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AN ANALYSIS OF SUSTAINABLE MICRO CONSTRUCTION TECHNOLOGY

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Abstract

Population growth and urbanization in India have boosted housing demand. The demand for housing is influenced by a number of factors. In addition to requiring more raw materials, larger homes also demand more energy to heat and cool each unit. In order to meet India's projected housing needs, this article tries to develop a suitable micro-construction technology for building sustainable dwelling units. In addition to using fewer resources, micro-building techniques are frequently economical and have no negative environmental impact. By comparing building costs and dwelling unit area, this study demonstrates the affordability and sustainability of micro-construction technology. To counter the tendency of rising resource use, there is a move towards minimalistic dwelling, and emphasis has switched to adopting laws that promote sustainable consumption and production. Consequently, this study introduces a fresh perspective on how to use micro-building technologies to create a sustainable environment.

Keywords: Micro construction technology, sustainable units, prefab units, container units.

I. INTRODUCTION

A. Need for sustainable building technology

The phrase "green building technology" is frequently used interchangeably with "sustainable building technology," which refers to the idea of a structure being built with less energy use, less time and money spent on construction, and greater design freedom. [5]

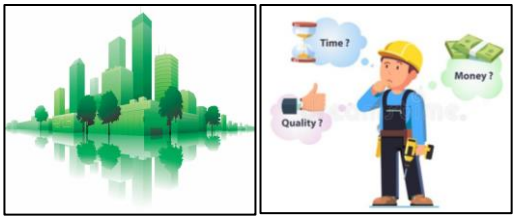


Fig.1 Need for sustainable building technology
(Source: https://invest-gate.me/features/the-future-of-sustainable-and-green-construction-in-egypt/)

B. Construction of a sustainable building

A sustainable structure must be constructed using the right technologies and building materials. Commonly used materials can be replaced with a variety of **alternative materials,** which should be chosen based on their **cost and resource efficiency**. Considerations include the **use of recycled materials**, the use of locally accessible and abundant natural resources (which lowers transportation costs and encourages the use of local materials), and the use of materials that outperform conventional materials in terms of durability and strength.

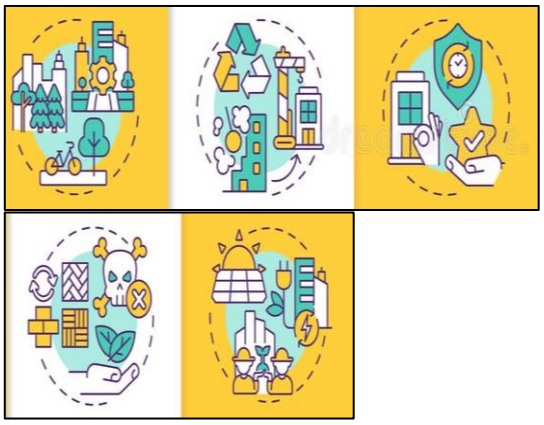


Fig.2 Sustainable building technology
(Source: https://www.vecteezy.com/free-vector/sustainability-report, Shutterstock)

II. SUSTAINABLE MICRO CONSTRUCTION TECHNOLOGY

A. Factors that are responsible for affordable housing demand

The lack of inexpensive land and unplanned expansion are a few variables that contribute to the need for affordable housing and increase the danger of homelessness. Other factors include migration, employment and educational growth, population growth, and migration. The concept of simple, creative living in today's urban environment with the most functional space in the smallest possible footprint is embodied by micro-housing.

B. Micro construction

What is a Micro-Unit?

A micro-unit is a one-room living arrangement with furniture for seating, a bed, a bathroom, cabinets for storage, and a kitchenette, sometimes with access to shared facilities. These compact housing units have advantages for both the landlord and the tenant in urban locations. Renters benefit from lower utility and rental expenses of 20 to 30 percent, accessibility to public transportation, and close proximity to jobs. [1].

