

# Design and Prototype of a 3D Printed House Model

**Kandekar Sonali Valmik**

Department of Civil Engineering,  
Amrutvahini College of Engineering,  
Sangamner-422608

**Khatal Kishori Dipak**

Department of Civil Engineering,  
Amrutvahini College of Engineering,  
Sangamner-422608

**Gondake Manisha Baban**

Department of Civil Engineering,  
Amrutvahini College of Engineering,  
Sangamner-422608

**Kokate Prashant Laxman**

Department of Civil Engineering,  
Amrutvahini College of Engineering,  
Sangamner-422608

**Prof. M. A. Nawale**

Department of Civil Engineering,  
Amrutvahini College of Engineering,  
Sangamner-422608

**Abstract—** The project titled “Design and Prototype of a 3D Printed House Model” focuses on the application of 3D printing technology in modern construction practices. The main objective of this project is to design and develop a small-scale prototype of a house using additive manufacturing techniques and to study its advantages over traditional construction methods. The project demonstrates how layer-by-layer fabrication can reduce construction time, labor dependency, and material wastage while improving design flexibility and precision.

The house model was first designed using Computer-Aided Design (CAD) software and then converted into an STL format for slicing and G-code generation. The prototype was fabricated using a 3D printer with suitable printing material such as PLA filament. Various parameters including print quality, dimensional accuracy, material consumption, and printing time were analyzed during the development process.

**Keywords:**

*3D Printing, Additive Manufacturing, House Prototype, CAD Modeling, Sustainable Construction, PLA Filament, Rapid Prototyping, Construction Automation, Smart Housing, Civil Engineering.*

## I. INTRODUCTION

In recent years, 3D printing technology, also known as additive manufacturing, has emerged as one of the most advanced innovations in the field of construction and civil engineering. Unlike traditional construction methods, where materials are cut, shaped, and assembled manually, 3D printing builds structures layer by layer directly from a digital model. This technology offers improved precision, reduced material wastage, faster construction speed, and greater design flexibility compared to conventional building techniques [1].

The construction industry faces several challenges such as increasing labor costs, shortage of skilled workers, long project durations, excessive material consumption, and environmental pollution caused by conventional construction activities [2]. Traditional methods require multiple stages including formwork, curing, plastering, and

finishing, which increase overall construction time and project cost [3]. In addition, construction waste generated from concrete, bricks, timber, and steel significantly affects environmental sustainability [4].

To overcome these limitations, researchers and engineers are exploring 3D printing as a modern solution for rapid and sustainable construction. In construction-based 3D printing, specially designed printers deposit concrete or other printable materials layer by layer according to a computer-generated design [5]. This automated process minimizes human intervention and improves dimensional accuracy while reducing construction errors [6]. Furthermore, 3D printing enables the creation of complex architectural shapes and customized housing structures without requiring expensive formwork or additional labor [7].

The application of 3D printing in housing construction has gained significant attention due to its potential to provide affordable and eco-friendly housing solutions. Large-scale 3D printers can construct walls and structural components within a shorter duration compared to traditional methods [8]. The technology also supports the use of sustainable materials such as geopolymers, concrete, and recycled construction materials, which help reduce carbon emissions and environmental impact [9]. As a result, 3D printing is considered a promising technology for future smart cities, disaster-relief housing, and low-cost residential projects [10].

## II. PROBLEM STATEMENT

The construction industry is currently facing major challenges related to increasing construction costs, shortage of skilled labor, excessive material wastage, long project completion time, and environmental pollution caused by traditional building methods. Conventional construction techniques require multiple manual processes such as brick masonry, formwork, curing, plastering, and finishing, which not only increase labor dependency but also reduce efficiency and productivity. Additionally, traditional methods generate a large amount of construction waste and consume significant natural resources, leading to sustainability concerns and higher carbon emissions. Rapid

urbanization and growing population have further increased the demand for affordable and fast housing solutions, especially in developing regions and disaster-prone areas where immediate shelter construction is essential. Existing construction practices often fail to provide economical, eco-friendly, and time-efficient housing systems capable of meeting modern infrastructure demands.

