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BENEFITS OF LAST PLANNER® SYSTEM IN MITIGATION OF DELAY CAUSES IN ROAD INFRASTRUCTURE PROJECTS

SANCHEZ, Omar G. (1); CASTAÑEDA , Karen M. (2); HERRERA, Rodrigo F. (3); PELLICER, Eugenio (4)

(1) Universidad Industrial de Santander, +5776344000, omar.sanchez@correo.uis.edu.co; (2) Universidad Industrial de Santander, +5776344000, karencasta.ing@outlook.es; (3) Pontificia Universidad Católica de Valparaíso, Pontificia Universidad Católica de Chile +56944132109, rodrigo.herrera@pucv.cl; (4) Universitat Politècnica de València, +34963879562, pellicer@upv.es

ABSTRACT

Delay is a phenomenon that affects road infrastructure projects around the world with serious consequences. The study of methodologies that allow mitigate delay causes is a key issue. One option is Last Planner® System (LPS) that is a collaborative planning method that improves the fulfillment of construction activities in time. LPS has the characteristics for mitigate delay causes in early stages and avoid delays happening during the projects. This study analyzes delay causes mitigation through LPS implementation in road infrastructure projects. The research method consisted in: literature review of the main delay causes in road infrastructure projects, benefits identification of LPS implementation in 10 road projects and analysis of relations between delay causes and LPS benefits. The results indicate that many delay causes in road infrastructure projects have relation with: financial difficulties by owner, shortage of materials, inadequate contractor experience. On the other side, the implementation of LPS provides benefits in: time reduction, improvement in communication, early identification of problems and others. Relations between delay causes and benefits show that LPS is an efficient tool for mitigate delay causes in road infrastructure projects.

Keywords: *Delay causes, Delay factors, Road infrastructure, Last Planner System.*

1 INTRODUCTION

Timely completion of road infrastructure projects is considered one of the most important success factors (Aziz & Abdel-Hakam 2016), however, deliver projects within schedule and budget has been a challenge in the construction industry. Amoatey & Okanta (2017) found that about 70% of road projects are affected by delays and 52% by cost overruns. This failures have caused that many professionals and researchers intent to identify and mitigate the causes of the problems. In search for delay causes, defects in planning has been identified as a critical factor that contribute to delay in road construction projects (Karunakaran et al. 2018).

Within project planning methods, Last Planner® System (LPS) has had great acceptance. LPS is a planning system that procures the reduction of workflow uncertainty (Ballard 2000) through four levels of planning (Alarcón & Pellicer 2009): 1) master schedule, 2) phase schedule, 3) look-ahead planning and 4) weekly work plans. Fernandez et al. (2013) studied 26 construction projects with LPS implementation; the benefits identified were: 1) smooth workflow, 2) predictable work plans, 3) reduced

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cost, 4) reduced time of project delivery, 5) improved productivity, and 6) greater collaboration with field personnel and subcontractors. Nevertheless, LPS has been implemented mainly in building projects, while in road infrastructure projects the use has been scarce (Ahiwako et al. 2015).

Considering this gap, the goals of this paper are, on the one hand, to identify benefits of LPS implementation in road infrastructure projects and, on the other hand, to identify delay causes in road infrastructure that could be mitigated with LPS implementation. The research method consisted on a literature review of delay causes in road infrastructure projects, later an analysis of cases study of road infrastructure projects with LPS implementation and, finally, an analysis of the relations between delay causes and LPS benefits.

2 MATERIALS AND METHODS

The review of delay causes in road infrastructure projects was through a systematic review with three inclusion/exclusion criteria for the document selection: 1) study of delay causes in construction projects, 2) ranking of 10 most important delay causes and 3) type of project (road infrastructure). A total of 295 documents were collected and finally 15 were selected for in-depth analysis (see Table 1); all of them were focused on road infrastructure projects. The selection of delay causes came from the 10 most important causes reported in the 15 documents selected; the process consisted in assign an inverse rank (IR) according to the rank reported (RR). For example, Aziz & Abdel-Hakam (2016) report: owner financial problems with rank 1, thus inverse rank is 10; shortage in equipment with rank 2, thus inverse rank is 9.

