# Cost, Risk Management, Planning and Scheduling of Industrial Machine Foundation

**Mr. Viraj D. Bhosale[1]* Prof. Ashish P. Waghmare[2]**

[1] (PG Student) Department of Civil Engineering, Dr. D. Y. PATIL School of Engineering and Technology, Lohegaon, Pune – 412 105, India

[2] (PG Co-ordinator) Department of Civil Engineering, Dr. D. Y. PATIL School of Engineering and Technology, Lohegaon, Pune – 412 105, India

***Abstract – Machine Foundations forms viral and expansive part of any industrial complex, with rapid pace of industrial growth of any country. Machine foundation are made in such a way that they can support Static load, in addition to static load the dynamic forces caused by the working of Machine. Theses Dynamic & Static forces are in turn, transmitted to the foundation of machine. While Construction these types of foundation accuracy is the first priority, machine's leg (foot) should be at right place as per the machine drawing this become a challenging job, various type of risk is involved and their mitigation technique are mention.***

***Keywords: Use of Thermocol for Pocket Formwork, Risk Management of Industrial Machine Foundation, Planning & Scheduling***

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## 1. INTRODUCTION

Various machines with impact or shock loads are used for production processes at plants and in industrial buildings. Forge and drop hammers are most powerful machines producing impact loads. Forge hammer production is usually accompanied with high vibration levels of ground vibrations because substantial dynamic loads are transmitted on hammer foundations, and these vibrations may detrimentally affect adjacent and remote structures. Machine Foundation is a structure used to receive and transfer to the ground the static load from a machine and the dynamic loads imposed during the operation of the machine as a result of imbalances in the moving parts.

### 1.1 Problem Statement

- Lack of Planning & Scheduling
- Low rate of Accuracy
- Due to Less Accuracy, Cost of Structure get increased
- Time of construction More, goes beyond Deadline

### 1.2 Objectives

- Planning & Scheduling of Foundation
- To Achieve More Accuracy by using Thermocol Formwork
- Cost Analysis
- Risk Management and Mitigation Techniques

## 2. METHODOLOGY

Step 1: - Excavation

Marking of excavation is done by adding 600mm on both-sides of original dismission of excavation.

1) Excavation is done in: -

- Soil or Murrum
- Soft Rock
- Hard Rock
- Exist Concrete Flooring

2) Equipment Used

- JCB (Back How Front Bucket Machine)
- Pork Clan Excavation Machine

Note: - If Hard Strata is not available than “Plump Concrete” is done for 1Ft

Step 2: - Disposal of Excavated Material

1) Equipment Used

- JCB (Back How Front Bucket Machine)
- Tractor or Dumper (to dumper the excavated material in specific place)

Step 3: - Ground Water Management

If Ground water is present it is removed by using dewatering system.

1) Equipment Used

- Electrical Dewatering Pumps

Step 4: - P.C.C

P.C.C Bed is provided of M10 concrete at Thickness of 4” (100mm) or 6” (150mm).

Step 5: - Water-proofing

By Shahabad Tiles

By Brunt Bricks

Step 6: - Marking of Foundation

Raft Reinforcement is marked for Installing of Formwork

Marking of Pockets are done.

Step 7: - Preparing of Raft

1) Raft are construct to transfer load evenly. Raft are two types

- Single Raft
- Double Raft (Box Raft)

2) Placing of Formwork for foundation reinforcement

3) Preparation of Pockets

This is the most popular method employed. Over-size holes are formed in the foundation concrete at the time of casting which have enough cross-section to permit a degree of lateral movement during the final positioning of bolts. When the bolts are positioned, the hole or pocket is filled with non-shrink engineering grout to ensure that the bolt is bonded to the foundation concrete thoroughly and reliably. The main advantages of pre-forming pockets are that less critical positioning tolerances are necessary compared with cast-in bolts and there is a choice of pocket size, shape and method of forming.

**Types of Pockets**

- Woods
- Bricks
- Thermocole

Step 8: - Filling of Raft/ Side Pardi

This Pardi is fill in levels e.g. If Pardi is 3m Depth it is filled in 1m intervals.

Advantage in fill the pardi in levels are

- Load on formwork is less.
- Tamping can be done easily and efficiently.
- Benefit for further Shuttering work.

Step 9: - Water-Proofing for Side Pardi

Water -Proofing is provided by Brick-work and Shahabad Tiles are place over it.

