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ANALYSING PRECAST & MODULAR CONSTRUCTION WITH RESPECT TO DESIGN AND COST

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Abstract: The article considers temporary methods of using modular units in construction. The advanced world experience in the construction of modular buildings is analyzed. It is emphasized that modular construction has the potential to shorten project design and engineering time, reduce costs and improve construction productivity. The installation of modular buildings is costefficient, safe and eco-friendly. Modern modular systems are based on using not only large elements such as «block rooms» but various small 3D building elements. The analysis result of Russian developments in the construction of modular buildings proves that Russia has great experience in the development of 3D reinforced concrete modules. As the research results the article shows promise for developing of modern modular construction systems in order to provide the population with affordable, comfortable and eco-friendly housing. The paper describes the prospects and relevance of introducing modular prefabricated units not only into low-rise but into multi-storey and high-rise construction as well.

INTRODUCTION

The conventional construction practice in the building industry has over time turned out to be labor-intensive and comes with so many concerns such as health and safety, procurement cost, changing weather condition, quality etc. Business wise, job-related injuries and illness in construction projects tend to affect the profitability of such projects. Costs that are directly associated with jobrelated injuries and sickness covers medical costs, workers premiums, liability, compensations and property losses [1]. From the angle of quality and productivity, the cost of labor is about 30% of the entire project cost [2]. Manpower mismanagement and delay in construction which was investigated by [3] expressed that the unproductive time of a typical construction worker's day is up to 40-60%. The cost related to construction rework (redoing an aspect of construction due to poor Manuscript received August 29, 2017; revised December 10 , 2017. craftsmanship) as discovered by [4] is about 12% of the entire construction costs excluding losses which are as a result of delayed schedule, lawsuit and other impalpable cost of substandard quality. Unsatisfactory quality of work and unsafe work environment and conditions have led to clients, companies and the general public to lose millions of dollars thereby causing severe hardship to the affected construction employees and their families [5]. Off-site Modular Construction as a sustainable construction method is taking a new leap worldwide in increasing and enhancing productivity level in the building and construction sector thus reducing the resulting social and environmental effects arising from the activities of conventional method of construction. Construction site work is one of the most hazard based jobs worldwide presently and the construction fatality rate likewise is on the increase globally with Europe having the highest fatality rate of 23% with Germany, France, Spain, United Kingdom and Portugal leading the ranks [6].

PROBLEM STATEMENT

Due to the intricate nature of construction, contractors sometimes find it arduous to deliver quality projects to clients, as a result some projects come with so many imprecision. The usage of substandard and defective materials in other to cut or reduce construction cost all contributes to substandard project delivery. The exposure of site workers to accidents on the construction sites might interfere with site work for some period of time which increases the contractor's liability to pay health and insurance premiums which adds to the overall cost of the project and unavoidably reduces profits

AIM

This paper aims at critically scrutinizing the subject of discuss in order to fully grasp how Off-site Modular Construction can be adopted in achieving productivity increase, reducing site workforce, reducing site work hours and minimizing construction risk towards improving Construction Quality and Safety.

METHODOLOGY

The first phase in this mini thesis is a thorough literature review explaining the modular construction, its benefits, cost analysis, comparisons and the basic understanding of the cost beneficial factors. • In the second phase, after establishing a thorough understanding of the concept of modular construction and its different types, along with its benefits, a detailed survey is needed to be conducted to determine the state of modular construction in India, and this will involve visiting the sites, meetings with the respective heads of the various departments in various companies engaged in this method of construction. This data collection will also be supplemented by inputs from all the sources within the construction industry, and the general public as well to determine the public perception about this method. The necessary facts and figures to be collected will be collected from the data available through the above methods and also with the help of internet resources. • The third phase begins with the end of data collection, and at this stage we analyze the received data, and compile it in a meaningful manner.

