iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 Issue: IX Month of publication: September 2020

DOI: https://doi.org/10.22214/ijraset.2020.31531

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue IX Sep 2020- Available at www.ijraset.com

Statistical Analysis of Delay Factors in Construction Projects

Mayur Verma[1], Dr. R. Kansal[2]
[1]PG student, [2]Professor, Civil Engineering Department, Madhav Institute of Technology and Science, Gwalior, (M.P.) India

Abstract: Delays in construction projects are unavoidable and may result in disputes, lawsuits, claims between different parties and adversely affect project success in terms of time, quality and cost. The purpose of this paper is to analyse the causes of delays in the completion of construction projects due to the failure of the owner, consultant and contractor during the construction phase. This study presents a framework for the causes of delays in a construction project using Student's T-test and the value proposition (RII) method. To this end, a questionnaire has been compiled after identifying 35 factors of delay, through a detailed book review process and discussions with experts from the construction industry. In this study, the reliability of the questionnaire was assessed using Cronbach's alpha, which is widely used to show internal data consistency. The level of items and groups shown is based on their level of importance in the delay. And finally, some recommendations have been made to reduce and control delays in construction projects.
Keywords: Delays, Relative importance index (RII), delay analysis, Construction projects, RII Ranking.

I. INTRODUCTION

In construction, a delay may be defined as additional time required or received in excess of the deadline for completion or beyond the date on which the project participants agreed on the completion of the project. Construction delays are considered to be the remaining time to complete the work from its term as per contract or can be defined as the completion of time or the start of work on the basic schedule, directly affecting certain costs. Delays in construction projects are considered to be one of the most recurring problems and are often accompanied by excessive costs. Delays analysis is either ignored or subdued by simply adding time events to meet the contract deadline. Delays can have serious consequences for work-related structures. The negative effects of delays increase the cost and timing of project completion and reduced quality and production, disputes, and termination of contracts (Majid 2006; Mahamid et al. 2012). Owner delay means loss of revenue due to lack of production facilities or dependence on existing facilities. Contractor delays mean higher costs due to longer construction time, and higher material and labor costs due to inflation. Predicting opportunities for delays plays an important role in project success (Luu et al. 2009). The contractor must carefully determine the possible delay for the success of the project. The objectives of this study are: (a) To recognize and classify the factors of delay in construction projects (b) To decide the overall significance of delay factors and gatherings, positioned by their degree of significance on delay by utilizing RII strategy (c) Validation of proposed delay by Cronbach Alpha test (d) Demonstrate the most significant delay factors and gathering based on overall ranking (e) To propose some suggestion and restorative activity to control and minimize delays construction ventures.

II. RESEARCH METHODOLOGY

A. Previous Studies

A few articles have examined reasons for delay in construction projects in various manners; a few examinations distinguished the fundamental driver of delay in a few nations and different undertaking types, while different investigations talked about the delay examination techniques and the proposed approaches to moderate it. Six examinations were fused in this investigation to gather a rundown of delay causes. The investigation of Baldwin et al. 1971 was done to decide the reasons for delay in the construction cycle in the United States. The following examination was by Mansfield et al. 1992 which explored the reasons for delay and cost invades that influence finished roadway construction in Nigeria. In Saudi Arabia, Assaf et al. 1995 contemplated the fundamental driver of delay in huge structure construction. The review secured an irregular example of contractual workers, advisors, and proprietors. As a contextual investigation with respect to the Nontaburi sidestep street venture, Noulmanee et al. 2000 examined the inside reasons for delay in an interstate development venture in Thailand. Ahmed et al. 2003 did an examination to distinguish the significant reasons for delays in building construction in Florida, at that point assigned the duties and sorts of delays for each cause. As to development undertakings, Choudhury and Phatak 2004 contemplated the causes that influence time invade.

The point of this paper is to portray the embraced philosophy in detail for delay examination in construction projects. This paper describes that 1. How the delay factors are recognized? 2. How the (data) information is gathered? 3.How the relative importance of delay factors is calculated for ranking of delay factors?

