CRITERIA OF SELECTING APPROPRIATE DELAY ANALYSIS METHODS (DAM) FOR MEGA CONSTRUCTION PROJECTS

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Original Scientific Paper

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Nowadays, one of the major sources of issues in the construction sector in the Middle East and North Africa (MENA) region is the Extension of time (EOT) claims, which is so hard to resolve. Authors and practitioners have started trials in numerous academic studies to show how to properly deploy Delay Analysis Methods (or "DAMs") and to give practitioners executive guidelines to support them with proper analyses and claim resolution. The awareness of the use of these methods is essential to realize their restrictions and capacity to fit in with various project circumstances and to select appropriate delay analysis methods. The main objective of this research is to provide a guide for the selection of appropriate DAM by defining a list of important criteria that have the most preference in choosing the effective method. These criteria will be rated by collecting feedback from experts in the MENA region through questionnaires. The survey was conducted in the United Arab Emirates (UAE) for the abundance of multinational firms working on mega construction projects with multicultural backgrounds and diversity of expertise in addition to the availability of carrying out interviews when needed and the widespread adoption of standard international construction contracts. Then, the possibility of ranking is calculated by using the Relative Importance Index (RII). This ranking will be considered as an important tool for the proper selection of convenient delay analysis methods. Ultimately this paper will facilitate the selection of appropriate DAM by Delay analyst through investigating project circumstances by mapping it with current ranked criteria.

Keywords: Delay Analysis Methods; MENA-region; Claims; Criteria; Project circumstances; Relative importance Index (RII).

INTRODUCTION

Selecting proper delay analysis techniques "DAM" are very difficult to present whenever a contractor requests a time extension, and the engineer decides on the entitlement. The choice of an appropriate method for schedule delay analysis is a major problem for all involved parties, as there are many choices available. When applied to a particular collection of project variables, such as the project type, contract documents, dispute resolution system, and other project execution aspects, each approach is thought to be unique (Yousri et al., 2023; Fadhel et al., 2020).

Furthermore, a mismatch between project variables and the chosen approach can significantly reduce the likelihood of recovery for a party, incur additional costs, and divert attention from legitimate entitlement concerns. It is acknowledged that the quality and availability of concurrent project documentation, the contract, the facts, applicable law, and other case-specific factors may affect the delay analysis methods to be used in a particular scenario as well as how a particular methodology may be carried out (AACE International, 2011).
Considering the above; the author used a group of criteria defined by previous studies which have a straightforward correlation with project circumstances that have considerable preference in

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the selection of appropriate delay analysis method. These criteria will be further examined and cited in the literature review section. The author will also refine the definition of various delay types, identify common delay analysis methods, and stand on the proper use of each delay analysis method.

Research Objectives

Reducing the level of subjectivity associated with the current research's purpose is the intended goal of this study. This is in full awareness of the fact that certain forms of subjectivity are unavoidably increased. Subjectivity eventually remains in professional judgment and expert thought, but subjectivity must be grounded on solid factual research and analysis whose procedures can be verified. The main aim of this study is to provide an inductive list of criteria that will help choose a suitable DAM that serves its function and is reasonable (i.e., allows for mutual agreement between all parties to establish a fair entitlement of time extension).

By Completion of Research, it is intended to achieve the following aims:

1. To identify criteria which affect the choice of delay analysis methodology.
2. To rate and rank factors related to criteria for the selection of appropriate DAMs based on project circumstances.

Scope and Limitations

This research was conducted on construction projects in the United Arab Emirates as a model for the booming construction market in the region. Literature review from previous studies will be considered in interviews and all experts will be from the United Arab Emirates (Middle East and North Africa or MENA region) with at least 10 years of experience in the planning and delay analysis field. The three booming construction markets are mainly allocated at Egypt, Saudi Arabia, and UAE, so selecting one of them can adequately represent the study margins in the MENA region. However, the involvement of the author may have not had a direct effect in avoiding any bias towards the results as the data collection will be based on a structured questionnaire. This data collection is explained in more detail within the research methodology section. Factors that lead to criteria selection will be related to the construction projects from experts' opinions in the MENA region and will be considered, ranked, and analysed to deduce the final recommendations for controlling these factors.

In scholarly works, the most frequently mentioned techniques for delay analysis are: 1) As planned versus As-built; 2) Impacted As-planned; 3) collapsed As-built; and 4) Window Analysis, Parry, 2013. And according to the (AACE International, 2011), Time Impact Analysis is the 5th method. Three primary parties that make up a construction contract parties are involved in this study, which focuses on the construction industry, as defined in Perrara (2016); 1. The Employer or Owner/client, 2. The Project Management Consultant (PMC)/ Engineer and 3. The Contractor.

THEORETICAL BACKGROUND

The literature review section outlines a comprehensive review for defining project variables that contribute to the appropriate selection of DAMs which is based on the literature review of previous studies pertinent to the same subject. In this section, initially, the delay is defined, Delay types are classified and then project circumstances or factors that affect the selection of appropriate DAMs are defined, presented, and highlighting the correlation features between each factor and the corresponding delay analysis method (Abdelalim, et al., 2016-2023).

