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Transforming Campus Plans into Tangible Models: A 3D printing Journey at SIET College campus

GOPINATH.G[a] , HARIHARAN.T[a] , SARAN D.K [a] ,VARUN K.R [a], PURUSHOTH KUMAR .D [a] and S. DEEPIKA [b].

[a] *Research scholar, Department of civil Engineering, Sri Shakthi college of engineering and technology.*
[b] *Guide, Ph.D Scholar, Department of civil engineering , Sri Shakthi college of engineering and technology*

ABSTRACT
The 3D model of Sri Shakthi College of Engineering and Technology's academic block, spanning dimensions of 200x200 units, encapsulates the essence of architectural brilliance and educational vitality. Through a meticulous blend of digital prowess and architectural finesse, this project aims to provide a comprehensive visualization of the institution's academic nucleus. In the introduction, the significance of Sri Shakthi College as an emblem of academic excellence underscored, highlighting the pivotal role of the academic block in fostering innovation and learning. Methodologically, detailed blueprints and architectural schematics were utilized to ensure precision in modeling, with cutting-edge software like AutoCAD, Revit and SketchUp employed for digital rendition. Each facet of the academic block was sculpted with precision, incorporating textures, lighting, and landscaping elements to enhance realism and evoke the ambiance of the actual site. The primary aim of this endeavor is to offer stakeholders an immersive experience, facilitating better understanding and appreciation of the structural design while serving as a valuable tool for prospective students, faculty, and visitors to the institution. In conclusion, the 3D model stands as a testament to Sri Shakthi College's commitment to excellence, embodying the spirit of innovation and learning within its virtual corridors and courtyards, and serving as a visual masterpiece that celebrates the institution's architectural and educational legacy.

KEYWORDS
3D model- Academic block-Revit- Structural design- Stakeholders

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I. INTRODUCTION

3D building models continue to prove themselves useful for a wide range of applications, across real estate, urban planning, and disaster management. Their applications can be classified into either visual or non-visual instances. In the former, attention is placed on the visual fidelity and aesthetic appeal and not necessarily much on accuracy and quality, e.g. visualization of apartments for real estate. In particular, 3D building models are convenient for estimating the volume and envelope area of buildings, operations previously not possible with traditional building information such as footprints, which are without a volumetric representation. [1]. Integration of Artificial Intelligence into the design process has the potential to revolutionize the way architects and designers approach their work.

The AI-aided generative design leverages the computational power of AI to generate design alternatives, taking into consideration the constraints of the project and the designer's multi objectives. This approach can help designers to overcome the limitations of traditional design processes, where generating numerous design options is time-consuming and requires significant manual effort. [2]. Using generative models for building volume generation, this study hypothesizes that after feeding a decent amount of data and iterative training, the generative network will map the complex building shape to a lower-dimensional latent vector, which captures the abstract and high-level core features of the intaking architecture style. [2].

3D generative models of objects are used in many computer vision and graphics applications. Present methods for constructing such models typically require either significant amounts of 3D data processed through specialized pipelines, substantial manual annotation, or extremely large amounts of 2D data. [3] . Three-dimensional (3-D) city models or geographic information systems (GIS)-based 3-D landscape analyses are crucial for urban planning, disaster management, virtual tourism, 3-D GIS, and other applications. [4]. This article reveals the 3D model of a college building with the data collected from the location and dimensions of the college.

1. THEORITICAL BACKGROUND

1. Introduction to the Maker Movement and 3D Printing

The maker movement is a contemporary cultural trend that emphasizes hands-on, technology-based, learning-through-doing activities. It is closely associated with the do-it-yourself (DIY) ethos, encouraging individuals to engage in the creation and modification of physical objects through the use of various technologies. 3D printing is a pivotal technology within the maker movement, allowing for the transformation of digital designs into physical objects. This process embodies the principles of the maker movement, where learning is achieved through practical, iterative experimentation and innovation. The accessibility and versatility of 3D printing have made it a cornerstone of maker culture, facilitating creative expression and problem-solving.

2. Social Constructivism and the Maker Movement

Social constructivism, a theory developed by Lev Vygotsky, posits that learning is inherently a social process. According to this theory, knowledge is constructed through social interactions and collaborative activities. In the context of the maker movement, social constructivism underscores the importance of community, collaboration, and shared experiences in the learning process. Makerspaces, which are communal workspaces equipped with tools and technologies such as 3D printers, serve as hubs for social learning. In these spaces, individuals collaborate, share ideas, and collectively solve problems, thereby constructing knowledge together. The maker movement's emphasis on community and collaboration aligns closely with the principles of social constructivism.

