Slipform: The New Era of Formwork of Unusual Structure

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Abstract- *Slip forming is the best techniques which carried out fast and rapid construction in an unusual structure like cooling towers, chimneys, silo and also in roadway construction bridge construction. Slip formwork techniques carried out with more than 16 m height structure and its very rapid and time saving erection techniques and also economical. Slip forming considers mainly 7.2 m per day which is fastest erection procedure. They content various components and after the completion of curtain height concreting by the hydraulic jack it lifted up and further concreting could be done. Hence these methods are rapid, time saving; economical and less labor force is required.*

Keywords- Silo, Rapid Construction, Slip Forming

I. INTRODUCTION

Slipform has been accepted as a precise construction technique within a comparatively short period of time - an indication of its considerable popularity. This popularity has in turn encouraged further research ensuring the adoption of new methods and modern materials, which have firmly established slipforming as an Economical, rapid and accurate form of construction.

Now that it is properly developed, the technique can be applied to many different forms of structure,

including tapering formations with straight or parabolic profiles incorporating constant reductions in wall thickness. Traditional applications for slipforming are silos, chimneys, bridge piers, water towers, special application like construction of pylons, lift core wall of building, lining for tunnel shaft, framed structures etc.,

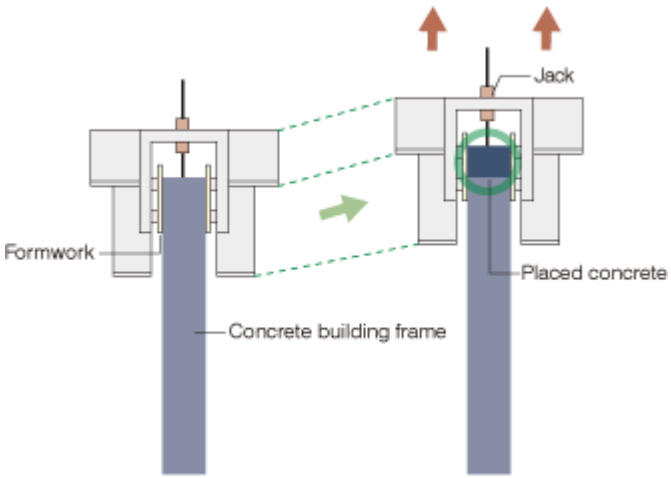
HISTORY OF SLIP FORMWORK

- The slip forming technique was discovered by America in 1910 for building silos, grain elevators and cooling towers.
- The first notable use of the slip formwork method in Skylon Tower near Niagara Falls, Ontario, which was completed in1965.
- Another unusual structure was constructed for the Sheraton Waikiki Hotel in, Hawaii, in 1969.
- In 1990s in U.K. Slip forming has even been adopted for the paving of roadways, bicycle paths, and kerb with the introduction of slip form paving equipment. And further Slip form paving was also implemented in the paving of airport aprons, taxiways, and runways.

WHAT IS THE SLIP FORMWORK AND METHOD OF USE

Slip forming consists of constructing a wall-shaped form approximately 1.0 to 1.2 meters high at the base of the structure. This type of formwork has a belt of forms, one for each surface, 1 to 1.5 meters wide usually about 1.2m (4ft) made of timber or steel. These surface forms placed on the internal and external surface of a wall, chimney and cooling towers etc. As the concrete is deposited, the form is slowly and continuously raised by jack screws, hydraulic jacks or pneumatic jacks.

As the form is raised, it can be adjusted to vary the taper of the structure and the thickness of the wall as needed. The rate at which the form is raised is between 100 to 300 mm/hour as per requirements. This around the clock operation results in a construction rate between 2.4 to 7.2 m/day, which cannot be attained by any other construction method.



PRINCIPLES OF SLIPFORM

Slipform construction, also referred to as sliding form construction, is similar to an extrusion process. Plastic concrete is placed in the forms, and the forms act as moving die to shape the concrete. Once the form has been filled with fresh concrete and hardening has started the form is gradually raised by the lifting devices on which it is suspended. The rate of movement of the form is regulated, so that the forms leave the concrete after it is strong enough to retain its shape while supporting its own weight. Pouring of concrete, tying of reinforcement, fixing of openings/inserts etc are performed gradually from a working platform.

An average sliding speed of 200mm an hour is common, rising to 300mm an hour under the best conditions and 100 to 150mm an hour when large or complicated structures are being slipformed.

