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Experimental investigation of mechanical stiffness in lattice structures fabricated with PLA using fused deposition modelling

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ABSTRACT

Purpose: The objective of the paper is to design and characterise with polylactic acid (PLA) material three cellular structures in the form of lattices which are diagonal-octet-centred shapes for two sizes 6x6x6 and 12x12x12 with a compression test to examine their stiffness using FDM technology compared to polyjet technology.

Design/methodology/approach: The study used two analytical approaches to investigate lattice structures: experimental analysis and theoretical analysis. Experimental methods such as compression tests were conducted to determine the characteristics of lattice structures. In addition, theoretical analysis was conducted using Hook's law and Ashby's Gibson model to predict appropriate behaviour. The combination of experimental and theoretical methods provided a comprehensive understanding of lattice structures and their properties.

Findings: The experimental study examined the impact of the shape and size of a lattice structure on the stiffness and lightness of objects 3D printed with FDM technology by PLA material. The research revealed that the 6x6x6 diagonal lattice structure size provided a good balance between stiffness and lightness. While the 6x6x6 byte structure was even lighter, with a mass ratio of 2.09 compared to the diagonal structure, it was less rigid, with a ratio of 0.43, making the diagonal structure more suitable for certain applications. The study highlights the importance of considering both the shape and size of the lattice structure when designing 3D-printed objects with specific mechanical properties; the chosen structure could be a good choice for applications where stiffness and lightness are important.

Research limitations/implications: The limitations of the research lie in its limited scope, focusing primarily on the effect of shape (octet-diagonal centred) and unit cell size on Young's modulus of PLA material. Other aspects of 3D printing, such as material selection and thermal properties, were not considered. Furthermore, the results obtained are specific to the printing parameters and experimental conditions chosen, which limits their generalizability to other 3D printing configurations or methods. However, these results have important implications for optimising the PLA printing process. They enable the identification of optimal parameters, such as unit cell shape and size, to produce stiffer, higher-quality structures. In addition, the research is helping to improve the mechanical properties of 3D-printed lattice parts, paving the way for more efficient manufacturing methods and stronger components.

Practical implications: Our analysis can be used as a decision aid for the design of FDM lattice parts. Indeed, we can choose the diagonal structure of 6x6x6, which would provide favourable stiffness for functional parts.

Originality/value: The paper explores the compression test of lattice structures using FDM technology, which presents a new direction for additive manufacturing. The study takes an experimental approach to evaluate the reliability of various additive manufacturing technologies for creating lattice structures. The study results provide insight into the most reliable technology for producing lattice structures.

Keywords: Additive manufacturing, Topological optimisation, Mechanical properties, Unit cell, Lattice structures

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PROPERTIES

1. Introduction

Additive manufacturing (AM) or 3D printing is a forming technology for producing three-dimensional parts. The object manufactured as a finished product is created by adding the material line by line, layer by layer, surface by surface or part by part [1] The shaping technology has had a strong influence on industries such as automotive, aerospace [2], motorsports, energy and medical [3]. The innovation has totally changed the design and manufacturing paradigms of the company. Products can be customised and designed into complex shapes using an additive manufacturing technology that offers unlimited design flexibility. The design for additive manufacturing aims to improve productivity so that the cost and manufacturing time should be minimal. at the same time, maximising the intrinsic functionality parameters of additively manufactured parts [4]. The materials used for the deposition of layers on one of the technologies are metals, ceramics and synthetic polymers, with extreme temperature conditions. Each layer built is controlled by a computer-aided design (CAD) modeller that measures the initial parameters, such as the trajectory of the tool of each product support and orientation. The 3D printer manufactures thin layers; the layer hardens in the selected area using a thermal or chemical source by an ultraviolet laser beam, solvent jet or binder to be controlled by a computer [1].

Topological optimisation is a computer-aided design method that automatically generates structural products with better characteristics and performance [5]. Topological optimisation is based on the distribution of materials in the discretised design domain [6]. The optimised product is not limited to its initial topology and can achieve improved performance compared to the initial state [6].

Topological optimisation leverages the best design as an advantage and potential and offers a broad design perspective for additive manufacturing. Still, it faces challenges such as performance characterisation, scaling effect in lattice structures, anisotropy, and material fatigue [7].

By tackling issues caused by scale effects and providing lightweight, strong, and effective solutions across diverse application domains, topological optimisation has the potential optimisation to contribute significantly to the design and optimisation of lattice structures. Since tessellation was developed to provide specialised channels for transferring stimuli like vibration, heat, weight, and fluid, lattice structures now serve a dual role. The mechanical and practical characteristics of lattice structures may be changed by changing the path that stimuli take during transmission. Studies in the field focus on metallic crystal stacking non-edge-to-edge tessellations that can be used in protective helmets and specialised sporting footwear [8].

