



An Overview of the Attributes of Aluminium Formwork Regarding High-Rise Building Construction

Neelima B. Kore^a

^aLecturer, RIT, Rajaramnagar, 415414, India.

ABSTRACT :

High-rise structures carry specific design challenges for civil engineers. High-rise buildings have technical and economic benefits in areas of high resident density and have become a distinct feature of housing accommodation in virtually all compactly populated city areas around the world. So for the construction of High-rise buildings the type of formwork used is the most crucial aspect in terms of cost, time, and quality in a high-rise building construction project. Formwork is the major cost constituent for a typical multistorey reinforced concrete building. Hence, the aluminium formwork can be used for a broad range of operations, from straightforward panels to more complicated structures. This paper gives overview of High rise building construction and details of Aluminium formwork required for it.

Keywords: High-rise building, Formwork, Aluminium formwork

1. Introduction

1.1. High-rise building

A high-rise building is a tall structure, as contrasting to a low-rise building, and is defined another way in terms of height reliant on the jurisdiction. It is used as a residential, office building, or any other functional building including hotel, retail, or with multiple purposes shared. High-rise structures carry specific design challenges for civil engineers. High-rise buildings have technical and economic benefits in areas of high resident density and have become a distinct feature of housing accommodation in virtually all compactly populated city areas around the world. In comparison with low-rise and single-family houses, High rise buildings accommodate more residents per unit of area of land and reduce the cost of municipal infrastructure.

1.2. Formwork

The type of formwork used is the most crucial aspect in terms of cost, time, and quality in a high-rise building construction project. The primary to be used is the conventional type formwork where the timber boards were supported on timber rods. With the expansion of technology, people used plywood sheets instead of timber planks, and steel pipes with jacks for support. Then people invented small units of formworks and attached the repeating units in the construction. The better units were invented like formworks such as columns, beams, slab panels, formworks for walls, etc. when similar basics are repeating so the material used to it was steel and it was very heavy. Then the plan was to reduce the weight of the system and the materials for formwork have extended to aluminium, plastic, fiberglass, etc. Formwork is the major cost constituent for a typical multi-storey reinforced concrete building. In the high-rise structures, the formwork system has an important role to play especially in systematizing the activities to increase productivity, achieve speed, and utilize the economy so to bring down the unit cost.

1.3. Aluminium Formwork

The Aluminium Formwork System for concrete is presumably the most adaptable ultramodern construction system. Unlike other systems, it's equivalently suited to both high and low rise construction. Specifically designed to allow the rapid-fire construction of multiple-unit projects at optimum productivity, the aluminium formwork can be used for a broad range of operations, from straightforward panels to more complicated structures.

The ease of Aluminium Formwork and the repetitious nature of the assembly practice makes it possible to precisely program construction arrangements and therefore cycle times well in advance.

2. Aluminium Formwork

The aluminum formwork system is determined to surpass the speed of construction of most of the other construction technologies. The work accomplishes the aluminum lightweight formwork method efficiently in order to speed up the specific progress, to encourage quality management and strength. Adoption of this system reduces the overall cost of the structure. It is one of the systems recognized to be very much appropriate for Indian circumstances for mass construction, where speed and quality can be attained at a great level. Before getting into depth of types of aluminium formwork it's essential to understand the component parts of aluminium formwork. Which are described as follows,



Fig no. 1 – Aluminium formwork system

2.1. Components of Aluminium Formwork

In aluminium formwork the fundamental element is the panel. Which is an expelled aluminium rail section, welded to an aluminium sheet and other components are also expelled sections. This manufactured a lightweight component with an admirable stiffness to weight ratio also under concrete loading it yield minimal deflection. To suit the necessities of projects all panels and units are designed and factory-made in particular size and shape. Following are the components of aluminium formwork which are frequently used in construction.

