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# ANALYZING THE IMPLEMENTATION OF TALL REINFORCED CONCRETE STRUCTURES BY USING SLIP FORM SYSTEM (SILOS AS CASE STUDY)

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## *ABSTRACT*

*For implementation of huge structures, in addition to the various issues that arise in their calculations and design, manufacturing technology is also an important issue that can have a huge impact on design. Reinforced concrete structures are not excluded from this issue. During years' different new methods have been developed in order to simplify shuttering: one of these methods is the use of Slip form, which are more commonly used for tall structures implementation. The sliding formwork technology has been used for more than half a century, but this technology has been designed in order to run concrete shells and walls such as silos, airport towers, chimneys, cooling towers, power plant and holes in elevators and in this field is the most practical method (Samavati et al., 2016). The cost of this framework is more expensive, and the implementation of openings, bumps, and expansion joints is more difficult than classical methods, and in general it requires more power and need more consideration. In this way, construction speed of the structures is very high and it is very economical for buildings more than 20 meters. The implemented structure is completely integrated and free of horizontal and vertical joints and in case of precision in execution, the concrete view will be quite good and acceptable. According to the results of this paper, the use of new and special methods in accordance with the specific project conditions and available resources can lead to significant savings in cost, time, execution quality, pay back investment, saving on materials consumption, reduction of manpower, adaptability Eco-friendly, more stability and durability, integrated structure, high flexibility and employee safety. (Samavati et al., 2016) Therefore, in similar projects can create value engineering by examining the conditions and analyzing the cost and time of new and innovative execution methods. In this research, a case study of silos construction (referring to a simulation model for silo execution by slip form), a component of the slip form, and a table and comparative graphs of how to implement all kinds of silos 1, 3, 4, 6, and 9 of the hive have been analyzed and investigated. The result Years of activity and field training in projects for the construction of silos and cooling towers of power plants in the country using a slip form, which is the achievement of this treatise.*[1]

***Keywords***: *Kurd tribes, ottoman Sultan Salim I, Idris Bitlisi, Shah Ismail Safavi I.*

## INTRODUCTION

Construction is one of the most important beliefs in developing countries that assign most investment. In our country, after Revolution, there are good opportunities for developing civil

[1] The paper is based on field and experimental research and library years of work as an expert in the field of high performance concrete construction (silo case) by sliding mold, (2019)

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activities and Iranian creativity. One of the most common methods in order to construct a silo is using slip form. Grain storage silos connect each other in multi hive shape (1,2,3,4,6,9). They design based on region requirement, storage capacity, soil bearing capacity and hive arrangement[2]. Executing building less than 15 floor or silo less than 20 m is not economic regarding to high cost of slip form.

Modeling and simulation was developed by Zaido Helping in 1973. It is a simple and popular tool for construction, and was proven by many researchers in 2001. In this research, a comprehensive and practical definition of the slip form technique has been presented. (Sharifi, Baciu and Zayed, 2006)

## *general specification*

### *Slip form background*

Studies shows that slip form were first used in the early 20th century in the city of Kansas to build a rectangular silo. (Dehkordi, Zabani and Amer, 2002) and then went to Europe. The first building complex was constructed using a slip form in 1980 in Tennessee, USA. In 1974, a slip form method was developed for the construction of a power plant shaft in Toronto, Canada, with a height of 335 meters (Sharifi, Baciu and Zayed, 2006). 1986, Semi-complete silos, smoke and cooling towers of power plants were commissioned by the experts of the Silo Development Company I started working with the mold and, since 1989, I started working with this company to produce 100,000 tons of wheat gilly wheat in Golestan province. I hope that this article will be useful for professors and enthusiasts in this field[3].

Similar structures, which in the past required heavy metal scaffolding around the structure, were removed by using a slip form method. Many scaffoldings around the structure were eliminated, and the speed of the work, along with a better view, increased.

In slip form method, in contrast to the usual methods of buildings, instead of metal and wooden molds, a special metal mold is used which moves upwards with the help of hydraulic jacks and metal jacks, gradually and creeping upwards, and surround the produced concrete and then after hardening it gradually gets out of the mold and becomes the main wall of the building. The slip form moves along the vertical with a uniform velocity, and this speed is such that each cross section of the concrete remains in the mold during the time it takes for the hardening. The vertical slip form is used for shell structures with constant or almost constant wall thickness.

Vertical slip form is driven upwards by jack, which operate on smooth rods (mill rolls) or structural tubes placed in hard concrete. These jacks may be manual, pneumatic, electric or hydraulic. The work platforms and scaffolds of the workers are also attached to the body frame and accompany it. [4]

## *review of available article and submit suggestion*

1- In an experimental study of the vertical deformation of slip form, which was developed by A. Szak Bouchiker Rissen and Dr.J.Jenscher 2016, the sample of the tested model has problem and corner connect with a 90 degree angle, which causes increased friction

[2] ibid
[3] ibid
[4] ibid

between frame and concrete, thus causing cracks in the concrete and disturbing the vertical movement of the slip form and unbalanced pressure to the jacks (Figure 1).

