# Site Layout Optimization of Casting Yard for Metro Rail Project

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*Abstract*— Casting yard plays a most important role in Precast Segmental Construction Project. Thus, maintaining efficient construction practice here and ensuring productivity according to owner's requirement is very essential. Hence, it is a challenging task for contractor. One of the most important but usually neglected task is of casting yard site layout planning. Job site layout is imperative and impacts almost all the operations required to deliver the final segment as a product. It has a direct influence on both costs and schedule of the total project. In this paper, we study the current site layout of casting yard and identify various operational problems practically faced. For systematic approach of planning, a generic procedure is followed to determine relative positions of different departments as a solution for faced problems. Thus, an optimized layout is prepared to minimize repeated handling of materials, to minimize travelling distances, to increase productivity and to create a safe working environment.

***Key words:*** Job Layout, Static Model, Dynamic Model, Relationship Chart, Activity Relationship Diagram

## I. INTRODUCTION

A job layout is prepared by contractor as part of mobilization activity before commencement of work on site. The larger and more complex the project, greater will be the need for planned job layout and detailing at site. Job layout can be defined as a site drawing of the proposed construction showing the location of entry, exit, temporary services, material stores and stocks, plant or equipment and site offices. It plays a crucial part of construction management, as sites can be very much complex involving high coordination and movements of men, material and machinery. To make the site a more effective workplace with better worker morale, careful sizing and positioning of temporary facilities is necessary. This can help reduce travel time, congestion, waiting time and eventually the overall project time.

Good site layout planning involves four basic processes:

1) Identifying the required site facilities
2) Determining the sizes, and other related constraints of facilities
3) Establishing the inter-relationship between the facilities identified
4) Optimising the layout of the facilities on the site

### *A. History of Job Layout*

In current practice, site layout objects are often located in the best available space on first come first serve basis. This can lead to decreased safety and productivity or impose unnecessary relocation costs of the project. Determining the optimum location of objects on the construction site before the commencement of construction, in order to minimize various travel distances and maximize safety and productivity, is referred to as site layout planning. [9] There is cost associated with the resources exchanged between objects which depends on the work flow and distance between locating objects close to each other can minimize this cost. [9]

Static models can not consider the changes in facility location that occur on construction sites onto the progress of time. These models assume that all facilities exist on the site for the entire duration of the project. Static models can be conformable for projects where space is plenteous, having large construction sites with short durations and for project where there are not many changes in the layout of the construction site over the course of time. However, where number of facilities to come and leave the project site over the course of construction in more complicated projects, static model are not practical with longer durations. Static models do not allow reusing the space occupied by facility which is no longer required on the site. [9]

Dynamic models consider the changes that occur on construction sites over the course of progress in project. The space usage on the site changes over the course of construction. The time and duration for which the facilities are required on the site depends on the activities they are attached with. The role of facilities on the construction site is to provide base for construction activities. A model shares locations to facilities where they can have better assistance for the activities. The dynamic model described that, both the required facilities and the space required to help them on the site, are subject to change. [9]

R.W.M.Wong's experience tells the industry that there is no fix rule or extremely powerful software in the planning of site layout, construction operations and the related issues. There are only basic principles. There are numerous options, alternative schemes, action agenda, management strategy or contingency plans to meet the actual requirements before or during the course of a construction project.

How to make the correct observation, identify the problems and arrive at the right decision is the main key to achieve the best solution. A well- experienced and practical construction executive or work team supported by a reasonable resources and management back up should be the best solution to all problems. [11]

Hence, in this paper, we are going to apply static model for our case study of casting yard for Metrorail project.

 

