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Introduction to advanced TUNNEL Formwork system: Case study of 'Rohan - Abhilasha'

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Abstract: *Now a day construction industry is becoming very time conscious. Time (i.e project completion time) or duration of the project is very important factor in construction industries these days. The quote " Time is money" is becoming truth, because time loss is ultimately money loss. Also as current situation of labour availability is very less, so industry should move from labour oriented to machine oriented. And formwork is best factor where we can move from labour to machine. Formwork perform key role in construction, in time as well as costs. Only formwork costs nearly 25% of total project cost. We know the complications & wastage in construction by using conventional formwork system. So we moved to formworks like mivan, aluminium for simplicity and good finish, but it is not enough. As we discussed time factor, by using systems like mivan, aluminum off course there is time saving but not up to that extent. So there is new emerging technology named TUNNEL formwork. Which is much beneficial than that of aluminium or mivan formwork. This paper describes the introduction to advanced TUNNEL formwork.*

Key Words: *TUNNEL formwork, slab cycle, economy, time saving.*

1. INTRODUCTION

Indian construction is known for its use of conventional/ typical formwork system, and it has not adapted advanced formwork systems in RCC works compared to developed nations. Formwork plays vital role in RCC framed / load bearing structures. Formwork is a mould or die used to shape and support the concrete until it attains sufficient strength to carry its own weight. The formwork is a kind of "baking tin", which holds the concrete until it hardens to attain the required shape and size.

Formwork constitutes 30% of the cost and 60% of the time in concrete construction. Quality of concrete finish and soundness of concrete depends very much on the formwork system. Formwork should be properly designed, fabricated, and erected to receive fresh concrete. If formwork is not done properly the desired shape of concrete is not possible. When concrete is compacted, it exerts pressure and the formwork must be strong and stable to take this pressure. The form should be leak proof to retain the concrete & slurry.

Advanced Tunnel formwork identified to be suitable for Indian conditions for mass construction, where quality and speed can be achieved at high level. The speed of construction by this system will surpass speed of most of the other construction systems. The labour in coordination with heavy machineries (eg. tower crane) handles this method effectively to speed up the construction, to assure quality control and durability. Adoption of this system reduces overall cost of the structure. This paper mainly focuses on advanced tunnel formwork systems, its components, working cycle and its benefits based on speed and economy.

2. OBJECTIVE

Objective of this paper is to introduce Indian construction industry to advanced TUNNEL formwork systems which is rapid and if used effectively ultimately economical based on,

a. Components
b. Working cycle
c. Economy.
d. Benefits and disadvantages.

3. THEORETICAL CONTENT

3.1 Current trends in formwork systems.

At present in Indian construction industry various types of formwork systems being used. Based on type of material, purpose of use and method of erection formwork systems listed as follows.

1. Conventional formwork.
2. Climbing formwork system.

3. Slip formwork system.
4. Permanent formwork.
5. Mivan/ Aluform/ Aluminium formwork
6. Tunnel formwork.

3.2 Introduction To Tunnel Formwork

Tunnel form is nothing but it is a box sized steel fabricated form which allows structure to be casted monolithic i.e. to cast RCC walls and slab in single continuous pour. The formwork system is supported with hot air blowers which accelerates the setting of the concrete. So that one can achieve one slab in one day i.e. 24 hours slab cycle.
This system becomes more economical for symmetric construction like mass housing projects and contains huge quantum of symmetrical work.

