ISSN: 2255-9671 (online)
2018, *6*, 116–130
doi: 10.2478/bjreecm-2018-0009
https://content.sciendo.com

IDENTIFICATION OF DELAY CAUSING ACTOR IN THE INDIAN REAL ESTATE PROJECT: AN AHP-BASED APPROACH

Shumank DEEP[1], Mohd ASIM [2], Neeti KESARWANI[3], Shweta KANDPAL[4]

[1]*School of Architecture and Built Environment, University of Newcastle, Callaghan 2308, NSW, Australia*
[2]*Himalayan Institute of Technology and Management, Bakshi Ka Talab, Lucknow 227007, UP, India*
[3]*Thomas International, New Delhi 110001, India*
[4]*Aqua Explorers, New Delhi 110001, India*
Corresponding author's email: *shumankdeep@uon.edu.au*

Abstract. Indian construction is a vital domain with an enormous employment potential and its contribution to the economy. Real estate is an essential domain of construction that tackles the housing demands. In the present scenario, this sector is experiencing a slowdown often failing projects. Thus, the aim is to identify the project participant and attributes that lead to delays in the schedule of real estate projects. In this process, we apply the hierarchical analytical process to identify the actor and the causes that result in an overrun. Our findings suggest that to a significant extent delays occur due to contractors under the influence of distinct factors discussed in the study.

Keywords: *Real estate, construction projects, project management, contractor performance, delays, cost overruns.*

INTRODUCTION

The construction sector has been the second largest employer in India; more than 35 million people are employed in the sector, second only to agriculture. Evidently from government records, the construction domain is valued over $126 billion and accounts for more than 60 percent of total investment in infrastructure. The primary cause of growth catalyst in this sector is technological advancement (Deep et al., 2016; Deep et al., 2017a; Deep et al., 2017b; Deep et al., 2017c; Deep et al., 2017e; Wahaj et al., 2017). Among such factors, innovative technologies and international players lead to enhanced employment across an infinite array of varying skills. Above all these advantages, government initiatives such as "Smart Cities" project and "Housing for All by 2012" are a major game changer for the construction sector in India. In this regard, amplified thrust to the affordable housing with fast approvals and policy changes resulted in a construction boom. Similarly, policy, i.e., "*Atal Mission for Rejuvenation and Urban Transformation (AMRUT)*" has catalyzed growth in infrastructure and related sectors. According to

information obtained from Right to Information Act, 2005, it has been estimated that the construction sector will grow up to 8 percent every year for the next decade (Deep et al., 2017e).

Regardless of these catalytic growth factors, the construction industry is affected by an acute availability of skilled workers, raw material, and political disturbances and above all twin balance sheet problem of Banks and Builders', which are resulting in NPA from the side of industries (Deep et al., 2016). The slowdown in Indian construction projects possesses inherent risk and increasing complexities, one of which is complication of time overshoot, i.e., delays in project handover, which leads to psychological and arbitrary misconceptions, increased costs of labour that result in increased cost of project, productivity loss, revenue loss, and project failures (Deep et al., 2017a; Deep et al., 2017c; Deep et al., 2017e; Wahaj et al., 2017). Hence, it is imperative to eradicate or lessen the delays in the handover. Therefore, in the present paper, we propose using the Analytic Hierarchy Process to choose a critical delay factor and delay accountability for the real estate sector in India.

1. THEORETICAL BACKGROUND

Construction projects are an essential element of countries' productive capacity and efficiency (Dawson, 2008; Osipova & Eriksson, 2011; Aitken & Paton, 2017; Ghadge et al., 2017). In the present scenario, globally the construction domain is experiencing growth regarding capital cost and complexity (Dawson, 2008). Dawson (2008) further stated that "importantly, there is an unprecedented level of proposed development and attainment of success in each project depends upon a number of issues which include global economic events"; the statement was further supported by Rahmani et al. (2017), Lloyd-walker et al. (2014), Burger and Hawkesworth (2011).

The construction industry is sceptical to innovation and is affected by negative attitudes and discontent (Wood, 2010; Caridi et al., 2014; Egan, 2014; Dang & Le-Hoai, 2016; Daniel et al., 2017; Nguyen & Watanabe, 2017) due to its hierarchical nature (Akintoye & Main, 2007; Babaeian Jelodar et al., 2016) that affects schedule/cost performance improvement in construction (Lam et al., 2004; Kale & Karaman, 2012; Love et al., 2017a). The primary constraint in the way of decentralization of markets and process in the construction industry is that it is a project-driven, sophisticated and conservative sector (Segerstedt & Olofsson, 2010; Fulford & Standing, 2014; Donato et al., 2015; Lessing & Brege, 2015). Since the projects are carried here at the temporary site by a temporary organisation comprising different parties, i.e., client, consultant, and contractor, and this also terminates after project closure, adds to the complexity and uncertainties associated with it.

Available literature has established that in the past few decades the construction industry in India is marred by unsatisfactory performance due to time and cost overrun. Timely completion, minimisation of cost overrun, lack of on-site hazards and satisfactory quality standards are a measure of a successful project (Palaneeswaran & Kumaraswamy, 2000; Palaneeswaran & Kumaraswamy, 2001;

Palaneeswaran et al., 2001; Palaneeswaran & Kumaraswamy, 2008). Risk allocation amongst the contracting parties is an issue that has affected the outcomes of procurement concerning built environment. To avoid any constraints affecting projects, the liability shall be equally distributed among the contracting parties (Deep et al., 2017b; Khan et al., 2017; Singh et al., 2017).