## II. CASE STUDY

### *A. Data Collection*

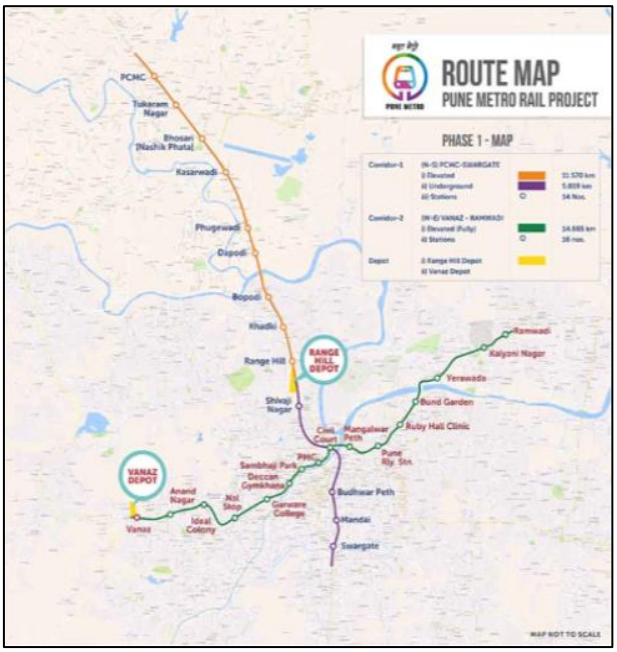


Fig. 1: Route Map of Pune Metro Rail Project

Pune Metrorail project comprises of:

1) Corridor I ( Pimpri to Swargate)
2) Corridor II ( Vanaz To Ramwadi)

As per map,the total route length of Corridor I is 16.589 kms. Out of which a stretch of 11.56 kms includes elevated stations (9) from Pimpri to Shivajinagar and remaining 5.019 kms includes underground stations (6) from Shivajinagar to Swargate for this elevated stretch, precast segmental construction is proposed for viaduct. Casting Yard I for casting segments required for this stretch is located near Phugewadi. Hence, data for research work is collected from casting yard located at this location. The total area of casting yard I is about 7 acres (28,328 sq mts). Total of 3926 precast segments are to be cast by using long line method of casting. [14]

The key for successful completion of this type of construction is production of segments at the estimated time and cost in casting yard.

The site layout details of casting yard I is as shown in figure 2.

### *B. Details of Case Study*

The total duration for construction of Metro corridor of length 11.56 kms between Pimpri Chinchwad Municipal Corporation and Range Hill is of 854 days. [14]

About 525 days are allotted for precasting elements production for precast segmental construction. The following work activities has to be completed in this estimated duration:

1) Casting yard layout design – 45 days
2) Setting up of casting yard – 60 days
3) Design of segment moulds – 30 days
4) Fabrication of segment moulds – 60 days
5) Mobilization and setting up of segment moulds, gantries and other equipments and machinary- 15 days
6) Casting of Segments – 420 days

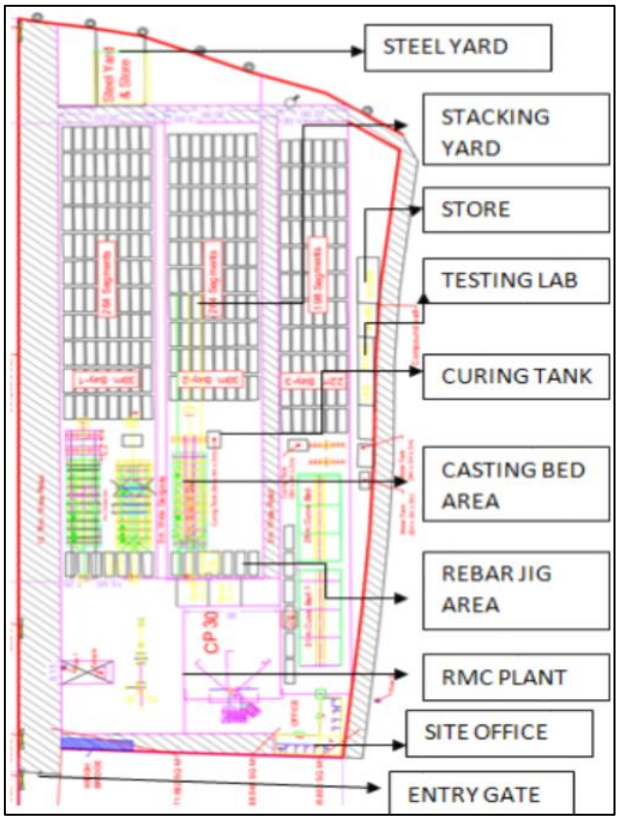


Fig. 2: Site Layout Details of Casting Yard I

Hence, it can be seen that around 60 % of the project duration is estimated only for such important activity of casting of segment. Thus, delay here can lead to delay in total project duration.

