Delay Analysis Methods and Factors Affecting their Selection in the Construction Industry in Gaza Strip

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Abstract

Delay in construction projects is a global phenomenon. The contracted parties resort to a variety of delay analysis methods (DAMs) to determine the parties responsible for delays. The delay analysis methods have various capabilities and requirements that limit their use in the construction industry. This paper aims to survey the commonly used DAMs and to determine the factors that influence their selection according to contactors and consultants perspectives in Gaza Strip. A total of 100 contractors and consultants were approached, of which 33 participated. The results indicated that, the most commonly used DAM in Gaza Strip is "As-planned vs. As-built". It has been found that, the most important factors which affect DAMs are: records availability, baseline programme availability and updated programme availability, while dispute resolution forum and applicable legislation are the lowest factors that affect the selection of DAMs. This paper stressed the importance of obtaining full records throughout the project life cycle in order to assist the disputed parties to select the appropriate DAM that gives relatively correct results. Training courses covering delay analysis methods and their requirements are recommended.

Keywords: Delay analysis methods, construction, disputes, life cycle, training.

1. Introduction

Most construction projects are executed through contracts which are not easy to comprehend even by professionals. As the size of project increase, the contract becomes more complex and ambiguities causing the project to undergo cost and time overrun, which in turn create ground for claims and disputes (Iyer et al., 2008). Construction projects are composed of many interrelated elements of labour, material, cost, schedule, and other resources, that make it difficult to decide the proximate causes of delay, and the parties responsible for delay (Kim et al., 2008).

Parties to dispute may seek compensation by submitting a claim. The equitable allocation of responsibility for project delays is essential to resolve most construction disputes and claims. Analysis of schedule delay is conducted to find out what happened in the project, when and how delay events impact schedule and which party causes that delay in order to settle the delay claim or dispute without litigation. For this, there are different methods available for schedule delay analysis methods (DAMs) in construction industry. The DAMs produce

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results of different levels of accuracy and the analysts have differences in the way they deal with the issues often in disputes. Hence the selection of the appropriate DAM is paramount (Palaneeswaran and Kumaraswamy 2008).

For this reason, Iyer et al. (2008) developed expert system that could give guide lines to owners and contractors to evaluate their claims before they are pursued. Palaneeswaran and Kumaraswamy (2008) formulated a knowledge- based decision guidance system to help all disputed parties to rationalized their approaches towards the preparation and evaluation of extension of time claims due to delay. Arditi and Pattanakitchamroon (2006) established a selection guide lines for the DAMs by comparing the most common DAMs under different circumstances. Braimah and Ndekugri (2008) have studied the factors that influence the analyst's selection from the DAMs. Adhikari et al. (2006) used the analytical hierarchy process to select the appropriate DAM.

In Gaza Strip no previous researches were conducted on the factors that control the selection of the appropriate DAM. This modest research is an attempt to survey the most commonly used DAMs in Gaza Strip and the factors that influence the analyst's selection from these DAMs. The objective of this paper is to survey the widely used delay analysis methods in Gaza Strip with respect to contractors, consultants and overall, and to determine the factors that influence analyst's selection from these delay analysis methods with respect to contractors, consultants and overall.

2. An overview of common delay analysis methods

The task of investigating the events that cause the project to delay in order to determine the financial responsibilities of the contracting parties arising from the delay is referred to as delay analysis (DA) (Braimah and Ndekugri, 2008). Delay analysis is a formidable challenge since the contracted parties each prone to view most delays as the responsibility of the others which give rise to disputes. Responding to such challenges, the industry has developed techniques used to prove or disprove the claims either in the course of the project, or after completion under arbitration or any other form of dispute resolution mechanisms (Arditi and Pattanakitchamroon 2006). Yang and Kao (2007) reviewed 28 articles regarding construction delay analysis techniques and developed a knowledge map for delay analysis.

