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Evaluating Delay Causes for Constructing Road Projects in Saudi Arabia

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Abstract: In this paper, we evaluate the causes of delays in road construction projects in Saudi Arabia. The research identifies four main groups of delay causes: external factors, contractor-related factors, project management factors, and environmental factors. External factors include changes in regulations and delays in obtaining permits and approvals. Contractor-related factors include inadequate resources and poor project planning. Project management factors encompass ineffective communication and poor coordination among stakeholders. Environmental factors include adverse weather conditions and unforeseen site conditions. The study recommends measures such as improved coordination, enhanced contract management, and advanced project management techniques to mitigate these delay causes. The findings provide valuable insights for stakeholders involved in road infrastructure development in Saudi Arabia, enabling them to implement strategies for timely project delivery and improved project performance.

Keywords: Delay Causes for Constructing, Road Projects, Saudi Arabia.

1. Introduction

Road construction project delays have a negative effect on the development process for both the government and the private sector in any country. Meanwhile, in many countries, the issue of construction project delays has been reported. This issue has financial and economic implications for countries as well as the construction industry. All project stakeholders have an impact on the project duration to varying degrees. Although project contractors are one of those stakeholders, they have a particular interest in reducing delays as they may face financial penalties. However, in some cases, the delay may be their fault. Studying contract terms by Alsuliman states that the project owner or their agent must ensure that information is sent to the contractor in a timely manner [1]. Other specified delays, such as severe weather, may be covered by contract terms that grant the contractor time extensions.

Some studies found that the groups and causes of delays differ by country, area, and project. Therefore, there are no general underlying causes [2]. Ellis and Thomas classified some causes of delay as events that were principled and precise enough to allow for corrective action [3]. Project managers can rate the importance of delay variables to aid in identifying the most critical variables and determining the best alternative solutions [4].

One of the crucial tools at the disposal of nations and organisations for bringing strategic aims and goals to life is road construction. The effectiveness of a country's work and its capacity to fulfil its development goals are measured by the performance of its road projects. Delay situations are so frequent that conferences are held to analyse the problem and come up with proposals and remedies. Some relevant authorities publish papers warning about the state of government initiatives [1,5]. The topic of project delays has previously been investigated in Saudi Arabia for various types of projects. This study examined road construction delay factors in more detail than had previously been considered.

2. Literature Review

Delays can vary from one country to another and from one construction project to another. Many small and large contractors have expressed their concerns in recent years about the difficulties of overcoming delay issues. Researchers have tackled the issue head-on with a slew of studies and research, but countries have different issues and reasons for delays. Faridi and El-Sayegh [6] identified the major causes of delay in the United Arab Emirates' construction industry as the approval of drawings, insufficient early planning, and the slow decision-making process of owners. Another

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study conducted by Kazaz et al. [7] evaluated the factors that cause delays in construction projects in Turkey through interviews, where they identified the most important reasons as design and material changes, late payments, and cash flow concerns, respectively.

Samarghandi et al. [8] employed a standard methodology to investigate the relevance and impact of frequent delay factors in Iranian construction projects. He found that the two most crucial elements of project delay were payment delay and lack of contractor expertise. Aziz [9] identified and ranked factors that affect delays in Egyptian construction projects. The Relative Importance Index (RII) was used to rank the examined data. In addition, a case study was developed based on the findings. Budayan [10] evaluated the causes of delays for the study conducted on projects in the Turkish market. Private sector participants stressed the importance of certainty on political and governmental issues for project design. Radman [11] identified and ranked the causes of delay in New Zealand. The results presented a list of 20 factors according to the project stakeholders' viewpoints. An integrated statistical strategy was suggested by Vacanas and Danezis [12] in order to discover the main causes of delays as well as the best and most often used methods for promoting delay mitigation. The findings revealed that, while there is a priori disagreement in each party's perception of delay responsibility, it is possible to identify and then suggest widely used delay reduction techniques.

About road construction projects, a study by by hasan et al. [13] highlighted work delays in Bahrain based on a field questionnaire survey. Business suspension, budget availability, consultant delays, and decision delays were the most common reasons cited by owners. Elfakhri et al. [14] created a conceptual model for the elements that affect the completion of Libyan road projects. Exploratory factor analysis extracted factors affecting the project's completion. Contractors, the government representatives as owners, consultants, government restrictions, externally linked issues, and utility services were considered factors, as determined by 31 different causal variables. Karunakaran et al. [15] explored the primary causes of delays in highway development in Malaysia, where poor planning was the most significant factor causing delays. In addition to some factors such as late payment certificates, bad weather, and unfavorable site conditions. Kumar [16] analysed the causes of delays in the construction sector, particularly in India's road and highway projects. Poor project planning and scheduling, the political situation, and awarding the lowest price for projects were the most common and frequent factors generating delays in construction projects, according to this analysis. Moreover, many research studies used different methods to assess road delay causes; for example, a fuzzy method was used in a research study applied to Benin roads [17], while an empirical evaluation was used in another research study applied to India roads [18].

The construction sector is plagued with delays all over the world, and Saudi Arabia is no different, as detailed by Albogamy et al. [19]. In his study in Saudi Arabia, a total of 98 questionnaires out of 182 were gathered as survey data. In his study in Saudi Arabia, a total of 98 questionnaires out of 182 were gathered as survey data. There were 63 delay factors listed in descending order of priority. Elawi et al. stated that infrastructure projects in Makkah, Saudi Arabia, were delayed by an average of 39% [5]. That delay was mainly due to land acquisition. The main consequences of road construction delays in Saudi Arabia were discovered [20]. This was done by conducting a detailed questionnaire survey, which was completed by 70 road construction contractors. The lowest bid price, poor labor productivity, improper planning, overtime, and a lack of contractor expertise were the most critical causes of timetable delay.

