

EFFECTIVE SELECTION OF FORM WORK FOR HIGH RISE BUILDINGS

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ABSTRACT

In a tall building construction with reinforced concrete structures, the selection of an appropriate formwork system is a crucial factor for the success of the project. Thus, selecting an appropriate formwork system affects the entire construction duration and cost, as well as subsequent construction activities. However, in practice, the selection of an appropriate formwork system has depended mainly on the intuitive and subjective opinion of working level employees with restricted experience. This study is to focus on identifying the qualitative factors affecting the selection of the formwork at high rise buildings from the various literatures and the interview with the selected respondents. Questionnaire has been prepared with keep in mind about residential and commercial projects only and the questionnaire will be distributed to various Project Managers, Planning Engineers, and contractors in Chennai, Bengaluru, Coimbatore and Erode. Developing a decision support model for formwork, incorporating all the major constraints, that will help whether the resources is necessary and feasible at site.

Key words: formwork system, decision support model, high rise buildings, constrains.

INTRODUCTION

GENERAL

Formwork is the use of support structures and moulds to create structures out of concrete which is poured into the moulds. There are many different types of formwork used in construction, usually differing according to what the building requirements and challenges are in construction.

Formwork is used by creating moulds out of wood, steel, aluminum or prefabricated forms into which the concrete is poured. This is then allowed to harden and set after which it is stripped, or in the case of stay-in-place formwork it is left as part of the structure. Formwork allows contractors to cast and construct the main parts of a building which are required to be strong and support the

structure such as floors and walls, as well as smaller parts of a building such as stairs relatively quickly. The most important factor in terms of cost, quality and speed in a high-rise building construction project is the type of the formwork used in the project.

The first formwork type to be used is the conventional type formwork where the timber planks were supported on timber columns. With the advancement of technology it developed gradually and people used ply wood sheets instead of timber planks and steel pipes with jacks were used to support the ply wood. Then people invented small units of formworks and connect the repeating units in the construction. The larger units were invented like formworks for slab panels, formworks for columns, beams...etc. when the same elements are repeating. Then finally the whole system of formwork is made and initially the material used to it was steel and it was very heavy. Then the aim was to reduce the weight of the system and the materials for formwork have extended to aluminum, plastic, fiber glass...etc.

A formwork system is defined as the total system of support for freshly placed concrete as well as supporting members, hardware, and necessary bracing. Formwork is the largest cost component for a typical multistory reinforced concrete building.

The formwork system has a vital role to play especially in the high-rise structures in mechanizing the activities to achieve speed, increase the productivity and to utilize economy of scale in bringing down the unit cost. Mechanization of construction activities at site is the order of the day and formwork is an important component which needs mechanization.

INNOVATIONS IN CONSTRUCTION

The traditional mode of construction for individual houses comprising load bearing walls with an appropriate roof above or reinforced concrete (RC) framed structure construction with infill masonry walls would be totally inadequate for mass housing construction industry in view of the rapid rate of construction. Further, such constructions are prone to poor quality control even in case of contractors with substantial resources and experience. Several systems are adopted at different places in the world; eventually the systems which are reasonably economical and easy for operation with skilled labor are useful in India. Certain systems are in vogue and more and more contractors are trying to bring in new technologies. These are essentially based on the basis of mode of construction, namely, pre-cast construction or in-situ construction.

Scope

With the tremendous increase in need for mechanization in the construction methods and

rising tall structures, there are number of factors to be considered in arriving at a decision of the most appropriate method and system or technology to be used for construction. In selection among different alternative methods and technologies for the faster and economical construction of buildings, it is necessary to formulate a base framework which aids to assist the planning team to choose the most appropriate system of formwork as per the specific requirement of the project.

Objectives

1. To identify factors affecting the selection of the formwork systems
2. To identify different systems of formwork, advantages, limitations and specific problems faced in using the formwork systems.
3. To develop a decision support system for selecting the appropriate formwork systems.