Other research investigates mesoscale lattice structures for large-scale item additive manufacturing. Nested hybrid Lattice Structures (NLS), which provide inexpensive and lightweight components that improve structural stability, are made using design and additive manufacturing processes. Topological Optimization attains the best attributes; several NLS compositions are being researched [9]. Those developments create new possibilities for large-scale additive manufacturing of networked components. As a result of the research, AFAMs 3D-printed materials inspired by biological structures have been created. The cubic metallic crystal formations impacted the tessellations utilised to make these materials. Through experimental procedures, the structural and functional qualities of each advanced functional architectured materials (AFAM) were assessed. The findings showed that AFAM face-centred cubic (FCC) has extraordinary strength and energy absorption capability, but AFAM simple cubic (SC) exhibits great ductility. Each AFAM uniquely reacts to loading and deformation. Multi-material features can be achieved by mixing AFAMs [10]. The intricate multifunctional requirements of additive manufacturing are successfully met by the method.

The study first focuses on the characterisation, scaling effect and cell types for lattice structures by testing each optimised structure by compressive loading. Second, the elastic modulus of each model (octet, diagonal, centred) and scale (6x6x6, 12x12x12) is to be calculated with Hook's law. Finally, we determined the elastic modulus by the Gibson Ashby model, which is the closest to the lattice structures with its shape and scale characteristics [6].

The paper is organised as follows. Section 2 presents the methodology and analysis process of the proposed cellular structures using polylactic acid (PLA) material. In section 3, the fabrication and compression results with the analysis of the mechanical properties of the lattice structure are presented and discussed. The conclusion is given in the last section.

2. Design approach

The DFAM approach involves a thorough understanding of the material behaviour during the manufacturing process and how it affects the final structure. The approach can be applied to various types of materials, including metals, polymers, and ceramics.

In addition to reducing manufacturing time and material waste, the DFAM approach also helps to optimise the structural design for specific requirements, such as strength, stiffness, and thermal resistance. It can be achieved by using lattice structures, characterised by their high specific strength and stiffness and ability to control heat flow.

Lattice structures can be designed to fit a wide range of applications, and they can be customised to meet specific requirements, such as the desired mechanical performance, thermal conductivity, or other functionalities. In order to fully utilise the potential of lattice structures, it is important to have a clear understanding of their design principles, as well as the properties and limitations of the manufacturing process used to produce them.

Overall, the DFAM approach can help achieve a more efficient and cost-effective manufacturing process while improving the final product's performance. By combining the latest advances in materials science, manufacturing processes, and structural design, the DFAM approach can help to push the boundaries of what is possible with additive manufacturing [4].

2.1. Methodology

The flowchart in Figure 1 outlines the methodology used to design and develop cellular structures. The first step is the prediction and analytical modelling of the lattice structures, which helps to understand their behaviour. The 3D printing of various models follows it to verify their performance through compressive testing. If the results of the tests are not significant, the geometry parameters are modified.

Lattice structures have the unique property of being either stochastically arranged with irregular cell geometries and non-periodic shapes that can be plastically deformed or non-stochastically arranged with periodic unit cells, which are commonly used in aeronautics. Those structures are known for their high strength-to-weight ratio and ability to meet custom functional requirements.

The lattice structures have a better capacity to resist loads and have adaptable mechanical properties than traditional structures. It makes them ideal for applications in areas such as shock absorption, where high deformation is required, or in aeronautics, where lightweight and strong structures are essential.

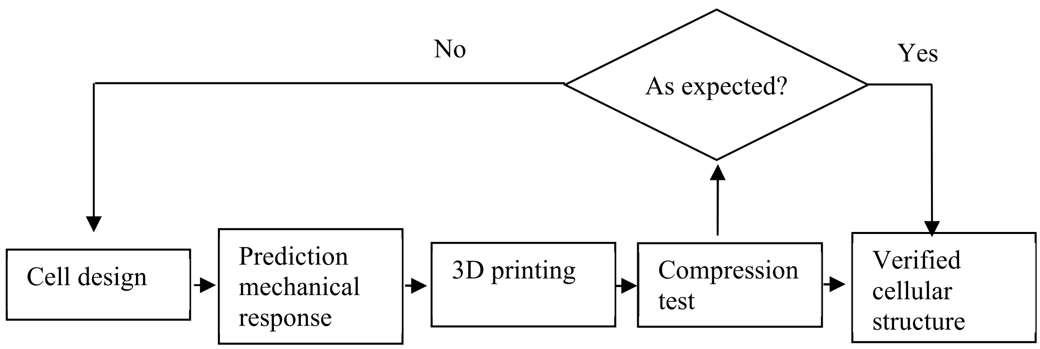


Fig. 1. Design and development of cellular structures

2.2. Prediction of the mechanical response

The behavioural law has been developed by advanced estimation techniques to predict the mechanical characteristics of cellular structures as a function of the unit cell used. The most important law used in porous structures is the Gibson-Ashby method with the equation below [11]:

$$\frac{P^*}{P_s} = c\left(\frac{\rho^*}{\rho_s}\right)^n \tag{1}$$

with $\frac{P^*}{P_s}$ it is the proportional response, which allows the proportionality constant (c) and the relative density of the cell structure to be related $\frac{P^*}{P_s}$ to the power of an exponent (n) depending on the nature of the dominant behaviour, which may be bending or stretching.

