

Estimation of timber parameters in existing structures based on core samples - research assumptions

JANUSZ BROL¹⁾, KATARZYNA ADAMCZYK¹⁾,
¹⁾Faculty of Civil Engineering, Silesian University of Technology

Abstract: *Estimation of the parameters of timber in existing structures based on the core samples - research assumptions.* The paper presents the aims and objectives of the studies undertaken for estimating the strength of timber in the existing structures based on cylindrical samples of small diameters taken from the existing structures. The scope of the research includes the study carried out on the full-size elements (including defects) as well as rectangular and cylindrical samples of small size. The aim of the study is to determine the correlation coefficients for determining the mechanical properties of timber depending on the size and type of the sample taken for testing. The aim of this article is to present the undertaken research and discuss the assumptions and methodology of the study.

Keywords: core drilling, laboratory tests, timber structures,

INTRODUCTION

In Poland, timber used as a structural material, is associated mainly as a historical building material for the construction of wooden houses, religious facilities in rural areas, as well as engineering structures such as small bridges or footbridges. In more recent applications, wood is used primarily for the roof support structure (on the roof construction of different schemes and different static load-bearing systems) as well as load-bearing wooden ceilings. Increasing use of this material requires in-depth analysis of the technical condition of the structure.

Currently, the most common diagnosis of timber structures is mainly based on macroscopic assessment - visual, possibly "tapping" the timber with a hammer. Visual assessment of structural elements should not be the sole basis for issuing a proper diagnosis of the timber mechanical properties. Used diagnostic methods of structure should not only determine the correctness of the implementation of the construction as well as validity of selection and quality of the materials used, but also enable obtaining the test results with the required accuracy and also enable statistical evaluation of the design with the precision required by the relevant regulations specified by standards [Adamczyk, 2013].

The most reliable method of assessing the condition of the timber in the structure is the laboratory tests. The obtained results are used to determine the mechanical properties of timber. Rarely, however, it is possible to get sufficient amount of material to perform destructive testing in accordance with currently applicable standards, e.g. PN-EN. The opposite of destructive methods is non-destructive testing (NDT). They do not affect the continuity of macro- and microstructure of timber, determine the physical and mechanical properties of the material and its possible disadvantages. However, the results obtained are ambiguous, as they are not always properly interpreted and using research equipment requires a lot of experience.

The most preferred solution is the use of so-called diagnostic methods, (SDT - semi-destructive tests), which cause at tests damage to the material, however, damage caused during the survey is limited, mechanical properties or utility of the material are slightly lowered or eliminated during further processing [Adamczyk, 2013].

One of the semi-destructive methods is testing of core samples taken from the member. Studies on this method were carried out, among others, in Germany [Erlar, 2004],

[Rug, Seeman 1991]. Ease of sampling for testing, the ability to perform laboratory tests, the scope of the information such as: the strength of the timber along the grain, density, humidity, saturation with protection chemicals, as well as the ease with which the damage can be repaired (analogous to the treatment of defects in timber) encouraged to carry out research based on national timber.

MATERIALS AND METHOD

Testing of mechanical properties of timber, in particular the flexural strength and the compressive strength should be carried out according to the Standards [PN-EN 408] and [PN-EN 384]. These standards recommend testing at bending on full-size elements, i.e. the elements having defects, such as knots. When commencing the study it was decided that the starting material for strength tests will be full-size structural beams (pine, spruce, larch) of different class, dimensions 0,075m x 0,15m x 3m subject to static testing at bending up to the failure, according to [PN-EN 408] presented in a research scheme in Figure 1, the spacing of supports 18h, which corresponds to the spacing of the support equal to 2,7 m.

