

MODERN METHODS OF CONSTRUCTION

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ABSTRACT

A wide variety of modern methods of construction (MMC) techniques and products have been developed that have completely changed the behavior of construction industry from what it was before. This change is amazing and is in the way to bring more and more developments in this sector.

Modern methods of construction (MMC) are suggested to deal more effectively with uncertainties that construction commonly presents to clients and contractors. e.g. time, defects, safety, environmental impact, costs, profits and lifecycle performance. But do MMC really reduce these uncertainties? Furthermore, MMC change stakeholders' frames of references and they also carry their own inherent uncertainties from the previous century, e.g. poor quality and social exclusion. Perhaps MMC introduce more uncertainty than they reduce? These questions are addressed in this thesis that covers current research from the leading construction management journals as well as institutional reports from India and UK. Uncertainties inherent in traditional construction are put in relation to the attributes offered by MMC, and the attributes are discussed with respect to their ability to reduce uncertainty, for clients and contractors respectively. Conclusions from the review are that the industrialized construction process, when fully implemented, does contribute to uncertainty reduction through its predictability regarding time schedules, costs, and improved working conditions.

We will get to know that whether the use of MMC is worth or not or if it is then which method is used most and what are the barriers and strategies to overcome the problems which are faced on these modern methods of construction.

INTRODUCTION

1.1 GENERAL

Many people prefer homes built the traditional way, board by board, nail by nail, right close by at the construction site. Nevertheless, they don't construct them like they used to. The huge mainstreams of houses these days are built with at least some factory-built components.

And a healthy proportion are put together almost totally off-site. The cause is generally cost. The building method approach to home building save time, and time is money, not just to the people who raise houses but as well to the people who pay money for them. Modern methods of construction (MMC) originated in the United Kingdom (UK) as a common term for offsite methods of construction and onsite methods of construction. Offsite MMC are prefabrication elements or parts of structures, constructed in factory, then transported and assembled on-site. Onsite MMC are building blocks and parts of structures takes place directly on site. Virtually all of the good quality products are built in factories around the world. Cars, planes, ships, computers, printers, cell phones, even the pen you write with are built in factories. In addition, even site built homes use many components that were produced in factories. Modular homes take a shorter time for construction compared with site-built homes. This is due to the fact that while the modular is being built in the factory, another crew is building the foundation at the same time.

The concrete industry embraces innovation and modern methods of construction (MMC) by offering concrete solutions which can be used to reduce construction time and promote sustainable development, as well as offering cost savings.

A wide variety of modern methods of construction (MMC) techniques and products have been developed that have completely changed the behavior of construction industry from what it was before. This change is amazing and is in the way to bring more and more developments in this sector.

1.2 Defining and Classifications of Modern Methods of Construction

MMC originated in the United Kingdom as a common term for offsite methods of construction and onsite methods of construction. Offsite MMC are prefabrication elements or parts of structures, constructed in factory, then transported and assembled on-site. Onsite MMC are building blocks and parts of structures takes place directly on site.

Authors Chen (Chen, 2010) argues that MMC in the construction industry has enhanced productivity and improved quality as well as several benefits as shortened construction time, lower overall construction cost, improved quality, enhanced durability, better architectural appearance, enhanced occupational health and safety, material conservation, less construction site waste, less environmental emissions, and reduction of energy and water consumption. MMC are about better products and processes. They aim to improve business efficiency, quality customer satisfaction, environmental performance, sustainability and the predictability of delivery timescales. MMC are, therefore, more broadly based than a particular focus on product.

They engage people and process to seek improvement in the delivery and performance of construction. Some authors defined MMC as those which provide an efficient product management process to provide more products of better quality in less time. It can be classified in various ways and may involve key services (e.g.) plumbing, key items (e.g. foundations) inner shell (walls etc), external walls, or any combination of these elements. It can also be classified by material (timber, steel, concrete and masonry). MMC are defined as a set of element or component which are inter-related towards helping the implementation of construction works activities.

He also expounded that MMC are an investment in equipment, facilities, and technology with the objective of maximizing production output, minimizing labor resource, and improving quality. MMC are also defined as a system in which concrete components prefabricated at site or in factory are assembly to form the structure with minimum in situ construction.



1.3 What are Modern Methods of Construction?

Modern construction methods (MMC) are methods that are developed in construction industry with proper planning and design so that each project reduces the construction time, cost and maintain overall sustainability.

Many of the benefits of using MMC for housing are as yet unproven or contentious. However, Government and manufacturers suggest the main advantages of MMC are:

- Economic – MMC houses typically have fewer defects and can be built more quickly.

- Environmental – the houses can be more energy efficient, may involve less transport of materials, and produce less waste.

- Social – there may be fewer accidents and less impact on local residents during construction.

There are many methods followed and constructed in the present scenario widespread. Most famous and highly applied methods of modern construction are listed and explained below.

1.4 Types of Modern Methods of Construction:

The different MMC used in construction field includes:-

1. Precast Flat Panel System.
2. 3D Volumetric Modules.
3. Flat Slab Construction.
4. Precast Concrete Foundation.
5. Twin Wall Technology.
6. Concrete Formwork Insulation.
7. Precast Cladding Panels.
8. Concrete Wall and Floors.
9. Prefab Bathroom Pods.
10. Mivan Construction.

1.4.1 Precast Flat Panel System.

This method of construction involves the procedure of making floor and wall units off site. For this, separate factory outlets and facilities is required.

Once the panel units are made as per the design specification and requirements, they are brought to the site and placed. This method is best suited for repetitive construction project activities.



The panels manufactured has the services of windows, doors and the finishes. This method also brings building envelope panels which are provided with insulation and decorative cladding that is fitted by the factory which can also be used as load – bearing elements.

Floor and wall cladding systems are produced off-site in a factory and erected on-site to form robust structures. Windows, doors, other services and finishes can be included within these system. Building envelope panels with factory fitted insulation and decorative cladding can also be used as load-bearing elements. This offers factory quality and accuracy, together with speed of erection on-site are some of the great achievements.

Precast floor and wall units are manufactured off-site in a factory and are transported to the site to be erected for form strong structures. They are most suitable for monotonous projects and tasks. Panels can include windows, doors, finishes and services. Building envelope panels are factory fitted with insulation and decorative cladding and can be used as a load bearing structure. Precast products can offer higher accuracy and quality as well as speed of erection on the construction site.

1.4.2 3D Volumetric Construction.

As the name implies, the 3D volumetric construction involves the manufacture of 3D units in the form of modules in off site. At the time of installation, they are brought to the site and assembled module by module.

Each modular unit manufactured are 3D units, hence this construction is called as 3D volumetric construction or modular construction.



The transportation of the modules can be carried out in various forms or methods. This can involve the transportation of the basic structure or a completed unit with all the internal and external finishes, services installed within it, that the only part remaining is the assembly.

The factory construction brings different unit of same product maintaining their quality throughout. Hence this method is best suited for repetitive projects so that rapid assembly of the products is possible.

Three-dimensional volumetric construction is a modern method of building by which large, often room-sized modules are manufactured in a factory, then transported to site and craned into place. The modules can also be fitted out before reaching site. The method is suited to buildings with lots of repetitive design such as houses, hotels, schools and prisons.

In its purest form, the volumetric modules slot together like a jigsaw and do not require a separate superstructure or extra facades. But the industry has yet to fully embrace the model, and projects often take a hybrid approach that combines offsite and traditional methods. For example, panels could be attached to a steel, timber or concrete frame, or a brick “skin” added to give the impression that the building has been conventionally constructed.

1.4.3 Flat Slab Construction

The flat slabs are structural elements that are highly versatile in nature. This is this versatility that it is used widely in construction. The flat slab provides minimum depth and faster construction. The system also provides column grids that are flexible.



Wherever it is necessary to seal the partitions to the slab soffit as a reason of acoustic and fire concerns, the flat slabs are a desirable solution. When compared with other forms of construction, the flat slabs are faster and more economic in nature.

The construction of flat slabs can be completed with good surface finish for the soffit, this enables to utilize the exposed soffits.