3. Constructionism and Hands-On Learning

Constructionism, introduced by Seymour Papert, extends constructivist theories by emphasizing the significance of creating tangible artifacts as a means of learning. Papert argued that individuals learn best when they are actively involved in constructing something meaningful. 3D printing exemplifies constructionism, as it allows learners to bring their digital designs to life, creating physical models that they can interact with and refine. This hands-on, iterative process of designing, printing, and modifying models facilitates deep learning and understanding. Through constructing physical objects, learners can concretize abstract concepts, making learning more engaging and effective.

4. Active Learning in the Maker Movement

The maker movement promotes active learning, a pedagogical approach where learners are actively engaged in the learning process rather than passively receiving information. In the context of 3D printing, active learning involves designing, prototyping, and testing models. This process requires critical thinking, problem-solving, and creativity. Students must apply their knowledge and skills to overcome challenges and improve their designs. The iterative nature of 3D printing, where failures and mistakes are viewed as opportunities for learning and improvement, fosters resilience and adaptability. Active learning in the maker movement encourages students to take ownership of their learning, resulting in a more meaningful and personalized educational experience.

5. Impact on Educational Practices and Future Prospects

The integration of the maker movement and 3D printing into educational practices has profound implications for teaching and learning. By aligning with the theories of social constructivism and constructionism, educators can create learning environments that are collaborative, hands-on, and student-centered. Makerspaces equipped with 3D printers can be incorporated into curricula across various disciplines, promoting interdisciplinary learning and innovation. As 3D printing technology continues to evolve, its applications in education will expand, offering new opportunities for experiential learning. The maker movement's emphasis on creativity, collaboration, and active learning will continue to inspire educational practices, preparing students for the challenges and opportunities of the future

II. 3D PRINTING TECHNOLOGY AND MATERIALS

The starting point for any 3D printing process is a 3D digital model, which can be created using a variety of 3D software programs, for Makers and Consumers there are simpler, more accessible programs available or scanned with a 3D scanner. The model is then 'sliced' into layers, thereby converting the design into a file readable by the 3D printer. The material processed by the 3D printer is then layered according to design and process. As stated, there are a number of different types of 3D printing technologies, which process different materials in different ways to create the final object . [5]

The idea of 3D printing was born already in 1983, when Charles W. Hull came up with an idea of hardening the tabletop coatings with the UV light. This simple thought has lead him to invention of stereolithography, first technology of 3D printing. Stereolitography was the first technology of rapid prototyping which means fast, precise and repeatable production of elements usually with computer support. First step in creating the technology was invention of additions to the synthetic resins that after lightening of the resins, were causing start of the polymerisation process. Stereolitography is a technology that can build objects with a high precision and extremely complicated geometry and that's the reason why it is used in many fields like for example: medicine, automotive and plane industry, and even art and design.

Similar technique for 3D printing is selective laser sintering (SLS) in which laser is used to melt a particles of powder together to create an object. Materials used in SLS technology usually have high strength and flexibility. The most popular ones are nylon or polystyrene. Fused deposition modeling FDM is a technology that was invented in 1988 by S. Scott Crump .

Ductile materials which are hardening itself during cooling process, are extruded through double headed nozzle. Both, modelling and supportive materials are being deposited according to the cross-section layers, generated from digital model supporting the printer. The nozzle contains resistive heaters that keep the filament in appropriate melting point, which allows it to flow easily through the nozzle, in case to form the layers. Like in the other technologies, after creating one layer, a platform is being lowered and next layer is created. This process is repeated until the whole object is completed. Materials usually used in FDM technology are called filaments and are used in printers as a rolls of thermoplastic materials like ABS (Acrylonitrile Butadiene Styrene) or PLA (Polylactic Acid) – which is a completely different kind of thermoplastic . [6]

III. 3D PRINTING TECHNOLOGY IN CONSTRUCTION METHODS

There is no one-size-fits-all 3D printing construction technology. Depending on the specifics of the project, different printing methods can be employed. These are the most common:

- **Extrusion:** Extrusion is the most common 3D printing technique as it can be used in almost all environments. Commonly used for modeling, prototyping and production applications, this method creates an object by layering material back and forth through one or more nozzles mounted on a robotic arm, gantry system or crane.

- **Powder Bonding:** Contrary to other 3D printer construction methods, powder bonding uses powdered raw material as its main component. There are two methods: powder bed jetting and binder jetting. The first is characterized by melting dust particles with a laser on the desired object layer by layer, while a coating sheet adds more material for each new layer.

On the other hand, the binder jetting uses a print head that deposits a liquid adhesive agent on the powder printing bed. The liquid binds the powder particles together to form each layer of the desired object. Then a new layer is added, and the process is repeated layer by layer. This one allows printing with a higher level of accuracy and can handle more complex prints.