3. Research Problem

Delays in road construction projects occur all over the world, and Saudi Arabia has a lot of them in any city with a road project [20]. According to the most recent statistics, roughly 70% of public sector projects in Saudi Arabia have been postponed in the last decade [19]. As a result, road construction projects in Saudi Arabia were experiencing significant financial losses, quality compromises, and long wait times to start providing public services. Many causes and variables of road projects have an impact on the country's general economy. Meanwhile, researchers have identified and evaluated some causes of delays in road construction projects. But there is still a need for further investigation to assess and pinpoint the causes of a wider range of Saudi Arabian road construction delays. Accordinglly, this study will try to the research gap of the delay causes.

4. Research Aim and Objectives

The study was conducted to identify the root causes of delays in constructing road projects in Saudi Arabia arised in the last three years (2019–2021).

Although Elawi et al. were concerned about project delays in Saudi Arabian road projects, their research only investigated the problem from the owners' perspective [5]. Furthermore, the delay factors evaluated were not sufficiently explicit, and only a small number of components were included. In this study, the delay causes explored by Mahamid, for Saudi Arabian road projects were expanded, updated, specified in more detail, and verified to include all connected risk variables [20]. The following investigated objectives attempted to fill some of the research gaps on Saudi

road projects:

- Identify specific and sufficient factors that are causing road project delays in Saudi Arabia.
- Identify the influence of delay factors according to different stakeholder perspectives.
- Apply an empirical equation to estimate the actual project duration.
- Examine the impact of the COVID-19 epidemic on road construction projects.
- Apply a real-case study to a public government road project.
- Suggest suitable recommendations to avoid road construction delays in Saudi Arabia.

5. Methodologies

To identify the root causes of delays for road construction projects in Saudi Arabia, successive steps were used. First, a complete literature analysis was conducted on a variety of case studies and research articles produced by scholars from all over the world, all of which focused on elements that contribute to construction project delays in a particular country. Since most of the research articles reviewed as part of the literature review focused on public-sector construction projects, a list of the most common factors of delay in the public-sector construction sector in various countries was summarised by analysing the frequency of each factor in the previous study results. By initiating the literary review, eight groups of fifty-one (51) delay factors were identified.

The next step in the process used in this research article was to create a questionnaire. Project stakeholders involved in Saudi Arabian road construction projects were the target respondents for this questionnaire to investigate their professional perspectives on delaying issues. The purpose of the survey was to determine how the Saudi Arabian road construction sector evaluates the relative relevance of delay factors. A pilot study was conducted to verify a proposed initial questionnaire. For this verification, ten experts from the Saudi Arabian road construction sector were interviewed. The final questionnaire, which was delivered to the target experts, was based on the final list of the major 51 delay causes as well as the COVID-19 impact.

After that, a communication strategy was devised to make the electronic data collection process as simple and precise as possible. Professionals with experience in road construction then responded to the questionnaire. The data were examined using the Overall Relative Importance Index (ORII) approach for trustworthy responses. The studied factors were ranked according to their relative importance, which led to identifying the significant factors and their categorized groups that cause delays. In addition, an approximate equation based on the investigated causes was used to determine the actual duration of road projects. Moreover, a case study was conducted to verify and explain the results of the questionnaire. Finally, the conclusion and recommendations have been provided at the end.

5.1 Road Projects' Delay Causes

By studying the literature that has detailed numerous causes and impacts of delays in the Saudi Arabian construction industry, Elawi et al. and Mahamid [5,20], were able to improve and emphasise the causes of delays in road construction projects in Saudi Arabia. As a result, Elawi's ten (10) risk delay variables were compared to Mahamid's thirty-four (34) risk delay elements and other general construction project factors specified in the literature review. This comparison reveals 51 essential elements (Table 1) that are consistent with the situation in the Saudi Arabian road construction sector. This study examines the factors that emerged in the three previous years to estimate their impact on road construction projects through the study year of 2022. The COVID-19 epidemic-related delays for these types of projects have also been given attention.

5.2 Questionnaire Form and Design

A questionnaire survey was created with specifications and characteristics that achieve the study objectives. Implementing this survey revealed how to identify the most common causes of road project delays.

The questionnaire consisted of three main parts (A, B, and C): the first part (A) asked potential respondents to enter background information related to their professions, such as their sector, job title, and the number of years of experience. The second part (B), Table. 1, asked them to rate each factor of delay and grouped them into eight categories. Finally, the last part (C) is shown in Section 10. 7. Impact of COVID-19 on road construction projects, which asked participants clearly to give their input about the delay due to the COVID-19 lockdown situation, the percentage of delay related to this issue, and the degree of effect of five major related factors causing that delay.

Furthermore, the questionnaires used a five-point scale ranging from "very little effect" to "very high effect" for some questions. The order of factors from most powerful to least powerful is determined by the highest rank and the

importance factor index.

5.3 Data Collection

Road projects in Saudi Arabia have four categories of stakeholders: the government as the owner; the consultant team; the design team; and the contractor team members. The questionnaires were sent out online to engineers, contractors, owners' representatives, and consultants who are working on or have worked on public sector road construction projects. The goal was to reach as many engineers, consultants, designers, experts, and contractors who worked on public sector construction projects as possible to gauge the most accurate results possible.

