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# APPLICATION OF LEAN CONSTRUCTION ON CEMENT CONCRETE ROAD PROJECT

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***Abstract:*** ***The construction industry has very low productivity as compare to other industries since many years even after the use of new technologies and new techniques use in construction. Lean concept is very popular in manufacturing industries to improve productivity by smooth work flow and minimize the waste. In this Research paper, studies of the lean construction concepts and its application to construction projects was done by live case studies. Case study was done by preparing questionnaires, observation on site and with the help of project management team of the cement concrete road project. Project was divided in two parts.1) Identifying lean waste on site by observation and with the help of PMC.2) Identifying Importance and avoidabilty of each waste by questionnaire. As a result, total 20 lean waste and its severity were identified on cement concrete road project at different locations which comes under the Surat city.***

***Keywords:*** **cement concrete road, lean construction, lean waste.**

## I. INTRODUCTION OF LEAN CONSTRUCTION

**A Lean construction is a "way to design production systems to minimize waste of materials, time, and effort in order to generate the maximum possible amount of value," here waste is different from pure construction waste. Designing a production system to achieve the stated ends is only possible through the collaboration of all project participants (Owner, Architect/Engineer, contractors, Facility Managers, End-user) at every stages of the project. Lean Construction is believed to be particularly useful on complex, uncertain and quick projects.**

**There are substantial researches that have been focused on Lean Construction theory. Some of the lean principles that are related to the construction industry are such improvements as the construction planning process, eliminating waste, construction supply chain, and downstream performance. Lean construction draws upon the principles of project-level management and upon the principles that govern production-level management.**

**Primarily, lean construction aims to reduce the waste caused by unpredictable workflow. Here Waste is defined in following categories: defects, delays due to waiting for upstream activities to finish before another job can begin, maintaining excess inventory, unnecessary transport of materials and unnecessary movement of people,**

**over allocated equipment and material on site, accident on site etc. Work is structured throughout the process to maximize value and to reduce waste at the project delivery level. Efforts to manage and improve performance are aimed at improving total project performance, because this is more important than reducing the cost or increasing the speed of any particular activity.**

## II. WASTE FROM A LEAN PERSPECTIVE

Waste has a broader interpretation in Lean than the physical wastes that are the focus of construction site activity. In fact waste is any activity (or inactivity) that does not add value to the product or service.

**Value-adding (VA):** this is the work that changes the shape or nature of the product (or service) in a way that contributes to the final form that the customer is willing to pay for.

**Essential non-value adding activities** (ENVAs, or support activities): these are the tasks that must be completed to enable the value-adding activity to be completed, but do not add value. For example, inspection does not add actual
value but is necessary up to the point where a process can be improved so that inspection can be eliminated.

**Waste:** this is any other activity or event associated with carrying out a particular work activity. Waste can be viewed from two perspectives: Waste in the work itself (e.g. excessive walking, looking for tools and materials, poor quality). Introduced or 'enforced' waste (e.g. waiting for information, materials not supplied), which has prevented work activity from being carried out.

- It is not enough to simply conduct a review of potential wasteful areas from an individual functional perspective. A proper end-to-end analysis should be conducted, with internal customer-supplier links well understood and considered when defining waste in order to ensure that the whole is indeed greater than the sum of the parts. Ideally waste and non-value adding activity should be defined by careful customer consultation, rather than by the process team working for the customer themselves.

## III. CEMENT CONCRETE PAVEMENT

Concrete pavement is, in general, consists of three layers, subgrade, base layer and the concrete slab. Generally bound base layers are used for concrete pavement construction.as per Indian specification, some example of such layers are Dry Lean Concrete(DLC),Roller Compacted Concrete(RCC),the concrete slab is generally of M30,M40,M50 grade of concrete as per the Indian specification and is called as Paving Quality Concrete (PQC) (IRC : 15-2002)

**Sequential Activity of cement concrete road construction**

**Excavation** This work shall consist of excavation, removal and satisfactory disposal of all materials necessary for the construction of roadway, side drains and waterways in accordance with requirements of these Specifications and the lines, grades and cross-sections shown in the drawings or as indicated by the Engineer. It shall include the hauling and stacking of or hauling to sites of embankment and subgrade construction, suitable cut materials as required.

