

EVALUATION CATEGORIES TO MEASURE THE LEAN ADOPTION FOR ORGANIZATIONS

Nozomi James Hirata¹, Robert Leicht², & John Messner³

ABSTRACT

There have been several assessment tools developed to evaluate the adoption of lean in construction industry organizations, but there is no generally accepted approach to consistently measure the adoption. Further, the existing models lack structure and use limited reference to the existing models outside of the construction domain. Some models have also excluded the involvement of industry experts in the development and evaluation process. Capability maturity models have been found to be a valuable approach for self-assessment, continuous improvement, and benchmarking. This study aims to formally identify categories for lean organization adoption as a foundational step to create a maturity model to evaluate the lean maturity of an organization. The authors found a total of 214 different categories in the literature and subsequently grouped, removed, and refined them with assistance from lean experts. This analysis yielded a total of 33 potential categories. These categories were then rated by industry experts to determine their inclusion in the maturity model. Future work will include developing a model, validating it, and disseminating the maturity model to the community.

KEYWORDS

Lean construction, continuous improvement/Kaizen, standardization, organization maturity.

INTRODUCTION

Lean construction has been adopted in the construction industry as a production management-based approach for the reliable and productive delivery of building projects. However, the implementation of lean construction faces challenges for any organization, and assessment tools are expected to help overcome those challenges (Comeli et al., 2019). Several lean assessment tools have been developed, such as the online tool on the LCI website (Lean Construction Institute, n.d.), but despite the availability of tools, there is currently no generally accepted approach for consistently measuring a construction industry organization's adoption of lean construction. Therefore, there is a need to develop a more consistent and adoptable model to better support organizations in assessing and advancing their lean implementation.

Maturity models have been found to be a valuable approach for self-assessment, continuous improvement, and benchmarking. In particular, the Capability Maturity Model (CMM), originally developed in the software sector (Paulk et al., 1993), has been used to evaluate an organization's maturity. The CMM consists of categories to measure maturity and the levels of

¹ PhD Candidate, Department of Architectural Engineering, The Pennsylvania State University, University Park, PA, USA, njh5734@psu.edu, orcid.org/0009-0006-7121-2838

² Professor, Department of Architectural Engineering, The Pennsylvania State University, University Park, PA, USA, rml167@psu.edu, orcid.org/0000-0001-6705-8141

³ Charles and Elinor Matts Professor, Department of Architectural Engineering, Director, Computer Integrated Construction (CIC) Research Group, The Pennsylvania State University, University Park, PA, USA, jim101@psu.edu, orcid.org/0000-0002-7957-1628

each measure to assess strengths, weaknesses, and areas for improvement. In the construction domain, a CMM based on a data-centric approach has been developed to assess the maturity of BIM usage in an organization (Construction Industry Institute, 2021). These models have shown the validity of the self-assessment approach through their implementation.

A foundational step in creating a capability maturity model is to define the categories that measure an organization's maturity. Therefore, this study aims to identify the categories that organizations can use to evaluate their lean adoption to date and to envision the ideal state of lean adoption. Thus, we have reviewed the literature to identify and define categories for measuring the organization's lean adoption maturity. This study contributes to the development of an accessible and reliable tool for evaluating lean adoption within an organization. Also, this study contributes to the community by showing specific maturity categories to improve lean adoption.

EVALUATION OF LEAN MATURITY FOR ORGANIZATIONS

Several studies have developed evaluation tools for assessing lean construction adoption in organizations. The Lean Construction Institute (n.d.) created a web-based tool for users to assess and access useful online resources. However, this tool does not provide clear measures or provide organizational maturity as an output of an organization's lean adoption level. Pakdil & Leonard (2013) developed a leanness assessment tool that combines qualitative and quantitative performance dimensions. However, they did not validate the model or engage industry experts, thereby limiting its potential applicability. Wong et al. (2014) proposed an integrated lean index based on the performance determinants of cost, quality, and on-time delivery. Then, they identified the enablers of those target outcomes, however, there were no experts involved to verify or validate the findings in this process. Nesensohn et al. (2014, 2016) developed a lean construction maturity model framework comprising six high-level factors and eleven key attributes. They validated the framework with focus groups via semi-structured interviews. However, this model does not give a clear description of each maturity level score, as in the model of Construction Industry Institute (2021). For example, ambiguity persists in the distinction between level 2 and level 3 of a single measure, which could limit scalability. Li et al. (2017) evaluated the level of lean construction in two Chinese firms that focused on lean methods. However, this evaluation is based solely on the adoption of technical methods associated with lean and does not consider organizational aspects, such as customer orientation. De Carvalho & Scheer (2017) documented the use of the DOLC (Degree of Lean Construction) in Brazil. DOLC uses 11 types of waste from Koskela (1992) to measure the level of performance and validated the model with the industry practitioners. However, this model lacks a clear description of each maturity level. Collectively, these studies demonstrate a wide range of approaches but also reveal inconsistencies in validation, scope, and maturity definition.