The investigation of the population in the field of construction engineering depends on the general authority for statistics annual reports in Saudi Arabia (2020) [21]. According to the authority, the average population of engineers and specialists in the previous year before the survey was N = 132,842 people. Taherdoost [22] and Raosoft [23] defined the sample size n and error margin E as shown in Eq. (1),.

$$\boldsymbol{n = \frac{N.x}{((N-1)*E^2+x)}} \quad (1)$$

where N is the population size, r is the fraction of responses, $\boldsymbol{x = \frac{Z_{score}{}^2}{r(100-r)}}$, $\boldsymbol{E = \sqrt{\frac{(N-n).x}{n(N-1)}}}$ and Z is the score taken at 1.96%, corresponding to a level of confidence of 95%. The sample size n = 384 was calculated with a desired confidence level of 95%, a margin error of 5%, and a fraction r = 50% for the available population N. The questionnaire was distributed to 400 individuals, all of whom were construction experts. The received data came from 252 respondents. However, 158 respondents said that they worked on road construction projects, but 94 of them do not participate in road construction projects. So, the data collected from those who don't participate in road construction projects (94 respondents) was excluded from the results to ensure that responses are reliable. By using the available, reliable data from the 158 respondents, the results have a 95% confidence level and an 8% margin of error. In this study, the collected data were be analysed to calculate the rank of each factor and order them according to their importance in affecting the delay of road projects from the point of view of the participants.

5.4 Data Analysis

A survey of the delay causes was undertaken. Its analysis included ranking the causes according to the RII of overall results and the RII of each party separately. In addition to ranking the causes within each group, the relationships between the various parties' responses were examined. The results that were received back were varied when it came to experience, with the respondents' years of experience ranging from 1 year to more than 20 years. Fig. 1 shows the percentages of respondents in terms of job titles. The percentages of responses in terms of job title (Fig. 1) are: 74 engineers represent 47%, 23 heads of department represent 15%, 53 managers represent 33%, and 8 others represent 5%. As a result, the respondents represent a range of management levels for road projects.

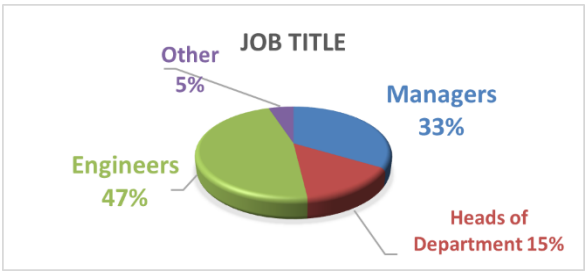

Fig. 1: The percentage of job title of respondent

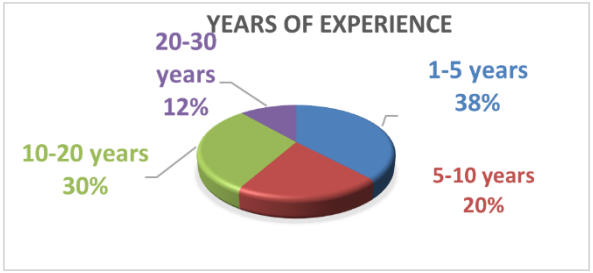

Fig. 2: The percentage of years of experience

The results of the number of respondents according to their years of experience, as shown in Fig. 2, are as follows:

60 participants represent 38% for 1 to 5 years, 32 participants represent 20% for 5 to 10 years, 48 participants represent 30% for 10 to 20 years, and 18 participants represent 12% for 20 to 30 years.

The sample shows that participants with less than 5 years of experience represented 38% of the sample, which indicates that 62% of the sample had experience suitable to evaluate the case study. Due to the respondents' extensive experience, the results are reliable.

However, respondents with no experience in road projects were excluded, but the rest of the respondents have some varied experience in road projects. Fig. 3 shows the distribution of years of experience among respondents to road projects only.

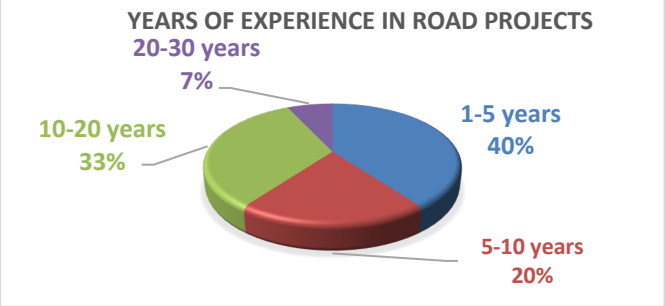

Fig. 3: Years of experience in road projects

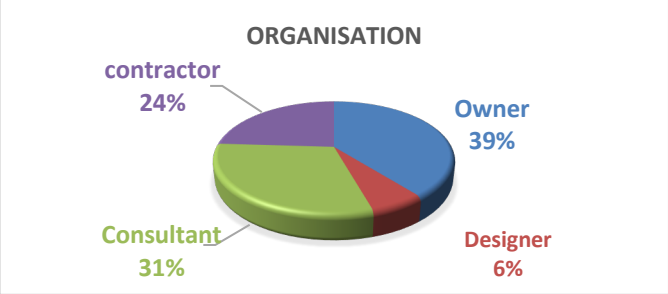

Fig. 4: The percentage of organisation scope

63 participants with 1 to 5 years of experience account for 40% of the total; 32 participants with 5 to 10 years of experience represent 20%; and 52 participants with 10 to 20 years of experience represent 33%, whereas 11 participants with 0 to 30 years of experience represent 7%. The last results of years of experience in road projects show that 60% of respondents have more than 5 years of experience. This could represent a fair judgement of the measured delay factors. The result of the number of respondents according to the organisation's scope, as shown in Fig. 4, was as follows: 48 consultants represent 31%, 38 contractors represent 24%, 62 owners represent 39%, and 10 designers represent 6%. These different categories of road project stakeholders could represent various viewpoints related to the investigated issues.