The calculation of the modulus of elasticity includes the Gibson-Ashby scaling law in the form:

$$\frac{E^*}{E_s} = c\left(\frac{\rho^*}{\rho_s}\right)^n \tag{2}$$

E^* and E_s are the elastic moduli of the optimised overall solid structure; ρ^*/ρ_s are the relative densities of the lattice structure, and n is a coefficient dependent on the cellular structures is dominated by the stress of a bending or stretching load.

The Gibson-Ashby scaling law uses the practical case of elastic force legs after the correlation coefficients have been properly determined. These are calculated as a function of the structure and material used. The methodology used is a non-linear regression method to identify the different constants '*c*' and '*n*' of the equation.

If we replace the relative modulus of elasticity (E^*/E_s) and density (ρ^*/ρ_s) by the variables Y and X respectively, the equation becomes of the following form:

$$Y = cX^n \tag{3}$$

Using a numerical gauss-newton method, we obtain the best-fit values as follows:
n=2 and c=1.15 for octet lattice structures,
n=1 and c=0.5 for diagonal lattice structures,
n=2 and c=0.67 for centred lattice structures.

3. Experimental setup

3.1. Fused Deposition Manufacturing (FDM)

One of the advantages of FDM technology is that it allows for the creation of complex shapes and geometries with relative ease. It is also a relatively low-cost option compared to other 3D printing technologies, making it accessible to hobbyists, small businesses, and educational institutions. Additionally, FDM technology can also produce strong, durable parts with good surface quality, making it suitable for a wide range of applications, including prototyping, manufacturing tooling, and end-use parts.

However, there are also some limitations to FDM technology. One of the main limitations is the relatively low precision of the finished parts compared to other 3D printing technologies. Additionally, the strength and durability of the parts can be limited by the type of plastic used, and the quality of the finished parts can be affected by the resolution of the printer and the layer thickness.

Overall, FDM technology is a versatile and widely used option in the world of 3D printing, offering a good balance between cost, ease of use, and functional capabilities. A wide range of plastics such as polylactic acid (PLA), polycarbonate (PC), acrylonitrile butadiene styrene (ABS), polyphenysulfone (PPS), polyethylene terephthalate (PET) and polyamide (PA) can be used for printing [11].

3.2. Material fabrication and testing: PLA

PLA, or polylactic acid, is a biodegradable polymer that can be derived from whey waste. According to Table 1 (source [12]), It has a wide range of potential applications, including in medicine as absorbable surgical sutures, in the production of implants [13] as biopolymers, and in various industries for the production of biodegradable bottles and disposable packaging, as well as 3D printer cartridges [14].

Table 1.
Mechanical properties of PLA material [15]

Property	Standard	Unit	Value
Tensile strength	ASTM D638	MPA	26-45
Elongation at break	ASTM D638	%	1.0-2.5
Modulus of elasticity	ASTM D638	MPA	2539-3039
Flexural strength	ASTM D790	MPA	45-84
Heat deflection	ASTM D648	°C	53

3.3. 3D Printer: RAISE 3D Pro2

The RAISE 3D Pro 2 is popular among professionals for its large build volume and high-performance capabilities. The dual extrusion capability allows for the use of multiple filament types, providing greater versatility in printing materials [16].

Additionally, its open-source design allows for customisation and greater control over the printing process, making it a suitable choice for local manufacturing labs.

It is a great option for producing high-quality, detailed prints, particularly for small parts [17].

The process of printing objects using FDM technology can be described as follows:

- Computer-Aided Design (CAD) software is used to create a 3D model of the object,
- The model is then saved in STL format, a standard file format for 3D printing,
- The STL file is then loaded into the slicing software, which converts the 3D model into a series of 2D layers that can be printed,
- The slicing software generates a G-code file, a set of instructions for the 3D printer that define the movement of the print head, the temperature of the extruder, and the flow rate of the filament,
- The G-code file is loaded into the control software of the RAISE 3D printer, which is responsible for controlling the printer and executing the instructions in the G-code file,
- The printer uses a 0.2 mm diameter nozzle to melt and deposit the filament layer by layer, building up the object until it is complete.

