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Influence on the accuracy of testing components made on substructures versus whole ones by Additive Manufacturing

Zsolt ASZTALOS[1], Maria Luminita SCUTARU[1], Ioan SZÁVA[1]

1. Transilvania University of Brașov, Romania,zsolt.asztalos@student.unitbv.ro
2. Transilvania University of Brașov, Romania, lscutaru@unitbv.ro
3. Transilvania University of Brașov, Romania, eet@unitbv.ro

Coresponding author zsolt.asztalos@student.unitbv.ro

Abstract: *The production of components intended for prototypes, respectively spare parts through Additive Manufacturing (AM) is currently a widely applied strategy. If the manufacturer does not have at his disposal a sufficiently complex and at the same time flexible 3D printing system, then he resorts to obtaining them through an assembly (for example by means of screws) of its component elements, i.e. of its substructures. The authors aimed to analyze the influence of the method of obtaining the respective product (through modular elements assembled with screws, respectively made of one piece) on its overall stiffness. In this regard, a relative simple structure (a relative long prismatic bar) was considered, which is the usual case would have required a more special 3D printing system, i.e. with a continuously expanding work area. Sets of elements were made, with different degrees of filling, obtained from components that can be assembled by means either of screws, or directly (with the nominal length). From the comparative testing of their stiffness, useful conclusions could be drawn regarding the accuracy of the results of the assembled structures compared to those of the original proposed structures.*

Keywords: *3D printing, aditive, manufacturing, system.*

INTRODUCTION

As is well known, 3D printing has become in recent years, among other things, a particularly useful tool for rapid prototyping in the manufacturing industry [1-17].

Even if it does not represent a very new technology, the main advantage lies in the use of cheap or relatively cheap 3D printers, with the help of which it becomes possible to make, at an indisputably low cost price, prototypes and spare parts of a large geometric complexity. That advantage of significantly reducing manufacturing waste, as well as reducing environmental pollution, should not be forgotten either [18-24] .

These 3D printing processes represent the essence of Additive Manufacturing (AM) technologies, which the authors dealt with in this work, especially Fused Deposition Modelling (FDM), using as a base material a polymeric one (Polylactic Acid –PLA) in the form of filament wound on a real spool. This PLA material has a relatively low melting temperature of approx. 175 ^{0}C, which ensures efficient use and low energy consumption.

With the help of the CAD model, which is the basis of 3D printing, it is possible to realize not only different configurations, but also different degrees of filling, respectively internal reticular structures as desired (Fig. 1).

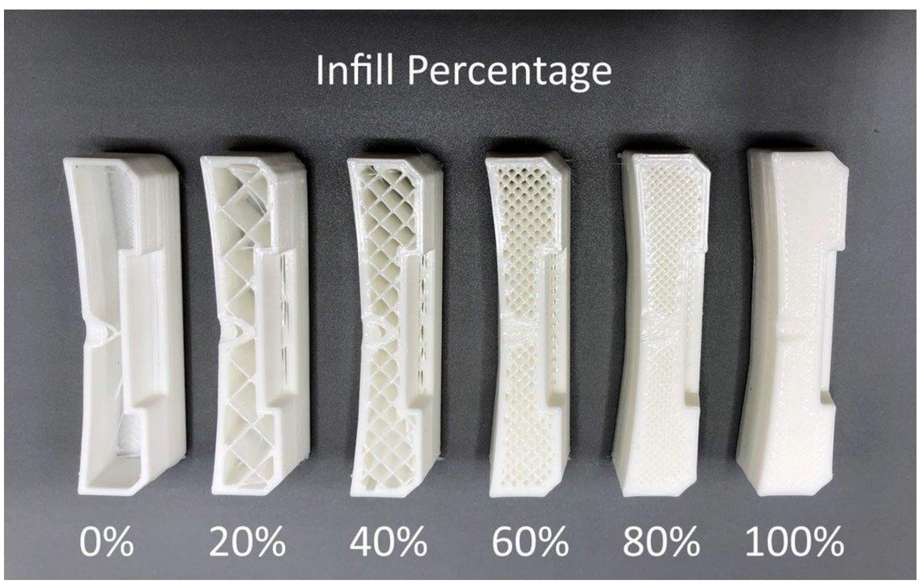

Fig. 1. Different filling percentages

The problem is the dimensions of the foreseen pieces. Thus, in the case of usual 3D printers, the dimensions of the part are limited by the working area of the printers. If it is desired to manufacture parts with dimensions larger than this working area of the printer, it is currently resorted to obtaining them by parts and their subsequent assembly (so with modular elements) or with removable elements (for example screws with or without nuts), or with non-removable elements (such as rivets or even gluing these parts).