The study ranks the importance of the factors influencing the delay of road projects in Saudi Arabian construction projects from the perspectives of various parties, such as owners, consultants, contractors, and designers. For each characteristic and each year of experience (k), the RII technique was applied to each set of respondents (i). Eq. (2) was used to calculate this index [24,25].

$$\boldsymbol{RII}_k^i(\%) = \left[\frac{1*(n1)+2*(n2)+3*(n3)+4*(n4)+5*(n5)}{5*(n1+n2+n3+n4+n5)}\right] * (100) \quad (2)$$

where k denotes the number of years of experience of the grouped participants (from the first to the last experience year, k = k) and $RII_k^i(\%)$ is the annual experience percentage of RII for each variable for each group of participants. That is determined individually for the corresponding year of experience of the categorised group. n1 to n5 were defined as group respondents' numbers who selected a 1 to 5 scale, with 1 being the lowest effect and 5 being the highest effect.

Eq. (3) used to compute the ORII for each type of respondent. Each of the following groups is represented by the symbol i: consultants, managers, engineers, owners, and contractors, from i = 5 to i = 1, respectively. The total number of years of experience was taken into account. The above ORII is calculated as a weighted average based on RII_k^i [9].

$$ORII_k^i(\%) = \sum_{i=1}^{i=4} \frac{i}{\sum_{i=1}^{i=i}(i)} * \left[\frac{\sum_{k=K}^{k=1}\left(k * ORII_k^i\right)}{\sum_{k=1}^{k=k}(k)}\right] \quad (3)$$

where ORII (%) is the overall weighted average percentage of RII for each element, which is figured using the combined total of all the respondents' experience years.

6. Results and Discussion

The issues that cause delays in road development projects in Saudi Arabia were examined from many angles. The collected data analysed to meet the study objectives. The ORII for each factor computed and included in the final results. These factors were graded and organised based on their ORII report, which summarises the replies received for each aspect that contributes to the delays in Saudi Arabian road construction projects.

6.1 Overall Delay Factors' Ranking

Table.1 shows that the respondents rank factor number (08), "the weakness of the financial and technical capabilities of some contractors," as the main cause of road construction project delays in Saudi Arabia. Due to this, it was observed that, when focusing on the top 20 factors and the categories that they were related to, the first factor, "The weakness of some contractors' financial and technical capabilities," related to the "Contractor Category," had the greatest impact with a RII of 71.97%, and the last factor, "Regular equipment breakdowns," related to the "Equipment Category," had the least impact with a RII of 59.65% of all factors. When investigating the top twenty ranked factors that were the most effective in causing delay issues, it is discovered that ten of the top twenty (50%) were related to the contractor category, four were related to the owner (20%), two were related to the labor category (10%), two were related to the equipment category (10%), one is related to the project (5%), and one is related to the design category. This indicates that each of the following groups—the contractor, owner, labor, equipment, project, and design—has a significant impact on project delay, in accordance with the order listed.

Table 1: Delay factors' ranking according to ORII

Factors affecting delay of road construction projects				
ID	**Factors**	**Category**	**(ORII)%**	**Rank**
8	The weakness of financial and technical capabilities of some contractors.	Contractors	71.97	1
7	Contractor failure to study the site and tender in the exact form.	Contractors	67.85	2
40	Problems of expropriation and removal of obstacles	Owner	67.50	3
13	The reliance of the contractor on low-experienced workers for saving the wage for the skilled workers, which is usually higher	Contractors	65.40	4
43	Bidding by non-specialized companies for road works affect the duration of the project?	Project	63.90	5
17	Payments required for subcontractors were delayed by the main contractor	Contractors	63.16	6
9	Lack of interest in following timetables and updating them constantly.	Contractors	63.15	7
14	The contractor received several projects at the same time	Contractors	62.64	8
18	Does the approval of the drawing affect the start of work?	Design	62.38	9
37	Government entities are late in giving financial rights to contractors.	Owner	62.00	10
28	Low motivation and morale of labor	Labor	61.88	11
12	Low level of wages for workers and engineers relative to the contract value	Contractors	61.60	12
29	Low productivity of labor	Labor	61.02	13
10	The contractor is late in submitting the samples and requesting the supplies.	Contractors	60.78	14
26	Insufficient number of machines used	Equipment	60.73	15
39	Poor project management	Owner	60.56	16
41	Owner slowness in making decisions	Owner	60.38	17
11	Expanding the use of subcontractors who are not qualified.	Contractors	60.35	18
15	Lack of the required number of workers	Contractors	60.05	19
27	Frequent equipment breakdowns	Equipment	59.65	20
21	Insufficient data collection and survey before design	Design	58.67	21
4	The weakness of experience of some engineers in studies and supervision.	Consultant	57.61	22
30	Shortage of labor	Labor	56.93	23
22	Mistakes and delays in producing design documents	Design	56.36	24
38	The period of the project is unrealistic and short set by the owner	Owner	56.27	25
46	The weakness of training and development of engineers and engineering departments.	Project	56.05	26

