TUNNEL FORMWORK TECHNOLOGY IN CONSTRUCTION INDUSTRY

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Abstract -In recent year's construction industry is observing increased demand in high-rise construction and repetitive flexible structures are becoming an important part of it. These structures require detailed planning in order to save cost and time. As formwork accounts for about 25-40% of the total project cost and almost 60% of the time in concrete construction, we need to pay attention to the advance in formwork practices and replace conventional formwork with new formwork techniques like tunnel formwork. This paper aims at focusing on the advantages and limitations of tunnel formwork in contrast to orthodox formwork.

***Key Words*:** Tunnel Formwork, MIVAN, ALUFORM.

1. INTRODUCTION

The surge in population and the restriction of space has leaded the way to high-rise buildings. In order to make these buildings sound, we need to focus on factors that impart strength to concrete and this is where formwork plays avital role.

Formwork is a provisional structure like a mould or die, used to contain poured concrete, to give concrete the desired shape and support it until it attains sufficient strength. Formwork should be capable of carrying all imposed dead and live load. It is found to be suitable for mass construction in Indian circumstances. It delivers quality and speed at a rate which is higher than the speed achieved by most of the formwork systems. The labour in coordination with heavy machines like tower gantry speeds up the construction, guarantees quality control and durability. This decreases overall time and cost of the structure. This paper mainly focuses on advanced tunnel formwork systems, its modules, working cycle, cost involved, its benefits and its restrictions based on speed and economy.

2. OBJECTIVE

1. Introduce innovativeformwork systems to Indian construction industry and stress on the high quality, speedy construction and if used effectively the economically which tunnel formwork yields.
2. Present relative study of tunnel formwork and conventional formwork to remove the reasons which act as obstacle for the local construction industries while selecting for new formwork techniques like tunnel formwork.
3. Slab cycle time
4. Cost parameters.
5. Quality parameters.

3. WORKING OF TUNNEL FORMWORK

Step-1:

Detailed plans of the mock up shuttering must be made. It must be made sure that the building's structural and architectural drawings are confirmed before the fabrication of the tunnel form.

Any alteration in the drawings will cause delay and increase in total cost of the project.

Step-2:

The surveyor provides marking for the concrete kickers, after which the reinforcement work starts followed by the placement of the tunnel formwork.

Step-3:

Once the tunnel form is in place, the reinforcement work for the slab is done along with the electrical duct work and column reinforcement for the upper slab.

Step-4:

Uniform concrete pouring is done for the slabs and the wall.

Table -1: Comparison of Tunnel Formwork and Conventional Formwork system

	TUNNEL FORMWORK	CONVENTIONAL FORMWORK
Slab1	14 Days	14 Days
Slab	14Days	14 Days
Floor 1	7 Days	14 Days
Floor 2	4 Days	14 Days
Floor 3 to Floor 12	40 Days. (Taking 4 days per floor)	140 Days. (Taking 14 days per floor)
Total:	3Months considering 26 working days a month	7 Months considering 26 working days a months

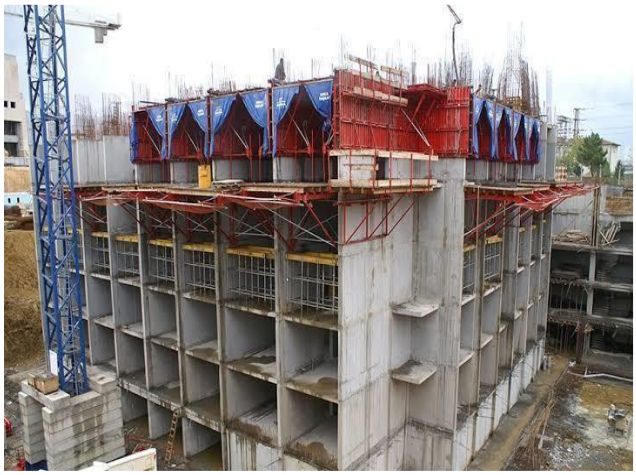

Fig -1: Tunnel formwork illustration (a)

Fig -2: Tunnel formworkillustration (b)

4. CONSIDERATION OF COST INVOLVEMENT IN TUNNEL FORMWORK

For all structural systems, the construction cost is noticeablyestimated to get higher as the number of floors. In case of tunnel formwork the past studies have shown that in the buildings of the same wall thickness, the unit cost per apartment drops as number of floors increases. The components which impact the cost are initial cost, cost of the assembly, reuse cost, machinery and operating cost and daily expenditure on labor. The initial cost is very high but it is economical in long run as the life cycle is reduced and reuse of form is possible. Reusability also reduces material, assembly and erection cost. Due to high quality finish the cost of finishing treatment is reduced. In order to maintain the durability of formwork, formwork oil (1 litre for 20-45 m2 of formwork) is applied at regular interval and thus it is a minor cost. Equipment cost involves the operating cost and the cost of hoists. As skilled labours are involved and the work is repetitive the total time of construction is reduced so the amount spent on daily cost on labour and administration cost is significantly reduced.