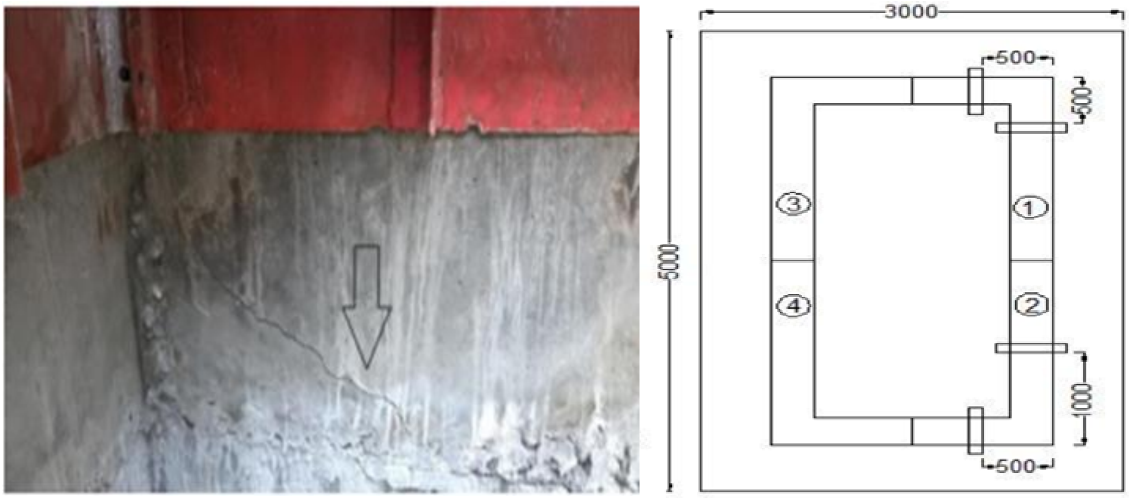


**Figure 1: problem in designing of slip form corner [4]**

In order to modify and remove the above problem, in slip form design, the frame corner should be changed to 45 ° or a quarter of a circle and observe the arising frame rules and the speed of the operation in concreting time.[5]

2- Reza Sharifi et al. In an article on the analysis of silo construction by slip form and paper about the use of slip form in concrete structure to simulate a concrete silo model at a height of one meter, using slip form technique, described the construction steps as follows (Figure 2):

Step 1: Slip-form considers to be started from specific level in the high of silo. In this step, tower-crane lifts reinforcements and embedded plates to the platform.Step 2: One-step jacking is done where the slip-form is driven up one jacking step (δ = 2 in = 5.08 cm). Step 3: Then, concrete will be poured to fill the empty form. Concrete will be cured and finished in order to be ready for the next step.
Step 4: Repeat step 2 four times to raise the form 20 cm. Rebar will be installed for the next 20 cm.
Step 5: Repeat the above four steps until the completion of one meter of concrete silo.
Step 6: Repeat the above five steps until the completion of the concrete silo.

[5] ibid

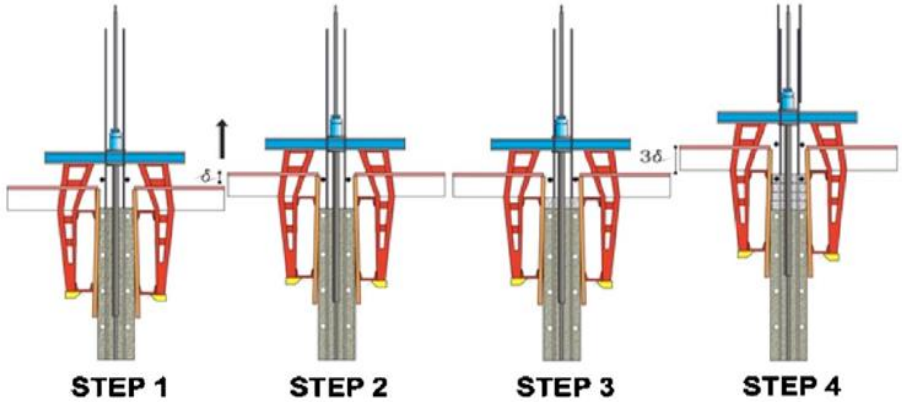


**Figure 2: Construction steps for concrete core using slip-forms. (Sharifi, Baciu and Zayed, 2006)**

Suggestion: steps 1 & 4 modify as following:
first step: completing reinforcement with a height of 130 to 150 cm (up to yoke) and installing the slip form component by the tower crane, according to the shape of the structure, which silos are commonly in circle one and the concreting in the 20 to 30 centimeters layers until the completion of concrete laying is approximately 1 meter (**Error! Reference source not found.**).
The second and third steps are similar to the simulation steps.
Step Four: Repeat step two four times to underneath the yoke bottom, and then close the horizontal sleeve rebar at a distance of 20 cm (**Error! Reference source not found.**).

**Figure 3: install rebar up to yoke**[6]

[6] ibid

Figure 4: using concrete pump at low height[7]

In the simulation model on how concreting by concrete pump and tower crane with a bucket, silos are provided with comparative tables that are effective at low height. Since silos and high towers are used at low altitudes, concrete pumps are used and at high altitudes generally Winch and tower cranes are used **(Error! Reference source not found.)**[8].