### III. OBJECTIVES

- To study the working principles and applications of 3D printing technology in the construction industry.
- To design a detailed house model using Computer-Aided Design (CAD) software suitable for 3D printing.
- To develop a small-scale prototype of a 3D printed house using additive manufacturing techniques.
- To analyze the printing process, including slicing, G-code generation, and parameter settings for accurate fabrication.
- To evaluate the prototype based on dimensional accuracy, material usage, printing time, and structural stability.

### IV. LITERATURE SURVEY

**Khoshnevis (2004)** presented an innovative construction approach in the paper “Automated Construction by Contour Crafting: Related Robotics and Information Technologies,” where the concept of large-scale automated 3D printing for buildings was introduced. The study highlighted how contour crafting technology could reduce construction time, labor dependency, and material waste through automated layer-by-layer fabrication. However, the research mainly focused on conceptual development and lacked practical implementation details for real-world housing projects.

**Buswell et al. (2018)** discussed the future scope and challenges of concrete-based 3D printing in their paper “3D Printing using Concrete Extrusion: A Roadmap for Research.” The authors explained extrusion techniques, material behavior, and printing accuracy in construction applications. The study emphasized the potential of sustainable and rapid construction methods but identified limitations related to structural reinforcement, interlayer bonding, and standardization.

**Perkins and Skitmore (2015)** reviewed the applications of additive manufacturing in construction through their paper “Three-Dimensional Printing in the Construction Industry: A Review.” The research analyzed the benefits of 3D printing such as reduced labor costs, faster project execution, and improved design flexibility. However, the study concluded that large-scale adoption is limited due to high equipment costs and the absence of universal construction standards.

**Wu, Wang, and Wang (2016)** conducted a critical review in the paper “A Critical Review of the Use of 3D Printing in the Construction Industry,” where they compared traditional construction techniques with additive manufacturing methods. The authors highlighted advantages including reduced waste generation and automated construction

processes. Despite these benefits, the paper noted challenges related to material strength, durability, and scalability for multi-story structures.

**Lim et al. (2012)** presented advancements in large-scale additive manufacturing in their study “Developments in Construction-Scale Additive Manufacturing Processes.” The research focused on concrete printing technologies and their application in building components and housing systems. The study demonstrated improved precision and faster fabrication but reported difficulties in maintaining print consistency and structural integrity during large-scale construction.

**Zhu et al. (2021)** explored sustainable materials for construction printing in the paper “Properties of Sustainable 3D Printed Concrete using Recycled Materials.” The authors investigated the use of recycled aggregates and eco-friendly concrete mixtures to reduce environmental impact. The study showed promising results in sustainability and printability; however, long-term durability and mechanical performance under varying environmental conditions still require further investigation.

#### Comparison Table

| Author & Year             | Method Used                               | Advantages                                     | Limitations                            |
|---------------------------|-------------------------------------------|------------------------------------------------|----------------------------------------|
| Khoshnevis (2004)         | Contour Crafting Technology               | Fast automated construction, reduced labor     | Lack of real-world implementation      |
| Buswell et al. (2018)     | Concrete Extrusion 3D Printing            | Improved printing precision and sustainability | Reinforcement and bonding challenges   |
| Perkins & Skitmore (2015) | Additive Manufacturing Review             | Reduced construction time and waste            | High equipment cost                    |
| Wu et al. (2016)          | Comparative Study of 3D Printing          | Automation and design flexibility              | Scalability issues for large buildings |
| Lim et al. (2012)         | Construction-Scale Additive Manufacturing | Faster fabrication and high accuracy           | Structural consistency problems        |
| Zhu et al. (2021)         | Sustainable 3D Printed Concrete           | Eco-friendly and recyclable materials          | Durability concerns                    |

### IV. WORKING OF SYSTEM

The working of the proposed 3D Printed House Model is carried out through a systematic process that converts a digital house design into a physical prototype using additive manufacturing technology. The complete workflow involves CAD modeling, slicing, G-code generation, 3D printing,

assembly, and evaluation of the final prototype. The system operates in the following stages:

### 1. Conceptual Design and CAD Modeling



Fig.1. Conceptual Design

The process begins with preparing the conceptual layout and floor plan of the house model according to the required dimensions and structural arrangement. The house model is designed using CAD software such as AutoCAD, SketchUp, or Fusion 360. The digital model includes walls, roof structure, doors, windows, and internal partitions. Proper wall thickness and structural detailing are maintained to ensure printability and dimensional accuracy.

