BIM AND 3D IMPRESSION

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Abstract

This research is the result of work carried out by the PIE-DIBARQ Group of Educational Innovation ETSEM-UPM during the 2016-2017 courses in its effort to implement a methodology adapted to the new requirements of European Convergence in Higher Education through the use of new technologies and the introduction to them for the students.

Nowadays we are not only teaching conventional techniques, but they´re trying, at least experimentally, to show each student more innovative ways in Architectural Representation. This is the case of the use of computers, and the new language BIM. We are not only referring to the computer-assisted instruction, where the teacher is developing several experimental units as fixing the theoretical concepts taught, but also to the use and knowledge of the computer as an element used by the professional as a graphic expression of their ideas, or studies.

Although the concept of 3D printer has its origin in the 80's it is now taking more and more strength, and it is already starting to be used in many industries. The future of 3D printers is promising and from 2014 we begun to be more familiar with them and for sure we will get better printer with a lower prices.

The 3D printer is considered by the European Space Agency (ESA) as a pioneering invention of the Third Industrial Revolution, as the steam engine and the internal combustion engine were once. The ability to print anything we have in our computer modelling before is a real change in our conception of production, being classified by experts as disruptive technology more powerful than the Internet itself. If it was possible to print parts for spaceships, food and even human organs, the range of possibilities expands the conception of a giant 3D printer in 24 hours can build a house of more than 200 square meters.

Although this is the future of printing the truth it is that when one starts to learn seriously about a 3D printer, discovers with some frustration that the information accessible is rather fanciful. Much is written about the potential of these machines, and we found images of beautiful sculptures of impossible shapes, jewellery or accessories that seem to be taken from a workshop of professional jewellery.

In this paper we will see the problems and resolution of the 3D printing in Architecture.

Keywords: Architectural Education; Edification; projects; new technologies; BIM. 3D Impression

1 INTRODUCTION

The three-dimensional impression, increasingly common in our society, tries to reflect objects using the method of adding the material, by superimposing successive layers, thus creating an object in three dimensions. [4]

There are numerous materials that are used in 3D printing as well as different printing techniques. We have chosen Fused Deposition Modeling (FDM) or Fused Filament Fabrication (FFF). [5]

The additive technique of molten deposition is a technology that consists on depositing molten polymer on a flat base, layer by layer. The material, which is initially in solid state stored in rolls, melts and is expelled by the nozzle in tiny threads that are solidifying as they take the shape of each layer. [6]

In the market there are more than 60 types of materials for 3D printing, among which we can stand out:

- Polylactic acid (PLA).
- Laywoo-d3, composite wood / polymer similar to PLA.26.
- Acrylonitrile Butadiene Styrene (ABS).
- High Impact Polystyrene (HIPS).
- PolyEthylene Terephthalate (PET).
- Thermoplastic Elastomer (TPE).
- Nylon, the most used.

The filaments are characterized by the diameter (millimeters); they are generally sold in reels by weight (kg). In addition to those mentioned above, there are other types of filaments, which due to their mechanical features create the possibility of printing objects with different applications.

This is the case of FILAFLEX, which is a plastic compound to which is added a chemical agent (plasticizer), to increase its flexibility and reduce the melt temperature and viscosity that allows the 3D printers to melt it and give it the desired shape, leaving the final product as a consistent piece that presents as main property to highlight its flexibility. Quality that other compounds lack such as the PLA or plastic of the ABS coils if they are in pure state. [7]

In our case, we want to work with the combination of ABS and FILAFLEX, because the physical and mechanical properties of both filaments, make possible the creation of pieces suitable for construction, which we will explain later. In order to combine such filaments, we need the printer by deposition of the molten material, to consist of at least two print heads.

2 OBJECTIVES

We propose a series of objectives to carry out this investigation.

2.1 General objectives

The main objective is to design a functional part, suitable for building construction in modules, to improve the features of existing bricks, and to provide all the advantages of new 3D printing technologies, in the field of building.

These modules are equivalent in size to the set of four bricks in facade facing, and will be printed in ABS material almost in its entirety, except for a vertical and horizontal membrane of FILAFLEX, which corresponds to the sealing of joints.

As for the method of assembly, it is done by tongue and groove in the vertical joints and union by means of staples in the horizontal joints, how can we observe in Fig. 1.