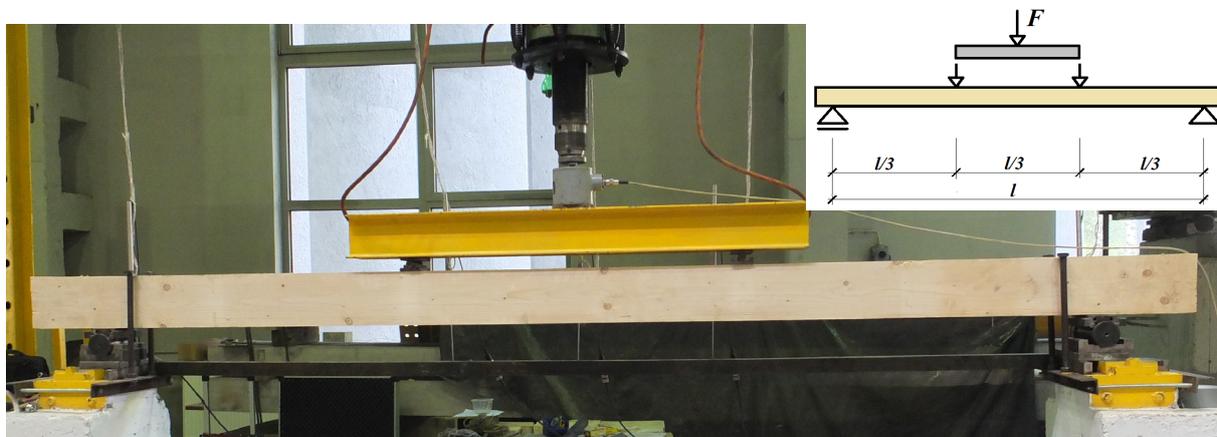


Figure 1. Scheme of full-size elements testing (K. Adamczyk)

Small samples without flaws are taken from the examined timber; cubical dices of dimensions 20x20x30 mm (long dimension along the fiber) beams of dimensions 20x20x400 mm (study in the diagram presented in Figure 1) and cylinders of the diameter of $\varnothing 10$ to $\varnothing 25$ mm and length of 30 mm.

Timber cores of the elements are collected using the hollow drills while maintaining a constant speed and an angle perpendicular to the fibers. To test cylinders for compression along the fiber plates with the cylindrical surface of the pressure ratio of 1/3 of the cavity radius have been prepared. Dimensions of plates with photo of the plates with testing element is given in Figure 2 and 3.

Pre-tests performed for wooden beams coring showed that cores having a diameter of $\varnothing 10$ get damaged easily, whereas the samples having a diameter of $\varnothing 25$ leave the hole/gap of too large diameter. With further analysis it was decided to focus primarily on samples with diameters of 15 and 20 mm and a length of 30 mm, this corresponds to a surface pressure perpendicular to the fibers, respectively 335,4 mm² and 447,3 mm² (pressure surface of a cube 20x20 mm to 400 mm²). Cubical and cylindrical samples are taken in the immediate vicinity to eliminate differences resulting from the structure of timber as much as possible.

In order to maximize the elimination of the influence of humidity and temperature on the results the tests are performed under constant thermal and humidity conditions i.e. the temperature 20°C, relative humidity 65% and timber moisture content about 12%. The time between studies and research on full-size and small samples should be as short as possible, because the influence of temperature and humidity is of particular importance when testing

small parts [Kozakiewicz, 2010], [Krzyśik, 1978]. Because the density has a major impact on the mechanical properties, and at the same time based on cylindrical and cubical samples, the density of timber was determined.

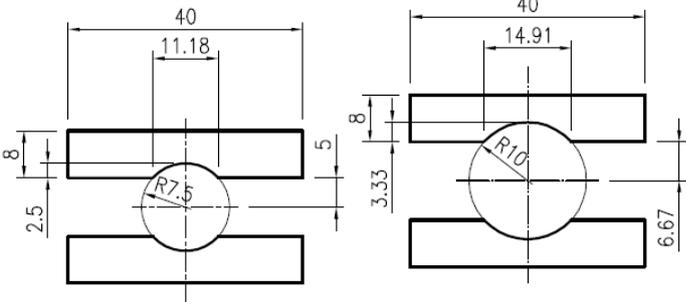


Figure 2. Plate's domendions (K. Adamczyk)

