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USING TECHNOLOGY TO ACHIEVE LEAN OBJECTIVES

P.R. Surendhra Babu[1] and N. Hayath Babu[2]

ABSTRACT

The construction industry is facing increased challenges and becoming more and more complex due to number of factors. Whether it is constructing a Building, Infrastructure or Industrial plant, the challenges remain there in every type of the project. This results in delays, waste, overruns and claims. So we need to develop new ways of doing things to manage the construction process. Adopting lean manufacturing principles in construction industry is an effective approach to bring improvements in design, procurement and construction to reap benefits and add value to the project. Using Technology is critical in the advancement of Lean Construction. This paper aims to discuss the need of Lean for our construction business and how technology is used within our organisation to achieve lean principles.

KEYWORDS

Lean construction, BIM, Leveraging Technology, Augmented Reality, Value additions

INTRODUCTION

Our organization is involved in constructing mega projects from concept to commissioning which include a variety of complex arenas:

- Buildings & Factories: Airports, Hospitals, Commercial & Residential Buildings
- Transportation Infrastructure: Roads, Runways, Elevated Corridors and Railways
- Heavy Civil Infrastructure: Metros, Ports and Power plants (Hydro & Nuclear)
- Power Transmission & Distribution
- Water supply and Treatment plants
- Metallurgical and Material Handling plants

In order to overcome the production and profitability challenges, the organization is continuously improving its design, procurement and construction processes and adopting the various technologies that support to achieve Lean Principles. This paper highlights

[1] Head-Digital Engineering, Larsen & Toubro Limited, Chennai, India, prs-ecc@Lntecc.com
[2] Head-BIM Implementation, Larsen & Toubro Limited, Chennai, India, hayathbabu@gmail.com

some key technologies which can help construction organizations to achieve good Value addition through the adoption of Lean Principles.

Some of the platforms that are implemented to achieve Lean Principles include:

- Using 3D models and visualization techniques to improve planning and communication.
- 4D planning to improve workflow, look-ahead scheduling, identifying the processes that deliver customer value and eliminate activities that do not add value, Just-in-time (JIT) deliveries.
- 5D BIM for value management techniques.
- Pre-fabrication.
- Integrating the supply chain through collaborative practices.
- Improve accuracy and efficiency through Lidar, Laser Scanning, AR/VR/MR, RFID and Equipment gateways.

TECHNOLOGIES IMPLEMENTED

The organisation is continuously exploring the potential applicability and benefit of using Technologies to achieve Lean Principles. The design teams are using BIM to support Lean Construction. They produce data rich 3D models which contain all the spatial, geographic and geometry information. A comprehensive and verified model improves construction efficiency considerably and also enhances effective operational management. It is always ensured that the final purpose of any model is clearly defined and developed to provide the greatest benefits.

Building or Infrastructure projects require many different design elements, often designed by multiple parties that must be integrated to form the final design. Models obtained from various sources are validated to confirm that they have been developed to support the asset's future operation and maintenance. In addition these models are updated from multiple sources to a common standard platform, and integrated. The working methodology ensures that these models are integrated with accuracy and transparency and all clashes or conflicts are resolved.

Technology such as AR/VR/MR is being used within the construction projects to improve visualization and identify errors / omissions quickly and correctly. Wearables enable collaboration between the office and sites to happen. Using models on this platform facilitates collaborative working and leads to better decision making.

The error due to working on incorrect version and sharing the right information on time across the project was one of the challenges in some of the projects. Cloud based common data environment was implemented for this purpose. Every team involved in the project was able to access the same latest data anywhere and anytime. Using digital tools on the cloud platform has taken collaboration to a different level. Now it is possible for the design, project, safety, quality and planning teams to work in tandem and updating

data is seamless and on time. This also enabled synergetic project management and informed accurate decision making.