According to Kornelius and Wamelink (1998), specifications of the product are determined by its consumer, and the same influence poses to be a significant impact on the activities being conducted at construction sites. Such factors lead to occurrence of short-term relationships in the construction industry between a client and a contractor (Dubois & Gadde, 2002; Fearne & Fowler, 2006; Qu et al., 2011; Ardeshir et al., 2014; Janipha et al., 2015; Cerchione & Esposito, 2016; Ali Kazmi, 2017; Ju et al., 2017) eventually making the price quoted by the contractor the critical factor for evaluation of its bid. It is essential to mention that losses incur to the construction industry due to cost overrun, disputes, claim settlement and the primary reason for occurrence of disputes and disruptions, and such situations are commonly observed due to a lack of accurate information visibility (Mahamid, 2017) and this contributes to the trend of lower profit margins and reduced productivity in this sector. Delays in construction projects occour as a result of , contamination at the site, the bankruptcy of supplier during execution, logistic failure, and community resistance. The absence of transparency and lack of information sharing in this sector have also affected productivity.

1.1. Decision Scenario

The real estate construction company, which was subject of study in this work, is a leading maker of specialized housing and township development. Its success will depend on completing the project according to its as-built schedule and getting and delivering new ones. Due to inherent risks and increased complexities of construction projects, delays and cost overruns can frequently be observed (Orangi et al., 2011; Hampton et al., 2012; Edwards et al., 2017; Shen et al., 2017). Delays can lead to many stereotypes, i.e., disputes between a client and contractors leading to arbitration cost overrun, productivity loss, revenue loss and the termination of work charge. To compensate the damage due to delay, both causes and actors responsible for them must be identified (Yeo & Ning, 2002; Ardeshir et al., 2014; Sigmund & Radujković, 2014; Deep et al., 2016; Barman & Charoenngam, 2017; Deep et al., 2017b; Dixit et al., 2017; Love et al., 2017b; Walker et al., 2017). The analysis involves delay time calculation, identification of causes and the actor responsible for the delay.

Client induced delays, i.e., delayed availability drawings and specifications, frequent changes and inadequate site information result in counterclaims from both the main contractors and sub-contractors and lead to arbitration and substantial financial repercussions (Mitkus & Mitkus, 2014; Ju et al., 2017; Mahamid, 2017). Contractor induced delays can be attributed to poor project management, lack of planning and poor financial management (Love et al., 2011; Barman & Charoenngam, 2017; Komurlu & Arditi, 2017). It is observed that topmost factors that cause cost overrun are the lack of involving contractor during design, meager

site management and supervision, theft on site, repeated design change, incomplete design, change in material specification, act of God, and mistake in design and financial management on site and constructor bankruptcy. This was confirmed in the findings by Srivastava and Banerjee (2015); Deep et al. (2016); Deep et al. (2017a); Deep et al. (2017b); Deep et al. (2017c, 2017d); Khan et al. (2017); Mathivathanan et al. (2017); Mishra et al. (2017); Sanderson et al. (2017); Singh et al. (2017); Wahaj et al. (2017).

The present study aims at identification of the actor causing maximum delays and the attributes responsible for the occurrence of delays. To achieve this aim, the following research question has to be answered:

- Which actor is responsible for the occurrence of delays?
- What are the attributes responsible for the occurrence of delays?

After exhaustive exploration of literature, four criteria have been identified to determine the party responsible for occurred delays, i.e., financial issues, partnering, error identification and rectification and site conditions. The validity of these attributes will be tested in further sections using the Analytical Hierarchical Process. The four criteria will be further discussed in detail.

1.1.1 Financial Issues

Successful execution of projects can be ensured by preventing cost overruns and ensuring the projects to finish within the time (Le-Hoai et al., 2008; Shehu et al., 2014). The real estate sector in India and other countries in the south Asian region is characterised by frequent overruns leading to the abandonment of projects (Deep et al., 2017b). The factors come under this category: requests for favourable quotes from the client side (Deep et al., 2018), delay in payments (Orangi et al., 2011; Hampton et al., 2012), insufficient financial planning, commercial pressure and client's bankruptcy.

1.1.2 Partnering

Partnering refers to the relationship between the client and the contractor in a construction project (Deep et al., 2017c). Highly transactional relationships are predominant in the construction sector. It is often governed by the number of potential partners available in the market, project complexities, subletting clauses and reliability of the firm considered as a partner. Furthermore, incompetent project team, unfavorable contract clauses also tend to deteriorate partnering characteristics.

1.1.3 Error Identification and Rectification

In developing countries, observation of design error is quite frequent, and the main reason for their occurrence is frequent design changes by the client. Frequent design changes tend to affect project performance; also they lead to negligence and errors (Cerchione & Esposito, 2016; Dang & Le-Hoai, 2016; Daniel et al., 2017).

Lack of error identification and rectification mechanism in construction leads to time overrun and results in disputes among project participants.