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue IX Sep 2020- Available at www.ijraset.com

B. Methodology Flow

Identification of Delay Factors & Groups

⇓

Sample Size

⇓

Questionnaire Survey

⇓

Determinations of Relative Importance of Delay Factors using RII method

⇓

Ranking of RII

1) *Identification of Delay Factors:* Absolute 35 components causing delay were recognized through conducting survey and conversation with construction specialists. In the wake of distinguishing the delay factors that may cause delay in construction projects. A questionnaire form to elicit information about importance level of each delay factor from construction experts was prepared in the following format given in Table-5.
2) *Linguistic Definition:* After identification of delay factors a meeting was arranged with construction experts. The linguistic term of importance of each delay factors are "Very Important", "Important", "Moderately Important", "Less Important", "Very Less Important". Meaning of each linguistic term associated to all delay factors are given below.

Table-1 Crisp Rating used in questionnaire

Linguistic Term	Crisp rating
Very Important (VI)	5
Important (I)	4
Moderately Important (M)	3
Less Important (L)	2
Very Less Important (VL)	1

3) *Questionnaire Survey:* Crisp rating of delay factors on Likert Scale of five-point, ranged from 1(Very Less Important) to 5(Very Important) which was commonly used in previous literature, is adopted in this research contained groups and factors causing delays in construction project.

C. Sample size of Questionnaire Survey

Before starting the questionnaire survey, it is required to decide the target population and sample size. The target population is the total individuals from which the sample might be drawn while sample size is the total count of individuals drawn from target population for study or survey. Questionnaire survey was conducted on the determined sample size. Individual of sample size is called as respondents and information elicited from respondents is called as response in this research. Target Population of construction experts is not definable and countable. So, to calculate the sample size for questionnaire survey Cochran's formula is used which is mathematically represented by,

$$n_0 = \frac{Z^2 pq}{e^2}$$

Where $n0$ = Sample Size

Z (Standard Normal deviation set at 90% confidence level) = 1.64 e (Sampling error, consider ±10%) = 0.10

p = degree of variability, consider 0.5 for maximum variability, q = 1-p = 1-0.5 = 0.5

Confidence Interval (CI) represents the precision of estimate. 90% CI is used in this research which represents that 90% sample provides an estimate within the set precisions and 90% sample certainly contains the true mean of population. Sampling error (e) speak for contrast between the population and the sample that exists only because of the observations that happened to be selected for the sample. This is a plus- minus figure e.g. ±10% sampling error is used in this research which represents if 70% respondents in sample rate a delay factor in some manner then it can be concluded that 55% to 85% of population have rate that delay factor in that manner. Degree of variability (p) describes the distribution of rating in the population. In worst and unknown variability cases it can be taken as 50% which represent maximum variability in population. From above formula, sample size was calculated as 69 but for more luckily, we got 81 respondents from the questionnaire survey. Three types of respondents i.e. clients, contractors, & consultants were chosen to fill questionnaire form. Total respondents have 16 clients, 30 contractors & 35 consultants.

Table-2 final respondents' profile

Sr. No	Respondents Category	Total Respondents
1	Owner /Clients	16
2	Contractor	30
3	Consultant	35

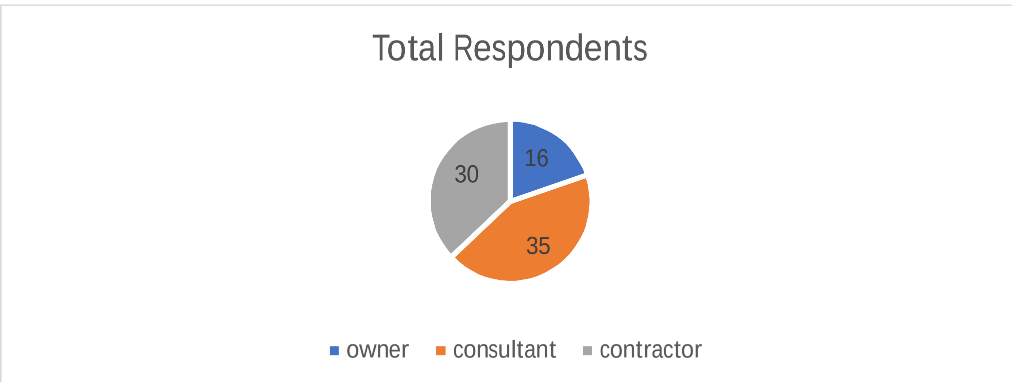


Fig.1- Pie Chart representing Total Respondents

1) *Reliability of Questionnaire Survey Data:* Reliability analysis is a method to identify the internal consistency of the data having various scales. Reliability of data means degree of stability and internal consistency of data collected in the questionnaire survey. In this research, reliability of questionnaire is assessed by using Cronbach's alpha, that is most used which shows the internal consistency of data i.e. how much a set of data is closely related. Table-3 shows the recommendations for internal consistency based on Cronbach's alpha value.