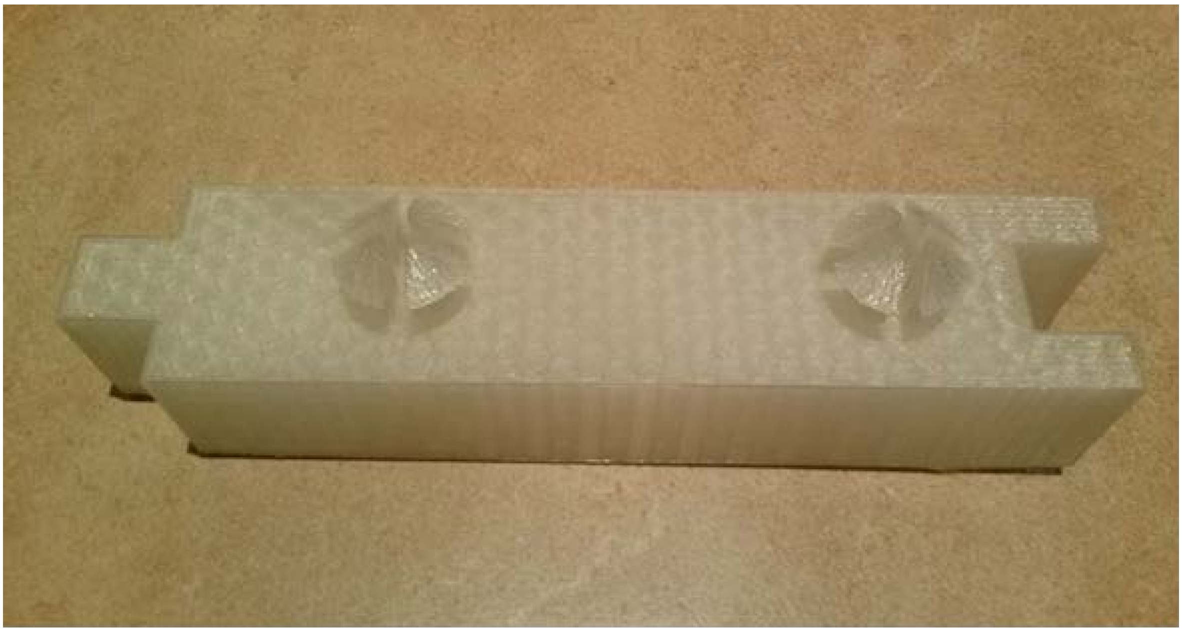

Figure 1. Source of author.

By means of this method of connection, and by the arrangement of the lower holes of the pieces, the installation can be done either "staggered" or "skirting", to guarantee the stability of the whole.

The design of the parts is sought, the speed of execution, the value for money and the ease of acquiring special parts for the realization of the system.

As for the study of the features, these pieces have the peculiarity of both the material with which they are printed and the execution process, and this makes them acquire special features that traditional bricks do not have. Among others, the modular part consists of inner cells that create air chambers that improve its acoustic and thermal features, while lightening the weight of the piece and can thus increase its dimensions.

Once the piece is designed and printed, the laboratory tests are performed for both bricks and plastics, and the results are compared with those of a ceramic brick to be used.

We highlight, among others, the different tests that occur in ceramic pieces.

- Dimensions.
- Face planning.
- Parallelism of faces.
- Geometry and shape.
- Apparent density.
- Absolute density.
- Compressive strength.
- Thermal resistance.
- Resistance to ice / thaw.
- Water absorption.
- Suction.
- Expansion by moisture.
- Soluble salt content.
- Reaction to fire.
- Adherence.

Once the physical and mechanical features of the pieces are known, we will proceed to set new uses, both in the building and construction fields.

2.2 Specific objectives

As regards the specific objectives, in order to design these pieces, we must, in addition to the general dimensions, size the number and dimension of the inner cells to improve their basic features, the transversal division of the staples, to guarantee their rigidity, the printing parameters, both to avoid warping and to streamline printing processes.

We must also determine the type of material for printing; in our case we have chosen ABS, for the following features: [9]

- It is a very impact resistant plastic, making it suitable to withstand inclement weather.
- It is a plastic that undergoes exposure to relatively high temperatures, becomes deformable or even melting, while in case it cools down sufficiently it hardens.
- It is composed of three blocks, acrylonitrile, butadiene and styrene, so it is called terpolymer.
- Each of the three blocks has different features. The acrylonitrile stiffness, resistance to chemical attacks, hardness and stability to high temperatures. Butadiene, temperature
- This mixture of properties makes the final product of great application for the construction and above all, for the manufacture of elements exposed to the elements.

- Its resistance to extreme temperatures, especially when these are of low zero make it a particularly interesting material for cold environments, staying unchanged where others become brittle.
- In addition, it absorbs little water and is easily coated with metallic layers because it is very receptive to metal baths.
- It can also be pigmented in most colours to get a good finish and is non-toxic.
- Not highly flammable, but maintains combustion.

As for FILAFLEX:

- It is the most elastic filament of the market, reaching to reach a 700% of stretch until the break.
- Has a high coefficient of friction.
- It is resistant to gasoline, solvents and acetone.
- Non-toxic, but not approved for medical or food use.
- It does not emit smells; it is totally odourless and does not produce toxic gases.