1.1.4 Site Conditions

Site conditions are vital to consider as they are the detriment of smooth execution of projects. Few factors that govern site conditions are the location of the construction site, logistical planning, inventory planning, management and supervision capabilities, onsite facility planning and equipment availability. Inadequate planning to deal with site conditions for a sub-contractor leads to a high risk situation that increases site vulnerability (Kale & Karaman, 2012; Fulford & Standing, 2014; Deep et al., 2016; Barman & Charoenngam, 2017; Deep et al., 2017e; Komurlu & Arditi, 2017). Furthermore, major administrative clearances are also essential to ensure smooth construction activity on site as it could lead to legal issues.

2. RESEARCH METHODOLOGY

Within the framework of the research, mixed research methods have been used, i.e., review of recent literature, a questionnaire-based survey, and a series of structured interviews. A survey is a non-experimental, descriptive research strategy broadly used to survey mentalities and qualities about the scope of subjects (Arantes et al., 2015). A web-based survey was conducted in November and December 2016, and the data were compiled in a web-based database. The structured interviews were conducted amongst 43 experts to document their views and to validate the results of the questionnaire-based survey.

The study is further based on the application of the Analytical Hierarchical Process (AHP) (Saaty, 2008) to identify critical delay factors. The study is a continuation of the work of Deep et al. (2017c), and apart from the identification of critical factors also focuses on the calculation of delay accountability. Application of AHP was useful to identify the most common criteria in a rational and transparent way. Choosing the AHP method for identification of delay causing attributes allows overcoming the limitations of traditional methods. As discussed before, our case study was managed in Lucknow region of Uttar Pradesh (India) due to high levels of investment incurred in real estate segment. Cost, time, and quality were the three main items on which managers mostly focus in order to control the projects, but project delay management by itself should be noticed as a factor that affects other items. Thus, to finalize the project and meet predefined objectives in terms of cost, time and quality, management regarding handover should be addressed parallel with other objectives.

2.1. Criteria for Pairwise Comparison

The decision hierarchy (conceptual framework) for critical delay factors appears in Fig. 1, and the pairwise comparison criteria received for the research are shown in Table 1.

Table 1. Scale for Pairwise Comparison (Source: Saaty 2008, p. 88)

Intensity of importance	Definition	Explanation
1	Equal importance	Two criteria contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favour one over another
5	Strong importance	Experience and judgment strongly favour each other
7	Very strong importance	One criterion is strongly favoured, and its dominance is demonstrated in practice
9	Absolute importance	Importance of one over another is recognised in practice indisputably
2, 4, 6, 8	Intermediate values	Used to represent compromises between the preceding priorities[1]

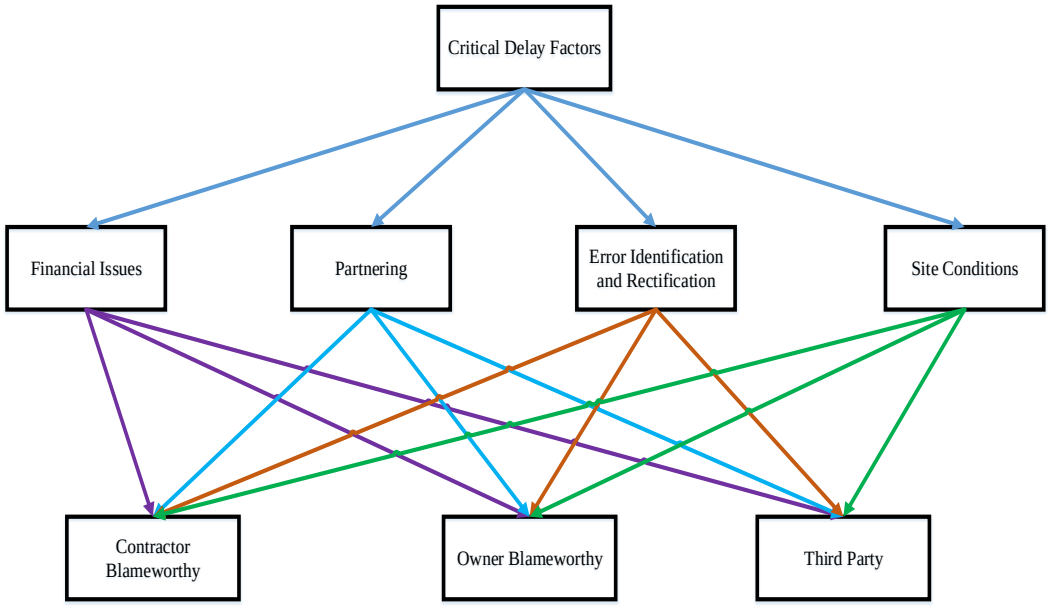

Fig. 1. Decision hierarchy (developed by the authors).

The priorities will then be consolidated through the hierarchy to give a general need for each actor. Application of AHP will determine priorities for the actors regarding each decision criterion, and priorities for each criterion are based on significance for achieving the objective. The gathering of priorities with the *unique* need will be the most responsible option, and the proportion of the gathered' priorities will show their relative qualities in achieving the objective.

[1] If criterion I has one of the previous numbers assigned to it during comparison with j, then j has a reciprocal value when compared with i.

2.2. Criteria for Measurement

The priorities derived from progression of measurements in light of pairwise comparisons will include all nodes of decision hierarchy. The nodes at each level will be compared in a 2×2 matrix based on dependence on the preceding node. The results of these comparisons will be handled numerically to infer the priorities for each node. The comparisons are made by comparing the choices with deference in their strengths to address each criterion. In this step, each criterion will be compared based on its significance for achieving the objective.