Delay Definition

Many Researchers have cited definitions of delay like it as time overrun beyond of contractual date or committed date**,** one of the most common definitions of delay is a time overrun of extended time to project completion which delay happens when either the actual progress is slower than planned one or expected completion date is greater than late planned completion date (Hegazy et al., 2005; Hegazy, 2012). Another meaning of delay is an action or occurrence that lengthens the amount of time needed to do the task; delays typically manifest as extra workdays or a delayed start to the task, and hence it could or might not extend the program to complete the contract's scope (Khaled Al-Barghouth, Elsamadony, & Abdelalim, 2016; Khedr, & Abdelalim, 2021, 2022; Stumpf, 2000)**.**

Delay Types Classification

Previous studies have categorized delay types in various shapes, and it is concluded that major classifications for delay types could be summarized in Table 1.

Table 1: Delay Event Classification

Type of Event	Employer Risk Event (ERE)	Contractor Risk Event (CRE)	Both CRE and ERE
Excusable	X		X
Non-Excusable		X	
Compensable	X		
Non-Compensable		X	X

The aforementioned definitions are used commonly in both UK and US terms to assist in classifying each of the events. Initially, risk events are raised due to action by the employer's risk or the contractor's risk (Hassanen, & Abdelalim, 2023).

Identification of Criteria for Selecting Appropriate DAM

Despite the abundance of delay analysis techniques, selecting the most appropriate ones depends on several factors, such as the dispute's value, the amount of time available, the available records, and the funds and effort allotted to the analysis. Other factors that influence the choice of the most practical analysis technique include the availability of scheduling data, the analyst's familiarity with the project's software, the contract's explicit provisions regarding the handling of concurrent delays, and the ownership of Float.

Moreover, (The Society of Construction Law, 2017) introduced some of the key changes introduced by the 2nd edition in comparison to 1st edition (Society of Construction Law, 2002) as follows:

> "The preferred methodology for delay analysis that involves analysing a distance from the delay event or its impact is no longer applicable."

Instead, the second edition lists the elements that should be taken into account when choosing the best delay analysis methodology for the given situation and gives a summary of the many approaches that are currently in use as of the publishing date. A summary of the elements or criteria selected from earlier research is shown in Table 2, where they are arranged as primary criteria and sub-criteria.

In this sub-section, each criterion is reviewed and cited based on pertinent previous studies which exist either in research, articles or books.

Project Type

Project type is selected based on construction industry divisions which consist of building construction (known as vertical construction) and heavy construction (known as horizontal construction), (Abd-Elhamed et al., 2020). It is known that the critical path for vertical construction is dependent on hard and soft logic sequence however critical path for horizontal projects is governed by resource availability and its movement. (AACE International, 2006) stated that the "TIA" approach is recommended for work plans that are less linear, often known as serial projects. The majority of nonlinear projects are vertical or building-related.

Project Amount

Provided that one of the factors that should be considered in the selection of appropriate DAM is the size of the dispute in terms of how much expenses have to be saved by a client to maximize the likelihood of reaching to satisfying settlement of the dispute (AACE International, 2011). So, by default, such an amount is dependent on the project amount the higher the project amount the higher the amount of dispute size which requires more spend to cover the appropriate choice of delay analysis method. For instance, if the client is estimating delay damages in the range of AED 100,000, the forensic delay analyst has to provide a practical, low-cost delay analysis technique that fulfils its intended function. However, if AED 50,000,000 in delay damages are sought, then the range of methods that must be chosen must be expanded due to the larger scope and associated costs of delay analysis, which is necessary for a larger claim. By default, delay damages are typically estimated as a function of the project amount. Thus, the forensic delay analyst needs to select a method for delay analysis that is appropriate for the scope of the dispute and reasonably priced.

Table 2: Criteria for selecting appropriate DAM

#	Main Criterion	Sub- Criterion
1	Project Type	Project Type- Vertical Construction (Buildings, Hotels,)
		Project Type- Horizontal Construction (Road, Infra....)
		Project Type- Mixed (Complex Villas, Housing)
2	Project Amount	Project Amount < 20M AED
		Project Amount (20M:100M AED)
		Project Amount (100M:500M AED)
		Project Amount > 500M AED
3	Project Duration	Project Duration < 12 months
		Project Duration (12 months: 24 months)
		Project Duration > 24 months
4	Availability of Specification	Imposed Specification
		Critical Activities Definition (Critical & Near-Critical Path)
5	Claim Classification	Complexity of Dispute
		Interim Claim
		Global Claim
6	The time when Delay Analysis Performed	Real-Time or Near time (Prospective)
		After the fact (Outcome of event is known) -Retrospective
7	Cause Occurring period	Cause Occurring period 1: 3 Months
		Cause Occurring period > 3 Months
8	Concurrency, Pacing, Mitigation measures and Compensation Calculation	Concurrency, Pacing calculation
		Mitigation measures
		Quantification of Excusable and Compensable Delays
9	Program Contemporary Records	Availability of Monthly Updated Program
		Quality of Updated Program, Out of sequence
		Source information for Factual As built
10	Problematic Issues	Change in Construction Methodology
		Disruption Consideration
11	Resources & Budget Availability for DA	Expertise of the Forensic analyst & resource availability
		Budget for Forensic Schedule Analysis
12	Time Allowed for DA	Time Allowed for Performing DA by Claimant
		Time Allowed for Performing DA by Defendant