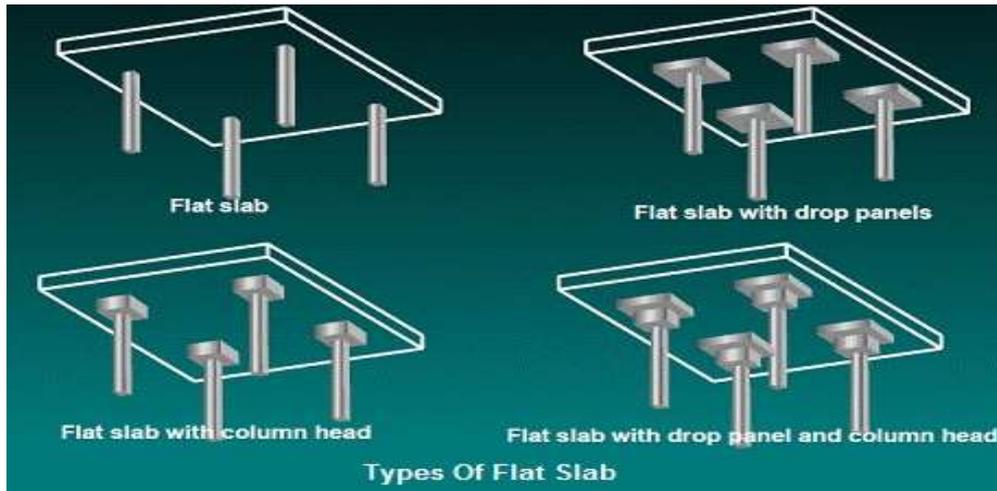
The flat slab construction is also a means of increasing the energy efficiency as this allows the exploitation of building thermal mass in the design of ventilation, heating, and the cooling requirements.

Flat slab is a reinforced concrete slab supported directly by concrete columns without the use of beams. Flat slab is defined as one sided or two-sided support system with shear load of the slab being concentrated on the supporting columns and a square slab called ‘drop panels’.

1.4.3.1 Types of Flat Slab Construction:

Following are the types of flat slab construction:

- Simple flat slab.
- Flat slab with drop panels.
- Flat slab with column heads.
- Flat slab with both drop panels and column heads.



1.4.3.2 Uses of Column Heads

- It increase shear strength of slab
- It reduce the moment in the slab by reducing the clear or effective span

1.4.3.3 Uses of Drop Panels

- It increase shear strength of slab
- It increase negative moment capacity of slab
- It stiffen the slab and hence reduce deflection



Drop panels play a significant role here as they augment the overall capacity and sturdiness of the flooring system beneath the vertical loads thereby boosting cost effectiveness of the construction. Usually the height of drop panels is about two times the height of slab.

Flat Slabs are considered suitable for most of the construction and for asymmetrical column layouts like floors with curved shapes and ramps etc. The advantages of applying flat slabs are many like depth solution, flat soffit and flexibility in design layout.

Even though building flat slabs can be an expensive affair but gives immense freedom to architects and engineers the luxury of designing.

1.4.4 Precast Concrete Foundations.

For the rapid construction of foundation, the precast concrete system can be employed. This method is more suited for a bespoke design.

Here, the elements required for the construction of foundation are constructed separately in the factory (off site) and brought to the site and assembled. The manufactured product must have the assured quality as specified by the designer.



The foundation assembled is mainly supported by concrete piles. During assembling, both the systems are connected together. These foundation systems helps in increasing the productivity, increase quality, decrease the soil excavation quantity.

This is best suited for extreme and adverse weather conditions. When the construction is dealt on a highly contaminated ground, this system of construction is a best choice.

The most popular precast foundation walls come as nearly finished panels, incorporating insulation and interior studs ready to accept drywall. On site, precast panels go up much more quickly than cast walls, including those constructed with insulating concrete forms (ICF). And since there's no concrete placed on site, construction can proceed in virtually any weather without concern about freezing or wet conditions. Precast wall erection is also simpler than cast-in-place or ICF construction and can be done by low-skilled workers with only one trained lead. "We feel it is the future of residential foundations," says Jim Costello of Superior Walls.

Insulated panels come in various configurations, depending on the owner's requirements. The exterior face of the monolithic panel is 2-inch-thick concrete with integral 6 ¾-inch-deep concrete studs and reinforced bond beams, top and bottom. Standard wall panels have an insulation value of R-5 from 1 inch of rigid insulation attached to the concrete between the studs. Thicker insulation can increase that to R-21. Manufactured in the controlled environment of a precast plant, the panels are typically 8 to 10 feet tall and as long as 20 feet. The panels can incorporate window or door openings. There are no stock panels; walls are cast specifically for each project and each panel is cast with its neighbor to match exactly.

This system results in crack-free and waterproof walls. The panels are made with 5000-psi concrete with low permeability. Since the concrete is cast in a factory setting, all shrinkage has taken place prior to erection of the walls so panels virtually never crack in service. A broom finish is standard for the exterior of the panels, although other finishes are available, including simulated brick or flagstone textures.

1.4.5 Twin Wall Technology.

The twin wall technology is a hybrid solution of wall system that combines the qualities of erection speed and precast concrete with the structural integrity of in-situ concrete. This type of wall system guarantees structural integrity and waterproof reliability for the structure.



The twin wall system has two walls slabs that are separated. The two slabs are separated by a cast in lattice girders.

The procedure involves:

1. The wall units are placed in the site.
2. The twin units are propped temporarily.
3. The wall units are later joined by means of reinforcing.
4. The gap between the wall units are filled by means of concrete.

This system of construction is faster than normal construction methods and economical. The twin wall system is mainly employed in association with the construction of precast floors.

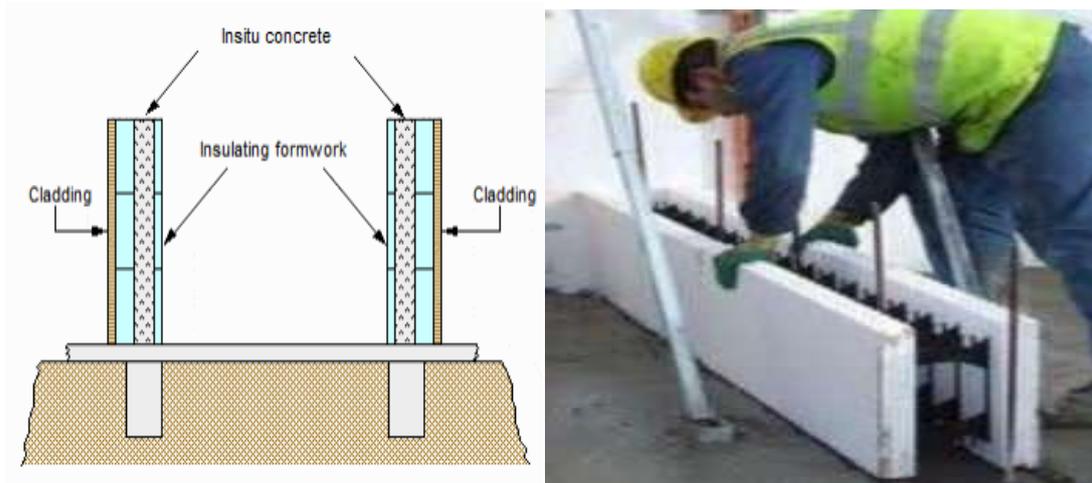
Twin wall construction is a walling system that combines the speed of erection and quality of precast concrete with the structural integrity of in-situ concrete to provide a hybrid solution. The prefabricated panels comprise two slabs separated and connected by cast-in lattice girders. The units are placed, temporarily propped, then joined by reinforcing and concreting the cavity on site. Twin wall is usually employed in association with precast flooring systems.

The panels are manufactured to exacting tolerances, have a high quality finish, and can incorporate cast-in cable ducts, electrical boxes and service ports. Installation rates are of up to 100m² per hour. Twin wall has excellent inherent fire resistance and acoustic performance.

1.4.6 Insulating Concrete Formwork.

The system of insulating concrete formwork (ICF) have twin walled panels that are either polystyrene panels or blocks are employed. These are built quickly to create the formwork as the wall of the buildings.

The formwork that is made is filled with concrete. This concrete is factory produced that have quality assurance so that a ready – mixed concrete. Mostly the mix is ready mix concrete.



Higher level of thermal insulation is provided by expanded polystyrene blocks. The concrete core will provide good robustness and better sound insulation.

Insulating concrete formwork (ICF) is a building system that uses lightweight formwork (made from an insulating material) to support concrete walls whilst they are being cast in-situ and which is then left in place as insulation.

ICF has proved to be robust, cost effective method of constructing of variety of building types – from houses and basements to multi-story cinemas and commercial buildings.