Table-3 Internal Consistency Recommendations

Cronbach's Alpha	Internal Consistency
$0.9 \leq \alpha$	Excellent
$0.8 \leq \alpha \leq 0.9$	Good
$0.7 \leq \alpha \leq 0.8$	Acceptable
$0.6 \leq \alpha \leq 0.7$	Questionable
$0.5 \leq \alpha \leq 0.6$	Poor
$\alpha \leq 0.5$	Unacceptable

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue IX Sep 2020- Available at www.ijraset.com

Cronbach's alpha equation,

$$\alpha = \frac{N \cdot \bar{c}}{\bar{v} + (N-1) \cdot \bar{c}}$$

Where,

a) N = the number of items.
b) $\bar{c}$ = average covariance between item-pairs.
c) $\bar{v}$ = average variance.

2) *Determination of Relative Importance of Delay Factors Using RII Method or Data Analysis Method:* After performing questionnaire survey, responses from questionnaire are unified using Relative Importance Index Method to determine the relative importance of each cause of delays, which is given by

$$RII = \frac{\sum W}{A * N}$$

Where $\sum W$ = Sum of responses i.e. sum of crisp rating of factor given by respondents A = Maximum value of crisp rating which is 5.

N = No. of respondents.

$0 < RII \leq 1$, higher the RII higher the importance of delay factor.

RII is calculated based on owner, consultant, contractor, and overall responses. Ranking of delay factors is done based on RII values from owner, consultant, contractor, and overall responses.

3) *Rank Correlation:* The Spearman's method is used for rank correlation, that indicate the agreement level on the ranking among different groups of respondents (i.e. owner, consultant, & contractor & overall) participating in the questionnaire survey. It is mathematically represented as –

$$\rho = 1 - \frac{6 * \sum d^2}{(N^3 - N)}$$

Where ρ = Agreement level between different respondents' groups ($0 \leq \rho \leq 1$). d = difference of the ranking of a delay factor.

N = total number of pairs in rank (in this case 35, as the no. of delay factors).

III. RESULTS AND DISCUSSION

A. *Reliability of Questionnaire Data*

Before starting of questionnaire data analysis, Reliability of questionnaire data is checked. That means degree of stability and internal consistency of data collected in the questionnaire survey is assessed by using Cronbach's alpha formula. Which shows the internal consistency of data i.e. how much a set of data is closely related. Table 4.1 shows results of reliability test.

Table-4 Data reliability test results

Respondents Category	Owner	Contractor	Consultant	Overall
Cronbach's Alpha	0.966	0.901	0.936	0.940

From the above results of Cronbach's alpha according to the questionnaire filled by owner, contractor, consultant, & overall. The questionnaire data have excellent internal consistency. These Reliability results are also verified by determining Cronbach's alpha using MS Excel software. So, we can further proceed to the next step of data analysis.

B. *Data Analysis*

The RII is calculated for each delay factor to identify the smallest and most important delays in project construction. Based on the calculated RII values from the responses of the consultant, contractor, owner, and all, these items of delay are calculated. There is a total of 81 answers we received through questionnaire and online research by construction experts. Of these 81 responses, 16 responses came from the owners, 30 responses from the contractor and 35 responses from the respondents. The RII value is between 0 to 1 (0 is not included), the higher the RI value, the more important is the 'delay' factor.

Table-5 Ranking of Factors Causing Delays according to Consultant, Contractor, Owner & Overall Responses

