ABSTRACT: The timber roofs have been characterized by defining the profile of the building. Solutions have not been capricious achieved, depended largely on the geographic context where they stood, the technique used and the material used. This paper analyzes the structural roof of large timber skeleton buildings located in Western Europe from the 11th to the 19th century. Case studies have been selected, in particular to characterize the building typologies and structural performance. It also features joints and different timber used. The paper demonstrate that many traditional trusses, have remained in good condition over time, based on knowledge of structural properties, good use of timber, maintenance and the adequacy of the roof to the climatic conditions of each place. Furthermore, traditional joinery back to become important in timber construction, due can be incorporated into mass-production methods, especially where timber is cut by precision CNC machinery.

KEYWORDS: Skeleton timber structure; Wide span roofing; Traditional timber details and joints;

1 INTRODUCTION

Until 19th century in the forested regions of Europe, wood was the most important material used to build the structure of the main buildings, especially in rural areas. Large public buildings such as markets, churches and barns were built dividing by columns the interior space in several naves and aisles, forming an entire heavy timber frame of beams and columns joined together. The timber roof was part of skeleton frame. From 12th century, timber roof becomes a more complex system. There are no uniform timber frame roofs in multi-aisle buildings, have a lot of members than a classic Romanesque roof (Fig. 1). They use beams, braces and plates with the same square section. It was common construction in northern France, Belgium and England.

2 CONSTRUCTION SYSTEM

Multi-aisle buildings use timber scissor trusses placed in the same direction of the frame structure and received loads of purlins. Usually, the span between columns in the main nave is not more than 8 m., and 4 m. in lateral aisles. Rules of proportion contributed the same distance in each bay, height and width of timber frame are similar. Columns are square section, and members of roof trusses like beams, diagonal braces, struts, collar tie and collar beams could be slightly rectangular.

2.1 TIMBER JOINTS

There is no single carpentry feature common to all multi-aisle timber frame European buildings studied, but some features are common. The oldest medieval European multi-aisle building has some mortise-and-tenons joints but they make considerable use of simple lap joint, notched lap joints and lap dovetails. Pegged scarf joints was used to joint plates to lengthwise of some European halls. Mortise and tenons joints was the system most used in timber frame structure. In French markets and barns, assemblies became sophisticated contact surfaces (Fig. 2).

The high pitched roofs in European halls have influence that the aisle-ties are set very low down the post.

2.2 TYPE OF TIMBER USED IN ROOF

Hardwoods, resistant to putrefaction and possibly easier to work were more used in construction. It got around the place to build, due to the habit of choosing the wood from the forests, as each building. This required not to be stored material, a constant supply and to use wood harvested without waiting for proper drying. The use of
wood as a structural system based on timber frame needs to know the advantages to other materials and has its limitations. It exploits the mechanical properties in tension and bending. Disadvantage during the time was the limitations of square sections and longer lengths. Oak was the wood most used in Europe to build timber frame and roof structure. Chestnut was another wood used to build roof structure. It was use in roof carpentry, where it was necessary smaller elements for triangulations, and where more work was needed in the construction of joints. The use of iron was low; most of these buildings did not use, or limited to use nails or metal plates in places where there was greater tensile strength solicitation, as the union of two tie-beams.

The trusses need to organize wood elements, by cutting to ensure the transmission of forces and the permanence of their connecting principles that were improved from the Middle Ages. It should ensure the non-deformability of the whole, so it require a triangular system. The axes of the different pieces that converge in a knot, coplanar or not, must be coincident at one point, thus avoiding secondary stress that could affect the overall safety. The most commonly used assemblies were those designed to transmit compressive forces. The transmission of forces takes place through tensions between the surfaces in contact, preventing the sliding of one piece on the other by mortise-and-tenons joints (Fig. 3).

3 ANALYSIS OF THE STRUCTURE

The timber roofs in multi-aisle building in Europe were erected using wooden elements with jointed based on transmission of compressive stresses, like mortise-and-tenons assemblies. Oak and chestnut were the wood most used. Through the knowledge of how mechanical structure works is be able to intervene successfully in future restorations. At the same time, this study supports the possibility of reuse traditional joints with the precision and moderns CNC machinery.

REFERENCES