Insulated concrete formwork consists of twin-walled expanded polystyrene panels that are stacked together to create the permanent formwork used to contain the ready-mixed concrete for the walls.

The insulated formwork remains in place to provide complete thermal insulation to the walls of the finished building. It also provides a uniform surface ready for direct application of most finishes and proprietary cladding systems. Many insulated concrete formwork systems also incorporate their own flooring system.

1.4.7 Precast Cladding Panels

The cladding system is the installation of a material over another that finally act as a skin or a layer. This system of layer is not only intended for aesthetics, but it can help in controlling the infiltration of the weather elements.



No kind of waterproof condition is provided by the cladding. Instead, the cladding is a control measure against water penetration. This safely help in directing the water or the wind so that there is control of the runoff. This helps to prevent the infiltration into the building structure.

Precast concrete cladding offers a cost-effective means of providing a robust, high-quality facade, with a great variety of durable textures, colors and patterns, including a range of facing materials such as stone and brick. It is also known

as architectural precast concrete cladding. Self-finished architectural concrete uses a carefully selected range of natural materials and is sometimes referred to as 'Reconstituted Stone' or 'Recon' due to an appearance more akin to stone than the usual look of concrete.

Precast concrete cladding can be installed quickly on site which, with just-in-time delivery, offers significant construction and programmer benefits. Other benefits include quality-controlled and pre-determined surfaces, low waste and material efficiency and high thermal performance.

Panels can be supported by the structural frame of a building, or self-supporting and restrained. Cladding panels can also be designed to be load-bearing to support floors.

1.4.8 Concrete Walls and Floors.

Concrete walls are mainly applied for seat walls, retaining wall, decorative exterior, and interior finishes.

The concrete is also used a flooring material. As per the latest technology, the concrete floors can be provided with good finish to provide smooth and attractive flooring.



When compared with any other material, the concrete floors provide a wide variety of material for applications like acid-stained painted, radiant floors, overlays, and micro toppings. The concrete flooring can also be called as cement flooring.

When compared with other flooring types, concrete flooring is affordable and maintenance is easy. Proper sealing of concrete flooring can be cleaned by a dust mop.

1.4.9 Prefab Bathroom Pods.

In the construction industry, time is an extremely valuable resource, even a slight interruption in timelines can set off a chain of events that can cause unprecedented project delays. This has prompted the real estate industry to embrace component-based assembly, which focuses on saving time, thereby bringing in a host of benefits such as speed, efficiency, quality and significant cost savings. Bespoke component assembly is proving to be a real game-changer in the building industry and it has now entered the domain of bathrooms. Prefabricated bathroom pods, are turnkey bathroom units, which are setting a trailblazing trend in the future of offsite construction. Pre-designed, pre-engineered and manufactured in factory-controlled environment, the bath pods are shipped to the project site, certified ready to plug and play, with all the fittings and fixtures, including tiles, sanitary appliances, mechanical and electrical installations. They are placed, connected on site for instant use—be it hotels, hospitals, apartments or commercial buildings. Needless to say, this greatly reduces the amount of time, headcount and work compared to the conventional methods on site.



This concept has found favor among a host of hotel chains and real estate developers globally and in India too. Globally, large hoteliers like Sheraton Hotel, Marriot, Star Wood, Holiday Inn and Hilton are increasingly opting for smart prefab bathrooms that offer tremendous economies of scale. In the residential sector in India, prefab bath pods are a nascent concept and are being fitted in premium residential complexes and luxury hotel projects, where time is literally money. Offsite construction leader, KEF Kattera is designing, fabricating and supplying over 6000 modular bathroom pods yearly. The units will be manufactured and transported from KEF Kattera's Modular Pod factory at Krishnagiri, Tamil Nadu. KEF Kattera is delivering several specialized projects in bathroom pods for clients such as Sands Infra, Meitra Hospital, Kovai Medical Center and Infosys.

1.4.10 Mivan Construction.

Mivan is basically an aluminium formwork construction technology developed by Mivan Company from Malaysia, hence the name Mivan. This is the latest building construction technology which is becoming popular with its increasing demand day by day. The need of using this technology is soaring due to its fast speed of construction and easy applicability for mass housing besides various other advantages like good quality and durability of the structure.



Mivan technology fits into this requirement of mass housing and serves the purpose pretty well.

Mivan is an Aluminum formwork technology where the whole structure is of RCC (Reinforced Cement concrete) and brick walls are not used. This gives a very strong earthquake resistant structure, easy to make typical floors with cement concrete pouring at one go for a large area with pipes & conduits for services embedded in it. The construction time taken is reduced to a great extent and also it results in a smooth impeccable finish. Also 'Mivan' technology reduces the need for skilled labor, masonry and rendering work. Mivan technology comes out to be reasonably economical and better equipped for fast construction of mass housing. In Mivan, walls and slabs are cast simultaneously at site by use of easy going lightweight aluminium shuttering formwork. Mivan system is much faster than the traditional beam, column, brick construction.

Due to less thickness of walls in Mivan in comparison to brick walls, more carpet area or bigger room sizes are gained in Mivan system.

- Impeccable smooth finish, even surface is acquired in Mivan system with no need of plastering as in case of brick wall construction.
- Less manpower and resources are required at site in comparison to the traditional brick construction method.
- Mivan technology is much faster than the conventional brick method which saves a lot of time and money.
- It is more earthquake resistant structure and safer also in case of strong earthquake because it is a monolithic concrete structure which shall act as a whole single strong unit.
- Mivan technology eliminates or reduces to a great extent the labour intensive activities like rendering and masonry and also results in negligible or very less wastage.
- Built by Mivan technology, the end product or the concrete structure requires negligible or less maintenance as it is much more durable than the brick masonry construction.

Mivan shuttering is a fast-paced construction technique which over's strength and durability to a building by use of aluminium formworks.

1.5 OBJECTIVE

1. The first objective is to achieve the modern aspects of the modern construction and to aware the people of the modern construction technology so as to save time, money, resources, and energy.
2. The objective of this project is to do a questionnaire survey on the modern methods of construction so that we can know that how much these modern methods are been used in India and what is the most used method in our construction industry with its advantages and disadvantages in our present scenario of construction industry.
3. The objective of the research is to develop a detailed study of the current level of use of Modern construction technology in different construction like cladding, concrete walls and floors, flat slabs, precast foundation, volumetric modules etc.
4. To know the current barriers which are been faced by the construction companies and firms.

5. To know whether the time duration of construction reduced by using the modern methods.
6. To know the advantages of the MMC.
7. To know whether it is economically, aesthetically cost effective by using these methods.
8. To recommend strategies to overcome the problems which are been faced in the modern construction.

CHAPTER-2

LITERATURE REVIEW

2.1 Journal of engineering and architecture.(march 2014).

Increasingly in the construction industry appears concept of modern methods of construction in delivering faster and more efficient construction. One of these systems and methods are volumetric structural systems. This article analyzes the modern methods of constructions, and points to one of their components, specifically to modular constructions.

2.2 Alan Thomas, Peter Farrell and Tony Auchterlounie. The University of Bolton, Deane Road, Bolton BL3 5AB, UK.

The aim of the study is to investigate whether modern methods of construction (MMC) will be used by housing associations (Has) to address undersupply of affordable housing in the UK. The population is development departments of Has, to determine answers to two questions: (1) is there an undersupply of affordable housing in the UK, and if so what factors are influencing it?, and (2) what factors are considered when choosing between MMC and traditional methods? The main research instrument is qualitative semi-structured interviews with nine senior development directors, validated by quantitative data obtained from development staff. It is confirmed that there is an undersupply of housing, and that MMCs alone cannot resolve this problem. The main conclusion is that Government needs to address the amount of bureaucracy currently hindering Has from developing. The study should inform the decision making process at inception stage for housing developers.

2.3 Alex davies , RICS MMC advisor (2018).

The demands on the residential construction sector are substantial. At a time when we are facing a skills shortage, we have increasing workloads and aspirations to deliver ambitious infrastructure projects and targets alongside other modernization goals such as improving productivity. A key issue at play, beyond planning and developers' business planning, is industry capacity. In his 2016 report about the construction industry, *Modernize or Die*, Mark Farmer identified a skills crisis in mainstream construction, likely to result in a decrease of 20-25% in the workforce over the next decade. The workforce is ageing, and the rate of new entrants is lagging behind those leaving. This is likely to be exacerbated by Brexit, as one in eight UK construction workers are foreign, rising to around one in four in London.

