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PREFABRICATED CONSTRUCTION FOR MASS HOUSING IN MUMBAI

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Abstract— Urbanization is the rapid influx of people migrating to cities. The UN has predicted that by 2050, 64.1% and 85.9% of the developing and developed world respectively will be urbanized. With limited resources of labour, time and finance, slums around the world continue to grow in size in uninhabitable conditions for humans. Prefabrication of houses, an innovation that has potential to address environmental and sustainability concerns at a rapid pace, mechanizes the construction process, enabling mass manufacture of affordable houses. This paper discusses the case of Mumbai, the city of maximum slum population density in the world, where prefabrication can be a promising solution to housing scarcity.

Key words— Urbanisation, uninhabitable, sustainability, affordable, prefabrication.

I. INTRODUCTION

Prefabricated structure is one, the component member of which is precast, either in factories or in temporary plants established on the site. These precast members are transported to the site and then they are hoisted, set into complete structure. Prefabrication method of construction as compared to the traditional in-situ construction of buildings results in faster rehabilitation models with more efficiency and reduced environmental damages.

Prefabrication, in one form or the other, has been in practise since many centuries. However, the first prefabricated building is known to be constructed in the year 1905. In the early years, materials such as stone and logs were extensively used, and such a construction was called as ultra-light construction. However, the boom in the prefabrication market occurred after the end of World War I. And since then, massive prefabricated buildings have been constructed, owing to the fluctuating trends in construction industries and demand for homes at cheaper rate, due to tremendous losses suffered in World War 1. The countries at the forefront of prefabrication were United States of America and the Western Europe.

Rapid urbanization and availability of jobs in Mumbai attracts thousands of people around the nation seeking work opportunities. Perhaps, a dearth of residential houses and rising prices has forced millions to live in slums in uninhabitable conditions. The slum rehabilitation model for Mumbai has fared miserably with just 13 per cent projects completed in 18 years [1]. To reduce costs and alleviate conditions of slum dwellers, prefabrication can be implemented.

II. BENEFITS OF PREFABRICATION

- The main advantage of prefabricated method is the celerity by which the construction process takes place. Rapid urbanization, tremendous shortage of skilled labour and the need for having hassle-free construction methods is a trigger to offer prefab technology to build homes faster.

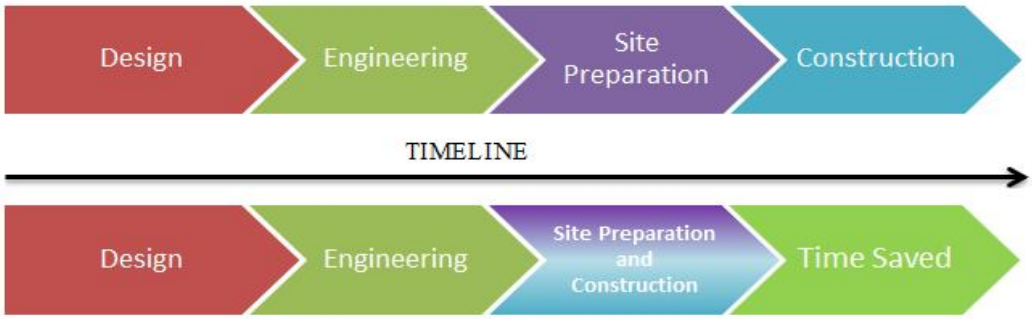

Fig 1. Time saved in modular construction

- Other great advantage of prefabrication is durability. These prefab houses show better performance as they undergo strict checking mechanism that ensures the product comes out to be defect-proof.
- These types of houses can be customized to specific needs/demands/requirements thus making it ideal than residing in conventional slums. These specific needs may include fire/ water/ sound proofing.
- Lesser waste generated due to planned construction

- Process unaffected by adverse climatic conditions such as rainfall, snowfall and heat.
- Requires less labour as compared to traditional forms.
- Utilisation of cheap labour forces away from construction site.
- Greater project certainty.
- Safer working environment
- Reduced air and noise pollution at construction site, especially useful when the site is situated near densely populated cities.

