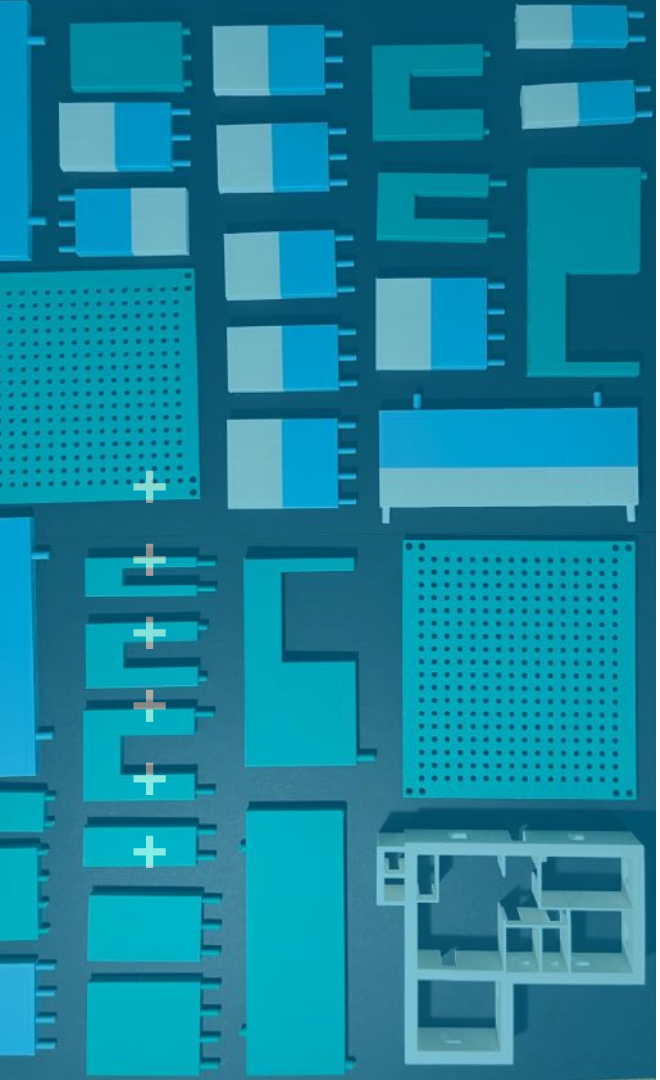


Compact Living with 3D Printing

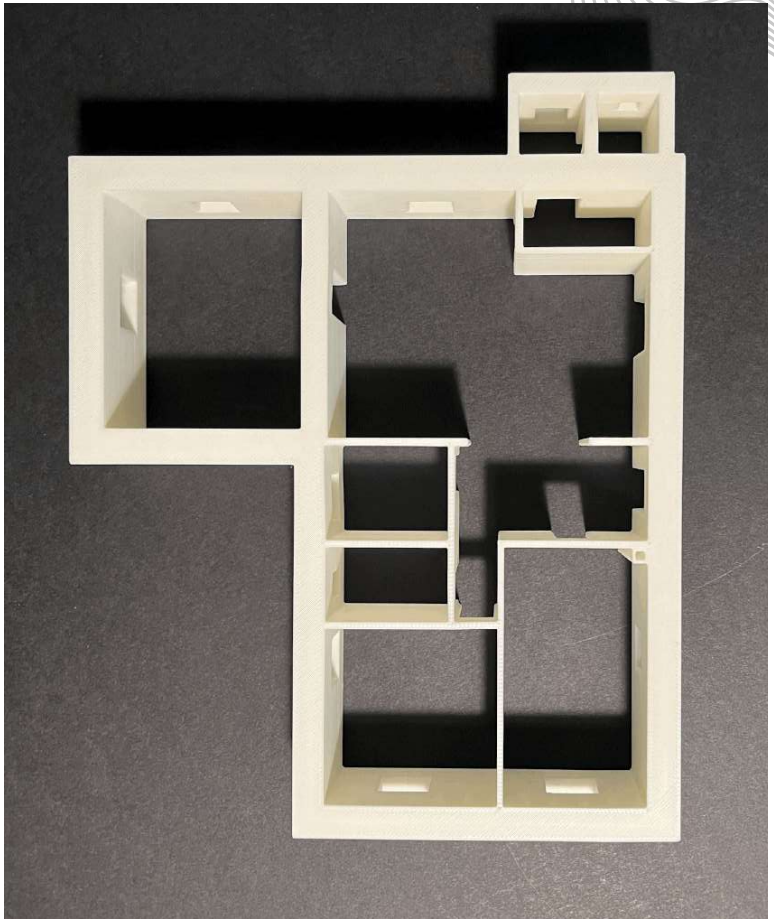
Project by- Gur Rehmat Majithia

Abstract

Through this project I created a modular 3D home that can be used to address and fix the housing problem in the Delhi NCR region and help the government with slum rehabilitation. I hoped to work on creating more hygienic, cost effective and environmentally friendly living spaces for people who don't have access to the same.