25	Malfunctions that occur in machines during work	Equipment	56.00	27
5	Poor salaries and financial incentives for engineers lead to a lack of interest in study and supervision	Consultant	55.87	28
49	Lack of communication and coordination between the various parties to the project.	Project	55.84	29
47	Not to punish those responsible for delaying projects, and not to specify the responsibilities for the delay.	Project	55.36	30
45	Frequent disputes between project parties.	Project	55.31	31
44	The vision is not clear from the government entities in the projects.	Project	55.07	32
32	Material price change frequently	Materials	54.96	33
42	Lack of owner experience in road construction projects	Owner	54.83	34
3	The consultant's delay in approving works and materials.	Consultant	54.69	35
6	The supervising engineer was late in finding solutions to some technical problems due to his lack of experience	Consultant	54.58	36
48	Poor contract management.	Project	54.37	37
36	Change orders	Owner	54.06	38
19	Insufficient details of implementation specifications in the executive drawings	Design	53.53	39
16	lack of implement safety rules well during work and insecurity for workers	Contractors	53.10	40
23	Misunderstanding of owner's requirements by design engineer	Design	51.81	41
34	Changes in material types and specifications during construction	Materials	51.55	42
20	Lack of communication and coordination between the designer and material suppliers at the design stage to ensure the availability of materials with the required specifications.	Design	51.51	43
1	Late in reviewing and approving design documents	Consultant	51.28	44
2	The number of supervisors engineers are not enough	Consultant	51.19	45
24	Unclear and inadequate details in drawings.	Design	50.42	46
35	Poor quality of construction materials	Materials	48.13	47
33	Unavailability of the required means to transport the materials	Materials	48.07	48
51	The material was delayed due to traffic difficulties.	Project	44.37	49
31	Labor injuries on site.	Labor	40.95	50
50	The project was delayed due to weather conditions.	Project	37.34	51

6.2 Ranking Factors for each classified category

To get the most important factor causing a delay in road construction projects in Saudi Arabia for each category individually, each group of factors related to the same category was investigated by calculating the ORII for each of its factors. Table 2 shows the highest factor for each of the eight categories.

Table 2: The demonstration of the highest factor for each of the eight categories

ID	**Factors**	**Category**	**(ORII) % / Category**
4	The weakness of experience of some engineers in studies and supervision.	Consultant	57.61
8	The weakness of financial and technical capabilities of some contractors.	Contractors	71.97
18	Does the approval of the drawing affect the start of work?	Design	62.38
26	Insufficient number of machines used	Equipment	60.73
28	Low motivation and morale of labor	Labor	61.88
32	Material price change frequently	Materials	54.96
40	Problems of expropriation and removal of obstacles	Owner	67.50
43	Bidding by non-specialized companies for road works affect the duration of the project?	Project	63.90

6.3 Ranking Factors According to Different Parties' Points of View

The RII and ranks of the top ten (10) factors according to each group of participants' points of view were investigated. From their point of view, the owners ranked "Factor 37"—government entities are late in giving financial rights to contractors—as the primary cause of delays in Saudi Arabian road construction projects, which is related to governmental rules and procedures (Table 3). Although the road owners in Saudi Arabia are governmental entities, they classified a factor related to them as the most important one, and that gives credibility to their point of view. In Table 1, factor (37) is ranked tenth in the total survey results, indicating how significant this factor is.

According to the consultants, "Factor 8"—the lack of financial and technical capabilities of some contractors—is the primary cause of delays in Saudi Arabian road construction projects (Table 3). Factor (8) has the highest rank in the total survey results (Table 1), which emphasises the importance of this factor.

Contractors, on the other hand, ranked "Factor 17: Payments required for subcontractors were delayed by the main contractor" as the primary cause of delays in Saudi Arabian road construction projects (Table 3). Factor (17) has the 6th highest rank for the total survey results (Table 1), which describes the effectiveness of this factor. Although. This ranking represents contractors' points of view, but they mentioned two factors (17 and 12) related to their category reasons. One could see that the first factor (17) is clearly related to the delay in governmental payments mentioned from the owners' point of view in factor 37, whereas the second factor (12) indicates the influence of low contract values on the level of wages for workers and engineers.

Moreover, the designers ranked "Factor 7"—the contractor's failure to study the site and tender in the exact form—as the primary cause of delays in Saudi Arabian road construction projects from their point of view (Table 3). Factor 7 has the 2nd highest rank in the total survey results (Table 1), which describes the effectiveness and importance of this factor.

By studying the number of repetitions of factors for different parties' points of view (Table 3), one can find that factors (7, 17, 30, 37, and 40) were repeated for three different parties' points of view out of the four participants. And at the same time, these factors were ranked as the most effective factors of the top ten factors for each point of view of the four participants. That ensures the significance of these factors.

Table 3: Ranking the top ten delay factors according to different parties' points of view

Rank	Different Parties' Points of View							
	Owners		Consultants'		Contractors		Designers	
	Category	ID	Category	ID	Category	ID	Category	ID
1	Owner	37	Contractors	8	Contractors	17	Contractors	7
2	Labor	30	Contractors	7	Design	18	Consultant	4
3	Contractors	17	Owner	40	Owner	37	Contractors	10
4	Contractors	13	Contractors	13	Owner	38	Labor	30
5	Contractors	10	Project	43	Owner	40	Consultant	3
6	Contractors	15	Contractors	17	Labor	28	Labor	28
7	Contractors	8	Contractors	9	Contractors	12	Contractors	11
8	Consultant	4	Contractors	14	Materials	32	Equipment	26
9	Contractors	7	Design	18	Consultant	6	Project	46
10	Owner	40	Owner	37	Labor	30	Contractors	14

6.4 Spearman Correlation Coefficient

To examine the agreement in ranking the overall importance index among different parties (owners, consultants, contractors, and designers), the Spearman Rank Correlation Test was conducted. The degree of agreement is expressed as a "correlation coefficient." The rank correlation coefficient (r_s) is calculated as shown in Eq. (4) [26].

$$\boldsymbol{r_s = 1 - \frac{6\sum d_i^3}{n(n^2-1)}} \quad (4)$$

where "d" is the difference between the ranks indicated by each pair of the different studied parties for an individual variable, and "n" is the number of delay causes (n = 51).