Ghosh & Heidenreich (2018) proposed a conceptual framework for measuring an organization's lean capability, predominantly focused on lean methods such as the Last Planner System. Comeli et al. (2019) developed an audit protocol comprising dimensions of four categories, fifteen evaluation items, and sources of evidence. However, this model focused only on literature from the construction domain, neglecting organizational research and practice from other industries. Cano et al. (2020) created a model that put emphasis on the relations between maturity elements. The elements were identified through inputs from LC literature and LC experts. However, the model lacks a definition of maturity levels, which limits its practical applicability for systematic assessment. Mohamed (2021) created a roadmap to assess lean organizations and proposed a lean construction assessment tool focused on adoption in Middle Eastern countries, developed through brainstorming with project teams. Asadian et al. (2023) focused on the continuous improvement approaches along with trade contractors. This focused on the approaches or processes of continuous improvement. Khan et al. (2024) identified 15

elements for lean construction implementation in trade contractor organizations. 15 elements were identified under 4P model from Liker (2004). The primary focus of this study was on trade contractors. Also, they focused on construction literature. The National Highways (2025) encourages suppliers to develop their own program based on the Highways Excellence Lean Maturity Assessment (HELMA). This tool focuses on providing customer value through lower costs, higher quality, and faster delivery. However, this framework focuses on lean supply chain principles and does not give sufficient attention to people or other unique construction organization challenges. The summary of these models is shown in Table 1. The authors specifically identify the limited number of project-based organizational evaluation models and highlight their limitations in organizational assessment. Taken together, these limitations highlight a gap in validated, clearly defined, and organization-focused maturity models applicable across project-based construction contexts.

Table 1: Comparison of models in the literature

Author	Lean Construction Institute (n.d.)	Pakdil & Leonard (2013)	Wong et al. (2014)	Nensensohn et al. (2014, 2016)	Li et al. (2017)	De Carvalho & Scheer (2017)	Ghosh & Heidenreich (2018)	Comeli et al. (2019)	Cano et al. (2020)	Mohamed (2021)	Khan et al. (2024)	Asadian et al. (2023)	National Highways (2025)
Criteria													
Used a Maturity Model		√		√		√	√	√			√		√
Has a Rigid Structure		√	√	√		√		√	√		√	√	√
Resource Outside Domain		√	√	√			√						
Clarity on Each Maturity Level													√
Validated with Industry Experts				√	√	√		√		√	√	√	
Organization Focused	√	√	√	√		√		√	√	√	√	√	√

The authors also reviewed the resources on lean adoption for organizations outside of the construction domain. The Lean Advancement Initiative (2012) has developed an enterprise self-assessment tool (LESAT) to assist in the enterprise transformation process by providing a structured tool. It uses the Capability Maturity Model format with detailed instructions on how to use the tool. Although it emphasizes enterprise transformation, it includes a structured evaluation consistent with the enterprise approach, which was initially developed and described by Nightingale & Mize (2002). This model has been validated through multiple implementations in the aerospace industry. Almomani et al. (2014) proposed a model of lean assessment and developed a lean radar tool to visualize the leanness score. Silverio et al. (2020) created a lean index based on the lean wheel system elements (Pessoa and Trabasso, 2016), indicating that each lean element works in concert with other elements. They have a concise definition of all the lean elements described in the model. Pakdil & Leonard (2014) developed a lean assessment tool that employs both quantitative and qualitative approaches to assess lean implementation. They used fuzzy methodology to evaluate both quantitative and qualitative measures. They also used a radar chart to visualize the current performance level. One finding was that all the noted studies emphasized the importance of assessing the current state in their future planning.