- **Wall Panel (WP)**

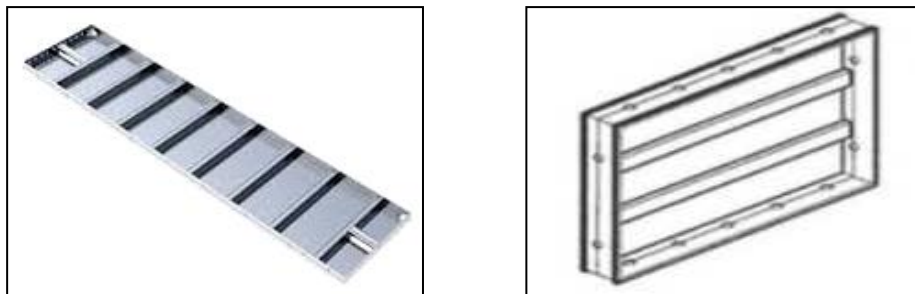


Fig no. 2 – Wall panel in AFS

Wall panels form the face of the wall. It is an aluminium sheet suitably cut to fit the precise size of the wall. Panel thickness is 4 mm, the standard size is 2400 mm X 600 mm, and self-weight is around 24 kg/sqm.

- **External Corner (EC)**

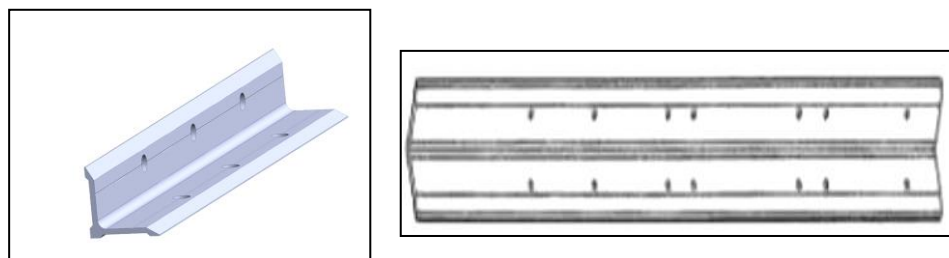


Fig no. 3 – External Corner in AFS

External corners connects horizontal or vertical parts of formwork together at right angle.

- **Internal Corner (IC)**

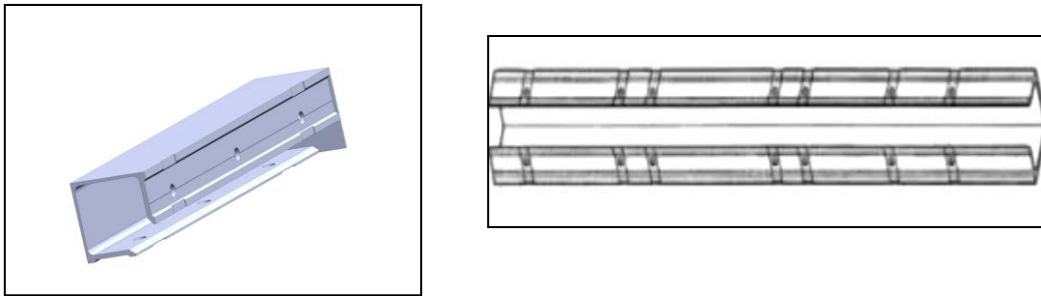


Fig no. 4 – Internal Corner in AFS

Internal corner connects two pieces of vertical parts of formwork at their internal joints.

- **Rocker (RK)**

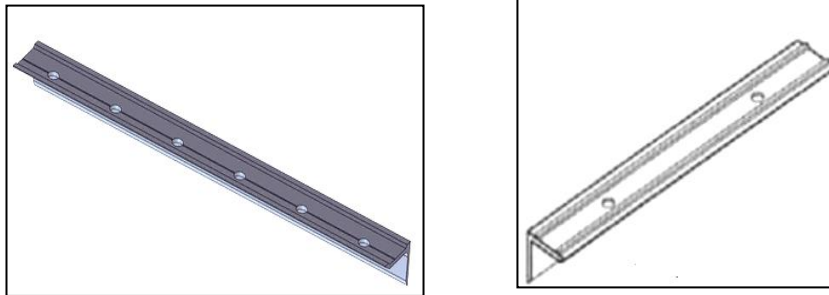


Fig no. 5 – Rocker in AFS

Rocker are supporting parts of wall. It is in L - Shaped part having holes for stub pin.