The popular and comparatively acceptable delay analysis methods (DAMs) include As-Planned vs. As-Built; Impacted as-Planned; Collapsed As-Built; Window Analysis and Time Impact Analysis (Braimah and Ndekugri 2008, Palaneeswaran and Kumaraswamy 2008, Yang et al. 2006 and Zack et al. 2006). However, no one method is accepted by project participants and suitable for all situations. Arditi and Pattanakitchamroon (2006) excluded the Window Analysis from being a common method, while Conlin and Retic (1997) excluded the Collapsed As-built and Window Analysis methods. The following is a brief discussion of the common DAMs:

2.1 As-planned vs. as-built method

This method compares the activities of the original critical path method baseline programme with those of the as-built programme, assesses the impact of delays on the project, identifies the sequences that actually define the duration of the project and determines the causes and the parties responsible for that delay. The advantages of this method are inexpensive, simple and easy (Braimah and Ndekugri, 2008). Arditi and Pattanakitchamroon (2006) concluded that as-planned vs. as-built relies on common sense, the analysis incorporates both as-planned and as-built schedules, and both contractor and owner delay events which facilitates the ability for recognizing concurrent delays and acceleration. He suggested using it as a starting point in relation to other complex DAMs.

Among the disadvantages, it assumes that both schedules are correct in activity duration and logic relationships sequences, failure to consider changes in the critical path and inability to deal with concurrent delays and complex delay situations (Braimah and Ndekugri, 2008). It lacks a systematic procedure to evaluate the impact of delay events individually (Arditi and Pattanakitchamroon, 2006). This method should not be used by itself except in the simplest cases (Zack et al., 2006).

2.2 Impacted as-planned method

The method uses only an as- planned schedule for delay analysis where delays and disruption are considered as activities into as-planned critical path schedule to demonstrate how schedule completion date is affected by those delays. The difference between schedules completion dates before and after the addition of delay activities will produce the amount of project delay due to each delay event. This method does not need as-built information to operate since it assumes that the planned construction sequences remain the same and does not consider any changes in critical path (Braimah and Ndekugri, 2008). Arditi and Pattanakitchamroon (2006) concluded that impacted as-Planned Method is the least favored method since it has theoretical flaws.

2.3 Collapsed as-built method

This method does not need as-planned schedule where an as-built critical path schedule with all the delays encountered should be ceated. Subtracting the delays from the schedule to create collapsed as-built schedule will indicate what would have occurred but for those events. It produces results of good accuracy (Braimah and Ndekugri, 2008). It is easy to understand by triers of fact and can determine delay impact in case of limited time and resources available for analysis (Arditi and Pattanakitchamroon, 2006). Great effort is required in identifying the as-built critical path, failure to consider changes to critical path and inability to deal with concurrent delays and complex delays (Braimah and Ndekugri, 2008).

2.4 Time impact method

This method depends on the assumption that running a series of analysis on schedule updates can assess the delay impacts to projects. This method is probably the most reliable technique when data and source documents are available in the required format and in the required time frame (Braimah and Ndekugri, 2008). Although it provides both parties to dispute to an opportunity to scrutinize the delay and reduce disputes, it is considered costly to operate particularly when large number of delaying events is involved and consumes lots of time (Arditi and Pattanakitchamroon 2006).

2.5 Window analysis method

Using as-built critical path schedule, the total duration of project is divided into number of time periods, which are updated chronologically from the as-built information including all delays encountered to get the project delay that occurred during a certain period. The project completion dates resulting from any time period under review is subtracted from that prior to the review. This method takes care of the dynamics nature of the critical path but it is considered as time consuming, costly to operate particularly when large number of delaying events is involved (Arditi and Pattanakitchamroon 2006, Braimah and Ndekugri, 2008).