### *Main component of a slip form*

Slip form performance depends on the its component. In Figure 5, a slip form system and its constituent parts has been shown[9]

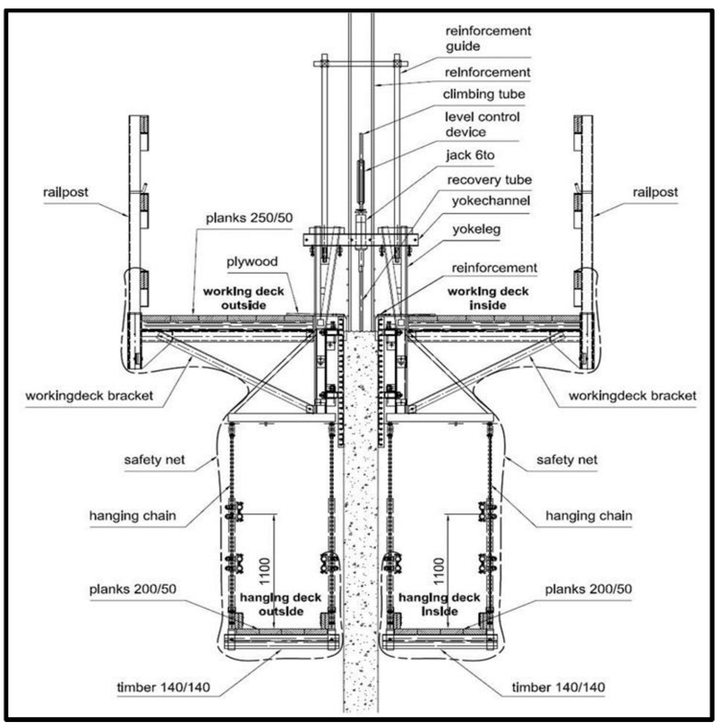


Figure 3: slip form component[10]

[7] ibid
[8] ibid
[9] ibid

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Figure 6: hydraulic power room[11]

Figure 4: bar jack & jack[12]

- The walls frame: the walls frame must be strong and firm enough. The walls material
- may be wooden or metal.
- Yoke: it installs on frame and has two responsibility
- Maintaining the frame and preventing its opening and collapse due to the fresh concrete lateral pressure.
- Transit all loads from the pockets, platforms, and pads to the jacks.
- Wale: one of the most important component from wood or metal or both
- Platforms: considered in three levels
- First level: to transit concrete to the second platform

[10] ibid
[11] ibid
[12] ibid

- Second level: At this level of work, which is placed above the floor and above the top of the frame, all sweepings and blasting operations, concreting and reinforcement operations, and coordination rooms for the execution and control of the slip form is carried out on the top platform (Figure 3).
- Third level: At this level of work for staging hangs or indiscriminately usually on both sides of the wall and have access to the shell's view, that recently following the mold of concrete, concrete technology and restoration operations concrete action out of a possible and installation of earthing and includes utilities Water pipes and installation of tower crane and loaders inhibitory belt etc, which pagard down.
- Note: on the platform should place the necessary valves to the bottom floor and the pendants stud . (Figure 5)[13].
- Bracing: bracing is one of the most important parts of the slip form. If frame bracing isn't enough,during arising the frame lots of problem happen. (Figure 5)
  Frame Bracing is done in different ways:
- By truss or moment beam
- By doing rigid frame corner
- By brace

- hydraulic jacks: in 3 or 6 tonnage capacity (figure5)
  slip form has raised by this jacks. Jacks install on the bar and putting up. Rising is similar to the person rising a tree. (Dehkordi, Zabani and Amer, 2002). It is clear in Micro Cyclon simulation better[14].
- Bar jack: jack install on bar steel bar jack, and bar jack tolerate all loading on frame. These bars rely on hard concrete on bottom and transit load to bottom like a column (Dehkordi, Zabani and Amer, 2002)(figure 5).
- Hydraulic power device: it (hydraulic pump) supplies the required power for jack's performance. This device put the oil with high pressure to the jack and then jacks climb up from the bar. Mostly device turn off, and in a special time turn on the device and raise the frame and then turn of up to the other special time.(figure 9,10)
- Crane tower: it contains a tower crane in central part. It transit rebar and concrete and install and uninstall frame and other equipment. (figure 4)(Dehkordi, Zabani and Amer, 2002).
- Winch: in slip form, transiting the concrete has been done by pump and winches in low and high height respectively. The second method is common (figure4)(Dehkordi, Zabani and Amer, 2002).
  Special strategy has been done before slip form working like water piping, installing power station, wiring, installing diesel pump, ….[15].

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[13] ibid
[14] ibid
[15] ibid

### Loading

Generally slip form exposed to dead loads like the weight of components, yoke, pump and frame and the live loads like friction between frame and concrete, lateral pressure of concerete, wind force and etc…. . (Dehkordi, Zabani and Amer, 2002)

6- raising the frame and execution speed

One of the most important part of slip form is controlling the raising of frame and execution speed. Lack of good controlling lead to huge damages and low quality of silos execution. Following parametrs influenced above mensioned issue:

Concrete hardening concerete, tempreture, speed of rebar execution, opening, add mixture, type of cement[16].

The produced concrete should tolerate its weight, surcharge weight and there is not more deflection. High speed of frame causes more problem, low speed causes hard the concrete and friction between frame and frame is more than compressive strength of concrete and it causes cracks. The maximum speed should be determined by experts. They considered tempreture, slump, setting time of concrete (Dehkordi, Zabani and Amer, 2002).