Technical specifications of the RAISE 3D printer, as shown in Figure 2, include its build volume, layer resolution, and the types of filaments it can use(Tab. 2). Other important specifications include the maximum speed of the print head, the maximum temperature of the extruder, and the connectivity options (such as USB, Ethernet, or Wi-Fi). It is also important to consider the ease of use, reliability, and support provided by the manufacturer when choosing a 3D printer [18].

It is crucial to remember that 3D printing parameters might change based on the printer being used, the material used, and the precise model of the object to be produced. It is advised to follow the manufacturer's guidelines, conduct testing, and make modifications to get the best printing results.

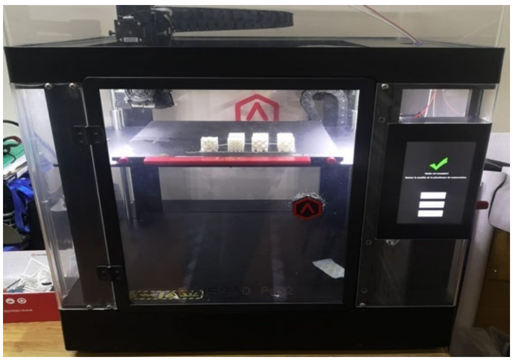


Fig. 2. The 3D printer machine RAISE 3D

Table 2.
Technical specification of the used 3D printer

Printing size	300×300×300 mm
Layer thickness	0.01-0.25 mm
First layer printing speed	30 mm/s
Print speed of other layers	150 mm/s
Filament	1.75 mm (PLA/ABS/HIPS/PC/TPU/TPE/PETG/ASA/PP/PVA/Nylon)
File Format	STL/OBJ/3MF/OLTP
Number of perimeters	2
Power supply	100-240 VAC, 50/60 Hz 3.3 A
Output	24 V DC, 600 W
Temperature	230°C

Depending on the settings used in Table 3, particularly when considering geometric complexity, printing time and weight may change.

Table 3.
Printing parameters of the lattice structure

Parameters	values	Unit
Layer thickness	0.3	mm
First layer printing speed	20	mm/s
Print speed of other layers	200	mm/s
Raster angle	0/45	°
Infill percentage	90	%
Number of perimeters	2	
Fill type	GRID	
Temperature	215	°C

Two main factors, manufacturing time and component cost, significantly impact the production of components using FDM (Fused Deposition Modelling) technology. Table 4 of finished parts shows that FDM technology uses a layer-by-layer approach to fabricate 3D objects in a limited amount of time; the time it takes to fabricate a part depends on the complexity of the design, the size of the part, and the resolution required. Similarly, several factors determine the cost of producing components using FDM technology, such as the cost of the material, the amount of material required per structure based on its weight (see Fig. 3), and the energy consumed during the manufacturing process. Hence, the time and cost required for manufacturing parts using FDM technology must be carefully considered to ensure the overall efficiency and effectiveness of the process.

Table 4.
The construction of the cell structure

Cell structure	Unit cell size	Model material used, gr	Print time, min
	Octet 6x6x6	3.6	55
	Octet 12x12x12	4.54	48
	Centred 6x6x6	6.92	69
	Centred 12x12x12	7.33	58
	Diagonal 6x6x6	7.53	67
	Diagonal 12x12x12	6.75	54

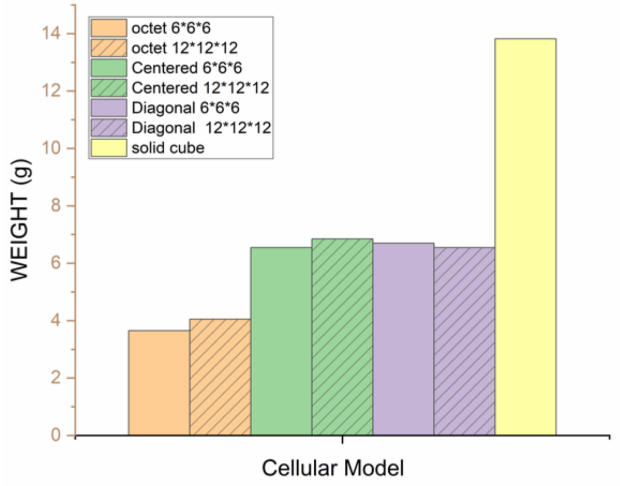


Fig. 3. Comparison in mass of the structures (octet-centred-diagonal) and the solid cube [19]

3.4. Compression test machine

Figure 4 shows that the RP25ATF Universal Press was used to test the stiffness of seven 3D samples printed with FDM technology by the RAISE 3D printer. The samples were of two different sizes and were tested at room temperature with a speed of 0.5 mm/s and a limit displacement of 10 mm. The objective of the test was to determine the optimised stiffness of the samples, and the results were used to evaluate the quality of the samples produced by the RAISE 3D printer [20]. The general characteristics of the machine shows Table 5.