2.4 Lychgate Projects Ltd. NHBC Foundation.(June 2016).

Alternative forms or modern methods of construction (MMC) have a long history in the UK. In the post-war period much use was made of a variety of innovative house-building systems and from time-to-time since then, there have been surges in interest. An industry survey, reported in this publication, was carried out at the end of 2015. It aimed to establish current attitudes to MMC amongst the larger house builders and housing associations.

The majority of the organizations surveyed have made use of MMC: 98% of large and medium-sized house builders and housing associations have used or considered at least one form of MMC in the last 3 years.

The most widely-adopted form of MMC is sub-assemblies and components with two-thirds having used them for at least one home during 2015. This category includes items such as door sets, timber I-beams, prefabricated chimneys and prefabricated dormers.

2.5 Heather Lovell December (2012).

A number of factory-based prefabricated house-building techniques are collectively termed modern methods of construction (MMC). MMC involves the manufacture of homes in factories, with potential benefits such as faster construction, fewer housing defects, and reductions in energy use and waste. This article describes the variety of MMC

used by house builders and assesses the main advantages and disadvantages. It then explores these issues through case studies of use of MMC in the United Kingdom and Japan.

2.6 Gann D. Etal. (1993)

Founded international proof on growing technologies of construction facing the background of forthcoming trends in UK dwelling construction and recommended that insufficiency of conventional skills, together with demand to comply with compelling environmental administration, may well give rise to forthcoming housing programs lay money on expanded use of modern technologies. He had also stated that industrialized housing techniques of construction had been used conveniently in a few countries.

2.7 Morales G. (1999)

Studied both countries Japan and US primary house construction techniques, social involvement, robotics and automation technology in construction, economic feasibility, development and research. He had also founded that automation and robotics has advances productivity, quality of work, safety, site work surroundings, environment circumstances and minimize construction time, work force and construction project costs. Construction quality and construction productivity in individual exercise robots have successfully been accomplished when a unique work is consecutive.

2.8 Khoshnevis B. (2004)

He found that Conventional techniques of construction of large structures slows the rate of growth in construction industry and stated that 3D concrete printing or Contour Crafting technique has the capability for instant requisition in minor income housing and extremity shelter construction. Construction of exorbitance structures with extraordinary architectural designs including, complicated curves and other compound geometries, which are costly to construct using conventional and manual approach, is extra competitor application speciality for Contour crafting.

2.9 Prof. Patil Hemant Chudaman (IJLTET)

Due to globalization in 21st Century nation require more infrastructure facility for economic development such as roads, ports, thermal and hydro electrical plant, dams, irrigation project, shopping malls, hospitals, education institutes, air ports etc. for supporting and increasing the GDP rates. It leads the pressure on construction industry and industry transforms their conventional methodology into modern construction methodology. The overall aim of this paper is to identify the effect of world trend on construction technique and discuss the evolution of building construction with respective of time scale.

2.10 Lenka Kyjakova (2016)

Term of “modern methods of construction” (MMC) comes from the United Kingdom as a common name for off-site and on-site methods of construction. Modular constructions consist of three-dimensional objects known as modules (off-site methods of construction). Modules are joined together at the construction site. Currently, the construction of modular schools in Slovakia is supported by the state government. This paper presents the advantages and disadvantages of MMC emerging at the technological preparation and implementation stages of buildings, which are manifested in modular schools.

2.11 School of Environmental Design and Management (2011)

This investigates the effect that Modern Methods of Construction (MMC) have had on the current availability of skills in the UK construction industry and the effect it is likely to have in the future. The review of literature surrounding the subject identified skills shortages as a problem within the industry. The published literature also showed contrasting views on how effective MMC is seen to be at addressing this problem of skill availability. In order to determine the severity of these skills shortages and whether MMC is seen as a solution to this problem, construction industry opinion was collected through the use of a survey. The data was then analysed to determine industry opinion on the subject, as well as opinion regarding how successful MMC is likely to be at addressing skill availability issues in the future. The data showed an overall opinion slightly in favour of MMC being effective at addressing skills shortages, however to date it was deemed to be ineffective because MMC usage is not currently widespread enough to have a significant

impact on this problem. This study revealed widespread opinion that MMC is likely to help address skills shortages in the future. However, the effectiveness of MMC at addressing skill availability is directly dependent on greater uptake of these methods within the UK construction industry.

2.12 VPS Nihar Nanyama , Riddha Basua , Anil Sawhneyb , Harsh Vikrama , Gourav Lodhaa Primarily (2017)

This study focusses on identifying the challenges faced by the precast technology under various categories. This study also presents a cost analysis model for precast technology versus traditional construction to address some of the challenges. Presented cost model is applied to two projects wherein precast technology and conventional technology are utilized to construct the project and an inference is drawn comparing the time and cost aspects of precast technology. Amicable solutions are proposed for adoption of precast construction from an Indian perspective.

2.13 Quality Parameters Perception of Modern Methods of Construction (2018)

In the study presented in the paper, we searched for already built and occupied wood-based family houses. The residents' attitudes towards such a type of buildings in the context with declared design and qualitative parameters of efficiency and sustainability are overlooked. The methodology of the research study is based on a socio-economic survey. Due to the large amounts of data collected through a questionnaire, only selected parts of the survey results are evaluated and discussed in the paper. The presented parts of the survey focus on two research questions. The first is aimed at determining the preferred parameters of wooden structures with future users and the second is aimed at evaluating the quality of buildings in view of users of existing wooden buildings. An expectations survey aims to determine the attitudes of users during their use of wooden buildings as one of the innovative technologies, MMC, and their view of the quality of construction and comfort while living in them.

2.14 Weil Pan , Alistair G. F. Gibb and Andrew R. J. Dainty,(2008).

This paper reports on research which examined house builders practices and strategies regarding the use of offsite-Modern Methods of Construction (offsite-MMC). A questionnaire survey of the top 100 housebuilders in the UK and a series of interviews were used to reveal the extent to which such technologies are being utilized and the factors which impinge on their popularity. The findings suggest that current offsite-MMC usage in large housebuilders is low, but that the level is likely to increase, given the pressures to improve quality, time, cost, productivity and health and safety. The wider take-up of offsite-MMC is, however, inhibited by perceived higher capital costs, interfacing problems, long lead-in time, delayed planning process and current manufacturing capacity.

2.15 Anjali Yadav , Nikhil Kumar Yadav. A Review on Comparison of Ancient and Modern Construction. (2016).

Now a days the objective of every construction project is to obtain maximum and good productivity with the minimum utilization of resources. Also, earlier strength development in short periods becomes the first motive of the Civil Engineers. In recent times, the use of modern construction materials helps the Engineers to obtain the desired properties in short duration of time. In ancient times, the use of common construction materials does not provide satisfactory and desired properties in short period of time. Also, in olden times, the use of waste and recycled materials did not become common by the Engineers. There are many advantages of using modern construction materials than ancient construction materials.

CHAPTER- 3

METHODOLOGY

3.1 GENERAL

The research focused on large and medium-sized house builders and housing associations.

The research was conducted in 6 stages:

3.2 STAGES

The stages which are been followed in this thesis are as followed:-

3.2.1 Stage 1

This stage consist of desk research stage, incorporating analysis of existing data from relevant available reports, government sources, literature reviews and any other secondary data sources to collect some of the modern methods of construction on which we have to evaluate.

3.2.2 Stage 2

This stage consist of extracting the ideas and then working on it by the use of data collected in the first stage.

3.2.3 Stage 3

In this stage we had prepared the questionnaire on the basis of which the survey is to be conducted, the analysis and the result is to be taken.

3.2.4 Stage 4

In this stage the survey is to be conducted and the data by the survey is to be collected by the help of the questionnaire which is prepared in the stage 3. The interviews are done with contractors, house builders, apartment builders, and there employs.

3.2.5 Stage 5

In this stage the data is been collected from the questionnaire and then the analysis of the collected data is been done in this stage.

3.2.6 Stage 6

Then from the analysis of the stage 5 the compilation of the data is been done which is supplemented by the result.