Sr. No.	Factors of Delay	Owner			Contractor			Consultant		
		∑W	RII	RANK	∑W	RII	RANK	∑W	RII	RANK
1.	Decision making	68	0.85	4	139	0.926	2	154	0.88	1
2.	Revising and approving documents by owner	65	0.812	7	116	0.773	13	137	0.782	12
3.	Financing and payments by owner	71	0.887	1	127	0.846	8	143	0.817	8
4.	Delivering construction site to contractor	63	0.787	9	120	0.8	11	134	0.765	14
5.	Changes to the project by owner	63	0.787	9	128	0.853	7	127	0.725	16
6.	Unrealistic enforced contract duration	65	0.812	7	105	0.7	20	124	0.708	19
7.	Inexperience owner (or owner representative) in construction projects	65	0.812	7	116	0.773	13	134	0.765	14
8.	Lack of experience of consultants	66	0.825	6	126	0.84	11	143	0.817	8
9.	Mistakes or discrepancies in documents issued by consultants	59	0.737	12	99	0.66	22	123	0.702	20
10.	Improper communication and coordination with other parties	68	0.85	4	128	0.853	7	146	0.834	5
11.	Inspection	63	0.787	9	114	0.76	14	128	0.731	15
12.	Complexity in financing the project by contractor	69	0.862	3	133	0.886	4	147	0.84	4
13.	Improper site management and supervision	70	0.875	2	138	0.92	3	151	0.862	3
14.	Improper planning and scheduling of project	65	0.812	7	124	0.826	10	144	0.822	7
15.	Rework errors during construction	63	0.787	9	120	0.8	11	141	0.805	10
16.	Sub-contractor's work	64	0.8	8	118	0.786	12	141	0.805	10
17.	Inexperience contractor (improper	67	0.837	5	131	0.873	6	142	0.811	9

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue IX Sep 2020- Available at www.ijraset.com

	qualification of contractors' staff)									
18.	Inappropriate construction methods	64	0.8	8	116	0.773	13	135	0.771	13
19.	Unsafe practice at site (Poor safety conditions on site)	65	0.812	7	106	0.706	19	126	0.72	17
20.	Shortage of construction materials	66	0.825	6	132	0.88	5	147	0.84	4
21.	Shortage of labours	65	0.812	7	142	0.946	1	152	0.868	2
22.	Unqualified workforce	65	0.812	7	132	0.88	5	145	0.828	6
23.	Lack of equipment's or equipment failure	65	0.812	7	139	0.926	2	139	0.794	11
24.	Confined job site (improper site access, traffic congestion)	61	0.762	11	107	0.713	18	127	0.725	16
25.	Shortage of utilities on site such as (water, electricity, etc.)	65	0.812	7	128	0.853	7	141	0.805	10
26.	Miss happening during construction	64	0.8	8	109	0.726	16	126	0.72	17
27.	Budget Inaccuracies	63	0.787	9	118	0.786	12	137	0.782	12
28.	Difficulties due to nearby structure or facilities	61	0.762	11	94	0.626	23	125	0.714	18
29.	Inflation and escalation of material prices	65	0.812	7	104	0.693	21	119	0.68	21
30.	Weather effect (heat, rain, etc.)	64	0.8	8	112	0.746	15	142	0.811	9
31.	Changes in government rules and regulations	63	0.787	9	106	0.706	19	124	0.708	19
32.	Performing final inspection and certification by a third party	62	0.775	10	106	0.706	19	128	0.731	15
33.	Global financial crisis	64	0.8	8	108	0.72	17	118	0.674	22
34.	Force Majeure (earthquake, etc.)	55	0.687	13	79	0.526	24	105	0.6	23
35.	Inaccurate bill of quantities	62	0.775	10	132	0.88	5	146	0.834	5

C. Rank Correlation Results

The Spearman's method is used for rank correlation that indicate the agreement level on the ranking among different groups of respondents (i.e. owner, consultant, & contractor & overall) participating in the questionnaire survey. Table.7 showing the results of Spearman's rank correlation.

Table-6 Spearman's rank correlation between different groups of respondents

Respondent Group	Owner (%)	Consultant (%)	Contractor (%)	Overall (%)
Overall	70	95	96	100
Contractor	60	87	100	-
Consultant	63	100	-	-
Owner	100	-	-	-

1) The highest correlation (96%) is found in between contractor responses & overall responses. This signify that the contractor understands the overall and general situation of construction of projects better than owner and consultants, & only contractor can provide such sufficient, precise, fair and accurate information before bidding stage of construction projects about the occurrence of delay that can save time, resources and efforts. Strong correlation between contractor and overall, also speak that pilot study on delay factors based on contractor's responses may only sufficient to save the project from unnecessary time overrun. This is one of the most important and methodological finding and a valuable suggestion for future researches.
2) The second highest correlation (95%) is found in between the consultant representatives & overall respondents, who strongly agreed with each other.
3) The poorest correlation (63%) is found in between consultant respondents & owner respondents. Consultant admits that their Professional output is not sufficient & is responsible for delay in construction of projects. They consider that a root cause of this is the low budget they receive, which do not motivate them to produce high quality designs that affect the quality of their work.
4) Similarly, the other correlations between various respondents are in range of 60-96%.