Project Duration

The claim's complexity should be taken into account by the delay analyst depending on the project's duration. For example, a straightforward comparison of the baseline with the as-built timeline can make sense if the project is short-term and linear, and the validated events are three delay events. On the other hand, the delay analyst might have to choose window analysis tools that split the project duration into smaller contemporaneous periods to isolate and identify dominant delays if the project is a complex process facility with a program of more than 5,000 activities and multiple discrete events occurring over five years (AACE International, 2011).

Availability of Specification "Imposed Specification & Critical Activities Definition (Critical & Near-Critical Path)"

Analysis methods can occasionally produce misleading results. This can happen when, for example, activities that have a high float at the start of a project end up on the critical path at a certain point in the project's duration and are later reversed to a non-critical path with some float time left at the end of the project. Because individual schedule analysis approaches, such as as-planned vs. as-built, impact as-planned, and collapsed as-built cannot account for key routes at different points in the project, several experts have verified the validity of these methodologies in this regard. The approach that utilizes a single schedule at one point is criticized by several writers. Just an as-planned schedule doesn't reflect the contractor's willingness to perform the scope of work.

This means that theories of critical paths and float ownership are important resources for identifying critical path(s) and near critical path(s). In construction projects, float is valued by all contract parties because it gives the contractor more flexibility in managing time and resources. However, throughout the project, the owner also needs float to cover any potential consequences of change orders. Contractual terms sometimes include a clause on floating ownership. A lot of contracts usually state that float is either project-owned or available on a "first-come, first-served" basis. A different way, when delays happened because of the client's requirement to consume the entire float, the contractor later added more delays that pushed back the project completion date and could have accrued if the owner hadn't utilized the entire project float. Similarly, if a contractor creates delays that result in using up the entire float at the start of the project, the owner would be liable for any delays brought on by change orders. In such a scenario, the delays might have been prevented if the contractor had not used up the entire float (Calvey, et al., 2006).

Many recommendations have been made in an attempt to find an equitable resolution to the float ownership issue. According to the UK Delay and Disruption Protocols, float ought to belong to a project if the relevant provision controlling float rights is not stated in the contract (Society of Construction Law, 2002). Stated differently, the utilization of float should be allocated on a first-come, first-served basis. As a result, once float ownership is established, it will be simple to identify the critical path(s) and near the critical path(s). The familiar critical path is defined by the total quantity of float in each path or by the longest path(s) in the network diagram (Arditi & Pattanakitchamroon, 2006).

Claim Classification (Complexity of Dispute, Interim Claim and Global Claim)

Complexity of Dispute

The majority of experts anticipate that if the analyst is able to accurately capture the real events that took place during the project inside the appropriate DAM, the results of the delay analysis will be trustworthy. However, in practice, most projects have schedules that are built of highly complicated networks, and many delays have been reported. In these situations, however, different delay analysis techniques may produce different results (Stumpf, 2000).

The intricacy of the dispute and the complexity of the delay analysis approach should be distinguished in this context, according to the delay analyst. It seems that certain complicated disputes can still be resolved by less sophisticated analytical techniques (AACE International, 2011).

Interim and Global Claim

The claim is classified in terms of submission either an interim claim (one by one) or a global claim which consolidates all occurred events and is submitted at once. Referring to the (Society of Construction Law, 2017), discourages making composite or global claims without maintaining accurate and complete records of the project happening as well as the proper establishment of a causative link between the employer's risk event and the resulting delay. So, a global claim is usually prepared either after project completion or the expiration of the employer risk event's effect and in both cases, availability of an updated program and as-built record should be available which delay analysis could be done retrospectively. Thus, methods like planned vs as-built method or window analysis using APAB are most preferred in case of global claims.

On the other side, an interim claim is submitted during the project construction and the majority of risk employer events are still ongoing or its effect is just ended, and this type of claim delay analysis could be implemented prospectively. So, Time impact analysis methods, Window analysis using TIA and contemporaneous APAB method are convenient for interim claims however most appropriate method could be subject to rating other factors if the actual interim claim is complex with many events, longer duration and size of dispute.

Time When Delay Analysis Performed – Prospective or / Retrospective

Delay analysis can be conducted at several trigger points associated with the event's occurrence time. Predictive analysis "Prospective analysis is carried out in situations when variation orders may be raised due to probable delays brought on by anticipated occurrences, such as future modifications. However, the best moment to evaluate delays that have already happened and are currently happening is when they first appear or begin**.**

Because project participants delayed their choice to take action or reach an agreement at the beginning of the delay, hindsight analysis, often known as "retrospective," became widespread practice in the construction industry. Because the team frequently believed that certain delay analysis techniques could not be used for retrospective or prospective analysis whenever desired. Since the concept of the collapsed as-built method is based on as-built information that was not available at the time, it makes sense that it cannot be used to assess the impact caused by a potential change order. However, impact as-planned or time-impact analyses may be employed in these situations. Likewise, since as intended vs. as-built depends on the as-built record, it is seen as a "retrospective" hindsight analysis.