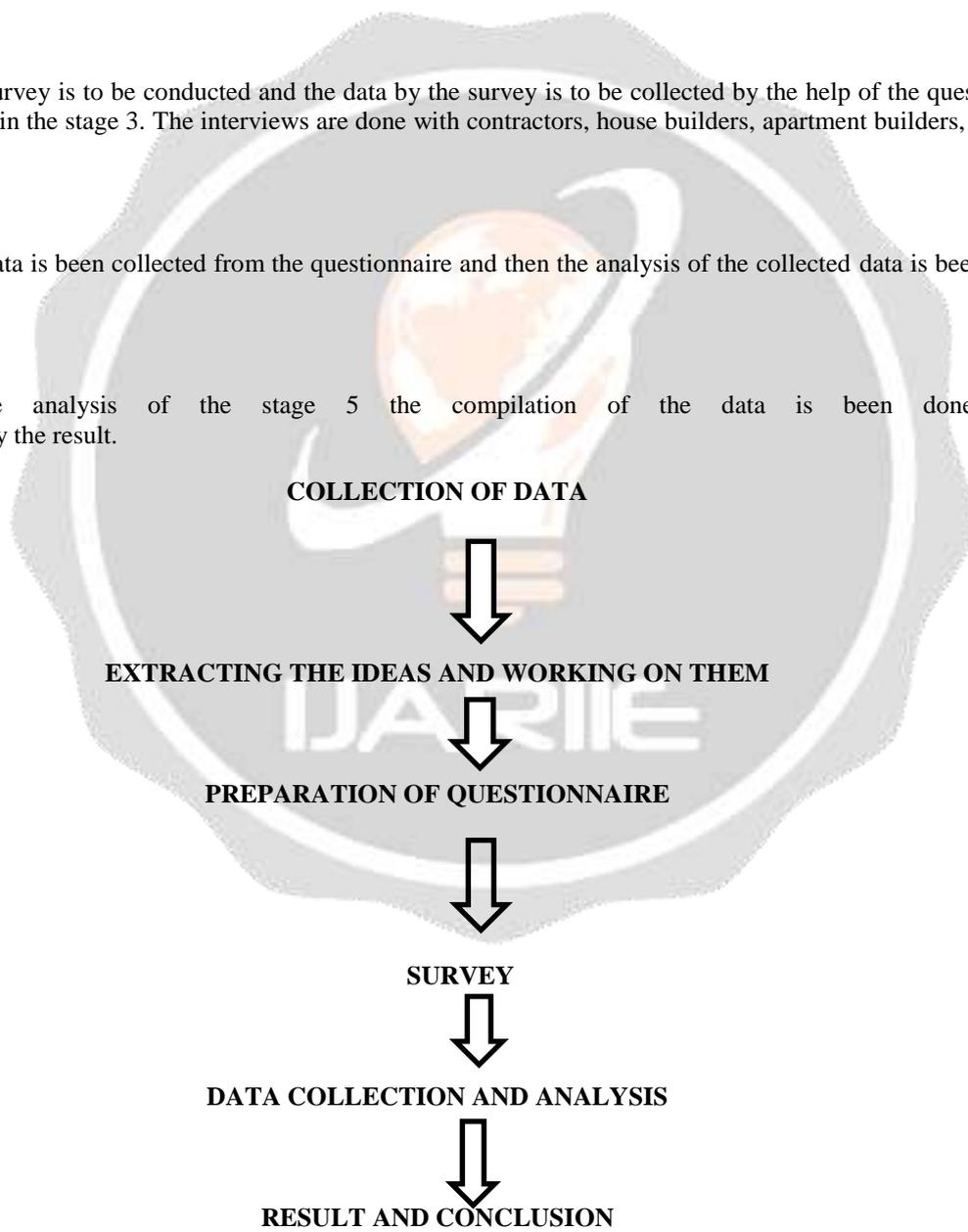


Fig.1. Methodology structure.

CHAPTER- 4

DATA COLLECTION AND ANALYSIS

4.1 GENERAL

In this stage all the data is been collected by the survey in the form of questionnaire which includes the questions regarding the modern methods of construction and how much are they used in our society and which method is been used mostly in construction field and some of the objectives which we have to find.

	No. of interviews
House builders	4
Apartment builders	6
Government projects	3
Private companies	26
Architect consultant	1
Total	40

A total of 40 interviews were conducted out of which 16 responders had said that they are using the traditional method and the remaining of 24 responders are using these modern methods of construction in which some of them are also using Precast Pre Stressed System, DOKA Hydraulic formwork and brick filling between the columns. All these interviews were done to the employs and experts of the respective fields with good basic knowledge and understanding of modern methods technology. Valid opinions were gathered using this approach to data sample collection.

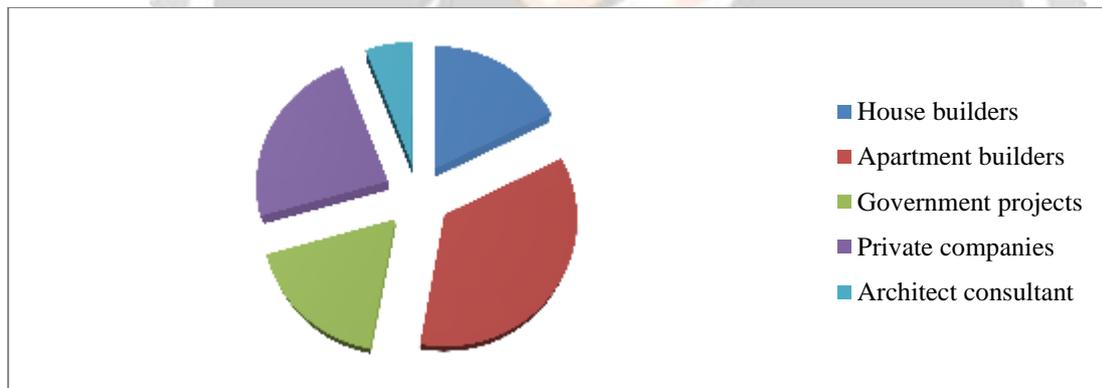


Fig 2. Participants demographic representation

4.2 By the survey which is been done some of the data which is been extracted from the questionnaire are as follows :

4.2.1 The most used method among the modern methods of construction is (in decreasing manner):

- Concrete floors and walls then,
- Mivan technology then,
- Concrete formwork insulation then,
- Flat slab construction then,
- 3D volumetric modules then,
- Precast cladding panels then,
- Precast concrete foundations then,
- Precast flat panel system then,
- Twin wall technology then,

- Least used is prefab bathroom pods.

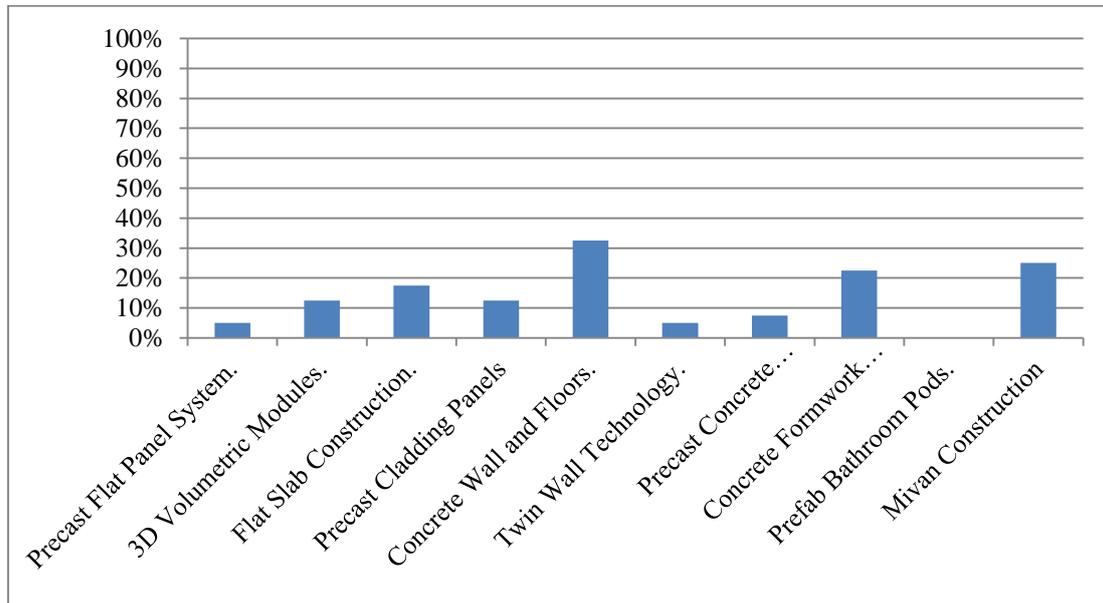


Fig.3. Current use of MMC components.