$\boldsymbol{r_s}$ is used as a statistical test to determine whether there is no relationship or agreement between results from different populations [26,27]. For a given value of alpha = 0.05 (level of significance = 95%) and for a two-tailed test, the rejection region of the null hypothesis arises if $r_s \geq r_o$, where r_o=0.275 for n=51 is the critical value of Spearman's Rank Correlation Coefficient [26]. The degree of agreement between two populations according to the correlation coefficient's r_s range value is shown in Table 4 [27]. The test results show that the correlation coefficient value r_s= 0.7653 > r_o between consultants' and owners' points of view for ranking the different delay factors, which indicates strong agreement between their points of view. The correlation coefficient values r_s= 0.6199 > r_o and r_s= 0.6205 > r_o between the consultants', designers', and contractors' points of view for ranking the different delay factors indicate moderate agreement between their points of view. Moreover, the owners' points of view correlation coefficient values r_s= 0.45873 > r_o and r_s= 0.4269 > r_o are similar to the designers' and contractors' points of view for ranking the different delay factors, respectively, which indicates moderate agreement between their points of view. On the other hand, the contractors' points of view have a correlation coefficient value r_s= 0.2577 < r_o with designers' points of view for ranking the different delay factors, which indicates negligible correlation (no agreement) between their points of

view. These various degrees of correlation between the different parties indicate that the survey results are of high validity and accuracy where the different points of view have been taken into consideration.

Table 4: Degree of correlation/agreement

r_s range	Strength of correlation/agreement
0.00 to 0.30	Negligible
0.30 to 0.50	Weak
0.50 to 0.70	Moderate
0.70 to 0.90	Strong
0.90 to 1.00	Very Strong

6.5 Equivalent Average Relative Importance Index / Category

The studied factors were categorized according to the following: consultant-related factors, contractor-related factors, design-related factors, equipment-related factors, labor-related factors, material-related factors, owner-related factors, and project-related factors. According to conflict of interest between parties, they try to shift for delays' blame onto each other. The comparison of each category's strength or importance is done by calculating the weighted average value per category. The tabulated results in Table 5 were calculated using the equivalent weighted average percent ORII priority rule formula (Eq. 5) for each category.

$$\boldsymbol{ERII_j}(\%) = \left(\frac{\sum_{n=1}^{n=N}(P_n * \boldsymbol{ORII_n})}{\sum_{n=1}^{n=N}(P_n)}\right) \quad (5)$$

Table 5: ERII of each category

Rank	Related Category	Equivalent Average Relative Importance Index $\boldsymbol{ERII_j}(\%)$
1	Contractors	64.96%
2	Owner	61.48%
3	Equipment	59.58%
4	Labor	58.54%
5	Design	56.91%
6	Project	56.28%
7	Consultant	55.29%
8	Materials	51.88%

Where n is the factor number of each category (from n = 1 to n = N), $ERII_j(\%)$ is the equivalent weighted average percentage of the RII per category, $ORII_n(\%)$ is the ORII per factor of a specific category, and P_n is the priority weight for each factor. The findings, which are listed in Table 5, are consistent.

6.6 Prediction of the Actual Project's Duration

Using Equations (6) and (7), the planner can predict the actual duration of any construction project before construction based on previous data gathered from the field of construction projects.

$$\boldsymbol{DC = 1 + \left(\frac{\sum_{j=1}^{j=N}(d_j * ERII_j)}{\sum_{j=1}^{j=N}(ERII_j)}\right)} \quad (6)$$

$$\boldsymbol{PAD = DC + PSD} \quad (7)$$

Where (dj) is a category's impact percentage ranging from (0.00–1.00), $\boldsymbol{ERII_j}$ **(%)** is calculated for each category, DC is a coefficient of the project delay, PAD is the predicted actual duration, and PSD is the total planned duration.

6.7 Impact of COVID-19 on Delay of Road Construction Projects

As this study was done during circumstances related to the COVID-19 pandemic and after 1.5 years since its beginning, a part of the questionnaire was customised for the effect of this issue. In addition, the level of impact caused by that issue was determined. The responses included 5 responses out of the validated 158 where they stated that COVID-19 does not affect road construction projects. So, these five responses were excluded when studying this part, and only 153 responses were analysed.

The result of the number of suspension times due to the COVID-19 pandemic, as shown in Fig. 5, was as follows: 99 respondents had their projects suspended only once, representing 65%; 38 respondents had their projects suspended twice, representing 25%; 9 respondents had their projects suspended three times, representing 6%; and 7 respondents

had their projects suspended more than three times, representing 4%. These different responses emphasise their previous responses about the existence of the COVID-19 effect on road projects. Moreover, the result indicates that 90% of respondents had their project suspended once or twice during the COVID-19 period, which is compatible with the fact that a complete lockdown in Saudi Arabia occurred once and a conditional lockdown occurred a second time.