- **Spray:** The autonomous robot sprays the construction material under pressure in the desired shape and repeats the process layer by layer. This method allows to fill the spaces of the structure with concrete, and its use is currently being studied for vertical and outstanding applications such as facades or ceiling decorations. [7]

IV. ENERGY AND ENVIRONMENTAL BENEFITS OF 3D-PRITING IN CONSTRUCTION

The referred studies either discussed, analyzed, or substantiated a wide range of benefits of 3D-printing in construction such as reduced time, material use and cost as well as maximized quality, design performance, efficiency, and productivity. Because each of these benefits relates to building design, material use, and construction processes, it can be mapped to one or more of the four major life cycle energy components of a building: (1) initial embodied energy (IEE); (2) operating energy (OE); (3) recurrent embodied energy (REE); and (4) demolition energy (DE) .

IEE is consumed directly in onsite and offsite construction, installation, fabrication, transportation, management, and other related processes and indirectly through the use of materials, assemblies, equipment, and vehicles, each of which consumes energy during its manufacturing process . As over 90% of IEE is attributed to material use, any material and waste savings generated by 3D- printing technology could help reduce IEE significantly.

When occupied, a building consumes OE in the processes of heating, cooling, lighting, and powering building appliances . Because 3D-printing technologies allow printing with materials and complex geometries to gain multi-dimensional and dynamic thermal properties, OE use could also be potentially lowered by reducing heating, cooling, and lighting loads. During the use phase, REE is consumed through construction products and processes involved in maintenance, repair, replacement, and renovation processes, which could also be reduced by 3D-printing with advanced materials with longer service life and lower maintenance requirements .

At the end-of-life, DE is used in building demolition, materials reuse and recycling, and disposal processes, which can also be enhanced by 3D-printing with highly recyclable and reusable materials . Any savings of embodied and operating energy could generate proportional savings in associated carbon emissions. [8]

2. TRENDS FOR IMPROVING 3DP

The biggest developments in 3DP have been, so far, in the material and printing systems. For the material, the focus is on the fresh properties, workability, extrudability and pumpability, and structural properties [119]. The research in 3D concrete printing can be divided into two key areas, controlling rheological properties, and improving structural performance. Controlling the material's rheology, through high yield stress and low plastic viscosity, is essential to ensure buildability. [9]

3. THREE-DIMENSIONAL PRINTING TECHNIQUES

According to different working principles, 3D printing technologies can be divided into three categories: PBF, light curing, and FDM**.**

3.1 Powder Bes Fusion(PBF)

Any powdered material, which can be sintered or fused by laser radiation and solidified by cooling, could be suitable for laser sintering or fusion technologies. According to the energy sources and powder materials, PBF is divided into the following printing technologies: selective laser melting (SLM), selective laser sintering (SLS), electron beam melting (EBM), and direct metal laser sintering (DMLS). All these technologies use heat to melt powdered materials.

In dentistry, PBF is used to manufacture all kinds of metal products including AM titanium (Ti) dental implants, custom subperiosteal Ti implants, custom Ti mesh for bone grafting-techniques, cobalt-chromium (Co-Cr) frames for implant impression procedures, and Co-Cr and Ti frames for dental implant-supported prostheses. Moreover, PBF shows considerable potential for manufacturing ceramic restorations, which can be used to manufacture frame crowns, model casting abutments, and models. [10]

3.2 Light Curing

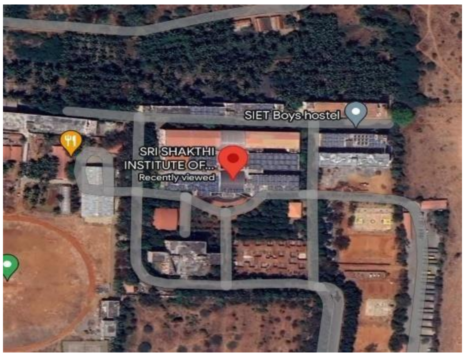
Light curing technology is a general term for a type of 3D printing technologies using photosensitive resin materials that are cured and molded under light irradiation. It consists of three main technologies: SLA, digital light processing (DLP), and photo jet (PJ). The printing process in SLA and DLP technologies can be divided into three discrete procedures: light exposure, building platform movement, and resin refilling.

3.3 Fused Depositing Modelling(FDM)

FDM is one of the most popular and cheap 3D printing technologies in dentistry. The filamentous thermoplastic material is heated and melted by the nozzle. Under the control of the computer, the nozzle and worktable move in the *X*- and *Y*-axis directions, respectively, and the material in the molten state is extruded and finally solidified through the accumulation of materials layer-by-layer to form the product.

4. LOCATION, DATA AND OUTPUT

4.1 Location



Sri Shakthi Institute Of Engineering And Technology, L & T Bypass Road, Coimbatore - 641062

4.2 Data Collection

Academic Block

The Academic block of the college is taken for the 3D printing. The specifications of the particular block are noted below.

