



Flow of Activities: Utilizing Parade of Trade to Develop Visual Management Tool Tailored for Infrastructure Projects

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Abstract

Parade of Trade (PoT) is a game used in Lean Construction to demonstrate the impact of variability on a production system and to promote the value of constraint management in an environment of dependent events. Infrastructure projects usually have a sequence of construction works to an extent matching with the PoT model. Different trades and activities distributed over a large-scale area combined with its arising particular issues, creates a challenging efficiency paradox. Therefore, there is a need to adapt a new tool that identifies pace maker of the production flow, shows the interactions between different construction stages and trades, and explains the impact of trade progress on one another. The PoT idea used to develop new Visual Management (VM) tool, tailored to bridge the gap in the current model of infrastructure construction management traditional tools, supports the effectiveness of resources utilization and optimizes the project as a whole. Starting from maximizing client's values and passing through selection methodology; this paper records the journey of developing and utilizing sustainable VM tool; tailored for infrastructure construction projects. It supports decision-making regarding resources allocation; adapting construction batch size; assist in determining takt time and takt zones. Furthermore, it opens the way for further studies from Lean researchers and practitioners to develop new Lean Construction tools tailored to serve infrastructure construction projects.

Keywords: Lean Construction; Infrastructure; Ashghal Enhanced Projects; Parade of Trades; Visual Management

1 Introduction

Although, Lean Construction tools, started and developed in building projects are utilized in infrastructure projects, insufficient attention has been paid for developing new tools particularly tailored for infrastructure projects. Infrastructure projects have a particular characteristics that differentiate it from building projects: it covers larger horizontal area, more affected by weather conditions, as it has no envelope to control the weather within the project's limit; has more interfaces with and impact on the public community. The previously mentioned characteristics denote that special cause variations would more affect infrastructure projects than building projects. Accordingly, there is an essential need to develop particular tools, tailored for infrastructure projects, focusing on minimizing the impact of special cause variations and maximizing owner's values.

Visual Management (VM) is a strategy for information management strongly related to one of the

core concepts of Lean production, which is increasing the process transparency and enhance shared understanding. In addition, the Parade of Trades (PoT) simulation game introduces concepts of sequential dependence and process variability in order to illustrate the detrimental impact such variability has on a system's performance (Tommelein, 2020). Deep utilities in infrastructure projects have a sequence of construction activities matching with the PoT model.

Public Work Authority (Ashghal), introduced Lean in construction programme as a part of their enhanced projects' contract form, intended to minimize project disruption and maximize residences satisfaction. This paper presents practical endeavour of developing a new VM tool; based on the Parade of Trade simulation idea, tailored for a programme of infrastructure projects worth approximately 1.7 billion QAR in the State of Qatar.

2 Pot as a Powerfull Learning Tool

The use of games in engineering teaching is common practice in classes with lecturers all over the world (Biotto, et al. 2021). PoT has been an iconic simulation game in teaching Lean main principals for three decades. The purpose of this game is to demonstrate the impact variability and dependence have in a construction environment where multiple trades follow each other in a linear sequence and work output by one trade is handed off to the next trade (Choo & Tommelein, 1999). Greg Howell used the Parade of Trades Game at the 6th Annual Conference of the International Group for Lean Construction. The Lean Construction Institute has been using it at many of their workshops, and the Associated General Contractors of America (AGC) have it as a part of their lean construction education program. As described by Bolivar A. Senior, (2011), it is a powerful learning tool showing the effects of dependency and variability in consecutive trades operating in a construction project. Therefore, PoT simulation game became a fundamental element of enhanced project's Lean Construction training. The game is physically played at the projects by both: Contractor and Supervision Consultant construction management teams; in order to elevate shared understanding, increase relatedness between project team members and focus on enhancing the project as a whole. The game highlighted the effectiveness of batch planning and clarified the efficiency paradox as explained by (Modig & Ahlstrom, 2021). Three rounds played simulating: the impact of variations on construction flow, the impact of bottle necks even with providing additional resources, and the enhancement of construction flow by working in small batches.