Secondly, about 43% of the total cost of the project of construction of elevated viaduct for corridor I is to be spent in the production of total 3926 precast segments. Thus, losses experienced in casting of segments can cause huge loss in total cost of project as a whole.

Each and every milestone starting from layout planning to casting of total 3926 segments for elevated viaduct involves efficient management of both time and costs.

### *C. Site Problems Identified*

Most construction sites in India run into trouble due to improper management rather than because of technical problems. The site based management can make significant improvement in the cost and time savings during the construction process. Among the most important task of site management is the site layout planning. If there is no systematic approach followed, extensive time loss and cost overruns could result in large projects, where number of workers, subcontractors and equipments involved are high.

The following problems are occurring currently on site due to absence of precise site layout planning:

*1) Inappropriate Location of Site Office*

Site office located is too remote with insufficient overview of site.

*2) Unsatisfactory Access*

Only one entry and exit gate is available. Sufficient internal roads are not provided.

*3) Unsuitable Location of Steel Yard*

Travel time and material handling cost to carry steel from back side of casting yard to front side up to rebar cage assembly area is unnecessarily increased. Due to this delays can occur and decrease in Labour productivity.

*4) Unfavorable Location of Stacking Yard*

Total segment to be cast is around 3926 in numbers. Contractor is planning for 250 segments to be cast in a month so they need to cast around 9-10 segments per day per bed without any delay. A realistic production rate is about 6 segments per six day week per casting bed. To keep the work in such a pace smooth functioning of yard is must. Also a stretch of 1 km contains almost 35 spans, to cover this much length of span around 280 segments are required on pier alignment site. Thus, trailor has to travel around 280 times to casting yard to load segment and to transport back on site. Hence, constant to and fro movement from stacking area will be required. The current position in the back side of yard for stacking can lead to indigent stacking of segments.

*5) Unreasonable Increase in Idle Time of Gantry*

75 Tonne gantry is required in back side to carry segment from bed to stacking area and 20 tonne gantry is required to lift rebar cage up to the bed area. As the stacking area is at back side, the time required to reach the trailor on the stacking location to load segments increases and hence idle time of gantry also increases.

*6) Isolated Positioning of RMC and Testing Lab*

RMC plant is in the front end and the testing lab is at the rear end of the casting yard increases the travel time.

*7) Job Safety and Privacy is absent*

Every contractor has its own level of management skills, job techniques and methodology privacy. Lack of privacy for execution of job technique of casting bed near front end

## III. METHODOLOGY ADOPTED

### *A. Systematic Layout Planning (SLP)*

Richard Muther (1913-2014) founder of "Richard Muther and associates "proposed "Simplified systematic layout planning" procedure in 1961. SLP is an organized way to conduct layout planning. It consists of a frame work of phases, a pattern of procedures, and a set of conventions for identifying, rating and visualizing the elements and areas involved in planning a layout. [12]

SLP does not require or preserve higher mathematics algorithms or computer software to get results. Rather it applies common sense "thoughtware" in an orderly way.

Key inputs require for this SLP process are P,Q,R,S,T. i) product ,ii) quantity, iii) routing, iv) supporting services, v) time.

The fundamentals of SLP are as follows:-

1) Relationships
   The relative degree of closeness desired or required among things.
2) Space
   The amount, kind and shape or configuration of the things being laid out.
3) Adjustments
   The arrangement of things into a realistic best fit.

SLP has been used in manufacturing industries site layout planning which resembles to casting yard where similar repetition of selected items is continuously done throughout the project.

The systematic layout planning procedure pattern has been detailed as below in the flow diagram:

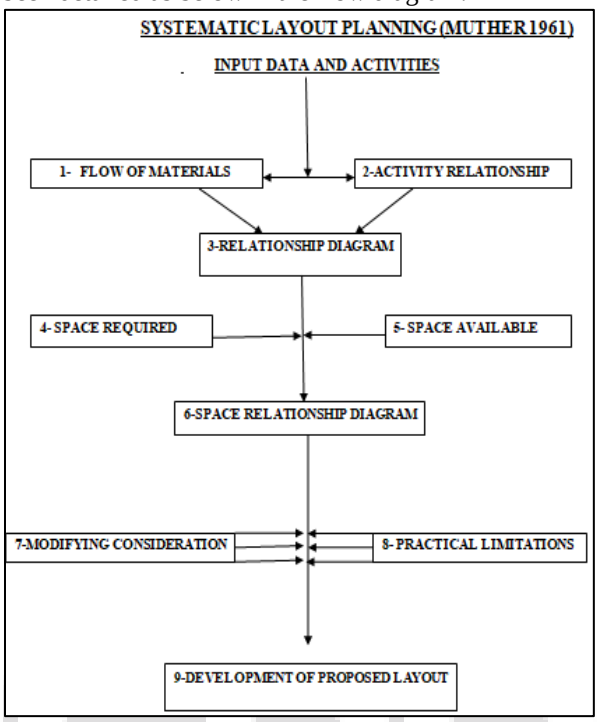


Fig. 3: Systematic Layout Planning

### *B. Procedure for Activity Relationship Analysis*

*1) Identification of Facilities*

The Following are the predominant facilities identified to be constructed on site: 1) Entry/ exit gate 2) site office 3) RMC plant 4) rebar jig assembly area 5) casting bed area 6) curing tank 7) stacking area 8) testing lab 9) store 10) steel yard

*2) Relationship Chart*

1) List out the identified activities on relationship chart. The left hand side of the relationship chart shows the list of identified predominant facilities and the right hand side of the chart shoes the description of relation between them.
2) To determine or establish the desired relationship for each pair of activities and reasons therefore, can be done by [12]

a) Personal visit and discussion with department managers or area supervisor involved.
b) By involving those with the most knowledge about the relationship.
c) By your knowledge of the operating practices.
d) By making the series of calculation for each major considerations.

Description of the relation between facilities can be denoted by alphabets as A, E, I, O, U, X.

The alphabet is also called as "proximity weight" or "proximity value" because we have fixed some relation of facilities with respect to each other depending on proximity relation. The chart shows the description about the proximity relation between facility locations therefore we called it as a "relationship chart".

 

3) Enter the data on relationship chart so as to have a set or approved, specific relationship and reason from which to plan your layout as per table I and II.

| Proximity Value | Closeness Rating |
|---|---|
| A | Absolutely Necessary that the two facility should be close (to be close). |
| E | Especially Important that the two facility must be close. |
| I | Important that the two facility may be close. |
| O | Ordinary closeness is ok |
| U | Unimportant |
| X | Undesirable |

Table 1: Value and Closeness Rating

The above rating is given to different departments as per below code and reasons

| Code | Reasons |
|---|---|
| 1 | Flow of materials |
| 2 | Ease of supervision |
| 3 | Common personal |
| 4 | Contact necessary |
| 5 | Convenience |

Table 2: Code with Reasons

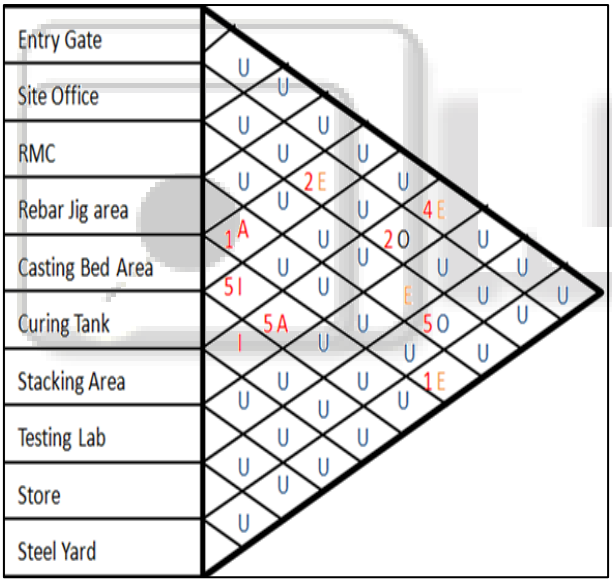


Fig. 3: Relationship Chart

*C. Facility Movements*

The following features can be obtained due to smooth functioning of site layout:

1) Easy site accessibility will keep the moral of the equipment and the vehicle drivers high minimize the chance of accident and save time in movement hence standardization of design is necessary to reduce the working hours for repetitive execution of same type of work. Closeness of casting bed and stacking area is absolutely necessary. Thus, Alphabet A is used between casting bed and stacking area.
2) For smooth mobility, reduce transportation cost, site safety and more productivity, closeness of entry gate and stacking area is especially important. Alphabet E is use between entry gate and stacking area.
3) Position of site office should be kept near casting bed to have a time to time inspection by engineers onto the process adopted, hence alphabet E is used between site office and casting bed area.
4) Transportation of rebar cage for jig to casting cell should be done carefully to avoid excessive distortions, hence alphabet A is used between casting yard area and rebar jig area.
5) If curing is proper and sufficient, it provides the necessary strength and control of drying shrinkage is achieved. Also for convenience purpose, closeness of casting and curing tank is important. Alphabet I is used between casting bed area and curing tank.
6) Testing lab is always preferred beside RMC plant, hence, alphabet E is used between RMC and testing lab.
7) To increase the overall efficiency of total work, closeness of stacking area from entrance is necessary. Hence, alphabet E is used between stacking area and entry gate. To reduce material handling cost, travel time and increase labour productivity, closeness or rebar jig area from steel yard is especially important. Hence, E alphabet is used between rebar jig assembly area and steel yard.

*D. Activity Relationship Diagram*

The method of diagramming relationship involves connecting the activities or facilities by number of lines code. The number insight the box shows the activity identification and the number of connecting lines indicated the rated closeness. The more the number of lines, the more the affinity of closeness of different heads.

| Proximity Value | Closeness Rating | Line code |
|---|---|---|
| A | Absolutely Necessary that the two facility should be close (to be close). | |
| E | Especially Important that the two facility must be close. | |
| I | Important that the two facility may be close. | |
| O | Ordinary closeness is ok | |
| U | Unimportant | |
| X | Undesirable | |

Table 3: Proximity Value with Line Code

Activity Relationship Diagram is Shown as Below

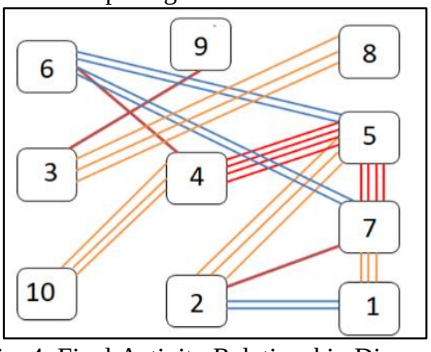


Fig. 4: Final Activity Relationship Diagram

 

From above activity relationship diagram it can be inferred that the maximum number of line showing affinity of closeness is between facility 5 and 7 (casting bed area and stacking area), 4 and 5 (rebar jig area and casting bed area), 2 and 5 (site office and casting bed area), 4 and 10 (rebar jig area and steel yard), 3 and 8 (RMC and testing lab), 1 and 7(entry gate and stacking area). Thus relative desirability of these facilities to be close to each other is strongest.

*E. Space Requirements*

1) Measure space currently assigned in the casting yard site layout.
2) Determine space requirement for each activity area considering the current area and future requirement to make optimized layout design.

Thus, we made our own work sheet to suit the particular requirements of the layout planning projects, established by matter of logic or educated approach.

According to the space required and space available, necessary area is given to all the temporary facility of casting yard. Total proposed area comes out to be 15,619 sq. mts for the occupancy of different facilities .The total area of casting yard layout is 28,328 sq.mts. The remaining area accounts for main aisles and circulation in the proposed casting yard layout.

The following table shows the list of different facilities with their current area and proposed area:

| Facility | Current Area(m2) | Proposed Area(m2) |
|---|---|---|
| Site Office – Sq. m. | 217 | 223.5 |
| RMC PLANT 1 (CP30) | 1323 | 1566 |
| RMC PLANT 2(M1) | 2052 | 1834 |
| Steel Yard | 1506 | 1691 |
| Testing lab | 58 | 155 |
| Store | 233 | 383 |
| Bed1 | 325 | 325 |
| Bed2 | 325 | 325 |
| Bed3 | 356.5 | 356.5 |
| Bed 4 | 441.4 | 441.4 |
| Bed5 | 402.4 | 402.4 |
| Pier bed 1,2,3,4,5 | 159.3 | 159.3 |
| Curing tank(1,2,3) | 72 | 72 |
| Water tank | 18 | 18 |
| Stacking area1 | 2805 | 2805 |
| Stacking area2 | 2805 | 2805 |
| Stacking area3 | 2057 | 2057 |
| Total | 15,155.6 | 15,619.1 |

