

Geometry generation of reciprocal systems made of non-uniform elements - *A case study of bamboo culms*

Martha GODINA *, Rodolfo LORENZO, Gert VAN DER HEIJDEN

* University College London
Gower Street, London, WC1E 6BT, UK
martha.godina.12@ucl.ac.uk

Abstract

The use of natural materials in construction is usually associated with a low level of technological development. In bamboo culms, the inherent non-uniform properties hinder the standardisation of elements, and thus details such as fitting of components are very difficult to achieve. This paper presents a formulation for the generation of the geometry of reciprocal systems that take into consideration the non-uniform geometry of bamboo culms. It integrates three different geometric properties of bamboo culms, namely the diameters, the out-of-straightness and the position of the nodes along the culm into the structural morphology of reciprocal systems. The formulation consists of two parts. The first is concerned with the geometry of reciprocal systems including the optimisation of the eccentricities (i.e. the orthogonal distance between two elements) according to the variable diameters of bamboo culms. The eccentricities are achieved by an iterative method that performs geometric transformations out-of-plane until the target eccentricities are reached (see Figure 1a). The second part is an optimisation routine for the automatic selection and position of bamboo culms for each of the elements in the reciprocal system so that the connections are as close as possible to the nodes in bamboo culms, while at the same time preventing clashing between the nodes and connection components. For this part, feasible regions are identified along the bamboo culms in which the connections can be installed. The formulation addresses well-known problems associated with the irregular geometry of bamboo culms in construction by taking advantage of digital tools. The potential of this approach to contribute to more sustainable construction is illustrated with a case study (see Figure 1b) using the geometric data of a batch of bamboo culms.

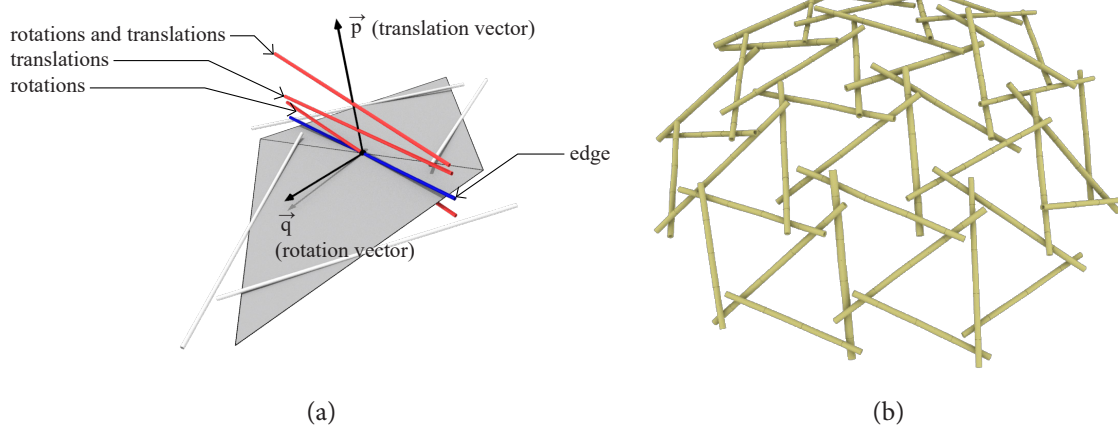


Figure 1: (a) Geometric transformations (rotations and translations) for eccentricities. (b) Case study of bamboo reciprocal structure.