ISSN: 2643-6876

DOI: 10.33552/CTCSE.2022.09.000711

Current Trends in Civil & Structural Engineering

Iris Publishers

Review Article

A Review on the Implementation of Lean Thinking in the Construction Industry

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Received Date: November 09, 2022

Published Date: December 14, 2022

Abstract

The impact of the construction wastes results in project delay, low productivity of construction projects, construction cost overrun, and disputes among construction players. The lean construction offers enormous advantages to reduce construction waste. However, lean construction in Malaysia is still new and not fully adopted. This is due to lack of effective strategy in adopting lean construction at construction phase

Background of the Study

The low productivity of construction projects construction, cost overrun, low quality of end projects, and project delay are the four main construction problems lead to project failure. Most problems are due to weak waste management in the construction stage. This shows that building waste management is one of the crucial elements that lead to the success of the management of construction projects. As a result, many attempts have been made by construction players particularly by the project team (contractor, architect, developer, and consultant) to improve quality at the construction phase through the implementation of lean construction.

Current Implementation of Lean Construction

On the basis of construction industry, local contractors, ranging from the smallest to medium class up sized project are not ready yet to utilize lean construction in this country. This is due to the use of LC between them is still low, as well as the LC philosophy that has not yet been fully explained to the public. However, PWD pointed that the Association of Consulting Engineers Malaysia (ACEM) hopes that LC can be properly practiced by the entire project team, where it reduces construction waste in the construction projects and therefore provides more quality and efficiency for projects in Klang Valley, Malaysia. Lean construction is dominated by an obsession with eliminating waste from all business processes, while the process that adds value to output will maximize to provide satisfaction to customers. The main steps advocated by lean production to cut down waste to achieve customer value can be categorized as follows. First, set up the infrastructure to accommodate variations should they occur (people and equipment) by modularity. Second, the production system should drive design where possible (concurrent engineering). Third, eliminate the variation through production processes in order to ensure time delivery. Fourth, do it right the first time (eliminate rework). Finally, continuous improvement or kaizen (emphasize measurement).

Therefore, for Malaysia construction industry, Building Information System (BIM) is very efficient, and advanced technique for Modularity and Industrial Building System and (IBS) is used to drive design where possible. Building Information Modelling (BIM), Supply Chain Management (SCM) and Conference Management

(CM) are used to eliminate the variation by insuring ensuring on time material delivery at the construction phase. Also, Total Quality Management (TQM) and Building Information Modelling (BIM) are used to get things at the first time. Lastly, Key Performance Index (KPI) and Health and Safety management (HS) are utilized for continuous improvement. Therefore, lean construction principle can only be applied fully and effectively in the construction sector in Malaysia by focusing on the improvement of the whole process and the detailed explanation of the implementation of these techniques as shown below. This means that all parties must be engaged, involved and strive to overcome the obstacles that could arise from traditional contractual arrangements.

Barriers in Implementing Lean Construction

Lean Construction has been involved in providing many benefits to the construction industry in Klang Valley, Malaysia. However, there are many barriers to LC implementation in construction projects, such as fragmentation, legal and contractual issues related to LC, costs of implementing LC, training and skills, lack of knowledge of LC and lack of an effective strategy to implement LC. Detailed explanations of the barriers to the implementation of the LC are given as follows:

Lack of effective strategy to implement LC

Lean construction adoption model, processes and guidelines are examples of an effective strategy for using LC in construction sites. Therefore, the lack of use of the standard process is one of the main obstacles that prevent construction teams from adopting LC in their construction sites. In particular, construction teams in a developing country such as Malaysia require a standard guidance form as an assistant or adoption model to help construction teams use LC properly and accurately.

Lack of top management support

The support of top management, especially senior management, plays a crucial role in obtaining lean construction implementation benefits. Senior management should devote sufficient time and resources to provide an appropriate strategy to implement Lean construction strategy. However, Eastman stated that the reluctance of senior management to provide true leadership as a key barrier in the development of LC's model and guidelines. While CIDB added that the most serious obstacle is existing with middle management rather than the top management of the companies. The full benefits of Lean construction are not as clear to middle-management as they are to top management. In other words, their level of experience and training is generally not sufficient to enable them to make fundamental changes to the conventional method. Their effective role increases productivity accelerates delivery and reduces potential challenges.