Table 'A'

Sr. No.	Name of State	No. of Urban Housing Units required in 2022	No. of Rural Housing Units required in 2022	Total Housing Units required by 2022
1	Uttar Pradesh	54	146	200
2	Madhya Pradesh	22	51	74
3	Rajasthan	21	45	66
4	Delhi	30	3	33
5	Haryana	11	14	25
6	Punjab	10	13	23
	Northern Region	**148**	**272**	**421**
7	Maharashtra	50	55	105
8	Gujarat	29	21	50
9	Goa	2	1	3
	Western Region	**81**	**77**	**158**
10	A.P. including Telangana	37	40	77
11	Tamil Nadu	39	18	57
12	Karnataka	28	21	49
13	Kerala	27	9	36
	Southern Region	**131**	**88**	**219**
14	Bihar	16	69	88
15	West Bengal	34	42	76
16	Orissa	9	26	35
17	Jharkhand	11	18	29
18	Chhattisgarh	8	14	22
	Eastern Region	**81**	**169**	**25**
19	Hilly Region	22	44	65
	All India	**4.63 crores**	**6.50 crores**	**11.33 crores**
20	Demand between 2014 and 2022	2.73 crores	2.70 Crores	5.43 crores
21	Urban Housing shortage of E.W.S. in 2012	1.055 crores		
22	Shortage of LIG in 2012	0.741 crores		
23	Shortage of M.I.G. in 2012	0.082 crores		
		1.878 crores		
24	Investment required upto 2022	1.80 Trillion Dollar	0.20 Trillion Dollar	2.00 Trillion Dollar

I. HOUSING SHORTAGE IN INDIA

Report of the Technical group on Urban Housing shortage (2012-2017) and working group on Rural Housing (2012- 2017) submitted the same in 2011 to their respective ministries. Report estimated that almost a quarter of Indian households lack adequate housing facility. Country is on the verge of large scale urbanization over the next few decades. As per 2011 census, country's population was 121 cores and expected to reach 150 crores by 2050. Present urbanization rate of 28% in 2011 is to accelerate to 52% by 2050. Urban population is expected to reach to 81 cores by 2050 as per "KPMG India Analysis July 2014". Housing is a basic need for humans. Central Government acknowledges the importance of housing and aims to provide housing to its entire citizen by 2022. In order to fulfill this vision, 4.63cores urban houses and 6.50 cores rural houses are required to be constructed by Government, private sector and on public private partnership. Details of state wise urban and rural housing requirement are given in **Table 'A'**

[*Source:* - *Report of the working group on Urban Housing shortage (2012-2017), Ministry of Housing & Urban Poverty Alleviation working group on Rural Housing for XII Five Year Plan, Ministry of Rural Development 2011. Census 2011 KPMG in India Analysis]*

Note: - *Above estimate reveal that 75 percent of housing requirement Until 2022 would be concentrated in ten states of U.P, Maharashtra, Bihar, West Bengal, Andhra Pradesh (including Telengna), Madhya Pradesh, Rajasthan, Tamil Nadu, Gujarat and Karnataka.*

The total housing requirement of 11.33 crores by 2022 includes housing shortage of 5.90 crores as on 2014. The break-up of current housing shortage, requirement between 2014 and 2022 is given in **Table 'B'** below:-

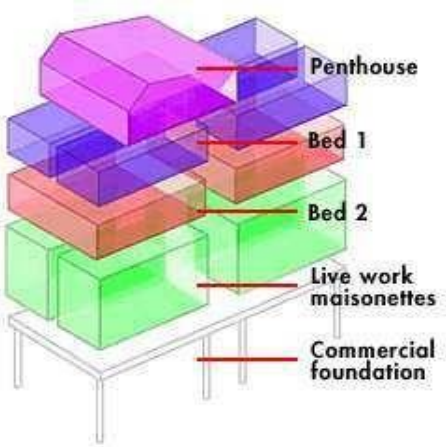
Sr. No.	Classification of Housing Units	Number of Units in Million	Shortage in percentage term
1	Economically Weaker Section (EWS)	10.55	56.18
2	Low Income Group 7.41 39.44	7.41	39.44
3	Middle Income Group & above	0.82	4.38
	TOTAL	**18.78**	**100**

[Source:-Report of Urban Technical Group (TG-12) on Urban Housing shortage (2012-2017), Ministry of Housing & Urban Poverty Alleviation September 2012.]

I. WHAT IS MODULAR CONSTRUCTION?

The term modular construction is used where a building is assembled from a series of volumetric steel modules, linked together to form a complete structure.