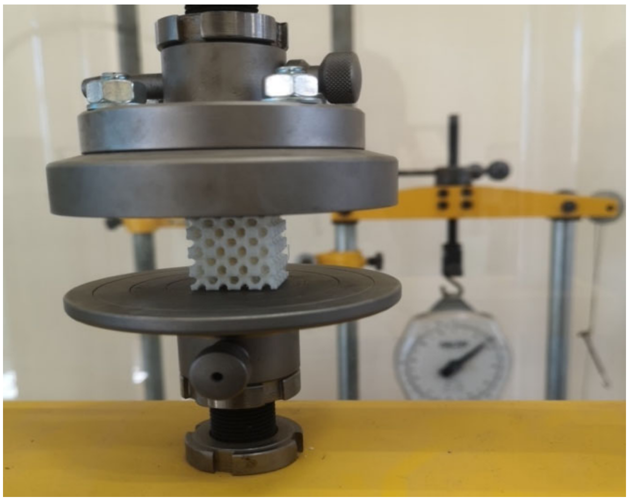


Fig. 4. The test machine series RP25ATF

Table 5.
General characteristics of the machine

Dimensions	1860x990x700 mm
Maximum force on the cross member	25 KN
Distance between columns	310 mm
Load cell capacity	25 KN
Resolution 1 N, accuracy	0.5%
Compression plates	96 mm diameter and 58 HRC
Power	800 W
Displacement sensor	300 mm stroke, resolution of 10 µm

Table 6.
The test of the cell structure

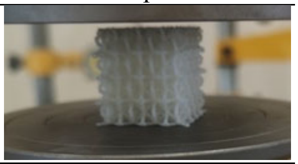
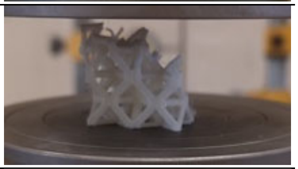
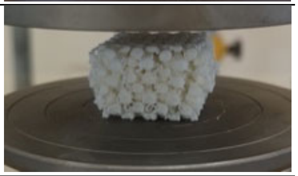
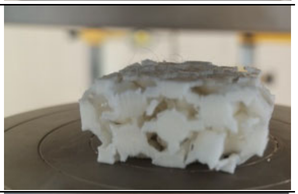
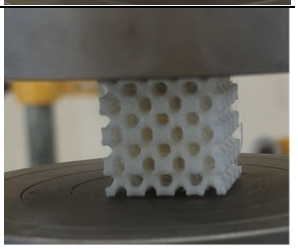
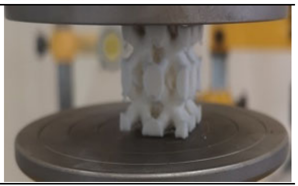
Cell structure	Unit cell size	3D samples test
CTET	6x6x6	
	12x12x12	
CENTRED	6x6x6	
	12x12x12	
DIAGONAL	6x6x6	
	12x12x12	

Table 6 contains the different shapes of the lattice structures (octet-centred-diagonal) stressed on the machine in a compression test with a displacement of 10 mm to verify the compressive stiffness of these six specimens.

4. Results and discussion

Layer thickness, filling, temperature variation, printing speed, compression test machine speed, and sample shape are among the variables that can affect the accuracy and mechanical properties of 3D printed parts as well as the outcomes of a compression test, according to a number of studies in the literature [21]. However, for our lattice construction, as seen in Figure 5, the indicated samples' stiffness values change due to their size and shape variations, which are important contributors to the variance. The mechanical characteristics of the samples may be challenged by the disparity in stiffness or face a "dilemma" as a result. Each sample's specific stiffness value, which is controlled by its form and size, seems to impact how well it can endure the stress and displacements they cause. As a result, it could be required to consider these elements while examining the samples' mechanical characteristics.

Load and displacement are fundamental concepts in the study of mechanics and material properties. Stress and strain are related to force and displacement through material properties such as Young's modulus, which measures the stiffness of a material in the elastic domain.

Hook's Law describes the linear relationship between stress and strain in the elastic domain, where the structure behaves elastically and can return to its original shape when the applied force is removed. Young's modulus is a measure of the resistance of different structures (octet-centred-diagonal) to deformation under stress, and it is an important parameter for determining the stiffness of a structure.

A comparison of Young's modulus values can help identify the structure and size with the greatest stiffness under certain stress and strain conditions. It can be important for the design and optimisation of structures and materials for specific applications such as impact resistance, etc.

Overall, understanding the relationships between force, displacement, stress, and strain, as well as the material properties that govern these relationships, is essential for the study of mechanics and the design of structures and materials.

Figure 6 shows the behaviour of structures (octet-centred-diagonal) with two sizes, 6x6x6 and 12x12x12, as a function of stress and strain.

