

# **The Combination of Project Construction Management and Lean Construction Techniques in the Architectural Project**

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**Abstract.** Main goal of Project Construction Management and Project Management is to delivery a project within scope, times and costs planned, obtaining a high quality standard. Instead, Lean Construction is focused on minimizing waste, in favor to creating maximum value for the client. The question to which this empirical research wants to answer is following: the integration of Project Construction Management and Lean Construction techniques could affect positively the respect of times and costs planned? To answer to the question it ideated a method that integrates the techniques of two methodologies. Then it applied in the architectural project of simulation in order to show the potentiality of the method. The workflow divided into three stages. At first stage, they identified the individual assegnments through Work Breakdown Structure. At second stage, it defined the Organizational Breakdown Structure. At last stage they planned the construction times and costs through Priced Bill of Quantity, Cost Breakdown Structure, Gantt Chart and Last Planner® System. The hypothesis on expected results deriving from the application of the method and they could led to thinking an improvement of project performance in terms of times and costs planned, respect to only Project Construction Management techniques. Future researches could be experimental, involving enterprises ed implementing the methodology in real study cases, using also the Building Information Modelling.

**Keywords.** Project Construction Management, Project Management, Project Manager, Lean Construction, Last Planner® System, Method, Workflow, Times and Costs

## **1. Introduction**

The ideation of several Project Management techniques and the introduction of new normative in the law in force, show the problems that in Europe and mostly in Italy, troubling the public and private works of Architecture Engineering & Construction (AEC) sector. A situation in which, low quality of architectural design, usually is combining with large construction times and costs overrun. In last years indeed, Project Construction Management (PCM) traditional techniques proved to be ineffective to guarantee the success of many construction project. In particular it estimated that the phenomenon of cost overrun regard to transport infrastructure projects, occurs 9 out of 10 projects [1]. Although, they are usually used in the practice, show some limits that cannot satisfy new needs of construction sector. On the other hand, these same limits have generated the first step toward the change, necessary to promote into enterprises the adoption and diffusion of new methodology of PCM that go beyond the

limits of traditional techniques. One of these methodologies is Lean Construction (LC). LC is a project management approach that adapts the principles and techniques of lean manufacturing to construction process. This document proposes the integration of PCM and LC techniques applied in an architectural project of simulation, to show the potentiality of the methodology itself. This empirical research motivated from the problems described previously and from a few applications of PCM in Italy. Indeed, the majority of experimental applications drove in Anglo-Saxon and Asian (Hong Kong, Japan, Singapore) country. The document starts with a short introduction about Project Construction Management and Lean Construction, then resumes the research question, purpose and proposed method. At the end there are the hypothesis on expected results and future researches.

## **2. Project Construction Management**

### *2.1. Project Management: an Overview*

Project Management is a results-oriented management system. It can be defined as "complex management of a single and determined enterprise, aimed at achieving a clear and predefined goal through a continuous process of planning and controlling differentiated resources and with interdependent cost-time-quality constraints. [2] 'The Project Manager (PM) plays a critical role in the leadership of a project team in order to achieve the project's objectives. This role is clearly visible throughout the project. Many PMs become involved in a project from its initiation through closing. However, in some organizations, a PM may be involved in evaluation and analysis activities prior to project initiation. These activities may include consulting with executive and business unit leaders on ideas for advancing strategic objectives, improving organizational performance, or meeting customer needs. In some organizational settings, the PM may also be called upon to manage or assist in business analysis, business case development, and aspects of portfolio management for a project. A PM may also be involved in follow-on activities related to realizing business benefits from the project. The role of a PM may vary from organization to organization. Ultimately, the project management role is tailored to fit the organization in the same way that the project management processes are tailored to fit the project'. [3]

### *2.2. Project and Building Life Cycle*

'A project life cycle is the series of phases that a project passes through from its start to its completion. A project phase is a collection of logically related project activities that culminates in the completion of one or more deliverables. The phases can be sequential, iterative, or overlapping. The names, number, and duration of the project phases are determined by the management and control needs of the organization(s) involved in the project, the nature of the project itself, and its area of application. Phases are time bound, with a start and end or control point. The project life cycle can be influenced by the unique aspects of the organization, industry, development method, or technology employed. While every project has a start and end, the specific deliverables and work that take place vary widely depending on the project. The life cycle provides the basic framework for managing the project, regardless of the specific work involved. Though projects vary in size and the amount of complexity they contain, a typical project can be mapped to the following project life cycle structure: Starting the project, Organizing and preparing, Carrying out the work, and Closing the project'. [4] Instead, a typical building project can be mapped to the following building life cycle structure: Briefing, Planning, Design, Construction, Use/ Maintenance/ Adaptation and End of Life/ Disposal. [5]