Cause Occurring Period

This criterion is subdivided into two sub-criterions where the first one causes an occurring period ranging from 1 to 3 months and the other one causes an occurring period greater than 3 months i.e. the longer period of the event's impact the more effort is required to analyse the effect's event on the claim. Thus, as per practice window analysis could be reasonable in the case of events with longer periods however APAB or TIA could be more practical for events with shorter periods.

Concurrency, Pacing, Mitigation Measures and Compensation Calculation

The principle of concurrent delay and pacing delays are similar. The most common definition for the concurrent delay is the contractor's delay that occurs on two or more paths that parallel to the critical path, and it is considered an independent effect from the owner delay effect. The main objective of concurrent delay analysis is to identify the responsible party for the delay. Regularly, case rulings have stated that two simultaneous, independent, concurrent critical path delays one delay caused by the owner and the other one caused by the contractor will ascertain the contractor's right to time extension (Rizk Elimam et al., 2022; Braimah, & Ndekugri, 2008). Contractors insisted on many occasions that the reason behind the cause for concurrent delay or "Pacing" delay is due to their management opinion not to *"hurry up and then wait"* because the owner delay exists on the longest path which means owner delay is driving project completion. That is the main reason of emerging "pacing" which several contractors presumed it as an excuse to justify stretching out their work to give more attention to others either critical work or near critical work.

The main difference between pacing delay and concurrent delay is as follows:

- Pacing delay is fully dependent on owner delay which contractor could be able to pace his activity in case if its predecessor is delayed due to owner's causes.
- Concurrent delay is considered as any other delay which is not related to the owner's delays, and it is fully independent activity(s) that exists on either the longest path or near critical path based on the scenario basis.

Program Contemporary Records -Availability & Quality of Monthly Updated Program

Generally, most practitioners conclude the use of a single DAM is not suitable for all delay scenarios and the most appropriate method is dependent on several factors or certain criteria, (Adhikari, I., & Kim, S. Y. 2006, Society of Construction Law, 2002). So various DAMs rely on analysis for a program(s) as is without implementing any program modification (s) like as planned vs as-built method which requires the availability of monthly updated program, and this method is considered as the simplest method in terms of exerted effort (Walker, 2015).

A major influence on the selection of suitable methods is the availability and accurate record for project contemporary since different program information is compatible with specific methods. For instance, if planned network work "baseline program' is available and developed in logic however it has not been updated due to lack of as-built record or any other reason. Thus, impact as planned might be convenient for such conditions, (Abd El-Karim et al., 2017). Conversely, if as planned network was not prepared adequately but an as-built record is available, the collapsed as-built method may be appropriate (Stumpf, 2000).

(AACE International, 2011): "emphasized that the availability of source data that can be verified as reliable for the analysis's purposes has a significant impact on the forensic scheduling approach selected, as stated in the source validation standards. For example, the observational DAMs 3.3 and 3.4 (Window Analysis (using TIA)) cannot be used if the project data indicate that there is just a baseline schedule and no schedule updates for the duration of the project. Therefore, the forensic schedule analyst must ascertain the quantity and quality of accessible contemporaneous project documents. After that, to determine whether the data is reliable for the delay analysis, the forensic scheduler has to review a selection of the project documents. The source schedules needed to implement the minimum required of each enhanced technique are shown in Table 3. below. Additional schedule sources are usually needed for each enhanced method.

Table 3: Source Data Validation Needed for Various Methods by AACE

Source of Data	Method					
	As Planned vs As-Built - =3.1	**Window Analysis (APAB)=3.2**	**Window Analysis (using TIA) =3.3,3.4**	**Time Impact Analysis = 3.5**	**Impact As Planned = 3.6, 3.7**	**Collapsed as Built = 3.8, 3.9**
Baseline Schedule	Min.	Min.			Min.	
Schedule Updates			Min.		Min.	Min.
As-Built Record	Min.	Min.		Min.		Min.

Problematic Issues "Change in CM and Disruption Consideration"

The contractor may have worked more or less productively than anticipated in some circumstances, and work sequences may occasionally need to be readjusted as a result of events that occurred—which may have been the result of employer action or inactivity. As a result, it makes sense that when the schedule undergoes significant alterations and readjustments, an analyst shouldn't rely solely on the as-planned schedule for delay analysis, as this approach will not accurately capture the effects of the delay events. Conversely, an as-built schedule assumes that there exists a single, constant critical path across the project's duration, which occurrence is rare in building projects (Arditi & Pattanakitchamroon, 2006).

Resources & Budget Availability for Analysis

One important consideration is the availability of resources capable of doing an accurate delay analysis. The other methods may be more practical for small- to medium-sized projects where resources may be few and precise records are frequently insufficient, as the advanced approach requires more time and resources to employ than the simpler ones. However, larger-scale projects with enough management resources should be able to employ advanced methods like window analysis and time impact analysis (Society of Construction Law, 2002).

