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Revisiting critical delay factors for construction: Analysing projects in Malaysia

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Construction industry; Developing countries; Project management; Schedule delays; Delay factors

Abstract
Although construction delays have been subjected to a considerable amount of research, this perennial problem continues to plague the construction industry globally. For this reason, this study contributes to the theory and practice of construction schedule management by identifying the primary delay causes of construction projects and uncovering the underlying factors involved. Following a meta-analysis of 52 common causes of delay identified from the literature review, 20 highly-cited causes are categorised under client-, contractor-, consultant-, labour and equipment-, material- and others-related. A field survey was employed to acquire the views of 148 Malaysian construction practitioners from client, consultant and contractor organisations. These causes are prioritised according to an importance index that integrates both frequency and severity indices, identifying the five leading causes as lack of proper planning and scheduling, too many change orders by clients, lack of competent site management and supervision, lack of competent sub-contractors and financial problems of contractors. Spearman’s rank correlation tests reveal a good consensus between the respondent groups to further corroborate the findings. A factor analysis identifies the five principal managerial capabilities influencing schedule delays to be competency management, communication and coordination management, financial management, risk management and site management. These findings are helpful for the praxis of critical reflection in the planning and management of production in construction. This study provides the international construction community with valuable insights to revaluate delay factors and realign project management strategies to ensure the timely delivery of projects.

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1. Introduction

The unnecessary delay of project delivery is a frequent root cause of complications in construction projects, particularly in developing countries [16,23,55,57] and Malaysia is no exception [87], where almost 80% of traditionally procured projects experience time overruns [76]. A comparable situation also occurs in
Saudi Arabia, for instance [16]. Previous research indicates that the reasons for delay are similar to those of cost overruns [65,89]. Delays adversely undermine the production planning and control dimension of operations [94], particularly in construction projects [75], regardless of the socio-economic status of the country involved [31]. Delays can cause such predicaments as increased construction costs, loss of profits due to low productivity, lawsuits between contracting parties and contract termination [19,36,70]. According to Alsuliman [16], a contractor will suffer a loss of output and their revenue due to missed opportunity costs. In Nigeria, the two most frequent effects of delays are cost overruns and time overruns [8]. In South Africa, the leading effects of schedule delays are extensions of time, cost overruns, loss of profits, disputes and substandard quality of work attributable to hastily performed tasks to complete the project [59]. Along these lines, the negative repercussions of schedule pressure can be attributed to out-of-sequence work, cutting corners and poor worker motivation, resulting in further losses in productivity and quality [61,86].

The Business Dictionary [26] defines delay as the “unplanned deferment of a scheduled activity because of some thing or occurrence that impedes its commencement or continuation.” Agyekum-Mensah and Knight [7] simply define delay as “the inability to meet the scheduled time”. Assaf and Al-Hejji [21] further articulate delay as being “the time overrun either beyond the completion date specified under a contract, or beyond the date that the parties agreed upon for delivery of a project” and Hanks et al. [40] simplistically interpret a delay as “a period of time by which something is late or postponed”. More recently, Arantes and Ferreira [20] note that the “timely completion of a project is usually regarded as the major parameter for measuring the success of a project”. Thus, completing a project behind schedule is undesirable and unwarranted [23,31], justifying the need for revisiting the delay factors for the better understanding of the causal factors involved so that effective measures can be devised for their containment.

Although construction projects worldwide have analogous characteristics, some remain very much country-specific [65]. Against this background, Mpofu et al. [57] opine that delay factors are country-specific and influenced by socio-economic and cultural backgrounds. In contrast, Toor and Ogunlana [80] observe that an analogous list of issues bring about construction delays in the developing world.

Despite being a popular academic area of research, however, the problem of poor project schedule management remains [31,63]: late completion continues to plague Malaysian projects, for example [87]. Given the persistence of the problem, the present study seeks to revisit the major delay causes and uncover the underlying dimensions of delays in the construction industry. Most importantly, this Malaysia-based study sheds light on the salient issues adversely undermining the timely delivery of construction production. The findings provide an opportunity for global construction project management practitioners to reevaluate and modify work practices to redress the current shortcomings.

2. Literature review

More than a decade ago, Sambasivan and Soon’s [71] examination of the association between causes and effects of the incidences of delays revealed the ten most influential factors of delay perceived by Malaysian construction practitioners. This was one of the earliest studies that established the association between each cause and effect empirically. In a separate study in the same year, Alaghbari et al.’s [13] investigation of the causal delay factors found the leading causes to be the owner’s financial complications due to economic problems, financial problems affecting contractor, consultants’ slowness in supervising works and decision-making, consultants’ inefficiency in issuing instructions and market shortage of materials. While these studies provide an increased understanding of the issues contributing to delays in Malaysia, they took place over a decade ago, when the construction industry’s maturity was at a lower level. Moreover, they only consider the causes using a single scale of either agreement or frequency, which may limit the reliability of their results. It is also worth noting that these studies only aimed to identify the significant causes and stopped short of analysing the underlying factors involved. To bridge these gaps, the present study re-evaluates the causes of delays by appraising importance indices that also take account of frequency and severity. Additionally, uncovering the principal dimensions of delays is useful to better understand the underlying factors affecting schedule performance. Later, in Vietnam, the primary reasons for delays concern personnel and managerial predicaments [52]. In Egypt, the financial problems of a contractor is the most critical [33]. Over in the Gaza Strip in Palestine, a dissimilar set of causes are identified, namely incursions, closure of checkpoints at the border and inadequacy in the supply construction materials, which may be attributable to the political environment in the region [34]. Analysing construction projects in India, Doloi et al. [30] reported that one of the most critical factors of project delay is the lack of commitment. In 2013, Akogbe et al. [10] prioritised the delay causes peculiar to Beninese construction projects by considering their severity and frequency of occurrences as evaluated by the respondents. The contractors’ limited financial strength, owners’ financial problems and subcontractors’ poor performance were found to be the major time inhibitors. On the other hand, in Uganda, Muhwezi et al. [58] employed the relative importance index (RII) as a tool for their analysis, finding that consultant-related factors contributed substantially to delays. In 2014, investigating from the Malaysian housing developers’ outlook, Mydin et al. observed that contractor-related causes are more significant compared to consultant-, client- and external-related causes. A similar observation was also reported earlier by Abdullah et al. [6] of Majlis Amanah Rakyat (MARA) management procurement projects (MARA is a government agency that aids, trains and guides Malays and other indigenous Malaysians). This is also consistent with other similar studies in Egypt where a contractor-related group of delay factors was most critical with RII = 79.91% [22], as well as in Pakistan with the leading cause being ‘difficulties in financing project by the contractor’ [45].

During the last five years, Larsen et al. [50] underscore that major factors impeding project schedule performance are consultant-related in Denmark, further demonstrating that delays also inflated costs and impeded project quality. In a Vietnamese study, Nguyen and Chileshe [62] reported that scanty planning and the incompetence of project personnel significantly contribute to project failures. The following year, another empirical study in low-income Burkina Faso observed
technical incapacity, inexperience and financial weakness of contractors as being the leading inhibitors of time performance [24]. For Egyptian road construction projects, the five leading delay causes are related to financing, equipment, the contractor and materials [23]. In the case of the United Arab Emirates, delay causes are associated with the hereditary adversarial practices of the primary stakeholders [57]. In Morocco, Bajjou and Chafi [25] classified the causes according to nine categories, the leading three deferred progress payments, deficient training and competency of project personnel and a poor waste management strategy. In China, variations, delayed progress, aggressive competitive bidding, poor performance of sub-contractors and communication breakdowns are the most common causes of delays [83]. In the same year, Zidane and Andersen [96] highlighted ten critical delay factors in Norway, in which frequent changes of design during construction, deferment of interim payments to contractors and ineffective planning and poor scheduling rank the highest.