I created a CAD design of the full scale house, then I made smaller panels. I scaled it down and took a 3D print to test the modularity of the 'pin-hole' design I was using.

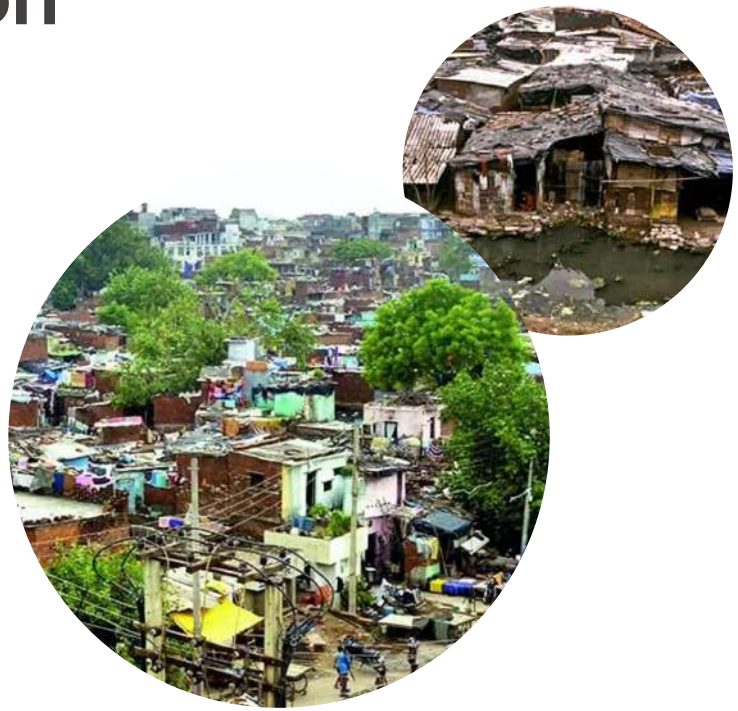
I found that these homes will be faster to assemble, easy to shift and change the design to fit users needs, lower cost and environmentally friendly thus making them a possible solution to the problem of substandard housing.