DESIGNCONSIDERATIONS:

The slipform should be designed so that the loads to which its various component parts are subjected are uniformly distributed, and the yokes are loaded as uniformly and axially as possible to avoid their overturning. The jacks should not be located in wall openings as for as ·possible. ·The loading should not exceed the lifting capacity of the jacks. The loads acting on slipform can be classified as follows,

BASIC LOADS

- Dead load due to the components
- Live loads due to Concrete
- Friction between form and concrete
- Workmen
- Materials
- Machinery
- Other installations
- Auxiliary load due to the way of application of live loads
- Crowds of workmen
- Piles of materials
- Shocks·produced·by material unloading

ACCIDENTALLOADS

- Wind pressure
- Adhesion between concrete and form due to long interruption.
- Friction due to incorrect position of form
- Failure of one jack

EXTRAORDINARYLOADS

- Breaking of certain members of the slipform
- Failure of two adjacent jacks

Minimum concrete

Strength required for slip form application,

2 Kgf /cm2-whenreleasingtheform.
4 Kgf /cm2-whencomingoutfromtheform.
20 Kgf/cm2-after24hourssincepouring.
200Kgf/cm 2 -after28days.
Note: 1N/mm2 = 10.197Kgf/cm2

TYPEOFSLIPFORM

The slipform can be broadly classified into,

- Straight slipform.
- Tapering slipform.
- Slipform for special applications.

Typical structures that are constructed using straight slipform technique are,

- Silos
- Cylindrical chimneys
- Water tank shafts
- Columns

Typical structures that are constructed using Tapering slipform are,

- Conical chimneys
- Ventilation stack
- Tapered bridge piers

Typical structures that are constructed using Special slipform are,

- Lift cores,
- Framed structures
- Preheater building
- RCC Pylons

Construction of block of flats, lifts and stair- well, bridge piers, preheater and RCC pylons for boiler supporting structure using slipform techniques comes under special applications because of their complex sizes, shapes and loads to be lifted along with slipform, like walkway trusses, etc. which is essential for construction.

Components of Slipform

Shutters and Walers:

The function of shutters and waler assemblies is to maintain correct profile of structure to be slip formed and resists concreting pressure. Horizontal walers prevents panel from deformation and supports the yoke legs.

Yoke Legs:

Yoke legs are used to lift the slip form structure as one integral unit, transfer lifting reactions to jacks and acts as the main connecting member for walkway platforms, masons' scaffold, yoke beams, top platforms, etc.

Yoke Beam:

Yoke beam is mainly a connecting member between inside and outside yoke legs. Two yoke beams are connected at top portion of yoke legs. Jacks are mounted over yoke beams. Yoke beam transfers lifting forces of jacks to yoke legs.

Lifting Jacks:

Lifting jacks facilitate lifting of Slip form assembly. Jacks are to be suitably located preferably at equal intervals to enable to lift slip form as one integral unit.

Jacking/Climbing Rods:

Jacking rods are normally located centrally in the wall to be cast or at equal distance in yoke beams depending upon the number of jacks. The lifting jack climbs over the jack rod. The entire load of the Slip form assembly is transferred to jacking rods when jacks are energized.

Hydraulic Pump:

Hydraulic pumps are provided to circulate required quantity of hydraulic oil at desired pressure for energizing jacks to lift the assembly and facilitate its uniform lifting.

Tapered Sleeve:

Tapered sleeve tubes are provided to prevent fresh concrete coming in contact with jack rods, thus, facilitates extraction of jack rods later. Taper sleeves are attached to yoke beam and move along with slip form and create a hole in concrete around jack rod.

ASSEMBLYPROCEDURES

STRIGHTSLIPFORM

1) Position the vertical and horizontal reinforcement with correct cover.
2) Casting of the starter. (min: 150 - 200mm)
3) Check starter for the correctness in level and diameter. .
4) Fix the inside and outside staging brackets/erect scaffold pipes, if required.
5) Fix timber runners connecting the walkway brackets. / Level the surface using cement morter.
6) Check the level.
7) Tie the vertical and horizontal reinforcement' up to shutter top height.
8) Mark the position of inside and outside yokes in the starter, starting from the tower location.
9) Ensure that three sets of yokes are located in between two tower verticals.
10) Align the panels and introduce steel washers at regular intervals to maintain 4mm slope both inner & outer faces.
11) Fix top and bottom waler pipe. Fix external supports both horizontal and inclined to align the shutter.
12) Fix filler panels.
13) Repeat the operation 10 to 12 for outside and make sure that washers are introduced at the bottom of shutters to achieve 4mm slope towards inside.
14) Fix the waler shoes, inside and outside yoke legs. Adjust waler shoe and check the verticality on both faces
15) Keep timber supports between top & bottom walers at yoke location.
16) Align the form panel by external supports.
17) Fix the yoke beam two numbers at the boom and one number at top.
18) Check the level of yoke beams with spirit levels.
19) Fix the inside and outside walkway brackets.
20) Finish the final alignment by suitably adjusting the waler shoe bolts. Ensure that all walers are touching the form panels. Provide packing wherever required.
21) Fix the flying tie rod assembly and support the center rings. Ensure uniform tightness is maintained in all the spokes.

DISMANTLING PROCEDURE

STRIGHT SLIPFORM:

1) Provide coil nuts in the final layer of concrete.
2) Fix dismantling brackets, handrails, finish planking and transfer the load of slipform assembly to the brackets.