Top ten factors of delay ranked by Relative Importance Index (RII) Method

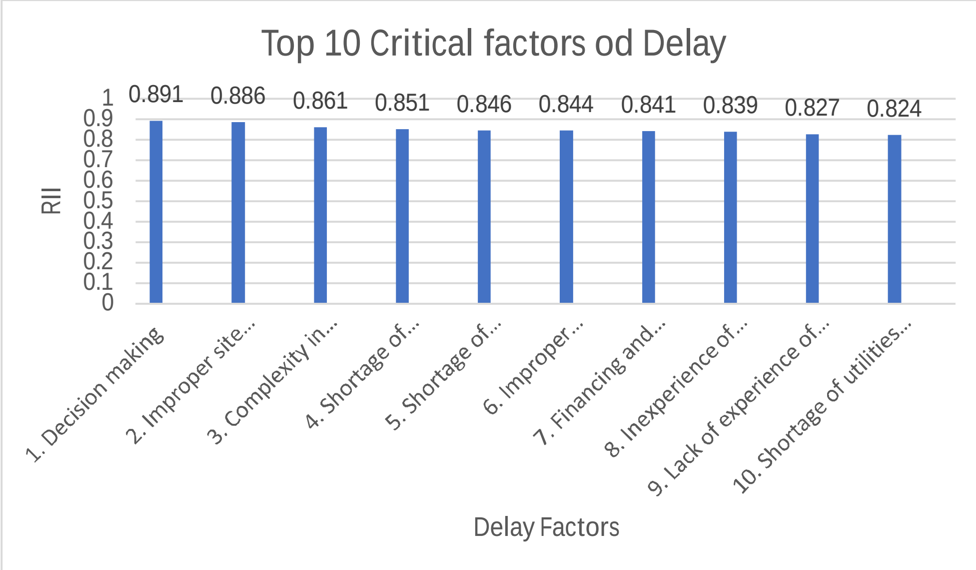
RII is designed for each item to identify the most important items. Features are set based on RII values. From the placement of the reduction to each delay factor, it was considered to identify the most important factors of the delay in construction projects.

Table-7 Top 10 Critical factors of Delay

Sr. No.	Critical factors of delay	RII
1.	Decision making	0.891
2.	Improper site management and supervision	0.886
3.	Complexity in financing the project by contractor	0.861
4.	Shortage of construction materials	0.851
5.	Shortage of equipment and/or equipment failure	0.846
6.	Improper communication and coordination with other parties	0.844
7.	Financing and payments by owner	0.841
8.	Inexperience of contractor (Poor qualification of contractors' staff)	0.839
9.	Lack of experience of consultants	0.827
10.	Shortage of utilities on site such as (water, electricity, etc.)	0.824

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue IX Sep 2020- Available at www.ijraset.com

Fig.2 Top 10 Critical factors of delay by RII Method



D. Conclusions And Recommendations

Delays can be kept away or reduced when their features are undoubtedly divided. The purpose of this study is to identify the factors that delay construction projects because delays are a serious problem in the construction industry. This paper used to look at things and circles that cause delays. Depending on the above results and outcomes, the following focus can be placed on avoiding or minimizing parts of the delay in construction projects. Construction participants should focus on the findings of the study to avoid delays in the project, looking for variables that contribute significantly to delays. According to the study, by looking at the list of the 10 most important causes of delays (Table 7), the following suggestions and recommendations can be made to reduce and control delays in construction projects:

1) Delays in site delivery to contractor (land acquisition), is the most important delay factor that caused by owners. The site should be handed over to the contractors on time after awarding the project. That should be free from legal hurdles.
2) Delay in obtaining clearance (permits / NOC) from concern authority (Railway, municipal, environmental, & forest etc.) is the second most important delay factor. The owner should facilitate the contractor to obtain clearance from the concern authority. This should be done on priority base otherwise the project may delay very badly.
3) The construction materials on location ought to be conveyed on an ideal opportunity to execute the work appropriately.
4) Delay in supporting significant changes in extent of work by owner likewise prompts delay in construction projects. Endorsement of configuration records ought not be late, which may ruin the progress of work.
5) Financial difficulties of owner/fund constraints that leads to delay in construction projects. Owners should open their budget in front of contractor & consultant for project financing and owners are required to keep the projects specifications within their budget.
6) Poor financial management by contractors in construction projects also affect the time of completion of the construction of projects. For proper financial management contractors are required to decide financing sources using scientific methods before the starting of construction projects.
7) Ineffective task arranging and planning by contractor is the most important delay factor caused by contractor. The robust attention should be paid by contractors for effective planning and scheduling. Scheduling and planning may be revised during construction, if necessary.
8) Mistakes and discrepancies in design document also leads to delay in construction of projects. The design consultancy should design the detailed design project reports with great efficiency and accuracy that avoid discrepancies in design documents.
9) Poor environmental management and control can also hamper project progress. The contractor must oversee the proper management of the facility and make the necessary arrangements to complete the projects within a certain time limit while meeting the quality and cost requirements.
10) Construction equipment's and machinery should be available on site to execute the work on as schedule.