Cost issues

One of the barriers preventing LC from being implemented in construction projects is related to cost issues. The main cost is the cost for training. Most construction firms have refused to implement LC completely and effectively because they need to invest in new LC tools and techniques. This is because the cost of adopting LC tools are very expensive. Zakaria showed that the total cost of adopting BIM technology in the construction project is 1 to 5 percents of the total project budget. As a result, construction firms have refused to adopt BIM software, and they also need to provide some amounts of money to train their staff on BIM.

Skill and Knowledge Issues

Knowledge and skills issues are also known as one of the obstacles to the effective and full implementation of LC. This barrier is related to the knowledge that is required to integrate the implementation of new technologies of LC and its techniques. These types of barriers occur when different construction teams refuse to learn and attend Lean construction courses. They refuse to pursue LC knowledge because the cost of attending LC or training courses is expensive, and it would take some time to complete the training. Moreover, there is no encouragement from its managers, particularly from the middle management, in the practice LC according to its lack of awareness benefits of LC.

Fragmentation

In the construction industry, the sequential flow contributes only to the fragmentation problem, which leads to serious coordination and communication problems within the project team, which ultimately focuses on project performance. Therefore, as one of the main results for the poor performance of the construction industry in Malaysia, that has to be addressed with team building.

Legal or Contractual Issues relating to LC

The traditional procurement system (design and built) is a crucial barrier that prevents the full implementation of lean construction techniques. It seems to create adverse relationships between the different parties involved in the project (all project teams), and therefore, construction waste could be generated and added to the process. These adversarial relationships develop transaction costs that are considered waste, thus hindering the implementation of lean philosophy. All of these barriers to LC implementation in Malaysia's construction industry. Participates to prevent the full implementation of LC between construction teams. Therefore, it is crucial to overcome the barriers to increase the implementation of LC in the project [1-121].

Conclusion

The construction industry is less affected by lean construction techniques, due to overwhelming evidence of construction waste during the construction phase, as can be seen in the review. For example, Marhani pointed out that, in the case of Bricklaying in Taman Putra Damai, which is a residential project at Taman Putra Damai in the Klang Valley, the wasted activity represents 43% of the operator's total time. The significance of the study examined by a brick subcontractor, which employs 50 bricklayers, found that the cost of construction waste in this activity is three times the annual profit obtained by the contractor. Thus, it could be argued that there is still a huge opportunity to assess the level of the implementation of lean construction to reduce construction waste.

Acknowledgement

None.

Conflict of Interest

No conflict of interest.