Since there are three alternatives (owner, contractor and third party) and comparison of each actor is necessary, three pairwise comparisons must be performed for each criterion: Owner versus Contractor, Owner versus Third Party and Contractor versus Third Party. For each comparison, the weaker actor will be identified by the criteria focused. At that point, a relative weight is allocated to the next party.

3. DATA ANALYSIS

The current study follows the data analysis methodology applied by Arantes et al. (2014); Arantes et al. (2015); Ferreira et al. (2015). In this study, a 2-step analytical hierarchical process has been used. Figure 2 shows the AHP hierarchy after the analysis. The objective of this process is to identify the actor who should be blameworthy for the occurrence of delay. After analysing the first leg of hierarchy, it has been observed that "contractor blameworthy" is the most preferred alternative with a priority of 0.493. It is preferred about a third over "owner blameworthy," whose priority is 0.358, and is about three times more than the "third party," whose priority is only 0.149. The criterion "Financial Issues" is the most important one concerning reaching the goal, followed by "Partnering," "Error Identification and Rectification," and "Site Conditions" whose relative weights are 0.547, 0.270, 0.127, and 0.056, respectively. We will further discuss the detailed calculation procedure. The results of the analysis are shown in Tables 2–6.

3.1. Calculation of Priorities

In this process, the next step will be to compare each actor by financial issues. For each comparison, a weaker actor will be identified and assigned a relative weight of 1. Then, relative weight is assigned to the fiscal matters of the other actor using AHP fundamental scale, and a similar process can also be repeated for other criteria.

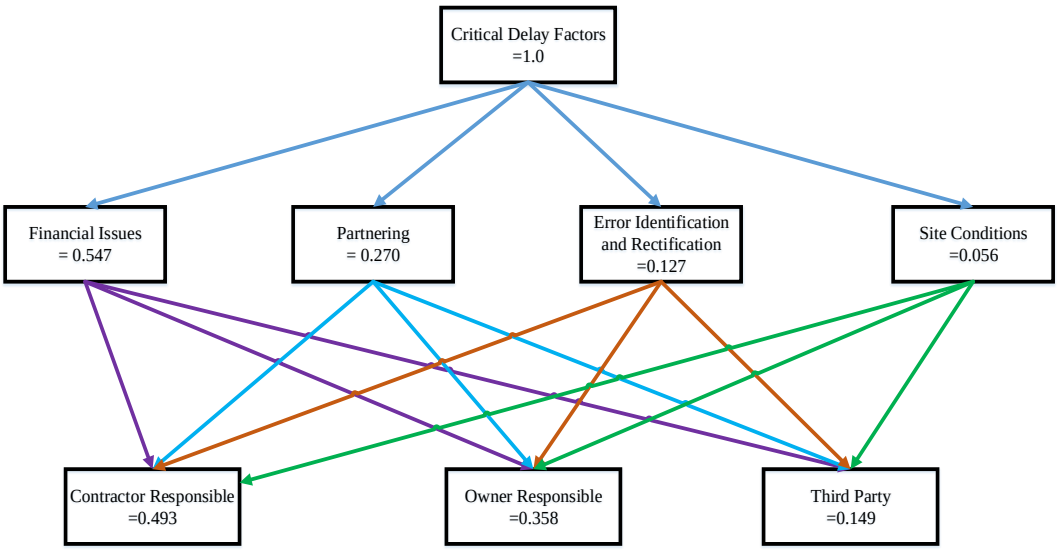

Fig. 2. Relative weights for a different criterion (developed by the authors).

Table 2. Financial Issues

Financial issues	**Owner**	**Contractor**	**Third party**
Owner	1.000	0.250(1/4)	4.000
Contractor	4.000	1.000	9.000
Third party	0.250(1/4)	0.111(1/9)	1.000
Sum of priorities 1.000 Inconsistency 0.035			

Table 3. Partnering

Partnering	**Owner**	**Contractor**	**Third party**
Owner	1.000	3.000	0.200(1/5)
Contractor	0.333(1/3)	1.000	0.142(1/7)
Third party	5.000	7.000	1.000
Sum of priorities 1.000 Inconsistency 0.062			

Table 4. Error Identification and Rectification

Error identification and rectification	**Owner**	**Contractor**	**Third party**	**Priority**
Owner	1.000	5.000	9.000	0.743
Contractor	0.200(1/5)	1.000	4.000	0.194
Third party	0.111(1/9)	0.250(1/4)	1.000	0.063
Sum of priorities 1.000 Inconsistency 0.069				

Table 5. Site Conditions

Site Conditions	**Owner**	**Contractor**	**Third party**	**Priority**
Owner	1.000	0.333(1/3)	5.000	0.265
Contractor	3.000	1.000	9.000	0.672
Third party	0.200(1/5)	0.111(1/9)	1.000	0.063
Sum of priorities 1.000 Inconsistency 0.028				

By solving this matrix, priorities can be derived for the parties concerning fiscal matters. The priorities are measurements of their relative strengths, derived from the judgments of the decision makers as entered into the matrix. Mathematically, priorities can be calculated by obtaining the eigenvector for the matrix. These priorities thus calculated are shown in Tables 2–5, along with an inconsistency factor.

3.2. Comparison of Criteria

After evaluating each actor by its strength to meet each criterion, each criterion will be evaluated by its significance to achieve objectives. Therefore, in this process, a series of pairwise comparisons will be performed. At this stage of work, structured interviews were used to assess each criterion. The comparisons will require a larger matrix, but they are analysed using the same process as smaller ones (see Table 6).