Most recently, based on Zidane and Andersen’s [96] 10 universal causes of delays, Arantes and Ferreira’s [20] study in Portugal reported that 6 of the 10 most significant causes are akin to the top 10 universal delays in construction projects. Their exploratory factor analysis manifested six underlying causes relating to inadequate planning, unsatisfactory consultant performance, disorganised site management, owner’s interference, bureaucratic red tape and substandard contracts. Toor and Ogunlana [80] proclaim that most delays are due to the failure to anticipate issues and procrastination in solving problems once they are identified. Moreover, they also observe a comparable pattern of problems across developing countries in many parts of the world.

To facilitate the investigation into the principal delay causes, the present study first involves a thorough literature review of 26 selected studies (Table 1) to shortlist 52 delay causes relating to client (10 causes), contractor (9 causes), consultant (11 causes), labour and equipment (3 causes), material (5 causes) and others (14 causes), as shown in Table 2. The five most highly-cited causes include ‘low productivity’ (19), ‘lack of proper planning and control’ (18), ‘incompetent subcontractors’ (17), ‘inadequate skilled labour’ (16) and ‘weather conditions’ (16). Upon further meta-analysis, the twenty (20) most prevalent delay causes are then selected as a basis for the empirical analysis.

### 3. Research methodology

#### 3.1. Questionnaire design

A primary questionnaire was drafted containing the 20 most common delay causes emerging from the systematic review of the literature obtained by searching academic databases using relevant keywords to pinpoint studies examining project delays (time overruns) as well as other salient issues undermining project performance. The finalised questionnaire contains three parts. Part I is used to collect demographic details of the respondents, such as their type of organisation, age, education background, working experience, nature of projects and type of procurement regularly involved.

Parts II and III entail appraising the viewpoints of key construction stakeholders, comprising representatives from client, consultant and contractor organisations of the 20 delay causes according to their frequency of occurrence and degree of severity during the construction stage using a five-point Likert scale as adopted in previous delay studies (e.g., [21,52,24]). For the frequency of occurrence, the numerical values allotted are 1 = never happened to 5 = always; whereas, for degree of severity, the numerical values allotted are 1 = not at all to 5 = extremely severe.

Being the research instrument, the questionnaire was piloted with 35 construction practitioners from client, consultant and contractor organisations to gauge its quality in terms of comprehensibility and unambiguity. All the pilot respondents had a tertiary education while approximately 60% had over 5 years’ construction experience. The majority of respondents had a total of 2380 electronic questionnaire forms were disseminated to construction practitioners nationwide, comprising clients (property developers), consultants (architects, engineers and quantity surveyors) and contractors (main and sub-contractor companies). One hundred and forty-eight (148) valid questionnaires were collected, recording a response rate of 6.2%. The low response rate is expected as studies by Abdul-Aziz [1] and Yong and Mustaffa [93] also had response rates less than 10% among Malaysian construction practitioners due to work commitment and lethargy towards research. Nonetheless, a sample size of > 100 with subjects-to-variables ratio exceeding five is considered sufficient for statistical testing and acceptable for factor analysis [35,87].

#### 3.2. Data collection

In the main survey, non-probability sampling techniques of convenience and snowballing [24,87] were used to distribute the questionnaire. Using email addresses obtained from the LinkedIn professional social media platform and personal contacts, a total of 2380 electronic questionnaire forms were disseminated to construction practitioners nationwide, comprising clients (property developers), consultants (architects, engineers and quantity surveyors) and contractors (main and sub-contractor companies). One hundred and forty-eight (148) valid questionnaires were collected, recording a response rate of 6.2%. The low response rate is expected as studies by Abdul-Aziz [1] and Yong and Mustaffa [93] also had response rates less than 10% among Malaysian construction practitioners due to work commitment and lethargy towards research. Nonetheless, a sample size of > 100 with a subjects-to-variables ratio exceeding five is considered sufficient for statistical testing and acceptable for factor analysis [35,87].
Table 3 summarises the respondents’ backgrounds. The response rate from clients, consultants and contractors are 11.5%, 46.6% and 41.9%, respectively. Table 3 reveals that almost 60% of the respondents are 31 years or older, 44% have over 10 years of construction experience, while 39% have five years or less working experience. These ratios reflect the current situation in the Malaysian construction industry where a large number of young professionals are employed to meet the vast demand for construction work. Likewise, similar observations are reported by Le-Hoai et al. [52] and Nguyen.
and Chileshe [62] in Vietnam and Yap et al. [86] in Malaysia. The majority has had a tertiary education (97%) and is currently involved in traditionally-procured private projects. The demographic profile of the respondents is therefore considered sufficiently representative of construction practitioners in Malaysia.

### 3.4. Index analysis approach

Following Assaf and Al-Hejji [21], Bagaya and Song [24] and Yap et al. [87], the survey data are analysed using three sets of indices. The delay causes are prioritised using occurrence, severity and importance indices, respectively.

The frequency index (F.I.), which gauges the rate of recurrence of each cause, is given by

\[
F.I. = \sum_i a_i n_i \frac{1}{SN}
\]

where \(a\) denotes a constant expressing the degree of frequency (ranges from 1 for never happened to 5 for always), \(n\) is the frequency of each response and \(N\) is the total number of responses.

The severity index (S.I.) measures the gravity of each delay factor and is given by

\[
S.I. = \sum i b_i n_i \frac{1}{SN}
\]

where \(b\) denotes a constant expressing the degree of severity (ranges from 1 for not at all to 5 for extremely severe).

The importance index (IMP.I.) which expresses the significance of each delay factor as a function integrating frequency of occurrence and degree of severity is given by

\[
IMP.I = F.I. \times S.I.
\]

### 4. Ranking of delay causes

Tables 4 to 6 present the frequency, severity and importance indices along with the ranking of delay causes in descending order according to the clients, consultants and contractors. Overall, IMP.I ranges from 0.261 to 0.539. A close examination of Table 6 reveals the five most significant causes of delays, after taking into account the rate of recurrence and severity of each cause, to be:

1. lack of proper planning and scheduling (IMP.I = 0.539)
2. too many change orders by clients (IMP.I = 0.537)
3. incompetent site management and supervision (IMP.I = 0.519)
4. incompetent sub-contractors (IMP.I = 0.512)
5. financial problems of contractors (IMP.I = 0.502).

Of the causes examined, contractor-related causes have the most significant effect on project delays overall (combined IMP.I. = 2.072); this is consistent with the findings of such studies in the developing world as Egypt [22] and Jordan [79]. The classification of delay causes according to group categories are contractor (35%), client (23%), labour/equipment (14%), consultant (9%), material (7%) and others (12%), from which it can be inferred that contractor-related causes have a significant effect on project delays. A similar trend is also observed by Hisham and Yahya [42], Mydin et al. [60] and Rao and Camron [68].

The clients and contractors viewpoints of delay causes differ as they tend to blame each other for unfavourable incidents [11,22,89]. For instance, the clients attribute the top five delay causes to the contractors’ poor financial, competency and site management. On the other hand, contractors perceive deferred payments by clients to be a major concern. On the issue of change orders, contractors and consultants share a similar perspective. Despite some differing perspectives in the ranking of the top five delay causes, there is an overall similar consensus among the three parties in the ranking of the five least critical delay causes.

Additionally, the main problem delaying construction projects, rated the highest on the severity scale, is the lack of proper planning and scheduling by contractors. Against this backdrop, it can be determined that the higher the frequency of occurrence, the higher the severity of the impact on the original completion date. These results show that contractors acknowledge their shortcomings in planning and scheduling.

