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Problems with buildings lacking basic design documentation

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Abstract

This paper discusses the problem of existing buildings which lack basic design documentation. This situation might have been caused by the old age of buildings or the loss of documentation. To solve this problem, time-consuming and expensive steps have to be taken, such as assessing the strength of construction materials, identifying loads, evaluating the technical state of structures and their strengthening. The authors present cases in which similar problems were solved.

Keywords: steel structures; ultimate tensile strength; concrete structures

1. Introduction

Civil engineers often prepare building regeneration, renovation or reinforcement projects, in which they encounter many problems. One of them is the lack of reliable data describing the used structural elements. This problem is really serious, because designers may have a problem with determining the durability and reliability of the buildings.

In steel structures, it is most important to determine the steel grade, whereas in concrete structures, it is necessary to determine the compressive strength class, location and type of reinforcement. This can be achieved using certain

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tests. To evaluate the ultimate strength of steel, direct and indirect methods can be used [1]. Destructive tests may be employed when it is possible to take a sufficient number of samples from the construction. Samples and tests should be prepared using standard [2] to reliably estimate the tensile strength of steel. Sometimes it is impossible, because taking larger samples from the construction could reduce the load capacity. In such situations, a tensile strength test may be conducted using the MT5000H micro-tester on small samples from the construction [3, 4, 5]. It is also possible to use indirect non-destructive methods, in which the Brinell hardness of elements is measured. Knowing the relationship between the ultimate tensile strength and the hardness of steel it is easy to estimate the strength parameters of steel. This relationship is presented in [6, 7]. The authors of article [8] claim that said relationship is well known for the steel used in buildings from the second half of the 20th century. However, there is a problem with old steel found in structures that still exist and often need to be repaired and reinforced. When using the indirect method of estimating the strength parameters of old steel, the said authors proposed to rely on numerous hardness measurements and to broaden the analysis of chemical composition.

The compressive strength class of concrete can be determined using destructive or non-destructive methods. When it is not possible to take a sufficient number of samples from the construction, non-destructive tests may be done. One of the most popular non-destructive tools of concrete testing is the Schmidt rebound hammer, which is a surface hardness tester [9]. Knowing the relationship between the compressive strength of concrete and the rebound number of the hammer, it is possible to estimate the strength parameter of concrete. However, the authors of article [10] pointed out that the Schmidt rebound hammer is not a tool for directly estimating the concrete strength. The authors of article [11] suggested that it is possible to directly determine the approximate value of compressive strength from the rebound number when the rebound hammer conversion chart is used. Reinforcement can be located using a special scanner. When old prefabricated halls are analysed, the old catalogues like [12, 13] may be used to identify structural elements. However, today civil engineers should be careful, because during the construction of buildings in the 60's – 80's their predecessors often made changes in structural elements because of the lack of materials, for example they sometimes used different reinforcement than shown in the catalogue.

Nomenclature

R_{eH}^i yield strength obtained using indirect methods
R_{eH}^d yield strength obtained using direct methods
R_m^i ultimate tensile strength obtained using indirect methods
R_m^d ultimate tensile strength obtained using direct methods

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2. Examples

2.1. A steel and concrete hall lacking design documentation

The first example is a multi-bay hall (see Fig. 1). It was an unfinished production and storage hall, because its construction had been stopped. Several years later, a new investor decided to finish it and to change the purpose of the hall. However, the data regarding structural elements had been lost. The most important part of the building is presented in Figure 2a. It was the bay with the greatest span and with runway beams for a 35 t crane. The hall consisted of frames made of reinforced concrete, non-prismatic columns with rigid bases and steel trusses (34.0 meters long) joined with columns using pinned connections. The columns were non-prismatic, because on their lower parts runway beams were installed. Truss purlins were supported by main frames spaced every 12.0 meters. On the purlins steel sheeting was used as roof cladding. In the roof, there was a dome skylight. The hall also had roof bracing and vertical bracing in the walls, which is not presented in Figure 2. The documentation had to be reconstructed. It was easy to identify the structural elements, type of reinforcement and compressive strength class of concrete. However, there was a problem with determining grade of steel. The initial static calculations, in which grade St3S (S235) of steel was assumed, proved that structural elements had insufficient load bearing capacity. To solve this problem, the strength of steel should have been assessed, but the authors had no permission to take standard samples. Therefore, four round samples (40 mm in diameter) were taken from the construction (see Fig. 3).