Time Allowed for Performing / Review Delay Analysis

(AACE International, 2006; Hoshino et al., 2011) identified another factor *Time Allowed for Forensic Schedule Analysis* which is similar to a subject factor in which AACE stated "*There also may be* occasions when the amount of time available to perform and produce a complete forensic schedule analysis is limited. Consideration should be given to the time required for research, data validation, and claim team coordination which may be extensive, as well as production of the report. In many situations, the need for forensic schedule analysis is not made early enough to allow complete flexibility in the choice of an analytical method or is made at the last minute due to time limitations designating testifying experts. In either situation, the forensic schedule analyst may have a very limited timeframe to complete its work. Should this be the case, the forensic schedule analyst may be constrained to recommend shortcuts or a method which can be completed in far less time than other forensic scheduling methods to meet the time available to perform the work".

So, the delay analyst should consider such factors in the selection of appropriate DAM and all risks that might be associated with the selection of any specific DAM should be recorded and reported to relevant stakeholders (AACE International, 2006).

RESEARCH METHODOLOGY

The research concept will be based on a qualitative approach however received results will be normalized based on the Likert scale and it will be more elaborated in the data analysis section. The following Figure 1 indicates the research process.

The questionnaire was divided into two parts and the first part aimed to receive feedback from experts on the credibility of pre-defined criteria. Thus, the selected sample for part 01 was carefully selected and narrowed to 10 experts in planning and delay analysis fields. The sample for the second part was extended to 53 nos. limited to experts in the planning field from different organizations this sample has been calculated based on the Likert formula as shown below (Amr Afifi, Elsamadony, & Abdelalim, 2020; El-Samadony et al., 2016; Özdemir, 2010):

$$SS = \frac{Z^2 \cdot (p) \cdot (1-p)}{e^2} \quad (1)$$

SS calculated sample size,
Z value for the confidence level (e.g. 1.64 for 95% confidence level),
p percentage picking a choice, expressed as decimal (0.2 used for sample size needed),
e confidence interval, expressed as decimal (e.g., o.08 = ±8%).

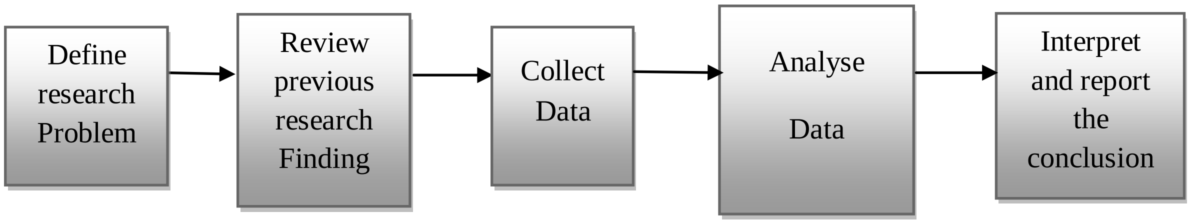

Figure 1: Research Methodology Flow Chart.

Population size is calculated based on Table 4:

Table 4: Universe and Sample unit (N=population size) calculations.

Population Category	Description	NOs
Universe (stratum):	Engineers in the MENA region as Per Societies of Engineers	45,000
Sample Unit (Total Sample Size=N):	Planning Experts and Delay Analyst = 10% *45,000	4,500

Method of Data Collection was selected to be by mailing of questionnaires which the questionnaire is mailed to the respondents with a request to return after completing the same. It is considered one of the most extensively used methods in various fields. The author has utilized Google Forms as the basis for uploading the structure of the questionnaire.

RESULTS

The analysis of the information received from the questionnaire survey is presented in this part and contains the qualitative rating of the importance criteria that contribute to the selection of appropriate DAM by using RII calculation. The main source of data was a detailed questionnaire which was sent to the planning experts and Delay analysts in the MENA region through both Google form and face-to-face interviews. This survey was carried out over the period from April 2019 to Dec 2019, and the response rate is as shown in the Table 5:

*Table **5**: Response rate summary*

Questionnaire Sent	Via Google Form	Face to Face Interview	Total
No. of Participant	500	12	512
No. of Responding	48	4	52
Response Rate	9.6%	33%	9.22%

The Description statistics of the sample

Estimating sample size is explained previously in the methodology section which was limited to MENA region only and the questionnaire contained a separate section to collect specific data regarding respondents to ensure achieving the target sample as well as reconcile with defined criteria which the following questions are answered and be analysed one by one (Abd El-Hamid et al., 2023; Forbes, 2016; El Dean, & Abdelalim, 2021).

Company Category

The total number of respondents is 52 where 11 are working as clients, 28 as project management/ Consultant and 13 as contractors. As the results respondents that work as PMC had 54% of the responses which is considered the highest one, however, the contractor side took 25% and the client side had 21% of the total responses, refer to Figure 2, which indicates the distribution of answers.