References

1. Abanda FH, Byers L (2016) An investigation of the impact of building orientation on energy consumption in a domestic building using emerging BIM (Building Information Modelling) Energy 97: 515-527.
2. Ahmad Latiffi A, Mohd S, Kasim N Fathi MS (2014) Building Information Modeling (BIM) Application in Malaysian Construction Industry. International Journal of Construction Engineering and Management 2(4A): 1-6.
3. Ahmad Latiffi A, Mohd S (2016) The Development of Building Information Modelling (BIM) Definition. Applied Mechanics and Materials (567): 625- 630.
4. Ahmad MF, Nee PS, Muhd NH, Chan SW (2017) Total quality management practices in Malaysia healthcare industry: A survey results. International Journal of Supply Chain Management 3 (6): 332-336.
5. Abd Jamil AHA, Fathi MS (2016) The integration of lean construction and sustainable construction: A stakeholders' perspective in analyzing sustainable lean construction strategies in Malaysia. Procedia-Computer Science 100: 634-643.
6. Abd Shakur AS, Mohammad MF, Mahbub R, Halil F (2016) Toward improving integration of supply chain in IBS construction project environment. Procedia- Social and Behavioral Sciences 108: 36-45.
7. Ahmed MEA, Wong LS (2018) Assessment of Lean Construction Practice at Selected Construction Sites in Klang Valley. International Journal of Engineering & Technology. 7: 125-130.
8. Akinradewo O, Oke A, Aigbavboa C, Ndalamba M (2018) Benefits of Adopting Lean Construction Technique in the South African Construction Industry. Proceedings of the International Conference on Industrial Engineering and Operations Management Pretoria/Johannesburg, South Africa, pp.1271-1277.
9. Alaloul WS, Liew SM, Zawawi ANW, Mohamoud BS, Adamou M, Musharat MA, (2020) Structral equation modelling of construction project performance based on coordination factor. Cogent Engineering, 1(7): 25-39.
10. Ajaya SO, Oyedele LO, (2018) Waste efficient material procurement of construction projects. A structural Equation Moelling for sucess factors. Waste management, (75): 60-69.
11. American lnstitute of Architects, (AIA) (2007) Integrated Project Delivery: A Guide. AIA California Council, 2010.
12. Alinaitwe HM (2009) Prioritizing lean construction barriers in Uganda's construction industry. J Constr Dev Ctries, 14: 15-30.
13. Arashpour M, Bai Y, Aranda-Mena G, Bab-Hadiashar A, Hosseini R, et al. (2017) Optimizing decisions in advanced manufacturing of prefabricated products: Theorizing supply chain configurations in off-site construction. Automation in construction, 84: 146-153.
14. Arif M, Egbu C, (2010) Making a case for offsite construction in China. Engineering Construction and Architectural Management 6: 536-584.
15. Arunkumar S, Suveetha V, Ramesh A (2018) A feasibility study on the implementation of building information modelling (BIM): from the architects' & en-gineers' perspective. Asian J Civ Eng19 (2): 239-247.
16. Asri MANM, Nawi MNM (2015) Actualizing Lean Construction: Barriers Toward the Implementation. Advances in Environmental Biology 9 (5): 172-177.
17. Azhar S, Khalfan M, Maqsood T (2013) Status of BIM Adoption and the BIM Experience of Cost Consultants in Australia. Australasian Journal of Construction Economics and Building, 12: 15-28.
18. Azhar S (2011) Building Information Modeling (BIM): Trends, Benefits, Risks, and challenges for the ACE Industry. Leadership and Management in Engineering 11: 241-252
19. Aziz RF, Hafez SM (2013) Applying lean thinking in construction and performance improvement. Alexandria Engineering Journal, 52: 679-695
20. Babalola O, Olanipekun A, Babalola O (2019) Assessment of the role of Lean Construction Practices in Environmental. Proceeding of 3rd International Conference on Science and Sustainable Development, Ogun State, Nigeria: International Institute for Sustainable Development, pp. 3321-3329.
21. Bakhary NA, Adnan H, Ibrahim A (2017) Improving construction claim management in Malaysia construction industry. Humanities and Social Sciences Reviews 2(7): 170-179.
22. Bove LL, Johnson LW (2006) Customer loyalty to one service worker: should it be discouraged? International Journal of Research in Marketing, 23: 79-91.
23. Braun V, Clarke V (2019) Reflecting on reflexive thematic analysis. Qualitative Research in Sport, Exercise and Health, 11(4): 589-597.
24. Braun V, Clarke V, Weate P (2017) Using thematic analysis in sport and exercise research. In: Smith B, Sparkes AC (Eds.) Routledge handbook of qualitative research in sport and exercise, pp. 213-227.
25. Bryde D, Unterhitzenberger C, Joby R (2018) Conditions of success for earned value analysis in projects. Int J Proj Manag 36: 474-484.
26. Bryde D, Broquetas M, Volm JM (2013) The project benefits of building information modelling (BIM) International Journal of Project Management 31(7): 971-980.
27. Briosoi X, Humero A, Calampa S (2016) Comparing point-to-point precedence relation and location- based management system in last planner system: a housing project of highly repetitive processes-case study. Procedia-Engineering 164: 12-19.
28. Cao X, Li X, Zhu Y, Zhang Z (2015) A comparative study of environment performance between prefabricated and traditional residential buildings in China. Journal of Cleaner Production 109: 131-143.
29. Carvajal-Arango D, Jaramillo S, Monsalve AP, Hernandez VA, Botero BFL (2019) Relationships between lean and sustainable construction: Positive impacts 121of lean practices over sustainability during construction phase. Journal of cleaner production 234: 1322-1337.
30. Charefa R, Emmittb S, Alakaa H, Foucha F (2019) Building Information Modelling adoption in the European Union: An overview. journal of Building Engineering, 25, 100777.
31. Chidambaram L, Palanisamy L, Leong NK, Wee TK, Leong TK, et al. (2011) Build Smart in Building and Construction (BCA) (2012-2016) Singapore: BCA Academy.
32. Construction Industry Development Board (CIDB) (2013B) Building Information Modeling. Kuala Lumpur CIDB. Construction Research Institute of Malaysia.
33. CIDB Manual Guidelines (2018) Manual for Assessment of Industrialized Building Systems. Kuala Lumpur CIDB. Construction Research Institute of Malaysia.
34. Construction Research Institute of Malaysia (CREAM) (2016) Issues and Challenges in Implementing Building Information Modeling (BIM) by SME's in the Construction Industry. Kuala Lumpur CIDB. Construction Research Institute of Malaysia.
35. Cortes H, Daaboul J, Le Duigou J, Eynard B (2016) Strategic Lean Management: Integration of operational Performance Indicators for strategic Lean management IFAC-Papers on Line 49(12): 65-70.
36. Dam R, Siang T (2019) Affinity Diagrams—Learn How to Cluster and Bundle Ideas and Facts. Arhus, Denmark: Interaction design foundation.