### Slip form setting

Movement shape of slip form is similar to car movement. The operator is worry about frame deviation. He is responsible that every two hours control the frame movement and during the deviation must be control the frame and return it to the path. Taller building causes more deviation. The frame could be deviate from the path way.

a. Noting accord the jack operator
b. Implying the asymmetric loads on jacks frame because of sliding of jacks on the bar that cuases deviation.

Also because of loading unloading issue it may deviation during the work. So it is required to consider the storage of rebars on platform, carring the welding equipment and gathering the workers during eating time and also concereting must be symmetric. Some devices help to understand deviations, like align hose, meter, mesurment on jacks bar, swathe, optic & lazic camera. During deviation, it can control by decreasing the jacks by high speed and increasing the speed of unsuitable jacks (Dehkordi, Zabani and Amer, 2002).

### simulations of Micro cyclone for modeling of executing of a silo (Sharifi, Baciu and Zayed, 2006)

**Table 1: General Project Data**

| Item Information | Item Information |
|---|---|
| Considered Silo height | 1.0 m |
| Wall thickness | 0.5 m |
| Silo inner diameter | 16.0 m |

[16] ibid

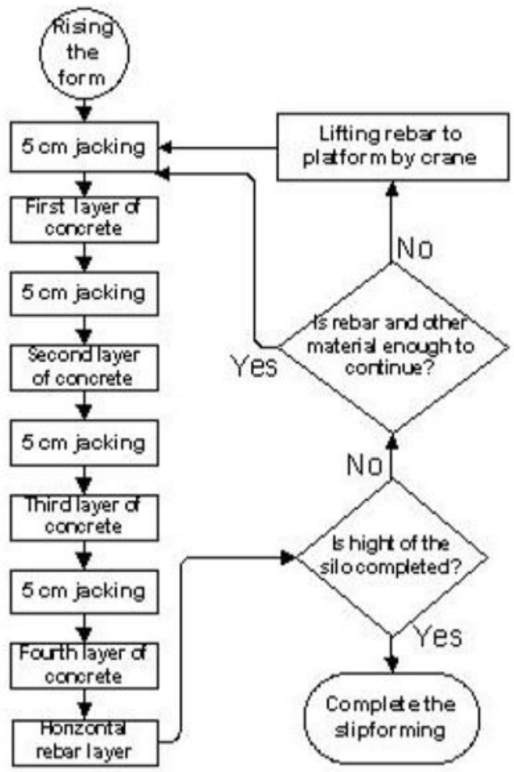



Figure 5: Construction algorithm of slip-form application to concrete silo (Sharifi, Baciu and Zayed, 2006)

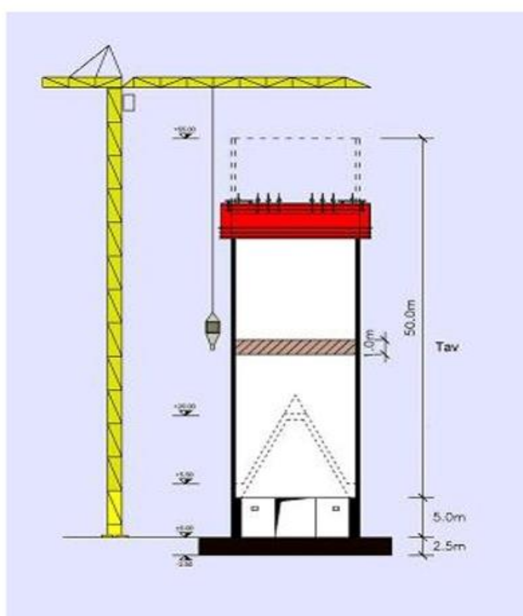



Figure 6: Construction process of Raw Meal silo by slip forming. (Sharifi, Baciu and Zayed, 2006)

### Simulation Model Application to Case Study:

The time for simulation estimated for the stating. Input include jacks capacity, concreting, installing the rebar, raising frame and executing velocity. analysis of silo concreting by pump and tower crane with bucket in different thicknesses and diameters are presented in tables 1,2,3 and charts 1,2,3.rebar install has been consider according to 8 workers and 24 houres for executing time. The jack movement velocity is from 10cm/h to 60 cm/h. the velocity concerteing by pump is 3min/m3 and by tower crane is 10 min/m3.(Sharifi, Baciu and Zayed, 2006).

**Table 2: Different productivity values using crane-buckets and pump for concrete Pouring in the case study silo (16 m diameter and 0.5 m thickness). (Sharifi, Baciu and Zayed, 2006)**

| Jacking Rate(Cm/h) | Productivity Using Bucket(M/h) | Productivity Using Pump(M/h) |
|---|---|---|
| 10 | 0.075 | 0.088 |
| 20 | 0.121 | 0.158 |
| 30 | 0.151 | 0.214 |
| 40 | 0.173 | 0.26 |
| 50 | 0.189 | 0.299 |
| 60 | 0.202 | 0.332 |