5. DIFFERENCE BETWEEN CONVENTIONAL FORMWORK & TUNNEL FORMWORK

CHARACTERISTICS	TUNNEL FORMWORK TECHNOLOGY	CONVENTIONAL FORMWORK TECHNOLOGY
1.Speed of construction	One day cycle per floor	Min cycle time is 21 days
2. Quality of surface finish	Excellent. Plastering is not required.	Bad. Plastering is required.
3. Pre planning of formwork system	Required	Not Required
4.Wastage of formwork material	Very less	In great amount
5. Accuracy in construction	Accurate construction	Accuracy is less
6. Material	construction Steel panels	Timber and ply
7. Labour	Skilled worker required	Unskilled workers also do
8. Cost	High initial cost but balances in long term	Double the cost required by steel panels
9. Operations	Crane oriented	Manually
10. Reuse value of formwork	250 -300	Maximum 50

6. ADVANTAGES

The overall advantages of tunnel formwork are characterised into four categories as follows.

1) Design:

- Hi-tech all-steel system of tunnel form with 3 mm. steel surface provides stability and strength.
- Folding strut provides clearance for form stripping, the composite wheel assemblies help in accurate form positioning and block outs eliminate the nailing.
- Multiple rooms can be concreted and that enables flexibility in planning.
- Proper concreting of ceiling to the wall results in lack of formation of beams.
- Tunnel form can be adapted to special building features, like terraces, galleries, etc. It gives liberty and diversity in architectural designing.
- The dimensional precision of the concrete structure allows the placement of walls and fixing of all other finishing material such as joinery right after casting.
- Standard push-pull struts can be used at every tunnel dimension due to its retractable nature and makes it easy to adjust horizontal and verticallevelling. High kickers make it easier to adjust tunnel heights which remove levelling errors. Tunnel form can be adapted to higher floor level easily.

2) Quality

- Setting up of all utility conduits in the shell reduces the internal finishing work.
- High quality and dimensional accuracy is achieved. 1/1000 deformation is allowed and can be accomplished. Low depreciation and long life of building.
- The obtained surface is even which reduces much of finishing work and allows direct application of paint after sandpapering off the fins at the joints connecting two forms and smoothing with paint filler.
- Monolithic components of the building avert thermal cracks which are witnessed in the heterogeneous materials because of temperature difference.
- Low scope of change in the original design of the building results in application of standard dimensions of windows, doors, wall etc.

3) Time

- In the high temperature zones and/or by thermal treatment, with the use of ordinary cement, the normal pace is one day per cycle. Achievable cycle of production is of 1-3 days.
- A monolithic structure with simultaneous casting of walls, partition wall and slab results in reduction in total construction time.
- Installation of electrical ducts, gas and water pipes in the shell reduces the inner finishing work, internal finishing proceeds with the concrete shell construction causing in reduced total building time. Reducing minor works and coinciding activities yields into high quality and speed of execution.

4) Cost

- Tunnel form can be reused and this reduces the overall cost of formwork for per m2 or per housing unit.
- The amount of rework and finishing work is reduced thus machinery, additional material and labour costs are saved.
- High quality construction and early completion of projects helps minimize cost in long run.
- Tunnel form system comes with highest safety due to its full perimeter platform system. This reduces cost associated with risk.

7. RESTRICTIONS IN IMPLEMENTATION OF TUNNEL FORM

- Initial investment cost is high and it further increases for small scale projects.
- Applying all internal walls in the form of reinforced concrete is needless which causes lack of changes in the plan and concrete increases dead load of the building.
- Precast elements like parapets, stairsetc. are used and this requires separate workshop arrangement.
- The activitywhich involves erection, removal and carriage of scaffolds, framework, and placing of pre-cast components to the necessary place involve use of tower hoists and this increases the cost. Topographic restrictions can make movement of hoistschallenging in some projects.

- All activities need to be planned and executed according to the need to reduce cost and time. This requires effective construction management and high cash flow.
- Large spans of slab cannot be performed due to increased gap between the tunnel form panels. Here combination of system may be adopted. Very short span of slab incorporates trouble in removal of tunnel form at the time of stripping and suspended ceiling is needed. Basement stories are avoided as it is hard to remove formwork.
- Axial system plays important role and load bearing walls must be designed continuously on the same axial system to resist horizontal forces.
- The number of labour required is less and it is more effective as associated to that in traditional formwork. Thus proper training is required to impart skills to handle tunnel formwork.
- Minimum wall thickness of 200 mm must be maintained throughout as the offsets for column beams are not possible.
- Separate provision of a workshop is required for the production of Lobbies, cladding panels and Pre-cast staircase.
- Complete dependence on the contractor for any change or alteration in the design.
- Due to high speed of construction, timely management of high cash-flow is a must.

8. CONCLUSIONS

Realestate industry has a status of not begin very technically sophisticated, generally lagging in modernisation, construction practices&administration. But now a day's lot of research is carried out in this sector, advanced TUNNEL formwork & ALUFORM system are good examples of this innovation. We can achieve 1 to 3 days slab cycle by TUNNEL formwork system, where as we also can use MIVAN or ALUFORM system by which we can achieve slab cycle of 7-10 days. In case projects having more than 25 storied building over large area, total economics may vary significantly. However this aspect requires additional study to arrive at conclusion. Also after studying and comparing both the systems it can be concluded that, though initial investment and per day operational cost in TUNNEL formwork is more than ALUFORM system, due to more reuses and reduced slab cycle time TUNNEL formwork works out in the end economical. Hence in long term consideration TUNNEL formwork system is beneficial than that of ALUFORM system

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