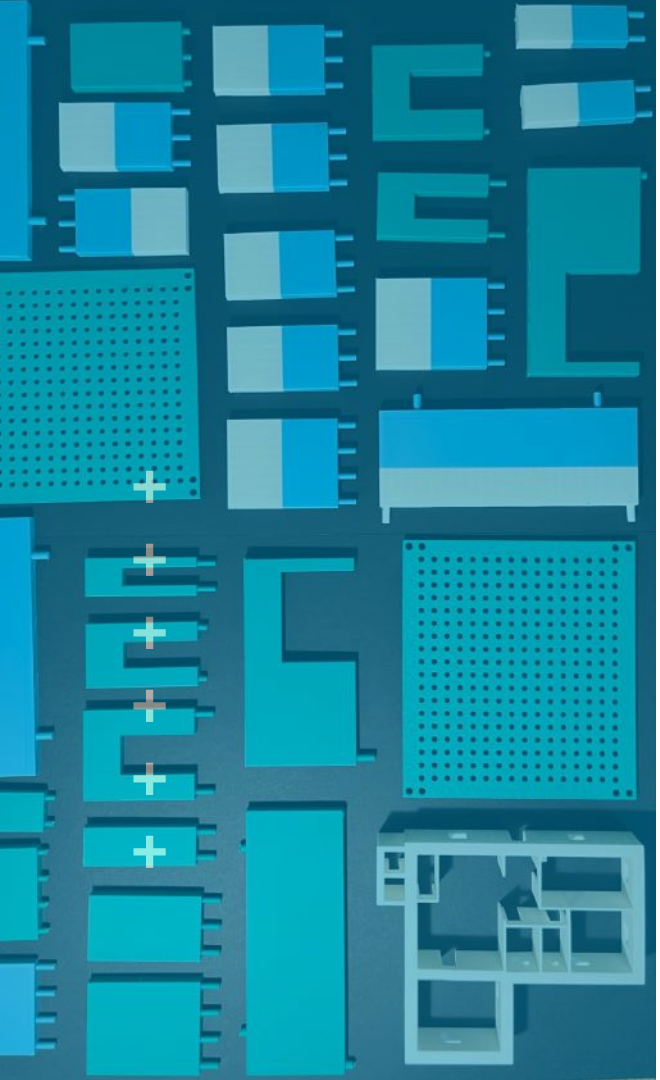


Introduction

Housing inadequacy in megacities is visible in various forms, such as informal settlements, homelessness, and overcrowding. According to the Economic Survey of Delhi 2021, 4.5 of Delhi's 19 million people live in informal settlements and another 0.5 million dwell in urban villages, which lack access to formal civic services.

This means city dwellers may not be able to afford or live in proper homes and have to resort to living in unhealthy and substandard living environments.





40%

Of the world, i.e. 3 billion people will need adequate housing by 2030 according to research by UN.

10 million

People worldwide are homeless according to UN.

1 in 4

People live in housing conditions harmful to their health, safety and prosperity according to UN data.

Causes of substandard housing

- Rate of housing not keeping pace with the demand. The population of India is rapidly increasing, but the total stock of housing is not increasing at the same pace.
- People are constantly moving from rural to urban settlement that lack proper housing facilities due to rapid urbanisation.
- The cost of construction of settlements is very high making it unaffordable for many.
- Other factors include time taken to build, man hours and pollution due to dust.

Other causes-

- Increasing cost of construction
- Absence of organized building sector
- Slow and hesitant adoption of modern technologies
- Lack of needed awareness
- Non – adoption of need based scientific developments in the field (materials & techniques)
- Low priority offered by Government in planning allocation of funds

Implications of concrete and substandard housing

Concrete housing

- Takes time to build
- Materials and labour is costly
- Drawbacks for environment
- Not adaptable

Substandard housing

- Unplanned and poorly regulated structures
- Unhealthy housing conditions, like overcrowded houses and shared accommodations
- Aged and deteriorated buildings – dilapidated or unhygienic
- Slum development due to lack of proper housing
- Polluted surroundings affecting livability
- Visually not appealing structures (eyesores)

Problem + Needs Assessment

Problem

India has about 65 million people living in slums and most are in regions of NCR. After surveying various literary sources on housing shortage in the Delhi NCR region, I realised there were a large number of substandard and dilapidated dwellings, slums and informal settlements. Furthermore, there were long waiting lists for low cost housing and a high rate of urban population growth.