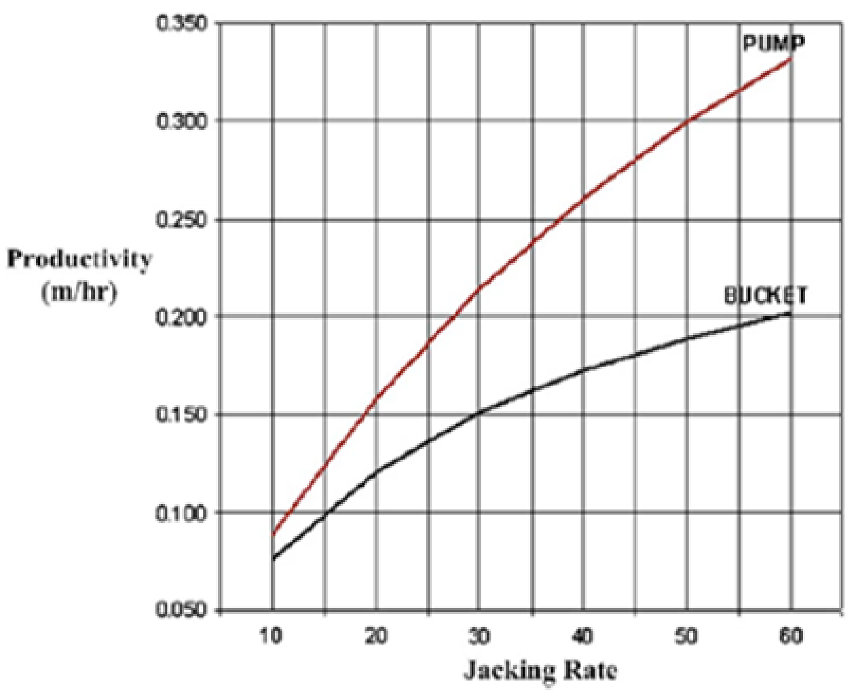



**Figure 7: Slip-forming productivity using crane-buckets vs. pump system to pour Concrete for case study silo (24 working hrs/day) (Sharifi, Baciu and Zayed, 2006)**

**Table 3: Different productivity values using crane-buckets for concrete pouring (Sharifi, Baciu and Zayed, 2006)**

| Silo diameter and thickness ft (m) | Jacking rate (cm/hr) | | | | | |
|---|---|---|---|---|---|---|
| | 10 | 20 | 30 | 40 | 50 | 60 |
| 8(0.40) | 0.888 | 0.158 | 0.214 | 0.261 | 0.3 | 0.333 |
| 10(0.40) | 0.086 | 0.15 | 0.201 | 0.241 | 0.274 | 0.301 |
| 12(0.50) | 0.08 | 0.134 | 0.172 | 0.201 | 0.223 | 0.241 |
| 16(0.50) | 0.075 | 0.121 | 0.151 | 0.173 | 0.189 | 0.202 |
| 18(0.60) | 0.069 | 0.106 | 0.129 | 0.145 | 0.156 | 0.165 |
| 20(0.60) | 0.067 | 0.101 | 0.122 | 0.136 | 0.145 | 0.153 |
| 22(0.70) | 0.062 | 0.089 | 0.105 | 0.144 | 0.121 | 0.127 |
| 25(0.70) | 0.059 | 0.088 | 0.096 | 0.104 | 0.11 | 0.114 |
| 28(0.80) | 0.052 | 0.071 | 0.081 | 0.087 | 0.09 | 0.093 |
| 30(0.80) | 0.051 | 0.068 | 0.077 | 0.082 | 0.086 | 0.088 |

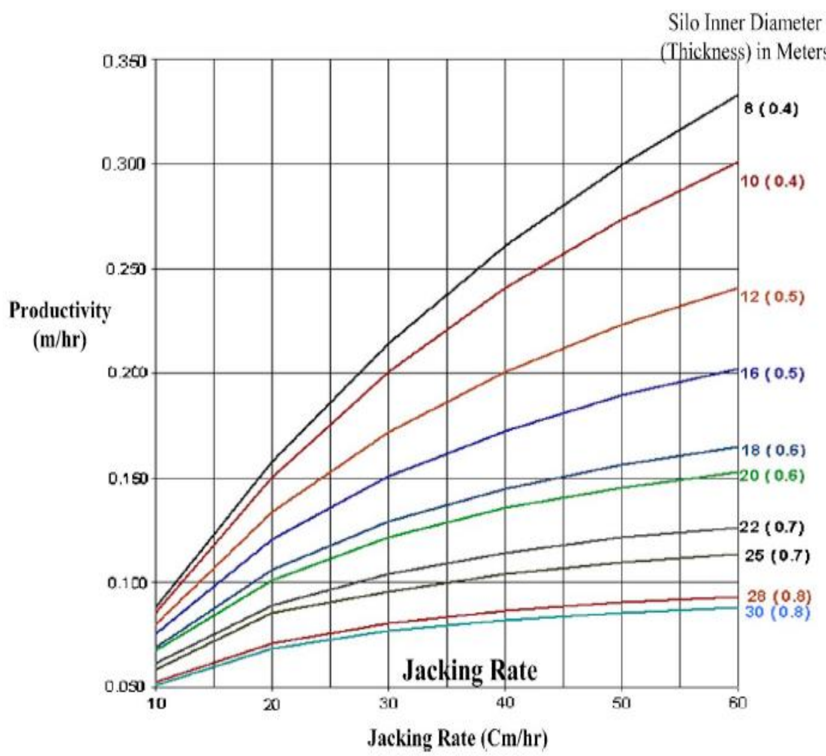



**Figure 8: Slip-forming productivity using crane-buckets vs. pump system to pour Concrete for case study silo (24 working hrs/day) (Sharifi, Baciu and Zayed, 2006)**