While the frequency of contractors’ financial problems is ranked ninth, it is ranked third in terms of severity of delay causes. An inadequate cash flow can significantly undermine the progress of work, as contractors may not be able to carry out construction activities according to schedule, causing the

| Type of organisation | Frequency (N = 148) | Percentage (%) |
|----------------------|--------------------|----------------|
| Contractor            | 62                 | 41.9           |
| Consultant            | 69                 | 46.6           |
| **Age**  
  20–30               | 63                 | 42.6           |
  31–40               | 33                 | 22.3           |
  > 40 38             | 52                 | 35.1           |
| **Education**  
  Master/MBA/MSc      | 36                 | 24.3           |
  Degree              | 89                 | 60.1           |
  Diploma             | 18                 | 12.2           |
  High School         | 5                  | 3.4            |
| **Working experience**  
  less than 5 years   | 57                 | 38.5           |
  6–10 years          | 26                 | 17.6           |
  11–15 years         | 17                 | 11.5           |
  16–20 years         | 14                 | 9.5            |
  > 20 years          | 34                 | 23.0           |
| **Characteristics of project**  
  Public              | 29                 | 19.6           |
  Private             | 119                | 80.4           |
| **Type of procurement**  
  Traditional         | 71                 | 48.0           |
  Design and build    | 44                 | 29.7           |
  Management contracting | 5               | 3.4            |
  Construction management | 25             | 16.9           |
  Turnkey             | 3                  | 2.0            |
**Table 4** Frequency index and ranking.

| No | Causes                                      | Overall (N = 148) | Client (N = 17) | Contractor (N = 62) | Consultant (N = 69) | Group             |
|----|---------------------------------------------|-------------------|-----------------|--------------------|---------------------|-------------------|
|    |                                             | Rank  | F.I. | Rank  | F.I. | Rank  | F.I. | Rank  | F.I. |                     |
| 1  | Lack of proper planning and scheduling      | 1     | 0.718 | 3     | 0.765 | 1     | 0.697 | 5     | 0.693 | Contractor          |
| 2  | Incompetent sub-contractors                 | 2     | 0.716 | 2     | 0.776 | 3     | 0.684 | 6     | 0.687 | Contractor          |
| 3  | Too many change orders by clients           | 3     | 0.715 | 9     | 0.706 | 3     | 0.684 | 1     | 0.757 | Client              |
| 4  | Incompetent site management and supervision | 4     | 0.705 | 1     | 0.800 | 11    | 0.642 | 8     | 0.672 | Contractor          |
| 5  | Slow in making decisions                    | 5     | 0.703 | 3     | 0.765 | 6     | 0.668 | 7     | 0.675 | Client              |
| 6  | Ineffective communication with others       | 6     | 0.701 | 1     | 0.741 | 9     | 0.652 | 3     | 0.710 | Contractor          |
| 7  | Inadequate coordination with other parties  | 7     | 0.694 | 13    | 0.706 | 2     | 0.655 | 2     | 0.722 | Contractor          |
| 8  | Construction mistakes and defective works   | 8     | 0.680 | 8     | 0.729 | 14    | 0.613 | 4     | 0.699 | Contractor          |
| 9  | Financial problem of contractors           | 9     | 0.679 | 3     | 0.765 | 5     | 0.677 | 14    | 0.594 | Contractor          |
| 10 | Inadequate skilled labour                   | 10    | 0.668 | 6     | 0.741 | 12    | 0.632 | 12    | 0.632 | Labour/equipment    |
| 11 | Low productivity                            | 11    | 0.666 | 9     | 0.706 | 7     | 0.655 | 9     | 0.638 | Labour/equipment    |
| 12 | Non-payment or delay of completed works     | 12    | 0.662 | 12    | 0.682 | 2     | 0.690 | 13    | 0.614 | Contractor          |
| 13 | Slow in approving scope changes             | 13    | 0.647 | 13    | 0.659 | 10    | 0.645 | 9     | 0.638 | Consultant          |
| 14 | Unforeseen site conditions                  | 14    | 0.620 | 14    | 0.612 | 14    | 0.613 | 11    | 0.635 | Others              |
| 15 | Weather conditions                          | 15    | 0.607 | 14    | 0.612 | 13    | 0.619 | 15    | 0.591 | Others              |
| 16 | Slow in implementing inspections and testing| 16    | 0.595 | 14    | 0.612 | 16    | 0.584 | 16    | 0.588 | Consultant          |
| 17 | Improper or insufficient plant and equipment selection | 17    | 0.554 | 14    | 0.612 | 19    | 0.506 | 17    | 0.545 | Labour/equipment    |
| 18 | Material shortages                          | 18    | 0.544 | 18    | 0.576 | 17    | 0.552 | 19    | 0.504 | Material            |
| 19 | Price escalation                            | 19    | 0.540 | 19    | 0.553 | 18    | 0.532 | 18    | 0.533 | Material            |
| 20 | Change in government policies and leadership| 20    | 0.479 | 20    | 0.506 | 20    | 0.439 | 20    | 0.493 | Others              |

**Table 5** Severity index and ranking.

| No | Causes                                      | Overall (N = 148) | Client (N = 17) | Contractor (N = 62) | Consultant (N = 69) | Group             |
|----|---------------------------------------------|-------------------|-----------------|--------------------|---------------------|-------------------|
|    |                                             | Rank  | S.I. | Rank  | S.I. | Rank  | S.I. | Rank  | S.I. |                     |
| 1  | Lack of proper planning and scheduling      | 1     | 0.751 | 2     | 0.765 | 3     | 0.716 | 1     | 0.771 | Contractor          |
| 2  | Too many change orders by clients           | 2     | 0.750 | 5     | 0.729 | 1     | 0.761 | 2     | 0.759 | Client              |
| 3  | Financial problem of contractors           | 3     | 0.735 | 1     | 0.800 | 4     | 0.713 | 10    | 0.693 | Contractor          |
| 4  | Incompetent site management and supervision | 4     | 0.734 | 3     | 0.753 | 6     | 0.694 | 3     | 0.757 | Contractor          |
| 5  | Non-payment or delay of completed works     | 5     | 0.727 | 7     | 0.729 | 2     | 0.748 | 8     | 0.704 | Client              |
| 6  | Incompetent sub-contractors                 | 6     | 0.714 | 4     | 0.741 | 5     | 0.706 | 9     | 0.696 | Contractor          |
| 7  | Slow in making decisions                    | 7     | 0.700 | 8     | 0.694 | 7     | 0.690 | 6     | 0.716 | Client              |
| 8  | Ineffective communication with others       | 8     | 0.695 | 8     | 0.694 | 9     | 0.674 | 6     | 0.716 | Client              |
| 9  | Construction mistakes and defective works   | 9     | 0.695 | 5     | 0.729 | 13    | 0.635 | 5     | 0.719 | Contractor          |
| 10 | Inadequate coordination with other parties  | 10    | 0.693 | 10    | 0.671 | 8     | 0.677 | 4     | 0.730 | Contractor          |
| 11 | Slow in approving scope changes             | 11    | 0.662 | 10    | 0.671 | 10    | 0.671 | 14    | 0.643 | Consultant          |
| 12 | Inadequate skilled labour                   | 12    | 0.661 | 10    | 0.671 | 12    | 0.639 | 11    | 0.672 | Labour/equipment    |
| 13 | Low productivity                            | 13    | 0.648 | 15    | 0.635 | 11    | 0.661 | 13    | 0.646 | Labour/equipment    |
| 14 | Unforeseen site conditions                  | 14    | 0.639 | 15    | 0.635 | 16    | 0.616 | 12    | 0.667 | Others              |
| 15 | Material shortages                          | 15    | 0.633 | 13    | 0.659 | 15    | 0.623 | 15    | 0.617 | Material            |
| 16 | Slow in implementing inspections and testing| 16    | 0.612 | 17    | 0.612 | 14    | 0.626 | 17    | 0.597 | Consultant          |
| 17 | Improper or insufficient plant and equipment selection | 17    | 0.610 | 13    | 0.659 | 19    | 0.558 | 16    | 0.614 | Labour/equipment    |
| 18 | Weather conditions                          | 18    | 0.595 | 18    | 0.576 | 17    | 0.613 | 18    | 0.594 | Others              |
| 19 | Price escalation                            | 19    | 0.583 | 19    | 0.565 | 18    | 0.597 | 19    | 0.588 | Material            |
| 20 | Change in government policies and leadership| 20    | 0.543 | 19    | 0.565 | 20    | 0.519 | 20    | 0.545 | Others              |
project to be delayed [22,67]. Contractors and clients share the same view of the consequence caused by incompetent sub-contractors, ranking cash flow and sub-contractors incompetence second and third, respectively. Hence, the method of contractor or sub-contractor selection is crucial for ensuring their competency to complete the work in both a satisfactorily and timely manner.