These enterprise-level papers highlight the importance of considering the embedding culture that enables a lean organization in the long term. Osman & Norani (2021) designed a tool to measure the level of lean culture. They insisted that using a self-administered questionnaire is the practical way to measure the level of lean culture to promote lean transformation. They defined five dimensions of lean culture: organizational environment, effective communication, teamwork, problem solving, and innovation. Urban (2015) created a lean management maturity model for an organization, emphasizing organizational culture, based on the perspective that culture reflects lean management advancements along the lean journey. The Shingo Institute (2025) developed the Shingo model, designed to guide an organization's cultural transformation toward ideal results. They have 10 principles that serve as the basis for building a lasting culture and achieving organizational excellence.

Based on these reviews, the authors adopted a structured categorization to select the evaluation elements for the maturity model. Resources outside of the construction domain are used in this research, and the categories are validated with industry experts.

RESEARCH PROCESS

The categories for the maturity model are chosen through the following sequence. The authors have searched databases from Engineering Village, the Lean Construction Journal (LCJ), and IGLC, then selected 14 resources from the construction domain that have categories to evaluate organizations with a maturity model. Since the categories for collection reached saturation, the authors expanded the search to include 10 additional resources outside the construction domain to consider broader possible categories for evaluating an organization's lean adoption. The saturation was determined by the frequency with which the same categories appeared more than 5 times, and adding resources did not help add new categories. The framework for the model uses the 4P model from Liker (2004): Philosophy, Process, People, Partners, and Problem-solving. This model was selected because the 4P model was created specifically to evaluate organizations and establish an organized structure. Additionally, this high-level structure will ensure the authors do not miss any organizational elements for evaluation. Once all the possible categories were identified, including checks for similar words or related terms for the same description, the authors consolidated the elements into filtered categories. Each filtered category contains similar words or descriptions that may vary slightly in wording but not in meaning, leaving the opportunity for industry experts to suggest better-fitting descriptions for these categories later in the process. For example, there was a filtered category of "customer

focus”. This was consolidated from the following identified categories: customer focus, customer, focus on value creation, voice of customer, customer value, create value for customer, and organizational values.

The authors assembled industry experts in lean construction. This lean expert team consists of owners, designers, general contractors (GC), construction managers (CM), and trade representatives to guide discussion, provide suggestions, and to validate the lean assessment categories for the maturity model. All participants are lean champions in their organization, all with deep involvement in the Lean Construction Institute (LCI) research committee, or the Communities of Practice (CoP) of LCI. They each have more than 15 years of experience in lean construction. There was an individual interview with each expert to set the expectations of this project. Then, workshops were held with the whole group using an online meeting tool for one hour on each development benchmark. Those benchmarks are: after the initial literature review, after creating the list of categories, and so forth. There is a total of 7 meetings with a total of 6 hours at this point, and more are planned as this project continues. After the initial discussion on the categories identified in the literature, experts helped by rating the categories and providing suggestions for adding or eliminating categories based on their experience. The rating was sent out as a survey, with a scale from 1 to 5, with 5 being most important, as shown in Figure 2.