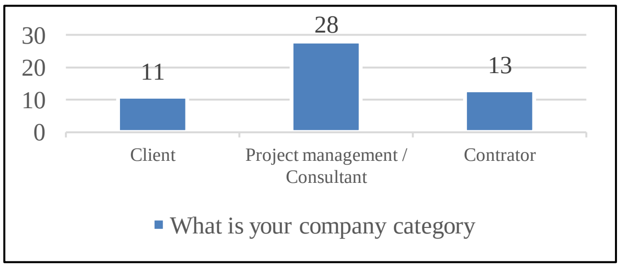

Figure 2: Distribution of responses based on Company Category.

Annual estimate budget for your company's projects

The total number of respondents is 52 of which 04 are working with a company scale of less than 100 AED, 14 with a scale of 100M to 500M AED,13 with a scale of 500M to 2B AED and 21 with a scale of more than 2 B AED. So, as per the received responses, the scale more than 2 B is the highest one. Moreover, the merging scale is more than 2B and a scale of 500M to 2B represent 65% of responses which is considered a good indicator that proper DAMs are more familiar in big-scale projects. Refer to figure 3 which indicates a distribution of answers.

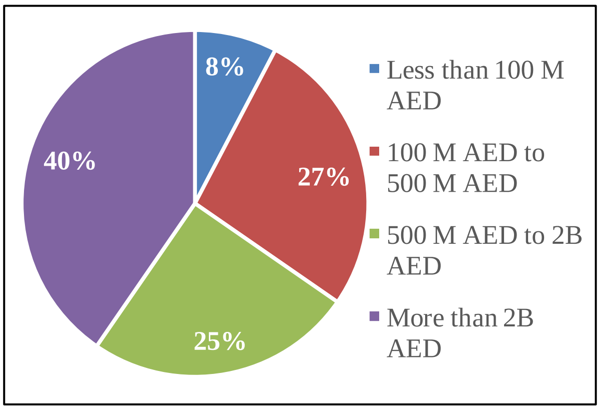

Figure 3: Distribution of responses based on the Company's Budget.

Years of experience for respondents

The total number of respondents is 52 which 04 answered with years of experience less than 10, 19 within 10-15, 20 within 15-20 and 9 more than 20 years. So, as per the received responses, the 15-20 years of experience is the highest one. Overall more than 10 years is 92 % of responses which almost matches with scope limitations in the target sample. Refer to Figure 4 which indicates a distribution of answers.

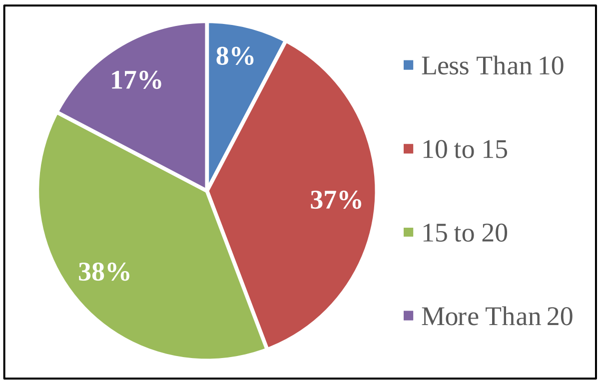

Figure 4: Distribution of responses based on years of experience for respondents.

DISCUSSION

Analysis of Criteria for Selecting Appropriate DAM

The relative importance of the various criteria to one another is ascertained using the Relative Importance Index (RII) approach. The methodology section explains the use of the Likert scale in the method, which uses a five-point scale ranging from 1 (extremely insignificant) to 5 (extremely important). This method forms the basis for calculating the relative importance indices (RII) for each factor using the formula below (Hegazy, 2005; Mohamed et al., 2020; El-Kholy, & Abdelalim, 2016; Özdemir, 2010):

$$RII = \sum \frac{W}{AN} \quad (2)$$

Where; W is the normalization sum for each criterion by the respondent's n number (Ranging from 1 to 5),

$$W = \sum (n1 \cdot 1 + n2 \cdot 2 + n3 \cdot 3 + n4 \cdot 4 + n5 \cdot 5) \quad (3)$$

The frequency numbers n1 and n2, represent the respondents who selected scales 1 and 2, respectively. There are 52 replies overall, with A being the highest number on the Likert scale (i.e., 5 in this instance). More significant was the criterion in selecting the right DAM, as shown by the RII value, which ranged from 0 to 1 (0 excluded). Since each sub-criterion was intended to yield data, the RII was utilized to rank both the main and sub-criterion based on computed RII. As a result, the RII for the main criterion was approximated as the average of the RII for the linked sub-criterion. Five Likert points on a scale of 1 to 5 reads as follows: 1 = Extremely Unimportant, 2 = Low Important, 3 = Medium Important, 4 = High Important, 5 = Extremely Important.

Analysis Results for Criterion based on RII

The collected data through the received answers from the questionnaire is considered the main source of the analysis. Based on RII calculation, the Sub-criterion is ranked based on the relevant value of RII Table 6 represents this ranking order for the sub-criterion from most important to least one.

Table 6: Ranking of Sub-Criterion based on RII value.