It is worth mentioning that all parties agree on price escalation, and changes in government policies and leadership are the least important causes of delays. This is most likely due to Malaysia’s politically stable environment.

5. Comparison with selected countries

The objective of drawing comparisons with selected countries is to consolidate the findings between this empirical study and studies in other developed and developing countries, in addition to validation purposes.

Of the selected studies as shown in Table 7, it is evident that ‘financial problems of contractors’ and ‘lack of proper planning and scheduling’ are not only evident in Malaysia. It also manifests in many African and Asian countries such as Burkina Faso, Benin, Egypt, Jordan, Uganda and Vietnam, recording an occurrence percentage of 27.8% of the top five delay causes (see Fig. 1). The next leading factor is ‘incompetent sub-contractors’ with 22.2%. However, it is interesting to note these leading delay causes are not significant in the UK. In agreement with Toor and Ogunlana [80], prevailing managerial interference issues persistently undermine project schedule performance. These findings suggest a failure to capitalise on past project experiences and recognise current flaws in the planning and control of projects. According to Love et al. [54], despite the plethora of studies on rework, the inability to critically reflect on the prevailing norms is resulting in recurring problems within the construction industry. This reinforces Alshahimi et al.’s [15] view that descriptive and explanatory research approaches are inadequate to contain delays in developing countries. Capacity-building efforts through project learning [82,84] and best value [18,17] are possible changes needed to transform the industry towards an improved schedule performance.

6. Agreement analysis

Spearman rank correlation coefficient is used to ascertain the concordance between pairs of parties. Table 8 presents the results, showing that the level of agreement between three respondent groupings in ranking the frequency, severity and IMP.I. of each delay cause is relatively good. Even though there are slight differences in opinion between clients and contractors, their level of agreement is the highest — the lowest level of agreement is between the clients and consultants.

7. Exploratory factor analysis

The principal groupings of the 20 delay causes is uncovered by factor analysis. The Kaiser-Meyer-Olkin (KMO) test and Bar-

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Table 6  Importance index and ranking.

| No | Causes                                      | Overall (N = 148) | Client (N = 17) | Contractor (N = 62) | Consultant (N = 69) | Group           |
|----|---------------------------------------------|-------------------|-----------------|---------------------|----------------------|-----------------|
| 1  | Lack of proper planning and scheduling      | 1                 | 0.539           | 3                   | 0.585                | Contractor      |
| 2  | Too many change orders by clients           | 2                 | 0.537           | 7                   | 0.515                | Client          |
| 3  | Incompetent site management and supervision | 3                 | 0.519           | 2                   | 0.602                | Contractor      |
| 4  | Incompetent sub-contractors                 | 4                 | 0.512           | 4                   | 0.576                | Contractor      |
| 5  | Financial problem of contractors            | 5                 | 0.502           | 1                   | 0.612                | Contractor      |
| 6  | Slow in making decisions                    | 6                 | 0.492           | 6                   | 0.531                | Client          |
| 7  | Ineffective communication with others       | 7                 | 0.487           | 8                   | 0.514                | Contractor      |
| 8  | Non-payment or delay of completed works     | 8                 | 0.482           | 9                   | 0.498                | Client          |
| 9  | Construction mistakes and defective works   | 9                 | 0.475           | 5                   | 0.332                | Contractor      |
| 10 | Inadequate coordination with other parties  | 10                | 0.462           | 10                  | 0.497                | Contractor      |
| 11 | Inadequate skilled labour                   | 11                | 0.442           | 10                  | 0.497                | Labour/equipment |
| 12 | Low productivity                            | 12                | 0.431           | 12                  | 0.448                | Labour/equipment |
| 13 | Slow in approving scope changes             | 13                | 0.428           | 13                  | 0.442                | Consultant      |
| 14 | Unforeseen site conditions                  | 14                | 0.396           | 15                  | 0.389                | Others          |
| 15 | Slow in implementing inspection and testing | 15                | 0.364           | 17                  | 0.374                | Consultant      |
| 16 | Weather conditions                          | 16                | 0.361           | 18                  | 0.353                | Others          |
| 17 | Material shortages                          | 17                | 0.345           | 16                  | 0.380                | Material        |
| 18 | Improper or insufficient equipment selection| 18                | 0.340           | 14                  | 0.403                | Labour/equipment |
| 19 | Price escalation                            | 19                | 0.315           | 19                  | 0.312                | Material        |
| 20 | Change in government policies and leadership| 20                | 0.261           | 20                  | 0.286                | Others          |
Tlett’s test of sphericity is used to determine the suitability of the variables for factor analysis \([78,86]\). The result of the KMO test is 0.816, whereas Bartlett’s test of sphericity is 1254.3 (\(q = 0.000\)) – both satisfying the aptness criteria for factor analysis (Table 9).

To determine the number of factors to retain, the cut-off value for eigenvalues is set at the conventional value of 1 \([86,92]\). The principal component analysis (PCA) yields five principal factors that account for 62.34% of the total variance explained, which is above the threshold of 60% needed to sustain validity \([38]\). ‘Slow in making decisions’ and ‘materials storage’ both have factor loadings below the usual threshold of 0.50 and are eliminated from further analysis. Varimax rotation is further applied for a higher explanatory power \([88,92]\).

Table 10 presents the factor profile. Each factor is interpreted and named accordingly with their factor loadings. Generally,

### Table 7  Major delay factors in other countries/regions.

| Selected countries | Major delay factors in Malaysia (2019) | Incompetent site management and supervision | Incompetent sub-contractors | Financial problem of contractors |
|--------------------|---------------------------------------|---------------------------------------------|-----------------------------|---------------------------------|
| Selected countries | Lack of proper planning and scheduling |                              |                              |                                 |
| Burkina            | √                                      |  √                                          | √                           | √                              |
| Faso\[24\]         |                                        |                                              |                             |                                 |
| Benin\[10\]        |                                        |                                              |                             |                                 |
| Egypt\[56\]        |                                        |                                              |                             |                                 |
| Jordan\[79\]       |                                        |                                              |                             |                                 |
| Malaysia\[71\]     |                                        |                                              |                             |                                 |
| Uganda\[58\]       |                                        |                                              |                             |                                 |
| Vietnam\[52\]      |                                        |                                              |                             |                                 |
| United Kingdom\[44\] |                                        |                                              |                             |                                 |
| Australia\[74\]    |                                        |                                              |                             |                                 |
| Total frequency    | 5                                      | 2                                           | 2                           | 4                              |