$$IR = 10 - (RR - 1) \quad (1)$$

Table 1 – Studies on delay factors of road infrastructure projects by country

Country	Reference
Algeria	(Rachid et al. 2018)
Cambodia	(Santoso et al. 2016)
Egypt	(Aziz & Abdel-Hakam 2016)
Ghana	(Amoatey & Okanta 2016)
India	(Venkateswaran & Murugasan 2017)
Iraq	(Hadithi 2018)
Kenya	(Seboru 2015)
Lybia	(Youniss et al. 2017)
Malawi	(Kamanga & Wynandsteyn 2013)
Malaysia	(Karunakaran et al. 2018)
Nigeria	(Omoregie & Radford 2006)
Pakistan	(Sohu et al. 2019)
Palestine	(Mahamid et al. 2012)
Saudi Arabia	(Elawi et al. 2015)
Thailand	(Thapanont et al. 2018)

The delay causes were grouped by similarity, obtaining an overall important rank (OIR) from the sum of individual inverse ranks (IR) for each k delay cause. Finally, the 10 delay causes with higher OIR were selected (see Table 2).

$$OIR_k = \sum_{i=1}^{15} IR_i \quad (2)$$

Table 2 – Main causes of delay on road infrastructure projects

Id	Delay cause	*OIR*
D1	Financial difficulties by owner	107
D2	Shortage of materials	69
D3	Inadequate contractor experience	56
D4	Weather	46
D5	Land acquisition	44
D6	Failures in design	41
D7	Shortage in equipment	41
D8	Inadequate project planning	38
D9	Poor site management	55
D10	Delays in activities	29

3 BENEFITS OF LPS IMPLEMENTATION IN ROAD PROJECTS

The identification of LPS benefits was performed through an analysis of the literature of studies implementing LPS applied to road infrastructure projects. The initial sample consisted of about 50 cases and most of them were discarded because they were focused on building projects. The final sample were comprised of 10 cases (see Table 3) located in: Africa, Asia, Europe and South America. Most cases come from the UK, where Highways England (a governmental agency responsible for the operation and maintenance of England's highways) has implemented successfully LPS in road infrastructure projects (Fullalove 2013); Highways England has the target of £1.2 billion cost savings using Lean techniques (including LPS), from 2015 to 2020 period (Sullivan 2016).

Table 3 – Studies on LPS implementation in road infrastructure projects

Case	Reference	Project	Stage with LPS	Location
C1	(Ansell et al. 2007)	3 miles of carriageways renewal	Design, Construction	UK
C2	(Jang et al. 2007)	Nam Chun Highway project	Construction	South Korea
C3	(Jang et al. 2007)	Seoul Ring Road project	Construction	South Korea
C4	(Olano et al. 2009)	7 km highway construction	Construction	Peru
C5	(Chen et al. 2012)	Asphalt laying on the A1 Dishforth to Leeming	Construction	UK
C6	(Chen et al. 2012)	The M53 Bidston Moss viaduct strengthening	Design, Construction	UK

Table 3 – Studies on LPS implementation in road infrastructure projects (cont.)

C7	(Fullalove 2013)	28 km of dual carriageway construction	Construction	UK
C8	(Ahiwako et al. 2015)	4 km standard single carriageway road construction	Construction	Nigeria
C9	(Daniel 2017)	Upgrade to replace dual carriageway with a three lane motorway	Design, Construction	UK
C10	(Daniel 2017)	Improve motorway to smart motorway	Construction	UK

Table 4 displays the benefits of LPS implementation. Some of these benefits of LPS implementation are: reduction of variability, improvement in team motivation, empowerment of the project team, early participation of stakeholders, reduction of equipment usage, risks reduction, better production control, opportunity for buildability/constructability review, improvement of quality, re-work reduction, and more efficiency in the construction process.

