INTRODUCTION

Aether Engineering is an engineering company founded in 2015 and located in Florence, Italy. Aether Engineering provides high-quality structural engineering services regarding timber structures and especially Cross Laminated Timber (CLT) construction. Additionally, the company operates in the field of software development specifically designed to facilitate certain analysis and verification procedures within the context of the structural design of buildings.

Wood, as a renewable and sustainable material, has attracted over the last years the interest of the construction industry, mainly because of the development of engineered wood products, such as CLT panels, which permit the erection of mid-rise and potentially high-rise buildings in the near future (Fig. 1).

Our vision is, given the lack in the market of software tools specifically designed for this type of construction, to create the necessary conditions that will give us the possibility to analyse and design extreme wood buildings with complex architectural layouts that incorporate innovative engineered wood products as main structural components. To achieve this objective, we take advantage of open-source software, such as Code_Aster, that provide the possibility to construct pre- and post-processing tools around their ecosystem, exploiting, thus, to the maximum extent the numerous capabilities that they offer.

CONTEXT

CLT panels is a relatively new engineered wood product that is composed of orthogonally oriented layers of wood boards, glued together to form a bi-dimensional component with high planar stability and out-of-plane flexural rigidity in both directions (Fig. 2a). With these characteristics, CLT panels can be used both as wall and floor components in a building structure. The behaviour of such type of construction, primarily under horizontal loads, is governed by the connections between the CLT panels that should be design to transfer shear and overturning loads where applicable (Fig. 2b).
MODELLING WORKFLOW

Our modelling workflow, summarized graphically in Fig. 3, starts by exporting the geometry of the elements of each floor (wall, floor, beam or column) from CAD, attaching through a Python script and a customized database, all the necessary related information like material properties and loads associated. Our Workflow Implementation tool, AETHERIUM, imports this data, creates the building model and allows the direct modification of the component properties as desired (Fig. 4). The user can then export dedicated scripts that permit the automatic construction of the geometry and mesh in Salome as well as the command file to be used for the analysis with Code_Aster.

Figure 3: Modelling Workflow for analysis of Cross Laminated Timber buildings with Code_Aster
**DESIGN WORKFLOW**

Our design workflow allows a holistic evaluation of the structural performance of CLT panels thanks to the visual projection and representation of the verification index of every CLT panel in the actual geometry of the model, similarly to viewing a contour plot of the stress resultants (Fig. 5). This procedure is implemented with a series of powerful commands, available in Code_Aster, that enable evaluating and projecting field values based on user-defined formulae, using as input data one or more field results.

The shear and tensile forces in the connections between panels, are obtained with dedicated Code_Aster commands and are extracted in AETHERIUM in order to define the required type and number of connectors to resist the design loads (Fig. 6). Additionally, the compressive forces between wall and floor CLT panels are used to design for compression perpendicular to grain in the floor panels.

This workflow can be greatly appreciated in complex and non-conventional structures, with difficult-to-predict load-transfer mechanisms or for the design optimization of large and strategic structures, providing a consistent approach to verify CLT panels and connections against the Ultimate Limit State failure mechanisms, according to Eurocodes.
Figure 5: Global verification index among all failure mechanisms

Figure 6: Connection forces in a CLT panel under horizontal and vertical loads