Step 10: - Providing Curving Angles

Curving Angles are provided to above edge of foundation to protects form Breaking.

Step11: - Cleaning of Pockets

Removal of Thermocol present in pockets by spraying petrol.

Step12: - Miscellaneous Work

Finalized the work, Final Touched ups.

## 3. CASE STUDY

### 3.1. Location:-

Bharat Forge Limited, Pune Cantonment, Mundhwa at New Fab Line Shop.

### 3.2 Name of Machine: -

Roller Conveyor Shot Blast Machine.

*Construction Blaster Type X roller conveyors* differentiate themselves from the Type G and Type HD roller conveyors by the shot blast wheels being installed at an angle to the direction of movement through the machine. The angled positioning of the shot blast wheels ensures that the blasting operation is perfect, especially on parts such as welded constructions, flame cut parts or other complex formed prefabricated parts with base ends.

### 3.3 Application of Machine: -

Cleaning, Corrosion Removal, Cosmetic Finishing, Deburring, Deflating, Internal Cleaning, Paint Stripping, Preparation for Painting, Bonding and Plating, Rust and Heat Scale Removal, Shot Peening, Surface Texturing

### 3.4 Foundation Type for this Machine: -

R.C.C Wall Type Machine Foundation. This type of machine foundation consists of a pair of walls with a slab resting on top. This type of foundation is constructed of homogeneous materials. It is used for small machines and the machine is rested on the top slab.

### 3.5 Planning and Scheduling of Roller Conveyor Shot Blast Machine Foundation

| Task Name | Duration | Start | Finish | Predecessors |
|---|---|---|---|---|
| **Short Blasting Foundation** | **50 days** | **Tue 20-06-17** | **Wed 16-08-17** | |
| **Excavation** | **9 days** | **Tue 20-06-17** | **Thu 29-06-17** | |
| Excavation in Concrete (300 mm) | 1 day | Tue 20-06-17 | Tue 20-06-17 | |
| Excavation in Soft Rock 830 mm | 1 day | Wed 21-06-17 | Wed 21-06-17 | 3 |
| Dewatering Process | 1 day | Thu 22-06-17 | Thu 22-06-17 | 4 |
| Excavation in Hard Rock (1645 mm) | 2 days | Fri 23-06-17 | Sat 24-06-17 | 4,5 |
| Disposal of Excavated Material | 4 days | Fri 23-06-17 | Tue 27-06-17 | 6SS,3,4 |
| **Bar Bending** | **6 days** | **Wed 28-06-17** | **Tue 04-07-17** | 7 |
| **P.C.C & Water-Proofing** | **4 days** | **Tue 04-07-17** | **Fri 07-07-17** | **10** |
| Plain Concrete M10 | 1 day | Tue 04-07-17 | Tue 04-07-17 | 10 |
| Box type Water-Proofing by Shahabad Tiles | 2 days | Wed 05-07-17 | Thu 06-07-17 | 12 |
| **Marking & Checking** | 1 day | Fri 07-07-17 | Sat 08-07-17 | 13,11 |
| **Preparing of Raft, Column, Pardi** | 3 days | Mon 10-07-17 | Wed 12-07-17 | 14 |
| **Raft Shuttering** | **4 days** | **Thu 13-07-17** | **Mon 17-07-17** | **15** |
| Raft 1 | 1 day | Thu 13-07-17 | Thu 13-07-17 | |
| Raft 2 | 1 day | Thu 13-07-17 | Thu 13-07-17 | 17SS |
| Concreting of 1 Raft (Evening) | 1 day | Fri 14-07-17 | Fri 14-07-17 | 18,17 |
| Finishing 2 Raft Shuttering | 1 day | Fri 14-07-17 | Fri 14-07-17 | 19FF,18SS |
| Concreting of 2 Raft | 1 day | Sat 15-07-17 | Sat 15-07-17 | 20 |
| **Level 1** | **11 days** | **Mon 17-07-17** | **Sat 29-07-17** | **16** |
| Reinforcement of Pardi Including Side Pardi Formwork Up to 1200 mm | 3 days | Mon 17-07-17 | Thu 20-07-17 | |
| Concreting Level 1 | 1 day | Thu 20-07-17 | Fri 21-07-17 | 23 |
| Removal of Out-side Formwork for Water-Proofing | 1 day | Fri 21-07-17 | Sat 22-07-17 | 24 |
| Shahabad Box Type Water-Proofing (up to 1200 mm) | 4 days | Fri 21-07-17 | Wed 26-07-17 | 25SS |
| Murrum Filling (up to 1200mm) & Compacting | 2 days | Wed 26-07-17 | Fri 28-07-17 | 26 |
| **Level 2** | **6 days** | **Fri 28-07-17** | **Fri 04-08-17** | **27** |
| Reinforcement of Pardi Including Side Pardi Formwork Up to 1200 mm | 1 day | Fri 28-07-17 | Sat 29-07-17 | |
| Concreting Level 2 | 1 day | Sat 29-07-17 | Mon 31-07-17 | 29 |
| Removal of Out-side Formwork for Water-Proofing | 1 day | Mon 31-07-17 | Tue 01-08-17 | 30 |
| Shahabad Box Type Water-Proofing (up to 1200 mm) | 2 days | Mon 31-07-17 | Wed 02-08-17 | 31SS |
| Murrum Filling (up to 1200mm) & Compacting | 2 days | Wed 02-08-17 | Fri 04-08-17 | 32 |
| **Preparing of Column & Final Level (up to 300mm)** | **4 days** | **Fri 04-08-17** | **Wed 09-08-17** | **33** |
| Installing Thermocol Pockets | 1 day | Fri 04-08-17 | Sat 05-08-17 | |
| Welding Plates | 2 days | Sat 05-08-17 | Tue 08-08-17 | 35 |
| Concreting Columns & Final Level | 1 day | Tue 08-08-17 | Wed 09-08-17 | 36 |
| **Preparing Staircase** | 4 days | Wed 09-08-17 | Mon 14-08-17 | 37 |
| **Miscellaneous Work & Hand-Over Foundation** | 2 days | Fri 11-08-17 | Mon 14-08-17 | 38FF |