- **Kicker (K)**

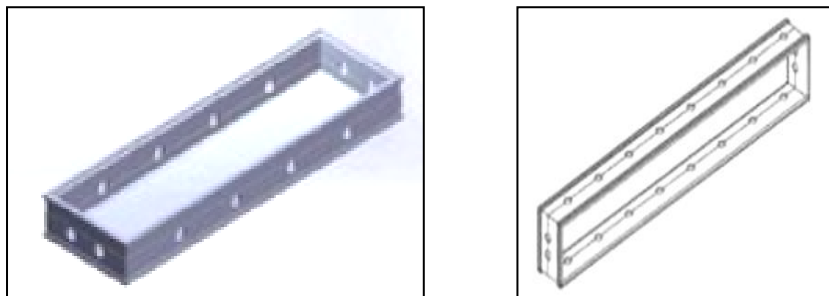


Fig no. 6 – Kicker in AFS

Kickers form the face of wall at the top of wall panels and perform as ledge to support.

- **Pin and Wedge**

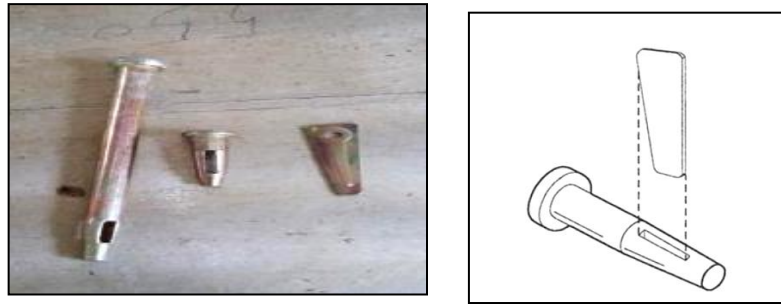


Fig no. 7 – Stub pin and Wedge in AFS

Stub pins and wedges used for joining two wall panels also it helps in connecting two joints.

- **Beam Panel (BP)**

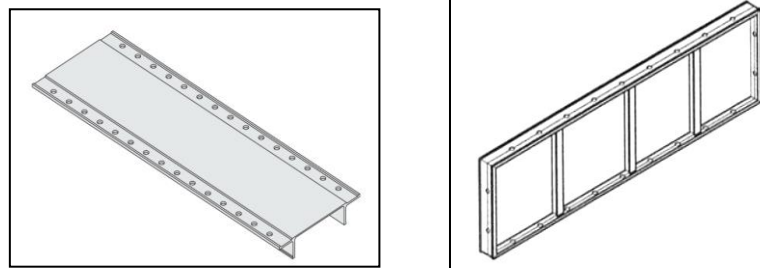


Fig no. 8 – Beam panel in AFS

Beam panel is a rectangular structure. It forms beam sides and these are cut according to beam size.

- **Bulk Head Horizontal (BHH)**

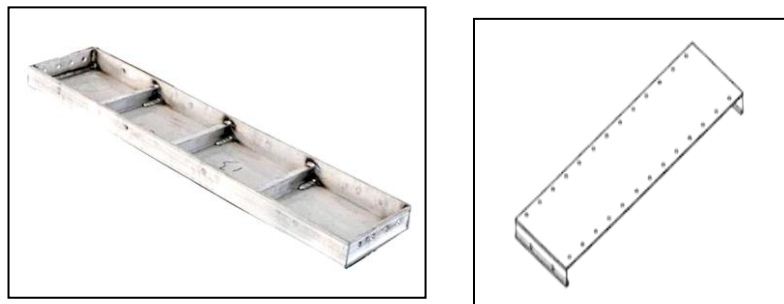


Fig no. 9 – Bulkhead horizontal panel in AFS

To carry the bulk load of beam, Bulk heads are provided.

- **Beam Prop Head (BPH)**

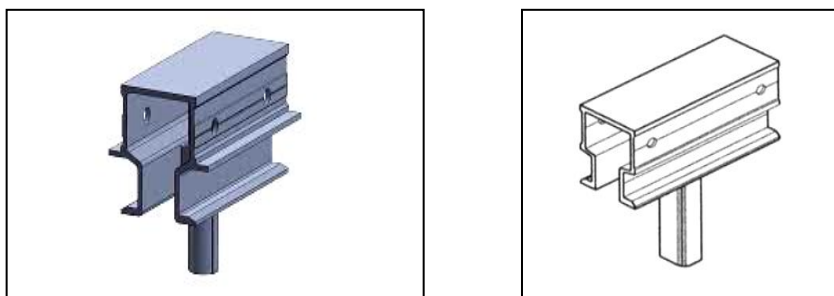


Fig no. 10 – Beam prop head in AFS

It is a head provided for easy dislodging of the formwork. It forms soffit beam.