### 2. STL Conversion and Slicing Process

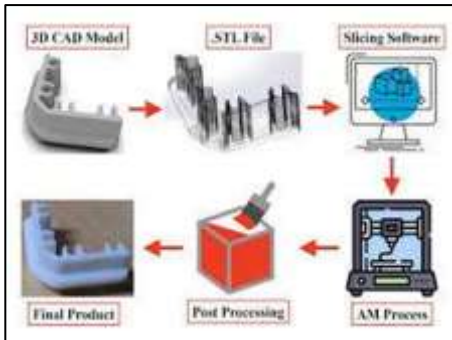


Fig.2. Slicing Process

After completing the CAD model, the design is exported into STL (Standard Triangle Language) format, which is compatible with slicing software. The STL file is imported into software such as Cura or PrusaSlicer, where the model is sliced into multiple horizontal layers. **G-Code Generation and Parameter Setup**

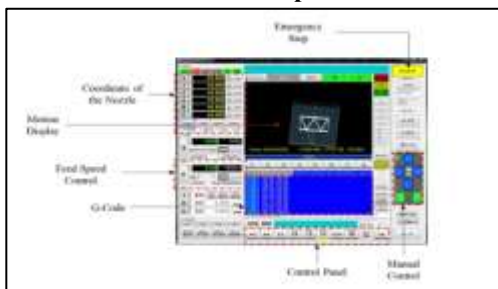


Fig.3. Parameter Setup

Once slicing is completed, the software generates G-code, which contains machine-readable instructions for the 3D printer. Printing parameters such as nozzle temperature, bed temperature, print speed, infill percentage, and support settings are configured according to the selected material. The generated G-code is transferred to the printer through USB or SD card for prototype fabrication.

### 4. Prototype Printing Process



Fig.3 Printing Process

The physical printing process begins by leveling the print bed and loading the printing material such as PLA filament into the 3D printer. The printer nozzle deposits the material layer by layer according to the G-code instructions. Each layer gradually forms the structure of the house model until the complete prototype is fabricated. Continuous monitoring is carried out to avoid printing defects such as warping, layer shifting, or nozzle blockage.

### 5. Removal and Assembly of Printed Parts



Fig.4. Removal and assembly of printed parts

After printing is completed, the prototype is carefully removed from the print bed. Support materials are removed, and surface finishing such as sanding or cleaning is performed if required. If the house model is printed in separate sections, the components are assembled using adhesive or interlocking joints to form the final structure.

### 6. Evaluation and Final Prototype Analysis



Fig.5. Final Prototype

The final prototype is evaluated based on dimensional accuracy, printing quality, material consumption, and total printing time. The printed dimensions are compared with the original CAD model to identify deviations or defects. Parameters such as surface finish, structural stability, and layer bonding are analyzed. The observations and results are documented for future improvements and project validation.

## V. SYSTEM DESIGN

### 1. Input and Design Module

This module is responsible for creating the conceptual layout and digital design of the house model. The structure of the house including walls, doors, windows, roof, and interior partitions is designed using CAD software such as AutoCAD, SketchUp, or Fusion 360. Proper dimensions and wall thickness are maintained to ensure the model is suitable for 3D printing and structurally stable.

### 2. STL Conversion and Slicing Module

After completing the CAD design, the model is converted into STL (Standard Triangle Language) format, which is compatible with slicing software. The slicing software divides the 3D model into thin horizontal layers and generates the layer-by-layer printing path. Parameters such as layer height, print orientation, infill percentage, and support structures are configured in this stage.

### 3. G-Code Generation Module

This module converts the sliced model into machine-readable G-code instructions that control the movement of the 3D printer. The G-code contains information related to nozzle movement, extrusion rate, print speed, layer thickness, nozzle temperature, and bed temperature. These instructions guide the printer during the fabrication process.