**Table 1. Planning and Scheduling of Roller Conveyor Shot Blast Machine Foundation**

### 3.6 Risk Management for Roller Conveyor Shot Blast Machine Foundation

1. Scaffolding was very difficult to install for water-proofing to pardi.

Sol: - Foundation Pardi was built in level of 1m brick work is done and after that the Shahabad tiles were placed.

Advantage: -

- Scaffolding is not needed i.e. Cost Effective.
- Extra excavation for installing scaffolding is eliminated.
- Only inner side the Formwork were used, by using only at one side formwork cost as well as time is saved
- By concreting in levels load on formwork is sustainable.

- After completing this level murrum is filled and that level is finished the job is 10% completed.

2. Making Pockets.

Pockets is an important aspect for this foundation because the machine's legs will be rest on these pockets. The challenge was to keep the demission of these pockets undisturbed.

Sol: - Thermocole Box are used i.e. Thermocole box are made as per the accurate Dimension and that box are placed in the place of these pockets.

Advantage of using Thermocole

- Dimension remains undisturbed.
- Removal of thermocole is easy after the concrete is set.
- While removing of thermocole the accurate demission is maintained.
- Thermocole and concrete does not have any type of bond in between them, so thermocole plays the role of separator.

**Fig 1. Use of Thermocole box as pockets formwork**

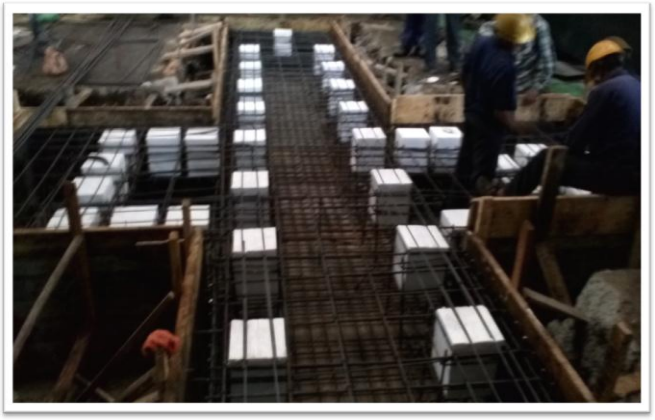

**Fig 2. Thermocole box are aligned as per pockets of Machine**

### 3.7 Cost Analysis for Roller Conveyor Shot Blast Machine Foundation

**Table II. Cost Analysis for Roller 3.7 Cost Analysis for Roller Conveyor Shot Blast Machine Foundation**

| Sr. No. | DESCRIPTION OF ITEMS | QTY | UT. | RATE | AMOUNT | SAC |
|---|---|---|---|---|---|---|
| 1 | Excavation in Concrete J.C.B Breaker | 12.88 | $M^3$ | 1250.00 | 16100.00 | 995433 |
| 2 | Excavation in Soft Rock | 6.22 | $M^3$ | 450.00 | 2799.00 | 995433 |
| 3 | Disposal of Excavation Material | 28.65 | $M^3$ | 250.00 | 7162.50 | 995433 |
| 4 | Murrum Filling Around Foundation | 51.42 | $M^3$ | 250.00 | 12855.00 | 995433 |
| 5 | P/L Plum Ready Mix Concrete M10 | 4.61 | $M^3$ | 3450.00 | 15904.50 | 995454 |
| 6 | P/L Ready Mix Concrete M60 | 4.80 | $M^3$ | 9250.00 | 44400.00 | 995454 |
| 7 | P/L Ready Mix Concrete M25 | 25.16 | $M^3$ | 6550.00 | 164798.00 | 995454 |
| 8 | P/C B.B Masonry | 5.56 | $M^3$ | 6125.00 | 34055.00 | 995456 |
| 9 | P/F Waterproofing Box Type Shabad Tiles | 21.83 | $M^2$ | 800.00 | 17464.00 | 995428 |