**Embankment** These Specifications shall apply to the construction of embankments including subgrades, earthen shoulders and miscellaneous backfill with approved material

obtained from roadway and drain excavation, borrow pits or other sources. All embankments, subgrades, earthen shoulders and miscellaneous backfills shall be constructed in accordance with the requirements of these Specifications and in conformity with the lines, grades, and cross-sections shown on the drawings or as directed by the Engineer.

**Subgrade Murrum** This work shall consist of laying and compacting clean, crushed, graded aggregate and granular material, premixed with water, to a dense mass on a prepared subgrade/sub-base/base or existing pavement as the case may be in accordance with the requirements of these Specifications. The material shall be laid in one or more layers as necessary to lines, grades and cross-sections shown on the approved drawings or as direction by the Engineer.

**Granular Sub base (G.S.B)** This work shall consist of laying and compacting well-graded material on prepared subgrade in accordance with the requirements of these Specifications. The material shall be laid in one or more layers as sub-base or lower sub-base and upper sub-base as necessary according to lines, grades and cross-sections shown on the drawings or as directed by the Engineer.

**Dry lean concrete (D.L.C)** The work shall consist of construction of dry lean concrete sub-base for cement concrete pavement in accordance with the requirements of these Specifications and in conformity with the lines, grades and cross-sections shown on the drawings or as directed by the Engineer. The work shall include furnishing of all plant and equipment, materials and labour and performing all operations, in connection with the work, as approved by the Engineer.

**Pavement quality concrete (P.Q.C)** A systems approach may be adopted for construction of the pavement, and the Method Statement for carrying out the work, detailing all the activities including indication of time cycle, equipment, personnel etc. the work shall consist of construction of unreinforced, dowel jointed, plain cement concrete pavement in accordance with the requirements of these Specifications and in conformity with the lines, grades and cross sections shown on the drawings. The above shall include the type, capacity and make of the batching and mixing plant besides the hauling arrangement and paving equipment. there are two types of paving equipment available for construction of cement concrete pavement which are mention below:

1. Construction by fix form paver machine The fixed form paving train shall consist of separate powered machines which spread, compact and finish the concrete in a continuous operation. the concrete shall be discharged without segregation into a hopper spreader which is equipped with means for controlling its rate of deposition on to the sub base. The spreader shall be operated to strike off concrete up to a level requiring a small amount of cutting down by the distributor of the spreader. The distributor of spreader shall strike off the concrete to the surcharge adequate to ensure that the vibratory compactor thoroughly compacts the layer.

2. Construction by slip form paver machine The slip form paving train shall consist of power machine which spreads, compacts and finishes the concrete in a continuous operation. The slip form paving machine shall compact the concrete by internal vibration and shape it between the sides forms with either a conforming plate or by vibrating and oscillating finishing beams. The concrete shall be deposited without segregation in front of slip form paver across the whole width and to a height which at all times is in excess of the required surcharge.

## IV. C.C ROAD AND SURAT

**Surat road network**

- Surat has very large, strong and wide road network.
- The city has very well developed infrastructure and because of vicinity to Mumbai & Ahmadabad (location advantage), the leading industrial organizations have set up their units in & around Surat. The growth of vehicles (two-wheeler, three-wheeler & four-wheeler) increased by substantially over last couple of years.
- The traffic cell of SMC has primarily planned to improve the heavy traffic roads by converting existing flexible pavement to rigid pavement i.e. cement concrete road considering road geometrics & traffic engineering concepts.Due to heavy traffic Surat Municipal Corporation tries to improve road infrastructure of the city.
- Surat has various type of road like ACC polymeric Road, Asphalt Road, and Cement concrete road.In this research work, case study of cement concrete road project has taken.
- Cement concrete road has 25-30 year life which is more than any other.
- Surat has more than 50km Existing Road network of cement concrete road.