It is a suitable material, to solve the encounters between modular pieces, to absorb the movements relative to the contractions and dilations of the changes of temperature and to avoid the humidity, either by condensation, capillarity or water leaks.

The binding method of P.T.M.P. (Printed thermoplastic modular piece) is performed both vertically and horizontally to ensure stability of the assembly and avoid movement in any plane.

As mentioned above, for the execution of said pieces, it is necessary to use a printer by deposition of the molten material consisting of two extruders.

It is about depositing or melting the plastic thread through two nozzles without stopping the machine and without any stops during the printing. That is, the same double extruder has two filament outputs to print layer by layer two materials at the same time. It is printed with a nozzle and when the 3D model requires it, the printer calls the second extruder and it automatically starts printing. [8]

This technique is very useful, if one wants to print a piece in multiple colors; with several materials or even if one of them serves as a water soluble support material

3 BACKGROUND-STATE OF ART

Throughout history, there have been several attempts to make pieces, replacing conventional bricks, made with plastic materials, especially underdeveloped countries, due to the scarce material resources and the need to recycle existing materials.

On the contrary, in Eastern countries, which achieve the greatest technological progress, we can know the most advanced 3D printing techniques, which are able to print entire buildings in a few hours, as is the case of the Chinese company WinSun, which had been able to construct by means of printing 3D ten houses in Shanghai, each of them with 200 m2 of surface, at the cost of 30,000 yuans (about 4,800 dollars) and thanks to the use of a printer of enormous size.

In any case, we have not found any research data related to our research, except for the "3D Ceramic-printed Brick" which, after participating in a six-week residency program at the European Ceramic Work Center. His research focused on the process of creating "ceramic on the scale of architecture", including the use of it to create interlaced and stacked bricks (honeycomb bricks). The 3D printing technique is used, but the material is ceramic.

4 THEORETICAL FRAMEWORK

This research aims to improve the properties of traditional bricks, so that in the future, it will be more cost effective to replace them with P.T.M.P.

4.1 General properties of ceramic materials. [10]

- They're hard.
- Non-combustible.
- Non-rusty.
- High resistance to high temperatures.
- Thermal isolation.
- Electrical isolation.
- Great resistance to corrosion and the effects of erosion.
- High resistance to almost all chemical agents.
- Low resistance to stresses.
- Low elasticity.

4.2 Additives used in ceramic materials. [3]

- Degreasers, especially considering blast furnace slag and fly ash from thermal power plant.
- The addition of sodium chloride which, in certain cases, improves drying and combat the caliche explosion.
- The addition of manganese dioxide, frequently used in the production of artificially aged products.
- The addition of crushed limestone, which allows us to reduce the dilations due to humidity.
- The addition of lime, to harden very damp clays.

5 STANDARDS

CTN 136 - CERAMIC MATERIALS OF COOKED CLAY FOR CONSTRUCTION

Ceramic clay pieces and products for construction such as: bricks, blocks, tiles, slabs and boards, in their aspects of definitions, classification, specifications and test methods. [1][2]

International relations.

CEN / TC 125 / WG 1 / TG 1 Masonry. Masonry products. Ceramic Products.

CEN / TC 125 / WG 9 Masonry. Dome of cooked clay.

CEN / TC 128 / SC 3 Discontinuous installation products for roofs and walls. Clay tiles.

CEN / TC 178 / WG 3 Units for pavements and curbs. Ceramic products.

Norma	**UNE-EN 772-19:2001**
Título español	**Métodos de ensayo de piezas para fábricas de albañilería. Parte 19: Determinación de la dilatación a la humedad de los grandes elementos de albañilería de arcilla cocida, perforados horizontalmente.**
Título inglés	Methods of test for masonry units - Part 19: Determination of moisture expansion of large horizontally perforated clay masonry units.
Título francés	Méthodes d'essai des éléments de maçonnerie. Partie 19: Détermination de la dilatation a l'humidité des grands éléments de maçonnerie en terre cuite perforés horizontalement.
Fecha Edición	2001-01-31
	Ver parte del contenido de la norma
Versión confirmada en fecha	2015-04-24
ICS	91.100.15-20 / Productos y materiales de arcilla cocida
Comité	CTN 136 - MATERIALES CERÁMICOS DE ARCILLA COCIDA PARA LA CONSTRUCCIÓN
Equivalencias Internacionales	EN 772-19:2000 - Idéntico

Figure 2. Spanish Association for Standardization and Certification.

6 METHODOLOGY

It is about carrying out some guidelines in research, in order to obtain the aforementioned objectives.

- Design of the piece.
- Study of physical and mechanical features.
- Solve warping problems.
- Print the parts needed to carry out the tests.
- Perform laboratory tests.
- Data collection of the results obtained.
- Analysis of the data obtained.
- Comparison of results and requirements of the standard.
- Improve initial conditions.
- Propose new uses.
- Raise future research lines.
- Last conclusions.