**Fig. 1** Percentages of the top five ranking delay causes in nine countries.

### Table 8  Spearman’s rank correlation of delay causes.

|                      | Frequency index | Severity index | Importance index |
|----------------------|-----------------|----------------|-----------------|
|                      | \(r_s\) | \(\alpha\) | \(r_s\) | \(\alpha\) | \(r_s\) | \(\alpha\) |
| Clients - Contractors | 0.711          | 0.01           | 0.859          | 0.01          | 0.808 | 0.01          |
| Contractors - Consultants | 0.678 | 0.01           | 0.813          | 0.01          | 0.795 | 0.01          |
| Clients - Consultants | 0.683 | 0.01           | 0.840          | 0.01          | 0.758 | 0.01          |

Note: \(r_s\) indicates Spearman’s rank correlation coefficient and \(\alpha\) indicates the significance level.
Table 9 Results of the KMO and Bartlett’s test.

| Parameter                          | Value         |
|------------------------------------|---------------|
| Kaiser-Meyer-Olkin measure of sampling adequacy | 0.816         |
| Bartlett’s test of sphericity       |               |
| Approximate chi-squared value       | 1254.3        |
| Degree of freedom                   | 190           |
| Significance value                  | 0.000         |

Table 10 Factor loading and variance explained.

| Factors and causes of project delays | Factor loading | Variance explained % |
|--------------------------------------|----------------|----------------------|
| Factor 1: Competency Management      | –              | 16.160               |
| Lack of proper planning and scheduling | 0.817         | –                    |
| Low productivity                     | 0.722          | –                    |
| Incompetent sub-contractors          | 0.695          | –                    |
| Incompetent site management and supervision | 0.691  | –                    |
| Factor 2: Communication and Coordination Management | –                | 16.090               |
| Inadequate coordination with other parties | 0.801        | –                    |
| Ineffective communication with other parties | 0.755        | –                    |
| Too many change orders by clients    | 0.695          | –                    |
| Slow in approving scope changes      | 0.620          | –                    |
| Slow in implementing inspection and testing | 0.592      | –                    |
| Factor 3: Financial Management       | –              | 11.573               |
| Non-payment or delay of completed works | 0.777         | –                    |
| Financial problem of contractors     | 0.601          | –                    |
| Change in government’s policies and leadership | 0.557    | –                    |
| Factor 4: Risk Management            | –              | 9.395                |
| Unforeseen site conditions           | 0.774          | –                    |
| Price escalation                     | 0.654          | –                    |
| Factor 5: Site Management            | –              | 9.117                |
| Inadequate skilled labour            | 0.632          | –                    |
| Weather conditions                   | 0.605          | –                    |
| Construction mistakes and defective works | 0.596    | –                    |
| Improper or insufficient plant and equipment selection | 0.563 | – |

8. Discussion of factor analysis results

8.1. Factor 1: Competency management

Factor 1 accounts for 16.2% of the total variance explained. As Haron et al. [41] opine, the new and emerging criteria to ensure successful completion of construction projects in Malaysia are built upon the know-how of the project team together with the performance of sub-contractors/suppliers. On the other hand, the inefficiency and incapability of a project management team can result in project failure [55] – a dominating trend in most Arabic Gulf countries. Accordingly, capacity building with proper competency management can overcome low productivity and reduce the severity of contractor-related issues, and thus improving the quality of construction work. Another recent study by Yap et al. [85] concludes that most design changes during building production are attributable to inexperienced (ignorant, unlearned and uninformed) project personnel – resulting in extensive rework and an extended duration. This factor is associated with contractor and labour and equipment-related causes. Performance-related issues in construction projects often contribute to project delays [89]. Intrinsically, incompetent sub-contractors/suppliers and an unskilled workforce often lead to poor performance and can eventually result in project delays [25,46]. This factor evidently suggests the need to improve learning and engage capacity building to improve organisational and project performance. To raise productivity and improve performance, Love and Smith [53] propose cultivating a learning culture to transform experiences into reusable knowledge that can help prevent errors in the future. They propose a growth mindset for learning that integrates enacting behaviour with authentic leadership and coaching. According to Shi et al. [77], the competencies needed for sustainable construction relate to the quality of personnel and troubleshooting skills on site, as well as continuing professional development. In this sense, experiential project learning provides the preventive mitigation of time overruns, leveraging of accumulated experience and increased expert judgment [84].

8.2. Factor 2: Communication and coordination management

This second factor accounts for 16.1% of the total variance explained. Butt et al. [27] and Yap et al. [85] consider that communication and coordination management have a significant influence on project success. As such, collaboration in the supply chain is essential [49]. According to Zidane and Andersen’s [96] systematic review of the extant literature, one of the leading factors of delay, as cited in 37 delay studies, is miscommunication and lack of coordination between contracting parties. The construction industry suffers from fragmentation, which frequently hampers effective communication, resulting in an adversarial ‘them and us’ attitude [89] as well as conflict and claims during the project [49]. A recent study by Bajjou and Chafi [25] in Morocco reported that the lack of collective coordination incapacitates planning and scheduling work. Communication and coordination management includes several processes, such as data generation, data collection, data distribution, data storage and data retrieval, to gather the project information required in an appropriate and timely manner [72]. This undertaking becomes more challenging when multiple tasks are outsourced to different sub-contractors. According to Laufer et al. [51], the intensiveness and extensiveness of on-site communications vary in dynamic conditions: they observe that most construction managers prefer informal interactions for sharing and gathering information. In this context, construction practitioners have a strong orientation toward...
the verbal communication of information. However, rich project communications are essential for effective coordination whatever the medium of communication [73].

8.3. Factor 3: Financial management

This third factor accounts for 11.6% of the total variance. According to Zidane and Andersen [96], universal financially-related delay causes are deferred payments to the contractor, insufficient financial resources of the contractor and the owner’s lack of sound financial management practices. Abdul-Rahman et al.’s [3] survey of key construction stakeholders and bankers in Malaysia reports the major financially-related delay causes to be poor cashflow management, late payments and deficient capital. Delays in progress payments is the leading cause of delays to Moroccan construction projects [25]. In another study, Enshassi et al. [34] emphasise that cashflow problems impede progress by deteriorating productivity, as contractors are incapable of purchasing the materials and equipment required to complete outstanding work. They further explain that these predicaments also extend to subcontractors and suppliers — generating a vicious cycle of slow progress and ultimately project delays. In Turkey, poor financial management is the primary root cause of project delays, which needs to be taken into account by construction practitioners [47]. Hence, sound financial planning, management and control provide the basis for smooth implementation [95].

8.4. Factor 4: construction risk management

According to Zidane and Andersen [96], a delay is an unavoidable risk for construction projects. As Zarei et al. [94] opine, delays are related to the degree of uncertainty and complexity of projects. A construction risk can be described as “an uncertain event or condition that, if it occurs, has a positive or negative effect on one or more project objectives such as scope, schedule, cost, and quality” [43]. Typical construction risks include escalation in material prices [34] and unforeseen site conditions [85]. By understanding the potential causes of delays, effective and proactive risk management measures can be developed to eliminate or minimise both their likelihood and impact [37]. A cause of concern is that the practice of risk management is generally lacking in Malaysia as its construction practitioners are ignorant of the risk management tools and techniques available [4]. Yaraghi and Langhe’s [91] examination of the success dimension concerning risk management systems concludes that organisational culture and knowledge are crucial influential factors. Given this understanding, knowledge of construction risk management is becoming crucial for dealing with the complexity of projects at different phases of the project life cycle and the risk tolerances involved [28].