In this contribution, the authors, based on their previous results, perform a comparative analysis of the stiffness, respectively the load-bearing capacity of some prismatic bars, obtained first from parts assembled with screws and nuts, respectively made mono-bloc (from an array) at a printer with extensible/continuous working area, i.e. with a continuously expanding work area [25-26].

2. CONSIDERATION FOR OBTAINING THE TWO TYPES OF BARS

Let consider a prismatic bar of *L=500 mm*, with dimensions *b*=10 *mm* and *h* =20 *mm* of the cross-section, which is related to the tri-orthogonal reference system *xGyz* (Fig. 2). The obtained beam will be loaded at its free end by the concentrated force *F*, thus being subjected to simple plane bending.

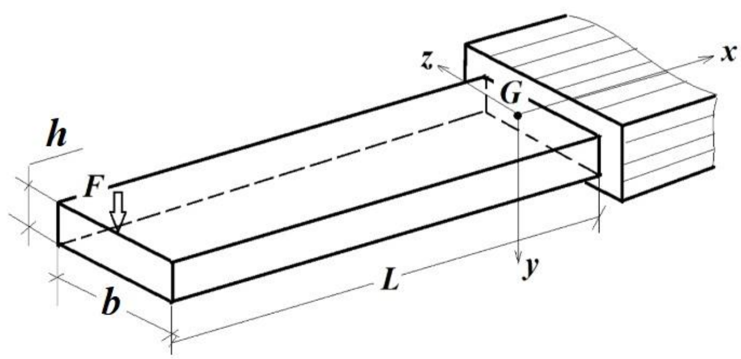

Figure 2. The analyzed beam [26]

The beam was made in two versions: one mono-bloc, on a 3D printer with continuously expanding work area, respectively from modules (Fig. 3), on a 3D printer with a limited work area. These modules were later assembled with bolts and nuts. In addition, both variants were made in two versions, with different degrees of filling, i.e. 10 % and 30 %.

Both types of beams were subjected to the same forces *F*, the vertical displacements v [*mm*] being monitored at the level of its free end, where in fact the force *F* was also applied.

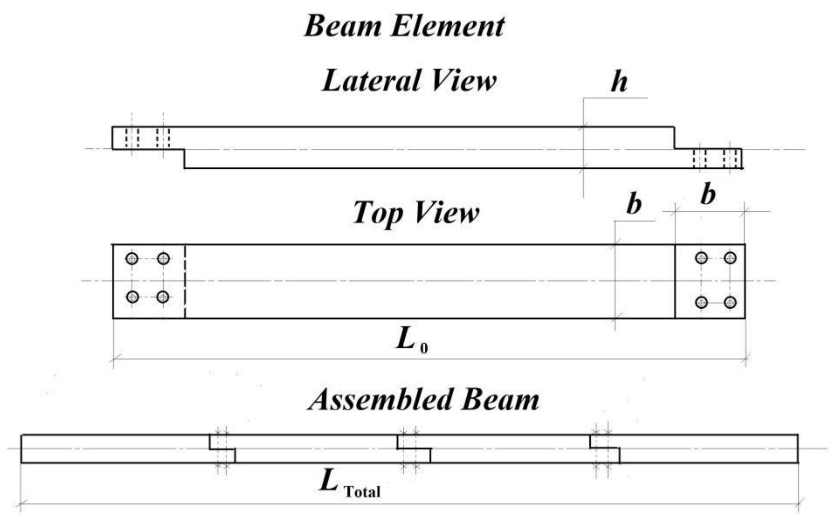

Figure 3. The beam elements and its assembled sketch

These results are summarized in Table 1, and the deviations [%] of the assembles variant compared to the mono-bloc beam are listed in parentheses.

Table 1. The measurements' results

***F* [*N*]**	**Beam type**	**Filling 10%**	**Filling 30%**
0.98	Monobloc	3.70	2,81
	Assembled	3,89 (5%)	2,94 (4.5%)
1.96	Monobloc	7.31	5,22
	Assembled	7,74 (6%)	5,51 (5.5%)
2.94	Monobloc	11.27	8,52
	Assembled	12.24 (8%)	9.14 (7.3 %)

3. Conclusions

Based on the careful analysis of the investigations' results on the two types of beams, the following useful conclusions can be drawn for those in the field:

- In the present cases, the modules were assemble by metrological-controlled tightening of all screws;

- Even if these deviations seems to be quite small, however, taking into account the magnitude of the applied force, these deviations at higher forces/loads will lead to significant losses of the original expected stiffness of the structures obtained from modules with respect to the mono-bloc one;
- If the assembly of the modules does not comply with the metrological-controlled and uniform tightening of all screws, then with the increase in the unevenness of these restrictions, a significant decrease in the stiffness of the assembly can be expected, highlighted by the increase in the size of the deformations of the component modules;
- Based on the obtained results, the authors recommend that, in the event that larger parts are expected to be manufactured, 3D printers with a continuously expanding area should be used.

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