### 2.3. Project Construction Management, Techniques and Tools

According to E. Fregonara, 'Project Management activities along the building life cycle can be grouped into two main groups: Project Construction Management, which consists of operations that fall into the preliminary phase/ pre-construction (from briefing to design phase) and the executive phase/ site (construction phase); Asset, Property and Facility Management, which consists of all real estate asset management operations (referring to individual buildings and/or real estate assets)'. [6] 'Compared to the building life cycle, PCM develops along the Briefing, Planning, Design and Construction stages, articulating in as many stages which managed through some most traditional techniques': [7] 1. Planning. PM at this stage is particularly important because he involves identifying the needs to be met, defining the objectives, developing the feasibility analysis and estimating the direct and total costs; 2. Programming. PM use techniques like as Work Breakdown Structure (WBS) and Organization Breakdown Structure (OBS) in order to identifying Work Package (WP) and developing Responsibility Assignment Matrix (RAM). He defines the logical sequence of works, logic-temporal connection and constraints. Then is involved with: construction times planning, through techniques like as Gantt Chart, Program Evaluation and Review Technique (PERT), Critical Path Analysis (CPA); costs planning, through Priced Bill of Quantity (PBoQ); economic planning though budget, discounted cash flow (DCF), risk and variance analysis and Cost Breakdown Structure (CBS); 3. Execution – 4. Monitoring and Control. PM check construction progress report, work accounting, monitors times-costs through Earned Value Method and replans the works if it's necessary. [8]

## 3. Lean Construction

### 3.1. An Introduction

During a seminar in 1992, L. J. Koskela brought to the attention of reference community, the limits of the traditional Project Management model based on the relationship between time, cost and quality to lay the foundations of a new theory. [9] Then, in 1993 it founded the International Group for Lean Construction (IGLC). Between 1992 and 1998, scholars as like G. Ballard and G. Howell demonstrated other anomalies of traditional management, such as only 50% (Percent Plan Complete) of weekly scheduled work assignments were completed by the end of the same week. [10] L. J. Koskela in 2000 noted that the discrepancy between conceptual models and observed reality, underscored the weakness behind the apparent efficiency of traditional management and signaled the need for a new model of manufacturing in the construction industry. This model is based on new three components: Transformation (T), Flow (F), and Value Generation (V) from which it borned the TFV theory of production. [11] In 2002, L. J. Koskela and G. Howell reviewed existing gaps in traditional construction process management, reworking planning, execution, and control methods. [12] On the one hand, there was recognition by many, because construction processes are reflected in prototypes of complex and chaotic behavior, especially with regard to the flow of information in and out of the construction site. This analysis led to another scholar, S. Bertelsen in 2003, to suggest for the construction management the use model and systems of chaos theory. Furthermore, according to the same scholar, the construction projects can be considered as a production process, but also as a diverse set of agents, operations and social system. [13] And so, 'Lean 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'. [14] C. T. Cain in 2004 suggested that LC can be defined by six goals: [15] 1. The building will offer maximum functionality in order to satisfy final client; 2. Final client will benefit of construction in favor of the most low cost; 3. Elimination of inefficiency and resources waste; 4. Involving from the beginning of project, materials provider for the integration and the buildability; 5. A single contact point in terms of design and construction in order to have more efficient coordination and clarity of responsibility 6. Establish day by day the performance to improve the results through measurement. There are many tools and techniques that belonging to LC. The technique object of this paper is Last Planner® System.

### 3.2. *The Last Planner® System*

‘The Last Planner (LP) is the person or group that makes assignments to direct workers. ‘Squad boss’ and ‘discipline lead’ are common names for last planners in design processes. ‘Superintendent’ (if a job is small) or ‘foreman’ are common names for last planners in construction processes’. [16] In effect, assignments prepared by Last Planners™ are directions for their crew and promises (commitments) to others that makes close coordination possible. [17] Main purpose of LPS is to increase the productivity in a construction process. It bases on a pull system, which allows resources to complete an assignment only if the process itself allows it. It can be understood as a mechanism for transforming what should be done into what can be done. [18] LPS develops on different detail levels and stages: 1. Should; 2. Can; 3. Will; 4. Did. [19] At first level the assignments are planned in long term, instead from second to third detail level the assignments are planned in near term. Should level corresponds with Master and Phase Planning stages, in which they will define the milestones of entire project and the necessary task to complete them. Can level corresponds with Six Week Look Ahead Planning (6WLA) stage, in which they will remove the constraints (Documents, Equipment, Staff, Purchases, Customer, Quality, Security) of next six working week. Will level corresponds with Weekly Work Planning (WWP) stage, in which it will plan a detail Weekly Work Plan. Did level corresponds with Learning stage, in which the PMs together LPs must will understand why (if) the activities included in the Weekly Work Plan (if) have not been 100% completed.