The modules, which are manufactured and finished (or partially finished) off-site, under factory conditions, are then transported to the building site and lifted on to pre-prepared foundations. The building is then connected to services and the exterior of the building dressed with cladding & roofing.



Modular construction is a more environmentally friendly method of construction than traditional techniques as minimal foundations are required for the installment/erection of and both modules and foundations can be prepared simultaneously, cutting construction times significantly. Importantly, as modules are produced under factory conditions, the likelihood of defects is minimized and better quality control is achieved.

While modular construction borrows techniques from the manufacturing industry, the end result does not look "mass produced". Highly sophisticated structures can be produced which are easily customizable to suit individual requirements? Finishing with appropriate cladding and roofing allows the building to blend in with its surrounding environment.

COMPARISON BETWEEN MODULAR CONSTRUCTION AND TRADITIONAL CONSTRUCTION METHODS

	Modular buildings	**Traditional construction methods**
Buildin gcodes	Homes built in a factory and treated as traditional homes that follow the local building code and regulations.	Traditional homes are subject to the local buildings code and regulations .
Floor Plans/Design	Most builders can provide 100's of sample plans to help guide your home selection. Modular homes are normally highly customized in their interior and exterior appearances. Full custom modular builders, while rare, offer the ability to design from scratch or accept private architect's renderings for conversion by the factory to modular.	Most custom builders can provide sample plans they've built, offer design services, or direct you to plans on the Internet. In either case, Full customization is standard. Larger builders/developers offer select plans only for Their lots.
Maintenance Cost	Climate controlled indoor construction eliminates most weather-related problems, including black mold. Framing likely will never be exposed to direct moisture (rainfall). Manufacturers must over-build modular components to withstand highway travel to job sites. The resulting square/level/plumb structure is less prone to settling, cracks, and stress on components.	Since they are built on-site in all types of weather, the quality of the product varies greatly. In-the-field "modifications" mean lesser tolerances and more unknowns. Research has shown that traditional homes are more likely to require repairs and higher maintenance costs.
Energy Efficiency	Part of the over-building process for roadworthiness includes screwing and gluing drywall and sheathing for tensile strength and reduced racking. This creates a tighter building envelope that is draft-resistant and energy efficient. Heavier 2x6 exterior walls containing R19 insulation are standard, as are dual-panel windows w/low-E glass.	Choices run the full gamut. In order to compete with the economies of modular building, many stick builders will offer cheap "builder-grade" construction and material finishes.
Greenness	Because homes are built on an indoor assembly line, jobsite impacts (waste, soil erosion & destruction) are greatly reduced. Most factories are resource-efficient recyclers of scrap materials, and most can readily source "greener" product lines from their suppliers.	It is physically impossible to duplicate Indoor building outdoors.
Resale Value	Modular homes increase in value over time. Once they are completed it is near impossible to tell	Traditional homes will increase in value over time. They can be improved and expanded

	the difference between traditionally built homes and modular homes. These homes can also be improved or expanded.	to accommodate new owner's preferences.
VTimeframe	This normal timeframe is8-14 weeks. There are some time savings since construction can begin in the factory at the same time your foundation is being created on your site. Weather has almost no impact on the schedule	The normal timeframe is 6-12 months. Since all construction occurs on site, work projects can not start until the previous project is completed. The work schedule is dependent on weather conditions.
Appearance	The same as any traditional site-builthome. Any style of window, door, wall or architectural feature can be added.	The appearance can be customized to the home owner's
Building Process	Assembly-line building.In a manufacturing factory. The removesdelays cause by the weather and vandalism damages. This more efficient process reduces the cost when compared to traditional homes.	The most costly building process which requires almost the entire house to be custom constructed. It will require more people which will take more timesince they do not work on the same type of house every day. It is also vulnerable to weather delays and vandalism costs. This process is the most likely to result in damaged bu ilding products like warped wood from rain exposure.

VIII. DESIGN PARAMETERS

The modular industry has benefitted greatly from advances in engineering and computer software. Design and customization that was once very difficult to accomplish has become much easier. A combination of modular and either panelized or site- built construction processes allow a developer to build almost any structure.