4.2.2 The barriers which are been faced by the use of modern methods of construction are:

- Far distance from the factory to site.
- High initial cost.
- High taxation problems.
- Lack of resources.
- Lack of co-ordination between the engineers and the labors.
- Great lack of skilled labors.
- Lack of capital.
- Lack of market demand.
- Heavy equipment.
- Increase in duration of project.
- Quality.

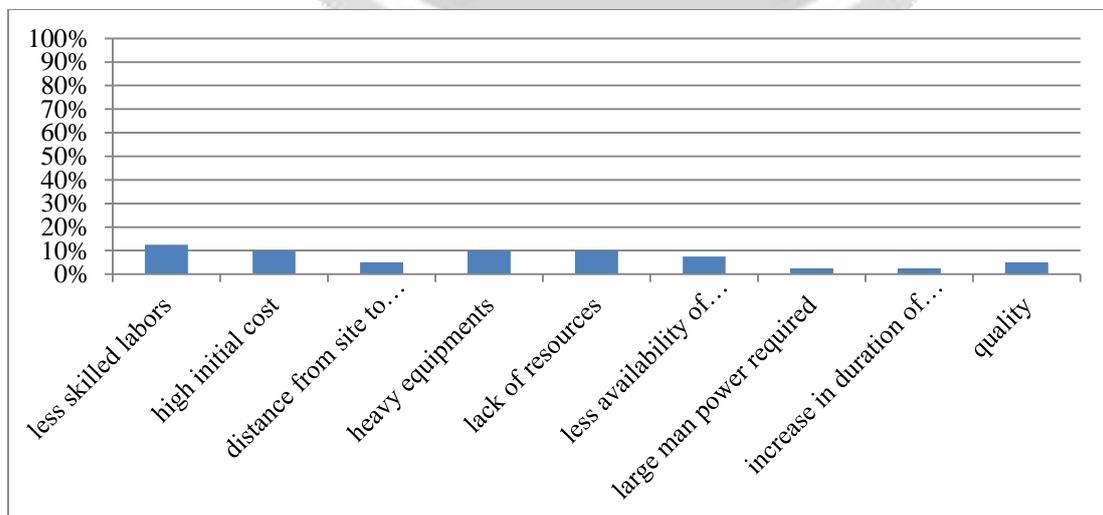


Fig.4. Barriers to MMC.

4.2.3 Advantages by the use of modern methods of construction are:

- It saves the construction time.
- It reduces the waste products.
- It improves the quality.
- Due to the MMC the site disturbance is less.
- Less quantity of labors are required.
- Reduce health and safety risk.
- It reduces the cost of the project.
- Gives better workability.
- It increases the strength.
- Easy construction.
- Simple construction.

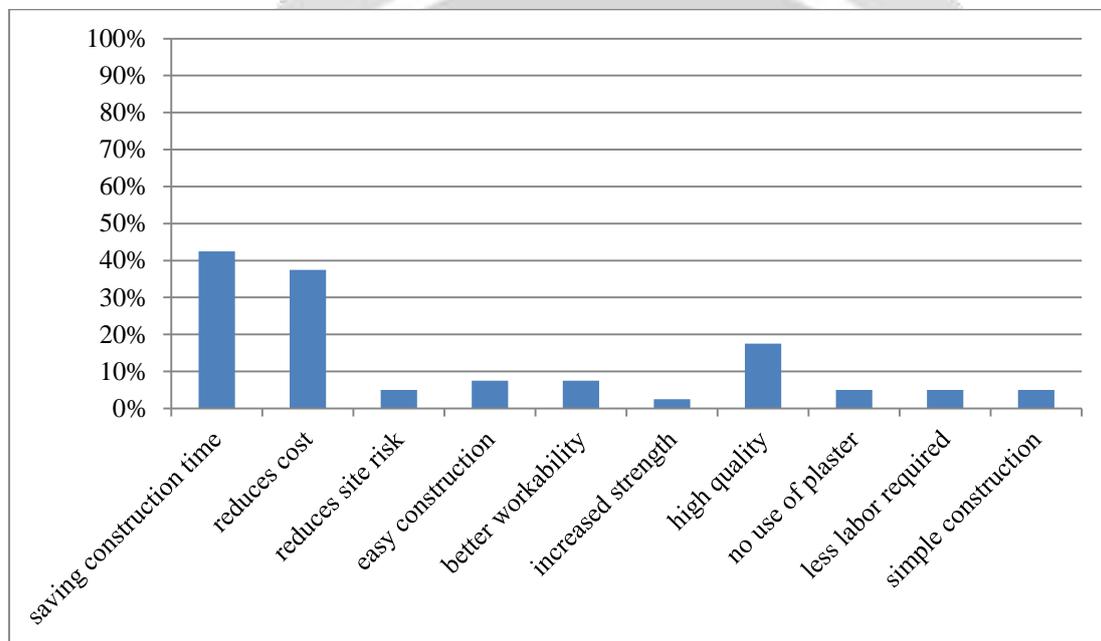


Fig. 5. Advantages of MMC.

4.2.4 There are some of the strategies to overcome those barriers which are been found by the survey are:

- Light weight panels should be used.
- Proper machinery should be used.
- Mandatory use of MMC in big construction sites.
- Self-manufacturing units to be developed in site.
- Gov. support for finance.
- Tax deductions.
- Collaboration with industries and institutes.
- Training at institutes.
- Providing incentives to company.
- Easy availability of materials.
- Cheap construction methods to be developed.
- Self-manufacturing units.
- Easy transportation should be provided.
- Mandatory use of MMC.

- Proper machinery should be designed or provided.
- Proper planning should be done.

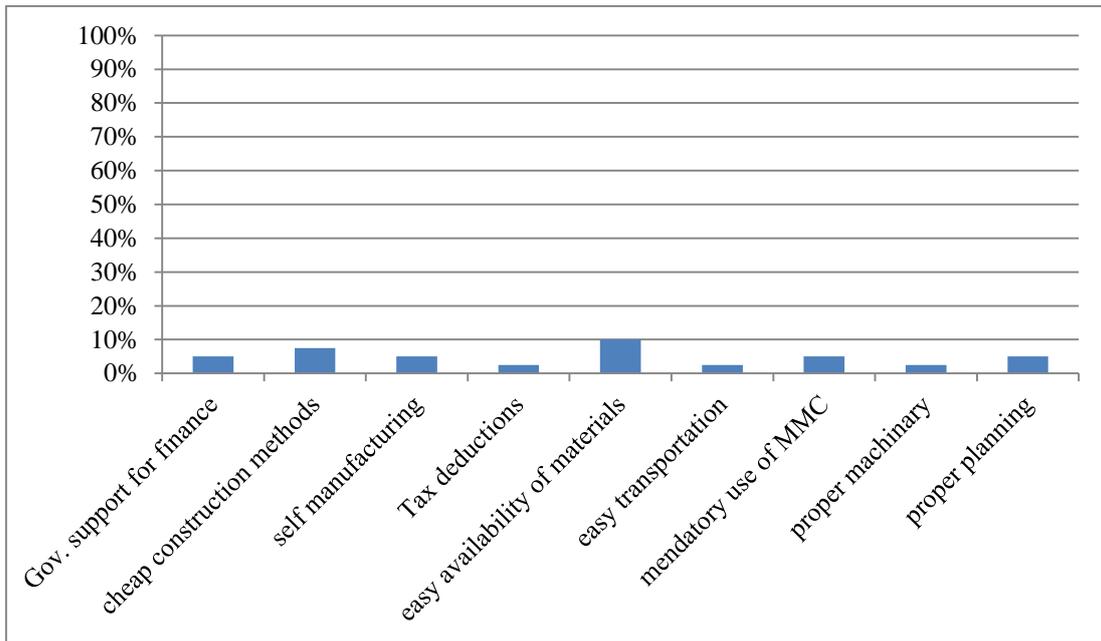


Fig.6. Strategies to overcome problems in MMC.

4.2.5. By the survey and analysis of the questionnaire we got to know that, yes these modern methods of construction saves the construction time of the project and it got a mean value of 3.85 on a scale of 5 by the survey.