3 Development of the New VM Tool

From early on, visual management VM has been a fundamental pillar of the Toyota Production System (TPS) and subsequently in Lean applications (Koskela et al., 2018). Mental operations, such as communication and decision-making are strictly seen waste in production; they are not adding value to the customer. Through VM, communication and decision-making can be accelerated. On the other hand, the higher reliability of VM translates into lower variability. Thus, VM has emerged as an intrinsic part of lean production as it is compatible with its first principles (Koskela et al., 2018). In Ashghal enhanced contract form, VM is included as one of four elements of Lean Construction Implementation Programme. Thereafter, the idea evolved for developing a new tool particularly tailored for the infrastructure construction activities. The focus of the new tool was to: maximize client values, support construction management decisions and enhance the project delivery as a whole.

3.1 Maximizing Client Values

The Associated General Contractors of America (AGC, 2013), describe Lean Construction as a set of ideas, practiced by individuals in the construction industry, based on the holistic pursuit of continuous improvements aimed at minimizing costs and maximizing value to client, (Forbes & Ahmed, 2020). Accordingly, maximizing clients’ value was the starting point towards developing a new tool.

Two of the main values addressed in Ashghal enhanced contract are: residents’ satisfaction, and disruption management. Open trenches for prolonged time affects both values. Open trenches accompanied as well with: HSE hazardous, operational costs, and impact on site look and feel. The foregoing justified why open trenches are a major concern for Ashghal. Subsequently, minimizing the length and the duration of open trenches is one of Ashghal’s main targets.

3.2 Selection of Activities to be Presented

Deep utilities in infrastructure projects have a sequence of construction works typical to the PoT simulation model. In addition, deep utilities present an average of 53% of the project’s total construction duration as shown in Table 1. An improvement in deep utilities construction duration certainly will contribute the most to the improvement of the project’s overall duration.

Table 1: Deep Utilities Duration Relative to Project’s Overall Duration

Project	A	B	C	D	E	F
Total Duration (months)	39	28	36	28	40	36
Deep Utilities Duration (months)	22	14	18	14	22	20
Deep Utilities Relative Duration to Project’s Construction Duration (%)	56.4	50	50	50	55	55.5

Accordingly, deep utilities related activities were selected for the application of the new VM tool. However, with each activity measured in a different unit, there is a need to develop a new measuring unit to link between different activities and be the base for data presentation.

3.3 The Need for a New Measuring Unit

A contractor typically measures the progress of different construction activities by different units; pipe laying (by linear meter), excavation (by cubic meter), backfilling (by ton) or based on specific layer thickness by (square meter), and surrounding material (by tons). The typical progress reporting methods of plan vs actual quantities, will not explain the interaction between different activities nor correlate between different units. The typical highlighted progress on a layout drawing needs considerable mental operations and time to correlate between–location, activities, corresponding quantities for different utilities and will not show the before and after conditions. Accordingly, there was a need for a reference-measuring unit that correlates between different activities and can be visually presented in a simple and clear way.

Hereafter the “Linear Meter of Trench” became a new measuring unit for deep utilities activity progress. Regardless of trench’s; depth, width, number or size of pipes; progress reported in linear meter of trench, e.g., two parallel pipes laid in the same trench for one meter reported as one linear meter of trench pipe laying; similarly, backfilling of three different utilities in the same trench

reported as one linear meter of trench backfilling. Complete accepted work only considered to report progress. Accordingly, a new VM graph was developed and standardized for progress reporting.

4 Results and Discussion

A new graph, Flow of Activities (FoA), developed based on the new measuring unit as shown in Figure 1, which represent a matured status of the project after utilizing the FoA graph.