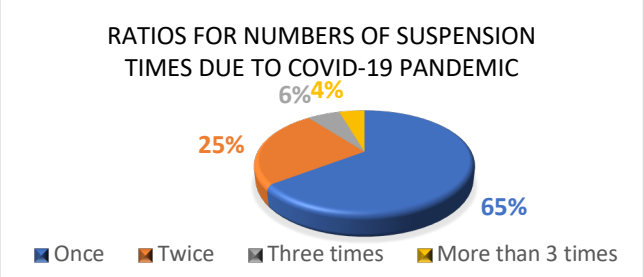

Fig. 5: Numbers of suspension times due to the COVID-19 pandemic

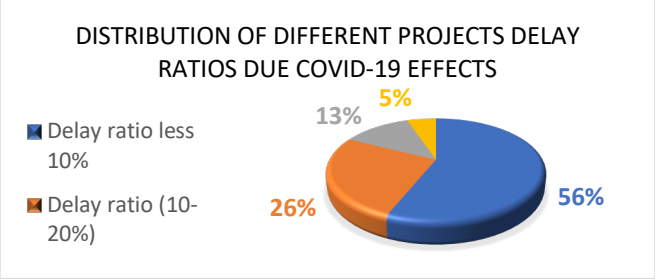

Fig. 6: Distribution of different projects' delay ratios due to COVID-19 effects

Fig. 6 shows the distribution of different projects' delay ratios due to COVID-19 effects according to stakeholders' responses.

86 respondents reported that their projects were delayed for a period less than 10% of the planned duration, representing 56% of responses; 40 respondents reported that their projects were delayed for a period between 10% and 20% of the planned duration, representing 26% of responses; 19 respondents reported that their projects were delayed for a period between 20% and 30% of the planned duration, representing 13% of responses; and 8 respondents reported that their projects were delayed for a period more than 30% of the planned duration, representing 5% of responses. According to these findings, 18% of projects were delayed for more than 20% of their planned durations, while 82% were delayed for less than 20%. This indicates that COVID-19 has a moderate effect on road project delays.

Table 6: Overall RII and ranking of time delay factors due to COVID-19 effects

Delay Factors Related to Covid-19 Pandemic				
ID	Factor	Percentage %	Mean	Rank
A	Additional requirements to new safety guidelines, checks, and other activities required to maintain a healthy work environment.	20.33%	2.42	4
B	The supply chain for building materials has been suspended.	30.60%	3.64	1
C	Absence of some construction workers as a result of being infected with Covid-19 or quarantined.	26.15%	3.11	2
D	Absence of some construction workers due to traffic restriction during lockdown periods.	22.91%	2.73	3
E	Financial revenue streams are declining due to Government imposed shutdowns have suspended some public construction work.	18.46%	2.20	5

For each of the five factors related to the COVID-19 pandemic, Table 6 shows the number of responses for their degree of effect. By analysing these results, the rank for each factor according to the mean of the effect's degree has been determined. The rank of the five (5) factors shows that the factor "the supply chain for building materials has been suspended" is the major factor in the COVID-19 situation that affects road project delays. The second effective factor was "the absence of some construction workers as a result of being infected with COVID-19 or quarantined." In the third rank, the factor "absence of some construction workers due to traffic restrictions during lockdown periods" came up. Finally, the final two effective delay factors are "additional requirements for new safety guidelines, checks, and other activities required to maintain a healthy work environment" and "financial revenue streams are declining due to

government-imposed shutdowns that have suspended some public construction work," respectively. According to the previous results, one could deduce that the road projects did not have a significant effect on the COVID-19 pandemic compared with other commercial activities, and this was due to the nature of road construction work, which involves working in open areas and maintaining enough social distances. Moreover, the Saudi Arabian government gave conditional exceptions to the road construction projects, which helped reduce the COVID-19 effect on the projects' delays.

7. Case Study

7.1 General Information

A case study was undertaken to test the concluding results on delays in road construction projects. The study was applied to the project "the intersection of the old Jeddah Road with Abdullah Al-Areef Street in the Holy Makkah Municipality," which was started in July 2019. The total planned project duration, beginning with the start date, was 22 months.

7.2 Reasons for Delays

As shown in Table 7, experts from the concerned case study project were polled about the delay and its causes, and their responses were converted to percentages of each category's impact to allow prediction of the actual project duration before completion.

Table 7: Impact of factors affecting the delay of the case study project

J	Category	ID	Factors affecting the delay of case study project	Impact Factor (dj)
1	Consultant	2	The number of supervisors engineers are not enough	67%
		3	The consultant's delay in approving works and materials.	
		4	The weakness of experience of some engineers in studies and supervision.	
		5	Poor salaries and financial incentives for engineers lead to a lack of interest in study and supervision	
2	Contractors	7	Contractor failure to study the site and tender in the exact form.	73%
		8	The weakness of financial and technical capabilities of some contractors.	
		9	Lack of interest in following timetables and updating them constantly.	
		11	Expanding the use of subcontractors who are not qualified.	
		13	The reliance of the contractor on low-experienced workers for saving the wage for the skilled workers, which is usually higher	
		14	The contractor received several projects at the same time	
		15	Lack of the required number of workers	
		17	Payments required for subcontractors were delayed by the main contractor	
3	Design	18	Does the approval of the drawing affect the start of work?	57%
		19	Insufficient details of implementation specifications in the executive drawings	
		21	Insufficient data collection and survey before design	
		22	Mistakes and delays in producing design documents	
		25	Malfunctions that occur in machines during work	
4	Equipment	26	Insufficient number of machines used	67%
5	Labor	29	Low productivity of labor	50%
		30	Shortage of labor	
6	Materials	33	Unavailability of the required means to transport the materials	50%
		34	Changes in material types and specifications during construction	
7	Owner	36	Change orders	57%
		37	Government entities are late in giving financial rights to contractors.	
		38	The period of the project is unrealistic and short set by the owner	
		40	Problems of expropriation and removal of obstacles	
8	Project	43	Bidding by non-specialized companies for road works affect the duration of the project?	55%
		45	Frequent disputes between project parties.	
		46	The weakness of training and development of engineers and engineering	

			departments.	
		49	Lack of communication and coordination between the various parties to the project.	
		51	The material was delayed due to traffic difficulties.	