Table 6. Results of Criteria Comparisons

Criteria	Fiscal matter	Partnering	Error identification rectification	Site conditions	Priority
Financial issues	1.000	4.000	3.000	7.000	0.547
Partnering	0.250(1/4)	1.000	0.333(1/3)	3.000	0.127
Error identification and rectification	0.333(1/3)	3.000	1.000	5.000	0.270
Site conditions	0.142(1/7)	0.333(1/3)	0.200(1/5)	1.000	0.056
Sum of priorities Inconsistency					1.000 0.044

As it can be observed in Table 6, financial issues are the highest ranked criterion, about twice as important for reaching the goal as the second-highest ranked criterion – error identification and rectification. Similarly, error identification and rectification is about twice as important as partnering, which in turn is more than twice as important as site conditions.

Decision making is a vital activity for construction projects, especially at early stages and based on the analysis of previous experiences. In this regard, AHP uses criteria and sub-criteria organised in a mathematically modelled hierarchical structure, which makes it possible to decide which alternative is best for achieving the intention. On this basis, a decision-support system can be developed to reduce the risks caused by the uncertainty of the decision and eliminate delays in a highly ambiguous project environment.

CONCLUSION

Calculation results of questionnaire-based survey and priority have demonstrated that the contractor is responsible for delays in construction projects. From survey results, it has been observed that factors, i.e., financial issues, partnering, error identification and rectification, and site conditions are the major attributes that affect contractor’s performance. A series of structured interviews conducted with experts and professionals have validated the findings. If these attributes are controlled, then cost and time overruns in a construction project can be checked to a greater extent. The knowledge gained about time overrun causes, and the way they are affecting the construction industry might prove to be beneficial to the stockholders involved in the construction domain, thus resulting in the improved performance of the real estate sector.

REFERENCES

Aitken, A., & Paton, R. A. (2017). The "T-Shaped Buyer": A transactional perspective on supply chain relationships. *Journal of Purchasing and Supply Management*, *23*(4), 280–289. https://doi.org/10.1016/j.pursup.2017.03.001

Akintoye, A., & Main, J. (2007). Collaborative relationships in construction: the UK contractors' perception. *Engineering, Construction and Architectural Management*, *14*(6), 597–617. https://doi.org/10.1108/09699980710829049

Ali Kazmi, S. (2017). Impact of Natural, Man-made Risks and Stakeholders Relationship on effectiveness of Supply Chain Management in Developing Countries. *KTH Royal Institute of Technology*. Retrieved from http://www.diva-portal.se/smash/get/diva2:1084790/FULLTEXT01.pdf

Arantes, A., Ferreira, L. M. D. F., & Costa, A. A. (2015). Is the construction industry aware of supply chain management? The Portuguese contractors' perspective. *Supply Chain Management: An International Journal*, *20*(4), 404–414. https://doi.org/10.1108/SCM-06-2014-0207

Arantes, A., Ferreira, L. M. D. F., & Kharlamov, A. A. (2014). Application of a Purchasing Portfolio Model in a Construction Company in Two Distinct Markets. *Journal of Management in Engineering*, *30*(5), 04014020. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000290

Ardeshir, A., Amiri, M., Ghasemi, Y., & Errington, M. (2014). Risk assessment of construction projects for water conveyance tunnels using fuzzy fault tree analysis. *International Journal of Civil Engineering*, *12*(4), 396-412. Retrieved from http://ijce.iust.ac.ir/article-1-878-en.pdf

Babaeian Jelodar, M., Yiu, T. W., & Wilkinson, S. (2017). Assessing Contractual Relationship Quality: Study of Judgment Trends among Construction Industry Participants. *Journal of Management in Engineering*, *33*(1), 04016028. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000461

Barman, A., & Charoenngam, C. (2017). Decisional Uncertainties in Construction Projects as a Cause of Disputes and Their Formal Legal Interpretation by the Courts: Review of Legal Cases in the United Kingdom. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, *9*(3), 04517011. https://doi.org/10.1061/(ASCE)LA.1943-4170.0000222

Burger, P., & Hawkesworth, I. (2011). How to Attain Value for Money. Comparing PPP and traditional infrastructure public procurement. *OECD Journal on Budgeting*, *11*(1), 91–146. https://doi.org/10.1787/budget-11-5kg9zc0pvq6j

Caridi, M., Moretto, A., Perego, A., & Tumino, A. (2014). The benefits of supply chain visibility: A value assessment model. *International Journal of Production Economics*, *151*, 1–19. https://doi.org/10.1016/j.ijpe.2013.12.025

Cerchione, R., & Esposito, E. (2016). A systematic review of supply chain knowledge management research: State of the art and research opportunities. *International Journal of Production Economics*, *182*, 276–292. https://doi.org/10.1016/j.ijpe.2016.09.006

Dang, C. N., & Le-Hoai, L. (2016). Critical success factors for implementation process of design-build projects in Vietnam. *Journal of Engineering, Design and Technology*, *14*(1), 17–32. https://doi.org/10.1108/JEDT-04-2013-0029

Daniel, E. I., Pasquire, C., Dickens, G., & Ballard, H. G. (2017). The relationship between the last planner® system and collaborative planning practice in UK construction. *Engineering, Construction and Architectural Management*, *24*(3), 407–425. https://doi.org/10.1108/ECAM-07-2015-0109

Dawson, B. (2008). The new world of value transfer ppps. *Infrastructure: Policy, Finance and Investment*, 12–13.

