

Applying Lean Thinking in Project/Product Designing and Development

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Abstract— Construction industry has put in continuous efforts for its survival in the current impulsive and competitive economy. In order to handle the critical situation, Contractors are trying to implement new and innovative techniques in their project design process by making it more effective and efficient. A detailed literature survey has been conducted to identify the lean practices in various manufacturing industry and now in Construction industry. The results revealed that the status of Lean Product Design, Development and implementation is still in thriving stage. This study may further help the industry to improve construction process, align it to the requirements of its customers and relentless contribution to manufacturing sector to enhance productivity, quality and competitiveness is immense. In this thesis case study, various projects on construction/production of toilet units for rural India were observed. And from the data a unique toilet block will be designed as per lean thinking and will be compared with traditional designs. This design may get green design certification and can be adopted by any individual construction firm to ensure faster delivery, best quality and controlled cost.

Key words: Lean Product Design, Precast Toilet Blocks, GFRC Precast Elements, Light Weight Precast Toilet

I. INTRODUCTION TO LEAN PROJECT DESIGN AND DEVELOPMENT

Lean Design and Construction is a production management-based approach to project delivery - a new way to design and build capital facilities Lean production management has caused a revolution in manufacturing design, supply and assembly. Applied to project design and delivery, Lean changes the way work is being done throughout the process. Lean Construction extends from the objectives of a lean production system - maximize value and minimize waste - to specific techniques, and applies them in a new project delivery process.

For this research, toilet was selected to apply lean thinking, and develop a new design which is optimized in time cost and quality with green aspects. This product was selected for design as, Swachh Bharat mission is currently in trend, Government is highly focusing the sanitation sector. Government has set plan to construct 12 crore toilets under the Swachh bharat mission. [1]

II. RESEARCH METHODOLOGY

Survey - Survey method is used as one of the key tools to understand the current conventional construction methods, quality issues, hygiene parameters. Survey was carried out for four different built type of toilets.

A. Interviews

Personal interviews helped to understand the onsite problems, site controls, cost related things, suggestions. Secondary research about the topic was carried out and a list

of close-ended and open-ended questions were prepared before conducting the interview.

Interviews were carried out with engineers/contractor/execution team for each case. The main purpose to have detailed information about different built type of toilet in rural area that can help in designing. Lean focuses on value maximization in every aspect quality, cost, time and environmental considerations. This data can help to improve quality by focusing the quality issues and then to fix the standardized process to obtain consistency in quality.

B. Questionnaire

Questionnaire was prepared in order to cater the information about facilities being provided, Material being used, Erection methods, manpower requirement, etc. and filled by the respective site person.

Questionnaire was divided into four parts. First part captured site profile like name, location and basic details. Second part was about toilet details and specifications. Third part dealt with their material details and specifications. Third and fourth section was about the erection methodology and cost details of material and labor.

Item	A Workmanship	B Mix proportion	Result
Plaster	1	0	0
Masonry	0	1	0
RCC Column Casting	0	0	0
Painting	1	1	1

Table 1: Questionnaire

III. CASE STUDY & QUALITY ANALYSIS

There were three case studies on their different built cabin/box from 1. Block masonry 2. Brick masonry 3. RCC panels.

Quality analysis was carried out for each of them, in terms of material quality, Mix proportion quality, workmanship. If the quality is up to the mark or good, then it was given 1 else 0. To calculate Quality percentage new lean tool was defined based on the logical gates.

A. Lean Quality Gates:

Entity has either 100% quality or 0, there is no in between. As the truth table in fig. 1

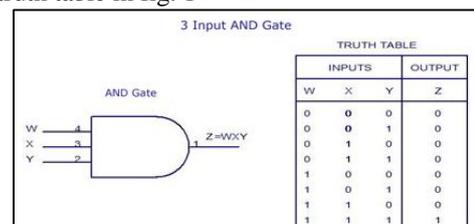


Fig. 1: Quality Gate

100 % Quality is shown by 1 and lower is 0.

Conditions/aspects are mentioned on one side of logical gate.

Gate output shows the Quality of product.

Special Factor for element is multiplied for final Quality Calculation.

Example.

We have two entities. Workmanship, Mix proportion.