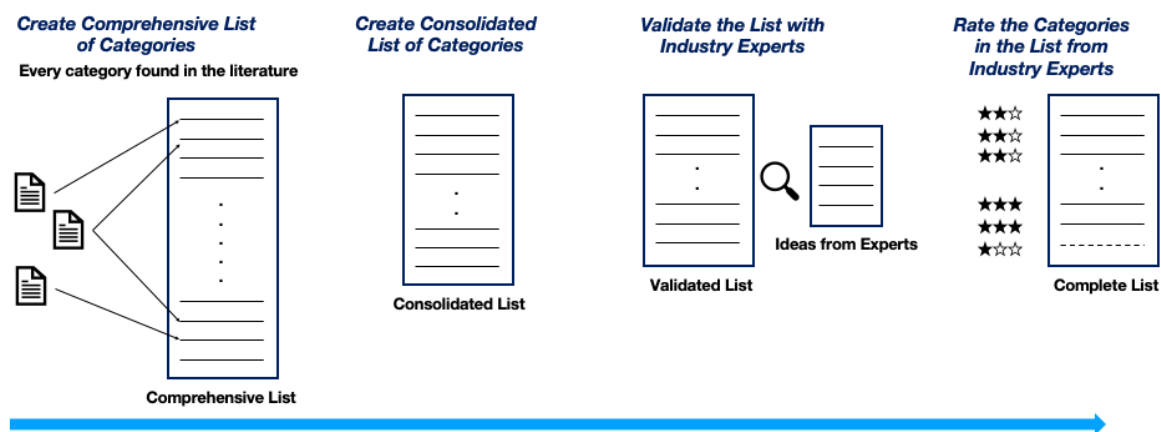


Figure 1: Development of categories to evaluate lean maturity models

Higher-Level Category 1 of 4: Philosophy

Please rate the importance of categories below.

2. Customer Focus *

Definition: The individual engaged in a conversation for action who will receive the results of performance either requested from, or offered by, the Performer. I.e – the person receiving goods/information from a performer. Customers can be internal (a foreman receiving answer to an RFI, Architect receiving mechanical loads from engineer), and external (end users, client organizations, etc). <https://leanconstruction.org/glossary/>

Also found in the literature as: Customer, Focus on value creation, Voice of the Customer, Customer Value, Create value for customer, Organizational values

☆ ☆ ☆ ☆ ☆

Figure 2: Example of forms to collect ratings and suggestions from industry experts

PRIMARY RESULTS AND DISCUSSION

The comprehensive list created consists of 214 different categories to measure an organization's maturity. These were organized under the Liker's 4P model, and similar words were grouped together to create the consolidated list. This consolidated list consists of 33 categories: 9 under the high-level "Philosophy" category of the 4P model, 14 under "Process", 6 under "People and Partners", and 4 under "Problem Solving". An example of the consolidated list is shown in Table 2. Comparing this list to the literature, such as LCMM, provides topical coverage sufficient to facilitate the expert discussion. This list was validated with the ideas provided by industry experts during the first brainstorming meeting to ensure its comprehensiveness. The consolidated list was then used to solicit ratings from industry experts on the perceived importance of measuring the lean adoption of organizations.

Table 2: Example of consolidated list of categories for evaluation

High-level Category	Category	Other terminology found in the literature
People and Partners	Lean Leadership	Leadership, Organizational Commitment, Deployment Management and Lean Infrastructure, Management Support, Field leaders
	Teamwork	Effective Communication, Organizational Environment, People Involvement, Inclusion of Employees at All Level, Employee's Involvement, Accounting Support for lean, Learning and Growth for Internal Clients, Employee Issues, Empowering People
	Supplier Engagement	Manage Relationship with Suppliers / Supply Chain, People and Partners, Supply Chain, Learning and Growth for Supply Chain, Supplier
	Training	Competencies, Technical and Leadership Training, Learning, Competences and Capabilities Across the Organization, Workshops/Training Offered to Employees, Cross Functional Employees, People Development, Organizational Capability, Learning and Competency Development
	Culture	Company Culture, Management Culture
	People	Organizational Enablers, Process Enablers, People Treatment, Human Resources, Respect Every Individual, Lean with Humility, Promote People, Develop Leaders and Grow Coaches

Based on the rating, the authors first considered excluding the categories with a mean score of less than 4. Then, the categories that are duplicated with higher-level categories were grouped together. Categories with highly varied ratings were carried forward for further discussion in the workshop. The results of this process are shown in Figure 3, which presents the distribution

of importance ratings for each category, including the mean, median, and min–max range across responses. It highlights both consensus and variability, as well as the impact of excluding outliers or discussion-based adjustments on the mean ratings. For example, the Last Planner System (LPS) showed significant variation, with some experts rating it as 1 and others as 5. Some argued that LPS is a project-level method and should not be included in organizational maturity, while others viewed it as a system that enables the deployment of lean principles across projects. Similarly, the category of business results was debated, with some suggesting it should be tied to lean decision-making, while others argued that its impact is difficult to measure quantitatively, such as through Return on Investment (ROI). These topics were further refined through workshop discussions. The group selected 20 categories for inclusion in the model. However, these selections are based on the initial rating and will be reevaluated based on future adoption and feedback.