Sub-Criterion	**RII**	**Rank**
9.1 Availability of Monthly Updates	0.885	1
8.1 Concurrency and Pacing Calculations	0.869	2
5.1 Claim Classification- Complexity of Dispute	0.869	3
4.2 Critical Activity Definition (Critical & Near Critical Path)	0.862	4
9.2 Contemporary records- Quality of Updated program, Out of Sequence	0.858	5
8.3 Quantification of Excusable and Compensable Delays	0.858	6
9.3 Contemporary records- Source of Information for Factual As built	0.854	7
Sub-Criterion	**RII**	**Rank**
6.1 Time When Analysis Performed- Real Time or Near Time (Prospective)	0.846	8
6.2Time When Delay Analysis performed - After the fact (Retrospective)	0.842	9
8.2 Mitigation Measures	0.838	10
2.4 Project Amount > 500M AED	0.831	11
12.1 Time Allowed for Performing Delay Analysis by Claimant	0.812	12
11.1 Expertise in the Forensic & resource availability	0.812	13
3.3 Project Duration >24 Months]	0.804	14
12.2Time Allowed for Review of Delay Analysis by Defendant	0.800	15
2.3 Project Amount (100M AED: 500M AED)	0.792	16
5.2 Claim Classification- Interim Claim	0.781	17
10.1 Problematic issues- Change in Construction Methodology	0.781	18
5.3 Claim Classification - Global Claim	0.777	19
10.2 Problematic Issues - Disruption Consideration	0.765	20
11.2 Budget for Forensic Schedule Analysis	0.758	21
1.1 Project Type- Vertical Construction (Buildings, Hotels)	0.758	22
7.2 Cause occurring Period > 3 Months	0.742	23
4.1 Imposed Specs	0.731	24
3.2 Project Duration (12 Months: 24 Months)	0.712	25
1.2 Project Type - Horizontal Construction (Infra, Road...)	0.708	26
1.3 Project Type- Mixed (Complex Villas, Housing)	0.704	27
7.1 Cause Occurring Period 1-3 Months	0.688	28
2.2 Project Amount (20M AED: 100M AED)	0.665	29
3.1 Project Duration <12 Months	0.635	30
2.1 Project Amount <20M AED	0.519	31

Source: Questionnaire

Discussion of Sub- criterion's Results

Refer to Table 6 which organizes the ranking for 31 sub-criteria in order of most important to less important. The top five important sub-criterion as well as the lowest five sub-criterion were analysed more deeply in this sub-section.

Top Five Important Sub-Criterion Results

Sub-criterion "Availability of Monthly Updates" ranked as the first most important sub-criterion which this ranking considered reliable because the availability of monthly updates is considered one of the mandatory requirements to implement a majority of common DAMs like APAB method, TIA method, CAB method and window TIA. Referring to the research (Amin Sherif, Abdelalim, A.M. 2023; Braimah & Ndekugri, 2008), which ranked record availability in first position.

Sub-criterion "Concurrency and Pacing Calculations" is categorized as 2nd important sub-criterion which is recognized as one of the most contentious issues among contract parties and requires mutual agreement between parties before starting the delay analysis process for establishing the way forward of its calculation.

Sub-criterion "Complexity of Dispute" is classified as the third important factor this ranking reflects the importance of considering the nature of events, and dependencies among the events whether they occur in independent, serial or concurrent and delay analyst should examine the availability of such sub-criterion to select appropriate method that can analyse like these events.

Sub-criterion "Critical Activity Definition (Critical & near Critical Path)" is deemed as the fourth important criterion which is considered as one of the logical essential steps during the establishing of the delay analysis process. Contract parties should agree in advance on who should own the float and subsequently, they should agree on defining critical activities either based on total float value or network paths. The major issue in case of disagreement on this sub-criterion will lead to two different results.

Sub-criterion "Quality of Updated program, Out of Sequence" ranked as the fifth importance criterion which is compatible with the previous criterion in its arrangement and importance. Where delay analyst should investigate the integrity of the updated program in terms of validity, reflecting site condition as per delay scenario's effect, absence of out of sequence and correctness of progress record.

Lowest Five Important Sub-Criterion results

Sub-criterion "Project Amount less than 20M AED" ranked as the lowest importance criterion this rating is considered rational rating since the lesser the project amount the lesser the complexity of the project which selection of appropriate delay analysis methods will be straightforward without having various dependent criteria.

Sub-criterion "Project Duration less than 12 Months" is sorted as the second lowest important criterion which the longer the project duration the more effort is required to maintain project contemporary records conversely the lesser project duration the less effort to track project control records which facilitates the selection of effective delay analysis process.

Sub-criterion "Project Amount (20M AED: 100M AED)" is sorted as the third lowest important criterion this project value range is classified as low to medium-scale projects and it is famous with less complexity either in scope or construction methodology which selection of delay analysis method will not major hurdle.