Fig.3 Micro unit apartment
(Source: https://www.google.com/search?q=micro%20apartments&tbm=isch&hl=en&tbs=rimg:CZJ4u3AQN5RnYRX48ku5d1B-sgIMCgIIABAAOgQIARAAwAIA&rlz=1C1JJTC_enIN990IN990&sa=X&ved=0CBwQuIIBahcKEwi45--Uuev-AhUAAAAAHQAAAAAQBw&biw=1407&bih=599)

Micro dwelling units have the following characteristics and a minimalistic design: People cut costs by living in tiny, space-saving apartments that are smaller than the majority of studio apartments. The size of the housing units ranges from 65 to 400 square feet. [1]

a) Types of micro-construction dwelling units:

- tiny houses,
- micro-units,
- OPods or capsule units,
- container units, and
- prefab units

And are best suitable for

- bachelors,
- students,
- the elderly,
- empty nesters, and
- slum dwellers.

b) Applications:

- Emergency shelters,
- Farm houses/Holiday homes,
- Hotels & Resorts,
- Camping sites,
- Mobile clinics.

C. The OPOD tube house

The reuse of concrete water pipes into tiny apartments for a creative housing solution This micro-apartment can meet the living needs of elderly people, students, and bachelors. may be rapidly stacked to create a low-rise building and a modular community. It may also be placed or transported to various locations across the city. Its size permits it to fit almost anywhere, which is essential in a city with a substantial population density [2].

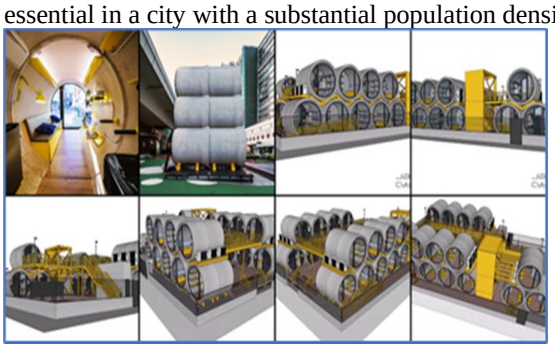


Fig.4 OPOD Tube House
[Source: https://mymodernmet.com/opod-housing-tubes-micro-apartments/, Dezeen]

The compact structure can slot into the spaces between buildings or it can be stacked on vacant lots. Their ease of portability also means that they can be transported to different places as required. And, because they weigh 22 tonnes, installation costs are kept low due to the absence of brackets or bolts needed to secure them. 8’ wide, each 100-square-foot space is designed to house 1 or 2 people.

Telangana Girl Builds Low-cost, Pod-style Home Using Sewage Pipes; Gets 200 Orders

The concrete dwellings contain modern amenities, including bedrooms, kitchens, bathrooms, and shelving, and are expected to last for about 100 years.

Fig.5 POD House
(Source https://indianexpress.com/article/cities/hyderabad/perala-manasa-low-cost-micro-houses-built-of-sewerage-pipes-7263271/)

D. Nakagin Capsule Tower Ginza, Tokyo

It is the first example of capsule architecture on the entire globe and was supposedly constructed for long-term, everyday use. Thirty flats were occupied by October 2012 in the building's two interconnected concrete towers, which have eleven and thirteen stories and 140 self-contained prefabricated capsules, respectively. Others are used as offices or storage areas. Each capsule was separately attached and cantilevered from the shaft, allowing for easy removal of any capsule without impacting the others. [5].