- **Soffit Corner Internal (SCI)**

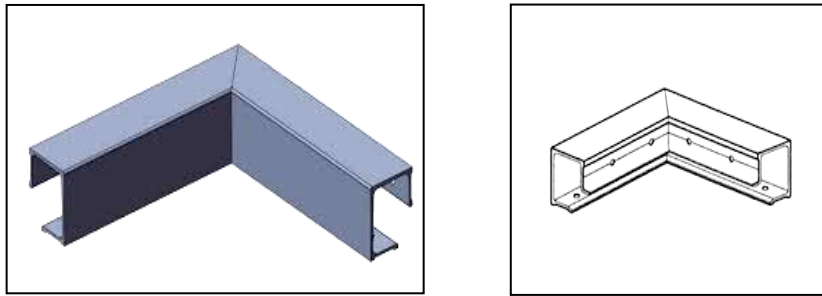


Fig no. 11 – Soffit internal corner in AFS

Soffit internal corner forms vertical internal corner between beams, walls and slab. Also it provides horizontal internal cornice between wall, beam and slab.

- **Soffit Corner External (SCE)**

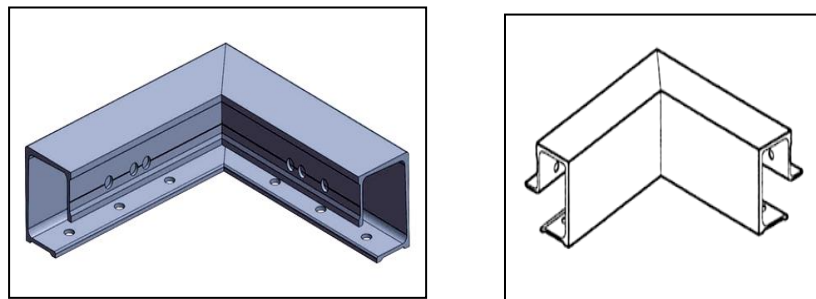


Fig no. 12 – Soffit external corner in AFS

Soffit external corner forms vertical and horizontal external corner between walls, beam and slab.

- **Beam Soffit Panel (BSP)**

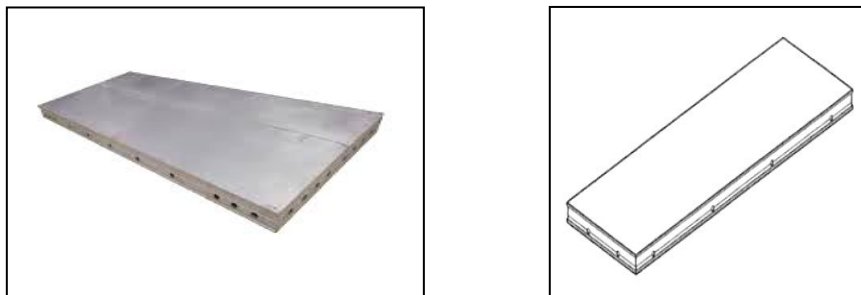


Fig no. 13 – Beam soffit panel in AFS

It is plain rectangular aluminium structure which supports soffit beam.

- **Slab / Deck Panel**

(SP)

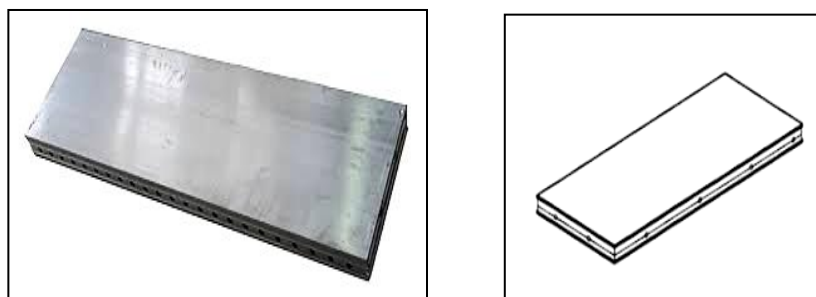


Fig no. 14 – Slab / Deck panel in AFS

It provides horizontal surface for casting of slab /deck. It also gives appropriate safety to workers.