Deep, S., Asim, M., & Ahmad, S. A. (2017a). Earned Value based Liability Calculation Algorithm for Schedule Delays in Construction Projects. *Indian Journal of Science and Technology*, *10*(15), 1–10. https://doi.org/10.17485/ijst/2017/v10i15/110324

Deep, S., Asim, M., & Khan, M. K. (2017b). Review of Various Delay Causing Factors and Their Resolution by Application of Lean Principles in India. *Baltic Journal of Real Estate Economics and Construction Management*, *5*(1), 101–117. https://doi.org/10.1515/bjreecm-2017-0008

Deep, S., Gajendran, T., Jefferies, M., & Davis, P. (2018, April). An analytical literature review of risks in collaborative procurement. Paper presented at the The Royal Institution of Chartered

Surveyors – Annual Construction, Building and Real Estate Research Conference, London, UK. Retrieved from http://www.rics.org/Documents/COBRA%202018/128-Deep-AN_ANALYTICAL_LITERATURE_REVIEW_OF_RISKS_IN_COLLABORATIVE_PROCUREMENT-220418-kp.pdf

Deep, S., Jefferies, M., & Gajendran, T. (2017). Resolving constraints in collaborative procurement through the lens of a portfolio purchasing model: A traditional literature review. Paper presented at the International Symposium on Frontiers of Infrastructure Finance, Indian Institute of Technology, Kharagpur, India.

Deep, S., Khan, M. B., Ahmad, S., & Saeed, A. (2017e). A study of various factors affecting contractor's performance in lowest bid award construction projects. *International Journal of Civil Engineering and Technology*, *8*(2), 28–33. Retrieved from http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=8&IType=2

Deep, S., Singh, D., & Ahmad, S. A. (2017). A Review of Contract Awards to Lowest Bidder in Indian Construction Projects via Case Based Approach. *Open Journal of Business and Management*, *05*(01), 159–168. https://doi.org/10.4236/ojbm.2017.51015

Dixit, V., Chaudhuri, A., & Srivastava, R. K. (2017). Procurement scheduling in engineer procure construct projects: a comparison of three fuzzy modelling approaches. *International Journal of Construction Management*, *18*(3), 189–206. https://doi.org/10.1080/15623599.2017.1314750

Donato, M., Ahsan, K., & Shee, H. (2015). Resource dependency and collaboration in construction supply chain: literature review and development of a conceptual framework. *International Journal of Procurement Management*, *8*(3), 344–364. https://doi.org/10.1504/IJPM.2015.069157

Dubois, A., & Gadde, L.-E. (2002). The construction industry as a loosely coupled system: implications for productivity and innovation. *Construction Management and Economics*, *20*(7), 621–631. https://doi.org/10.1080/01446190210163543

Edwards, D. J., Owusu-Manu, D.-G., Baiden, B., Badu, E., & Love, P. E. (2017). Financial distress and highway infrastructure delays. Jou*rnal of Engineering, Design and Technology*, *15*(1), 118–132. https://doi.org/10.1108/JEDT-02-2016-0006

Egan, J. (2014). Rethinking construction, construction task force report for department of the environment, transport and the regions. ed: HMSO, London.

Fearne, A., & Fowler, N. (2006). Efficiency versus effectiveness in construction supply chains: the dangers of "lean" thinking in isolation. *Supply Chain Management: An International Journal*, *11*(4), 283–287. https://doi.org/10.1108/13598540610671725

Ferreira, L. M. D. F., Arantes, A., & Kharlamov, A. A. (2015). Development of a purchasing portfolio model for the construction industry: an empirical study. *Production Planning & Control*, *26*(5), 377-392. https://doi.org/10.1080/09537287.2014.906679

Fulford, R., & Standing, C. (2014). Construction industry productivity and the potential for collaborative practice. *International Journal of Project Management*, *32*(2), 315–326. https://doi.org/10.1016/j.ijproman.2013.05.007

Ghadge, A., Dani, S., Ojha, R., & Caldwell, N. (2017). Using risk sharing contracts for supply chain risk mitigation: A buyer-supplier power and dependence perspective. *Computers & Industrial Engineering*, *103*, 262–270. https://doi.org/10.1016/j.cie.2016.11.034

Hampton, G., Baldwin, A. N., & Holt, G. (2012). Project delays and cost: stakeholder perceptions of traditional v. PPP procurement. *Journal of Financial Management of Property and Construction*, *17*(1), 73–91. https://doi.org/10.1108/13664381211211055

Janipha, N. A. I., Ahmad, N., & Ismail, F. (2015). Clients' Involvement in Purchasing Process for Quality Construction Environment. *Procedia - Social and Behavioral Sciences*, *168*, 30–40. https://doi.org/10.1016/j.sbspro.2014.10.207

Ju, Q., Ding, L., & Skibniewski, M. J. (2017). Optimization strategies to eliminate interface conflicts in complex supply chains of construction projects. *Journal of Civil Engineering and Management*, *23*(6), 712–726. https://doi.org/10.3846/13923730.2016.1232305

Kale, S., & Karaman, E. A. (2012). A diagnostic model for assessing the knowledge management practices of construction firms. *KSCE Journal of Civil Engineering*, *16*(4), 526–537. https://doi.org/10.1007/s12205-012-1468-x

Khan, M. A., Deep, S., Asim, M., & Khan, Z. R. (2017). Quantization of risks involved in supply of ready mix concrete in construction industry in indian scenario. *International Journal of Civil Engineering and Technology*, *8*(3), 175-184.

