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Exploring the impacts of COVID-19 pandemic on risks faced by infrastructure projects in Pakistan

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Abstract: The current COVID-19 pandemic is making a huge impact on society. Most projects are either abandoned or halted due to this pandemic, especially in developing countries. We have conducted this study to evaluate the impact of COVID-19 pandemic on construction projects by using the concept of rework projects. 'Rework project' is a class of projects that are initiated to achieve the intended objectives in the second attempt after failing to achieve the goals in the first attempt. People who were involved in the selected projects in different capacities were interviewed and analysis of the responses was performed. The unique challenges/risks such as time urgency, overburdened resources, and mobilization of contractors, inappropriate documentation gaps, and technological changes were highly significant in rework projects. By having clear recognition to these highly significant risks, organizations will be well equipped in devising strategies to manage and complete the rework projects in the post-pandemic world.

Keywords: COVID-19; pandemic; project management; developing countries; risk management; rework projects; engineering projects; Pakistan.

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1 Introduction

The COVID-19 pandemic outbreak has disturbed all sectors of life. In a tightly linked and unified world, the effects of the disease go way beyond mortality (Tisdell, 2020). As such, companies around the world have been developing contingency plans to deal with the pandemic (Maneenop and Kotcharin, 2020). The pandemic necessitates a ‘new normal’ where companies need to adopt interactive and continuous contingency planning. The worldwide lockdown has resulted in a decrease in consumption and disruptions to production in most countries (Sun et al., 2020). Generally, the pandemic has disrupted the global supply chains all over the world (Sharma et al., 2020). Every day we hear perturbing news about more companies shutting down operations, revising estimates, or announcing layoffs (Wang et al., 2020).

The dynamic growth of the today’s competitive world has made the making critical decision more challenging (Ali et al., 2019a; Aranizadeh et al., 2019; Mirmozaffari, 2019; Mirmozaffari et al., 2020a; Chen et al., 2019; Sumrit, 2020; Yazdani and Jolai, 2015; Yazdani and Ghodsi, 2017; Shahmansouri et al., 2021). ‘Risk’ and ‘uncertainty’ are two terms that are widely pronounced in different fields of the research (Aghapour et al., 2019; Khalili et al., 2016, 2017; Yazdani et al., 2020; Hafezi et al., 2020; Hosseini et al., 2017; Zhang and Song, 2020; Mousavi and Gitinavard, 2019; Faraji and Fleischhacker, 2020; Olfati and Javadian, 2020; Yazdani et al., 2018, 2021). Project

Management Institute has defined the term 'risk' as an uncertain condition or event that, when occurs, can have positive or else adverse effects on the objectives of a project (Golilarz et al., 2019a; Kabirifar et al., 2020). In the current era, the proper management of risks is a very important determinant of the project's success because the attention has increased to any variation in time, cost, or quality performance (Azadeh et al., 2016, 2015; Yazdani et al., 2019; Mirmozaffari, 2019). It has been obvious that failing to properly deal with risks encountered in a project is one of the main reasons for exceeding the budget limits, falling behind the timelines (schedule), and failure to achieve performance targets and milestones (Yuan et al., 2020; Kabirifar and Mojtahedi, 2019). In industries like construction and engineering, a situation like this could get even worse because a huge amount of money is normally invested in these projects, along with many stakeholders and resources, and can also be characterised by instable political and economic environment, so this introduces a very high complexity level. Just like any other economic activity, engineering and construction projects are very risky (Akbarzadeh Bengar et al., 2020; Nematzadeh et al., 2020; Shahmansouri et al., 2020; Alkaissy et al., 2020). The implementation and success of engineering projects are highly dependent on the level of risk involved in the project (Paslawski, 2013; Shahmansouri et al., 2019). It is generally perceived that engineering projects have more risk inherent because many contracting parties are involved, such as contractors, owners, designers, and suppliers, etc. (Alkaissy et al., 2020; Agarwal and Kansal, 2020). Cost overruns in construction due to rework represent a common problem in the construction field (Hegazy et al., 2011). If construction companies can effectively control these key factors and formulate prevention strategies, not only can cost overruns be avoided, but overall profits on projects can be augmented (Forcada et al., 2017). The analysis of risks and proper management is a critical part of the whole decision-making process particularly in engineering projects (Kamalzadeh et al., 2019; Mirmozaffari et al., 2020b). When these projects fail to achieve their intended outcome in the first attempt, the organisations are left with two options. The first option is to completely abandon the project. The other option is to re-initiate the project with the intent of achieving the objectives, which were not met in the first attempt. Yim et al. (2015) have defined these projects as rework projects. The concept of rework has become a common thing in the engineering projects and several authors, but rework projects were not classified as a different class of project until recently by Yim et al. (2015). Hence, there is a limited amount of work done on these rework projects, particularly the unique risks to the rework projects. This research has focused on identifying frequent risk indicators for two different types of engineering projects. The first type as original projects while the other type of projects defined as rework projects. The overall goal is to aid managers in successfully developing strategies to prioritising and proactively manage risks to manage the rework projects in a better way, and to guide the rework projects to the completion.