- **Slab Prop Head (SPH)**

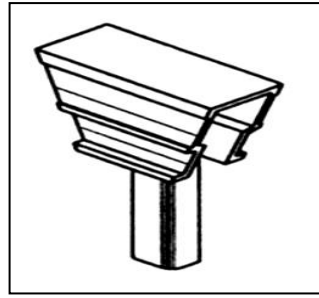


Fig no. 15 – Slab

prop head in AFS

Slab prop head is a 'V' shaped provided to support deck or slab and it also bears load coming on it via slab panel.

- **Mid / End Beam (MB / EB)**

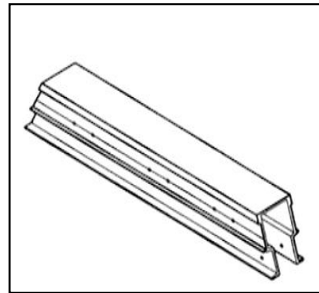


Fig no. 16 – Mid / End beam in AFS

Mid or end beam supports middle portion of beam it also carries concrete.

- **Beam Splice Bar (BSB)**

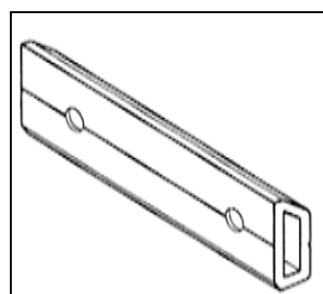
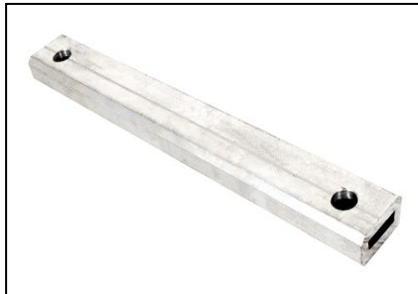


Fig no. 17 – Beam splice bar in AFS

This part supports slab and beam.

- **Prop Length (PL)**

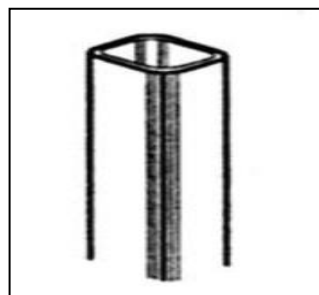


Fig no. 18 – Prop length in AFS

It the length of prop depends upon span and height of slab.

