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MONOTONIC TESTS OF STRUCTURAL CARPENTRY JOINTS

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ABSTRACT: An experimental campaign on traditional diagonal front notched timber joints was carried out in order to assess their rotational behaviour. This campaign included ten different test conditions, comprising some of the most frequently observed configurations of the rafter and tie beam joint in Portuguese roof structures. The joints' mechanical behaviour was appraised with regard to their geometric parameters, presence of metal fastening devices and moisture content of timber. The experimental results show that the joint's response is different when opening or closing the skew angle and that specific load bearing mechanisms dictate the different performances exhibited by each typology.

KEYWORDS: timber structures, connections, carpentry joints, tests, mechanical behaviour

1 INTRODUCTION

1.1 BACKGROUND AND OUTLINE

Modern standards and building codes focus primarily on modern industrialized mechanical or bonded timber joints, providing little or no guidance to design engineers regarding traditional timber carpentry joints; likewise, appraising engineers often face difficulties when making assumptions about carpentry joints in ancient timber structures, especially if calculation checks are to be carried out. Therefore it is necessary to establish reliable design and detailing rules and to provide rational criteria for the assessment of joints in existing structures, as well as recommendations for repair or strengthening interventions.

The rafter and tie beam joint in traditional roof structures allows a wide range of possible layouts [1], with or without different metal parts. These joints are sometimes exposed to severe environmental conditions and, due to their location near the supports, withstand the highest internal forces in the roof trusses. For structural analysis purposes they are usually assumed as either pinned or rigid, when their actual behaviour lies somewhere in between [2-5]. The metal parts are often applied disregarding their influence in the joint's stiffness and failure mode, consequently influencing the overall structural behaviour.

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The experimental campaign carried out at the Structures Department of the National Laboratory for Civil Engineering (LNEC) intended to characterize the rotational behaviour of some of the most frequently observed configurations of the rafter and tie beam joint in timber roof structures, concerning the influence of different factors related to the joint geometry (such as the notch depth and the presence of interior mortise and tenon), commonly employed metal fasteners (stirrups and clamps) and timber moisture content (due to the frictional nature of the joint's response when increasing the skew angle).

A literature review was first carried out regarding the rafter and tie beam joints, namely their common typologies, behaviour, design errors and repair/strengthening methods. Afterwards, the layout of the experimental campaign was defined, accounting for the data collected in the previous step and the test specimens were then fabricated and subsequently conditioned to the required moisture content levels. The test set-up design [6] was focused on the specific requirements of these tests, namely the application of loads parallel and perpendicular to the rafter and the need to quickly assemble and disassemble the test specimens. Finally, the obtained test results are presented and discussed.

1.2 RAFTER AND TIE BEAM JOINTS

Carpentry joints often connect timber elements without any other devices other than notches in the connected members. These joints rely on the timber-to-timber compression and friction forces to keep facing surfaces in close contact and seldom in metal fasteners.

1.2.1 Typologies

The three main geometrical configurations of the rafter and tie beam joint are the widespread front notched joint (Figure 1 a)), the rear and the double notched joints. An