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A REVIEW ON INNOVATING FORMWORK SYSTEMS

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Abstract: ***Formwork is a structure, usually temporary, used to contain poured concrete and to mould it to the required dimensions and support until it is able to support itself. It consists primarily of the face contact material and the bearers that directly support the face contact material. Construction is one of the significant sectors of Indian economy and is an integral part of the development. Today India's urban population is the second largest in the world and its future development leads to increased demand for housing to cope with this problem India should desperately need to plan for acquisition of land and rapid creation of dwelling units. Construction is a complex process involving basically the areas of Architectural planning, Engineering & Construction. There is growing realization today that speed of construction needs to be given greater importance especially for large housing projects. This is not only essential for the faster turnover of equipment and investment – leading possible to the reduction in the housing cost but also for achieving the national objective of creating a large stock to overcome shortest possible time. Fortunately, some of the advanced technologies catering to faster speed of construction are already available in the country. For e.g. Prefabrication, autoclaved blocks, tunnel formwork, aluminum formwork of construction etc.***

Keywords: **Cost effectiveness, Time effectiveness, Quality control**

I. INTRODUCTION

Formwork development has paralleled the growth of concrete construction from its earliest uses through its many applications today. As concrete has been used for increasingly complex and significant structural and architectural tasks, formwork engineers and contractors have had to keep pace. Projects involving rapid construction schedules create challenges for the form designer and for the control of field forming operations. The increasing use of concrete as an architectural medium presents the form builder with several challenges, ranging from the selection of appropriate sheathing materials to the maintenance of rigid tolerances.

Formwork and its supports (falsework) is a structural system and must be designed and built accordingly. The actions (loads) on it may be temporary but they can be extremely large. Frequently they are different in nature to those imposed on the finished concrete structure. Concrete is an extremely plastic and mouldable material which will accurately reflect the shape, texture and finish of the surface against which it is cast. Any imperfection or inaccuracy in this surface will be indelibly inscribed on the concrete surface. Form-face materials must therefore be chosen both to achieve the

required surface finish and, in conjunction with all the supporting elements, to maintain accuracy and stability under all the loads imposed during erection and concreting, and for some days into the life of the concrete structure.

II. SELECTING CRITERIA FOR FORMWORK SYSTEM

The selection of the proper formwork system requires adequate information about available horizontal (Slabs), and vertical (Columns/Walls) forming systems. The information collected that describes the formwork systems should include the criteria used by contractors to select the system. These criteria are:

1. The formwork system should be available and economically feasible for the contractor.
2. All major parties – owner, designer, and contractor – should be familiar with the selected forming systems, since certain systems, such as slip forms, require special economic evaluation, design configurations, and safety precautions.
3. The selected formwork system must be consistent with architectural and structural requirements of the building. For example, if architectural concrete is required for the external columns, then slip form systems do not provide the appropriate forming solution.

The selection system must be compatible with the mechanical and electrical requirements of the building. For example, flying forms are not an economical solution when there are extensive penetrations through the slab (e.g. electrical and mechanical).

III. FACTORS AFFECTING CONTRACTOR PERFORMANCE

Good formwork should satisfy the following requirements:

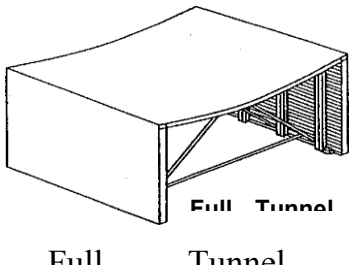
1. It should be strong enough to withstand all types of dead and live loads.
2. It should be rigidly constructed and efficiently propped and braced both horizontally and vertically, so as to retain its shape.
3. The joints in the formwork should be water-tight against leakage of cement grout.
4. Erection of formwork should permit removal of various parts in desired sequences without damage to the concrete.
5. The material of the formwork should be cheap, easily available and should be suitable for reuse.
6. The formwork should be set accurately to the desired line and levels. It should have plane surface.
7. It should be as light as possible.
8. The material of the formwork should not warp or get distorted when exposed to the elements.
9. It should rest on firm base.

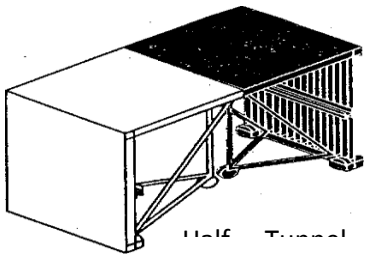
IV. CRITICAL FORMWORK SYSTEMS

1. Tunnel Formwork Systems

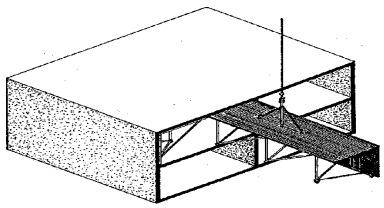
Tunnel forms are factory-made U-shaped or inverted L-shaped steel forms which permit casting of both the slab and supporting walls at the same time (See Figure a). For stripping, after the concrete has gained enough strength, the tunnels are collapsed or telescoped and moved to the next pour (See Figure b).