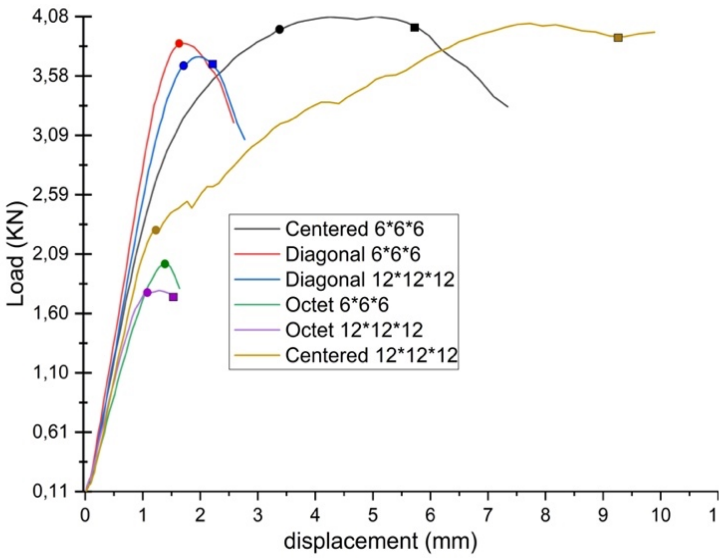


Fig. 5. Load/displacement graph for the 6-cell structure; Each curve will be broken down into three zones as follows:
● the zone limited by the shape of a circle is an elastic zone,
■ the zone bounded by the circle and square shapes is a plateau zone,
the rest is a densification zone.

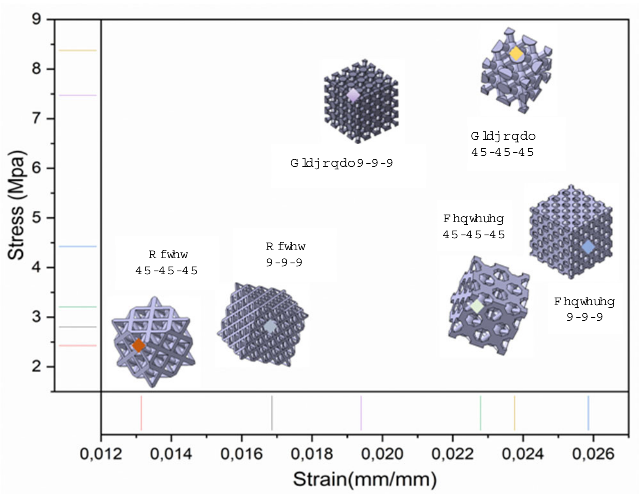


Fig. 6. Stress/strain graph for the 6-cell structure

According to the literature, the diagonal structure is light and rigid, often used to support axial loads and often used in bridges, antennas, kites and aircraft.

The diagonal structure is fabricated with FDM technology using PLA material and appropriate printing parameters, and we achieved acceptable average strain and stress with a unit cell size of 6x6x6 which must be carefully selected according to the intended application.

Finally, evaluating the performance of a diagonal structure with the choice of unit cell size allows us to identify areas of the structure that may require additional reinforcement to ensure the desired stiffness with a trend in Young's modulus towards the material data sheet [21].

The diagonal structure is characterised by high mechanical stiffness, as clearly shown in Figure 5, which provides a case study for comparing the results of the numerical analysis performed with Abaqus with those of the experimental analysis, shown in Figure 7 below. The numerical curve is divided into three zones: elastic, plateau, and densification, whereas the experimental curve shows only two zones: elastic and densification. It underlines the reliability of the experimental analyses.

<u>Calculation and comparison of elastic modulus</u>

Lattice structures are typically used in additive manufacturing to create lightweight parts with high strength-to-weight ratios. Two popular 3D printing technologies for creating lattice structures are Fused Deposition Modelling (FDM) and PolyJet. The elastic modulus of lattice structures printed using those two technologies can vary depending on various factors such as the lattice design, printing parameters, material properties, etc. According to Table 7, FDM technology produces lattice structures with lower elastic moduli than PolyJet technology. It is because FDM uses thermoplastic materials with lower elastic modulus than

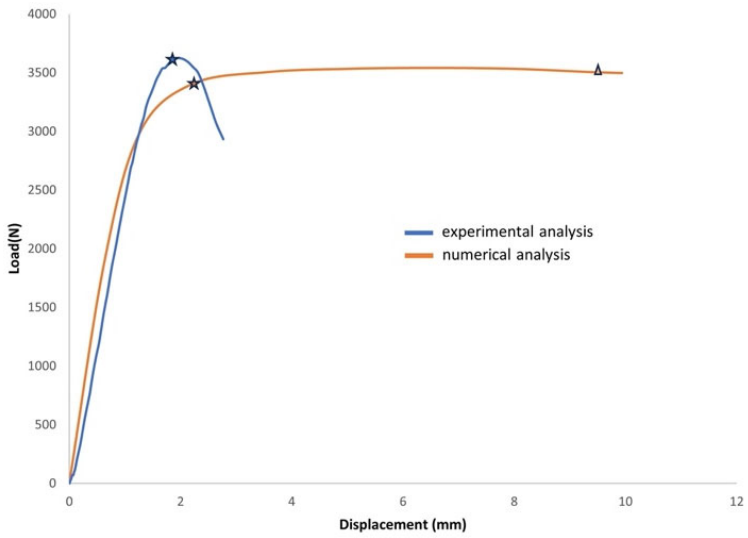


Fig. 7. Graph for analysis of numerical and experimental the Diagonal 6x6x6 structure