3) Remove the flying tie rod assembly and lower the same.
4) Remove the inside and outside hanging scaffold and shift the planks to the staging brackets.
5) Remove the jacks and sleeves.
6) Remove the yoke assembly, which consists of yoke legs, yoke beams and waler shoes.
7) Remove inside & outside walers.
8) Remove the walI forms, while removing the waler.
9) Extract the jack rods and grout the holes.
10) Remove dismantling brackets after completing other works.

CAREDURINGSLIPFORMOPERATIONS:

- Uniform layer of concreting.
- Regular cleaning of shutters.
- Penetration testing of concrete, for setting time.
- Freeness of tapered sleeves.
- Periodical plumb readings.
- Adjustment for tilt & twists
- Prevent overflowing of concrete.
- Maintain a free board of 100 mm.
- Uniform distribution of load on the platform.
- Lowering of unwanted materials periodically.
- Proper handling of lasers.
- Cooling of jacks where the temperature is very high.
- Protection of high pre hose.
- Protection of turnbuckle spindles. .
- Greasing of all moving parts I outside the shutters.
- Ensure free movement of shutters, walers, intermediate form supports, planks and handrails.
- Consistent quality of concrete.
- .Periodical checking of concrete slump.
- Fixing of required setting time for concrete based on slipping speed.

SLIPFORM REINFORCEMENT

The progress of slipform is mainly determined based on the time consuming for concrete pouring speed and reinforcement tying. if any delay in these two the progress will affect drastically. As the space available for tying the horizontal is restricted in slipform, it is very essential to plan all the activities well in advance and to be prepared before starting of slipform.

The following points have to be considered while making the schedule.

- The length of vertical/horizontal bars should be restricted to 5 mtr. Due to the constraints in lifting and handing at heights.
- The diagonal bars around openings should be avoided.
- Wherever stirrups are used it should be in 2 pieces only.
- It is not possible to have verticals in yoke locations and hence alternate bars should be placed nearby.
- Wherever concrete is taken through a chute the verticals below the chutes have to be lapped with smaller lengths by means of welding.
- The total requirement of reinforcement should be cut I bent and kept near the slipfo1m structure before starting slipform. The stocks should be kept with proper tag for easy identification.

DISTRIBUTION:

CONCRETE:

1) Tower erection, tower foundation, guy rope foundations, B'hoist erection.
2) Wire ropes for tower, hoisting, rope clamps.
3) Protective sheds for mixers, winches etc.
4) Concrete mixing, lifting, placing, vibration, finishing, curing etc.
5) Hire charges for mixers, Builder hoists, vibrators, water pumps etc.

SHUTTERING:

1) Labour for assembly, slipping operation, dismantling, jack rod extraction.
2) Arrangements like plumb pedestals.
3) Entire slipform materials (depreciation cost / 100% debit)
4) Timber, nails, hydraulic oil, coil nuts, grease etc.
5) Spares for pumps & jacks, hoses.
6) Hire charges for pumps, lasers etc.

REINFORCEMENT:

1) Hire charges for reinforcement winches, trailers if any for shifting.
2) Labour charges for unloading, straightening, cutting bending, & tying.

ADVANTAGES

- Provision of a joint less structure.
- A saving of shuttering material both initially as well as lesser wastage.

- Scaffolding is not required.
- Very rapid concreting. It is at least four times faster.
- Better finishing of concrete.
- Reduced labour cost.
- Slip form does not require the crane, minimizing crane use.
- No plastering required.
- Accuracy is more than regular formwork.
- Strength is more than regular formwork.
- Save formwork material.
- Economical for structure above certain size.

DISADVANTAGES

- Greater time required for arranging of various components.
- Expert supervision and operations needed for uniform movement of the slip form system.
- Stocking of material on the site is difficult
- Good coordination and site organization required.
- Large quantities of equipment (e.g. Generators, lighting systems, and hoists) needed.
- Labour force may require familiar with equipment and methods.
- The operation must be continued in any weather
- High initial expense.
- Need 24-hour service facilities (e.g. Canteen, material supply, maintenance team, primary clinic

ECONOMICAL CONSIDERATION

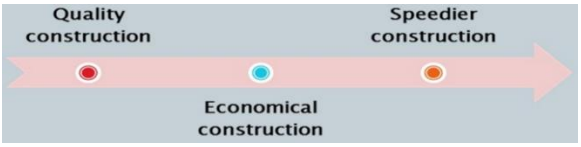
- This type of form works only economical when the height of the structure is a minimum of 16m high.
- The thickness of the wall should be a minimum 15cm.
- This system is only suitable for a structure like silo, cooling towers, chimneys, tall building and piers.

II. CONCLUSION

With the invention of slip forming technique and due to speedier completion of work by the technique, there are substantial savings in cost in terms of wages and interest. This technique has no comprises against quality control and Homogeneity of structure.

- The cost saving will not appear automatically just because slip forming has been used.
- This technique has a lot of scope for improvement. But it can be adapted for tall structure.

Thus a slip form system involves:-



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