III. LIMITATIONS

As compared to traditional methods of construction prefabrication of building elements has certain drawbacks. Availability of roadway width, height under bridges and pavement strength limits the transportation scope of the materials built at the factory. Traffic in cities can lead to delay in projects. Temporary bracings during transportation, lifting equipment and specialized framing to support prefabricated elements on site are additional costs incurred. A very high degree of accuracy, precision, planning and coordination are required. An error in design of mass production can be a serious risk. Any defect would be replicated on a large scale.

IV. PREFABRICATION IN INDIA

Prefabrication in India came into effect with the foundation of Hindustan Housing Factory in 1950 as a solution to the housing crisis resulted from the influx of refugees from West Pakistan (now known as Bangladesh) [2].The Hindustan Housing Factory pioneered the production of pre-stressed concrete railway sleepers to replace dilapidated wooden sleepers on Indian Railways. This government run company, located in Delhi and now known as Hindustan Prefab limited (HPL), mainly prefabricates precast concrete for various civil and architectural projects throughout India.

Prefabricated materials are well-known for their durability and quality in India. Protection from climatic damages, precision work in computer controlled manufacture in factories and environmental-friendly techniques have attributed to the good quality standards of prefabrication. With an extremely competitive construction industry, construction management with the help of BIM (Building Information Modelling) techniques is being used to pre-plan and visualize the construction process. This makes the construction process leaner and gives scope for prefabrication before the actual site works begins, resulting in lesser wastage. These building systems are gaining popularity in India due to the need to use very scarce resources optimally. They also have the potential to address the problem of mass housing crisis in India that we face today.

L&T owns heavy engineering workshops at Powai (Mumbai), Hazira (Gujarat), Kansbahal(Odisha), Chennai, Vadodara(Gujarat), Kattupalli (Tamil Nadu) which have a combined fabrication area of about 1.2 sq.m with over 150,000MT capacity [3]. L&T started a fully precast residential G+23 building project in Parel, Mumbai in 2011. This project will provide a total built up area pf 1.2M sq. ft. 6 building towers. Construction of three towers has been completed in a record time of just 3 months [4]. Speedy construction and design conforming to all IS design codes with less labour intensive operations are the major objectives achieved by this project.

The TATA housing group is working on a housing project based on innovative prefabricated technologies. These houses will cost as low as INR 32,000. Tata Group will provide a kit consisting of structural elements which can be erected or assembled. These houses have an area of 20-30 sq mtrs and lifespan of 20 years. The project is still in pilot stage and will soon be implemented across the country. [5]

A myriad of prefabrication companies are emerging within India in order to serve the housing demand of one of the most dense, heavily populated, and fastest growing economy in the world. An estimated 12 million low cost housing is required by India at this very moment. A low cost house can be described as a house having an area less than 400 sq. ft or less [6]. Such houses are currently the need of the hour in big metropolitan cities, having a large number of slum dwellers. Prefabricated residential projects can significantly reduce the cost of housing and could be effective solution to the massive shortage of housing.

V. MASS HOUSING- A CASE FOR PREFABRICATION

The world faces a huge housing crisis in cities which has rendered millions to live in uninhabitable circumstances. The only way to clear this backlog is mass housing. Due to the rising prices of residential land in urban cities and building materials, private residences seem beyond the reach of the common man. The idea of mass housing with a higher density and floor area ratio seems to solve the problem considerably. This reduces cost on individual owners. Sharing of building material per unit and per cluster reduces cost equally. Mass housing facilitates economic layout of services like common sewer lines, man holes, septic tanks, etc. this process of sharing results to economy. Maintenance cost of common facilities like parks, garages, etc. are likewise shared. Mass housing further economises by standardising materials and structural components, thus resulting in efficient management of materials and resources.

TABLE I
COMPARISON TO TRADITIONAL METHOD

	Prefabricated construction	**Traditional methods of construction**
Cost	Significantly lower than traditional methods	High cost
Speed	Faster method of construction	Slow as compared to prefabricated construction.
Wastage	Less wastage of materials due to green practices and controlled environment in prefabrication construction	High waste due to in-situ construction practices
Flexibility	Less flexibility due to standardisation of units	More flexible
Quality	Higher quality control due to production under controlled environment	In-situ construction practices are subject to weather changes. They may lead to poor quality construction.
Labour	Less labour intensive due to Computer Integrated Manufacture (CIM)	Skilled personnel and labour required.