Needs

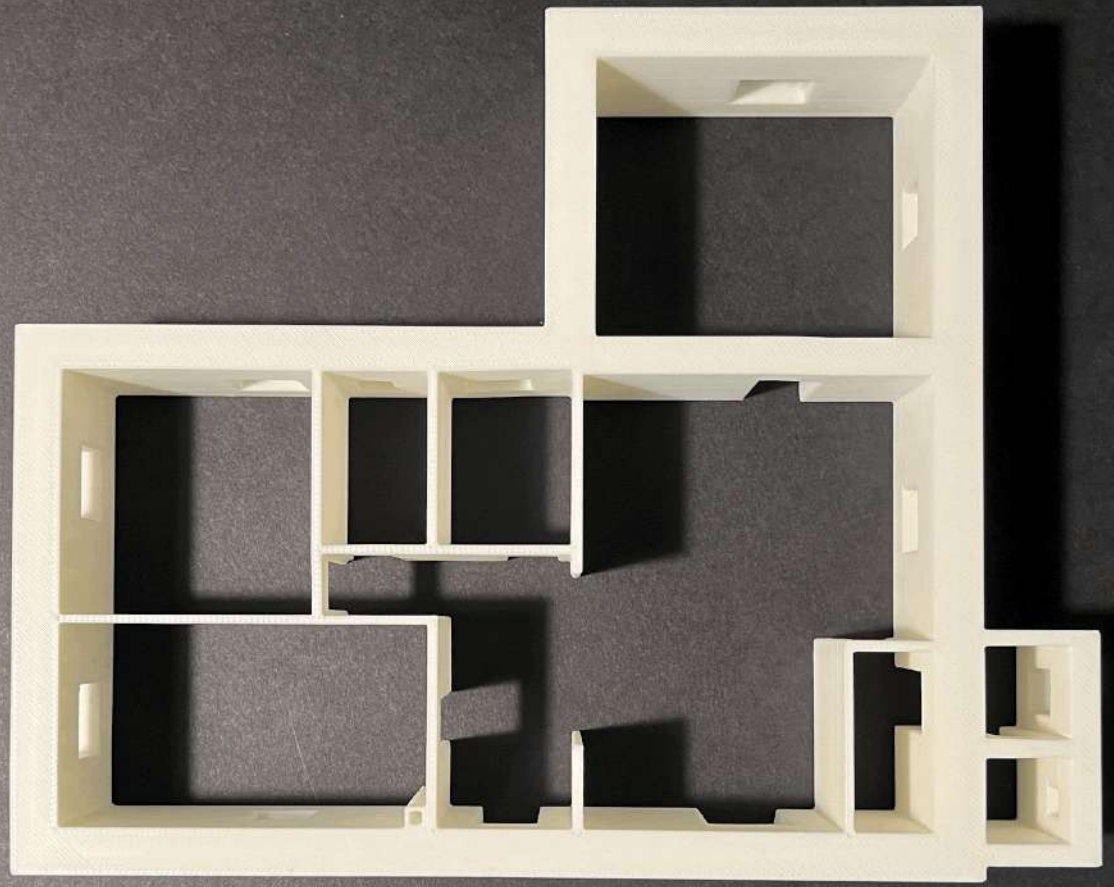
Many of the houses needed to be built needed to tackle and reduce constraints of current housing. These include:-

1. affordability of materials and labour
2. long construction time
3. labour requirements and their skill dependency
4. lack of modularity, flexibility and adaptability in shapes to terrain and climate
5. sustainability

3D model design creation

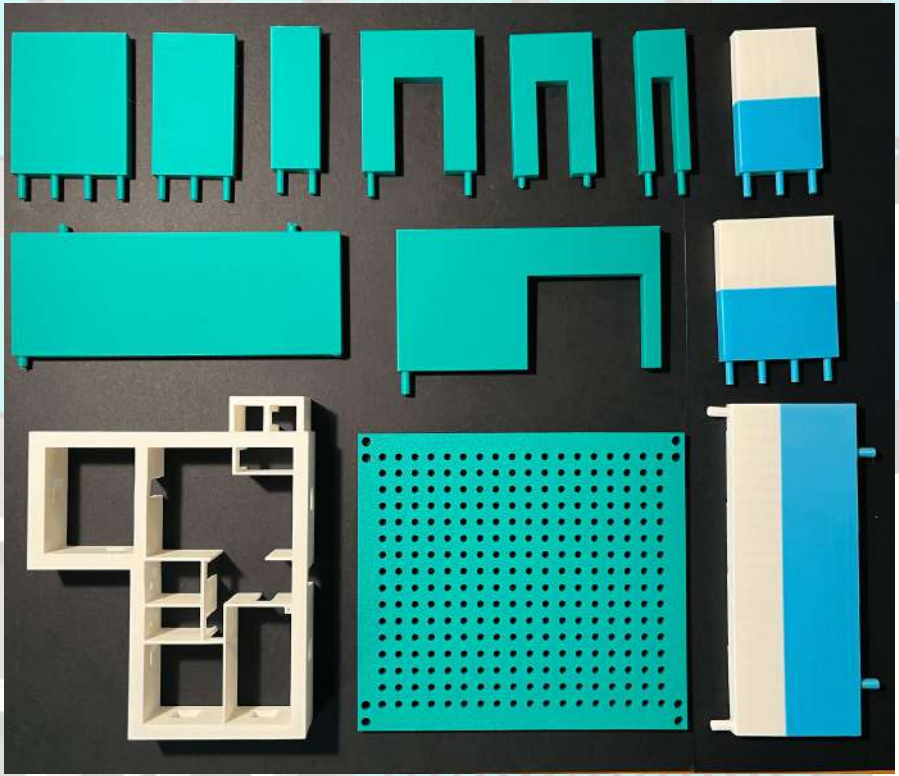
I used AutoCAD to design a sample 3D model of the home. I also took a 3D print of it.