3. Factors influencing the selection of the appropriate DAM

In the construction industry there is no single, standard and accepted procedure to determine the impact of schedule delay. However in given circumstances, one method can be more beneficial than another (Bubshait and Cunningham 1998. The selection of the suitable DAM depends on the ability of scheduling data, the familiarity of the analysts with the capabilities of the software used in the project, clear specification in the contract concerning concurrent delays and float ownership and time, fund and effort allocated to the analysts (Arditi and Pattanakitchamroon, 2006). Braimah and Ndekugri (2008) identified 18 factors that affect the selection of the appropriate DAM. These factors are: records availability, baseline programme availability, nature of baseline programme, updated programme availability, time of the delay, reason for the delay analysis, the other party to the claim, applicable legislation, the form of contract, cost of using the technique, size of project, duration of the project, complexity of the project, nature of the delaying events, skills of the analyst, the amount in dispute, dispute resolution forum, and the number of delaying events.

4. Methodology

Quantitative research strategy involving the use of a cross sectional survey was adopted. The first stage in questionnaire design process was an extensive review of the literature relevant the most commonly used DAMs in Gaza Strip, and the factors influence their selection. The questionnaire design was composed of three sections to accomplish the aim of this research. The first section is general information about the respondents. The second section is a survey of the most commonly used DAMs in Gaza Strip. The third section requires respondents to score on 5- point likert scale (1 for "very important" and 5 for "not important") the listed factors on their degree of importance in their decision making as the appropriate DAM to adopt in any given situation.

The targeted sample that consists of contractors and consultants was chosen randomly. 100 questionnaires were distributed (50 for consultants and 50 for contractors) and 33 questionnaires were returned (18 for consultants and 15 for contractors). The data was measured at ordinal level. Non-parametric statistics involving frequencies and relative important index was conducted for each selection factor to facilitate their ranking with respect to contractors, consultants and overall.

The relative importance index (RII) of each selection factor was computed using Eq. (1) to facilitate their ranking (Braimah and Ndekugri, 2008).

$$RII = \frac{100\%}{n} * \sum_{i=1}^{i=5} w_i f_i \qquad \text{Eq. (1)}$$

Where fi is the frequency of response; wi is the weight for each rating (given by rating in scale divided by number of points in the scale which is 5; and n is the total number of responses.

The degree of agreement between the contractor group and the consultant group in their ranking was investigated using Kendall's coefficient of concordance (W) as defined by Eq. (2) (Legendre, 2005).

$$W = \frac{12 \times s}{k^2 (N^3 - N)} \qquad \text{Eq. (2)}$$

Where s is the sum of square of deviations of ranking sum of the factors from the mean, k is the number of respondent groups, which is 2 in this case and N is the number of factors ranked.

Eq. (3) is used to determine the significance of W using a chi-square approximation of the sampling distribution with (N – 1) degrees of freedom (LEGENDRE, 2005).

$$x^2 = k(N-1)W \qquad \text{Eq. (3)}$$

5. Analysis and discussion

5.1 Characteristics of the respondents

The contractor's response was 30%, while the consultant's response was 36%. Figure 1 shows the distribution profile of respondent's designation. The contractor's respondents lack the existence of claim consultant and about 60% of them have been acting as project managers and site engineers. About 60% of the consultant's respondent's have been acting as firm managers and office engineers. Besides 10% of them are claim consultants.

Figure 2 shows the distribution profile of respondent's experience. About 60% of the consultant's respondent's have more than 15 years experience, while less than 30% of contractors have more than 15 years experience.

Figure 3 shows the distribution profile of respondent's education. The education of the consultant's respondents is better than contractor's respondent. 92% of contractor's respondents have just Bachelor's degree and none of them have PhD. Degree. 33% of the consultant's respondents have Master degree and 14% of them have PhD. degree. The results reveal that the consultant's respondents have higher experience and education and hence are more suited than contractors to comment on the delay issues covered in the questionnaire.