If and only if the component has both value as 1 then it gets 100% Quality.

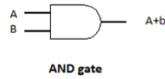


Fig. 2: EX for Lean quality gate

Case studies on the basis of the built form	Quality of material	Quantity of mix proportion of material	workmanship	Quality Audit	Product % Quality with cost factor
Block Masonry	87%	60%	73%	47%	61%
Brick Masonry	87%	67%	67%	40%	44.83%
RCC Panel	93%	79%	64%	50%	57.50%

Table 3: Results

This was further studied with lean tools 5why, A3 sheet brainstorming to find root cause of lack of Quality.

Further it was compared in terms of the different aspects like Material consumption,

- Material availability
- Labor requirement,
- on site man hours,
- Embodied energy
- Equipment requirement
- Cycle time
- Modularity
- Standardization
- Durability
- Site controls.
- Space management
- Sanitation
- Hygiene conditions
- Safety
- Material handling

Conclusion/recommendation for new lean design were made from each case study. Each summary concluded that quality is being compromised because of poor workmanship, material's mix proportion that is again due to human errors.

Then some criteria were fixed to select casting/erection method such as site controls, modularity, standardization, mass production, quality consistency. Finally, precast was selected as casting/erection method for new design.

In the same way material selection was carried out, with the criteria like, durability, light weight, weather proofing, shape freedom, strength, and some green points like embodied energy. GFRC was selected from different options like Brick masonry, Block masonry, Rcc Panels Pvc cabins, Container type cabin, FRP, GFRC, Wooden Racks, GLASS, Gi sheets, which can fit in all the selection criteria.

IV. LEAN PRODUCT DESIGN

Size: 4'X4'X 6.5'

Shape: Diamond like shape

Thickness: 18mm

Assembly details: 3 L shaped panels, 1 base, a lid/cover

Here it gets the output when both conditions are satisfied. Here it Gets 1out of 4 points, so it is said that it has 25% Quality.

Now it is further Multiplied by Factor, that is VCF. VCF – Value cost factor.

Now if Painting has 20% Contribution to overall cost then Over Quality Number is

$$25 \times 0.20 = 5\%$$

It is said that Product has 5% Quality.

All three case study were analyzed in the same way and results were

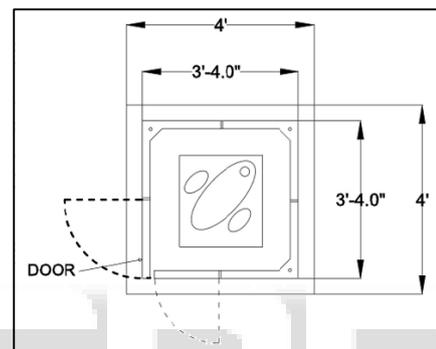


Fig. 1: PLAN: Precast GFRC Toilet Block

Sr. No	Item	Size
1	Base	4' X 4'
2	Panel	1'8" X 6'6"
3	L Shape	1'8" X 2" (1'8" on both the wings)
4	Door	1'7" X 6'
5	Cover	3'10" X 3'10"
6	Thickness	18mm

Table 1: Area table

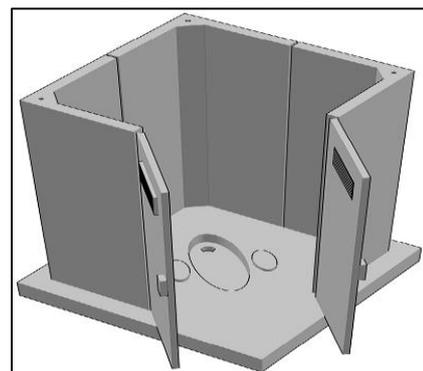


Fig. 2: Isometric 3D View

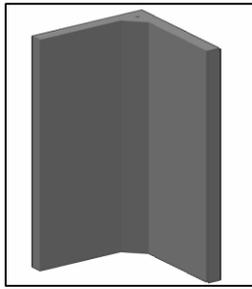


Fig. 3: GFRC Lightweight Panel

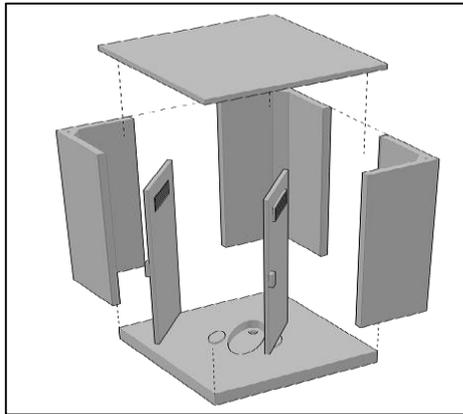


Fig. 4: Precast assembly system

This design was casted at Arya Precast Pvt.Ltd. sanand.