Table 4 – Main benefits of LPS implementation in road infrastructure projects

Id	Benefit of LPS implementation	Project code
B1	Reduction of time duration of construction activities	C1,C4,C5,C6,C7,C8,C9,C10
B2	Improvement in communication and transparency among the project's stakeholders	C2,C3,C6,C7,C9,C10
B3	Early identification of key barriers	C1,C5,C6,C7,C8,C10
B4	Safety improvement	C5,C7,C8,C9,C10
B5	Cost reduction	C5,C6,C7,C9
B6	Collaboration in decision-making	C2,C3,C8,C9
B7	Improvement planning and the reliability of plans	C1,C4,C7,C8
B8	Improvement of the workflow reliability	C4,C6,C7
B9	Design improvement	C6,C9
B10	Logistic improvement	C5,C8

4 RELATION BETWEEN DELAY CAUSES AND LPS BENEFITS

The next step was identify relationships between delay causes (10 identified in Table 2) and benefits of LPS implementation (10 identified in Table 4). The result was a matrix with 45 relations displayed in Table 5.

Table 5 – Relationships between delay causes and LPS benefits

Id	Delay cause	Benefits of LPS in road projects*									
		B1	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**	**B9**	**B10**
D1	Financial difficulties by owner			✓		✓					
D2	Shortage of materials		✓	✓				✓	✓		✓
D3	Inadequate contractor experience				✓		✓				
D4	Weather			✓			✓	✓			
D5	Land acquisition			✓			✓	✓	✓		
D6	Failures in design		✓	✓			✓			✓	
D7	Shortage in equipment		✓	✓				✓	✓		✓
D8	Inadequate project planning	✓	✓	✓	✓		✓	✓		✓	
D9	Poor site management	✓	✓	✓	✓		✓	✓			
D10	Delays in activities	✓		✓	✓		✓	✓	✓	✓	✓

* Codes according to Table 4.

Inadequate project planning, poor site management and delays in critical activities are the causes of delays in road construction that can be reduced or mitigated by the greater amount of LPS benefits. This is because LPS is a tool that allows to standardize the management in an engineering project using a collaborative and gradual approach (Ballard & Howeell 2003). Collaboration generates transparent work environments that strengthen trust among team members, achieving reliable commitments in the fulfillment of tasks based on real and updated information (Salazar et al. 2018). The gradual planning allows to have updated information to execute the tasks in the medium and short term. A better communication and transparency between the team members allows to manage correctly both, early stages and the construction site (Rodríguez et al. 2011).

The shortage of materials or equipment can be reduced when applying LPS, since with this tool it is possible to identify restrictions to progress in order to anticipate and minimize these problems. In addition, if the planning and workflow is reliable, it is possible to have a defined logistics for the delivery of materials and availability of machinery and equipment (Zegarra & Alarcón 2013). In the same way it is possible to anticipate failures in the design, since the verification of the design is a restriction that must be released in the look ahead planning before the planning of any activity in the short term schedule (Matta et al. 2018).

On the other hand, there are some causes of delay such as financial difficulties by owner and land acquisition that are more difficult to solve with LPS, since they depend on a different level of planning. However, if these causes are considered as restrictions, it can be anticipated in the phase plan or in the look ahead planning; the objective is not making decisions before these key factors are solved and, therefore, not assuming costs for having idle workforce. The inadequate experience of the contractor is difficult to solve with the application of LPS in the project execution; however, if collaborative decision making is implemented in early stages, the choice of contractor may be more appropriate. Finally, weather is a cause of delay that cannot be eliminated, but it is possible to plan considering this factor when defining resources for short-term activities.

5 CONCLUSIONS

Benefits of LPS implementation in road infrastructure include, among others (Table 4): 1) reduction of time duration of construction activities; 2) improvement in communication and transparency among the stakeholders on the project; 3) early identification of key barriers to progress and anticipate, minimizing daily problems; and 4) improvement in safety. The delay causes in road projects that are possible to mitigate with LPS implementation are, among others (Table 5): 1) delays in activities; 2) inadequate project planning; 3) poor site management; and 4) shortage of materials and equipment. Results show that LPS implementation in road infrastructure projects has the potential for mitigate delay causes through an improvement in planning activities. The limitations were the low number of road infrastructure projects with LPS implementation reported in the literature and the lack of studies of delay causes of road infrastructure projects in Europe and America. Future works can focuses in exploration, analysis and categorization of the relationships between LPS benefits and delay causes.

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