I first created a general floor plan and then dissolved into many parts that can be easily redesigned and moved around according to the residents and areas needs.



General floor plan

Modular panels

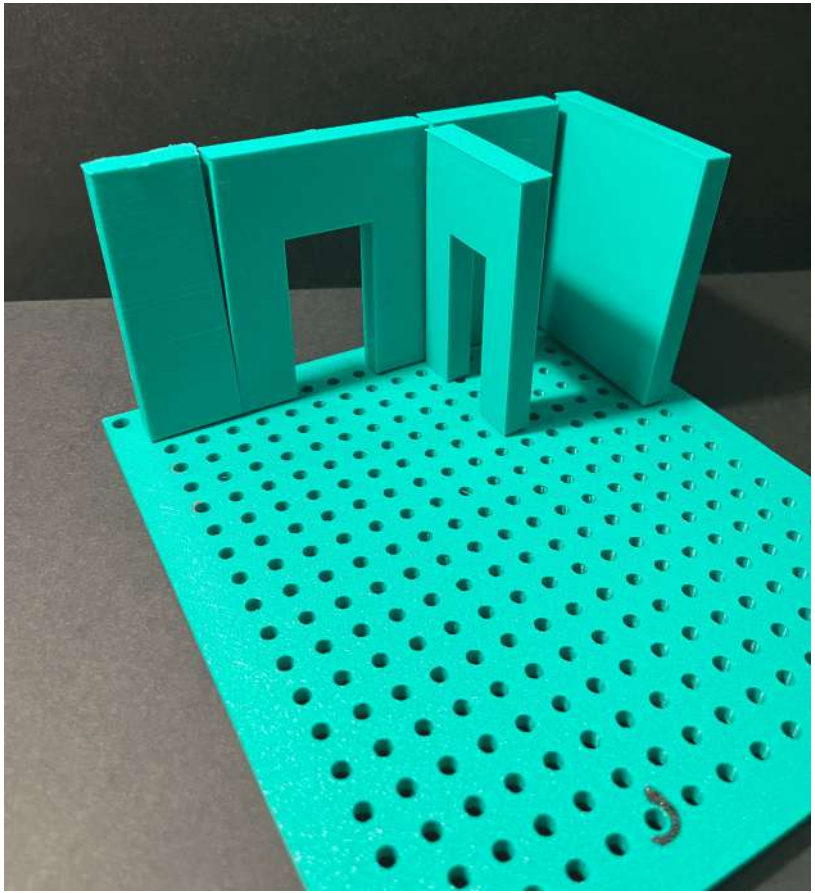


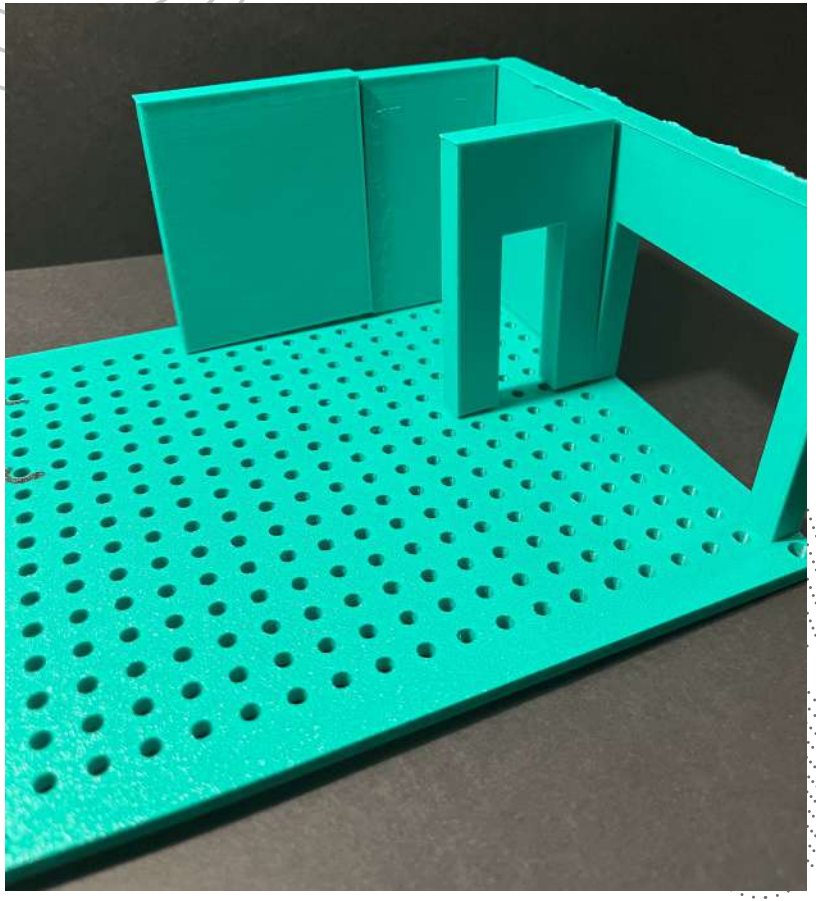
Doors and windows can be changed and rearranged to allow assemblage in different layouts and designs.