7.3 Case Analysis

Based on investigations into this project and data analysis, it was discovered that the final actual project time was 36 months, which is 14 months longer than the original plan. Equations (6) and (7) can be used to determine the project's real overall duration as follows:

DC =1.61 & PAD = 1.61 x 22 ≈ 35.4 months.

According to the project analysis, the total project duration increased by 63.6% over the planned project duration. On the other hand, the predicted actual project duration increased by 61% (its variance is +15 days, or 2.27%). So there is convergence between the results, which emphasize the research's concluded results.

8. Conclusions

This study identified 51 issues that were delaying road development projects in Saudi Arabia and calculated their relative influence ranks. The detected factors were ranked in terms of their significance. With the help of questionnaire analysis, this goal was accomplished. All factors and groups were ranked using the computed indices (ORIIs). This study evaluated the factors that cause delays in accordance with the groups that cause them. This evaluation was done by ranking these factors and groups. Consequently, the top ten factors are listed as follows: the weakness of the financial and technical capabilities of some contractors; the contractor's failure to study the site and tender in the exact form; problems of expropriation; and the removal of obstacles. The contractor's reliance on inexperienced workers, non-specialized companies bidding for road work that affects the duration of the project, and payments required for subcontractors were all delayed due to the main contractor's lack of interest in adhering to timetables and constantly updating them. The contractor received several projects at the same time, late approval of the drawings, and government entities giving financial rights to contractors.

Furthermore, the factors in each category were ranked separately to identify the most effective delay factor for each one of the eight categories. On the other hand, the top ten delay factors according to each of the different parties' points of view were determined. This classification declared that the various parties' points of view on some of the most common delay reasons frequently stated by each of them separately are consistent, as follows: the contractor's failure to study the site and tender in the exact form; payments required for subcontractors were delayed by the main contractor; a shortage of labor; government entities being late in giving financial rights to contractors; problems of expropriation; and the removal of obstacles Furthermore, the Spearman correlation coefficients between the responses of different parties (owners, consultants, contractors, and designers) were investigated, and the overall correlation coefficients indicate that the survey results were of high validity and accuracy.

For each of the eight studied categories, the equivalent average relative importance indices $ERII_j(\%)$ were calculated. Accordingly, it has been used in deducing an empirical equation to predict project duration. A case study has been applied to predict the project's duration for a road project in Holy Makkah Municipality. The results coincide with the actual project duration, with an acceptable variance of +2.27%.

Over and above the impact of COVID-19 on road construction projects investigated, 90% of the survey participants stated that the suspension time of their road projects wasn't exceeding 30% of their planned project duration. That indicates the significance of COVID-19's effect on road projects. Additionally, the delay factors related to the COVID-19 pandemic were ranked according to the participants' points of view. These factors were arranged in the following order of effectiveness: 1) the supply chain for building materials has been suspended; 2) the absence of some construction workers as a result of being infected with COVID-19 or quarantined; 3) the absence of some construction workers due to traffic restrictions during lockdown periods; 4) additional requirements for the new safety guidelines, checks, and other activities required to maintain a healthy work environment; 5) financial revenue streams are declining due to government-imposed shutdowns that have suspended some public construction work.

9. Recommendations

Based on the aforementioned conclusions, the following recommendations can be made in order to decrease and manage delays in road construction projects: selecting specialists with prior experience or a specialty in road construction; contractors shall have a high classification certificate (issued by the Ministry of Municipal, Rural Affairs, and Housing) to let them participate in road construction projects; choosing a subcontractor with high experience and qualifications in road projects; and coordinating with various government authorities to remove obstacles, monitor

sufficient budgets for them, and develop appropriate solutions before announcing the project tender. Consultants shall take restrictive and suitable actions with contractors who are using low-experience workers, increasing labor resources through a variety of training programs, and imposing appropriate actions and penalties on contractors who fail to align their completed work with the planned schedule. Government entities shall state a suitable plan to give financial rights to contractors in their schedules. Government entities shall overcome obstacles that lead to delays in contractors' dues. Consultants chosen for road projects shall be highly qualified to control and coordinate the drawings and document approval process without delay. The Ministry of Human Resources shall update their studies to avoid a shortage of technical labor and improve human resource capabilities in the construction industry.

Furthermore, with the COVID-19 pandemic around the world, some recommendations should be followed to avoid any potential delays in road construction projects. Based on the survey's responses, the following recommendations were concluded:

Ensure timely delivery of materials on the construction site and establish contingency plans to ensure that the necessary building materials are available for site work in the event of an emergency or pandemic. Make alternate preparations to continue working if certain workers are unable to do so due to an emergency or pandemic. Make alternate plans to transport workers to their work sites in the event of a lockdown. Make plans to train employees to follow safety guidelines, perform checks, and perform other activities required to maintain a healthy work environment. Make alternative plans to provide financial facilities to contractors and reduce the impact of delaying contractors' financial rights in emergencies and epidemics.

The findings of this study are crucial for pinpointing delays in Saudi Arabian road projects. This will allow for the preparation and mapping out of plans for overcoming delays and enhancing productivity and performance. The study has a limitation according to used geographical scope, sample size, and participants types. However, whenever the study is applied more broadly, other outcomes can be observed. This suggests that comparable research should be done in other areas of the country or the Middle East. This will allow for a comparison of results.

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Conflict of interest

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