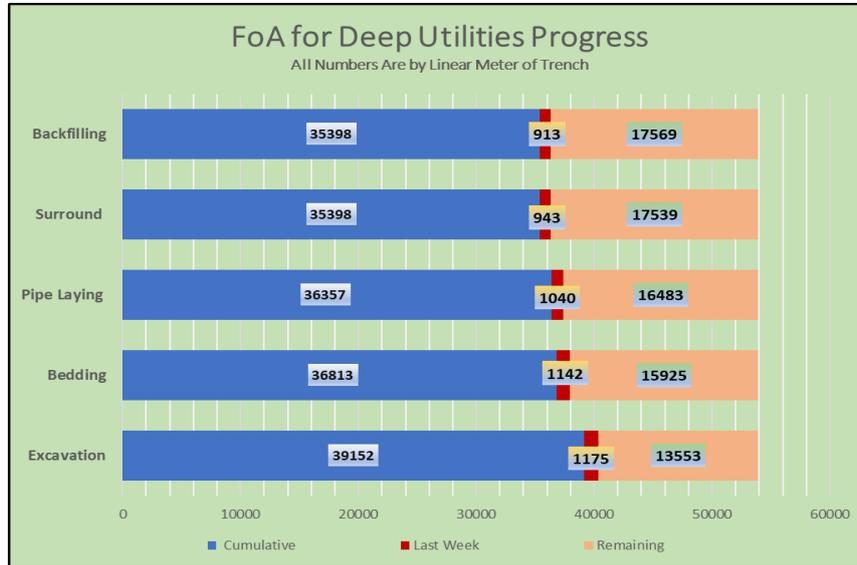


Fig. 1: FoA for the Deep Utilities' Activities

The FoA presented deep utilities; Foul Sewer (FS), Ground Water (GW), and Surface Water (SW) activities as physically constructed; from bottom to top; plotted over a scale referenced to the new measuring unit: linear meter of trench. It presented for each activity: cumulative length completed, last week length completed, and remaining length till the end of project. Major activities visualised for the project; interaction and dependence are clear in one page. It showed the progress of each activity relative to its predecessor and successor activity. It gave guidance for: which activity has an open front work, which activity is blocked, which activity is proceeding faster than the others, which activity needs more resources or even less resources to slow down and direct its resources to another activity.

When the FoA started to be used, a clear gap identified between excavation and subsequent activities; rate of progress of each trade was found different from the others; some activities found with no open front work, as predecessor and successor activities have almost the same completed quantity. Furthermore, through the first few weeks, pipe laying activity was identified to be the pace maker of the progress. Pipe laying and connection's production rate controlled the ability to achieve more progress with other activities. Hereafter, GEMBA Walk took place to identify probable gaps in pipe laying and connection process, followed by Value Stream Mapping (VSM) for pipe laying and connection, to find better methods for increasing productivity. Furthermore, it was noticed that; while resources increased and excavation work became more efficient; there were no considerable improvements in final product delivery (trench backfilling). Hence, efficiency paradox became clear. All the foregoing gave the project management quick reference for effective decisions making related to: resource allocation and material utilization. In addition, open trench status is clearly displayed with numbers, which is a client's main value.

The FoA included project's visual KPIs: A ladder shape in the graph, is an indicator of open front work for all activities; having on the graph approximately the same thickness of the weekly progress, is an indicator of effective utilization of resources and smooth flow of work; increase in the thickness of weekly progress, is an indicator for productivity improvement; In addition; the difference between completed excavation and backfilling quantities present the project open trench status, and the volume of Work In Progress (WIP); both are client's main concerns.

One of the added values of the FoA is the determination of the work batch size. Working in small batches is a key factor to speedy delivery and reduction of WIP. The determination of the batch size has been a challenge, as it has no theoretical method of determination. However, with the new graph the batch size can be determined by interpreting the weekly progress (by linear meter of trench) to a particular quantity of work for each separate activity and allocate the required resources accordingly. Furthermore, batch size will be a reference for short-term planning and further improvement. For over a year the project's Percent Plan Completed (PPC), for the first project started to implement FoA, which was between 85% to 95%.

The utilization of the FoA extended to cover road works and micro-tunnelling work as well. Furthermore, it could be used to support takt planning in determining the preliminary takt time and takt zones for infrastructure projects.

5 Conclusion

This paper provides an example of developing new VM tool for infrastructure projects. It illustrates practical method for determining construction batch size. It can be used further to identify the preliminary takt time and takt zones for takt planning purposes in infrastructure projects. VM provide better shared understanding and guidance for decision making, more than the traditional methods. There is still considerable room of enhancement for lean construction implementation that requires more studies from researchers and practitioners to develop innovative Lean tools to serve the particular conditions of infrastructure projects.

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