37. Dajadian SA, Koch DC (2014) Waste Management Models and Their Applications on Construction Site. International Journal of Construction Engineering and Management 3(3): 91-98.

38. Dave, Bhargav, Hämäläinen, Juho-Pekka, Koskela, et al. (2015) Exploring the Recurrent Problems in the Last Planner Implementation on Construction Projects. Proceedings of the Indian Lean Construction Conference (p.9) Mumbai, India: Institue for lean construction Excellence. P.122.

39. Demirkesen S, Ozorhon B (2017) Impact of integration management on construction project management performance. International. Journal of project management 35: 1639-1654.

40. Durdye S, Ismail S, Ihtiyar A, Abu Bakar NFS, Darko A (2018) A partial least square structural equation modeling (PLS-SEM) of barriers to sustainable construction in Malaysia Journal of Cleaner Production 204: 564-572.

41. Egan J (1998) Rethinking construction: report of the construction task force. Crown: London.

42. Esa MR, Halog A, Rigamonti L (2017) Strategies for minimizing construction and demolition wastes in Malaysia Resources, Conservation and Recycling, 120: 219-229.

43. Eastman C, Teicholz P, Sacks R, Liston K (2011) BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Constructions. 2nd ed. New Jersey: John Wiley & Son Inc.

44. Fadeyi MO (2017) The role of building information modelling (BIM) in delivering sustainable building. Value International Journal of Sustainable Built Environment 6: 711-722.

45. Fee CK, Nordin N (2016) Analysis of lean management implementation in construction sector. Proceeding of the 6th - 7th Conference in technology, building and construction, Malaysia (pp.322-329**)**: Kula Lumpur, Malaysia: School of Technology Management & Logistics (Universiti Utara Malaysia).

46. Fernandez-Solis JL, Porwal V, Lavy S, Shafaat A, Rybkowski ZK, et al. (2014) Survey of motivations, benefits and implementation challenges of last planner system users. Journal of Construction Engineering Management 139: 354-360.

47. Field A (2013) Discovering Statistics Using IBM SPSS Statistics. SAGE, London.

48. Forbes LH, Ahmed SM (2017) Modern Construction Lean Project Delivery and Integrated Practices first edition. North California: Taylor and Francis Group, LLC. P.123

49. Forbes LH, Ahmed SM (2020) Lean Project Delivery and Integrated Practices in Modern Construction 2nd Edition. London: Routledge.

50. Furneaux C, Kivit R (2017) BIM: Implications for Government. CRC for Construction Innovation. Brisbane Australia: Net Pty Ltd.

51. Garza-Reyes JA, Kumar V, Chaikittisilp S, Tan KH (2018) The effect of lean methods and tools on the environmental performance of manufacturing organizations, International Journal of production economics, 200: 170-180.

52. Gambatese JA, Pestana C, Lee HW (2017) Alignment between Lean Principles and Practices and Worker Safety Behavior. J Constr Eng Manag 143(1): 43-62.