8.5. Factor 5: Site management

Poor site management contributes to project delays and leads to poor construction productivity [56]. Site management is concerned with project monitoring, distribution of resources, the commitment of site workers and communication and coordination between all parties [29]. Table 8 shows ‘inadequate skilled labour’, ‘weather conditions’, ‘construction mistakes and defective works’ and ‘improper or insufficient equipment selection’ to be the site management factors involved, and account for 9.1% of the total variance explained. With this in mind, well-organised site management and adequate supervision are of paramount importance for improving the schedule performance of construction projects [30].

9. Concluding remarks

As the ubiquitous nature of construction project delays continues worldwide, the causal factors involved have received considerable academic attention to date, although the descriptive and explanatory nature of the research conducted thus far has yielded little success in containing the problem. This study uses a Malaysian field survey to prioritise the 20 most prevailing causes of construction project delays with respect to the cognisance of key stakeholders from client’s, contractor’s and consultant’s organisations according to the importance index (IMP.I.) reflecting the combined effect of their frequency of occurrence and degree of severity. In the overall context, the five most critical causes are ‘lack of proper planning and scheduling’, ‘too many change orders by clients’, ‘incompetent site management and supervision’, ‘inept sub-contractors’, and ‘financial problems of contractors’. The Spearman’s rank correlation tests indicate a good agreement between the three respondent groups in relation to the frequency, severity and importance of the delay causes, further affirming the validity of the findings in revealing that contractor-related causes contribute the most to project delays.

A comparative analysis with selected countries indicates that most developing Asian and African countries face a similar situation, with the most prominent reason being a lack of contractor competencies and awareness, and an industry-wide inability to deal with the many flaws in project management practices. As mentioned in several recent studies, the long-running tenacity of the problem and failure to find any practical solutions of note point to what Love et al. [54] term the ‘praxis of stupidity’ by reason of the inability to learn and thus repeating similar mistakes from one project to the other, with more attention being needed to create a mindfulness to learn from the recurring managerial problems involved — implying a radical change in terms of a shift towards transformative approaches such as project learning [5, 90] and best value construction [18, 17].

The factor analysis identified the five principal factors involved to be competency management, communication and coordination management, financial management, risk management and site management, indicating the importance of proper planning and scheduling, sufficient site management and supervision, employment of proper financial management, minimising the degree of change orders by clients and selection of qualified and eligible sub-contractors being the stakeholders’ main focus before the commencement of any project procurement process.

These research findings benefit both academics and construction practitioners with deeper insights into the root causes of schedule delays, particularly to the construction industry in developing Asian and African economies. The continued expansion of knowledge and understanding regarding the importance (criticality) of these causes will help stakeholders reduce the incidences of delays and lead to appropriate strate-
gies to enhance project schedule performance and also guide future research in the industry. Furthermore, construction practitioners need to be cognizant of the five principal managerial capabilities influencing schedule delays in their projects to avoid their lack of knowledge and awareness undermining the delivery of projects. The principal factors uncovered can also be integrated into the education and training of construction professionals to enhance their ability to distinguish and address the primary causes of project delays.

While the study makes several contributions to construction schedule management, it is limited by the single data collection method using field survey possibly causing method bias. Although the use of a structured questionnaire survey facilitates data collection from a large sample of practitioners for statistical analysis, unlike the interpretative approach using purposeful interviews it is unable to probe respondents for their rich experiences in confronting delay issues. Nevertheless, the results are largely substantiated by data triangulation in comparing them with previous studies. Further such comparative studies would be beneficial to explore the influence of procurement systems and level of experience of construction stakeholders on the perceptions of delay factors in other geographic and economic contexts. Future prescriptive research using action and constructive research approaches would also help examine the strategic mitigation measures needed to reduce and control the extent of schedule delays to deal with the managerial problems involved.

Declaration of Competing Interest

The authors declared that there is no conflict of interest.

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References

[1] A.-R. Abdul-Aziz, Control mechanisms exercised in Malaysian housing public-private partnerships, Construction Management and Economics 30 (1) (2012) 37–55.
[2] H. Abdul-Rahman, M.A. Berawi, A.R. Berawi, O. Mohamed, M. Othman, I.A. Yahya, Delay mitigation in the Malaysian construction industry, Journal of Construction Engineering and Management 132 (2) (2006) 125–133.
[3] H. Abdul-Rahman, R. Takim, W.S. Min, Financial-related causes contributing to project delays, Journal of Retail and Leisure Property 8 (3) (2009) 225–238.
[4] H. Abdul-Rahman, C. Wang, F. Sheik Mohamad, Implementation of risk management in Malaysian construction industry: Case studies, Journal of Construction Engineering and Management 2015 (2015) 192742.
[5] H. Abdul-Rahman, I.A. Yahya, M.A. Berawi, W.W. Low, Conceptual delay mitigation model using a project learning approach in practice, Construction Management and Economics 26 (1) (2008) 15–27.
[6] M.R. Abdullah, I.A. Rahman, A.A.A. Azis, Causes of delay in MARA management procurement construction projects, Journal of Surveying, Construction & Property 1 (1) (2010) 123–138.
[7] G. Agyekum-Mensah, A.D. Knight, The professionals perspective on the causes of project delay in the construction industry, Engineering, Construction and Architectural Management 24 (5) (2017) 828–841.
[8] A.A. Aibinu, G.O. Jagboro, The effects of construction delays on project delivery in Nigerian construction industry, Int. J. Project Manage. 20 (8) (2002) 593–599.
[9] A.A. Aibinu, H.A. Odeyinka, Construction delays and their causative factors in Nigeria, Journal of Construction Engineering and Management 132 (7) (2006) 667–677.
[10] R.K.T.M. Akogbe, X. Feng, J. Zhou, Importance and ranking evaluation of delay factors for development construction projects in Benin, KSCE J. Civ. Eng. 17 (6) (2013) 1213–1222.
[11] A. Al-Kharashi, M. Skitmore, Causes of delays in Saudi Arabian public sector construction projects, Construction Management and Economics 27 (1) (2009) 5–23.
[12] A.H. Al-Momani, Construction delay: A quantitative analysis, Int. J. Project Manage. 18 (1) (2000) 51–59.
[13] W. Alagbari, M.R.A. Kadir, A. Salim, Ernawati, The significant factors causing delay of building construction projects in Malaysia, Engineering, Construction and Architectural Management 14 (2) (2007) 192–206.
[14] H. Almaitwe, R. Apolot, D. Tindiwensi, Investigation into the causes of delays and cost overruns in Uganda’s public sector construction projects, Journal of Construction in Developing Countries 18 (2) (2013) 33–47.
[15] A. Alsehaimi, L. Koskela, P. Tzortzopoulos, Need for alternative research approaches in construction management: Case of delay studies, J. Manage. Eng. 29 (4) (2013) 407–414.
[16] J.A. Alsuliman, Causes of delay in Saudi public construction projects, Alexandria Engineering Journal 58 (2) (2019) 801–808.
[17] M. Alzara, M. Algahtany, J.S. Kashwayi, Improving the current procurement system in Saudi Arabia: A university case study, Journal for the Advancement of Performance Information and Value 9 (2) (2020) 63–78.
[18] M. Alzara, J. Kashwayi, D. Kashwayi, A. Al-Tassan, Using PIPS to Minimize Causes of Delay in Saudi Arabian Construction Projects: University case study, Procedia Eng. 145 (480) (2016) 932–939.
[19] C.T. Amoatey, Y.A. Ameyaw, E. Adaku, S. Famiyeh, Analysing delay causes and effects in Ghanaian state housing construction projects, International Journal of Managing Projects in Business 8 (1) (2015) 198–214.
[20] A. Arantes, L.M.D.F. Ferreira, Underlying causes and mitigation measures of delays in construction projects: An empirical study, Journal of Financial Management of Property and Construction 25 (2) (2020) 165–181.
[21] S.A. Assaf, S. Al-Heiji, Causes of delay in large construction projects, Int. J. Project Manage. 24 (4) (2006) 349–357.
[22] R.F. Aziz, Ranking of delay factors in construction projects after Egyptian revolution, Alexandria Engineering Journal 52 (3) (2013) 387–406.
[23] R.F. Aziz, A.A. Abdel-Hakam, Exploring delay causes of road construction projects in Egypt, Alexandria Engineering Journal 55 (2) (2016) 1515–1539.
[24] O. Bagaya, J. Song, Empirical study of factors influencing schedule delays of public construction projects in Burkina Faso, J. Manage. Eng. 32 (5) (2016) 05016014.
[25] M.S. Bajjou, A. Chafi, Empirical study of schedule delay in Moroccan construction projects, International Journal of Construction Management, Taylor & Francis (2019) 1–18.
[26] Business Dictionary. (2020). “What is delay? definition and meaning - BusinessDictionary.com.” <http://www.businessdictionary.com/definition/delay.html>.