| 10 | P/L Shuttering | 53.60 | $M^2$ | 352.00 | 18867.20 | 995452 |
| 11 | P/F Pockets (0.20 x 0.30 x 0.35) | 16.00 | Nos | 450.00 | 7200.00 | 995428 |
| 12 | P/F Pockets (0.32 x 0.0.42 x 0.35) | 8.00 | Nos | 500.00 | 4000.00 | 995428 |
| 13 | P/F Pockets (0.35 x 0.40 x 0.35) | 8.00 | Nos | 550.00 | 4400.00 | 995428 |
| 14 | P/L GP2 Concrete | 1.05 | $M^3$ | 45000.00 | 47250.00 | 995454 |
| 15 | P/A Plastering | 4.78 | $M^2$ | 338.00 | 1615.64 | 995472 |
| 16 | Misc. Work | 1.00 | Nos | 6500.00 | 6500.00 | 995433 |
| 17 | Charges for Reinforcements of Steel | 452.65 | Kgs. | 8.00 | 3621.20 | 995428 |
| | | Rate of Taxes | | Sub Total | 408992.04 | |
| Amount In Words | | CGST 9% | | | 36809.28 | |
| | | SGST 9% | | | 36809.28 | |
| Four Lakh Eight-Two Thousand Six Hundred Ten & Paise Sixty-One Only. | | | | Total Amt. | 482610.61 | |

## 4. CONCLUSIONS

### 4.1 Achieve More Accuracy: -

Accuracy is achieved by using Thermocole Box as pocket formwork. The accurate demission is maintained.

### 4.2 Risk Management: -

Foundation Pardi was built in level of 1m brick work is done and after that the Shahabad tiles were placed.

Pockets is an important aspect for this foundation because the machine's legs will be rest on these pockets. The challenge was to keep the demission of these pockets undisturbed.

### 4.3 Cost Effective: -

Foundation Pardi was built in level of 1m brick work is done and after that the Shahabad tiles were placed. That Scaffolding is not needed, cost of Scaffolding is eliminated.

Hence it Cost Effective.

### 4.4 Outcomes: -

The project details literature provided explains concept of Machine Foundation is a structure used to receive and transfer to the ground the static load from a machine and the dynamic loads imposed during the operation of the machine as a result of imbalances in the moving parts.

To Sustain these type of load, foundation is designed, while Execution many Risk are involved to mitigate these Risk is challenging job. While mitigating this Risk the cost should be in economy side.

### 4.5 Recommendation: -

- While Excavation extra dimension should be considering i.e. by adding 600mm on both-sides of original dismission of excavation.
- Thermocole should be use Mandatory in these types of structure to achieve accuracy

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**Corresponding Author**

**Viraj D. Bhosale***

(PG Student) Department of Civil Engineering, Dr. D. Y. PATIL School of Engineering and Technology, Lohegaon, Pune – 412 105, India

**E-Mail – virajbhosale33@gmail.com**