**Table 4: Different productivity values using pump for concrete pouring (Sharifi, Baciu and Zayed, 2006)**

| Silo diameter and thickness ft (m) | Jacking rate (cm/hr) | | | | | |
|---|---|---|---|---|---|---|
| | 10 | 20 | 30 | 40 | 50 | 60 |
| 8(0.40) | 0.095 | 0.179 | 0.255 | 0.324 | 0.387 | 0.444 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 10(0.40) | 0.093 | 0.174 | 0.245 | 0.308 | 0.365 | 0.415 |
| 12(0.50) | 0.09 | 0.164 | 0.225 | 0.277 | 0.321 | 0.36 |
| 16(0.50) | 0.088 | 0.158 | 0.214 | 0.26 | 0.299 | 0.332 |
| 18(0.60) | 0.085 | 0.147 | 0.195 | 0.232 | 0.263 | 0.288 |
| 20(0.60) | 0.083 | 0.143 | 0.188 | 0.222 | 0.25 | 0.273 |
| 22(0.70) | 0.08 | 0.133 | 0.171 | 0.2 | 0.222 | 0.24 |
| 25(0.70) | 0.078 | 0.128 | 0.162 | 0.188 | 0.207 | 0.222 |
| 28(0.80) | 0.073 | 0.116 | 0.144 | 0.163 | 0.178 | 0.189 |
| 30(0.80) | 0.072 | 0.113 | 0.139 | 0.157 | 0.17 | 0.181 |

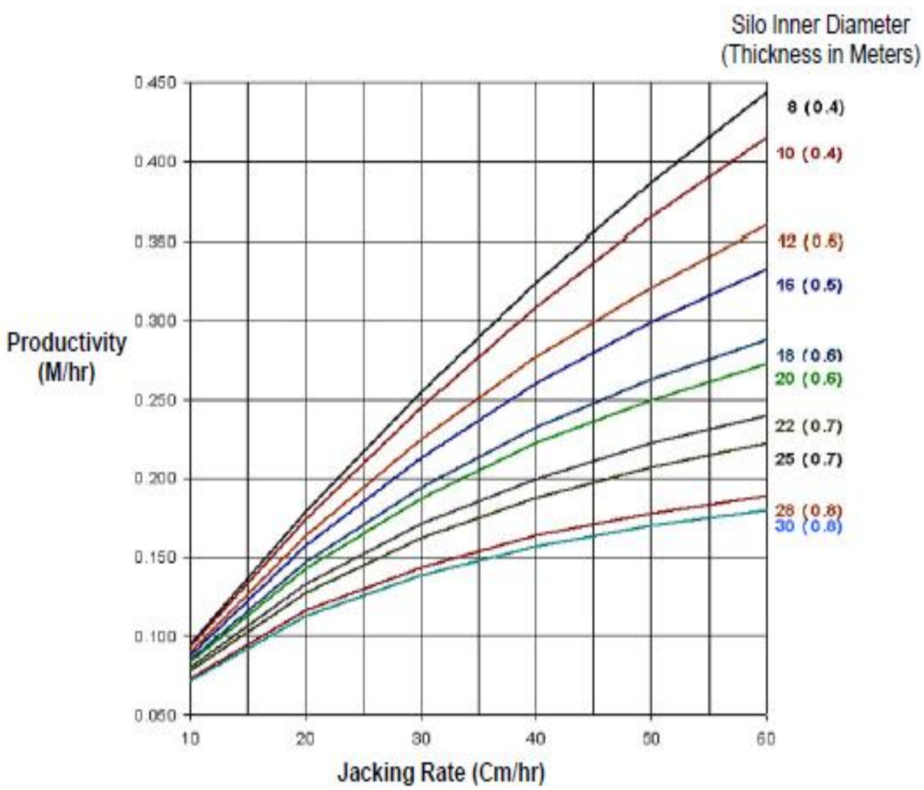



**Figure 9: Slip-forming productivity vs. silo diameter using pump in concrete pouring (24 working hrs/day) (Sharifi, Baciu and Zayed, 2006)**

## CONCLUSION

According to the surveys and analysis and attached tables the best method for executing silos is using slip form technology.[17]