1. There are several class rooms located in the ground floor, first floor, second floor and in the third floor
2. Rest room area is located both in the first floor and the second floor

3. U shaped stairs are constructed for the passage of floors
4. Circular portico is constructed relating all the floors
5. Class rooms differ in their sizes based on their area of location

5. APPLICATIONS OF 3D PRINTING IN CONSTRUCTION

Several applications of 3D printing in civil engineering have been demonstrated successfully. The Eindhoven University of Technology designed a new type of 3D printer, which can print constructions with high accuracy in 2015. In 2016, the first multi-story building was printed using the same method, and it has been already used as the Museum of the Future in Dubai. It was printed in Shanghai by WinSun Company in 17 days. The building was shipped to Dubai and assembled in two days. The cost of the building was approximately US$140,000 and the area was 242 m^2. 3D printing reduced labor costs by 50–80% and reduced waste by 30–60%

WinSun showed that AC could be implemented to the tall building constructions by building a five-story building. The company also printed an 1100 m^2 villa. The company stated that it had used ground construction and industrial waste around a base of quick-drying concrete mixed with a special hardening agent. The company is aiming to build large-scale structures in the future, such as bridges and skyscrapers. [11]

6. PREPARATION OF COMPUTER MODELS FOR 3D PRINTING

So far we have discussed issues related to physical part of the manufacturing process. These are of course the key issues for the adoption of 3D printing technology. An important element is however also preparation of computer model for the parts to be manufactured. Fortunately, the level of 3D computer graphics both in terms of software and hardware makes it possible to build such digital models without much difficulties. It can be done using many commercial as well as Open Source software packages. [12]

7. RESEARCH LIMITATIONS/IMPLICATIONS

Online business seems to be beneficial for user entrepreneurship in 3D printing. Policy makers can foster user entrepreneurship by expanding entrepreneurship education and lowering administrative barriers of business foundation. [13]

8. MAIN CHALLENGES

Despite the benefits of 3D printing such as the freedom of design, customisation and the ability to print complex structures, there are a few drawbacks that would require further research and technological development. These drawbacks include high costs, limited applications in large structures and mass production, inferior and anisotropic mechanical properties, limitation of materials and defects. The research and development of materials and methods have helped to circumvent some of these drawbacks.

V. CONCLUSION

Overall, the potential of 3D printing is too great to ignore. While the industry may never reach a point where it's used exclusively, it's only a matter of time that the technology will be improved and advance significantly. Overall, 3D printing is poised to be a viable solution that offers key benefits in cost savings and environmental friendliness for our building's future.

References

[1]. F. B. Hui En Pang, 3D building reconstruction from single street view images using deep learning, vol. 112, no. August, 2022.
[2]. Y. J. L. C. Xinwei Zhuang, Synthesis and generation for 3D architecture volume with generative modeling, vol. 21, no. 2, 2023.
[3]. B. E. &. J. T. Skylar Sutherland, Building 3D Generative Models from Minimal Data, vol. 132, pp. 555-580, 2023.
[4]. J. L. Byungyun Yang, Improving accuracy of automated 3-D building models for smart cities, 2017.
[5]. Y. C. K. Mehmet Sakin, 3D Printing of Buildings: Construction of the Sustainable Houses of the future by BIM, vol. 134, pp. 702-711, 2017.
[6]. A. G. R. P. Izabela Hager, 3D printing of buildings and building components as the future of sustainable construction, vol. 151, 2016.
[7]. How 3D printing in the construction industry works, 2013.
[8]. M. K. Dixit, 3-D Printing in Building Construction: A Literature Review of Opportunities and Challenges of Reducing Life Cycle Energy and Carbon of Buildings, 2019.
[9]. A. S. N. S. Pessoa, 3D printing in the construction industry - A systematic review of the thermal performance in buildings, vol. 141, 2021.
[10]. C. C. X. X. Yueyi Tian, A Review of 3D Printing in Dentistry: Technologies, Affecting Factors, and Applications, 2021.
[11]. G. I. E. S. S. S. Md. Hazrat Ali, A critical review of 3D printing and digital manufacturing in construction engineering, 2022.
[12]. A. G. ,. R. P. Izabela Hager, 3D printing of buildings and building components as the future of sustainable construction, 2016.
[13]. R. J. B. A. A. S. E. J. S. Patrick Holzmann, User entrepreneur business models in 3D printing, 2017.
[14]. Izabela Hager, Anna Golonka, Roman Putanowicz , 3D printing of buildings and building components as the future of sustainable construction?, International Conference on Ecology and new Building materials and products, ICEBMP 2016