VI. MUMBAI: A MARKET FOR PREFAB INDUSTRY

Mumbai has a population of approximately 20.5 million. According to a BBC World article from 2011, about 60% of that number lives in the makeshift dwellings in conditions unfit for Human habitation [7]. Mumbai is home to the world's 3rd largest slum, Dharavi. It is located in central Mumbai and holds a population of 800,000 to 1 million in just 2.39 sq. km. (or 0.92 sq. miles) making it the most densely populated area in the world with a minimum of 334,728 people per square kilometer [8].

The projected population of Mumbai for 2020 is 24 million [9]. Greater Mumbai (which includes the cities Mumbai, Navi Mumbai, Thane, Bhiwandi and Kalyan) currently has a population density of 27,348 people per square kilometer, this will reach a peak of 101,066 per square mile, which will be the highest on earth. [8]

These figures lead to health care, sanitation and cleanliness concerns, and indicate a need for environmental regulations. Lack of planning and uncontrolled and haphazard growth of slum sizes continues to expose a major proportion of the population to hazardous and toxic chemicals. Unregulated effluents are drained in open sewers from small scale industries based within slums. Incidences of deadly waterborne diseases like cholera, jaundice, typhoid, diarrhea as well as common cold, cough and fever are higher among people accounting about 83 percent in Mumbai compared to malaria, dengue and other diseases [10].

A. The role of SRA:

Slum Rehabilitation Authority (SRA) has the responsibility to undertake slum redevelopment schemes in Mumbai. It provides protection to slums built before January 1, 2000. Slums built prior to this date will not be razed and its occupants evicted. However, rehabilitation schemes have not seen much progress since 1995, when the SRA was established [11]. This is due to three major impediments that the rehabilitation projects have been facing during the past two decades:

1) Slum lands are converted into vertical replacement houses for the slum dwellers. Hence, builders have not found the slum spaces attractive enough to build, harvest extra FSI for sale in open market thereby subsidizing the rehabilitation.

2) The government has been unable to come at a simple and endurable scheme and set consistent rules.

3) High real estate prices and scarcity of housing forces thousands of people every year to live in slums causing them to mushroom at locations near workplaces, making it difficult to keep track of slum dwellers and implement rehabilitation schemes systematically.

B. The Mass Prefab Housing Dilemma

The question whether or not to adopt mass prefabrication of houses cannot be resolved unless a continued market on a large scale is assured. The capital invested in factories needs to run at full capacity to economize the production. This cannot be achieved without the necessary demand and time bound financing from housing programs. This causes a vicious cycle leaving the housing scarcity problem unresolved. [12]

Considering the average household size in Mumbai of 4.85 [13], a population of 9 million in Mumbai slums would approximately require (9000000/4.85=) 1855671 houses. This would mean producing 1 house every minute, continuously, for 3 years 6 months. Moreover, this figure excludes the huge number of new people migrating into the city every year.

This indicates a vast market for prefab industry, making the high initial investment into manufacturing, transporting and assembling equipment feasible. The slum population can be surveyed to determine the actual demand for prefab houses using

questionnaires and other sampling methodologies. Ensuring a market for prefabricated houses will attract investors and developers to set-up capital for production of these houses.

Costs are incurred to the developer due to reallocation of PAP (Project Affected People) and construction of PAP tenements. SRA project builders rent MHADA (Maharashtra Housing and Area Development Authority) transit housing camps for project-affected-people. However, many builders have failed to pay pending dues to MHADA for renting its units [14]. These side-costs incurred in redevelopment projects act as disincentives for developers. Prefabrication minimizes these costs as construction is carried out away from slum lands, eliminating the need to vacate the premises.

There is a rising concern over the surge of infrastructure projects in Mumbai. Prefabrication plants set up away from development sites will help to keep free of emissions and noise produced during construction. Sustainable methods of fabrication can be adopted in controlled factory space to eliminate potential hazards during construction.

