Numerical model for the characterization of 3D printed composites

MARINE 2023

Montserrat Dolz*[1], Francesc Turon*[2] and Xavier Martinez*[3]

[*] International Center for Numerical Methods in Engineering (CIMNE)
Universidad Politécnica de Cataluña
Campus Nord UPC, 08034 Barcelona, Spain
[1] mdolz@cimne.upc.edu
[2] fturon@cimne.upc.edu
[3] xmartinez@cimne.upc.edu

ABSTRACT

Composite materials are used through a wide variety of processes and technologies in order to optimise cost and weight, as well as to improve the performance of the manufactured product. The shipbuilding sector is gradually incorporating these processes. However, shipyards, despite their interest in composites show a certain reticence towards the implementation of these materials in a non-conventional way. In this context is framed the Fibre4Yards project, which aims to improve the manufacturing methods and procedures used by the shipyards in order to improve their productivity. Among these methods it is considered the use of additive manufacturing for the construction of ships and ship parts and components. However, in order to incorporate this technology to the shipyard, there is a need for numerical models that are able to predict the behaviour of these materials.

Additive manufacturing, or 3D printing, is a manufacturing method that produces highly anisotropic composites, as it generates planes of weakness between the deposition planes of the material due to the type of adhesion between the layers. This anisotropy is accentuated by the addition of long fibres along the deposition direction. Therefore, in order to capture accurately the resulting composite performance, it is necessary the use of anisotropic constitutive models to simulate the 3D printed composite.

This paper presents an anisotropic formulation that transforms any given isotropic formulation in an anisotropy one, by means of a Space Mapping. The formulation consists of mapping a real anisotropic deformation state to an isotropic fictitious one in which the stresses are obtained and then mapped back to the real anisotropic space. For the characterization of the composite material, the serial-parallel mixing theory is used. This theory assumes that all directions have an iso-stress behaviour and in the fibre direction there is an iso-strain behaviour. Using this formulation, it is possible to obtain the performance of the composite from the constitutive performance of its constituent materials. The capabilities of the formulation developed are shown by reproducing the experimental results of several 3D printed composites. The agreement obtained between the numerical and the experimental results validates the approach proposed. This is expected to facilitate the analysis of these composites and their use by shipyards in order to improve their productivity.