Table 7.
Comparison of the elastic modulus of lattice structures with FDM and PolyJet technology

Cell structure	Unit cell size	Modulus Ashby FDM	Modulus Hooke FDM	Modulus Hooke PolyJet	Modulus Ashby PolyJet
OCTET	6x6x6	170	166.08	168.91	167.67
	12x12x12	170	184.68	194.69	193.43
CENTRED	6x6x6	285	171.12	138.8	112.69
	12x12x12	285	140.56	101.88	137.21
DIAGONAL	6x6x6	469	385.12	340.39	450
	12x12x12	469	352.34	531.54	460

the photopolymer resins used in PolyJet technology. However, the elastic modulus of lattice structures can also depend on the infill density, infill pattern, and printing direction. Higher infill densities and more complex infill patterns can generally lead to lattice structures with higher elastic modulus.

In summary, the elastic modulus of mesh structures printed using FDM and PolyJet technologies can vary depending on multiple factors, including mesh design, printing parameters [22], material properties, fill density and fill pattern. However, in general, FDM technology is able to produce lattice structures with higher elastic modulus when using the optimal parameters. In the case of Figure 8 and with these parameters already quoted, we found that the diagonal 6x6x6 structure is stiffer than that of the PolyJet technology, and the same with the centred structure.

Based on Table 8 and Figure 9 below, it is true that the choice of the right structure depends on several parameters, including stiffness, lightness, field of use, cost, environmental aspect, and more. Each of those parameters can influence the choice of structure in different ways. For example, stiffness is an important parameter when designing structures that need to withstand compressive or tensile stresses. The diagonal 6x6x6 structure may be a better choice for applications that require high stiffness, as it can resist 2.3 times more than the octet 6x6x6 structure. On the other hand, if the goal is to reduce weight, the octet 6x6x6 structure may be a better choice, as it is 2.09 times lighter than the diagonal 6x6x6 structure.

Table 8.
Percentage of the elasticity modulus derived from the size

Cell structure	Modulus Hooke FDM, %	Modulus Hooke PolyJet, %
OCTET	11.20	15.26
CENTERED	17.86	26.59
DIAGONAL	8.51	56.15

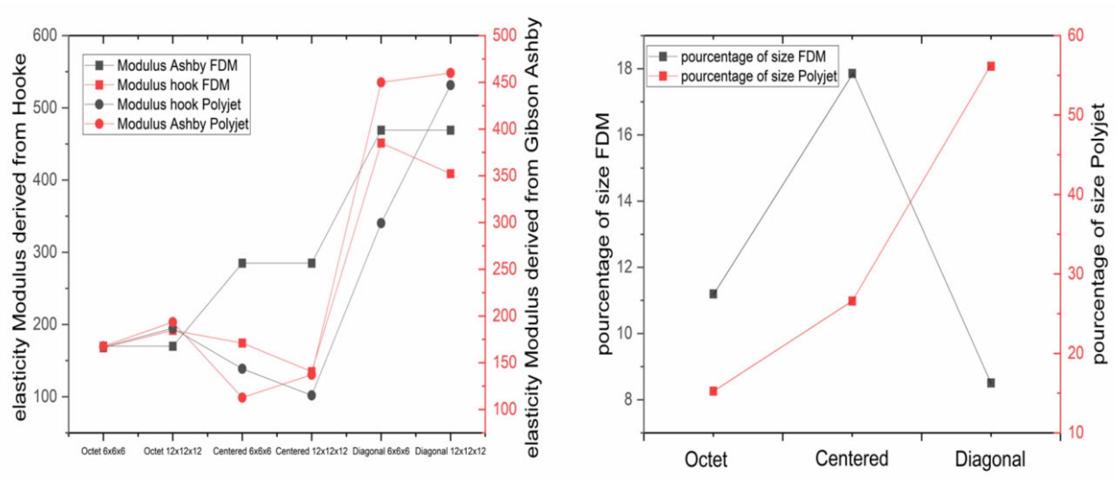


Fig. 8. Comparison of Hook law modulus and Ashby modulus of lattice structures with FDM and PolyJet technology