53. Goh M, Goh MY (2019) Lean production theory-based simulation of modular construction processes. Automation in Construction, 101: 227-244.

54. Government HM (2012) Industrial strategy: government and industry in partnership: Building Information Modelling. Wales: England.

55. Haron NA, Dev, P, Hassim S, Alias AH, Tahir MM, et al. (2017) Project management practice and its effects on project success in Malaysian construction industry. Materials Science and Engineering, International Conference on Architecture and Civil Engineering, 291: 012008.

56. Hasmori MF, Said I, Deraman R, Abas NH, Nagapan S, et al. (2018) Significant Factors of Construction Delays Among Contractors in Klang Valley and its Mitigation. Int. J. Of Integrated Engineering, (10) 32-36.

57. Haron AT (2013) Organisational readiness to implement building information modelling: A framework for design consultants in Malysia (Doctoral dissertation, University of Salford).

58. Hossam HA (2016) Survey on exploring key performance indicators. Future computing and informatics journal pp. 47-52.

59. Hsieh Y, Hiang S (2004) A study of the impacts of service quality on relationship quality in search-experience-credence service. Total Quality Management, 15 (1): 43-58.

60. Ibina (2015) BIM Belum Meluas di Malaysia. Kula Lumpur, Malaysia: Association of Consulting Engineers Malaysia.

61. Johonson RC, Eatough EM, Chang CHD, Hammer LB, Truxillo D (2019) Home is where the mind is Family interference with work and safety performance in two high risk industries. Journal of Vocational Behaviour. 110: 117–130.

62. Jong YC, Sim SKA, Lew YT, Nonino F (2019) The relationship between TQM and project performance: Empirical evidence from Malaysian construction industry. Cogent Business & Management, 6(1): 1568655.

63. Kaliannan S, Nagapan S, Abdullah AH, Sohu S (2018) Determining Root Cause of Construction Waste Generation: A Global Contex Civil Engineering Journal 4(11):2539.

64. Kiew PN, Ismail S, Yussof AM (2016) Integration of Quality Management System in the Malaysian Construction Industry. The journal of Organization Management Studies 16: 1-9.

65. Keng TC, Hamza AR (2015) Study of Quality Management in Construction Project. Chinese Business Review, ISSN 1537-1506, 10: 542-552.

66. Kline RB (2005) Principles and Practice of Structural Equation Modelling (2nd ed.) New York: The Guilford Press.

67. Kline RB (2010) Principle and Practice of Structural Equation Modelling. Guildford publication, New York.

68. Kim D, Park HS (2006) Innovative construction management method: assessment of lean construction implementation. KSCE J Civ Eng 10(6): 381–388.

69. Knotten V, Laedre O, Hansen GK (2017) Building design management–key success factors. Archit. Eng Des Manag, 13: 479-493.

70. Kolaventi SS, Momand H, Tadepalli T (2019) Construction Waste in India: A Structural Equation Model to Identification of Causes. Construction waste management. Engineering sustainability 173(6):1-10.

71. Koskela L, Huovila P (1997) On Foundations of Concurrent Engineering. Proc. 1st International Conference on Concurrent Engineering in Construction, The Institution of Structural Engineers, London pp.22-32.

72. Koskela L, Rooke J, Bertelsen S, Henrich G (2007) The TFV theory of production: new. Proceedings of the 15th Annual Conference of the International Group for Lean Construction, (pp2-12) Michigan: Michigan university.

73. Kylili A, Fokaides PA, Jimenez PAL (2016) Key performance approach in building renovation for the sustainability of the environment: review of renewable and sustainable energy. Renewable and Sustainable Energy Review, 56: 906-915.

74. Kothari CR (2004) Research Methodology: Methods and Techniques (2nd Edition) New Delhi: New Age International Publishers.

75. Levy SM (2010) Construction Process Planning and Management: An Owners Guide to Successful Projects. America: Elsevier, Inc.

76. Li S, Wu X, Zhou Y, Liu XA (2017) Study on the evaluation of implementation level of lean construction in two Chinese firms. Renewable and Sustainable Energy Review, 71: 846-851.