FORMWORK SYSTEMS

Formwork is a mould or die used to shape and support the concrete until it attains sufficient strength to carry its own weight. Formwork is an important enabling work, which has to keep pace with the modernization of concrete construction. Formwork is the largest cost component for a typical multistory reinforced concrete building. Formwork is the largest cost component for a

typical multistory reinforced concrete building. Important aspects in the construction of tall structures include type of formwork system, method of concreting, geometric control, material handling etc. there are many ways a tall structure can be constructed using different formwork techniques like more than 5 stories steel formwork, steel frame with plywood formwork, aluminium formwork, plastic formwork, etc. details on the different systems, their advantages, disadvantages are discussed below

Conventional Formwork

This is the oldest type of formwork used in the construction industry. This type uses timber, bamboo, masonry and carpentry in the construction. This type is very much suitable for small houses with two to three stories and still they are in use for such constructions. But this is not suitable for the big projects or high-rise buildings.



Wooden formwork

- Low initial cost, low experience factor, low weight is some of the advantages of this type

- Poor finish, high labor requirement, skilled labor requirement and consume lot of time are some of the disadvantages.

1.6.2 Modern Conventional Form Work (Plywood Form Work with Steel Frame)

In modern conventional formwork more advanced materials are used and they can reuse for several times. The differences of both types are that steel props and various types of jacks (U jacks, T jacks) are used as supports in the formwork instead of timber supports and plywood sheets are used instead of timber planks on slab decks, beams and columns.



Semi conventional formwork

- Low initial cost, low skilled labor requirement, can even use in small places

and when there are lot of deviations in the structure are some of the advantages.

- While poor finish of the concrete surface, high labor requirement and the higher floor cycle are the disadvantages.

1.6.3 Steel Formwork

Mostly used in large construction projects or in situations where large number of re-uses of the same shuttering is possible.

- It is Suitable for circular or curved shaped structures such as tanks, columns, chimneys etc. & also used for structures like sewer tunnel and retaining wall.
- Strong, durable & have longer life. Reuses can be assumed to vary from 100 to 120.
- Steel can be installed & dismantled with greater ease & speed resulting in saving in labour cost. No danger of formwork absorbing water from the concrete and minimizing honeycombing.
- Proper maintains should be needed, material weight are some of disadvantages.



Steel formwork

1.6.4 Mivan (or) Aluminium formwork

Forms made from aluminum are in many respects similar to those made of steel. However, because of their lower density, aluminum forms are lighter than steel forms.



Mivan formwork

- The formwork turns out to be economical if large numbers of reuses (above 300) are made in construction, integral and smooth finishing of wall and slab, fast construction
- Concrete surface finishes are good to receive painting directly without plaster.

- The major disadvantage of aluminum forms is that no changes can be made once the formwork is fabricated.

1.6.5 Plastic Formwork

- Plastic formwork system has a very low surface tension and so it does not stick to concrete making and reuse without any major cleaning work
- The system is very light weight and therefore easy to handle. It does not get spoilt in water so it can be used in anywhere the and given working conditions onsite it does not need a dry area to store
- There is no need to plaster, apply putty and paint directly
- Repetition around 80 to 100 times.



Plastic formwork floor completion



Plastic formwork system

$RII = \sum w/A * N$ Where,

w = weight of scale; A = highest weight ('5' in this case);

N = total number of respondent

WORKING METHODOLOGY

1. Review the relevant literature regarding formwork selection in construction
2. Form the clear methodology about the project.
3. Design of questionnaires with the help of literature review, field people.
4. Conduct the questionnaire survey and analysis the data.
5. Prepare the decision support model and find accuracy of that model.
6. Conclusion.