## V. GENERAL INFORMATION RELATED CASE STUDY

Lean approach is generally used in repetitive construction work. As per the literature, road project was maximum used as a case study of lean construction. Road project is repetitive in nature so it is easy to apply lean tools and techniques on it.

- Case study will be done on the ongoing project which are enlisted below.

**Table 1 Cement concrete road project under S.M.C**

| Site | Site name | Road length(m) | Project cost(INR) | Project delays |
|---|---|---|---|---|
| Site 1 | Pandesara – G.I.D.C. Road | 9540 | 26,86,51,231 | 1 year delay (extended) |
| Site 2 | Dindoli - Kharvasa Road | 3000 | 19,30,46,119 | 7-9 months (expected) |
| Site 3 | Pal Haveli –Bhesan Treatment Plant - Nita Satbhaya circle(Hazira road) | 7600 | 49,49,61,159 | 1-2 year (expected) |
| Site 4 | Dumas Road Phase 2 | 3400 | 24,64,26,806 | 5-6 months (extended) |
| Site 5 | Amroli - Chaprabhatha Road | 3600 | 24,40,75,941 | 3-5 months (expected) |

## VI. IDENTIFICATION OF LEAN WASTE FROM SITE

- Probable lean waste for cement concrete road construction sites are identified on the base of observation interviews and brainstorming session with project management experts and shown as in table 2

**Table 2 Different Types of Lean Waste**

| Sr.no | Lean waste |
|---|---|
| 1 | Gas line problem |
| 2 | Electric poll or transformer problem |
| 3 | Political hindrance |
| 4 | Leakage from utilities |
| 5 | Electric line cable |
| 6 | Machinery problem-break down or unavailable |
| 7 | Unpredictable Weather or rise in temperature |
| 8 | Defect or rework |
| 9 | Drainage line problem |
| 10 | Forest approval |
| 11 | Traffic hindrances |
| 12 | Alignment problem : a)Land Acquisition b) Illegal construction |
| 13 | Water line problem |
| 14 | Material or inventory control -not proper |
| 15 | TP scheme Not clear |
| 16 | Financial Problem |
| 17 | Strom water line Shifting |
| 18 | Manpower problem- Unskilled labour |
| 19 | Soil bearing capacity not good |
| 20 | Holidays |

## VII. SEVERITY OF LEAN WASTE

Survey was done on the basis of Questionnaire:-

Respondents of Questionnaire
Engineers of Surat Municipal Corporation
Engineers of Project management Consultancy
Engineers of Contractor

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**Screenshot of Questionnaire**

**Fig 1 Screenshot of Questionnaire**

| Sr. No | Lean waste | Importance | | | | | Type | | | Delay days |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Avoidable | Partially avoidable | Unavoidable | |
| 1 | Strom water line | 1 | 2 | 3 | 4 | 5 | | | | |
| 2 | Drainage line | 1 | 2 | 3 | 4 | 5 | | | | |
| 3 | Electric poll or transformer | 1 | 2 | 3 | 4 | 5 | | | | |

**Importance** - 1 – higher order (very severe)------5-lower order (less severe)

**Avoidable :** work is continue by avoiding
**Partially avoidable :** temporarily solution
**Unavoidable :** work is stop due to this waste, further activity will not Execute

Calculation for importance:

$$\text{Relative Importance of lean waste} = \frac{\sum \text{Sum of All importance for particular one waste}}{\text{Total no of respondents}}$$

Calculation of Avoidability

$$\text{Unavoidability \%} = \frac{\text{Total no of unavoidable respondent for one waste}}{\text{Total no of respondent}} \times 100$$

E.g. Sample calculation for hindrance of Gas line (lean waste)

Relative importance of hindrances of Gas line

$$= \frac{\sum (2+1+3\ldots\ldots\text{upto 50 response.})}{50} = 106/50 = 2.12$$

Unavoidability of Gas line

$$= \frac{(\text{No of U) response for unavoidability}}{50} \times 100 = 38/50\ \% = 76\ \%$$