77. Liu J, Yi Y, Wang X (2020) Exploring factors influencing construction waste reduction: A structural equation modeling approach. Journal of Cleaner Production 276(4): 123185

78. Mesa HA, Molenaar KR, Alarcón LF (2016) Exploring performance of the integrated project delivery process on complex building projects. Int J Proj Manag 34: 1089–1101.

79. Ma Z, Cai S, Mao N, Yang Q, Feng J, et al. (2018) Construction quality management based on a collaborative system using BIM and indoor positioning. Automation in Construction 92: 35–45.

80. Ma M, Tam VWY, Le KN, Li W (2020) Challenges in current construction and demolition waste recycling: A China study. 118: 610-625.

81. Mafimisebi B, Jones K, Sennaroglu B, Nwaubani S (2018) A validated low carbon office building intervention model based on structural equation modelling. Journal of Cleaner production, 200: 478-489.

82. Maguire M, Delahunt B (2017) Doing a Thematic Analysis: A Practical, Step-by-Step Guide for Learning and Teaching Scholars. Dundalk Institute of Technology, 3 (9): 3351-3364.

83. Maher C, Hadfield M, Hutchings M, de Eyto A (2018) Ensuring rigor in qualitative data analysis: A design research approach to coding combining NVivo with traditional material methods. International Journal of Qualitative Methods, 17 (1): 1–13.

84. Marhani MA, Jaapar A, Ahmad-Bari NA (2012) Lean construction: towards enhancing sustainable construction in Malaysia. Procedia-Social and Behavioral Sciences, 68: 87-98.

85. Marhani MA, Jaapar A, Ahmad-Bari NA, Zawawi M (2013) Sustainability through lean construction approach: a literature review. Procedia - Social and Behavioral Sciences 101: 90-99.

86. Marhani MA, Ahmad-Bari NA, Ahmad K, Jaapar A (2018) The Implementation of Lean Construction tools in Malaysia. Chemical engineering transaction 63: 289-294.

87. Martens A, Vanhoucke M (2017) A buffer control method for top- down project control. European Journal of Operational Research Measurement, 262: 274-286.

88. Martinez-Aires MD, Lopez- Alonso M, Martinez Rojas M (2018) Building information modelling and safety management: A systematic review 101: 11-18.

89. Memon AH, Abdul Rahman I, Abdullah MR, Aziz A, Asmi A (2011) Time overrun in construction projects from the perspective of Project Management Consultant. Journal of Surveying, Construction and Property 2(1): 54-66.

90. Meng X, Boyd D (2107) The role of the project manager in relationship management. Int Jour of Project Management, 5 (35), 717-728.

91. Mohammad MF, Abd Shukor AS, Mahbub R, Hali FM (2014) Challenges in the Integration of Supply Chains in IBS Project Environment in Malaysia Procedia - Social and Behavioral Sciences, 153: 44- 54.

92. Mohammad MF, Baharin AS, Musa MF, Yusof MR (2016) The Potential Application of IBS Modular System in the Construction of Housing Scheme in Malaysia Procedia - Social and Behavioral Sciences ,222: 75-82.

93. Molwus JJ, Erdogan B, Ogunlana S (2017) Using structural equation modelling (SEM) to understand the relationships among critical success factors (CSFs) for stakeholder management in construction. Eng Constr Archit Manag 24: 426-450.

94. Monyane TG, Emuze F, Awuzie BO, Grafford G,(2020) Challenges to Lean Construction Implementation in South Africa. The Construction Industry in the Fourth Industrialpp.Central University of Technology pp.337-344.

95. Müller R, Zhu F, Sun X, Wang L, Yu M (2018) Identification of temporary horizontal leaders in projects: The case of China. Int Journ of project management (36): 95-107.

96. Nitzl CJL, Roldan JL, Cepeda G (2016) Mediation Analysis in Partial Least Squares Path Modeling: Helping Researchers Discuss More Sophisticated Models. Ind Manag Data Syst 116(9): 1849-1864.

97. Nesteby AI, Aarrestad ME, Lohne J, Bohne RA (2016) Integration of BREEAM- NOR in construction projects: utilizing the last planner system. Procedia-Energy 96: 100-111.