RELATIVE IMPORTANCE INDEX

(RII) ANALYSIS

Relative Importance Index (RII) analysis was employed to measure the Likert (ordinal) importance scale. In this study, five scale rating was used and the weight was give as below:

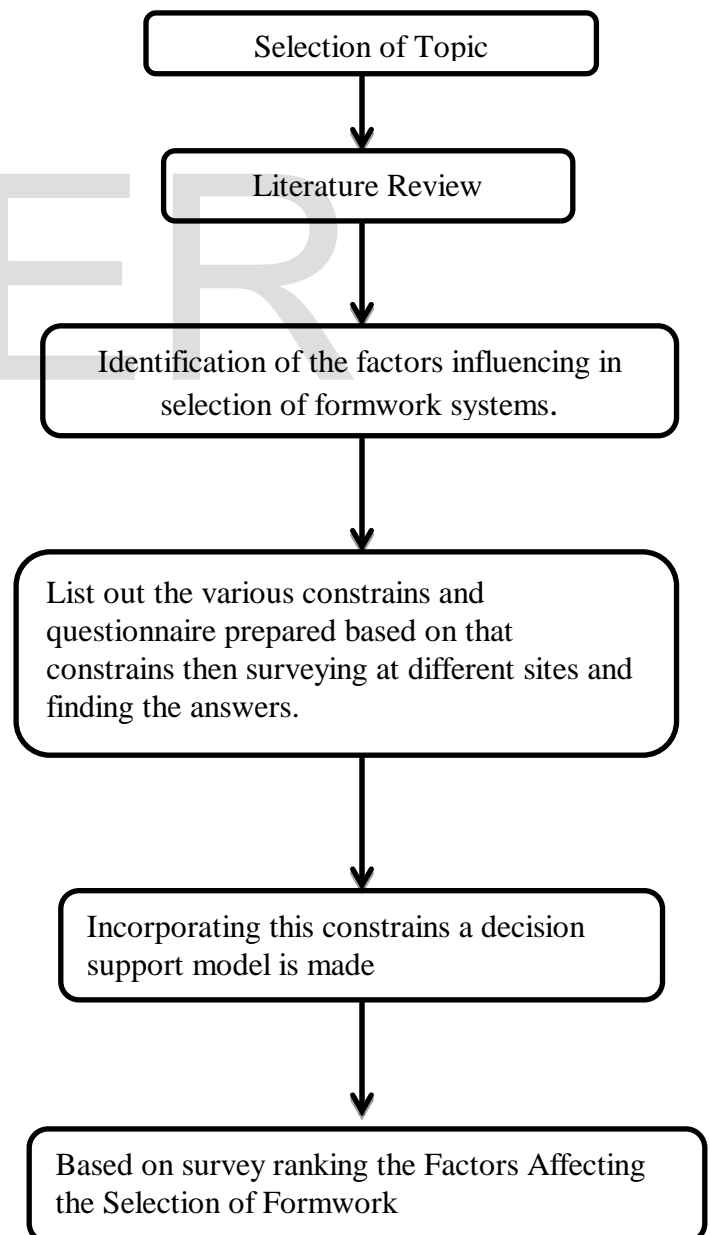
5 – Very High; 2 – Negligible;

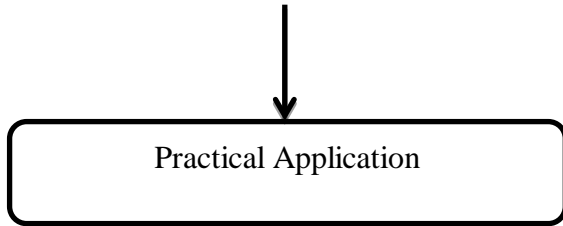
4 – High; 1 – Not Much;

3 – Moderate;

The RII was calculated by using the formula as below

METHODOLOGY





FACTORS INFLUENCING SELECTION OF FORMWORK SYSTEM

FACTORS

From the literature survey the factors influencing the formwork systems were identified as shown below.