	Case study 1	Case study 2	Case study 3	Lean Design
Material from earth KG/weight of toilet block	1949	1565	1621	300
Cycle time in days*	5	5	3	2
No of labor required on site for different activity	6	6	4	2
Man hours on site (hr.) (Cabin only Without soak pit) *	9.5	11	4	0.5
Embodied Energy MJ*	2977	3250	2951	800

Table 2:

Embodied energy is calculated for material only.

1) Features of Lean Design in Different Aspects

- a) Material
- Material Consumption is very low / Volumetric material consumption Is very low
 - GFRC has very low energy consumption in comparison of all alternates studied over here.
 - High durability
 - Shape freedom/ design freedom
 - Energy efficient
 - Economical
 - Weather and fire resistant
 - Easy installation
 - Very low maintenance
 - Lower embodied energy
 - Light weight panels.
 - High Compressive, Flexural and Tensile Strength

- b) Shape/Design
- It has diamond like shape which add more value to space management, maximum space is being used by this type of shape provision
 - L shaped Panels are easy to stalk, they are self-standing.
 - Base has groove to fix these panels, with perfect fitting and finishing. This gives elimination of alignment by plum bob.
 - Cover has the same groves that fits the panels easily.
- c) On site Erection time
- Erection time is about 30 minutes only. Which is very low compared to others.
- d) Casting methodology
- Precast gives the best possible site controls.
 - Consistency in quality
 - Proper and accurate customization.
 - Quality audits filter the Defected items, which Gives Quality assurance.
 - 2 people can handle the erection.
 - No floor tiling joints
 - Monolithic
- e) Durability
- GFRC itself is highly durable material, so it gives higher wear and tear resistance.
- f) Weather Effect
- GFRC is concrete made composite structure, as it has higher Weather effect resistance as RCC.
 - It has water repellent coating so that it does not absorb water, which maintains dry conditions and hygiene condition.
- g) Modularity
- It has 3 panels for wall, 1 Base, 1 cover. In this 5 components it gets ready. It results in lesser joints.
- h) Hygiene conditions
- There are two ventilation window provided, which refreshes the air
 - Surface of all the panels are water repellent, which do not absorb water, which gives dry environment. That prevents the water logging in the pores and ultimately fungi deposition.
- i) Standardization
- It is being casted in the controlled environment, all the process is being standardized and accordingly execution is being carried out. Which gives, Accurate results, Consistent Quality, Same design features, as all the things are pre decided and tested.
- j) Space management
- Diamond like shape gives it batter spacious feel from both the sides as well as from the front and back side.
- k) Transportation and material handling
- This is factory made, for erection only five elements are need to be assembled, so it eliminates material stacking on site.
 - This further helps in waste minimization of material on site.
 - Transportation of this panels is also easier, than other precast cabins (Such as the Container type

cabin), this panels gets fit one into another which results in lesser volume requirement and more Nos of panels can be transported in a single trip.

- This reduces energy consumption.
 - This unit is being transported from the single agency, in conventional method it has number of agencies involved for each and every material which increases number of trips for material dumping, and further it results in more energy consumption.
- 1) Embodied Energy
- GFRC is green Material; it uses the minimum energy resources.
 - This toilet made by GFRC consumes 1/3 embodied energy compared to these conventional methods.

V. CONCLUSION

Lean design is new way to design project/product to have optimisation in time quality cost with minimum possible resources. It helps in improving the efficiency. Before some time practice of lean was limited to manufacturing industry only, but now a days it is widely being accepted in different industries. Lean practices increases productivity as well as product value.

In this study, lean design for toilet is developed which uses minimum resources, and creates maximum product value.

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