Sub-criterion "Cause Occurring Period 1-3 Months" is ranked as the fourth lowest important criterion in which the period of cause's impact is vital and the longer the period the more complexity might arise in delay analysis. If the cause of the period is less, evaluation of the effect will be easier which will narrow the limitation selection of reasonable delay analysis. Thus, the rating of this sub-criterion is reliable since it does not have major importance in the selection of a specific Delay analysis method.

Sub-criterion "Project Type- Mixed (Complex Villas, Housing)" is categorized as the fifth lowest importance criterion which this type considered neither vertical construction nor horizontal construction. The critical path in this project type depends on either logic, resource movement or together which leads to a simplified selection of appropriate DAM based on prevailed features of the project type either logic based on vertical construction or resources movement based on several available resources.

CONCLUSIONS

AAs per the data analysis section; it is recommended to investigate project circumstances prior selection of DAM to have mutual agreement among parties before starting the delay analysis process specifically the following criteria which are considered as top five important criteria as per feedback from the experts:

1. Contemporary records- Availability of Monthly Updates.
2. Concurrency and Pacing Calculations.
3. Claim Classification- Complexity of Dispute.
4. Critical Activity Definition (Critical & Near Critical Path).

5. Contemporary records- Quality of Updated program, Out of Sequence.

Also, a Full list of 31 criteria rated in the Section on Data Analysis could be considered during the selection of the appropriate delay analysis method. In addition, refer to Table 7 which concludes the mapping among the top 10 criteria and relevant DAM based on both data analysis and literature review.

IAP is Impact is as planned, TIA is Time impact analysis, APAB is as planned vs as-built method, W-TIA is window analysis using time impact analysis method, W-APAB is window analysis using APAB and CAB is collapsed as built but for method.

Table 7: Mapping among top 10 Criteria and common delay analysis methods.

Sub-Criterion	IAP	TIA	APAB	W-TIA	W-APAB	CAB
9.1 Availability of Monthly Updates		X	X	X	X	X
8.1 Concurrency and Pacing Calculations			X		X	
5.1 Claim Classification- Complexity of Dispute			X	X	X	
4.2 Critical Activity Definition (Critical & Near Critical Path)		X	X	X	X	
9.2 Contemporary records- Quality of Updated program, Out of Sequence			X		X	
8.3 Quantification of Excusable and Compensable Delays			X		X	
9.3 Contemporary records- Source of Information for Factual As built			X	X	X	X
6.1 Time When Analysis Performed- Real Time or Near Time (Prospective)		X		X		
6.2Time When Delay Analysis performed – After the fact (Retrospective)			X		X	
8.2 Mitigation Measures			X		X	

Recommendations for Future Research

The recommendation for future researchers is to expand their study into other industries, such as the energy and oil and gas sectors. The target sample might be expanded to cover skilled resources handling construction dispute resolution stages like claim consultants, mediators, arbitrators, and lawyers. Another dimension which could be considered by authors is to design a database for project criteria to have a hub for factors that govern the selection of delay analysis method.

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KRITERIJUMI ZA IZBOR ODGOVARAJUĆIH METODA ANALIZE KAŠNJENJA (DAM) ZA MEGA GRAĐEVINSKE PROJEKTE

Danas, jedan od glavnih izvora problema u građevinskom sektoru u regionu Bliskog istoka i Severne Afrike (MENA) su vremenska potraživanja (EOT), koja su veoma teško rešiva. Autori i stručnjaci su započeli ispitivanja u brojnim akademskim studijama kako bi pokazali pravilnu primenu Metode za analizu kašnjenja (ili „DAM-ove") i da bi stručnjacima dali smernice, koje će im pomoći u pravilnim analizama i rešavanju zahteva. Svest o upotrebi ovih metoda je od suštinskog značaja kako bi se shvatila njihova ograničenja i kapacitet da se uklope u različite okolnosti projekta, a kako bi se odabrale odgovarajuće metode analize kašnjenja. Osnovni cilj ovog istraživanja je određivanje smernica za izbor odgovarajućeg DAM-a, kroz definisanje liste važnih kriterijuma koji imaju najviše prednosti pri izboru efektivne metode. Ovi kriterijumi će biti ocenjeni prikupljanjem povratnih informacija od stručnjaka iz regiona MENA putem upitnika. Istraživanje je sprovedeno u Ujedinjenim Arapskim Emiratima (UAE) na većem broju multinacionalnih firmi, koje rade na velikim građevinskim projektima, sa multikulturalnim poreklom i stručnjacima raznih profila, a pored dostupnosti obavljanja intervjua, kada je to potrebno i široko usvajanje standardnih međunarodnih ugovora o izgradnji. Zatim se izračunava mogućnost rangiranja korišćenjem Indeksa relativne važnosti (RII). Ovo rangiranje će se smatrati važnim alatom za pravilan izbor pogodnih metoda analize kašnjenja. Na kraju, ovaj rad će analitičarima olakšati odabir odgovarajućeg DAM-a uz pomoć Analize kašnjenja kroz istraživanje okolnosti projekta, tako što će ga mapirati trenutnim rangiranim kriterijumima.

Ključne reči: metode analize kašnjenja; MENA-region; Tvrdnje; Kriterijumi; Okolnosti projekta; RII.