These are used as they can be assembled without much need for skilled labour. If the resident were to change the design or shift the home elsewhere, they could just open the pins to move the panel pieces and reassemble the home. This will save money, time and materials, making the design very practical.

Prototype

- Method- Looking at the original 3D printing house process, I created CAD models of those houses in a scaled down process that fits on my desktop 3D printer with bed size of 235x235x235 mm. After creating a CAD model, I converted it into to a STL file and print it using a desktop 3D printer. I monitored the dimensions, the layer height and thickness and infill percentage, as the 3D printer printed the home layer by layer.
- I printed a scaled miniature 3D model using PLA material for a demonstration and prototype of the actual home. I wanted to check the tolerance, alignment and stability of my structure.
- I used 3D printing as it uses the same technology as the one used for 3D printed homes. I did not have access to actual 3D home printing technology so I had to create a miniature prototype.
- The prototype model took 7 hours to print and 2 hours for one person to remove the excess materials and finalise its panels.
- 3D housing printing and 3D printing technology have the same process of nozzle extrusion. The first uses cement and concrete materials at a large scale and the latter uses PLA/ABS material usually making smaller designs.



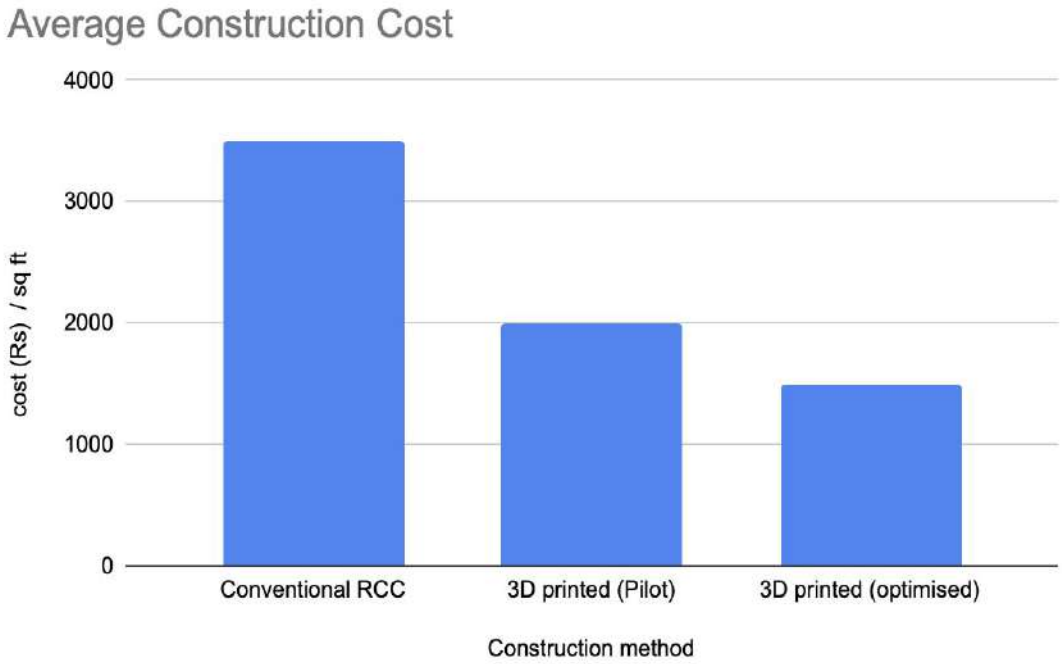


comparison of concrete vs 3d printed

Metric	Conventional Concrete / RCC + Brick (India)	3D-Printed Housing (India / Pilots)
Typical cost per sq ft (finished)	₹2,500 – ₹4,500 (depending on finishes, location)	Pilot claims: ₹1,000 – ₹2,500 (for basic shell + walls)
Demonstrated pilot cost (India)	–	Tvasta's 3-D printed house: ₹ 5.0–5.5 lakh (~500–600 sq ft scale) (1)
Time to completion	6–12 months typical for full structure	L&T / COBOD Post Office: 43 days (94.9 m^2) vs ~8 months conventional (2)
Cost / time reduction claimed	–	~40% cost saving, ~80% time reduction (in L&T project) (2)
Material & waste	Moderate material waste (formwork, cuts)	~⅓ waste of conventional methods claimed by Tvasta (3)
Technology maturity / risk	Very mature, widely accepted by regulators	Early stage; regulatory approval / structural assurance is barrier
Scalability in India	Fully scalable with current supply chains	Promising, especially via local players (Tvasta, L&T + COBOD)
Use of local materials	Yes (cement, aggregates, bricks)	Tvasta's mix: cement + sand + geopolymers + fibres (extrudable concrete) (4)
Case for Delhi (climate, earthquake, regulations)	Well understood; codes exist (NBC, IS codes)	Needs proof for thermal insulation, fire & seismic, approvals with authorities

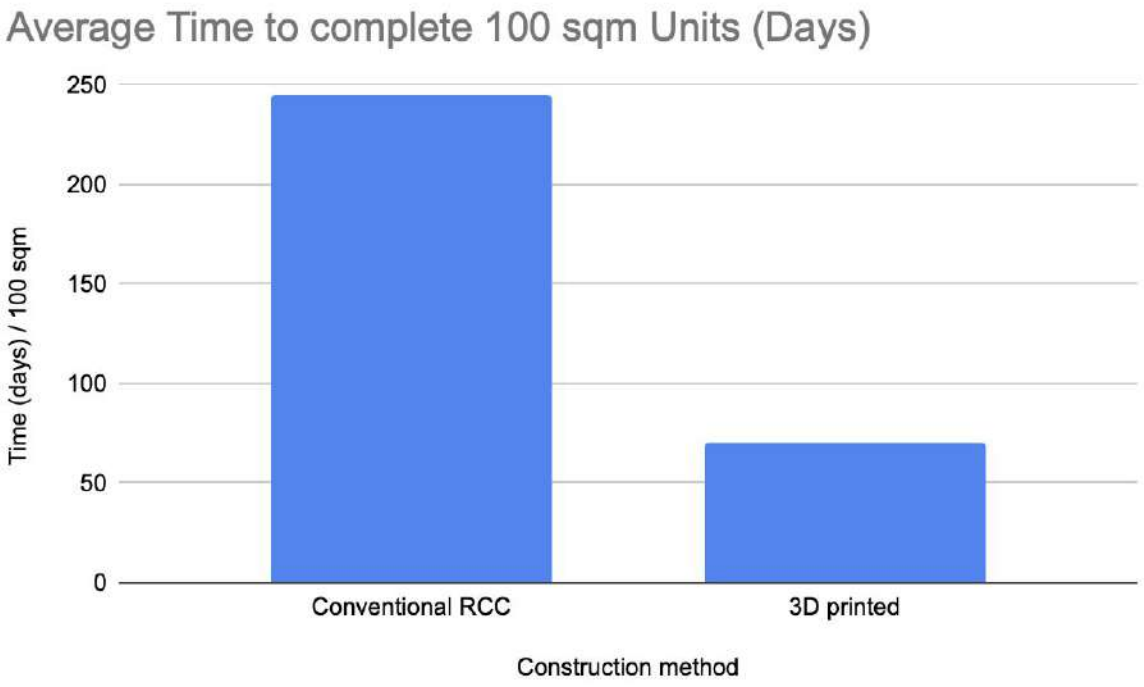
Average Construction Cost

Construction method	cost (Rs)/sq ft
Conventional RCC	3500
3D printed (Pilot)	2000
3D printed (optimised)	1500