## VIII. RESULTS OF ANALYSIS

**Table 3 Contribution of Activities as Lean Waste in terms of Relative Importance**

| Lean waste | Relative Importance |
|---|---|
| **Water line** | 1.4 |
| **Drainage line** | 1.66 |
| **Strom water line** | 1.78 |
| **Electric poll or transformer** | 1.98 |
| **Leakage from utilities** | 2.14 |
| **Electric line cable** | 2.16 |
| **Gas line** | 2.24 |
| **Forest approval** | 2.28 |
| **Manpower problem- Unskilled labour** | 2.34 |
| **Material or inventory control** | 2.4 |
| **Machinery problem-break down or unavailable** | 2.68 |
| **Traffic hindrance** | 2.74 |
| **Financial problem** | 2.82 |
| **Land Acquisition** | 2.9 |
| **Illegal construction** | 2.92 |
| **Political hindrance** | 2.98 |
| **Holidays** | 3 |
| **Defect or rework** | 3.16 |
| **Soil bearing capacity** | 3.4 |
| **T p scheme Not clear** | 3.72 |
| **Unpredictable Weather or rise in temperature** | 3.82 |

**AVOIDABILITY**

**Table 4 Percentage Wise Response of Avoidably of Lean Waste in C.C Road Projects**

| Lean waste | Unavoidability (%) | Partially Avoidable (%) | Avoidability (%) |
|---|---|---|---|
| **Strom water line** | 92 | 8 | 0 |
| **Drainage line** | 86 | 14 | 0 |
| **Leakage from utilities** | 86 | 12 | 2 |
| **Electric poll or transformer** | 82 | 18 | 0 |
| **Water line** | 80 | 16 | 4 |
| **Gas line** | 76 | 24 | 0 |
| **Forest approval** | 76 | 18 | 6 |
| **Electric line cable** | 72 | 22 | 6 |
| **Machinery problem-break down or unavailable** | 68 | 22 | 10 |
| **Manpower problem-Unskilled labour** | 48 | 36 | 16 |
| **Material or inventory control** | 48 | 26 | 26 |
| **Soil bearing capacity** | 46 | 44 | 10 |
| **T p scheme Not clear** | 40 | 54 | 6 |
| **Unpredictable Weather or rise in temperature** | 40 | 46 | 14 |
| **Defect or rework** | 36 | 48 | 16 |
| **A)Land Acquisition** | 32 | 46 | 22 |
| **b)Illegal construction** | 26 | 54 | 20 |
| **Financial problem** | 22 | 46 | 32 |
| **Holidays** | 20 | 62 | 18 |
| **Traffic** | 14 | 38 | 48 |
| **Political hindrance** | 12 | 38 | 50 |

## IX. Conclusion

- This paper addresses how the construction companies can improve productivity by lean management Approach. It also shows the proper approach to implement the lean technique on construction for future works and enlist the construction waste and lean construction techniques to improve productivity.
- Lean construction concept may be established in construction industry to identify and reduce the repetitive causes of delaying project and consequences elided with such delay. Project study has focused on cement concrete road construction site of Surat Municipal Corporation.
- With context to cement concrete road project, total **20 lean waste** are identified which are Gas line problem, Electric poll or transformer problem, Political hindrance, Leakage from utilities, Electric line cable, Machinery problem-break down or unavailable, Unpredictable Weather or rise in temperature, Defect or rework, Drainage line problem, Forest approval, Traffic hindrances, Alignment problem by

Land Acquisition or Illegal construction, Water line problem, Material or inventory control -not proper, TP scheme Not clear, Financial Problem, Strom water line Shifting, Manpower problem- Unskilled labour, Soil bearing capacity not good, Holidays.

- Out of the Twenty lean waste Identified for cement concrete road ,**Most Unavoidable** waste have been categorized as Hindrances of Water Line, Drainage Line, Electric Poll And Transformer, Electric Line Cable, Leakage From Utilities, Water Line.
- Out of the twenty lean wastes Identified for cement concrete road, **Avoidable** waste have been categorized as hindrances of Traffics, Holidays, Defect or Rework and Financial Problem.

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