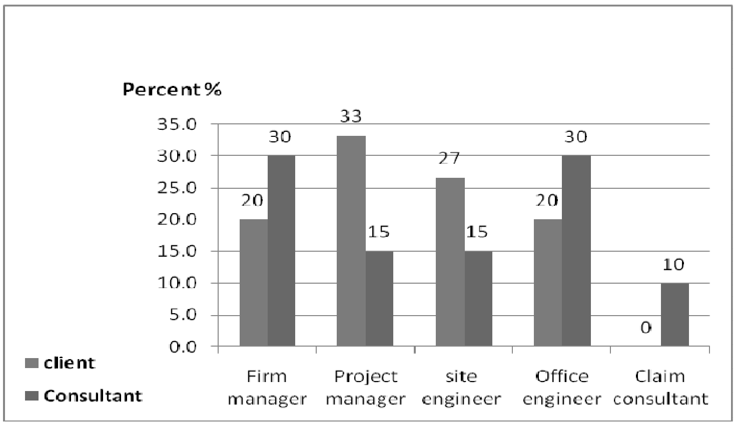

Figure 1: Respondent's designations

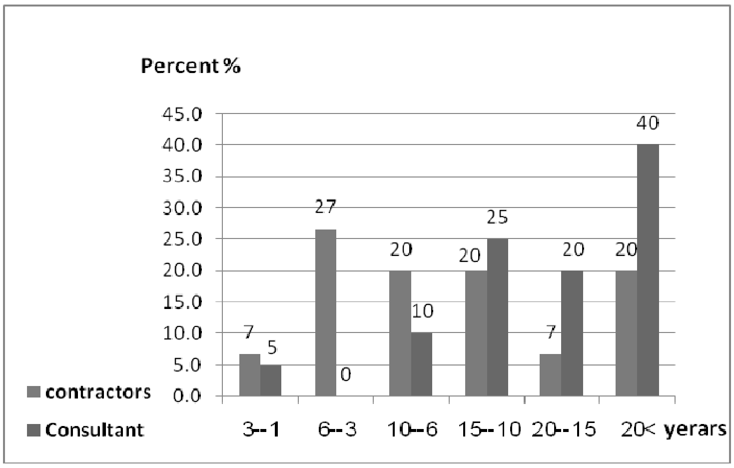

Figure 2: Respondent's experience

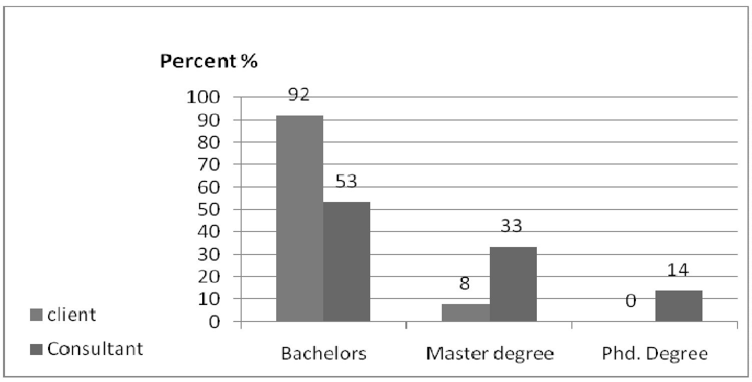

Figure 3: Respondent's education

5.2 The common used DAMs in Gaza Strip

Figure 4 Shows that 80% of the contractor's respondents have consent that the As-Planned vs. As-Built Method is the most widespread method in Gaza Strip. The other methods used in rare situations. 20% of them are recognizable with impact as-planned method and Time impact method.

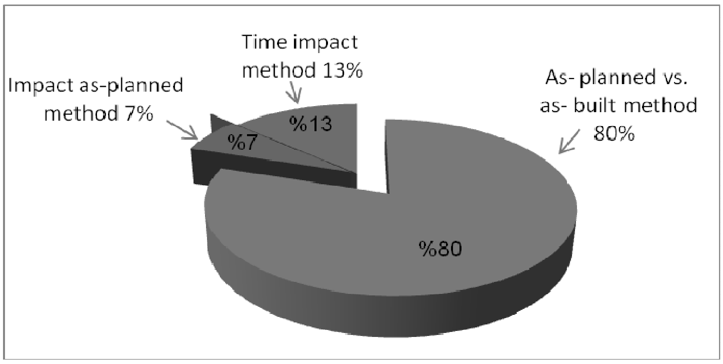

Figure 4: The percentage of the common used DAMs by contractors

Figure 5 Shows that 56.3% of the consultant's respondents agreed that the As-Planned vs.As-Built Method is the most common method in Gaza Strip while the Collapsed as-built method ranked the second common DAM in Gaza Strip according to consultant's respondents. The results indicated that, contractor's and consultant's respondents have consent that the As- planned vs. as-built is the most used method in Gaza Strip. The reason for this is the simplicity of this method since it relies on common sense and the environment of construction projects in Gaza Strip where approximately no complex projects were executed that could force practitioners to resort to the other DAMs.