- **Wall and Slab Assembly Details**

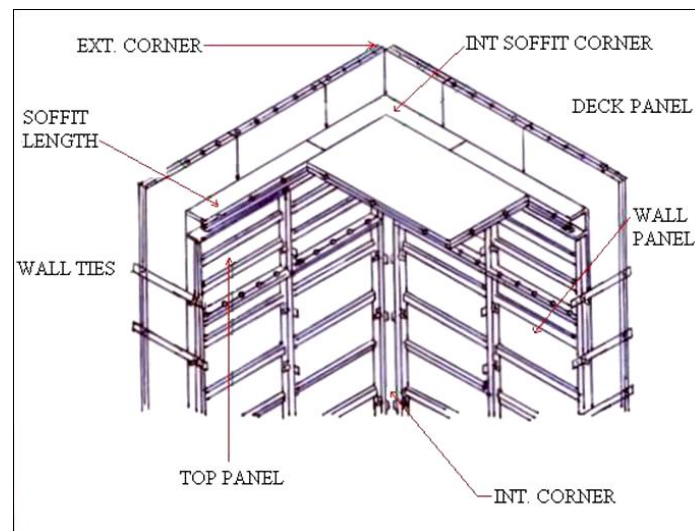


Fig no. 19 – Wall and Slab assembly details in AFS

- **Beam Assembly Details**

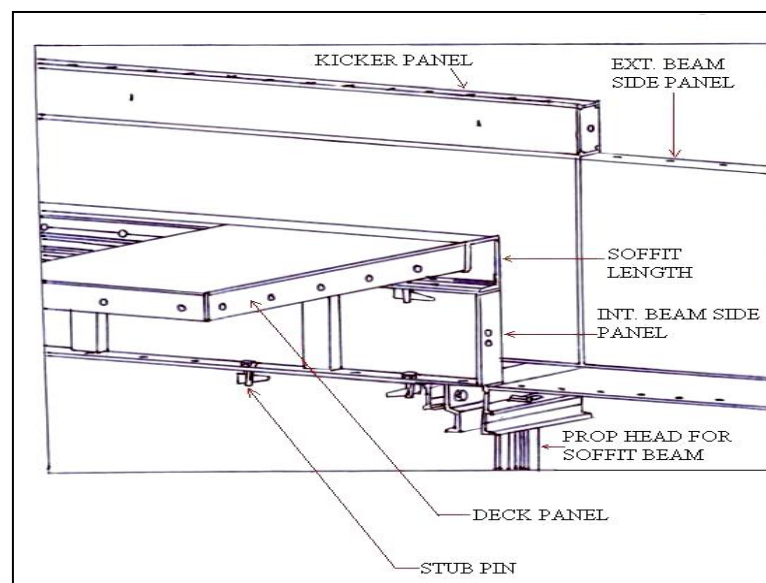


Fig no. 20 – Beam assembly details in AFS

2.2. Types of Aluminium Formwork

Following three types of aluminium formwork were studied for this research work.

- **Mivan Aluminium Formwork**



Fig no. 21 – Mivan AFS

In 1990, the company from Malaysia initiated manufacturing these formwork systems. Mivan is a quality aluminum structure industrialized by a European construction company recognized as Mivan Company Ltd. This innovative form of work is actually suitable for constructing houses in large amounts at a faster speed. The speed of construction needs to be given higher significance, especially for large casing systems or township systems. In order to respond to these unusual challenges in terms of time, cost, and quality, the real estate industry has come up with a smart system of construction known as the “MIVAN formwork system”.

There are a number of structures in Mumbai that are being constructed with the help of the Mivan technology, which has been declared provident as well as satisfying for the overall Indian real estate request. Mivan technology has been used extensively in Europe, Asia, Gulf Countries, and other zones of the globe. It's suitable for constructing a large number of houses in a short period of time using room size forms to construct walls and slabs in one constant pour on concrete.

- **Maini Aluminium Formwork**



Fig no. 22 – Maini AFS

MAINI Construction Equipment (Pvt.) Ltd is an ISO 9001:2000 qualified company. It is also a prominent name in Scaffolding and Formwork Solutions for above 25 years. In the leadership of Mr. Ajay Maini, the company's Director, MAINI has accomplished huge milestones during this arena.

MAINI is the Indian company to supply end-to-end solutions within the field of Aluminium Formwork Systems. With a proven data of producing and supplying quality products in time, MAINI has established itself as a number one organization during this field in India and is extending its wings throughout the globe. The corporate is supplied with a highly competent R&D team and has completed many admired projects where customer demands and functional necessities were taken care of with utmost professionalism. Also, the company contains internal range of modern equipment, tools, and challenges for manufacturing both conventional and contemporary formwork and scaffolding systems.

MAINI Group launched a brand new venture called MAINI Aluminium Formwork System (AFS) in April 2008. Presently, there are over 25 running sites where aluminium formwork is getting used and implemented under the supervision of competent engineers and specialists.

- **Aluform Aluminium Formwork**



Fig no. 23 – Aluform AFS

The brand 'Aluforms' deals with producing the most modern aluminum formwork as per the need of a market, as well as providing the experts to ensure that, the customers are getting the best service throughout the entire process. Those who had experience with Aluforms products know firsthand the value provided and how much it can minimize construction schedules and overall costs. Aluforms was established in 1998 in Atlanta, Georgia, USA. It provides superior aluminum formwork systems internationally for over 20 years. South Korea and Thailand are the main branches to better serve a global clientele.