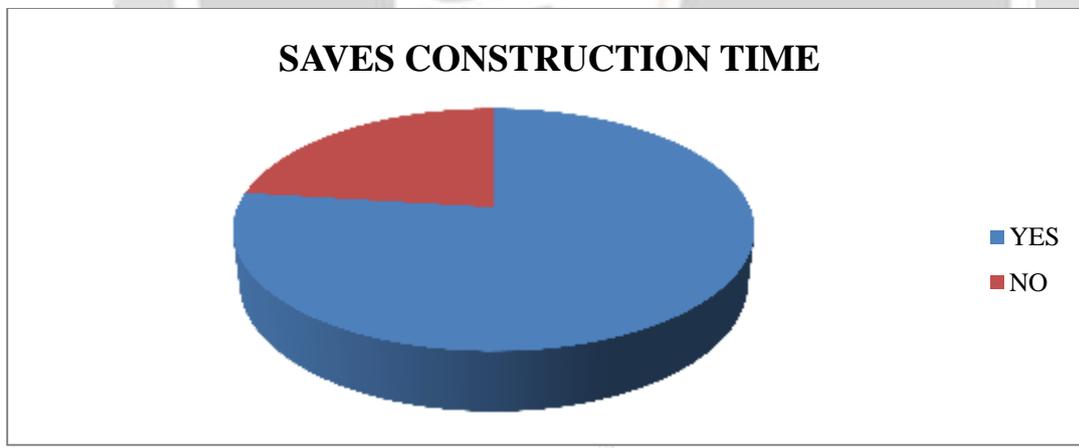


Fig.7. Graphical representation of construction time analysis.

4.2.6. By the survey and analysis of the questionnaire we got to know that, yes these modern methods of construction are cost effective and it got a mean value of 3.22 on a scale of 5 by the survey.

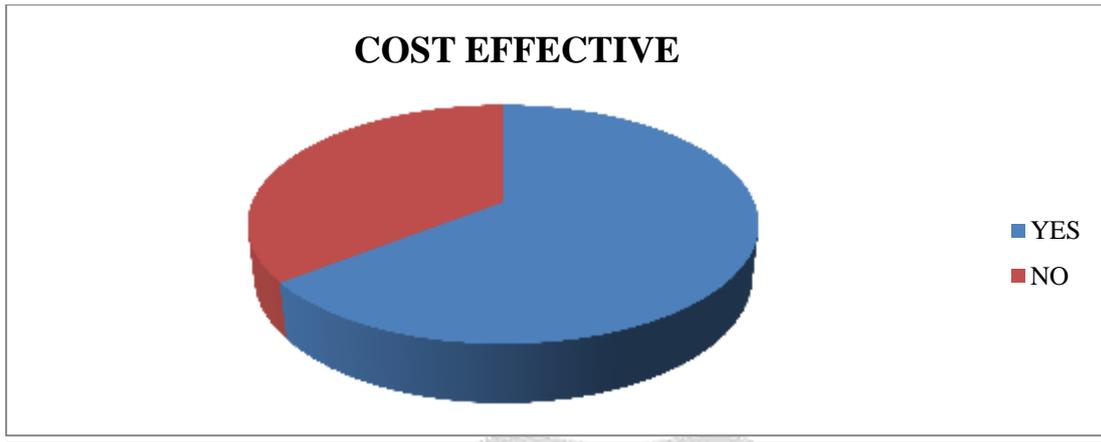


Fig. 8. Graphical representation of cost effectiveness analysis.

4.2.7. By the survey and analysis of the questionnaire we got to know that, yes these modern methods of construction gives a good quality and it got a mean value of 4.01 on a scale of 5 by the survey.



Fig. 9. Graphical representation of quality analysis.

4.2.8 By the survey and analysis of the questionnaire we got to know that, yes these modern methods of construction are sustainable on a long time and it got a mean value of 3.35 on a scale of 5 by the survey.

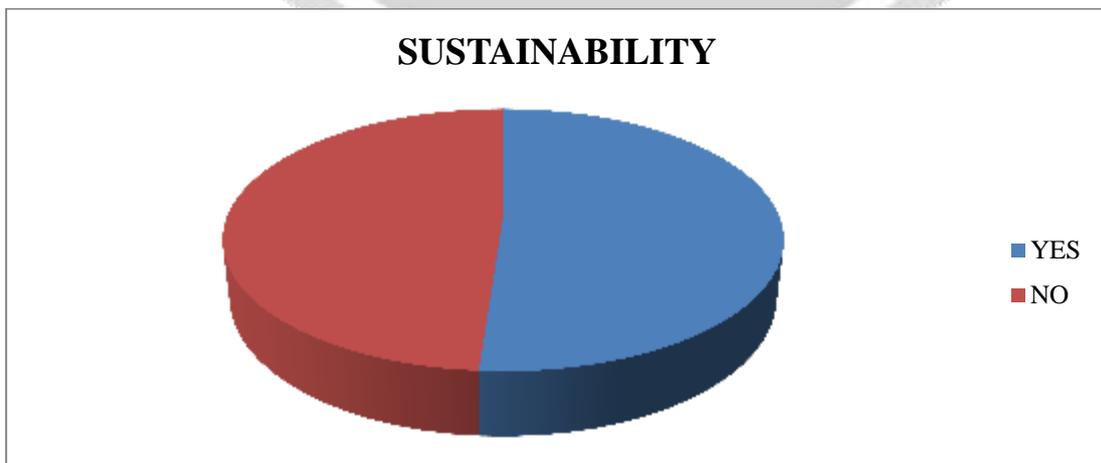


Fig. 10. Graphical representation of sustainability analysis.

4.2.9 By the survey and analysis of the questionnaire we got to know that, yes these modern methods of construction are value for money and it got a mean value of 3.68 on a scale of 5 by the survey.

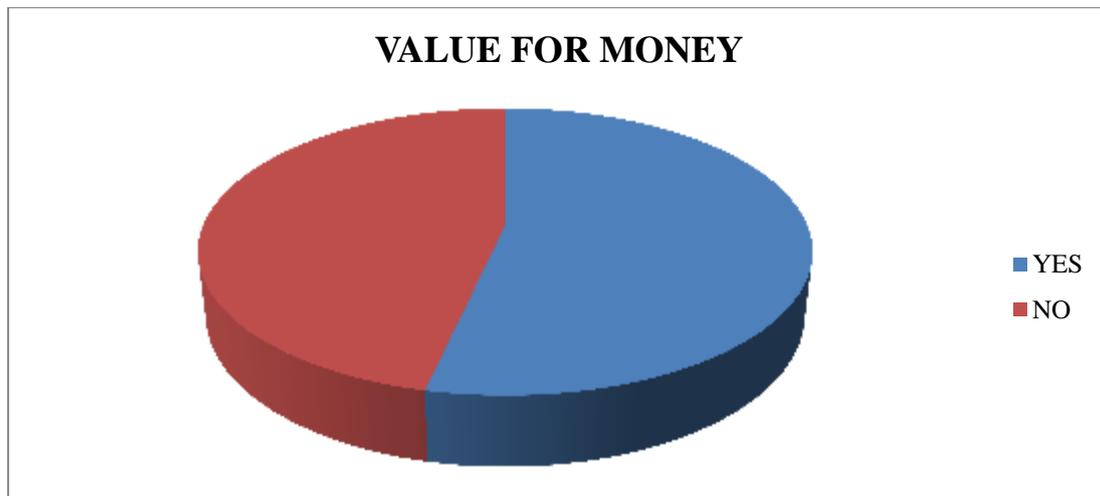


Fig. 11. Graphical representation of value for money analysis.

CHAPTER-5

RESULT AND CONCLUSION

5.1 GENERAL

The benefits of modern methods of construction are too positive to be ignored. Modern methods of construction can provide large numbers of sustainable, well-designed homes in a short period of time. Modern methods of construction also afford an opportunity to overcome the skills shortage in the construction industry through factory production. Modern methods of construction will be a key tool in addressing this challenge and should be viewed as an opportunity for the house building sector to increase capacity and choice in the housing market. Modern construction technology have evolved from the more conventional methods to a large extent. Modern construction technology is those that provide greater efficiency in the construction process, resulting in increased production, better quality, in less time and with less waste, so reducing the environmental impact. Modern construction technology is a process to produce more, better quality homes in less time.