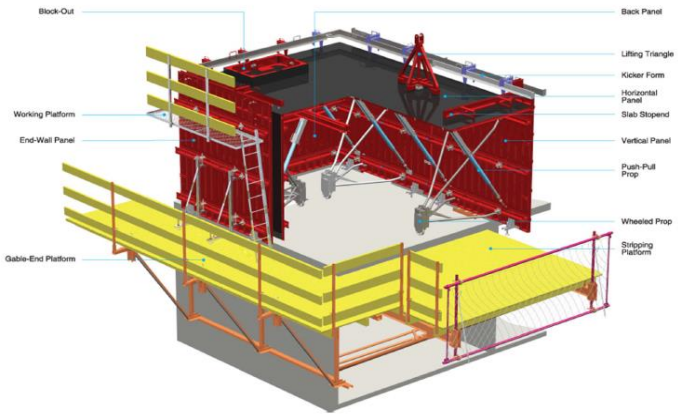

Figure 1 :- Tunnel Form and its components

3.3 Components

Components of tunnel formwork are detailed as follows:-

1. Vertical, Deck and back panel: Retain fresh concrete until it gets set and cured.
2. Stripping platform, gable end platform and working platform: Provided for movement and working of labors and machinery and also for stripping out tunnels.
3. Push-pull props, wheeled prop: To maintain line and level of tunnel.
4. Lifting triangle: Placed at centre of mass of tunnel form deck panel for lifting by tower crane.
5. Kicker form: Provided as starter formwork at slab level to maintain position of next level tunnel form.
6. Slab stop end, Wall stop end: Provided as stopper to retain fresh concrete up to wall and slab line.
7. Block outs: Block outs are fixed at vertical panels to provide door, window and ventilation windows in walls.

Figure 2 :- Tunnel Form at Site

3.4 Working Cycle

Working Cycle of Tunnel form system is mainly divided into three parts. Viz
I. Striking Of Formwork.
II. Setting Of Formwork.
III. Concreting Operation.
These 3 activities are divided as follows
a. Formwork panels are cleaned and oiled at the time of Deshuttering itself
b. Ready wall reinforcement are placed in position and after placing beams are fitted manually.
c. Forms are placed in position guided by concrete starters
d. Slab reinforcement mesh and electrical-plumbing conduits are fixed in reinforcement.
e. Walls, slab along with kickers (starters) are casted in one continuous pour.
f. Formwork panels are ready to de shutter and shift to next location by tower crane.

3.5 Economy

Basic cost considerations in economy of tunnel formwork are follows
1. Depreciation cost of material, heavy machinery
2. Machinery operational cost.
3. Daily cost expenditures on labour
4. Supervision cost.
Though initial investment in material and heavy machinery is very high due to reduced slab cycle and more reuse potential for large multistoried projects tunnel formwork becomes ultimately economical. As construction speed is very high than that of other formwork systems, As turnover is more within a short period, returns of investment made will be early. Also good quality finish results in minimizing labour and material cost in finishing items and requires less finishing treatment.
Precast element is one of the critical activity at the time of using tunnel formwork, it results in increased productivity

with fabulous architecture view after erection at very short period of time which again results in time and cost saving.

Figure 3 :- E1 Building During Tunnel Casting

3.6 Advantages and disadvantages

3.6.1 Advantages

I. Time Advantages

1. A production cycle of 1-3 days can be achieved.
2. Depending on the production speed of load bearing system succeeding production activities in the building can also be accelerated.
3. The project can be completed in a short time compared to traditional construction systems.
4. Due to accelerated production, effects of climatic conditions on productivity are minimized.

II. Quality Advantages

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

III. Cost Advantages

1. Formwork cost per m^2 (or per housing unit) can be reduced by using formwork up to number of times.
2. Due to smooth surfaces, walls and slabs do not need any additional finishing such as plaster.
3. Early completion of project provides financial opportunities such as rental incomes.
4. Repetitive nature of buildings provides effectiveness in production and minimization of labor costs.

