LEAN DESIGN MANAGEMENT IN A MAJOR INFRASTRUCTURE PROJECT IN UK

Bruno Mota, Clarissa Biotto, Athar Choudhury, Simon Abley and Mike Kagioglou
Introduction

- Design management has been left to improvisation: (Freire and Alarcon 2002)
  - Poor communication among stakeholders
  - Incomplete documentation for the subsequent process
  - Unclear input information
  - Poorly levelled resources
  - Unbalanced workloads
  - Lack of coordination between different disciplines
  - Erratic decision making

- Lean process, tools and methods have been developed for the design management to improve these deficiencies (Ballard and Koskela 1998), (Freire at al. 2002), (Koskela et al. 1997)
  - Design Structure Matrix (DSM)
  - Last Planner System (LPS)
Introduction

- This paper presents:
  - A case study of lean design management implementation in a major infrastructure project in the UK
  - 2 phases:
    - In phase 1 - Collaborative Planning with LPS
    - In phase 2 - DSM incorporated into the Gives & Gets tool, supported by a control room.

- Identify the main benefits of implementing lean design management into a major infrastructure project, its limitations and room for improvement.

- The main contribution of this paper is the contextualisation of two different project organisational structures and its influence on the success of the LDM tools implementation.
Literature Review

- **Design Management**
  - The design process in the AEC industry is known for being problematic: High levels of rework, change orders, delays and un-constructible solutions for construction (Emmitt et al. 2004), (Macomber et al. 2012).

- In an AEC project, design management is a challenging effort that must deal with increasing architectural complexity, a high number of interdependencies, uncertainty, and erratic decision-making by authorities and clients (Koskela et al. 1997).

- In construction projects is often carried out under time pressure which requires a proper planning and control system, with a focus on information flow among participants (Tzortzopoulos et al. 2001)

- **Lean Design Management (LDM)** is a response from the lean construction community to overcome the chaotic design process.
  - It is rooted in the Transformation, Flow and Value (TFV) Theory (Koskela 2000),
    - it considers the design as a production process (Ballard 2002; Ballard and Koskela 1998).

- A set of tools and methods is recommended to facilitate design management and enhance transparency
  - The Design Structure Matrix (DSM) and the Last Planner System (LPS) have been deployed in lean design management with some success (Koskela et al. 1997).
Literature Review

Last Planner System in Design

- LPS in design promotes process transparency, designers’ collaboration and communication, and the use of project performance measurement. (Biotto 2018)

- LPS requires more flexibility and adaptation to the design context (Hamzeh et al. 2009), (Bolviken et al. 2010; Tiwari and Sarathy 2012)
  - High amount of change orders or delays in the clients’ decisions,
  - Difficulties in the lookahead plan, analysing the root causes, and planning the design activities (Biotto 2018)

- In the UK, the partial use of LPS is known as Collaborative Planning Limited to a few elements of the LPS - Use in the design is scarce (Daniel et al. 2017)

Design Structure Matrix

- Design Structure Matrix (DSM) to support the flow view in design management.

- The DSM is a network modelling tool for visually representing elements of a system and their interactions and supporting the decomposition and integration problems (Browning 2001; Eppinger and Browning 2012).

- DSM can be applied in different contexts
  - product development, project planning, project management, systems engineering and organisation design
Project and Joint-Venture (JV) Descriptions

- Europe’s largest infrastructure project - New high-speed railway (UK)
  - 555km of new track (Birmingham, Manchester and Leeds)
  - From July 2017 to be completed in 2033 (expected)
- When fully operational, the railway should carry:
  - 100 million passengers a year,
  - Up to 48 trains running per hour
  - 25 stations served directly.

- JV - Section between Birmingham and London - main civil work contract
  - 80km section
  - 17 viaducts
  - 22km of road diversions
  - 75 overbridges
  - 24 million cubic metres of excavation.

- At the JV office, there were 165 employers divided into 19 functions: Procurement, Finance, Safety, Logistics, Risk, among others.

- All functions were responsible for:
  - Receiving the drawings from the design subcontractor - DJV
  - Producing deliverables to the owner, e.g. drawings, reports of cost, accessibility, logistic, environmental, programme, risk, health and safety.