Average Time to complete 100 sq units a day

Construction method	Time (days)/ 100 sqm
Conventional RCC	245
3D printed	70



Results

- In pilot projects within India, 3D-printing has shown up to **40% cost reduction** and **~80% time compression** compared to conventional methods (e.g. L&T + COBOD's 3D printed post office: ₹26 lakh equivalent, 43 days vs ~8 months)
- The **Tvasta 3D printed home** (India) cost ~₹5.0–5.5 lakh (for a small unit), representing roughly **20% of cost** of a standard 2BHK conventional build (for same land + finishes) in that location
- Waste is lower- Tvasta claims ~**⅓ the waste** of conventional construction for the same volume of material placed
- Technology maturity is uneven: while structural shells are feasible, auxiliary systems (roofing, MEP, finishing, approvals) remain conventional. Regulatory compliance (e.g. for fire, seismic, thermal performance) is an unresolved hurdle.
- Use of **local materials** is feasible in India: Tvasta has developed mixtures using cement, local aggregates, admixtures and fibres to suit Indian conditions.
- Scalability in dense markets like **Delhi** is promising especially when deployment is backed by major builders (L&T) and local tech (Tvasta). But pilot scale must precede mass roll-out.

Link of my design to the Delhi NCR housing problem

Delhi NCR has a rapidly growing population, There is massive urban migration and job opportunities in and around Delhi, causing demand to exceed housing supply, especially affordable housing. Most available houses now are informal settlements and substandard housing with poor structure, sanitation, etc.
Conventional construction faces high material costs (cement, steel, labour), delays (site preparation, permitting, weather), and inefficiencies (waste, over-ordering, formwork etc.).
My design avoids all these problems creating a home that can be quickly assembled, standard structure and less waste inefficiencies.
The different features like the hole and pin design mean it can be transported and ‘recycled’.

How my design helps

More affordable

Quality and standardisation

Faster construction

Low environmental impact and waste

Support of government policies

Flexible and modular

Reduced dependency on skilled labour

How my design is different from other 3D home designs

My use of pins and holes is complementary to previously used 3D printing homes that are often built.
A similar home- project by IIT Madras built a 600 sq ft 3D printed home in 5 days. It cost 5.5 lakhs, much lower compared to conventional buildings.
It is reported that 3D printed homes can reduce construction time and waste drastically.
My modular approach mitigates challenges of integration of steel and fibre to increased stability through connecting pins and holes.
Also usually as homes become bigger it becomes harder to move them from place to place. My disassemblable design helps mitigate and avoid this problem and also helps in easy transportation.

There are only very few companies like Tvasta that have explored this style of printing in India. But they have used it to create luxury and high end homes not to create efficient homes and models to help the substandard settlement and housing of India.

Conclusion

- The aim of this project was to create a feasible solution to the affordable housing crisis in the Delhi NCR region. This project does so by creating a modular, attachable and detachable housing model inspired by full-scale 3D-printed construction. Designed using AutoCAD and printed on a desktop 3D printer, the prototype showcases the potential for fast, low-cost, low-labour housing assembly using pins and holes for customisable use.

- The limitations of the project are that it was not possible to create a full size 3D printed modular structure so the price and time are only estimates of what it will be when replicated in real life.
- Key issues that need to be considered are regulatory acceptance, thermal insulation, water/dampness, integration of services, long-term durability when creating the large scale design.

- The implications and application real life of the project is that when it is in full-scale, this design offers significant reductions in construction time, labour dependency, and material waste. These are key problems in the current housing sector. The design also has flexibility of different site layouts and future expansion.
- It addresses pressing urban challenges such as the increase of substandard settlements and aligns well with government objectives under schemes like PMAY (Pradhan Mantri Awas Yojana).
- By combining the advantages of digital fabrication, modular design, and contextual problem-solving, the model not only supports innovation in civil engineering and construction, but also holds real-world potential to transform how affordable housing can be provided in rapidly urbanising regions like Delhi NCR.

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