Fig.6 Nakagin Capsule tower, Tokyo
(Source: wikipedia)

Each capsule serves as a compact living or work space and measures 2.5 m (8'2") by 4.0 m (13'1"), with a 1.3 m (4'3") circular window at one end. Larger rooms can be created by connecting and combining capsules. One of the two main shafts is attached to each capsule. Before being transported to the construction site, the capsules were outfitted with inside fixtures and utilities before being fastened to the concrete towers.[2]

E. Pre-Fab Loom Crafts

Loom Crafts offers prefabricated modular homes and cottages that can be used as no-construction zones, second homes, vacation homes, hotels, and resorts. Customization options are available to customers. These houses and cottages are made off-site at factories in Bangalore, Karnataka, and Ghaziabad, Delhi NCR, from which they are supplied in panelized form and put together on-site, sparing the customers' clients from having to pay high transportation charges. [6].

Offers a 20-year warranty for any manufacturing flaws or rain-related leaks, and all of our products are built to resist the harshest weather conditions. shielded from any weather conditions. Any structure's complete exterior surface is adequately protected by weather-proof membranes, ensuring years of durability. The design life of a home can last up to 50 years or more with continuous upkeep.

Fig.7 Prefabricated modular homes
(Source: https://www.loomcraftsprefab.com/)

F. Shipping Container Home

A building constructed from one or more commercial shipping containers is known as a shipping container home. They might be stacked on top of each other. They have a completely blank slate when it comes to configurations. They can be arranged similarly to Tetris. Containers can be piled and placed perpendicularly for a distinctive and distinctly modern silhouette, or they can be placed next to each other and combined into a single large chamber. They are fashionable and environmentally beneficial because of the seemingly unlimited personalization options, their industrial look, and their simple architecture. [3].

Fig.8 Shipping Container homes
(Source: https://mymodernmet.com/modern-shipping-container-homes/

Honomobo is a company known for building beautiful homes made from shipping containers.

Developed a range of adaptable, modular components that meet a variety of applications. They provide everything required to make it move-in-ready and offer six floor designs. The enormous home's construction cost $450K USD, but it took 24 weeks to complete. This is a remarkable achievement given the size and spectacular additions—it has an eco-saltwater pool. It turned out to be a wise investment. In 2014, the house was sold for more than twice what it had cost to build.[10]

Fig.9 Honomobo Shipping Container homes
(Source: Container home made by Honomobo)

III. HOUSING POLICIES IN INDIA

- National Urban Housing & Habitat Policy (NUHHP), 2007:
- National Housing Policy (NHP)
- The Rajiv Awas Yojana Project (RAY)
- National Urban Housing Mission (NUHM) 2015
- Jawaharlal Nehru National Urban Renewal Mission (JNNURM)
- Pradhan Mantri Awas Yojna (PMAY)
- Pradhan Mantri Yojna (Gramin)
- Pradhan Mantri Awas Yojana Housing for All (Urban)

National Urban Housing Mission (NUHM) 2015

(Source: http://www.tnscb.org/housing-for-all/) Fig.10 Housing Polices in India
PMAY (U) Housing for all by year 2022

Tamil Nadu Slum Clearance Board (TNSCB)

IV. COMPARATIVE ANALYSIS

- Types of Micro construction
- Housing policies in Tamil Nadu

http://www.tnscb.org/housing-for-all/

Table 1: Comparative Study Of Micro Construction Dwelling Units Across World

Name of the project	Location	Area (Sq-ft)	Users	Construction material	Cost per unit in (Rupees)	Life span (Years)
The OPod Tube House	Hong Kong	100	2	Concrete water pipe	1,25,000	100
Nakagin Capsule Tower	Ginza, Tokyo	107.42	4	Prefabricated capsules. Steel and RCC	1,30,000	25
PRE- FAB Loom Crafts	50+ cities in India	Customized	4	Load bearing steel modules, DPC, OSB, Rockwool insulation	3,50,000 4,00,000	50+
Shipping container home	Brisbane, Australia	320	4	Corten steel The corrugated wall panels, frame, cargo doors	3,55,000	25+

