, near the supports, gave also the effect of spring action.

Because of both, historical value and good serviceability, the steel structures constructed in the 19th and beginning of the 20th century should be strengthened and renovated. Steel products manufactured in that time have low strength, heterogeneous chemical composition and usually they are not suitable for welding. Strengthening and renovating of these structures require unconventional technologies. The technologies should take into account properties of historical steel and also historical value of the structure. Renovation done in a proper way can considerably elongate technical live of old structures. What's more, properly strengthened structure can be useful for loads of modern production processes.