- This thesis presented the views of the respondents working in construction industry. Survey conducted for this thesis was mainly answered by respondents from Delhi, Noida, Bombay and rest was from Lucknow. Some of the companies were Supertech Realstate Construction, Alwaliya Construction, Akbar Ali Constructions, Arabian Construction Company and some of the local builders etc. Majority of the respondents of this survey have experience between 2 to 20 years and also out of 40 respondents 24 respondents said yes to the use of MMC field and 16 respondents said that they are still using the traditional method means no to MMC. This indicates that there is a good significant usage of modern technology in high developed cities but still in some areas or low developed cities they are still using their traditional methods . But from various news articles it was found that there is considerable progress in prefabrication even though the progress was very few, such as incorporation of prefabricated housing in government own buildings, hospital, school etc.
- By this thesis we got to know that the most used method was the Concrete walls and floors which got a percentage of 32.5% which is been followed by the Mivan technology which got a percentage of 25% of popularity in the construction sites which is known by the survey.
- By this thesis we also got to know about the barriers in MMC some of them are expensive long distance, taxation problems, lack of skilled labors, lack of capital etc.
- By this thesis we also got to know the strategies to overcome the problems which are been faced by the companies some of them are government support of finance, training programs, tax deduction, mandatory use of MMC etc.

- By this thesis we also got to know that these modern methods of construction are saving construction time which got a mean rating of 3.85 on the scale of 5.
- By this thesis we also got to know that these modern methods of construction are cost effective which got a mean rating of 3.22 on the scale of 5.
- By this thesis we also got to know that these modern methods of construction gives a good quality in construction which got a mean rating of 4.01 on the scale of 5.
- By this thesis we also got to know that these modern methods of construction are sustainable with time which got a mean rating of 3.35 on the scale of 5.
- By this thesis we also got to know that these modern methods of construction are value for money which got a mean rating of 3.68 on the scale of 5.

5.2 Advantages of MMC over traditional: The three main advantages of MMC came down to time, quality and sustainability:

- **Time:** Over two thirds (67%) of responders with their staff confirmed a reduction of construction time on site.
- **Quality:** 81% of responders considered quality to be better with MMC housing, this is due to constant quality of manufactured components from a factory. Most of them considered one of the main advantages of MMC is it delivers 'better degree of quality control'. With two selecting volumetric construction 'I guess the most tight quality control you can get in volumetric manufacturing'. According to the responders MMC received high scores for quality is; people considered a high percentage of work being carried out in dry controlled factory conditions, which is the case with volumetric.
- **Sustainability:** The research found that on average 60% of people selected volumetric construction to be the most economical method of construction currently available in delivering sustainable housing, compared to only 40% selecting traditional construction to be best. However, four of the senior managers considered during the survey, that the word sustainability was in fact a long-term issue, 'durability' and 'longevity'. Therefore, for that reason alone traditional construction would be the best long-term solution, being tried and tested.

5.3 Disadvantages of MMC over traditional: From research there are far more disadvantages than advantages, each area is considered separately.

- **Value for money:** All senior managers considered various MMC cost more than traditional forms of construction to build, the average on-cost being in the region of 12%. Almost two thirds (61%) of those completing the questionnaires agreed, MMC cost more than traditional methods. However, 34% considered there to be no difference in costs between MMC and traditional, with a further 15% having a view MMC cost less.
- **Commercial risk:** In the open quantitative questionnaires the largest concern people had is procurement through the supply chain (34%), 'too many horror stories of long lead in times due to suppliers being too busy and unable to meet demands. The client becomes too reliant on one supplier placing all your eggs in one basket'. Senior managers raised similar concerns. Typical comments from senior managers were 'no we should not take any more risks than anybody else'.
- **Maintenance:** When asked do they consider long-term maintenance costs of various methods of construction, it drew conflicting replies. Senior managers considered that traditional methods would deliver less defects. From the replies of the respondents, it became quite apparent that this information is either unknown or that more than likely no one had considered the long-term costs.
- **Flexibility:** Responders confirmed in their views traditional construction to be the most flexible method of construction; with 26% percent of responders considering mivan construction to be the second most adaptable.

5.4 SCOPE FOR FUTURE WORK

The scope of this report is to make the use of modern construction technology and their materials throughout the world for minimal use of natural resources and to save it for future generation. "Over the next few years I expect to see the majority of our program done offsite".

SAMPLE OF QUESTIONNAIR:-

SAMPLE 1-

QUESTIONNAIRE ON CURRENT CONDITION OF MODERN METHODS OF CONSTRUCTION

GENERAL INFORMATION

- NAME: ATUL GARG.
- POSITION: Ch. M. (PROJECT) CONTACT NO: 8505832909
- COMPANY NAME: SUPERTech REALSTATE Pvt. Ltd.

Some of the modern methods of construction on whose basis this survey will conduct.

1. Precast Flat Panel System. ✓
2. 3D Volumetric Modules. ✓
3. Flat Slab Construction. ✓
4. Precast Cladding Panels. ✓
5. Concrete Wall and Floors. ✓
6. Twin Wall Technology. ✗
7. Precast Concrete Foundation. ✗
8. Concrete Formwork Insulation. ✓
9. Prefab Bathroom Pods. ✗
10. Mivan Construction. ✓

Please state the answers in YES or NO and if yes then state the level of importance of the following questions on the scale of 1 to 5 which includes:
(1-least important, 2-less important, 3-neutral, 4-important, 5-most important.)

Q 1. Do your company use modern methods of construction? If yes then which method is used most?

A 1. Yes, 5th

Q 2. What are the advantage of the method which is used?

A 2. Saves time, reduce cost.

Q 3. What are the disadvantages of the method which you use?

A 3. Initial cost is high, lack of labour.
site is far from factory.

Q 4. What are the barriers which are faced in that method?

A 4. Same as above.

Q 5. What are the strategies to overcome the barriers in modern construction?

A 5. less cheap const. methods.

Q 6. Do these modern methods saves construction time or not? If yes then rate.

A 6. Yes, 3

Q 7. Do these modern methods of construction are cost effective or not? If yes then rate on its cost effectiveness.

A 7. Yes, 3

Q 8. Do these methods give the quality construction or not? If yes then rate on its quality.

A 8. Yes, 4

Q 9. Do these methods are sustainable over a long time? If yes then rate on its sustainability.

A 9. Yes, 3

Q 10. Do these modern methods are value for money? If yes then rate.

A 10. Yes - 4

Now, comment on the future scope of the modern methods of construction:-

Atul Gangi
SIGN: 04/07/2019.

SAMPLE 2-

**QUESTIONNAIRE ON CURRENT CONDITION OF MODERN
METHODS OF CONSTRUCTION**

GENERAL INFORMATION

- NAME: SANDEEP SATHIAK CONTACT NO: 8851869855.
- POSITION: ASD. PROJECT MANN.
- COMPANY NAME: Alwalija Contracts Incl. Ltd.

Some of the modern methods of construction on whose basis this survey will conduct.

1. Precast Flat Panel System.
2. 3D Volumetric Modules.
3. Flat Slab Construction.
4. Precast Cladding Panels.
5. Concrete Wall and Floors.
6. Twin Wall Technology.
7. Precast Concrete Foundation.
8. Concrete Formwork Insulation.
9. Prefab Bathroom Pods.
10. Mivan Construction.

Please state the answers in YES or NO and if yes then state the level of importance of the following questions on the scale of 1 to 5 which includes:

(1-least important, 2-less important, 3-neutral, 4-important, 5-most important.)

Q 1. Do your company use modern methods of construction? If yes then which method is used most?

A 1. Yes - (3)

Q 2. What are the advantage of the method which is used?

A 2. Better workability, Cost Comprehensive, less time taking.

Q 3. What are the disadvantages of the method which you use?

A 3. (a) Shortage of Skilled Labour
(b) Availability of Raw material
(c) Eco friendly.

Q 4. What are the barriers which are faced in that method?

A 4.

Q 5. What are the strategies to overcome the barriers in modern construction?

A 5. We are planning to spread the self manufacturing units at site only.

Q 6. Do these modern methods saves construction time or not? If yes then rate.

A 6. Yes. - (4)

Q 7. Do these modern methods of construction are cost effective or not? If yes then rate on its cost effectiveness.

A 7. Yes. - (3)

Q 8. Do these methods give the quality construction or not? If yes then rate on its quality.

A 8. Yes - (5)

Q 9. Do these methods are sustainable over a long time? If yes then rate on its sustainability.

A 9. Yes - (2)

Q 10. Do these modern methods are value for money? If yes then rate.

A 10. No, Depend on the nature of client & Customer

Now, comment on the future scope of the modern methods of construction:-

(a) As our concern the future scope is also limited because the construction technology is updating in every six month. As per my experience in last three years 50% of technology is updated and hence so in the future.

SIGN:

Apurva ..

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