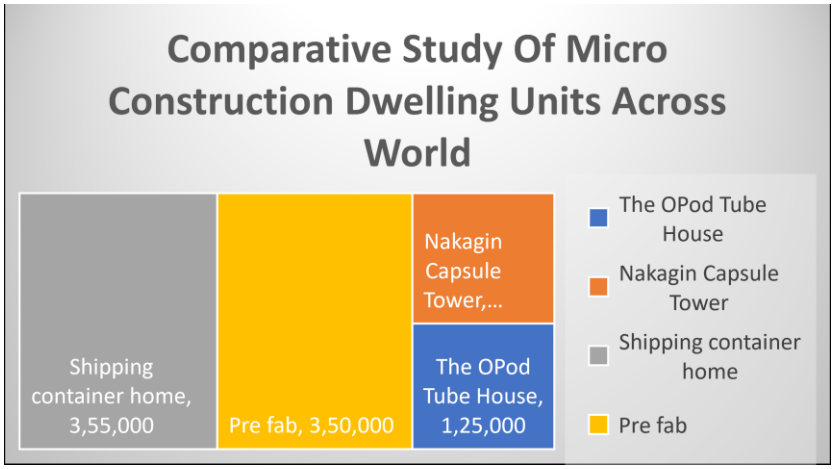


Table 2: Comparative Study Of Housing Projects In Tamil Nadu

Housing policy	Project	Fund	Area of a dwelling unit (Sq.ft)
National Urban Housing Mission (NUHM) 2015	Rehabilitation project	Grant of 1 lakh per house	210- 270
Pradhan Mantri Awas Yojana Urban PMAY (U)	On site rehabilitation	1 lakh per house	250 -350
Pradhan Mantri Awas Yojana Urban PMAY (U)	Affordable Housing in Partnership central assistance	1.5 lakhs per house	250 -350
Tamil Nadu Slum Clearance Board (TNSCB)	AHP -Affordable Housing in Partnership Central and state shares	1Lakh - 2 lakhs	300 -350

https://www.pmindia.gov.in/en/news_updates/housing-for-all-by-2022-mission-national-mission- for-urban-housing/
http://www.tnscb.org/housing-for-all/

Table 3: Comparative Study Of Housing Projects In Tamil Nadu

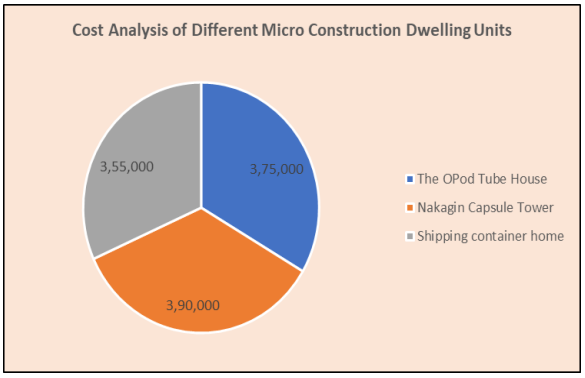
PROJECT	LOCATION	PROJECT COST	AREA (Sq. ft)	TENEMENTS	OCCUPANCY	BLOCKS
TNSCB PMAY	Karambayam village, Pattukkottai	90.62 Crores.	305	960	4800 (5/unit)	28 blocks having G+3 floors
PMAY(U) BLC	In situ reconstruction	GOI 1.5 lakhs GoTN 7 lakhs Beneficiary 1.5 lakhs - 10 Lakhs/unit	400	Individual unit	Single family	NA
Moolakothalam PMAY(U) AHP	Chennai resettlement at alternate locations	Rs.84.24 Cr GOI Rs.9.72 Cr GoTN Rs.38.88 Cr Rs.16.20 Cr 10 lakhs/unit	303.40	648	2592	22 blocks (G+9) floors
Sathya Nagar AHP	Alampalayam resettlement at alternate locations	GOI Rs.3.84 Cr GoTN Share Rs.15.36 Cr Beneficiary Rs.3.77 Cr 8.97 Lakhs/unit	319.5	256	1024	6 Blocks (G+3)