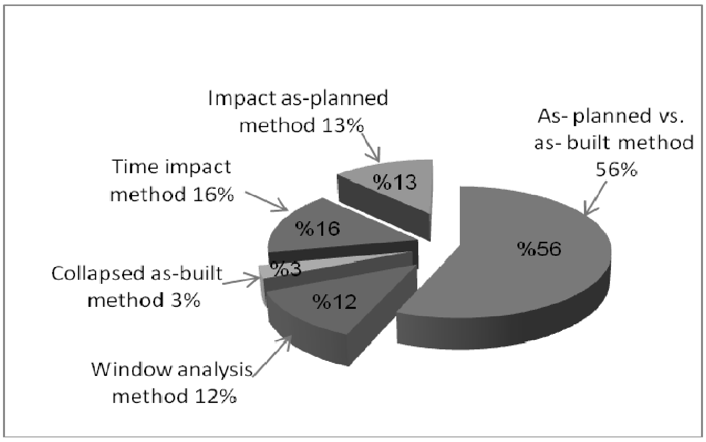

Figure 5: The percentage of the common used DAMs by consultants

Due to the higher level of education and experience to consultant's respondents 44% of them are recognizable with the other four DAMs compared with 20% of contractor's respondents recognizable with Time impact method and Impact as-planned method.

5.3 Relative importance index of factors influencing DAMs selection

Table 1 shows the relative importance index (RII) and ranking of the factors that affect the selection of DAMs for contractors, consultants and overall. The degree of agreement between contractor's and consultant's respondents equal 0.925 and this was statistically significant at 98% confidence level. The ranking of the "records availability" as the most important factor according to contractor's and consultant's respondents was expected, since regardless of the method adopted the analysis depends on the available data, although the amount of records required varies for various DAMs. For example Window analysis and Time impact analysis methods required the existence of certain records to operate, the lack of these project information will enforce practitioners to resort to less reliable methods. The ranking of record availability in the first position is confirmed by Braimah and Ndekugri (2008).

Table 1: RII and Ranks of DAM selection factors

Selection factor	Contractors		Consultants		Overall	
	(RII)	Rank	(RII)	Rank	(RII)	Rank
Records availability	0.666	1	0.880	1	0.788	1
Baseline programme availability	0.574	5	0.810	2	0.708	2
Nature of baseline programme	0.48	16	0.750	6	0.622	12
Updated programme availability	0.6	3	0.760	4	0.702	4
Time of the delay	0.546	8	0.680	14	0.622	12
Reason for the delay analysis	0.56	7	0.740	9	0.662	7
The other party to the claim	0.546	8	0.640	16	0.600	16
Applicable legislation	0.506	15	0.560	18	0.538	18
Type of contract	0.574	5	0.700	12	0.646	11
Cost of using the technique	0.48	16	0.700	12	0.606	15
Size of project	0.534	11	0.800	3	0.686	5
Duration of the project	0.52	13	0.760	4	0.658	8
Complexity of the project	0.546	8	0.740	9	0.658	8
Nature of the delaying events	0.6	3	0.740	9	0.680	6
Skills of the analyst	0.654	2	0.750	6	0.708	2
The amount in dispute	0.52	13	0.750	6	0.652	10
Dispute resolution forum	0.48	16	0.590	17	0.542	17
The number of delaying events	0.534	11	0.670	15	0.612	14
W=0.925	X^2=31.35			df=17 ; X^2 critical =31.7		

Baseline programme availability has been ranked by contractor's respondents in the fifth position, while ranked in the second position by consultant's respondents. Both of them have ranked it within the top five factors. The difference in the contractor's and consultant's respondents ranking is due to the variation in their level of education and experience. In the absence of base line programme the DAMs that rely heavily on it cannot be used. Braimah and Ndekugri (2008) have ranked this factor in the second position as consultant's respondents do in this research which confirms in general the importance of this factor.