Komurlu, R., & Arditi, D. (2017). The role of general conditions relative to claims and disputes in building construction contracts. *New Arch-International Journal of Contemporary Architecture*, *4*(2), 27-36.

Kornelius, L., & Wamelink, J. (1998). The virtual corporation: Learning from construction. Supply Chain Management: An International Journal, 3(4), 193-202.

Kornelius, L., & Wamelink, J. W. F. (1998). The virtual corporation: learning from construction. *Supply Chain Management: An International Journal*, *3*(4), 193–202. https://doi.org/10.1108/13598549810244278

Lam, E. W. M., Chan, A. P. C., & Chan, D. W. M. (2004). Benchmarking design-build procurement systems in construction. *Benchmarking: An International Journal*, *11*(3), 287–302. https://doi.org/10.1108/14635770410538763

Le-Hoai, L., Lee, Y. D., & Lee, J. Y. (2008). Delay and cost overruns in Vietnam large construction projects: A comparison with other selected countries. *KSCE Journal of Civil Engineering*, *12*(6), 367–377. https://doi.org/10.1007/s12205-008-0367-7

Lessing, J., & Brege, S. (2015). Business models for product-oriented house-building companies – experience from two Swedish case studies. *Construction Innovation*, *15*(4), 449–472. https://doi.org/10.1108/CI-02-2015-0009

Lloyd-walker, B. M., Mills, A. J., & Walker, D. H. T. (2014). Enabling construction innovation: the role of a no-blame culture as a collaboration behavioural driver in project alliances. *Construction Management and Economics*, *32*(3), 229–245. https://doi.org/10.1080/01446193.2014.892629

Love, P. E. D., Zhou, J., Edwards, D. J., Irani, Z., & Sing, C.-P. (2017a). Off the rails: The cost performance of infrastructure rail projects. *Transportation Research Part A: Policy and Practice*, *99*, 14–29. https://doi.org/10.1016/j.tra.2017.02.008

Love, P. E. D., Davis, P. R., Sai On Cheung, & Irani, Z. (2011). Causal Discovery and Inference of Project Disputes. *IEEE Transactions on Engineering Management*, *58*(3), 400–411. https://doi.org/10.1109/TEM.2010.2048907

Love, P. E. D., Irani, Z., Smith, J., Regan, M., & Liu, J. (2017b). Cost performance of public infrastructure projects: the nemesis and nirvana of change-orders. *Production Planning & Control*, *28*(13), 1081–1092. https://doi.org/10.1080/09537287.2017.1333647

Mahamid, I. (2017). Analysis of common factors leading to conflicts between contractors and their subcontractors in building construction projects. *Australian Journal of Multi-Disciplinary Engineering*, *13*(1), 18–28. https://doi.org/10.1080/14488388.2017.1342515

Mathivathanan, D., Kannan, D., & Haq, A. N. (2018). Sustainable supply chain management practices in Indian automotive industry: A multi-stakeholder view. *Resources, Conservation and Recycling*, *128*, 284–305. https://doi.org/10.1016/j.resconrec.2017.01.003

Mishra, D., Gunasekaran, A., Papadopoulos, T., & Hazen, B. (2017). Green supply chain performance measures: A review and bibliometric analysis. *Sustainable Production and Consumption*, *10*, 85–99. https://doi.org/10.1016/j.spc.2017.01.003

Mitkus, S., & Mitkus, T. (2014). Causes of Conflicts in a Construction Industry: A Communicational Approach. *Procedia - Social and Behavioral Sciences*, *110*, 777–786. https://doi.org/10.1016/j.sbspro.2013.12.922

Nguyen, L., & Watanabe, T. (2017). The Impact of Project Organizational Culture on the Performance of Construction Projects. *Sustainability*, *9*(5), 781. https://doi.org/10.3390/su9050781

Orangi, A., Palaneeswaran, E., & Wilson, J. (2011). Exploring Delays in Victoria-Based Astralian Pipeline Projects. *Procedia Engineering*, *14*, 874–881. https://doi.org/10.1016/j.proeng.2011.07.111

Osipova, E., & Eriksson, P. E. (2011). How procurement options influence risk management in construction projects. *Construction Management and Economics*, *29*(11), 1149–1158. https://doi.org/10.1080/01446193.2011.639379

Palaneeswaran, E., & Kumaraswamy, M. (2001). Recent advances and proposed improvements in contractor prequalification methodologies. *Building and Environment*, *36*(1), 73–87. https://doi.org/10.1016/S0360-1323(99)00069-4

Palaneeswaran, E., Kumaraswamy, M. M., & Zhang, X. Q. (2001). Reforging construction supply chains: *European Journal of Purchasing & Supply Management*, *7*(3), 165–178. https://doi.org/10.1016/S0969-7012(00)00025-3

Palaneeswaran, E., & Kumaraswamy, M. M. (2000). Contractor Selection for Design/Build Projects. *Journal of Construction Engineering and Management*, *126*(5), 331–339. https://doi.org/10.1061/(ASCE)0733-9364(2000)126:5(331)