Table 4: Analyzing Area, Cost And Occupants In Micro Construction Dwelling Units

	OPOD HOUSE	CAPSULE UNIT	CONTAINER HOUSE
No. of units	50	50	50
No. of occupants per dwelling unit	2	4	4
Area per unit (Sq.ft)	**100**	**107.5**	**320**
Cost per unit (Rs.)	**125000**	**130000**	**355000**
Cost for 50 units (Rs.)	62,50,000	65,00,000	1,77,50,000
Total no. of occupants	**100**	**200**	**200**
Floors (10*5)	G+4	G+4	G+4
Width (ft)	8' x 10 = 80'	8'2" x 10 = 81'8"	8' x 10 = 80'
Length (ft)	12'6"	13’	40’
Ground coverage (Sq.ft)	12'6" x 80' = 965	13' x 81'8" = 1062	40' x 80' = 3200
	0.022 acres	0.025 acres	0.073 acers

Table 5: Analyzing Area, Cost And Occupants In Micro Construction Dwelling Units

	OPOD HOUSE	CAPSULE UNIT	CONTAINER HOUSE
No. of occupants per dwelling unit	4	4	4
With incremental design Area per unit (Sq. ft) OPod and capsule unit	**300**	**322.5**	**320**
Cost per unit (Rs.)	125000	130000	355000
With incremental design Cost per unit (Rs.) OPod and capsule unit	**3,75,000**	**3,90,000**	**3,55,000**
Cost for 50 units (Rs.)	1,87,50,000	1,95,00,000	1,77,50,000
Total no. of occupants	**200**	**200**	**200**
Floors (10 x 5)	G+4	G+4	G+4
Width (ft)	8'x10 = 80'	10’x10 = 100’	8'x10 = 80'
Length (ft)	12'6"x3	32’ 6”	40’
Ground coverage (Sq. ft)	80' x 37'6"= 3000	100' x 32’ 6”= 3250	40' x 80' = 3200
	0.069 acres	**0.075 acres**	**0.073 acers**



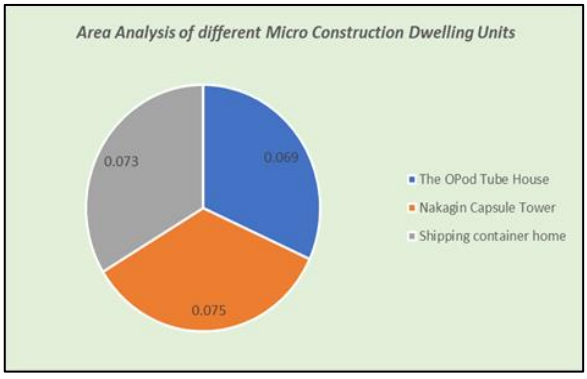
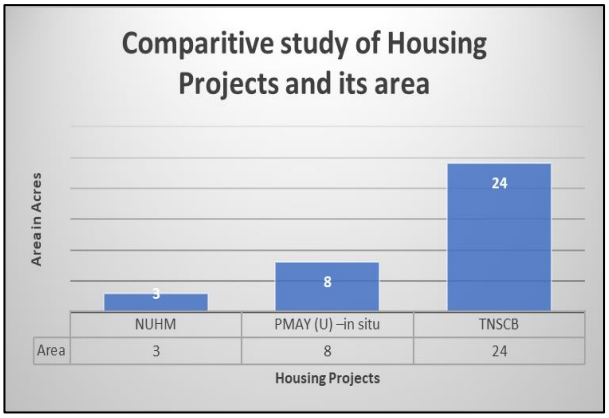
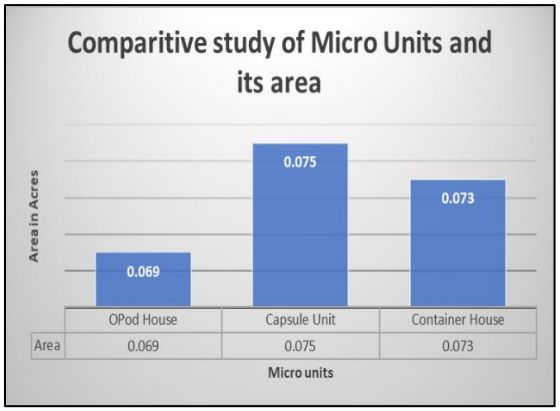