Half tunnels are used for spanning wide rooms - full tunnels for spanning narrow rooms. Standard modular panels offer a wide range of flexibility in room size. Widths from 13 ft. to 24 ft., heights from 7.5 ft. to 10 ft., and lengths up to 40 ft. may be specified.





(a) U or Inverted L shape Steel Tunnel Forms



(b) Stripping of Half Tunnel Form

- **Process Efficiency**

For the right type of building site and structure this is a very rapid form of construction. High quality surface finishes are possible. The engineered nature of the formwork can result in a high dimensional accuracy of the finished structure. Requires a smaller but multi-skilled workforce on site. It is easier to plan construction activities due to the repetitive nature of the work.

- **Safety**

Tunnel formwork systems include standard health and safety features such as guard rails. Market leading systems often have edge protection built-in. Most tunnel forms are delivered to site partly assembled, resulting in less manual handling. Assembly is completed at ground level. The completed formwork assembly is robust and provides a stable working platform. The repetitive nature of the work ensures that site operatives can quickly become familiar with health and safety aspects of their job. Formwork suppliers often provide materials and resources to help train the workforce. The need to use power tools for assembly is moderate.

- **Advantages:**

RELATED TO TIME:A production cycle of 1-3 days can be achieved. Depending on the production speed of load bearing system succeeding production activities in the building can also be accelerated. The project can be completed in a short time compared to traditional construction systems. Due to accelerated production, effects of climatic conditions on productivity are minimized. Due to learning curve, laborers obtain specialization and “zero defect” production pattern.

RELATED TO QUALITY: Higher precision in production of walls and slab units (1/1000 deformation is allowed and can be achieved) Smooth surfaces for the walls and slabs are obtained that can be covered with wallpaper right after easy and quick cleaning. Standard dimensions for the other components such as carpet, windows, and doors can be applicable due to strict dimensions of load-bearing system elements.

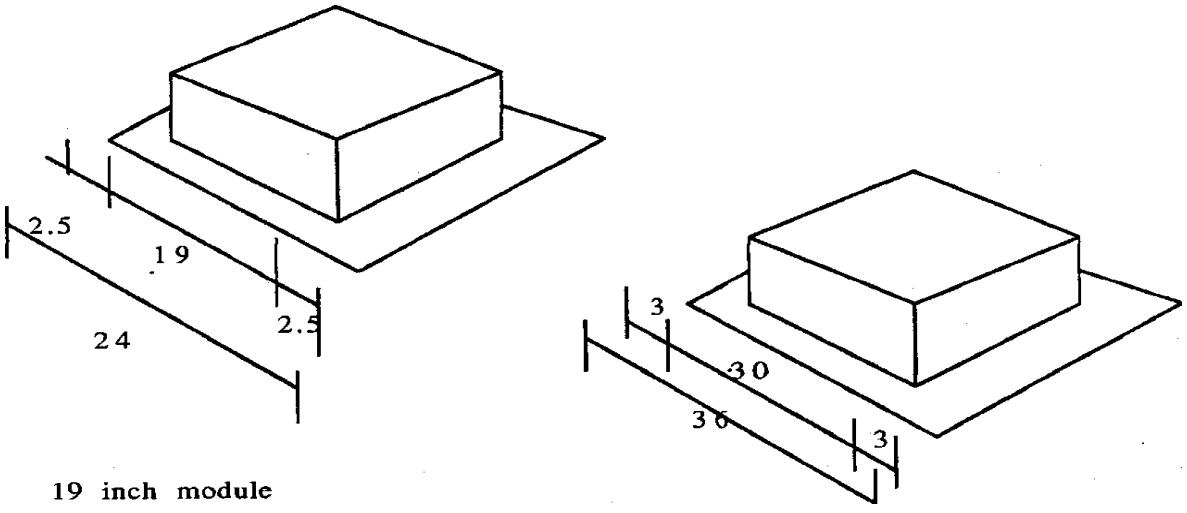
RELATED TO COST: Formwork cost per m2 (or per housing unit) can be reduced by using formwork up to 8 hundred times. Due to smooth surfaces, walls and slabs do not need any additional finishing such as plaster. Early completion of project provides financial opportunities such as rental incomes. Repetitive nature of buildings provides effectiveness in production and minimization of labor costs.