Completing the project on time and within budget is always a challenge for planners. To make a realistic schedule, it is important to take care of all the risks which can affect the construction of a project. The inter-departmental coordination is highly essential. Each department should give its input in the preparation of the schedule. So 4D planning was introduced in the projects. The planners simulate the various construction tasks to be completed and create models known as 4D BIM that accurately represent the planned sequences of construction. The sequences can be reviewed to explore options and choose the solution that will provide the desired result both in terms of constructability as well as programme. This allows construction timelines to be planned effectively by coordinating the activities of different trades across all areas of the construction and by optimizing procurement lead times. 4D BIM modelling is also a key tool to forecast and address problems, using different methodologies much before they occur on site. Using the 4D aspects of BIM, project managers can now vividly see the schedule of each sub activity, analyse the what if scenarios and also plan JIT.

BIM based approach is also used for estimating, applying material take-offs and costing through the project design phases. 5D BIM uses a BIM model directly for cost estimation in such a way that any change in the design can be reflected in the cost immediately. This enables architects, contractors, and engineers to work collaboratively on a live model and make more informed decisions by comparing multiple cost estimates with the project's target cost thus achieving timely delivery, cost efficiency and quality. Quantity take off from models is done by the QS and contracts team to get an accurate assessment of planned vs actual.

Precast technology has proved to be an ideal choice for Lean Construction which facilitates planning and control, maximize value and minimize waste throughout the construction process. The building process is very efficient and safe in a centralized and controlled environment. Building systems that have been pre-assembled can be rapidly installed, requiring less rework than traditional methods. Prefabrication from a coordinated model assures project team members that building elements will be fabricated and installed accurately.

The other challenges include possibility of effectively implementing technology such as laser scanning and LiDAR that collects three dimensional point cloud data of the asset and convert this physical data of an object into a digital file (3D Point Cloud) allowing an extremely accurate survey details and record of the built environment. This will help the project team to produce a model of existing conditions rapidly and accurately.

Equipment gateways are being used for the fleet of construction machinery. This enabled the teams to efficiently monitor fuel consumption, equipment downtime and health of the machine. This data is accessible through cloud and the dashboards can be viewed, assessed and actioned by the management teams anytime remotely. RFID tags are used in construction sites for monitoring the activities of workmen and to ensure that

they are efficiently deployed and redeployed where necessary. This has significantly reduced the idling time of labour.

CASE STUDY - DESIGN AND CONSTRUCTION OF FORD GLOBAL TECHNOLOGY AND BUSINESS CENTRE.

ABOUT THE PROJECT

Location: Sholinganallur, Chennai
Plot Area: 28.5 Acres
Built up area: 26, 33,130 sq.ft
Start Date: 07-09-2016
Target Completion: 06-10-2018

WHAT WAS DONE

- A Project BIM strategy was developed to support design and construction and encourage collaboration and communication.
- Also developed interactive 3D models of all disciplines and shared with team for better collaboration.
- The 3D models were delivered to act as a 'single source of truth' and facilitated the use of 4D planning and 5D estimation.
- Mobile devices and Cloud collaboration were implemented.
- HoloLens was used to improve visualisation, collaboration and better communication.

BENEFITS ACHIEVED

Figure 1: On-Site BIM review meet

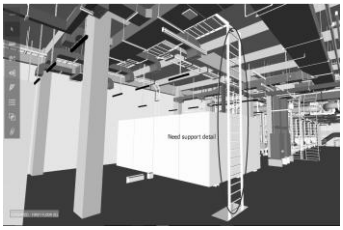

Figure 2: Design RFI through BIM

- Facilitated clear communication within project teams by sharing 3D models to Construction team, enabling them to visualize the design intent clearly before

executing the work. This encouraged better collaboration between the design and construction teams and reduced the number of RFIs.