## 4. Research Question and Purpose

The difference between described methodologies is in the methodology itself, that are basic principles that impose the use of different techniques. Indeed as wrote previously, the foundation of classic PCM/PM are the respect of scope, times and costs, instead LC is focused on minimizing waste in favor to creating maximum value for client. The question to which this empirical research wants to answer is following: the integration of PCM and LC techniques could affect positively the respect of times and costs planned? Ideated method in this paper tried to answer the question. This method applied in an architectural project of simulation, that is innovative elementary school (object of master’s thesis in architecture) for Santa Maria a Vico (CE), Italy. Main purpose was describing the possible differences, deriving from empirical observations, between the work presented in this document and the hypothesis that times-costs would planned through only PCM techniques.

## 5. Proposed Method

The workflow used at planning phase and it divided into three different stages: 1. Identifying the individual assignment through the Work Breakdown Structure (WBS); 2. Defining the organizational structure through the Organizational Breakdown Structure (OBS); 3. Costs planning through the Priced Bill of Quantities (PBoQ), the Cost Breakdown Structure (CBS) and times planning through the Gantt Chart and LPS. The project management techniques just mentioned applied also to construction site, structural and system projects in order to have a complete overview about project.

### 5.1. *Identification of Individual Activities*

At first stage, the individual activities deconstructed and analytically defined through WBS, by creating a simplified logical path based on the subdivision operation, operating at successive levels. The structure follows a hierarchical order; indeed, the school project broke into four others projects (macro task): 1. Construction Site; 2. Structural; 3. Architectural; 4. Systems. Then each project broke into the micro task.

### 5.2. Definition of The Organizational Structure

At second stage, it defined the organizational structure. Central was the technique known as the OBS, which usually accompanies the WBS through the organization of responsibilities. Through OBS it was possible to assign for each task the responsibility, that is the construction companies responsible of each specific task.

### 5.3. Cost and Time Planning

At last stage, they planned the construction times and costs. The latter planned through the PBoQ, with the support of a regional public work price list (2018). This was partially useful, because most work prices calculated as new with the analysis of production factors, considering for each work skilled workers, safety obligations by 3%, overhead expenses by 15% and builder profit by 10%. The main reasons are pushing to calculate new prices were two: 1. the price list used doesn't include prices of work which the project needs; 2. some of the work price are too generic compared to the work requested by project. The PBoQ drew-up for each project (site, structural, architectural and plant) respecting the previous WBS. Once planned the costs they broke into a Cost Breakdown Structure (CBS) for each project and activity, in order to have a global view of project costs. Instead the construction times planned at the four stages of the Last Planner® System, two in long term and the other two in short term with support of Gantt Chart: 1. Master Planning. In which the post-it® with different colors represented the milestones and different project, linked to each other with arrows that indicating the logical sequence of construction. Milestone represented the beginning and end of each project and sub project; 2. Phase Planning. In which Milestones broke into more detail activity, in order to achieve what is decided in Master Planning. Meanwhile the milestone and the assignments resumed also in Gantt Chart; 3. Make Ready Planning. In which the first six working weeks planned with Gantt Chart and analyzed in order to remove most of the constraints related to documents, equipment, personnel, purchases, customer, quality and security; 4. Weekly Work Plan. In which it planned a first Weekly Work Plan of the project.

## 6. Expected Results Hypothesis and Future Researches

Traditional PCM techniques, doesn't forecast the exchange of information between all construction process stakeholder, including also unskilled and skilled workers. Furthermore, PM at the planning stage plan in complete autonomy and compare the work done with others or superior manager, neglecting completely who will materially realize planned works. Instead in our case, the Last Planner® System impose the sharing of information, mostly with workers, creating an integrated approach that together others practices and techniques could be led to Integrated Project Delivery. [20] In addition, it's a system that in the practice could provide the indications about why was made mistakes and consequently understand how can we doesn't make more them.