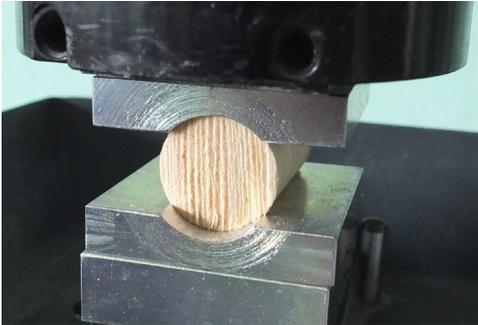


Figure 3. Plate with the testing model (K. Adamczyk)

OBJECTIVE OF TESTS

The paper does not contains tests results, due to the initial stage of implementation. It presents the scope and methodology of the studies undertaken to determine the strength parameters with particular emphasis on the need to determine the coefficients of correlation between the test results obtained for the full-size (C) and small-size (D) as well as of cubic (B) and core (A) elements. The idea of sought coefficients is shown in Figure 4.

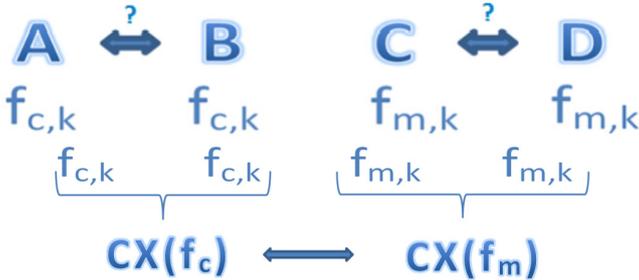


Figure 4. Block diagram for determining the relationship between research (K. Adamczyk)

- wherein: A - timber compression test along fibers performed on the cylindrical samples
- B - timber compression test along fibers performed on the cubical samples
- C - timber bending test on components of a small scale
- D - timber bending test on full size components
- $f_{c,k}$ - characteristic compressive strength
- $f_{m,k}$ - characteristic bending strength
- CX – timber class

The adopted research methodology is to determine the possibilities of using it for assessment of the compressive strength based on semi-destructive testing using cylindrical samples. The current implementation of the research shows that the sampling roller is not a problem, it is easy and possible to apply in the existing buildings. However, due to the work of the structural element the samples should be taken close to the neutral axis and should not violate the edge of the element. The disadvantage of this method is that the results are obtained from the samples without defects, which does not correspond directly with the strength of timber obtainable in research on the elements of a full-size. It allows, however, to estimate the mechanical parameters of the existing structures sometimes dozens or hundreds

year-old. Having the strength of timber for compression on small samples, performing macroscopic evaluation of the element and taking into account the dependence of $f_{c,0,k}=5(f_{m,k})^{0,45}$ which exists according to [PN-EN 338] between the bending strength and compressive strength it is possible to estimate fairly accurately full-size element built in in the evaluated structure.

The studies carried out so far are promising in relation to the thesis of the research.

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Streszczenie: *Szacowanie parametrów drewna w istniejących konstrukcjach na podstawie próbek rdzeniowych – założenia badawcze.* W referacie przedstawiono założenia i cele podjętych badań szacowania wytrzymałości drewna w istniejących konstrukcjach na podstawie pobieranych próbek walcowych, niewielkich średnic, z istniejących konstrukcji. Zakres rozpoczętych badań obejmuje badania na elementach pełnowymiarowych (z uwzględnieniem wad) oraz prostopadłościennych i walcowych próbkach niewielkich rozmiarów. Celem badań jest określenie współczynników korelacji wyznaczania parametrów wytrzymałościowych drewna w zależności od wielkości i rodzaju pobieranej próbki do badań wytrzymałościowych. Celem artykułu jest zaprezentowanie podjętych badań oraz poddanie pod dyskusję przyjętych założeń i metodyki badań.

Corresponding author:

Katarzyna Adamczyk
Akademicka 5
44-100 Gliwice, Poland
email: katarzyna.adamczyk@polsl.pl
phone: 32 2372288