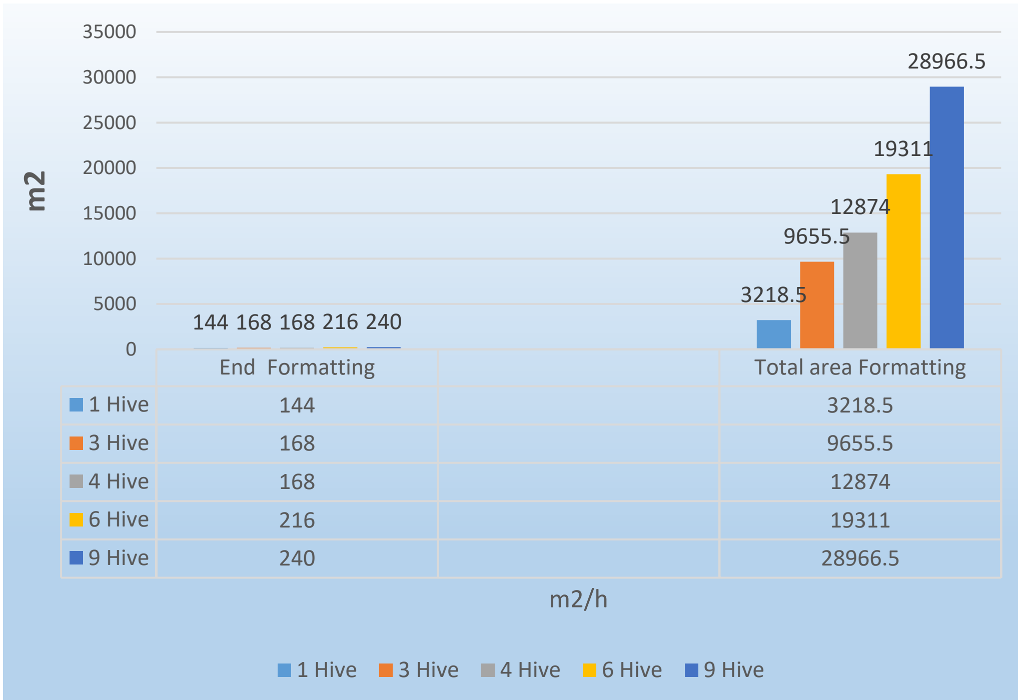
[17] ibid

## Table 5: comparison of executing silos[18]

Comparison table of executing time for hives (1,3,4,6,9) based on framing area and rebar weight and concrete volume for slip form

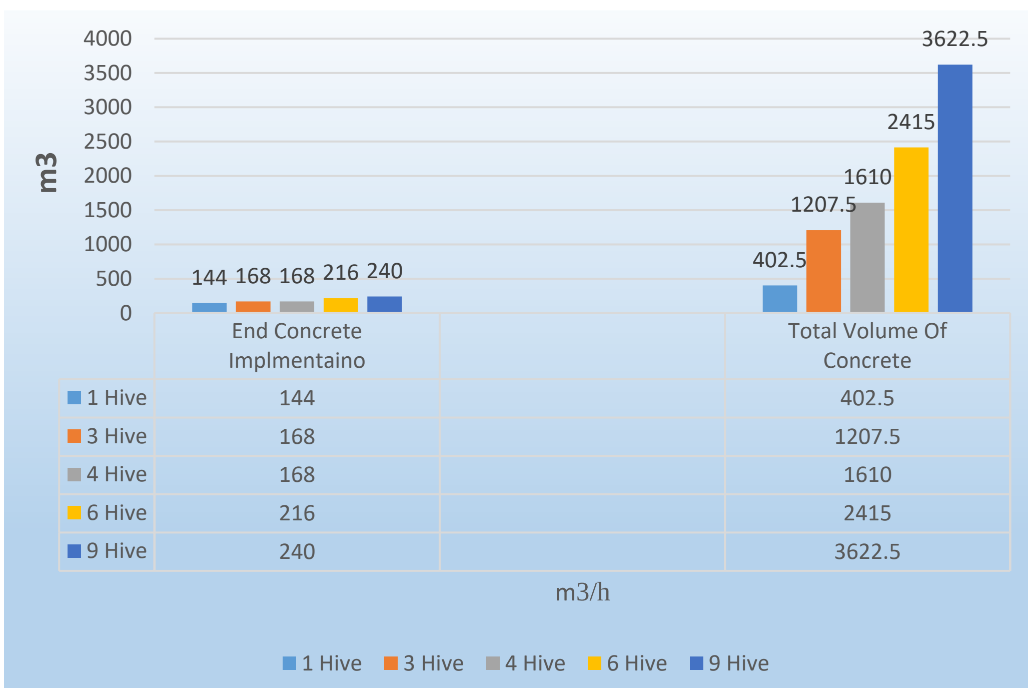
| row | Number of silos | diameter | Thickness (cm) | Height of silo(m) | Concerting for 1m height of silo | Area for 1m height of slip form | Framing for assembly of slip form(m2) | Assembly time for slip form(a shift work) | Total volume for hives concerting(m3) | Total area for hives framing(m2) | Total weight of rebar’ s (ton) | Concrete workers in a shift work ,12 hr | Rebar man in a shift work (person –day) | Frame man (conducting slip form) | Frame movement in a shift work | Concrete ending(two shifts ) | Framing area in a shift 12 hr | Concrete volume in a shift 12 hr | Rebar weight in a shift | Dismantling of slip form |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 10 | 0.25 | 50 | 8 | 33 | 8 | 4 | 408 | 3119 | 75 | 5 | 3 | 4 | 4 | 6 | 132 | 32 | 9 | 4 |
| 2 | 2 | 10 | 0.25 | 50 | 24 | 99 | 12 | 10 | 1208 | 9656 | 225 | 12 | 7 | 6 | 4 | 7 | 366 | 89 | 30 | 6 |
| 3 | 4 | 10 | 0.25 | 50 | 32 | 132 | 14 | 12 | 1610 | 12874 | 300 | 20 | 9 | 7 | 4 | 7 | 462 | 113 | 43 | 7 |
| 4 | 6 | 10 | 0.25 | 50 | 48 | 198 | 16 | 16 | 2415 | 19311 | 450 | 22 | 13 | 8 | 3 | 9 | 534 | 130 | 83 | 9 |
| 5 | 9 | 10 | 0.25 | 50 | 72 | 297 | 18 | 20 | 3623 | 28967 | 675 | 25 | 16 | 9 | 3 | 10 | 742 | 181 | 135 | 12 |