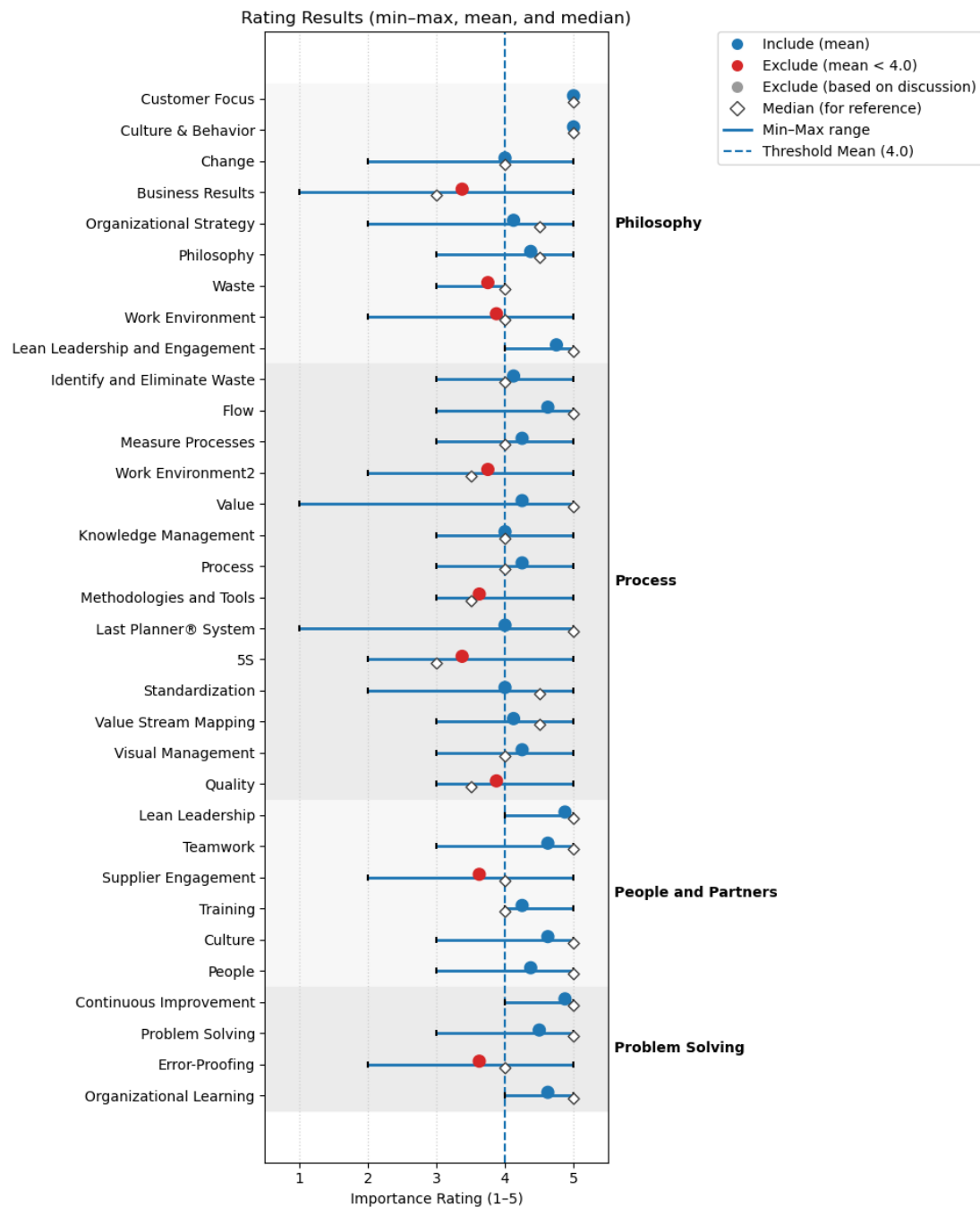


Figure 3: Full consolidated list with the rating and inclusion/exclusion

CONCLUSION

The authors reviewed articles on the maturity levels of lean organizations, both specific to construction and drawn from other domains. As a fundamental step, the authors followed a rigorous process to identify and define categories for evaluating organizations' lean maturity, selecting and refining all possible categories. The resources used to select the categories included the unique considerations for construction and project-based organizations as well as literature from other domains. The developed list was refined using expert experience and feedback to create a consolidated list. Then, the consolidated list was validated using scores from experienced construction industry experts. Finally, the categories in the consolidated list were rated by industry experts to determine which to include in the model.