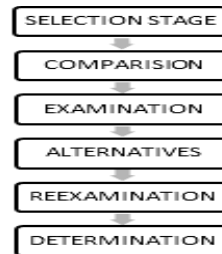
The advancement of the construction method of aluminium formwork panels was first introduced in the 1960s as a lighter and less costly alternative option to steel. As metropolitan development continues to fast expand around the world, so efficient and effective construction methods are the global demand. Aluform continues to be a leading option for aluminium formwork for concrete poured buildings and construction projects of all types.

3. Technical Aspects

3.1. High-rise Building and Formwork Selection

High-rise buildings becoming prominent these days due to scarcity of land, increasing demand for business and residential space economic growth technological advancement innovations in structural system desire for aesthetic in an urban setting cultural significance and prestige human

aspiration to build higher. Formwork system plays a very important role in the construction of high-rise buildings. The selection of an appropriate formwork system can reduce project costs, improve the quality of work, and speed up the construction process that means it has a huge impact on the construction cost of high-rise buildings. These days various types of aluminium formwork such as Mivan, Maini, and Aluform are used for the construction of high-rise buildings. But the great task is to select an appropriate formwork type because it requires years of experience in formwork design. With the lack of such experts, costly outsourcing becomes essential otherwise the selection of a particular formwork type might not be appropriate. For this, the following selection process is used.

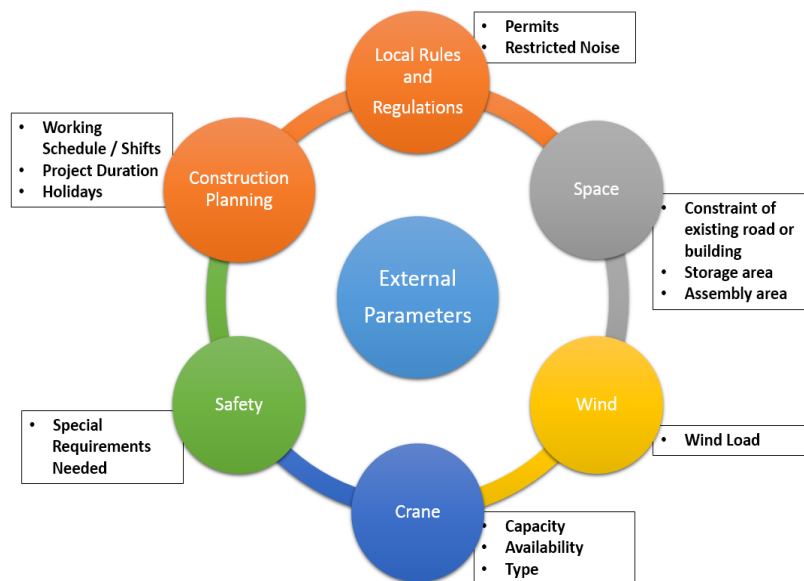


Flow Chart no. 1 – Selection process of formwork system for high-rise building

3.2. Factors affecting construction cost of high-rise building from formwork selection point of view

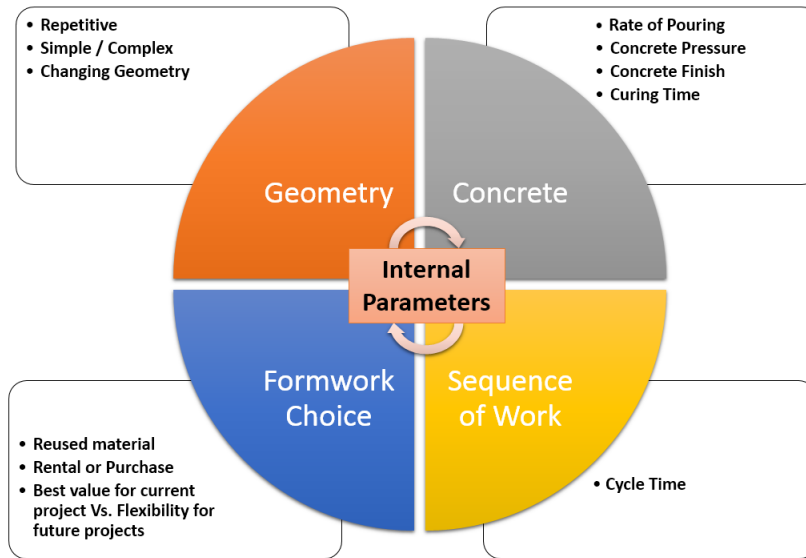
These factors were considered by taking reference from IS 14687:1999 (False work for concrete structure guidelines), BMTPC (Building Material & Technology Promotion Council-Ministry of Housing & Urban Poverty Alleviation, GOI) and Compendium of High-rise Building (Central Public Work Department (CPWD) – Ministry of Housing and Urban Affairs).