The real design limitations come from transportation regulations and from the structural nature of a modular box. The 16 foot width limitation makes it more difficult to create rooms with wide open spaces. The only real way to accomplish this is to combine two modules and open the walls between the two. If additional structural support is added then an opening of 16 foot is possible. Height limitations of around 13'6" including trailer, limit finished ceiling height to approximately nine feet. A 9'6" ceiling height is accomplishedregularly with the use of a tray ceiling but this is the absolute maximum. Similar to site-built construction, the higher a ceiling is, the more expensive the building becomes to construct.

There is an incremental cost increase to expanding the width of a module being used for the construction, both in construction cost and because the unit will require transportation permits, off hour's shipment etc.

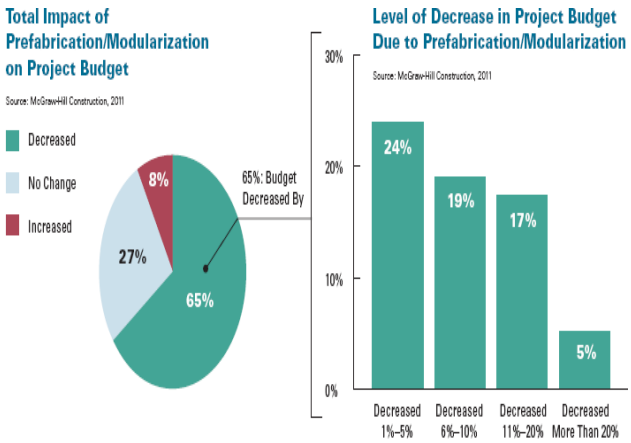
IX. MODULAR CONSTRUCTION– THE COST EFFECTIVECONSTRUCTION METHOD

Modular building is a remarkably cost-effective construction method. Concurrent construction allows work to begin sooner and in parallel with site preparation, which means cost savings at the outset. Modular structures require fewer calendar days to complete than conventionally constructed buildings. Precision fabrication allows design replication, so there is less material waste. Centralized factory manufacturing reduces energy consumption, building expenses and operating costs.

Quicker time to occupancy means greater productivity, income generation and improved cash flow for the end-user in any sector. For example, the sooner a medical center is completed, the sooner patients may receive health care; the quicker a school is opened, the faster students may begin learning.

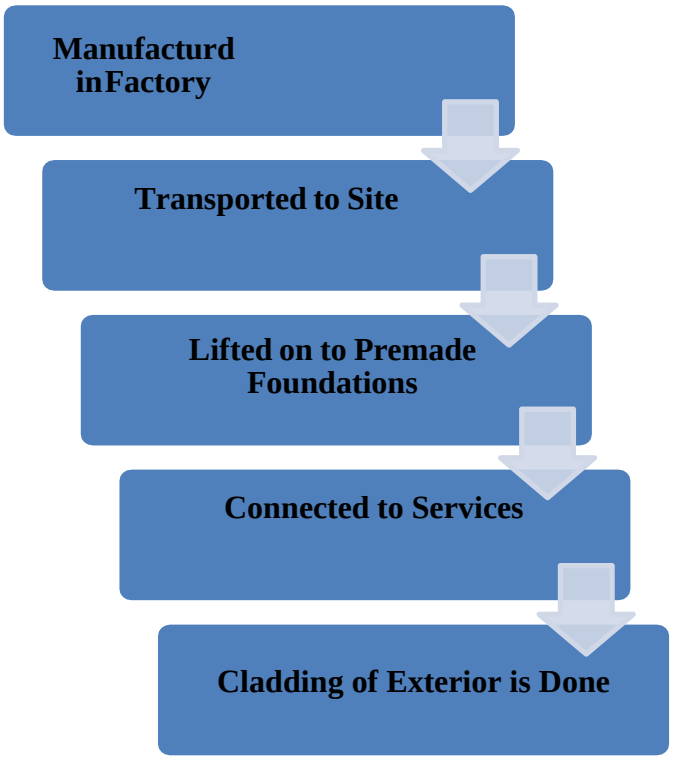
When the building is completed more rapidly, billing may commence sooner. Another advantage of modular building is flexible financing unique to this construction method, including off-balance sheet treatment of building assets and management of facilities as an operating expense rather than within capital budgets.

