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Diagnostic method for revealing major risk factors of wrought iron building structure elements

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Abstract

Wrought iron building structure elements like tie bars, balk irons, stone cramps, or door hinges were applied as parts of the different structures of historic buildings. These elements often have important role in the work of the structural system. Because of the characteristics of the wrought iron, the reliability of the material is often questionable, that occasionally means a considerable stability risk of the heritage structure. In case of larger scale wrought iron structures, like bridge elements, the usual way of estimating the quality of wrought iron is taking small sample pieces of the material for strength test and micrographic analyses. In case of smaller building structure elements however, especially if the building is listed, because of the small cross sections and the heritage value of the original fabric, it is not feasible. This paper aims to demonstrate a potential, non-destructive method for the risk examination in case of wrought iron structural elements with X-ray tests. The main risk factors can be detected on the bases of these examinations without disturbing the historic fabric.

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Keywords: wrought iron, structural risk, heritage buildings, non-destructive testing, X-ray test

1. Introduction

1.1. The material

Mild steel production was started in the second half of the 19th century with the introduction of Bessemer and Siemens-Martin processes. All iron-carbon alloys that were used for building structures before that time should be considered as wrought iron. Although there were more technological shifts in the field of iron and steel production,

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we cannot consider the low-carbon (below 2 mass % carbon content) iron alloys as homogeneous materials up to the above-mentioned evolvement of the steel industry. [1][2] In consequence of the different metallurgical processes and the traditional technology of smith forging, contaminants, and fibrous structure are common characteristics of wrought iron material, which cause its varying quality, and its different strength in the longitudinal than in the transversal direction. These phenomena were already known by the smiths of the old times. Material tests, like hurling the iron bars to an anvil or making test forging in the hearth to eliminate the material, which was not of useable quality (red-short or cold-short) were part of the everyday work of a smith. [5][9][12]

In the last 100 years thinking about iron alloys as inhomogeneous and fibrous material is not anymore common, however we cannot forget the relevant characteristics of the historic material if we aim to preserve wrought iron building structure elements.

1.2. Wrought iron structures

Wrought iron was not the most frequently used construction material in historic times, but it was used in many cases for strengthening elements of various building structures. There are elements of stairs, columns, cornices, grills, railings, hinges, and other ironware of doors and windows, stone cramps and connecting elements of roof structures. Balk irons secure the connection of the beams to the wall, wall ties play the role of the ring beam in many historic structures, and tie rods secure the vaults in several cases. [3][4][5][6][7][8][9] Regarding to the point of view of structural stability wall ties, balk irons (beam ties), tie rods, stair and column elements can be considered as the most relevant ones. Irrespective of the function, there are decorated elements in exposed position or simple and functional, hidden ones. The most common structures and elements are to be seen on *Figure 1*.

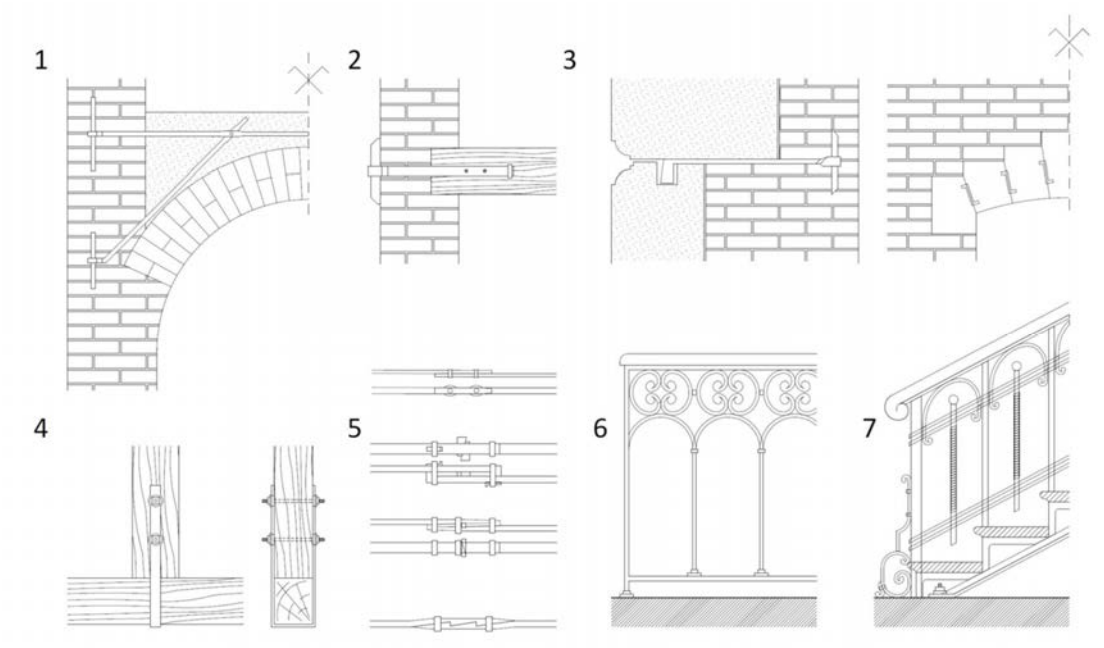

Fig. 1. Wrought iron structures: (1) tie-rod; (2) balk-iron; (3) stone cramps, (4) roof structure element, (5) wall ties, (6) railing; (7) stair