3.6.2 Disadvantages.

1. Investment cost of formwork system increases formwork cost per m^2 if project is small sized.
2. A continuous and fast cash flow that complies with the speed of production is essential.
3. Due to high production speed management-related functions are vital. Coordination problems cause remarkable delays in schedule.
4. Skilled labor force is needed compared to traditional systems.
5. Equipment costs are relatively higher due to the cranes that are needed by each block.
6. Tunnel formwork system is not convenient for some building types such as music halls, theaters, etc., that contains large spans.
7. Lowered slab is not allowed since it prevents the removal of formwork, suspended ceiling is required.
8. Load bearing walls must be designed continuously on the same axial system due to the resistance requirements against horizontal forces.
9. Basement stories cannot be constructed by using tunnel formwork system; removal of formwork is not possible
10. Tower cranes are required for the erection, removal and carriage of formworks, scaffolds, and pre-cast components.
11. A workshop is required for the production of precast components such as stairs, parapets, and walls.
12. A crane can serve max. 2 blocks at the same time Movement of cranes has difficulties according to some topographic conditions.

4. CASE STUDY

1. Name of organization: Rohan Builders India Pvt Ltd.
2. Name of project: Rohan Abhilasha.
3. Location: Wagholi- Lohgaon road, Pune.
4. Type of project: Real estate.
5. Scope of work considered:
I. Rohan Abhilasha 'E- Block'. E block consist of four 14 (2G+12) storied towers.
II. Underground water tank (Master Balancing reservoir)- Capacity 700000 Liters
III. Transformer room.
6. Area of RCC construction: 32000 Sq. Ft
7. Type of formwork used:
I. Up to 2nd parking level: Conventional formwork
II. 3rd to 14th floor : Tunnel formwork.
8. Contractor hired for execution: BUYUK ISKENDER, Ankara, Turkey.
9. Architectural consultant: Mindspace architects, Banglore.
10. RCC consultants: JW Consultants, Pune.

Figure 4 :- E1 Building in finishing stage

5. CONCLUSIONS

Construction is a complex and risky process requiring extensive planning, engineering, procurement, and construction management. When all of these activities operate in concert with each other, the result is a successful project. Formwork is key component of any structure, quality of construction is directly depend on formwork used. There are various types of aluminium formwork used in construction industry from conventional formwork to special forms.

Real estate construction industry has a reputation of not begin very technologically sophisticated, generally lagging in innovation, construction techniques & management. But now a day's lot of research is carried out in this sector, advanced TUNNEL formwork is good examples of this innovation. We can achieve 1-3 days slab cycle by TUNNEL formwork system.

Heavy machinery and on site management are critical factors in implementing tunnel formwork. Also high cash flow management is essential to carry out work properly. Coordination problem cause remarkable delay in schedule. Also after studying the tunnel formwork system it can be concluded that, though initial investment and per day operational cost in TUNNEL formwork is more, due to more reuses and reduced slab cycle time TUNNEL formwork works out ultimately economical. Also returns from initial investment regained due rapid completion of project Hence in long term consideration TUNNEL formwork system is beneficial. As turnover is more within a short period, returns of investment made will be early. And hence when considered for longer period of time over large area, tunnel formwork works out to be economical.

Figure 5 :- Transformer room using Tunnel Form

6. FUTURE SCOPE OF WORK

This research could be used as an avenue for other researchers to conduct additional studies of various formwork systems. This study is limited as technique used is relatively new to Indian construction industry. Further study could be done in following

1. As this study is mainly aims for cost and slab cycle time of formwork systems, one can focus on increase in productivity by using advanced techniques in formworks. Use of tower crane plays critical role in reducing slab cycle time, the study of tower crane and its optimum use also can be the research area for researchers.
2. Though tunnel formwork system involves heavy investment in procurement, heavy machineries, specialized expert labour it becomes uneconomical. In case project involves more than 20 storied building over large area, total economics may change considerably. However this aspect will require further study to arrive at conclusion.
3. At present only RCC items for towers are taken into consideration & respective time and cost to complete same is worked out using tunnel formwork and Aluform. The scope of the project work is limited to above items only. There is further scope available when all the items of work are completed for these towers, overall economy can be worked out considering cost incurred against the expected returns at market value.

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