Nature of baseline programme has been ranked by contractor's respondents in the sixteenth position, while ranked in the sixth position by the consultant's respondents. As mentioned the As-planned vs. as-built method is the most common method used by contactor's respondents which rely on common sense and doesn't require the baseline programme to exist in the CPM format, thereby the contractor's respondents rank it in the sixteenth position. Braimah and Ndekugri (2008) have ranked this factor in the forth position in the neighborhood of consultant's respondents ranking which confirms in general the importance of this factor. Updated programme availability has been ranked by contractor's respondents in the third position, while ranked in the forth position by the consultant's respondents. Braimah and Ndekugri (2008) have ranked this factor in the fifth position. This corroborates the importance of this factor that enable the use of certain DAMs more than the others.

Time of delay refers to occurrence of delay relative to the stage of the project. The delay analysis can be carried out prospectively or retrospectively. Prospectively refers to analyzing delays when they start brewing or began to occur in order to determine their likely impact on the project performance. Impacted as-planned method is best suited for this situation. On the other hand retrospective analysis required the delay analysis to be done after their occurrence. Collapsed as-built is best suited for this situation. Time of delay has been ranked by contractor's respondents in the eighth position, while ranked in the fourteenth position by the consultant's respondents and Braimah and Ndekugri (2008).

Reason for delay analysis may be either to get extension to project duration or to get compensation. Reason for delay analysis has been ranked by contractor's respondents in the seventh position, while ranked in the ninth position by the consultant's respondents. Braimah and Ndekugri (2008) have ranked this factor in the tenth position. The other party to claim is related to behavior of the opposing party to the claim. When the opposing party to claim is capable to deal with delay issues fairly, the parties to claim usually resort to less expensive methods of DAMs and vice versa. Reason for delay analysis has been ranked by contractor's respondents in the eighth position, while ranked in the sixteenth position by the consultant's respondents. Braimah and Ndekugri (2008) have ranked this factor in the seventeenth position which is too near to consultant's ranking.

Applicable legislation has been ranked by contractor's and consultant's respondents in the fifteenth and eighteenth position respectively. Braimah and Ndekugri (2008) confirm this result by ranking this factor in the eighteenth position as did the consultant's respondents revealing that this factor has a minimum influence on the methodologies that could be used to analyze delays. Type of contract; contract clauses may require the availability of specified type of baseline programme and its updating which facilitate the use of certain DAMs to a great extent than others. This factor has been ranked by contractor's respondents in the fifth position while the consultant's respondents ranked it in the twelfth position. Braimah and Ndekugri (2008) confirm the consultant's respondents by ranking this factor in the eleventh position.

Cost of using the technique; sophisticated DAMs such as window analysis required the use of powerful planning software which is expensive and a skill person is essential to operate it. When the amount in dispute is relatively small compared to project cost, the parties to claim may resort to use less expensive DAMs. This factor has been ranked by contractor's respondents in the sixteenth position while the consultant's respondents ranked it in the twelfth position. Braimah and Ndekugri (2008) confirm the consultant's respondents by ranking this factor in the twelfth position too.

Size of project; as the size of project increase the number of activities increase. This factor has been ranked by contractor's respondents in the eleventh position while the consultant's respondents ranked it in the third position. Duration of project also influence the methodologies that could be used to delay analyses. This factor has been ranked by contractor's respondents in the thirteenth position while the consultant's respondents ranked it in the fourth position. Braimah and Ndekugri (2008) rank size of project in the fifteenth position and rank duration of project in the sixteenth position. The relatively high ranking of these two factors by consultant's respondents is surprising and need more investigation.