- **Disadvantages:**

Investment cost of formwork system increases formwork cost per m2 if project is small sized. A continuous and fast cash flow that complies with the speed of production is essential. Due to high production speed management-related functions are vital. Coordination problems cause remarkable delays in schedule. Skilled labor force is needed compared to traditional systems. Equipment costs are relatively higher due to the cranes that are needed by each block.

2. Dome Forming System

Standard size domes are usually used for waffle slab construction. They are based on two, three, four, and five ft. modules. The two ft. size modules utilize 19 x 19 in. domes, with 5 in. ribs between them, and the 3-ft. size modules can be formed with 30 x 30 in. domes and 6 in. ribs. Figure shows the two standard modules that are used for waffle slab construction.



19 inch module

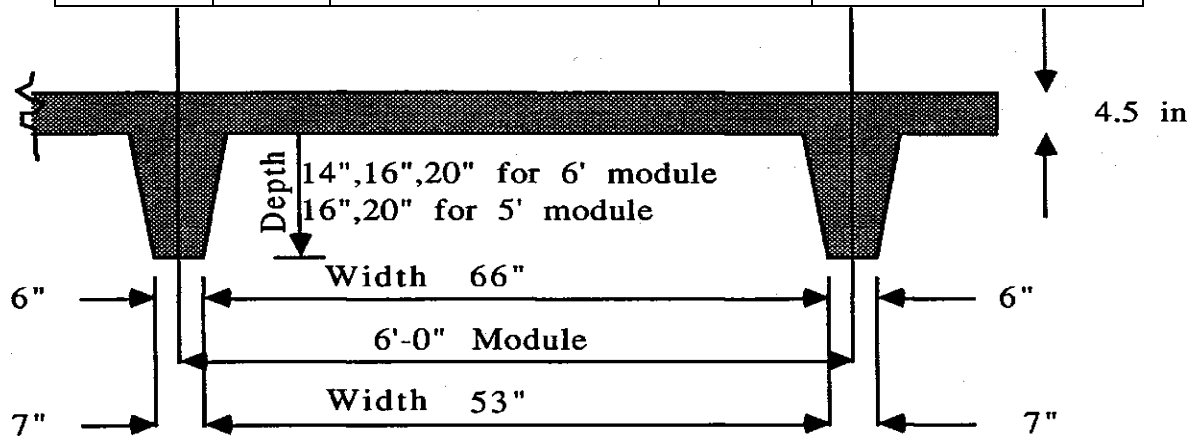
V. ADVANCED FORMWORK SYSTEMS

1. Joist-Slab Forming System

A one-way joist slab is a monolithic combination of regularly spaced joists arranged in one direction and a thin slab cast in place to form an integral unit with the beams and columns (Figure). One-way joist slabs have frequently been formed with standard steel pans. Table 1 shows the dimensions of the standard form pans and the special fillers for one way joist construction. It should be noted that any spacing between pans which exceeds 30 in. is referred to as a wide-modular or skip-joist system.

Table 1: Dimensions of Forms for One-Way Joist Construction (All dimensions in inches)

MODULE	STANDARD FORMS		SPECIAL FULLER FORMS	
	Width	Depth	Width	Depth
2'	20	8,10,12	10,15	8,10,12
3'	30	8,10,12,14,16,20	10,15,20	8,10,12,14,16,20
4'	40	12,14,16,18,20,22,24	20,30	12,14,16,18,20,22,24
5'	53	16,20	-	-
6'	66	14,16,20	-	-



2. Self-Raising Forming System

This system consists of upper form(s), and lower lifters (self-raisers). The lifters are attached to the wall already cast below the form. Figure shows a schematic representation of the sequential steps involved in self-raising forms which can be explained as follows:

Step 1. The forms and lifters are placed against the wall, as they were after the last lift of concrete was placed.

Step 2. The lifters are unbolted from where they are attached and pulled away horizontally by stripping jacks.