[Source-*http://www.dcd.com/insights/mayjun_2008.html*]

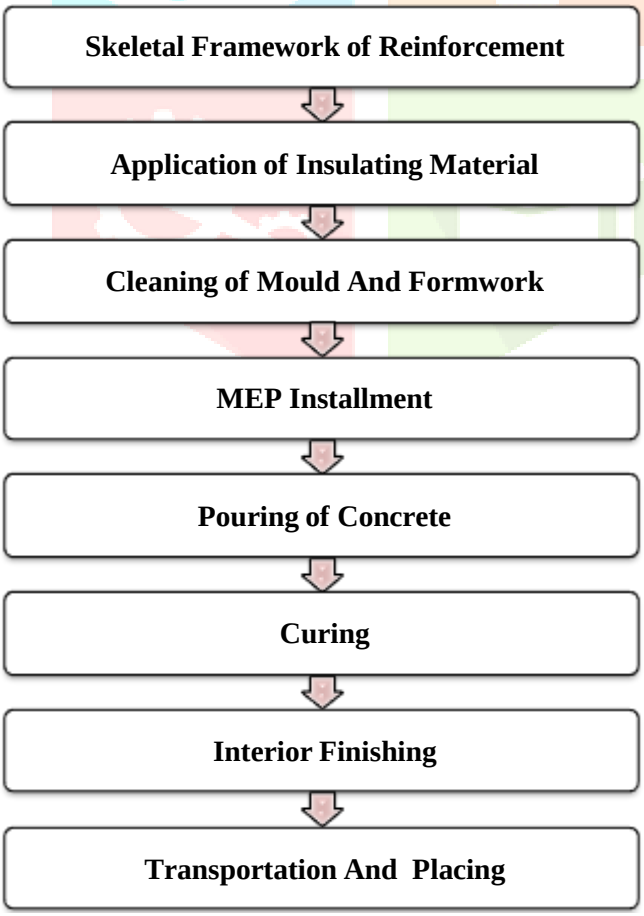


X. MODULAR CONSTRUCTION SYSTEM

A building is termed as modular when manufactured and assembled in systematic way in factories rather than conventional methods of construction. (Note- In convectional construction system all the construction activates are performed on site.)

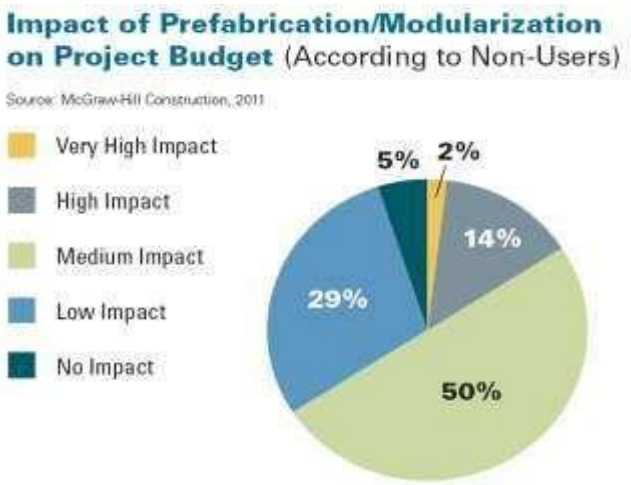


XI. PROPOSED METHADOLOGY FOR CONSTRUCTION



XII. COMPARISION BASED ON CAPITAL COST

Elements of construction	Traditional	Modular
External works and service connections	9	9
Foundations and sub structure	7	6
Framework and Floors	10	NA
Modular units (fully fitted out)	NA	50
Internal fittings	12	Included in units
Roof structure and roofing	5	3
External Cladding	15	10
Communal areas, access etc	8	8
Mechanical and Electrical services	15	5
Drainage and water	4	4
Site preliminaries	15	5
Total	100%	100%



XIII. CONCLUSION

Affordable housing with adequate facilities being the need of the hour.

Modular buildings in general have the potential to benefit from higher quality with respect to improved material quality, improved building performance, sustainability, etc. In addition, production in factory environment results in higher worker productivity and a safer and healthier environment in modular construction compared with on-site construction.

Modular construction allows for cost savings with crane and material rentals General Conditions and General Requirements such as flagging and on-site offices, as well as a reduction in labor wages,

XIV. ACKNOWLEDGMENT

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