The capability to correctly predict the risks before the initiation of the project will enable the organisations to apply proper strategies and techniques to manage risks and thus, increasing the chances of completing the project in the post-pandemic era.

2 Literature review

Even though the overall concept of a rework within a project is thoroughly defined in the literature of project management, the terminology of 'rework projects' is not highly common (Yim et al., 2015). Rogge et al. (2001) defined rework in a project as the activities which are to be done twice or more or those activities which intend to remove the work done by the previous attempt in the project. Fayek et al. (2004) defined rework as the total cost directly associated with re-doing activity in the field without considering the initiating cause. Love (2002) has defined rework more broadly. He defines rework as an 'unnecessary attempt of doing for the second time any activity or process that was not implemented correctly for the first time. A rework project could be defined as redoing an engineering project for a second time because the original project has failed to achieve the goals of the engineering project. The class of rework projects is very costly, highly undesirable, and seen as an unnecessary effort of doing a project for the second time (Yim et al., 2015). Rework is a pervasive problem that adversely impacts the performance of construction projects and has become one of the most common concerns of the industry and academia (Hwang et al., 2019). Several research studies have identified the causing factors of rework projects (Fayek et al., 2004; Golilarz et al., 2019c; Golilarz and Demirel, 2017a). Those factors which are examined as contributing in any way to rework include a poor definition of the project, pre-project planning is not appropriate, communication between parties is poor and a lack of the constructability (Golilarz et al., 2019c). Love (2002) stated that rework in a project can arise because of many factors such as errors in design, omissions, and changes during design and rework is found to be responsible for 52% of cost overrun in projects. The available knowledge about the cost associated with a rework is limited, especially those costs which are indirect. This is mainly because there is generally no system present for monitoring and controlling rework within a project (Golilarz et al., 2019c). As claimed by Love (2002), the main factor contributing to rework is the strategic decisions that are taken by the key decision-makers or the top management who trigger such conditions for adopting the processes, structures, and technologies that are not appropriate for projects. On the other hand, Hwang et al. (2019) suggested that uncertainty, poor communication, leadership, and inappropriate decision-making are the main causes leading to rework.

This amalgamation of problems means that rework in engineering projects has now become a very serious but hidden problem and consequently the costs associated with rework are found to be significant (Golilarz et al., 2017b). In addition, the situation has been induced by pandemic can exacerbate number of abandoned projects. The now those high number of projects which do not become successful, it is obvious that organisations normally undertake the project for the second time, stated here as rework project (Golilarz and Demirel, 2017b). Just like any other economic activity, engineering and construction projects are very risky. The implementation and success of engineering projects are highly dependent on the level of risk involved in the project (Golilarz et al., 2019a). It is generally perceived that engineering projects have more risk inherent because many contracting parties are involved, such as consultants, contractors, owners, designers, and suppliers, etc. (Golilarz et al., 2018). The analysis of risks and proper management is a critical part of the whole decision-making process in engineering projects. Engineering projects are mostly linked with a high level of risks due to macro, and micro-environments specific to construction (Golilarz and Demirel, 2017b). Engineering projects do not have a good reputation in properly dealing with risks as a

high number of projects fail in meeting deadlines and targeted costs. As a result of this, the owner, contractors, and the public have suffered because the outcomes were not achieved as desired (Golilarz et al., 2019b). Therefore, it is critical to understand the actions required by project managers that can help in ensuring the successful completion of rework projects (Yim et al., 2015).

After reviewing many relevant types of research and articles, it is evident that although rework projects are very common in the context of engineering projects, a very limited amount of work has been done so far on managing rework projects and managing unique risks associated with rework projects, particularly in developing countries. This creates the challenge for project managers to successfully develop the risk managing strategies and complete the rework projects. The findings of this study can be used by project managers and organisations, particularly in developing countries in the post-pandemic era, in devising effective risk management strategies and successfully manage the rework projects.

3 Research methodology

3.1 Research design

The purpose of this research was to explore the relationship between rework projects and risk factors in the context of engineering projects in developing countries in the pandemic situation. Therefore, the inductive approach was followed as not much work has been done in this field. Interviews were conducted with the people involved in selected projects undertaken by a large engineering consultancy firm. A qualitative approach was selected as it was most suitable in offering an in-depth understanding of the phenomenon being studied. As no previous studies are available in the context, a qualitative research approach was more appropriate as it allowed us to gain in-depth insights into the relationship. Therefore, an exploratory approach best suited the purpose. As the motive of this research was to find out whether the projects reinitiated for the second time (rework projects) faced the same risks or different than the projects completed in the first attempt (original projects), the selected projects were categorised as rework projects or original projects. Projects, that were re-initiated as those projects failed to achieve the goals in the first attempt, are termed as rework projects. Interviews will be conducted from team members and people who were directly involved in any of the projects selected for this research.