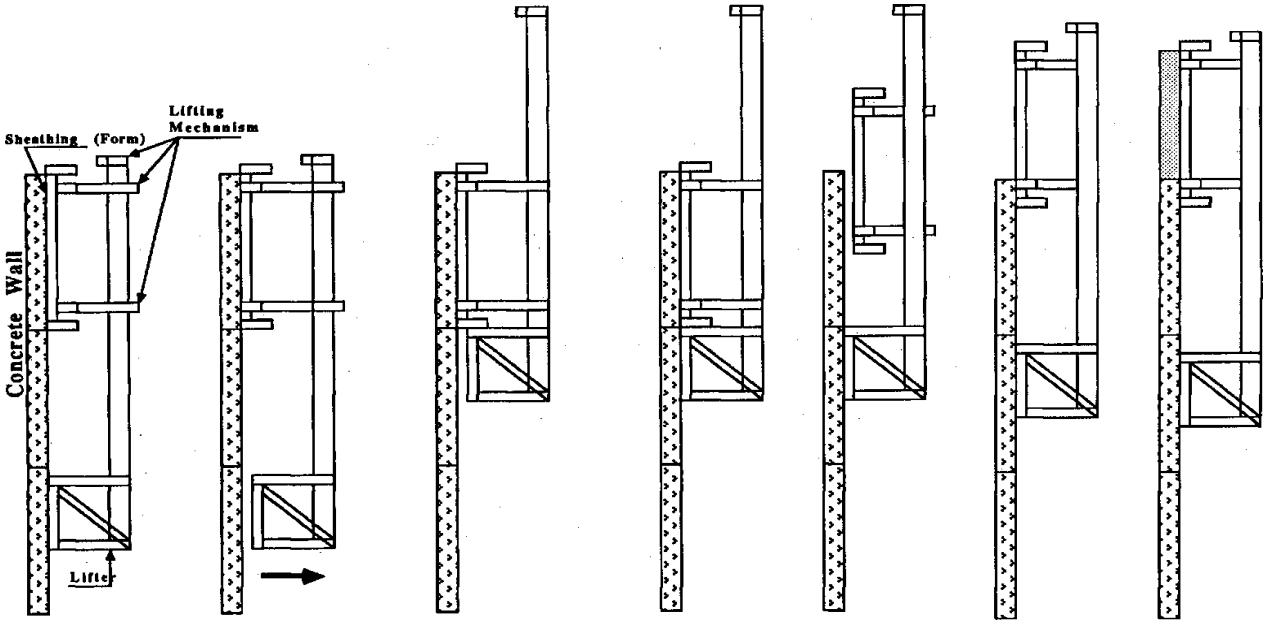
Step 3. The lifters are lifted by hydraulic, pneumatic, or electric jacks to a new position immediately below the forms. It should be noted that the top pour has to gain enough strength to support the weight of the lifters.

Step 4. The lifters are pushed back against the wall by stripping jacks, and then re-anchored to the wall just below the forms.

Step 5. The forms are unbolted, stripped, and dragged with the stripping jacks.

Step 6. The forms are lifted to the next casting position.

Step 7. The forms are brought into line, ties rods are installed, and the concrete is placed below the top of the form. It should be noted that the first two floors above the ground should be formed by a conventional forming systems before the self-raising form is used.



3. Jump Form System

Jump forms are used where no floor is available on which to support the wall formwork, or the wall and column proceed ahead of the floor. Jump-forms consist of a framed panel attached to two or more strong backs. They can be one floor high, supported on inserts set in the lift below. Two sets, each one floor high, that alternately jump past each other can also be used. Typical jump-form cycle consists of three basic operations: strip, fly, and reset. Generally, jump form systems comprise the formwork and working platforms for cleaning/fixing of the formwork, steel fixing and concreting. The formwork supports itself on the concrete cast earlier so does not rely on support or access from other parts of the building or permanent works. Jump form, here taken to include systems often described as climbing form, is suitable for construction of multi-storey vertical concrete elements in high-rise structures, such as: Shear walls, Core walls, Lift shafts, Stair shafts, Bridge pylons.

These are constructed in a staged process. It is a highly productive system designed to increase speed and efficiency while minimising labour and crane time. Systems are normally modular and can be joined to form long lengths to suit varying construction geometries. Three types of jump forms are in general use:

- Normal jump/climbing form – units are individually lifted off the structure and relocated at the next construction level using a crane. Crane availability is crucial.
- Guided-climbing jump form – also uses a crane but offers greater safety and control during lifting as units remain anchored/guided by the structure.
- Self-climbing jump form – does not require a crane as it climbs on rails up the building by means of hydraulic jacks.

- **Benefits**

Fast construction can be achieved by careful planning of the construction process. Self-climbing formwork cuts down the requirement for crane time considerably. By allowing the crane to be used for other construction work this may reduce the total number of cranes needed on site. The formwork is independently supported, so the shear walls and core walls

can be completed ahead of the rest of the main building structure. High quality surface finishes can be achieved. Climbing forms can be designed to operate in high winds. Highly engineered nature of jump form systems allows quick and precise adjustment of the formwork in all planes. Some formwork systems can be used at an inclined angle. A small but skilled workforce is required on site. It is easier to plan construction activities due to the repetitive nature of the work.