- Raising the design RFI by marking up on the 3D models enabled the design team to clearly understand the issue at site and resolve them immediately, rather than the traditional chain of communication.
- Colour coded status on 3D model enabled the team to identify the critical areas easily and helped the project control team to take necessary actions at a faster pace.
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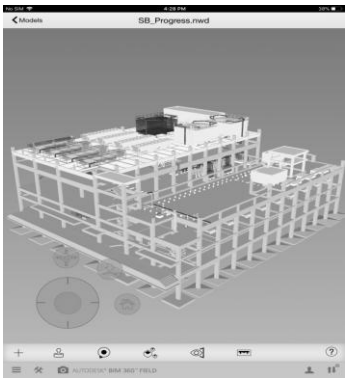


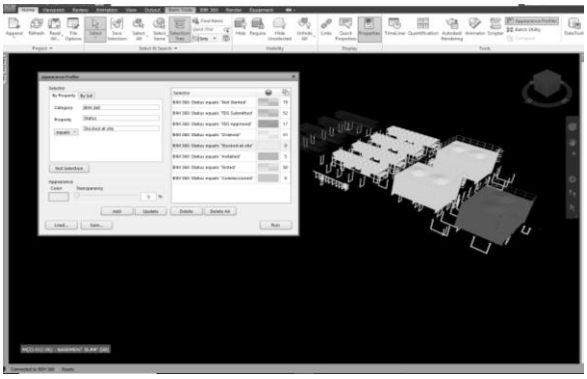
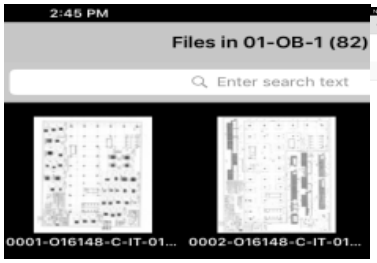


Figure 3 & 4: Colour coded 3D BIM

- Use of 3D models on mobile devices improved visualization for site personnel and they were able to propose easy/ alternate methodologies for construction resulting in lesser duration and costs.
- Availability of Project documents tagged to 3D models on Mobile devices enabled the team to access the data anywhere anytime.



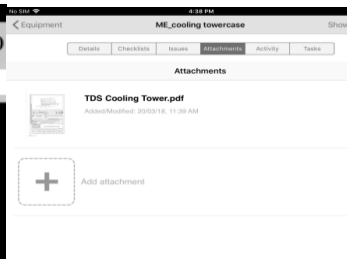


Figure 5: Project documentation on Mobile device, Figure 6: 3D BIM on Mobile device

- The 4D BIM tool enabled the project team to monitor the project in terms of planned vs actual. This facilitated mid-course corrections. Based on the schedule it was possible to extract the relevant quantities and track them on daily/ weekly/ monthly basis.

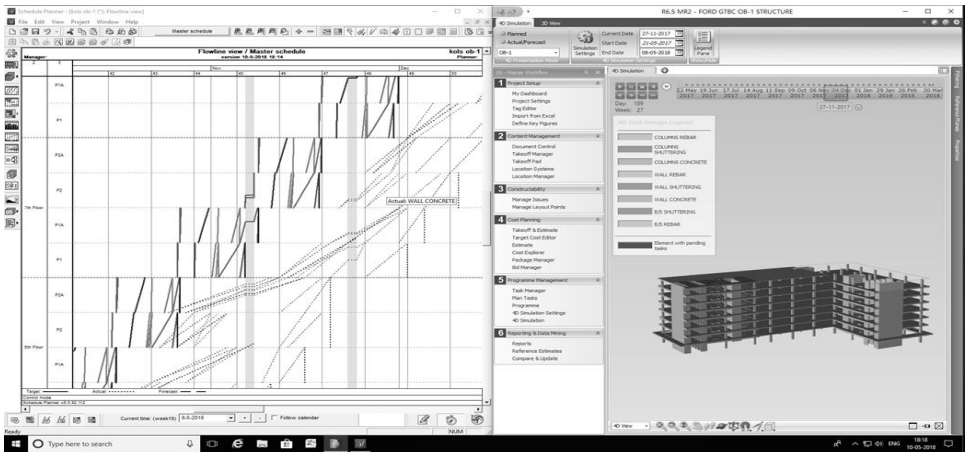


Figure 7: Planned vs Actual

- Quantity take-off through BIM enabled the team to reduce the time required to quantify the complete building, when compared to manual take-off. There was more than three fourths saving in time when BIM is used for quantity take-off.