LIMITATION AND FUTURE WORK

These identified categories will be used to create a draft maturity model. This model will then be validated through case studies involving several organizations. These categories and the detailed measures under them will evolve through adoption. After refinement, reflecting feedback from the initial case studies, this maturity model will be shared with the community. This model contributes by aggregating a combination of elements regarding where the organization stands, both from construction and project-based work, as well as from organizational literature, and potentially offering direction to advance the unique challenges of construction industry lean maturity. Once benchmarking data has been obtained, the authors intend for users to review the data periodically to evaluate their lean journey. For potential impact and adoption, it is necessary to make this model accessible to a wider range of users. One way to achieve this is to create a supplemental document to support the model's use.

The authors acknowledge the limitations of this study thus far, given the ongoing nature of the development process. The work published does not account for differences in organizations' scope of work, such as design or trade contractors. Also, there may be a bias due to the selection and participation of the experts. However, the authors intend to create broader applications and refinement through future steps to improve the reliability and generalizability.

ACKNOWLEDGEMENTS

The development of the ideas presented in this paper was supported in part by research funding from the Lean Construction Institute. The authors also acknowledge the industry advisory group for their support of this project. All support is gratefully acknowledged. Any opinions, findings, conclusions, or recommendations expressed in this paper are those of the authors and do not necessarily reflect those of contributors to LCI.

REFERENCES

- Almomani, M., Hadi, A., Mumani, A., Momani, A., & Aladeemy, M. (2014). A proposed integrated model of lean assessment and analytical hierarchy process for a dynamic road map of lean implementation. *The International Journal of Advanced Manufacturing Technology*, 72, 161–172. <https://doi.org/10.1007/s00170-014-5648-3>
- Asadian, E., Leicht, R. M., & Messner, J. (2023). A comparative analysis of lean approaches among trade contractors. *Lean Construction Journal*, 2023, 41–68. <https://doi.org/10.60164/5yx6ufx7x>
- Cano, S., Botero, L., García-Alcaraz, J. L., Tovar, R., & Rivera, L. (2020). Key aspects of maturity assessment in lean construction. In *Proceedings of the 28th Annual Conference of the International Group for Lean Construction (IGLC)* (pp. 229–240). <https://iglc.net/Papers/Details/1795>
- Comelli, M. L., Veras de Carvalho, Y. M., Marinho, R. C., Cândido, L. F., & Barros Neto, J. de P. (2019). Assessing the level of implementation of lean construction: An audit protocol. In *Proceedings of the 27th Annual Conference of the International Group for Lean Construction (IGLC)* (pp. 999–1022). <https://iglc.net/Papers/Details/1738>
- Construction Industry Institute. (2021). Applying a data-centric approach to the collaborative execution of capital projects (Final Report No. 372). Construction Industry Institute. <https://www.construction-institute.org/applying-a-data-centric-approach-to-the-collaborative-execution-of-capital-projects>
- de Carvalho, B. S., & Scheer, S. (2017). Analysis and assessment for lean construction adoption: The DOLC tool. In *Proceedings of the 25th Annual Conference of the International Group for Lean Construction (IGLC)* (pp. 429–435). <https://iglc.net/Papers/Details/1449>