The four broad categories are:

- General factors
- Building aspects
- Job specific
- Local conditions

The factors which fall under each category are mentioned below:

1. General factors

- Adaptability & flexibility (fixable sizes)
- Duration & repetition (lifespan)
- Quality and surface finish
- Availability
- Cost

- Safety
 - Supply
2. Building aspects
 - Type of structure
 - Maximum load capacity
 3. Job specific
 - Time factor
 - Accessibility to work
 - Erection and dismantling (de shuttering)
 - Suitability of work for labours
 4. Local condition
 - Weather condition
 - Skilled labour requirement

Adaptability & Flexibility (Fixable Sizes)

Formwork should be modular and adaptable for various sizes and shapes of the structural system, so that it can be used for many projects. Formwork should be viable for the particular project based on cost and availability.

Quality & Surface Finish

Quality of structural finish of the concrete is to be adequately addressed by strength of the formwork as well as its resistance to deformation. Architectural finish of the concrete depends on sheathing material used. The sheathing materials such as plywood, steel, aluminium, and rubber should be appropriately chosen based on the required finish and feasibility.

Repetition (Life Span)

Repeating the same layout from floor to floor assures that the workers learn quickly, thus increasing productivity and decreasing labour cost. The forms also can be effectively reused from floor to floor.

The form face material must be selected to be capable of consistently imparting the desired concrete finish (smooth, textured, featured or exposed aggregate etc.)

Availability

Material and supplier availability consider for avoiding shortage problems during execution.

Cost

This is a vital factor for deciding formwork system as one must know the capital provision for formwork in the project. It is always beneficial to work out these details at the time bid. That cost influenced initial cost, reuse cost, maintenance cost, and availability of lifting device. All the formwork is very expensive. On average about 35% of the total cost of any finished concrete unit or element can be attribute to its formwork; of this just over 40% can be taken for material for formwork and 60% for labour.

Type Of Structure

The structure may be commercial building or a residential building and the system to be chosen is based on adaptability of formwork to suit the requirement.

Maximum Load Capacity

Formwork must be capable of safely withstanding without distortion or danger the dead weight of the fluid concrete is placed on it, labour weight, equipment weight and any environmental loadings.

Time Factor

Faster floor cycle is always desirable for contractors and owners. For contractors, faster floor cycle allows the contractor to finish on schedule or earlier which reduces the overhead cost. For the owner, faster floor cycle reduces the short term financial charges and allows early utilization of the constructed facility.

Accessibility to Work

Proper access to work place is an important requirement and sufficient space for the shifting of panels and storage.

Erection and Dismantling

Form panels and units should be designed so that their maximum size does not exceed that which can be easily handled by hand or mechanical means. In addition all formwork must also be designed and constructed to include facilities for adjustments, leveling, easing and de shuttering without damage to the form work or concrete.

Suitability of Work for Labours

Easy handling of form materials and work with comfortable that include lifting, erection and dismantling.

Accuracy

Formwork must be accurately set out so that the resulting concrete product is in a right place and is of correct shape and dimension. All joints in formwork must be either close fitting or covered with form tape to make them grout tight. If grout leakage occurs the concrete will leak at that point. Leakages cause honey combing of the surface.

Weather Condition

Vertical forming systems are sensitive to weather conditions. Typically, in vertical forming systems, the newly placed concrete is supported by the wall already cast below it. The lower wall section must gain sufficient strength to support the fresh concrete above. The rate of strength gain for the lower wall is influenced by ambient temperature, moisture content, and freezing and thawing cycles. Another factor that affects the economy of the selected system is the effect of stopping forming and concreting because of extreme weather conditions.

Skilled Labour Requirement

In areas where the labour force is expensive and unskilled, the use of formwork systems can substantially reduce the cost in areas where the labour force is inexpensive and skilled. A conventional formwork system is an economical alternative even if the building features are compatible with a sophisticated formwork system.