- **Safety**

Working platforms, guard rails, and ladders are built into the completed units of market-leading formwork systems. Self-climbing formwork systems are provided with integral free-fall breaking devices. The completed formwork assembly is robust. The reduced use of scaffolding and temporary work platforms results in less congestion on site. The setting rate of concrete in those parts of the structure supporting the form is critical in determining the rate at which construction can safely proceed. The repetitive nature of the works means site operatives are quickly familiar with health and safety aspects of their job.

- **Other considerations**

Jump form is typically used on buildings of five storeys or more; fully self-climbing systems are generally used on structures with more than 20 floor levels. Trailing and suspended platforms are used for concrete finishing and retrieving cast-in anchor components from previous pours.

VI. CONCLUSION

The task of housing due to the rising population of the country is becoming increasingly monumental. In terms of technical capabilities to face this challenge, the potential is enormous; it only needs to be judiciously exploited. Traditionally, construction firms all over the world have been slow to adopt the innovation and changes. Contractors are a conservative lot. It is the need of time to analyze the depth of the problem and find effective solutions. Our aim is to serves as a cost effective and efficient tool to solve the problems of the mega housing project all over the world. Our aim is to maximize the use of modern construction techniques and equipments on its entire project. We have tried to cover each and every aspect related to conventional and aluminium form construction. We thus infer that aluminium form construction is able to provide high quality construction at unbelievable speed and at reasonable cost. This technology has great potential for application in India to provide affordable housing to its rising population. Thus it can be concluded that quality and speed must be given due consideration with regards to economy. Good quality construction will never deter to projects speed nor will it be uneconomical. In fact time consuming repairs and modification due to poor quality work generally delay the job and cause additional financial impact on the project.

REFERENCES

[01] "Construction Equipment",CE&CR,May1992,Pg.50-52.
[02] "Emerging Trends In Formwork And Scaffolding", CE & CR, Sep 92,Pg.46-49.
[03] "Formwork & Scaffolding, Steel Scaffolding, Centering, Formwork", CE & CR, July 1998, Vol. 11, No. 7, Pg. 57-60.
[04] “Building Cost Comparison Between Conventional and Formwork System: A Case Study of Four-storey School Buildings in Malaysia” Nuzul Azam Haron, Ir. Salihuddin

Hassim, Mohd. Razali Abd. Kadir and Mohd Saleh Jaafar, American Journal of Applied Sciences, ISSN NO:1546-9239

[05] "Building Formwork".Building construction By B.C.Punmia (2008 edition).

[06] "Cost Effective and Speedy Construction for High-Rise Buildings in SriLanka by Using Aluminium Panel System Formworks" D.M.Wijesekara, ACEPS – 2012.

[07] "Emerging Trends in Formwork-Cost Analysis & Effectiveness of Mivan Formwork over the Conventional Formwork", Miss. Patil Dhanashri Suryakant , Prof. Desai D , Second International Conference on Emerging Trends in Engineering (SICETE) Testing.

[08] "Formwork & Scaffolding", CE & CR, September 1992, Vol. 05, No. 9, Pg. 46-57.

[09] "Guideline for the design & Erection of false work for the road & bridges By IRC 2005".(Date 14th Dec 2011).

[10] "Mechanisation in Mivan Formwork", Handbook of Rigging, lifting, hoisting, scaffolding for construction & industrial operation Edition 5 by McDonald J., Rossnagel W. & Higgins L.R. (Date 28th Nov 2011).

[11] "Mivan Formwork Products" Products & Services, MFE Formwork Technologies, (Date 20th Dec 2011).

[12] Ashok Mandal, "Scaffolding & Formwork- Maintenance & Safety", CE & CR, August 2006, Vol. 19, No. 8, Pg. 46-50.

[13] IS14687(Falsework For Concrete Structures-Guidelines)

[14] Ketan Shah, "Modular formwork for faster, economical and quality construction", Indian Concrete Journal, July 2005, Volume 79,Pg.6-23.

[15] http://www.concretecentre.com/technical_information/building_solutions/loadbearing_walls/tunnel_form.aspx

[16] http://theconstructor.org/concrete/tunnel-construction-technique/8574/

[17] http://www.mesaimalat.com/en/h20p-plywood-wall-form-system

[18] http://www.mfgcp.com/_files/docs/file_77.pdf

[19] http://www.cityu.edu.hk/CIVCAL/production/advanced/jump_form.html

[20] http://theconstructor.org/constrution/slipform-construction/185/

[21] http://www.be-con.com/S_Slipform_Construction.htm