Table 4: Current Area Vs Proposed Area

*F. Proposed Layout*

Finally, we are able to continue the process of moving towards a more efficient site layout by placing the activity relationship diagram over the existing site plan. And we get layout plan which is near to optimized site layout covering the following objectives:

1) Minimizing overall production cost and time
2) Utilizing existing space most effectively
3) Providence for employ convenience, safety and comfort.
4) Maintain flexibility of arrangement
5) Minimizing material handling cost

The site problems identified can be solved in the current proposed layout. The points to be highlighted are as follows:

1) Stacking area for segments is kept close to entry gate for smooth mobility and reduce transportation cost.
2) Site office is kept near casting bed to have time to time inspection.
3) Proper positioning of internal roads to connect and maintain easy access is provided.
4) Steel yard is kept close to rebar JIG assembly area so as to reduce material handling cost, travel time and increase labour productivity.
5) Curing tank is kept close to casting bed area and stacking area
6) The sequence of steel yard, Rebar Jig assembly area, Casting bed and then stacking area is maintained to increase the overall efficiency of total work.
7) Stacking area is kept in the front side of casting yard near entry gate thus, Idle time of gantry reduces
8) Testing lab us kept beside the RMC plant for convenience purpose.
9) Job safety and privacy is maintained, as casting bed area is shifted away from front end of entry gate and kept close to site office.

The proposed layout of casting yard is as shown below:

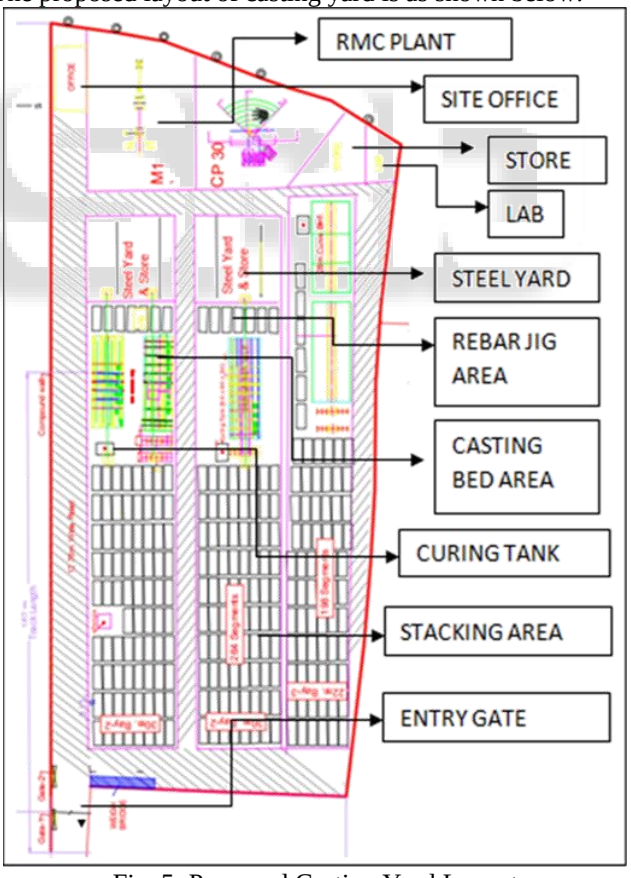


Fig. 5: Proposed Casting Yard Layout

## IV. CONCLUSION

A fundamental aspect is to emphasize the necessity of creating awareness about the effective site layout planning. By following the generic procedure and applying basic fundamental principles, some of the suggestions are provided

 

by analysing the currently faced problems on the site. In this project, we have suggested an optimized site layout for Pune Metro Rail Project. Suggested site layout is based on relationship chart and activity relationship diagram drawn on the basis of practically faced challenges. The grouping of facility is helping us to keep the proximity relationship of the temporary facility. The suggested site layout for Pune Metro Rail Project is prepared in such manner that major work proceeds smoothly without any delay and will decrease overall project cost and duration.

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