Palaneeswaran, E., & Kumaraswamy, M. M. (2008). An integrated decision support system for dealing with time extension entitlements. *Automation in Construction*, *17*(4), 425–438. https://doi.org/10.1016/j.autcon.2007.08.002

Qu, X., Meng, Q., Yuanita, V., & Wong, Y. H. (2011). Design and implementation of a quantitative risk assessment software tool for Singapore road tunnels. *Expert Systems with Applications*. *38*(11), 13827-13834. https://doi.org/10.1016/j.eswa.2011.04.186

Rahmani, F., Maqsood, T., & Khalfan, M. (2017). An overview of construction procurement methods in Australia. *Engineering, Construction and Architectural Management*, *24*(4), 593–609. https://doi.org/10.1108/ECAM-03-2016-0058

Saaty, T. L. (2008). Decision making with the analytic hierarchy process. *International Journal of Services Sciences*, *1*(1), 83–98. https://doi.org/10.1504/IJSSCI.2008.017590

Sanderson, M., Allen, P., Gill, R., & Garnett, E. (2018). New models of contracting in the public sector: A review of alliance contracting, prime contracting and outcome-based contracting literature. *Social Policy & Administration*. *52*(5), 1060-1083. Retrieved from https://onlinelibrary.wiley.com/doi/pdf/10.1111/spol.12322

Segerstedt, A., & Olofsson, T. (2010). Supply chains in the construction industry. Supply Chain Management: *An International Journal*, *15*(5), 347–353. https://doi.org/10.1108/13598541011068260

Shehu, Z., Endut, I. R., Akintoye, A., & Holt, G. D. (2014). Cost overrun in the Malaysian construction industry projects: A deeper insight. *International Journal of Project Management*, *32*(8), 1471–1480. https://doi.org/10.1016/j.ijproman.2014.04.004

Shen, L., Zhang, Z., & Long, Z. (2017). Significant barriers to green procurement in real estate development. *Resources, Conservation and Recycling*, *116*, 160–168. https://doi.org/10.1016/j.resconrec.2016.10.004

Sigmund, Z., & Radujković, M. (2014). Risk Breakdown Structure for Construction Projects on Existing Buildings. *Procedia - Social and Behavioral Sciences*, *119*, 894–901. https://doi.org/10.1016/j.sbspro.2014.03.100

Singh, M. K., Deep, S., & Banerjee, R. (2017). Risk management in construction projects as per indian scenario. *International Journal of Civil Engineering and Technology*, *8*(3), 127–136.

Srivastava, S. D., & Banerjee, R. (2015). Hybrid renewable energy systems & their suitability in rural regions. *IOSR Journal of Mechanical and Civil Engineering*, *12*(3), 117–120. Retrieved from http://www.iosrjournals.org/iosr-jmce/papers/vol12-issue3/Version-1/S01231117120.pdf

Wahaj, M., Deep, S., Dixit, R. B., & Khan, M. B. (2017). A study of project success and procurement frameworks in indian construction industry. *International Journal of Civil Engineering and Technology*, *8*(3), 167–174. http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=8&IType=3

Walker, D. H. T., Davis, P. R., & Stevenson, A. (2017). Coping with uncertainty and ambiguity through team collaboration in infrastructure projects. *International Journal of Project Management*, *35*(2), 180–190. https://doi.org/10.1016/j.ijproman.2016.11.001

Wood, P. S. (2010). Comparing cost uplift in infrastructure delivery methods: A case based approach. (A dissertation submitted as fulfilment for the Degree of Doctor of Business Administration, Queensland University of Technology, Brisbane). Available from Alliance Contracting Electronic Law Journal. http://alliancecontractingelectroniclawjournal.com/wood-p-2010-comparing-cost-uplift-in-infrastructure-delivery-methods-a-case-based-approach/

Yeo, K., & Ning, J. (2002). Integrating supply chain and critical chain concepts in engineer-procure-construct (EPC) projects. *International Journal of Project Management*, *20*(4), 253–262. https://doi.org/10.1016/S0263-7863(01)00021-7

AUTHORS' SHORT BIOGRAPHIES

Shumank Deep is pursuing his Doctor of Philosophy at the School of Architecture and Built Environment, University of Newcastle, Australia. Previously he worked as an Assistant Professor at the Department of Civil Engineering, Integral University, Lucknow, UP, India. His research interests include construction delays, procurement process of construction projects, lean construction management, equipment management and supply chain management.

Mohd Asim is a Lecturer at the Department of Civil Engineering, Himalayan Institute of Technology and Management, Lucknow. He obtained the Professional Bachelor Degree with honors in Civil Engineering and was awarded a gold medal for M.Tech (Construction Technology and Management). His research interests include real estate construction project delays, sustainable construction, construction equipment maintenance and lean construction management.

Neeti Kesarwani works as a Business Development Manager at Thomas International, India. She has 7 years of work experience from ITES and pharmaceutical industry. She has completed her Master's Post-graduation in Business Development at Birla Institute of Technology, Mesra, India. Her research interests include business analytics and psychometrics.

Shweta Kandpal works as an Environmental Consultant at Aqua Explorers, India. She completed her Bachelor's studies in Environmental Engineering in 2003, followed by Master's studies in Technology at the National Institute of Technology, Allahabad, India with specialisation in Environmental Geotechnology.