REFERENCE

[1] Abdul-Rahman, H., Berawi, M. A., Berawi, A. R., Mohamed, O., Othman, M., and Yahya, I. A. (2006). "Delay mitigation in the Malaysian construction industry." J. Constr. Eng. Manage., 132(2), 125–133.

[2] Ahmed, A. G. (2003). "Assessment of construction contracting companies' performance in Egypt." Ph.D. thesis, Zagazig Univ., Zagazig, Egypt.

[3] Ahmed, S. M., Azhar, S., Kappagantula, P., and Gollapudi, D. (2003). "Delays in construction: A brief study of the Florida construction industry." ASC Proc., 39th Annual Conf., Clemson Univ., Clemson, S.C., 257–266.

[4] Alwi, S., and Hampson, K. (2003). "Identifying the important causes of delays in building construction projects." Proc., 9th East Asia-Pacific Conf. on Structural Engineering and Construction, Bali, Indonesia, Institut Teknologi Bandung, Nusa Dua, Bali, Indonesia.

[5] Amer, W. H. (1994). "Analysis and evaluation of delays in construction projects in Egypt." Master thesis, Zagazig Univ., Zagazig, Egypt.

[6] Assaf, S. A., and Al-Hejji, S. (2006). "Causes of delay in large construction projects." Int. J. Proj. Manage., 24(4), 349–357. Assaf, S. A., Al-Khalil, M., and Al-Hazmi, M. (1995). "Causes of delay in large building construction projects." J. Manage. Eng., 11(2), 45–50.

[7] Ayyub, B. A., and McCuen, R. H. (1997). Probability, statistics and reliability for engineers, 2nd Ed., Chapman and Hall/CRC Press, Boca Raton, Fla.

[8] Choudhury, I., and Phatak, O. (2004). "Correlates of time overrun in commercial construction." ASC Proc., 40th Annual Conf., Brigham Young Univ., Provo, Utah.

[9] Baldwin, J. R., Manthei, J. M., Rothbart, H., and Harris, R. B. (1971). "Causes of delay in the construction industry." J. Constr. Div. 97(2), 177–187.

[10] Desai, M., & Bhatt, R. (2013). Critical causes of delay in residential construction projects: case study of central Gujarat region of India. International Journal of Engineering Trends and Technology, 4(4), 762-768.

[11] Fugar, F. D., & Agyakwah-Baah, A. B. (2010). Delays in building construction projects in Ghana. Construction Economics and Building, 10(1-2), 103-116.

[12] Guest, G., Bunce, A., and Johnsons, L. (2006). "How many interviews are enough? An experiment with data saturation and variability." Field Methods, 18(1), 59–82.

[13] Ibahim Maha mid, Amu nd Bruland & Nabil Damaidi (2012) "Causes of delay in road construction projects" Journal of Management in Engineering.

[14] Mansfield, N. R., Ugwu, O. O., and Doran, T. (1994). "Causes of delay and cost over runs in Nigerian construction projects." Int. J. Proj. Manage., 12(4), 254–260.

[15] Majid, I. A. (2006). Causes and Effects of delays in ACEH Construction Industry (Doctoral dissertation, Universiti Teknologi Malaysia).

[16] Mobarak, M. S. (2004). "Consultations in stumble of large projects." World Econ., 146, 96 (in Arabic).

[17] Noulmanee, A., Wachirathamrojn, J., Tantichattanont, P., and Sittivijan, P. 2000. "Internal cause of delay in highway construction project in Thailand." (http://www.languages.ait.ac.th/talkbasework/july99/ construction.htm).