• Internal Parameters



Flow Chart no. 2 – Internal Parameters affecting formwork selection for high-rise building

• External Parameters



Flow Chart no. 3 – External Parameters affecting formwork selection for high-rise building

The understanding of the criteria related formwork and high-rise building helps for the selection of appropriate aluminium formwork.

3.3. Factors affecting selection of aluminium formwork type

These factors were considered by taking reference from IS 14687:1999 (False work for concrete structure guidelines), BMTPC (Building Material & Technology Promotion Council-Ministry of Housing & Urban Poverty Alleviation, GOI) and CAMTECH (Centre for Advanced Maintenance Technology - Handbook of Formwork for buildings)

- **Adaptability and flexibility**

A formwork system should have good adaptability to suit different site conditions. Also, it should have good flexibility for an easy way of working such as erection and dismantling. And it should support concrete pouring activities effectively with good strength.

- **Duration & Repetition**

The duration of erection and dismantling of the formwork system should be less and the formwork system and its parts should serve repeatedly without failure and less maintenance.

- **Quality & Surface Finish**

The material of formwork system should be quality material, it should be non-absorbent and strong enough to sustain load of concrete pouring and holding. Also, it should give a very pleasant surface finish which will reduce the cost of plastering and other finishing work.

- **Mobilization Time**

The transportation time for the formwork system and assembling of it should be less to reduce mobilization cost and cost of heavy equipment required for the lifting of component parts of the formwork system. For that formwork should be lightweight.

- **Cost**

As the cost of formwork system consumes around 50 to 60 % cost of overall concretework of the project, reduction in such cost is very remarkable and for that, all the factors should be studied at design level such as material type, size and shape, other accessories and prefabricated formworks etc.

- **Safety**

While considering formwork it should be always safe to work with. Formwork system components should be lightweight and the material of formwork should be fire resistant to avoid accidental scenarios.

- **Building Aspect**

The formwork system should be flexible enough to work with the position, view, directions and size & shape of windows, doors and other openings so that the building should get the maximum benefit of natural energies.

- **Type of Structure**

The formwork should be suitable as per the type of structure and its other features.

- **Maximum Load Carrying Capacity**

As the formwork should be lightweight to carry and work with but it should have good load-carrying capacity as it deals with fresh as well as set concrete. Generally it's 6000 to 8000 Kg/sq. m. To have this kind of capacity an aluminium formwork of grade 6061 T6 is most suitable.

- **Accessibility to work**

All the component parts of formwork should be easy to assemble and disassemble so to maintain the time factor of construction work.

- **Suitability of work for labors**

The detailing of formwork connection should be easy to understand for workers.

- **Local conditions**

The formwork system and accessories required for it should be easily available locally to reduce transportation cost and also it should be flexible enough to support local site weathering conditions.

- **Skilled labour requirement**

Formwork system should be easy to understand for workers and it should be convenient for handling. Formwork system connections and handling should not always require skilled labours as appointing skilled labours also increases project costs. So, a formwork system should be such that an unskilled or semi-skilled worker can also handle it properly.

Conclusion

It's very easy to do selection from different things but it becomes very complex when to deal with similar things. Such as the object of this paper is to understand various factors required for selection of aluminium formwork type for construction of high-rise building. Mivan, Maini and Aluform these objects of paper have same material and structural components but their performance affects construction activities based on various factors mentioned above. As aluminium formwork contributes a vital role in management of construction cost of high-rise building project. In high-rise building when there is a demand of monolithic structure then the use of aluminium formwork is the best option.

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