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Structural Rehabilitation of an Industrial Steel Building

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Summary

The industrial steel building analyzed in the paper was constructed in 1967 and has been exploited in an aggressive atmosphere for about 25 years. The electrochemical corrosion occurred at the surface of the steel elements which together with design, construction and maintenance faults have significantly decreased the loadbearing capabilities of each structural member. The technical state of the structural system has been evaluated using visual inspection and nondestructive testing. Suitable strengthening and rehabilitation solutions have been proposed in order to restore the functional and structural performances of the industrial steel building.

1. The anatomy of the industrial building

The industrial building designated to shelter a zinc coated, cold-formed light gauge sections workshop has been designed and constructed between 1965 and 1967.
The framing system consists of ten main transverse steel frames, each of 3x24 m span (fig.1). The spacing between frames is 12 m. Seven overhead traveling cranes with handling loads of 125 kN to 500 kN are operating inside the building and transmit their load effects to the main structural system. Continuous tapered solid web welded sections have been selected for the main girders of the transverse frames. The main girders are supported on steel stepped built-up welded columns. The roof decking is made of prefabricated concrete elements which support thermal insulation and waterproofing. The roof decking is sustained by solid web welded purlins rigidly connected to the main transverse girders. The painting system applied on the steel members surfaces consisted of two main components: two layers of red-lead primer and two coats of chlor-rubber based paint.

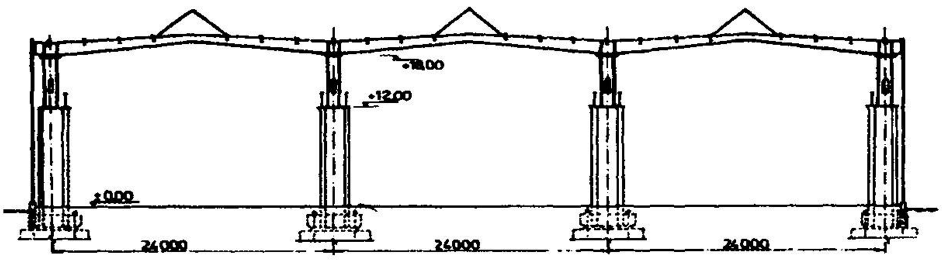


Fig.1 The transverse frame of the industrial steel building

2. The corrosive effects on the structural steel members

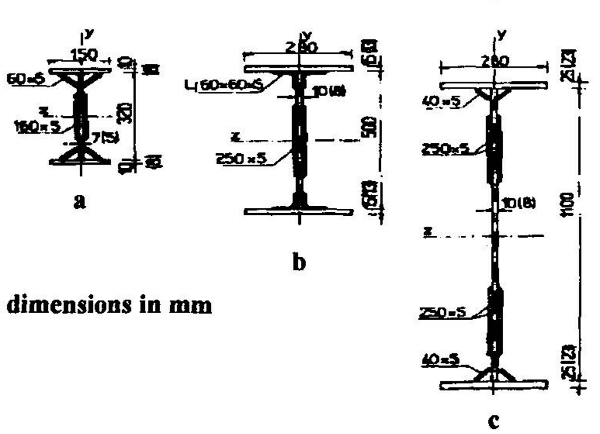
The structural steel members were exploited in a very aggressive environment (involving the use of sulfuric acid, chlorine hydride and hot water) between 1967 and 1980 and in a less corrosive atmosphere until 1992. All structural steel members have been severely affected by the corrosion process. Depending on the type of the element, the stress level and the local corrosive factors, extensive damages of the protective coatings, from 7% to 100% have been identified and corrosion penetrations up to 1.5 mm have been determined.

3. The influence of the corrosion on the loadbearing elements capacities of the structural members

The verification procedures for ultimate limit states and for serviceability limit states have been applied according to the Romanian Standard STAS 10108/0, and to the Code P-100-92, for design of structures in seismic zones. To assess the corrosion effect on the loadbearing capacity of the structural steel members the initial geometric characteristics (**A_o**=the noncorroded initial area and **W_o**=the noncorroded initial section modulus) have been compared with the same properties after exploitation in corrosive atmosphere (**A_c**=the corroded cross-sectional area and **W_c**=the section modulus of the corroded structural members). The numerical values of the deterioration ratios have been calculated for all main structural members as follows: purlins, W_c/W_o = 0.785; crane girders, W_c/W_o = 0.912; columns, W_c/W_o = 0.789 and A_c/A_o = 0.820; frame girders, W_c/W_o = 0.823 at midspan, and W_c/W_o = 0.901 on columns.

4. Retrofitting solutions

To restore the initial loadbearing capacity of the steel members, the strengthening solutions presented in figs.2 and 3, have been proposed. The strengthening pieces illustrated by dashed areas have been attached to the weakened members after careful cleaning of the corroded elements. The dimensions given in the parenthesis correspond to the corroded areas. After consolidation the ratios between the strengthened sections characteristics (**W_1, A_1**) and the initial ones (**W_o, A_o**) have been calculated: purlins, W_1/W_o = 1.03; columns, W_1/W_o = 1.04 and A_1/A_o = 1.02; frame girders, W_1/W_o = 1.08 at midspan, and W_1/W_o = 1.02 on columns.
The complete project of the structural and functional rehabilitation of this industrial steel building also implied: closing the space between the individual components of the compound bars; replacement of the deteriorated unsafe elements of the bracing system; concrete encasement of the column steel bases and of the lower steel column portions in the working areas with high humidities; remaking of the corrosion protective system on the steel members surfaces; improving the ventilation conditions inside the industrial building; observing the periodical maintenance cycles and the current repairs; reducing the atmospheric agressivity by blocking the pollutants at source; cleaning the industrial dust from the roof at least once a year; systematic observation and periodic inspection of all structural and nonstructural building elements.
The authors of the project and the owner consider that the proposed set of actions would extend the service life of this industrial building to a convenient period and at an acceptable cost.



- dimensions in mm

Fig.2 Strengthening solutions of bent elements: a-purlins; b&c-tapered frame girders

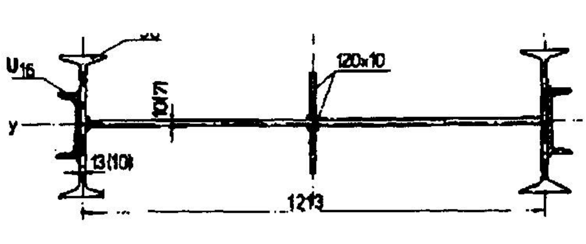


Fig.3 Cross-section strengthening of the main steel columns