[27] A. Buti, M. Naaranoja, J. Savolainen, Project change stakeholder communication, Int. J. Project Manage. 34 (8) (2016) 1579–1595.

[28] A.C. Cagliano, S. Grimaldi, C. Rafele, Choosing project risk management techniques: A theoretical framework, J. Risk Res. 18 (2) (2015) 232–248.

[29] B.W.Y. Chiu, J.H.K. Lai, Project delay: key electrical construction factors in Hong Kong, Journal of Civil Engineering and Management 23 (7) (2017) 847–857.

[30] H. Doloji, A. Sawhney, K.C. Iyer, S. Rentala, Analysing factors affecting delays in Indian construction projects, Int. J. Project Manage. 30 (4) (2012) 479–489.

[31] S. Durdevic, M.R. Hosseini, Causes of delays on construction projects: a comprehensive list, International Journal of Managing Projects in Business 13 (1) (2019) 20–46.

[32] Ejaz, N., Ali, I., and Tahir, M. (2013). “Assessment of Delays and Cost Overruns during Construction Periods in Pakistan.” Civil Engineering Department University of Engineering & Technology, Taxila – Pakistan Abstract, 1–9.

[33] M.E.A. El-Razek, H.A. Bassioni, A.M. Mobarak, Causes of delay in large building construction projects, Journal of Construction Engineering and Management 134 (11) (2008) 831–841.

[34] A. Enshassi, M. Kumaraswamy, A.N. Jomah, Significant factors causing time and cost overruns in construction projects in the Gaza Strip: Contractors’ perspective, International Journal of Construction Management 10 (1) (2010) 35–60.

[35] R. Fellows, A. Liu, Research methods for construction, John Wiley & Sons Ltd, UK, Oxford, UK, 2015.

[36] P.T. Gbahabo, O.S. Ajuwon, Effects of project cost overruns and schedule delays in Sub-Saharan Africa, European Journal of Interdisciplinary Studies 3 (2) (2017) 46–58.

[37] C.S. Goh, H. Abdul-Rahman, The identification and management of major risks in the Malaysian construction industry, Journal of Construction in Developing Countries 18 (1) (2013) 19–32.

[38] J.F. Hair, W.C. Black, B.J. Babin, R.E. Anderson, Multivariate data analysis, Cengage Learning, Hampshire, United Kingdom, 2019.

[39] N. Hamzah, M.A. Khoiriy, I. Arshad, W.H.W. Badaruzzaman, N.M. Tawil, Identification of the causes of construction delay in Malaysia, World Academy of Science, Engineering and Technology 72 (12) (2012) 312–317.

[40] P. Hanks, J. Pearsall, A. Stevenson, Oxford dictionary of English, Oxford University Press, USA, 2010.

[41] N.A. Haron, P. Devi, S. Hassim, A.H. Alias, M.M. Tahir, A.N. Harun, Project management practice and its effects on project success in Malaysian construction industry, IOP Conference Series: Materials Science and Engineering 291 (2017) 012008.

[42] Hisham, S. N. A., and Yahya, K. (2016). “Causes and effects of delays in construction industry.” 1st Proceeding of the Civil Engineering Vol 2 Construction Management, Geotechnics and Transportation, Faculty of Civil Engineering, Universiti Teknologi Malaysia, Johor Bahru, 78–89.

[43] M.M. Hossen, S. Kang, J. Kim, Construction schedule delay risk assessment by using combined AHP-RII methodology for an international NPP project, Nuclear Engineering and Technology 47 (3) (2015) 362–379.

[44] P.Y. Hsu, M. Aurisicchio, P. Angeloudis, Investigating schedule deviation in construction projects through root cause analysis, Procedia Comput. Sci. 121 (2017) 732–739.

[45] S. Hussain, F. Zhu, Z. Ali, H. Aslam, A. Hussain, Critical delaying factors: Public sector building projects in Gilgit-Baltistan, Pakistan, Buildings 8 (1) (2018) 6.

[46] D. Ikediashi, S. Ogumana, A. Alotaibi, Analysis of project failure factors for infrastructure projects in Saudi Arabia: A multivariate approach, Journal of Construction in Developing Countries 19 (1) (2014) 35–52.

[47] A. Kazaz, S. Ulubeyli, N.A. Tuncbilekli, Causes of delays in construction projects in Turkey, Journal of Civil Engineering and Management 18 (3) (2012) 426–435.

[48] R.A. Khan, U. Gazder, A. Qayoom, Comparison of delay factors and remedies rankings for building construction projects in developing countries, International Journal of Advanced and Applied Sciences 4 (4) (2017) 33–42.

[49] S.-Y. Kim, V.T. Nguyen, A structural model for the impact of supply chain relationship traits on project performance in construction, Production Planning & Control 29 (2) (2018) 170–183.

[50] J.K. Larsen, G.Q. Shen, S.M. Lindhard, T.D. Bruene, Factors affecting schedule delay, cost overrun, and quality level in public construction projects, J. Manage. Eng. 32 (1) (2015) 04015032.

[51] A. Laufur, A. Shapira, D. Telem, Communicating in dynamic conditions: How do on-site construction project managers do it?, J. Manage. Eng. 24 (2) (2008) 75–86.

[52] L. Le-Hoi, Y.D. Lee, J.Y. Lee, Delay and cost overruns in Vietnam large construction projects: A comparison with other selected countries, KSCE J. Civ. Eng. 12 (6) (2008) 367–377.

[53] P.E.D. Love, J. Smith, Toward error management in construction: Moving beyond a zero vision, Journal of Construction Engineering and Management 142 (11) (2016) 04016058.

[54] P.E.D. Love, J. Smith, F. Ackermann, Z. Irani, The praxis of stupidity: An explanation to understand the barriers mitigating rework in construction, Production Planning & Control 29 (13) (2018) 1112–1125.

[55] I. Mahdi, E. Soliman, Significant and top ranked delay factors in Arabic Gulf countries, International Journal of Construction Management (2019) 1–14.

[56] M.M. Marzouk, T.I. El-Rasas, Analyzing delay causes in Egyptian construction projects, J. Adv. Res., Cairo University 5 (1) (2014) 49–55.

[57] B. Mpofu, E. Godfrey, O.C. Moobela, A. Pretorius, Profiling causative factors leading to construction project delays in the United Arab Emirates, Engineering, Construction and Architectural Management 24 (2) (2017) 346–376.

[58] L. Muhewezi, J. Acai, G. Otim, An assessment of the factors causing delays on building construction projects in Uganda, International Journal of Construction Engineering and Management 3 (1) (2014) 13–23.