98. Nguyen D, Le-Hoai L, Tran DQ, Dang CN, Nguyen CV (2018) Fuzzy AHP with applications in evaluating construction project complexity. In: AR Fayek (Ed.) Fuzzy Hybrid Computing in Construction Engineering and Management, Emerald Publishing Limited, UK, pp. 277–299.

99. Nowotarski P, Pastawaski J, Matyja J (2016) Improving construction processes using lean management methodologies- cost case study. Procedia Engineering 16: 1037-1042.

100. Obradovic V, Bjelica D, Peterovic M, Mihic M, Todorovic M (2016) Whether we are still immature to assess the environmental KPI. Procedia - Social and Behavioral Sciences 226: 132-139.

101. Oetomo W (2016) Model of Influence to D elay Construction Projects of Multistoried Buildings Using Multi-Dimensional of Stage with Analysis of Second Order. J. Basic Appl Sci Res 6(1): 15–25.

102. Ogunbiyi O, Goulding JS, Oladapo A (2014) An empirical study of the impact of lean construction techniques on sustainable construction in the UK, 14(1): 88- 107.

103. Orihuela P, Pacheco S, Orihuela J (2017) Proposal of Performance Indicators for the Design of Housing Projects. Procedia Engineering 196: 498 – 505.

104. Othman I, Ghani SNM, Choon SW (2020) The Total Quality Management (TQM) journey of Malaysian building contractors. Ain Shams Engineering Journal 3: 697-704.

105. Panuwatwanicha K, Tung Nguyenb T (2017) Influence of Total Quality Management on Performance of Vietnamese Construction Firms. Procedia Engineering 182: 548- 555.

106. Pelliecer E, Cervero F, Lozzano A, Tenda JLP (2016) The last planner system for construction planning and control as a teaching and learning tool. Proceeding of the 9th International Technology, Education and Development Conference. Madrid: Web of science, pp. 4877-4884.

107. Pearce A, Pons D (2019) Advancing lean management: The missing quantitative approach, Operations Research Perspectives, 6: 100-114.

108. Piaw PY (2013) Mastering research statistics. McGraw-Hill.

109. Public Work Department (2016) Unit Building Information Modelling (BIM) (2016-2020) Kula Lumpur, Malaysia: Ministry of Works Malaysia.

110. Project Management Institute (2018) A guide to the project management body of knowledge (6th) Philadelphia: Project Management Institute.

111. Ramli MZ, Malek MA, Hanipah H (2018) Study of factors influencing construction delays at rural area in Malaysia. Journal of physics 1049 (1): 1-8.

112. Rahman RAB (2015) Managing Safety at Work Issues in Construction Works in Malaysia: A Proposal for Legislative Reform. Canadian Centre of Science and Education 9(13): 1852-1913.

113. Rosli MF, Tamyez FM, Zahari AR (2020) The effects of suitability and acceptability of lean principles in the flow of waste management on construction project performance. International Journal of construction management 20: 35-53.

114. Unit Perancang Ekonomi (2016) Rancangan Malaysia Kesebelas 2016-2020. Malaysia. Percetakan Nasional Malaysia Berhad.

115. Shakerian H, Dehnavi HD, Shateri F (2016) A framework for the implementation of knowledge management in supply chain management 3rd International Conference on New Challenges in Management and Organization: Organization and Leadership, 230: 176-183.

116. Schoenwitz M, Potter A, Gosling J, Naim M (2017) Product process and customer preference alignment in prefabricated house building, int j. prod econ 183: 79-90.

117. Shang G, Low SP (2014) The last planner system in China construction industry: a SWOT analysis on implementation. International Journal of Project Management 32: 1260-1272.

118. Singh S, Kumar K (2020) A study of lean construction and visual management tools through cluster analysis. Ain Shams Engineering Journal, 1(12): 1153-1162.

119. Tafazzoli M, Mousavi E, Kermanshachi S (2020) Opportunities and Challenges of Green-Lean: An Integrated System for Sustainable Construction. Sustainability 12: 1-12.

120. Tauriainen M, Marttinen P, Dave B, Koskela L (2016) The effect of BIM and lean construction of design management practices. Procedia-Engineering 164: 783-792.

121. Tezel A, Koskela L, Aziz Z (2018) Lean thinking in the highways construction sector: motivation, implementation and barriers. Production Planning & Control 29(3): 247-269.