Table 6: Comparative Analysis Between Housing Projects In Tamil Nadu And Micro Construction Dwelling Units

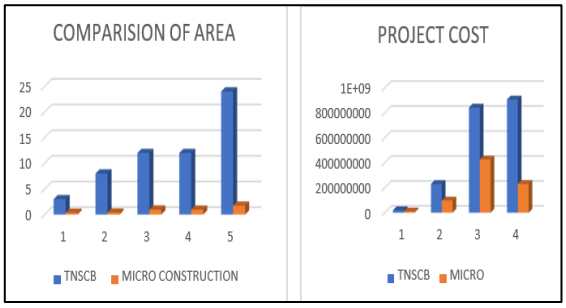
	NUHM	PMAY (U) –in situ	PMAY (U) – AH	TNSCB
No. of occupants per dwelling unit	4	4	4	5
Area per unit (Sq. ft)	210-270	250-350	250 - 350	300-359
Cost per unit in Rs.	100000	100000	150000	1+2 lakhs
Area	3 acres	8 acres	12 acres	24 acres
Project Cost	2 Cr.	22.97 Cr	84.24 Cr	90.62 Cr
Total no. of occupants	100	1024	2592	4800
Floors	G+6 / 1B	G+3 / 6B	G+9 /22B	G+3/ 28B
	OPod House	**Capsule Unit**	**Capsule Unit Container House**	**Container House**
50 units	0.069 acres	0.075 acres	0.075 acers 0.073 acres	0.073 acers
Area	0.069 x 5 = 0.345 acres	0.075 x 5 = 0.375 acres	0.075 x 12.96 =0.972 acres 0.073 x 12.96 =0.95 acres	0.073 x 24 =1.75 acres
Project Cost in rupees	93,75,000	9,75,00,000	Capsule Unit- 25,27,20,000 Cr Container House 23,00,40,000	42,60,00,000





V. ANALYSIS

A.Comparative Analysis Between Housing Projects In Tamil Nadu And Micro Construction Dwelling Units



B. Advantages Of Micro Construction – Shipping Container Dwelling Units

This technology **minimises harmful impacts** upon its surrounding natural areas and

- saves
- construction costs,
- time, and
- space.

By opting for a micro unit, the user can downsize and save money while living closer to the city's centre with less of an environmental impact. facilitating quality of life by occupying vacant space and providing dwellings close to workplaces.

The dwelling has to be a prototype that maximises the full extent of available space. Each residential unit shall have a built-up area of not more than 350 square feet and be able to accommodate up to four people. The design has to enhance the users' standard of living. The project should promote a sense of community and reflect the cultural norms and individual needs of the selected residential area. Small areas can become usable spaces when furnished with space-saving furniture. [10]

VI. CONCLUSION

Based on the analysis of different types of micro-construction dwelling units and housing policies that are practised in Tamil Nadu, Shipping container homes are probably the best-suited micro-construction technology, as they may substantially reduce construction costs, time, materials, and area.

A high-rise constructed from recycled shipping containers reflects both economic and environmental sustainability.

Without any additional supports, containers can be stacked ten stories high.

The steel skin of the container serves as a component of the structure and can support the load on its own, thereby saving the cost of building structural columns and beams.

The elderly, bachelors, and students can affordably live in shipping container homes, which can also be used to house empty-nesters. These container homes improve people's quality of life while simultaneously being environmentally friendly.

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