THE THEORY OF CRITICAL DISTANCES TO MODEL THE STATIC STRENGTH OF ADDITIVELY MANUFACTURED CONCRETE/POLYMERS CONTAINING MANUFACTURING DEFECTS/VOIDS

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Abstract

The technologies that are most commonly used to additively-manufacture polymers and concrete make use of an extrusion process where the objects are built layer-by-layer by depositing filaments of the parent material. One of the key features of 3D-printing is that this technology allows objects with intricate designs to be manufactured at a relatively low cost, with this being done by reaching a remarkable level of accuracy in terms of both shape and dimensions. However, the specific features and the intrinsic technological limitations of additive manufacturing result not only in particular material mico-/meso-structural features, but also in defects that are introduced during fabrication. Both material morphology and manufacturing flaws do affect the overall mechanical behaviour and strength of additively manufactured objects.

In this setting, the present paper deals with the use of the Theory of Critical Distances to model the detrimental effect of manufacturing defects and voids in 3D-printed concrete/polymers subjected to static loading. The validity and robustness of the proposed approach is assessed against a large number of experimental results that were generated by testing 3D-printed specimens of both concrete and polylactide (PLA) containing manufacturing defects/voids. The sound agreement between experiments and predictive model (Figs 1 and 2) makes it evident that the Theory of Critical Distances (TCD) is not only a reliable design approach, but also a powerful tool suitable for guiding and informing effectively the additive manufacturing process.

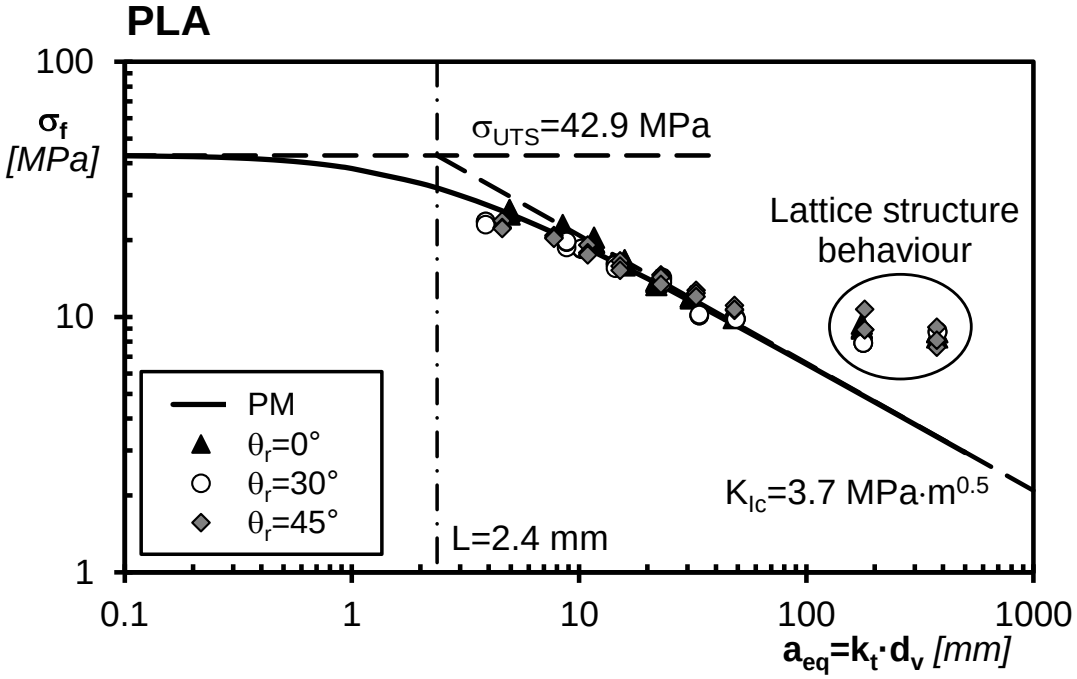

Fig.1 – Accuracy of the TCD used in the form of the Point Method (PM) in estimating the static strength of plain PLA 3D-printed with an in-fill level lower than 100%.

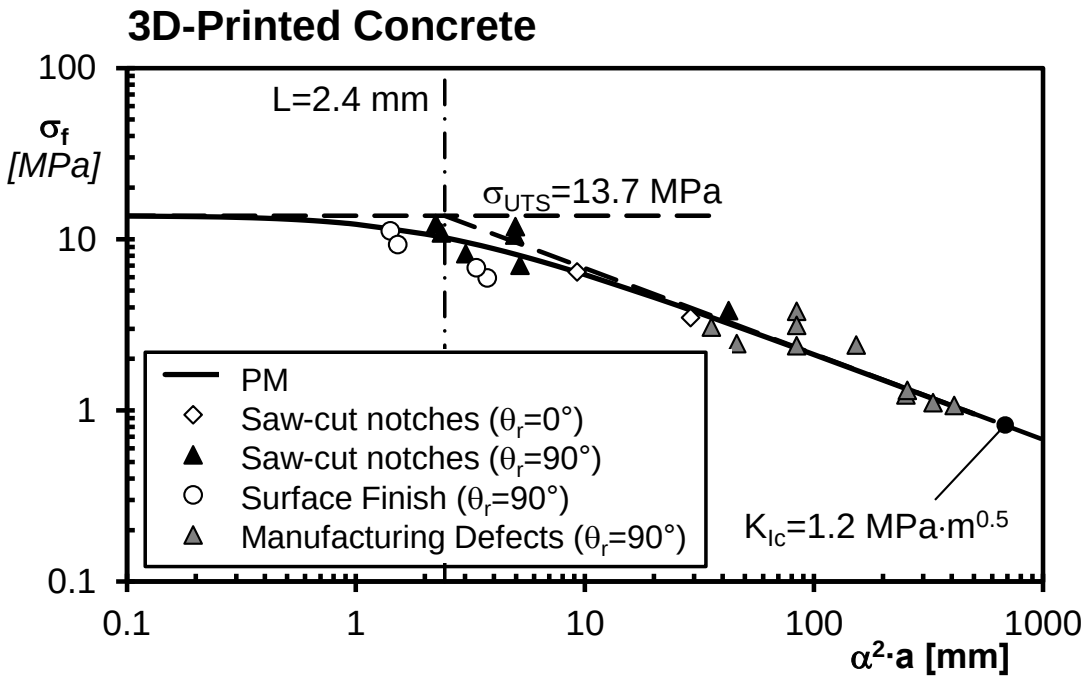

Fig. 2 – Accuracy of the TCD used in the form of the Point Method (PM) in estimating the static strength of 3D-printed concrete weakened by cracks and defects.

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