[18] ibid




| | End Formatting | | Total area Formatting |
|---|---|---|---|
| 1 Hive | 144 | | 3218.5 |
| 3 Hive | 168 | | 9655.5 |
| 4 Hive | 168 | | 12874 |
| 6 Hive | 216 | | 19311 |
| 9 Hive | 240 | | 28966.5 |

chart 1: Comparision of different type of silos based on framing area and executing time (hr)[19]




| | End Concrete Implmentaino | | Total Volume Of Concrete |
|---|---|---|---|
| 1 Hive | 144 | | 402.5 |
| 3 Hive | 168 | | 1207.5 |
| 4 Hive | 168 | | 1610 |
| 6 Hive | 216 | | 2415 |
| 9 Hive | 240 | | 3622.5 |

chart 2: Comparision of different type of silos based on framing area and executing time (hr)[20]

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[19] ibid
[20] ibid

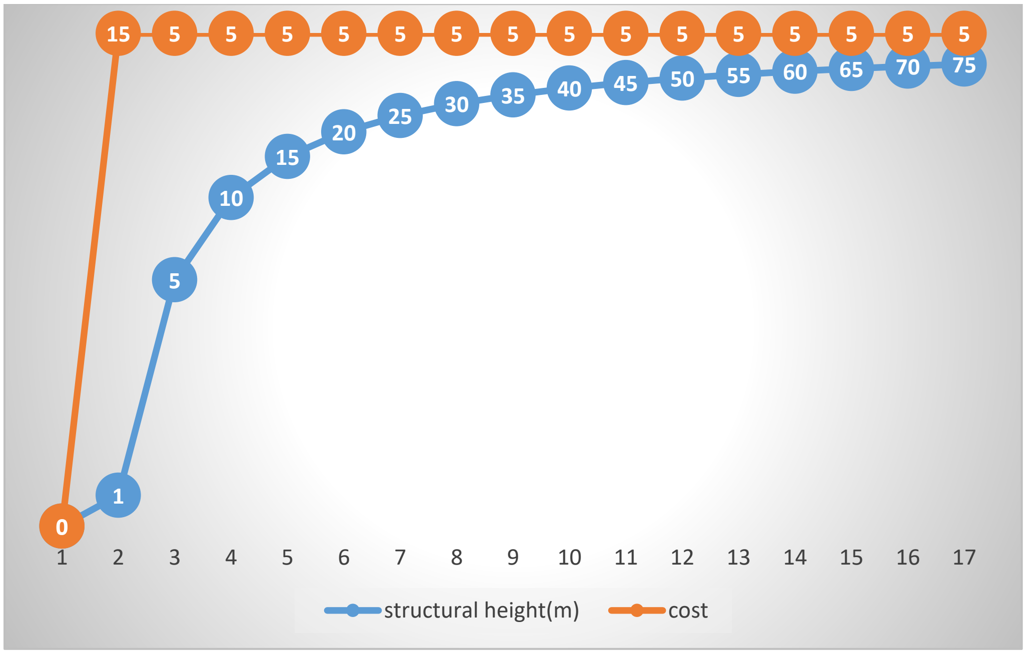


chart 3: Ralation between slip form cost and structure height[21]

## DISCUSSION:

According to survey and experiment following should be concidered in execution by slip form:

- Avoiding each changes in execution
- Being a unique type of plan based on primary cost of framing
- Testing materials and confermtions before execution (including stones, cement type, rebar,…) and depositing in nearest place of silos
- Forecasting, controling and supplying slip form equipment

The implemented structure is completely integrated and free of horizontal and vertical joints and in case of precision in execution, the concrete view will be quite good and acceptable.

Slip form has some problem like: hard supplement of executing, opening in structure, expensive cost, expert workers and engineers[22].

## FINAL CONCLUSION

In notice to reaserches in this study and charts and presented tables by this theses can be conclude that the best method for circular structure construction silos and tall building, is using of slip form and by a correct management in cost control, time, procurement and equipment and machinery and human resources can be achieved to the highest quality and energy saving in construction and compatibility and helping to environment[23].

[21] ibid

[22] ibid

[23] ibid

## ACKNOWLEDGMENT:

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## References

Raisi Dehkordi A., Zabani A. and Amer R. (2002). Sliders "Advantages and Disadvantages, Implementation and System Implementation Methods".

Samavati F., Fazeli M., Bakhshi A. A. and Kiaie E. (2016). Rapidly executing technology for concrete structures of tall structures using slider system.

A,Sheik Abuthakir Riswan1.G,Jaisankar.(2016). Experimental Investigation of Vertical

Slipform Deformation . Geoinformatio,ISSN:2321-3361

Sharifi M. R., S. Baciu S. and Zayed T. (2006). Slip-Form Productivity Analysis for Concrete Silos, Department of Building, Civil, and Environmental Engineering, Concordia University, Montreal, Quebec, Canada.