- The authors of this paper were lean consultants for the JV,
  - Facilitate the production of these deliverables through the lean design management in the scheme design phase of the project.
  - The consultancy focused on integrating the production from different functions, planning and control the information flow, reducing the lead-time, rework, and times of gathering information.
LDM Implementation Process

- Phase 1
  - JV Functions working in ‘silos’
  - Independent schedules
  - Unbalanced workload
  - No collaboration (JV, DJV and owner)

- Phase 2
  - Co-located
  - Mixed in working groups
  - Type of Deliverable (Programme, cost, structure, etc.)
LDM Development – Phase 1

- Collaborative Planning (CP) Sessions
  - Set goals
  - Define main phases
  - Pull key activities

- 2 sessions
  - 32 Functions leads
  - 19 different functions + Owner and Design Team

- Identify interdependencies
- Improve sequence of activities
- Create unified and optimized plan
LDM Development – Phase 1

- Last Planner
  - Weekly meetings for each Function
LDM Development – Phase 1

- Make-Ready Planning
  - Identifying and removing constraints
- Commitment Planning
  - Control ‘last week’ and commitment ‘following week’
  - PPC and Reasons for non-completion
LDM Development – Phase 2

- Gives & Gets
  - Adapted Design Structure Matrix
  - Similar to constraint analysis on the LPS
    - Responsible, deadline and status
  - Integrated to the programme
- Heat Map
LDM Development – Phase 2

- Control Room (Obeya)
  - Visual Management
  - Graphics and Charts
    - Programme
    - Cost
    - Milestones
    - progress-to-date information
- Results as a team
  - Accelerated decision making
  - Encouraged collaboration
  - Increased transparency
## Discussion: Comparing Phase 1 vs. Phase 2

- Collaboration culture among teams
- Stakeholder involvement
- Acceptance of project context
  - changes in requirements and deadlines

<table>
<thead>
<tr>
<th></th>
<th>LDM in Phase 1</th>
<th>LDM in Phase 2</th>
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</thead>
<tbody>
<tr>
<td><strong>Project organisation</strong></td>
<td>Silos: over the wall approach (segregated functions)</td>
<td>Cross-functional teams (OPTs)</td>
</tr>
<tr>
<td><strong>LDM method to Master Planning</strong></td>
<td>Collaborative Planning Sessions to integrate different functions schedules</td>
<td>Primavera P6 file</td>
</tr>
<tr>
<td><strong>LDM method to Make Ready Planning</strong></td>
<td>Adapted LPS (integrated meetings)</td>
<td>Gives &amp; Gets</td>
</tr>
<tr>
<td><strong>LDM method to Weekly Planning</strong></td>
<td></td>
<td>Primavera P6 file</td>
</tr>
<tr>
<td><strong>Visual management</strong></td>
<td>CP post-its; Charts of metrics (only electronic report)</td>
<td>Control Room; Gives &amp; Gets cards and panel</td>
</tr>
<tr>
<td><strong>Meetings frequency</strong></td>
<td>Weekly</td>
<td>Weekly</td>
</tr>
<tr>
<td><strong>Metrics</strong></td>
<td>Constraints status, PPC, Reasons for non-completion</td>
<td>Deliverables status</td>
</tr>
<tr>
<td><strong>Number of people involved</strong></td>
<td>165 people</td>
<td>≈ 250 people</td>
</tr>
<tr>
<td><strong>Co-located work</strong></td>
<td>No. Only the same function employees.</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Discussion: Comparing Phase 1 vs. Phase 2

- **Phase 1**
  - Better control (weekly metrics)
  - Focus on activities, commitments and constraints
  - Collaborative Session – only opportunity to visualise relationships and constraints between functions

- **Phase 2**
  - Change structure – ‘silos’ to working groups
  - Co-location
    - Enhanced problem-solving
    - Process more agile
  - Gives & Gets
    - Better engagement and number of constraints
  - Fewer control measurements
  - Control Room – fundamental support for visual management
LDM Results

- **Key Benefits**
  - Organisational culture and structure
    - Changes in the organisational structure facilitated the planning of constraints and improved staff engagement
  - Effective communication
    - High participation in sessions
    - Commitment to weekly meetings
  - Teamwork
    - Increased collaboration

- **Limitations**
  - Lack of Lean knowledge
  - Several change orders
  - Lack of collaboration (Working in ‘silos’)  

- **What to improve**
  - Better requirements management
  - Change management (deliverables)
  - Lean training
  - Feedback data from weekly plans to master plan
  - Combine Last Planner with Gives & Gets
Conclusions

- Improvements in short time (7 – 8 months) - Lean efforts are worth

- Lean Design Management is a suitable effort for improving performance and embedding a continuous improvement culture

- The project had effectively adapted Lean to the Design phase

- Phase 1
  - Collaborative Planning sessions was crucial to integrate different Function schedules
    - Difficult to visualize the constraints across the Functions
  - LPS was important to formalize the planning and control process – providing metrics for continuous improvement

- Phase 2
  - Structure into cross-functional teams - Better collaboration
  - Facilitated visualization of constraints among teams – DSM matrix and Gives & Gets tool
  - Fewer metrics
  - Control room enhanced visual management
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