Figure 3. Warping problems.

7 DEVELOPMENT OF THE STUDY

It is necessary to plan in detail the material resources necessary for the realization of the tests, as well as their order, depending on whether it is destructive or non-destructive tests, to economize the process and collaborate with the sustainability of the same.

7.1 Solving warping problems.

There are many ways to resolve warping problems.

School glue.

Common lacquer.

Adhesive of spray contact UHU.

Lacquer (hair spray NELLY).

Kapton's tape and lacquer NELLY in warm bed.

Kapton's tape, lacquer NELLY and ABS Juice in warm bed.

Warping: This is due to the contraction, the material exits the extruder at 260 degrees Celsius, collides with the platform which is about 60, and cools, creating a contraction. The center material pulls away from the corners, causing the corners to rise. In a well calibrated printer and in a normal environment, without direct air currents, warping should not occur, except for parts with a large base surface.

8 COMPARATIVE STUDY

Comprehensive, orderly and concise data collection of all the information in the process is required.

These data will be compared with those found in the regulations, and the difference between the two data will be evaluated, both in numerical index and in percentage, in order to arrive at a correct conclusion.

Figure 4. Solve warping problems.

9 CONCLUSIONS

With this new execution system, we can print on-site, every piece required at any time. Thanks to the properties of ABS, we can improve the conditions of traditional brick.

With the new design of the pieces P.T.M.P. we can streamline construction processes and save costs. One of the most important data to know is the compressive strength of the product, and yes, it can behave like a load element.

The possibility of placing them dry, eliminates a game of execution and makes the construction process simpler, with what this entails. If the pieces P.T.M.P. are more insulation, they will also be more sustainable. Low cost for construction in large quantity.

The main disadvantage is that it does not allow placement error, without the destruction of the piece. In contrast, these pieces are called "foolproof" , they do not admit an error in the placement between them, except for staking errors.

This innovative technique for the manufacture of parts allows it to be very accessible, and for anyone with minimal computer skills to have the possibility to manufacture the part they want at any given time. So you do not need qualified staff for your printing and placement.

With this information we can propose a series of hypotheses based on data that serve as the basis for initiating an investigation.

The pieces P.T.M.P. They may be:

- More affordable, when it comes to special pieces in meetings.
- More agile construction processes.
- Improvement of resistances.
- No bonding mortar required.
- More insulation.
- More sustainable.
- 100% recoverable.
- Lower cost of production on a large scale.
- Less manufacturing power is used.
- Printing in different colors, even translucent.
- Some difficulty in inserting installations inside.
- Lower transport costs.

These hypotheses remain unresolved from the results of the laboratory tests, and their subsequent comparative analysis with a traditional brick.

REFERENCES

[1] UNE-EN 771-1: 2011. Specifications of parts for masonry factory. Part 1: Parts of baked clay. (2011).

[2] UNE-EN 772-1: 2011. Test methods for masonry pieces. Part 1: Determination of compressive strength. (2011).

[3] L. Alviset and G. Arle, “Modification of the properties of the clays by means of additives”, Building materials, vol. 17, nº 126, págs. 55-66, 1967.

[4] Franz Eulate, EMERGING TECHNOLOGIES, 3d print, April 13, 2015.

Obtained from http://tecnoemergentes.host-es.com/t5-impresion-3d.

[5] 3DILLA. 3D PRINTER. Fused deposition modeling. Accessed the May 15, 2017.

Obtained from http://es.3dilla.com/impresora-3d/fused-deposition-modeling/.

[6] C. Escobar, 3D PRINTERS, Types of 3D printers, September 2, 2016.

Obtained from https://impresoras3d.com/blogs/noticias/102883975-tipos-de-impresoras-3d.

[7] QUECARTUCHO. What it is and what you can do with the flexible filament of 3D printers. Accessed the June 16, 2017.

Obtained from https://quecartucho.es/blog/que-es-y-que-se-puede-hacer-con-el-filamento-flexible-de-impresoras-3d/.

[8] S. Casal Otero, KILO3D, How to print in 3D with double extruder, July 28, 2016.

Obtained from http://kilo3d.com/como-imprimir-en-3d-con-doble-extrusor/.

[9] C. Escobar, 3D PRINTERS, The ABS printing material and its features, May 13, 2013.

Obtained from https://impresoras3d.com/blogs/noticias/102832135-el-material-de-impresion-abs-y-sus-caracteristicas.

[10] P. Landin, PELANDINTECNO, Ceramic materials: properties, classification and obtaining, February 7, 2013.

Obtained from http://pelandintecno.blogspot.com.es/2013/02/materiales-ceramicos-propiedades.html.