[59] M. Mukuka, C. Aigbavboa, W. Thwala, Effects of construction projects schedule overruns: A case of the Gauteng Province, South Africa, Procedia Manuf., Elsevier B.V. 3 (2015) 1690–1695.

[60] M.A.O. Mydin, N.M. Sani, M. Taib, N.M. Alias, Imperative causes of delays in construction projects from developers’ outlook. MATEC Web of Conferences 10 (2014) 06005.

[61] M.P. Nepal, M. Park, B. Son, Effects of schedule pressure on construction performance, Journal of Construction Engineering and Management 132 (2) (2006) 182–188.

[62] T.P. Nguyen, N. Chileshe, Revisiting the construction project failure factors in Vietnam, Built Environment Project and Asset Management 5 (4) (2015) 398–416.

[63] Nurul, A. J., Aminah, M. Y., Syuhaida, I., and Chai, C. S. (2016). “Public construction projects performance in Malaysia.” Journal of Southeast Asian Research, 2016, Article ID 940838.

[64] A.M. Ödeh, H.T. Battaineh, Causes of construction delay: Traditional contracts, Int. J. Project Manage. 20 (2002) 67–73.

[65] Y.A. Olawale, M. Sun, Cost and time control of construction projects: Inhibiting factors and mitigating measures in practice, Construction Management and Economics 28 (5) (2010) 509–526.
Revisiting critical delay factors for construction: Analysing projects in Malaysia

[60] A. Othman, S. Ismail, Delay in government project delivery in Kedah, Malaysia, Recent Advances in Civil Engineering and Mechanics (2014) 248–254.

[61] J.D. Ovalabi, L.M. Amusan, C.O. Oloke, O. Olusanya, P. Tunji-Olayeni, O. Dele, P. Joy, O. Iganatious, Causes and effects of delay on project construction delivery time, International Journal of Education and Research 2 (4) (2014) 197–208.

[62] P.B. Rao, C. Joseph Camron, Causes of delays in construction projects: A case study, International Journal of Current Research 6 (6) (2014) 7219–7222.

[63] H. Samarghandi, S.M.M. Tabatabaei, P. Taabayan, A.M. Hashemi, K. Willoughby, Studying the reasons for delay and cost overrun in construction projects: The case of Iran, Journal of Construction in Developing Countries 21 (1) (2016) 51–84.

[64] M. Sambasivan, T.J. Deepak, A.N. Salim, V. Ponniah, Analysis of delays in Tanzanian construction industry: Transaction cost economics (TCE) and structural equation modelling (SEM) approach, Engineering, Construction and Architectural Management 24 (2) (2017) 308–325.

[65] M. Sambasivan, Y.W. Soon, Causes and effects of delays in Malaysian construction industry, Int. J. Project Manage. 25 (5) (2007) 517–526.

[66] S. Senaratne, M. Ruwanpura, Communication in construction: A management perspective through case studies in Sri Lanka, Architectural Engineering and Design Management 12 (1) (2016) 3–18.

[67] R.R. Senescu, G. Arandal-Mena, J.R. Haymaker, Relationships between project complexity and communication, J. Manage. Eng. 29 (2) (2013) 183–197.

[68] R.K. Shah, An Exploration of Causes for Delay and Cost Overrun in Construction Projects: A Case Study of Australia, Malaysia & Ghana, Journal of Advanced College of Engineering and Management 2 (2016) 41–55.

[69] P. Shahasavand, A. Marfat, M. Parchamjital, Causes of delays in construction industry and comparative delay analysis techniques with SCL protocol, Engineering, Construction and Architectural Management 25 (4) (2018) 497–533.

[70] Z. Shelu, G.D. Holt, I.R. Endut, A. Akintoye, Analysis of characteristics affecting completion time for Malaysian construction projects, Built Environment Project and Asset Management 5 (1) (2015) 52–68.

[71] L. Shi, K. Ye, W. Lu, X. Hu, Improving the competence of construction management consultants to underpin sustainable construction in China, Habitat International 41 (January) (2014) 236–242.

[72] E.G. Sinesilascie, S.Z.S. Tabish, K.N. Jha, Critical factors affecting schedule performance: A case of Ethiopian public construction projects - engineers’ perspective, Engineering, Construction and Architectural Management 24 (5) (2017) 757–773.

[73] G. Sweis, R. Sweis, A.A. Hammad, S. Shboul, Delays in construction projects: The case of Jordan, Int. J. Project Manage. 26 (6) (2008) 665–674.

[74] S.-U.-R. Toor, S. Ogunlana, Problems causing delays in major construction projects in Thailand, Construction Management and Economics 26 (4) (2008) 395–408.

[75] B. Trigunarsyah, M.S. Islam, Construction delays in developing countries: A review, Journal of Construction Engineering and Project Management 7 (1) (2017) 1–12.

[76] C. Wang, J.B.H. Yap, L.C. Wood, H. Abdul-Rahman, Knowledge modelling for contract disputes and change control, Production Planning & Control 30 (8) (2019) 650–664.

[77] T.K. Wang, D.N. Ford, H.Y. Chong, W. Zhang, Causes of delays in the construction phase of Chinese building projects, Engineering, Construction and Architectural Management 25 (11) (2018) 1534–1551.

[78] J.B.H. Yap, H. Abdul-Rahman, C. Wang, Preventive mitigation of overruns with project communication management and continuous learning: PLS-SEM approach, Journal of Construction Engineering and Management 144 (5) (2018) 04018025.

[79] J.B.H. Yap, H. Abdul-Rahman, C. Wang, M. Skitmore, Exploring the underlying factors inducing design changes during building production, Production Planning & Control 29 (7) (2018) 586–601.

[80] J.B.H. Yap, J.R. Chong, M. Skitmore, W.P. Lee, Rework causation that undermines safety performance during production in construction, Journal of Construction Engineering and Management 146 (9) (2020) 04020106.

[81] J.B.H. Yap, J.N. Chow, K. Shavarebi, Criticality of construction industry problems in developing countries: Analyzing Malaysian projects, J. Manage. Eng. 35 (5) (2019) 04019020.

[82] J.B.H. Yap, P.L. Low, C. Wang, Rework in Malaysian building construction: Impacts, causes and potential solutions, Journal of Engineering, Design and Technology 15 (5) (2017) 591–618.

[83] J.B.H. Yap, M. Skitmore, Investigating design changes in Malaysian building projects, Architectural Engineering and Design Management 14 (3) (2018) 218–238.

[84] J.B.H. Yap, M. Skitmore, Ameliorating time and cost control with project learning and communication management leveraging on reusable knowledge assets, International Journal of Managing Projects in Business 13 (4) (2020) 767–792.

[85] N. Yaraghi, R.G. Langhe, Critical success factors for risk management systems, J. Risk Res. 14 (5) (2011) 551–581.

[86] G. Ye, Z. Jin, B. Xia, M. Skitmore, Analyzing causes for reworks in construction projects in China, J. Manage. Eng. 31 (6) (2014) 04014097.

[87] Y.C. Yong, N.E. Mustaffa, Critical success factors for Malaysian construction projects: An empirical assessment, Construction Management and Economics 31 (9) (2013) 959–978.

[88] B. Zarei, H. Sharifi, Y. Chaghkheue, Delay causes analysis in complex construction projects: A semantic network analysis approach, Production Planning & Control 29 (1) (2018) 29–40.

[89] X. Zhang, concessionaire’s financial capability in developing build-operate-transfer type infrastructure projects, Journal of Construction Engineering and Management 131 (10) (2005) 1054–1064.

[90] Y.J. Zidane, B. Andersen, The top 10 universal delay factors in construction projects, International Journal of Managing Projects in Business 11 (3) (2018) 650–672.