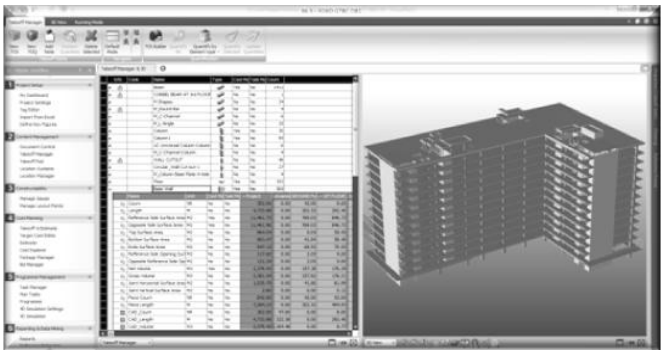


Figure 8: Model based automated Quantity Take Off

- HoloLens were used collaboratively between site and design office. Interaction led to issues being resolved and questions answered within minimal time. The constructability issues and appropriate solutions were proposed by the site team and led to value engineering.

Figure 9 & 10: Wearable Technology for improved Collaboration and Communication

CASE STUDY - SARDAR PATEL CRICKET STADIUM

ABOUT THE PROJECT

Location: Ahmedabad, India
Spectatorship: 110 K (World's largest)
Duration: 24 months
Start Date: 8th Dec, 2016
Target Completion: 7th Dec, 2018

WHAT WAS DONE

- High levels of collaboration and integration ensured amongst all project partners through BIM models.
- Weekly meetings through 3D model for coordination and constructability reviews.
- Availability of 3D BIM on mobile devices used by site engineering for visualisation.
- Planned vs Actual reviewed through 4D BIM.

BENEFITS ACHIEVED:

- The project involved precast construction of complex elements. The 3D models with high level of detailing helped in the visualisation of the critical aspects and junction details. This was used during the review meetings involving the design planning and construction teams. The sequencing of activities could be fine-tuned using the same.

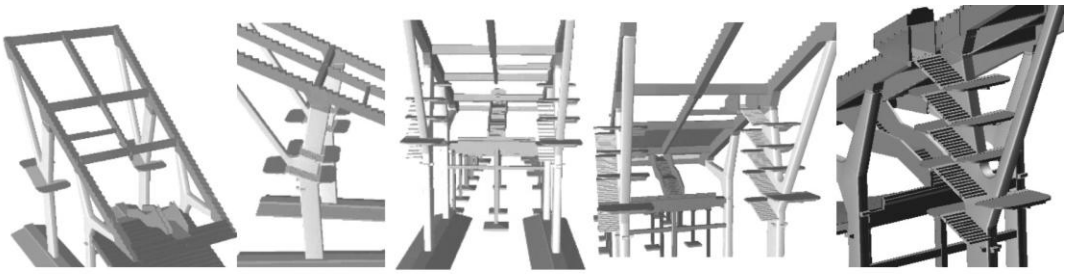


Figure 11: 3D model of Precast Elements

Figure 12: Weekly review meetings

Figure 13: 3D BIM on Mobile Device

- The availability of 3D models on handheld devices enabled the construction team to visualize the critical junctions of the precast elements at site while working on the methodology of critical erection activities.
- Use of 4D enabled the project to be delivered as per the challenging programme by facilitating continuous monitoring and extracted look ahead quantity schedules. These schedules were shared with execution and procurement teams thereby giving advance information about the upcoming activities to be executed and resulted in smooth and better progress.