DATA ANALYSIS

In this phase data were collected from 30 respondents that collected data are to be analyzed using Microsoft excel and RII method.

Data analysis table

FACTORS	IMPORTANCE SCALE					TOTAL	RII
	5	4	3	2	1		
Cost	10	15	5	0	0	30	0.83
Availability	3	11	15	1	0	30	0.70
Safety	9	17	2	2	0	30	0.82
Cost	10	15	5	0	0	30	0.83
Availability	3	11	15	1	0	30	0.70
Safety	9	17	2	2	0	30	0.82
Erection and dismantling	2	7	20	1	0	30	0.66
Lifespan	12	12	6	0	0	30	0.84
Easily fixable size	2	6	18	0	0	30	0.62
Quality work and surface smooth	11	17	2	1	0	30	0.86
Time factor	11	17	1	1	0	30	0.85
Suitability of work for labours	1	7	18	1	0	30	0.64
Market trend	0	10	15	5	0	30	0.55

Inaccessible to supply	0	5	15	8	2	30	0.57
Climatic factors	3	2	9	1	5	30	0.53
Design	6	9	11	4	0	30	0.71

Rank table (RII method)

FACTORS	RII VALUE	RANK
COST	0.83	4
AVAILABILITY	0.70	7
SAFETY	0.82	5
ERECTION AND DISMANTLING	0.66	8
LIFESPAN	0.84	3
EASILY FIXABLE SIZE	0.62	10
QUALITY AND SURFACESMOOTH	0.86	1
TIMEFACTOR	0.85	2
SUITABILITY OF WORK FOR LABOURS	0.64	9
MARKET TREND	0.55	12
INACCESABLE TO SUPPLY	0.57	11
CLIMATIC FACTOR	0.53	13
DESIGN	0.71	6

RESULT AND DISCUSSION

From the data analysis following results were obtained. The top 5 factors according to the average and rank index.

Factors	RII method	Rank
Quality and surface smooth	0.86	1
Time factor	0.85	2
Lifespan	0.84	3
Cost	0.83	4
Safety	0.82	5

After identification top factors comparative table was prepared. Based on this decision support model was made

Comparative table for different formworks

TYPES OF FORMWORK	QUALITY AND SURFACE SMOOTH	COST	SAFETY	LIFESPAN (REPE TATION)	CYCLE TIME	MAXIMUM LOAD CARRYING CAPACITY
PLYWOOD FORMWORK	MODERATE	ECONOMIC	MODERATE	16-18 TIMES	18-21 DAYS	2-3T
DOCA FORMWORK	GOOD	ECONOMIC	MODERATE	22-25 TIMES	18-21 DAYS	2-3T
STEEL FORMWORK	GOOD	ECONOMIC	GOOD	OVER 100 TIMES	15-20 DAYS	6-7MT
STEEL WITH WODDEN FORMWORK	GOOD	ECONOMIC	GOOD	OVER 100 TIMES	15-20 DAYS	6MT

ALUMINIUM FORMWORK	V.GOOD	MOST ECONOMIC	V.GOOD	OVER 200 TIMES	6-7 DAYS	6MT
PLASTIC FORMWORK	V.GOOD	CONSIDERABLE	GOOD	OVER 100 TIMES	6-7 DAYS	6MT

CONCLUSION

Total 13 factors affecting selection of formwork were identified through literature study & experts opinion. A questionnaire survey is conducted on high rise building construction projects (above G+5) to find out factors influencing formwork selection in construction projects. The study received 30 respondents the collected data was analyzed through both Relative Important Index method and Microsoft excel. According to their rank indexes the top 5 factors has been ranked accordingly for 30 completed surveys. The top 5 factors are quality and surface smooth, time factor, lifespan, cost and safety. Based on these factors comparative table was prepared from that decision support model was made. And this was analyzed on ongoing and completed projects it gives more than 90% accurate results. From this model the project managers can select the formwork easily based on their requirements.

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