It's possible to hypothesize the methodologies together, could provide positive results in terms about respect of times and costs. Because PM plan the activity and costs at first phase and at second phase plan construction times together also the workers, obtaining waste reduction of resources, detailed planning with good probability (together the costs) they will be respected. In addition, the integration of Gantt Chart and LPS offer two modality of time schedule visualization. Mostly the first, are only hypothesis formulated from the application of methodology in the academic architectural project. A next step of scientific research could be confirming this hypothesis conducting an experimental research involving real enterprises and applying the methodology in the different study cases. Another research could focus on use of Building Information Modelling (BIM) methodology.

**References**

- [1] B. FLYVBJERG, S. BUHL, K. M. SKAMRIS: Underestimating Costs in Public Works Projects: Error or Lie? *J. of the American Planning Association*, ISSN 0194-4363, 68 (3), 279-295 (2002).
- [2] R. D. ARCHIBALD: Project Management. La Gestione di Progetti e Programmi Complessi. La Gestione di Progetti e Programmi Complessi (10<sup>th</sup> Edition), ISBN 9788846451798 (2008).
- [3] PROJECT MANAGEMENT INSTITUTE: A Guide to the Project Management Body of Knowledge (6th Edition), ISBN 9781628253924, p. 54, Newtown Square, Pennsylvania, (2017).
- [4] PROJECT MANAGEMENT INSTITUTE, op. cit., pp. 547-548 (2017).
- [5] E. FREGONARA: Evaluation Sustainability Design Life Cycle Thinking and International Orientations, EAN 9788891765185, p. 19 (2015).
- [6] E. FREGONARA, op. cit., p. 176 (2015).
- [7] E. FREGONARA, op. cit., pp. 178 (2015).
- [8] E. FREGONARA, op. cit., pp. 179-194 (2015).
- [9] L. J. KOSKELA: Application of the New Production Philosophy to Construction. Technical Report # 72. Center for Integrated Facility Engineering Department of Civil Engineering, Stanford University, CA (1992).
- [10] G. BALLARD, G. A. HOWELL: Shielding Production: Essential Step in Production Control. *J. of Construction Engineering and Management*, Vol. 124, No.1 (1998).
- [11] L. J. KOSKELA: An Exploration Towards a Production Theory and its Application. Espoo 2000. Technical Research Centre of Finland, ISSN 1455-0849, VTT Publications (2000).
- [12] G. BALLARD, G. A. HOWELL: The Underlying Theory of Project Management is Obsolete. Proceedings of the PMI Research Conference, Seattle, Washington, USA (2002).
- [13] S. BERTELSEN: Complexity - Construction in a New Perspective e Construction as a Complex System. Eleventh Annual Meeting of International Group for Lean Construction. Blacksburg, Virginia, USA (2003).
- [14] L. J. KOSKELA, G. A. HOWELL, G. BALLARD, I. TOMMELEIN: The Foundations of Lean Construction, in R. Best & G. De Valence (eds.), *Design and Construction: Building in Value*, ISBN 978-0750651493 Oxford, UK (2002).
- [15] C. T. CAIN: Performance Measurement for Construction Profitability. ISBN 978-1405114622 Blackwell (2004).
- [16] G. BALLARD, I. TOMMELEIN, F. HAMZEH: The Last Planner Production Workbook-Improving Reliability in Planning and Workflow (2007).

- [17] G. A. HOWELL: A Guide to the Last Planner™ for Construction. Foremen and Supervisors, Lean Construction Institute. Retrieved 01, April, 2020 from:  
<<http://www.leanconstruction.org/media/docs/wpapers/tools/LastPlannerguide.pdf>>
- [18] G. BALLARD: The Last Planner™ System of Production Control. Doctoral thesis, University of Birmingham, School of Civil Engineering. Birmingham, U.K. (2000).
- [19] LEAN COSTRUCTION INSTITUTE: The Last Planner® Business Process Standard and Guidelines. Retrieved 03, April, 2020 from:  
[https://www.leanconstruction.org/media/docs/chapterpdf/israel/Last\\_Planner\\_System\\_Business\\_Process\\_Standard\\_and\\_Guidelines.pdf](https://www.leanconstruction.org/media/docs/chapterpdf/israel/Last_Planner_System_Business_Process_Standard_and_Guidelines.pdf)
- [20] AIA: Integrated Project Delivery: A Guide AIA. Retrieved 05, April, 2020 from:  
<[https://help.aiacontracts.org/public/wp-content/uploads/2020/03/IPD\\_Guide.pdf](https://help.aiacontracts.org/public/wp-content/uploads/2020/03/IPD_Guide.pdf)>