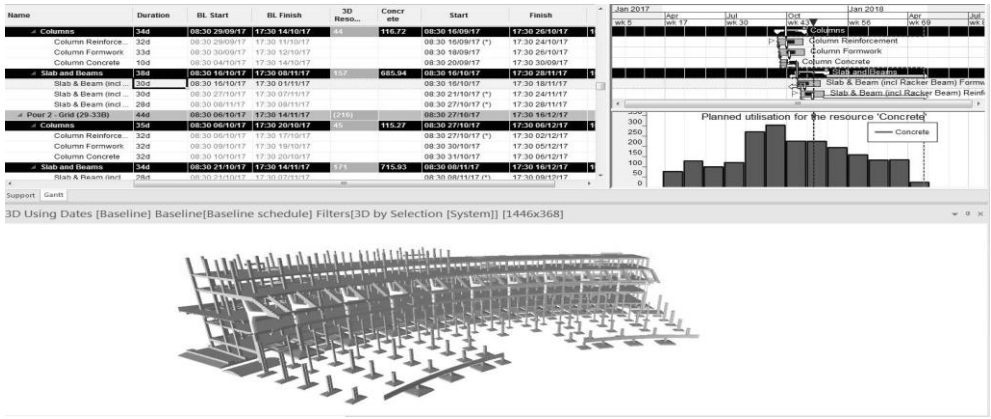


Figure 14: 4D BIM

- 4D BIM enabled the team to compare the baseline and actual progress. This alerted the team to focus on achieving milestone events and come up with solutions either by rescheduling the construction sequence or increase the resources. The multiple options could be simulated to arrive at the optimum solution.

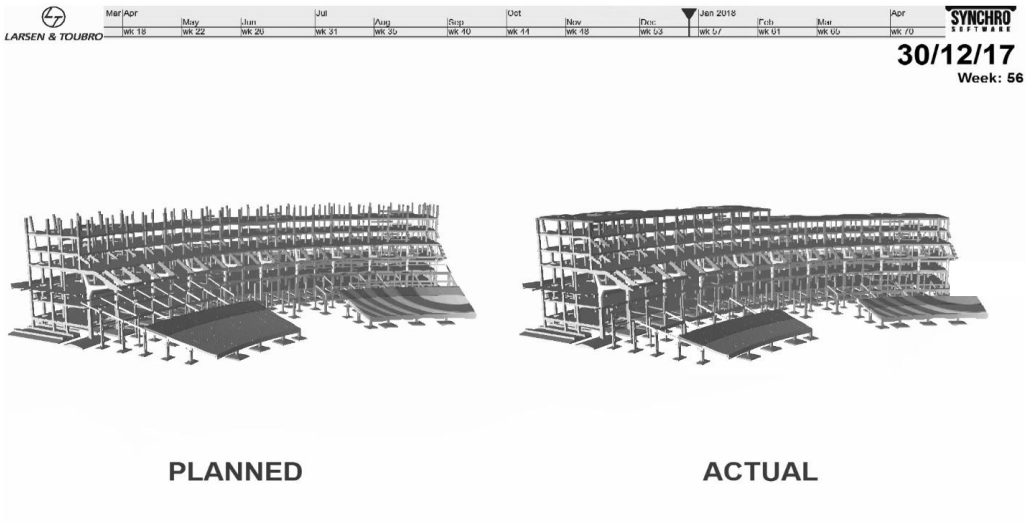


Figure 15: Progress monitoring

CASE STUDY - PROVIDENT SUNWORTH HOUSING

ABOUT THE PROJECT

Location: Venkatpura, Bengaluru
Configuration: 60 Towers
Built up area: 70 Lac sq.ft
Duration: 60 months

WHAT WAS DONE

- Precast system was used against conventional construction system.
- Methods of mould fabrication & yard set up were suitably modified to cater to Indian Construction Industry.
- Maximum utilization of moulds was planned for achieving savings in cost of moulds.

BENEFITS ACHIEVED

- High Quality concrete was produced in a controlled pollution free environment with minimum wastage.

- Reduction in the number of activities resulted in lesser material, labour and costs. High speed and quality was achieved with the deployment of lesser resources.
- Minimum finishing works meant lesser amount of scaffolding and labour deployment.
- Use of BIM tools led to better planning and detailing and tried up with the precast and erection activities



Figure 16: Precast Erection Figure 17: Precast Yard

CONCLUSION

To sum up, construction needs to be Lean and Digitized. The emerging technologies are enablers and if they are harnessed well one could see the industry delivering consistent high quality products on time within estimates. This paper has presented case studies where in multiple principles and technologies were deployed to maximize value and enabled lean construction. The industry will continue and adopt various technologies to add value to the customers.

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