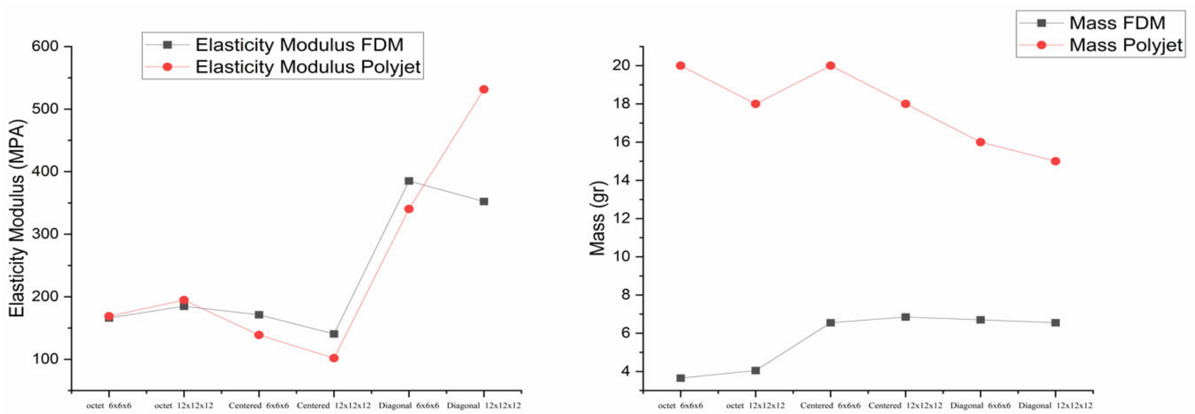


Fig. 9. Comparison of elasticity modulus and mass for lattice structures with FDM and PolyJet technology

In addition to stiffness and lightness, the field of use can also play a role in selecting the right structure. For example, a structure designed for aerospace applications may have different requirements than one designed for building construction. Cost is another important consideration, as some structures may be more expensive to manufacture than others. Environmental factors may also come into play, as some structures may have a larger carbon footprint than others or may be more difficult to recycle.

Ultimately, the best structure for a given application will depend on various factors, and engineers and designers must carefully consider each parameter when deciding. In the case of Young's modulus, the diagonal structure with a unit cell size of 6x6x6 may be the best choice, but other structures may be better suited for different applications.

To achieve the goal, we will fabricate lattice structures with varying parameters, such as cell size, spacer thickness, and fill density. We will then perform mechanical tests, such as compression tests, to evaluate the stiffness and strength of the structures. By analysing the data and correlating it with the manufacturing parameters, we seek to identify the optimal parameters to fabricate lattice structures with the desired mechanical properties. The information can be used to design and fabricate high-performance lattice structures for various applications.

5. Conclusions

The paper proposes using PLA polymer-based reticular structures as a design resource for additive manufacturing, which has potential applications in various industries such as automotive, aerospace, motorsports, energy and medical. The study investigates the mechanical properties of three types of reticular structures: the octet, diagonal and centred, using idea maker software as a manufacturing simulator and machine compression tests based on Hook's law and Gibson-Ashby model.

We must concentrate on impression orientation and component geometries in order to compare the module of elements produced with PolyJet and FDM properly. The orientation of the layers during printing, which can produce anisotropies, affects the mechanical characteristics of 3D-printed items. Therefore, for a fair comparison, it is preferable to align the components of both technologies equally. Furthermore, it is essential to choose the same geometry for PolyJet and FDM prints, considering elements like size, form, and complexity. Any major modifications to these aspects might result in modifications to the module's mechanical properties. The intrinsic variations between PolyJet and FDM technologies, such as resolution, surface quality, and material qualities, may still result in discrepancies, even with equal settings. Therefore, considering the piece's geometry and impression orientation is crucial while considering any variances brought on by variables in technology and material.

The study compares the mechanical properties of two additive manufacturing technologies, FDM and PolyJet, for different sizes and shapes of the reticular structures. The measures compared include mass and stiffness, and the results show that FDM generally has a lower mass and higher stiffness than PolyJet for the same material shape and size. However, the stiffness of the reticular structures varies depending on the shape and size of the material, with the diagonal structure showing the highest stiffness for the 6x6x6 size for both FDM and PolyJet technologies.

In future work, the authors plan to modify printing parameters to achieve a higher stiffness for the reticular structures and further advance the understanding of their mechanical properties and potential applications in various fields.

Overall, the study provides valuable insights into the mechanical properties of PLA polymer-based reticular structures and their potential as a design resource for additive manufacturing in various industries. Still, the choice of material and shape will depend on the specific requirements of the application, as well as the cost and availability of each material shape.

Additional information

The article is part of a presentation at the Casablanca International Conference on Additive Manufacturing 2022 (CASICAM'22) entitled "Mechanical performance of cellular structures in additive manufacturing by Fused Deposition Modeling".

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