### 4. 3D Printing Module

The 3D printing module performs the actual fabrication of the house prototype using additive manufacturing technology. The printer deposits material layer by layer according to the generated G-code instructions. PLA filament or similar printable material is used for prototype development. This process ensures high precision, reduced material wastage, and faster model fabrication.

### 5. Assembly and Finishing Module

After printing, the prototype components are carefully removed from the print bed. Support materials are removed, and surface finishing processes such as sanding or cleaning are carried out if necessary. If the house model is printed in multiple sections, the parts are assembled using adhesives or interlocking joints to obtain the final structure.

### 6. Evaluation and Analysis Module

The final prototype is analyzed based on dimensional accuracy, material consumption, printing quality, and total printing time. The printed model is compared with the original CAD design to identify defects such as layer gaps, warping, or dimensional deviations. The observations and results are documented to evaluate the efficiency and feasibility of 3D printing technology in construction applications.

## VI. RESULTS



Fig 6.Final Output

The developed project successfully demonstrated the design and fabrication of a 3D printed house model prototype using additive manufacturing technology. The CAD model was accurately designed and converted into STL format for slicing and G-code generation. The prototype was printed successfully using PLA filament with proper dimensional accuracy and structural stability. The printing process showed smooth layer-by-layer material deposition with minimal material wastage and reduced manual effort compared to conventional model-making methods.

The final printed prototype achieved good surface finish, proper alignment of walls, roof, and openings, and satisfactory dimensional precision according to the designed CAD model. The total printing time and material consumption were effectively optimized through proper slicing settings and print parameter selection. The study also proved that 3D printing technology can significantly reduce construction complexity, labor dependency, and fabrication time while allowing greater flexibility in architectural design.

The project highlighted the practical feasibility of using 3D printing in construction-related applications such as low-cost housing, rapid prototype development, sustainable building systems, and smart construction practices. The obtained results indicate that additive manufacturing has strong potential to transform traditional construction methods into faster, more economical, and environmentally friendly processes.

## VII. CONCLUSION

The project titled "Design and Prototype of a 3D Printed House Model" successfully demonstrated the application of additive manufacturing technology in the field of construction and civil engineering. The study involved the complete workflow of designing a house model using CAD software, converting it into STL format, performing slicing operations, generating G-code, and fabricating the prototype using a 3D printer. The final prototype was developed with good dimensional accuracy, structural stability, and proper surface finish.

The project proved that 3D printing technology can significantly reduce construction time, material wastage, and labor dependency when compared to traditional construction

methods. The layer-by-layer fabrication process provided better precision and design flexibility, allowing the creation of complex architectural structures with minimal manual effort. The use of digital modeling and automated manufacturing also improved efficiency and reduced the possibility of human error during fabrication. Furthermore, the project highlighted the future potential of 3D printing technology for sustainable and affordable housing solutions. The technology can play an important role in rapid construction, disaster-relief housing, smart city development, and eco-friendly infrastructure systems. Overall, the developed prototype successfully validates the feasibility and effectiveness of 3D printing as an innovative solution for modern construction practices.

### VIII. FUTURE SCOPE

The future scope of 3D printing technology in construction is highly promising due to its ability to provide rapid, cost-effective, and sustainable building solutions. In the coming years, large-scale 3D printers can be used for constructing complete residential and commercial buildings with minimal human intervention. Advanced printable materials such as fiber-reinforced concrete, geopolymer concrete, and recycled construction materials can further improve the strength, durability, and environmental sustainability of printed structures. Integration of technologies like Artificial Intelligence (AI), Building Information Modeling (BIM), robotics, and IoT can make the construction process more automated, accurate, and efficient. Future research can also focus on multi-story 3D printed buildings, improved reinforcement techniques, and smart housing systems with embedded electrical and plumbing components. Additionally, 3D printing can play a major role in disaster-relief shelters, low-cost housing projects, and sustainable smart city development. With continuous advancements in material science, automation, and digital fabrication, 3D printing technology has the potential to revolutionize the global construction industry and replace many limitations of traditional construction methods.

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