- Ghosh, S., & Heidenreich, L. T. (2018). Conceptual framework for a lean construction capability model. In *Proceedings of the 54th Annual International Conference of the Associated Schools of Construction (ASC)* (pp. 432-440). <http://ascpro0.ascweb.org/archives/cd/2018/paper/CPRT169002018.pdf>
- Khan, M. A. H., Asadian, E., & Leicht, R. M. (2024). Identifying elements for lean construction implementation in trade contractor organizations. In *Proceedings of the Construction Research Congress 2024: Innovation for Resilient* <https://doi.org/10.1061/9780784485286.050>
- Koskela, L. (1992). Application of the new production philosophy to construction (Technical Report No. 72). Center for Integrated Facility Engineering, Stanford University.
- Lean Advancement Initiative. (2012). *LAI enterprise self-assessment tool (LESAT) (Version 2)*. Massachusetts Institute of Technology. <https://dspace.mit.edu/handle/1721.1/84688>
- Lean Construction Institute. (n.d.). *Organization lean assessment*. Retrieved December 2025, from <https://leanconstruction.org/organization-lean-assessment/>
- Li, S., Wu, X., Zhou, Y., & Liu, X. (2017). A study on the evaluation of implementation level of lean construction in two Chinese firms. *Renewable and Sustainable Energy Reviews*, 71, 846–851. <https://doi.org/10.1016/j.rser.2016.12.112>
- Liker, J. K. (2004). *Toyota Way: 14 Management Principles from the World's Greatest Manufacturer* (1st Edition). McGraw-Hill Education. <https://www.accessengineeringlibrary.com/content/book/9780071392310>
- Mohamed, A. H. (2021). An Assessment Tool to Measure the Lean Construction Maturity Level. In S. M. Ahmed, P. Hampton, S. Azhar, & A. D. Saul (Eds.), *Collaboration and Integration in Construction, Engineering, Management and Technology* (pp. 15–19). Springer International Publishing. https://doi.org/10.1007/978-3-030-48465-1_3
- National Highways. (2025). *National Highways lean maturity assessment—HELMA 2024*. Retrieved December 2025, from <https://nationalhighways.co.uk/suppliers/becoming-a-supplier/lean-supplier-support/national-highways-lean-maturity-assessment-helma-2024/>
- Nesensohn, C., Bryde, D., Ochieng, E., & Fearon, D. (2014). Maturity and maturity models in lean construction. *Construction Economics and Building*, 14, 45–59. <https://doi.org/10.5130/CEB.v14i1.3641>
- Nesensohn, C., Bryde, D., & Pasquire, C. (2016). A measurement model for lean construction maturity. In *Proceedings of the 24th Annual Conference of the International Group for Lean Construction (IGLC)* (pp. 13–22). <https://iglc.net/Papers/Details/1338>
- Nightingale, D., & Mize, J. (2002). Development of a Lean Enterprise Transformation Maturity Model. *Information-Knowledge-Systems Management*, 3, 15–30. <https://doi.org/10.3233/IKS-2002-00047>
- Osman, A., & Norani, N. (2021). Measuring Lean Culture: Designing a Research Instrument. *Journal of Modern Manufacturing Systems and Technology*, 5, 7–17. <https://doi.org/10.15282/jmmst.v5i1.5821>
- Pakdil, F., & Leonard, K. (2014). Criteria for a lean organisation: Development of a lean assessment tool. *International Journal of Production Research*, 52(15), 4587-4607. <https://doi.org/10.1080/00207543.2013.879614>
- Paulk, M. (2002). Capability maturity model for software. In J. J. Marciniak (Ed.), *Encyclopedia of Software Engineering* (1st ed.). Wiley. <https://doi.org/10.1002/0471028959.sof589>
- Pessôa, M. V. P., & Trabasso, L. G. (2017). Lean Thinking. In M. V. P. Pessôa & L. G. Trabasso (Eds.), *The Lean Product Design and Development Journey: A Practical View* (pp. 43–53). Springer International Publishing. https://doi.org/10.1007/978-3-319-46792-4_3
- Shingo Institute. (2025). *The Shingo model* (Version 15.4). Utah State University.

- Silverio, L., Trabasso, L. G., & Pereira Pessoa, M. V. (2020). A roadmap for a leanness company to emerge as a true lean organization. *Concurrent Engineering: Research and Applications*, 28, 3–19. <https://doi.org/10.1177/1063293X19888259>
- Urban, W. (2015). The Lean Management Maturity Self-assessment Tool Based on Organizational Culture Diagnosis. *Procedia - Social and Behavioral Sciences*, 213, 728–733. <https://doi.org/10.1016/j.sbspro.2015.11.527>
- Wong, W. P., Ignatius, J., & Soh, K. L. (2014). What is the leanness level of your organisation in lean transformation implementation? An integrated lean index using ANP approach. *Production Planning & Control*, 25(4), 273–287. <https://doi.org/10.1080/09537287.2012.674308>