TABLE II
DEVELOPMENT PLAN RESERVATIONS ON SLUM LANDS [15]

	AREA-SQKM	%
GREATER MUMBAI BOUNDARY	482.74	100.00%
LAND AREA RESERVED FOR HOUSING	102.17	21.16%
SLUMS ON HOUSING RESERVATION	6.07	1.26%
SLUMS ON RESIDENTIAL RESERVATION	14.02	2.90%
SLUMS ON COMMERCIAL RESERVATION	0.72	0.15%
SLUMS ON INDUSTRIES RESERVATION	2.55	0.53%
SLUMS ON AMENITY RESERVATION	2.37	0.49%
SLUMS ON OPEN SPACE RESERVATION	7.47	1.55%
SLUMS ON NATURAL ASSETS	0.32	0.07%
SLUMS ON NDZ RESERVATION	4.22	0.87%
SLUMS OON RAILWAYS, AIRPORT AND PORTS	0.44	0.09%
SLUMS ON SERVICES RESERVATION	1.02	0.21%
SLUMS ON DP ROAD RESERVATION	3.08	0.64%
TOTAL SLUMS LAND AREA	42.28	8.76%
MUMBAI'S POPULATION (as per 2011 census)	12.43 MILLION	100.00%
SLUM- DWELLERS POPULATION (as per 2011 census)	6.53 MILLION	52.50%

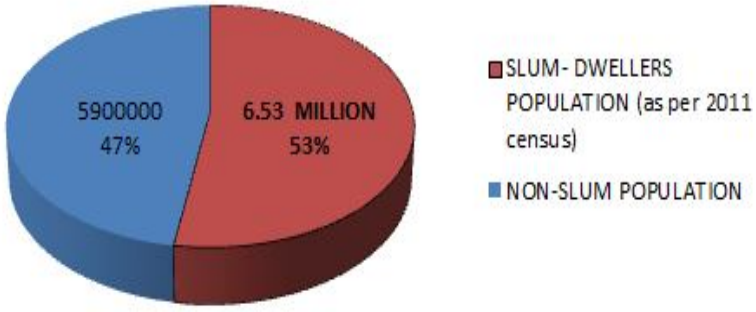

Fig 2. Population Distribution

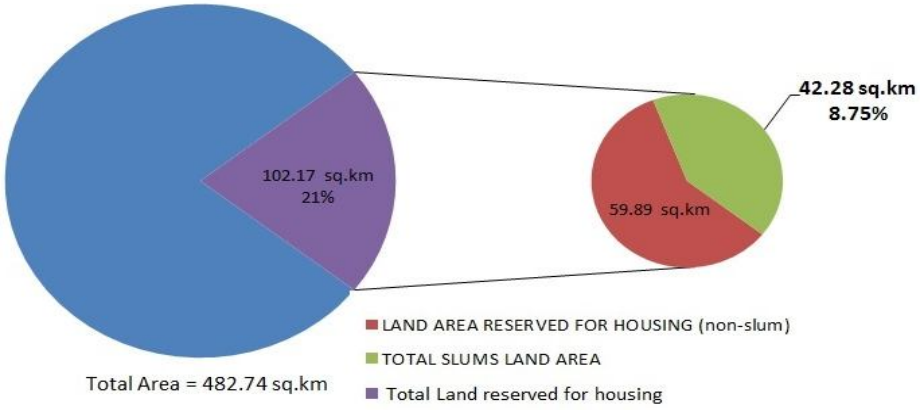

Fig 3. Slum Land Proportion

With a limiting area of 42.28 square-km for an estimated population of 9 million inhabitants, energy efficient layouts must be designed to meet the needs of the population. Houses can be pre-designed with layouts with optimum floor space utilization and sustainable design. In Dharavi there is only one toilet per 1,440 people [16]. Over 90% of slum dwellers rely on public sanitary units and many are forced to defecate in the open leading to unhygienic and adverse conditions for health. Modular sanitary units and portable toilet cabins, which are designed for durability, easy maintenance and hassle-free instalment, can work as easy solutions to sanitary problems.

VII. CONCLUSION

A review has been carried out in this paper to plan, analyze and design residential building using prefabricated techniques in Mumbai, bearing in mind, the cost of total construction and planning of the building are done in such a way that the maximum area utilization is achieved for minimum space and cost. An effort has been made to show that the prefabricated housing innovation system provides a useful organizing tool to enhance the standard of living of slum dwellers.

Considering the current plight of slum inhabitants in Mumbai, it is imperative that the construction stakeholders consider the importance of alternative construction methods such as prefabrication with reference to its improvement of health and safety in the construction industry. Prefabrication has the capability to make a difference within the Indian construction industry in economic, social and environmental terms. It is essential that the potential benefits of this innovation are yielded so that required development can take place.

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