Complexity of project; in complex projects innovative procedures with overlap of phases are often used thereby necessitating the use of certain DAMs to a greater extent than others in case of delay occurrence. This factor has been ranked by contractor's respondents in the eighth position and the consultant's respondents ranked it in the ninth position. Braimah and Ndekugri (2008) confirm the consultant's and contractor's respondents by ranking this factor in the seventh position. Nature of delaying events; the existence of concurrent delays influence the methodologies that could be used to analyze delays. This factor has been ranked by contractor's respondents in the third position while the consultant's respondents and Braimah and Ndekugri (2008) ranked it in the ninth position.

Skill of the analyst; sophisticated DAMs require skill analysts to operate. This factor has been ranked by contractor's respondents in the second position, which is surprising and require further investigation. The consultant's respondents ranked it in the sixth position. Braimah and Ndekugri (2008) rank this factor in the eighth position. The amount in dispute; as the amount in dispute increase, the parties to claim resort to more sophisticated DAMs in order to recover their losses. This factor has been ranked by contractor's respondents and Braimah and Ndekugri (2008) in the second position while the consultant's respondents ranked it in the sixth position.

Dispute resolution forum has been ranked by contractor's respondents in the sixteenth position while the consultant's respondents and Braimah and Ndekugri (2008) ranked it in the seventeenth position. The three parties have consensus on the minimum effect of this factor in selecting the appropriate DAM. The number of delaying events; as the number of delaying events increase, the delay analysis become more complex thereby, necessitating the use of certain DAMs to a greater extent than others. This factor has been ranked by contractor's respondents in the eleventh position while the consultant's respondents ranked it in the fifteenth position. Braimah and Ndekugri (2008) rank this factor in the sixth position. The insufficient appreciation by contractor's and consultant's respondents of the importance of this factor is attributed to the environment of construction in Gaza Strip.

6. Conclusion

The aim of this paper is to survey the commonly used DAMs and to determine the factors that influence their selection according to contactors and consultants perspectives in Gaza Strip. The most commonly used DAM is As-planned vs. as- built, this is attributed to the lack of complex construction projects in Gaza Strip. Eighteen factors that could assist the disputed parties to choose the appropriate DAM have been ranked according to their relative important index. According to contractor's respondents the top five factors are "Records availability, Skills of the analyst, Updated programme availability, Nature of the delaying events and Baseline programme availability, while the consultant's respondents exhibit that the top five factors are" Records availability, Baseline programme availability, Size of project, Updated programme availability, Duration of the project". The contractor's and the consultant's respondents rank record availability in the first position and agreed on the importance of "Baseline programme availability and Updated programme availability", this is not surprising since programmes are now considered the vehicle for analyzing delays. But they both failed to address "Nature of baseline programme" as an important factor, this is attributed to the fact that most of them are using Microsoft project for scheduling were bar chart and CPM are available. Both contractors and consultants agreed that "Dispute resolution forum and Applicable legislation" are the lowest factors that affect the selection of DAMs. According to contractor's respondents the lowest five factors are " Nature of baseline programme, Cost of using the technique, Dispute resolution forum, Applicable legislation, Duration of the project" while the consultant's respondents stated that the lowest five factors are" Applicable legislation, Dispute resolution forum, The other party to the claim, Cost of using the technique, The number of delaying events".

Both contractors and consultants agreed that "Dispute resolution forum and Applicable legislation" are the lowest factors that affect the selection of DAMs. Ranking the "Nature of baseline programme" as the least important factor by contractors is surprising because bar charts are unable to show critical paths, interrelation and interdependencies between activities which enforce analysts to select certain method of DAMs. The rank of "The amount in dispute" is the sixth according to consultant and the thirteenth according to contractors.

This research stressed the importance of obtaining full records throughout project life cycle or at least at time where a delay dispute is brewing in order to empower the disputed parties to select the appropriate DAM that gives relatively correct results. Training courses covering delay analysis methods and their requirements are recommended. A comprehensive survey should be carried out to confirm the findings of this research and to provide more reliable ranking to guide contractors and consultants how to select the appropriate DAM.

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