3.2 Data collection

Sampling technique was used in this research as a data collecting technique. In this research, non-probability sampling was adopted due to the limitations experienced in access to practitioners and experts in this field. The participating organisation was requested to provide information on engineering projects completed in recent times. Five projects were selected in Pakistan, having almost the same scope and size. The organisation was also requested to provide us with other important information related to these selected projects such as information about the people involved in these projects and their roles and responsibilities in these projects. From this information, a list of participants was generated for this study, and the organisation was asked to contact these

people and invite them for participation in this study. The selected participants were from different departments, with project managers, architects, clerks, and schedulers engaged in interviews. Taking the narrative of a diverse range of participants gave a very balanced perspective of important events during different stages of selected projects.

3.3 *Sample data procedure*

The data collection for this research was based primarily on reviewing and analysing firstly, the existing published documentation, publications, and literature reviews. Primary data was collected through interviews with the selected participants. For this research, the semi-structured interviews were more suitable because the answers of the interviewees varied depending on perception and the discussions led to areas that not previously considered although they are significant to the research and gave the researcher more flexibility with the interviewees. Interviews were conducted using a face-to-face or in-person interview method. The approximate period was 30–60 minutes per interview. The participants were asked to recall any significant incidents during the life of the project to identify the risks experienced in these projects.

3.4 *Data analysis techniques*

3.4.1 *Software used for analysis*

The software used for the analysis of qualitative data collected through interviews was done using NVivo 11. The advantage of using NVivo is that it helps in coding the required data and ease of arranging the data and finding the required information. With the help of NVivo, the most frequent words used in interview transcripts will be found, and the most frequent risk indicators, based on the frequency of those risks mentioned in interview transcripts will be identified for both original and rework projects.

3.4.2 *Relative importance index (RII)*

The RII is a technique used to illustrate different risks' ranking. This method is adopted in this study to gauge the responses of the participants on the risks experienced in selected projects. The RII scale of five points will be adopted, with 1 as of low importance and 5 being highly important for each risk. It will then be transformed into the RII using the below formula.

$$RII = \frac{\sum W}{A * N} \quad (0 \leq RII \leq 1) \quad (1)$$

Here, W is used as the respondent's weightage specified to every risk factor (with the value from 1–5), the maximum weightage is represented as A here, having a value of 5. The total number of respondents is represented by N . The value of RII will range from 0–1, with higher value of RII indicates higher importance of risk and its impact on the project.

4 Data collection and analysis

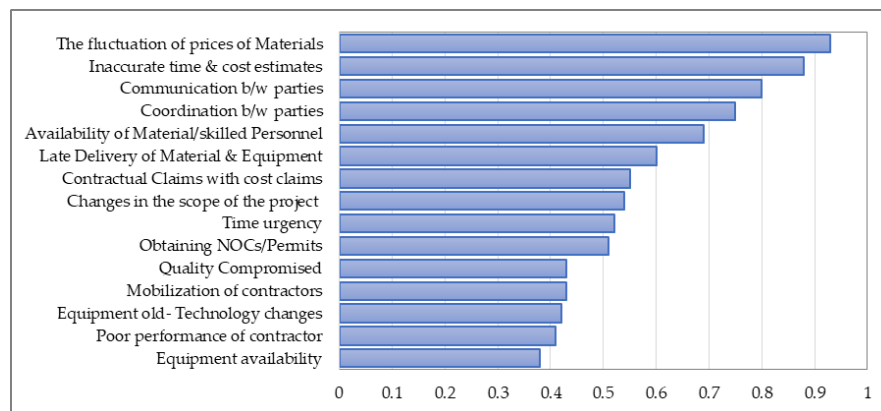
4.1 Data collection

For conducting this study, five projects were selected for data collection. Three of the projects are categorised as original projects while two projects are categorised as rework projects. The risks or the challenges faced by the project teams involved in the people involved in those projects. The details of the projects and the risks identified in those projects are described in the next section.

4.2 Data analysis

After collecting data from all five selected projects by conducting interviews of participants who have been involved in either of these projects, a comprehensive list of risks has been developed by picking all the risks that have been identified in any of the projects. Figure 1 shows risk indicators in all projects based on word frequency using NVivo 11.

Figure 1 Risk indicators in all projects based on word frequency using NVivo 11 (see online version for colours)



4.2.1 Risk common in original projects

Once the interviews are completed, all the risks identified are listed down in the above tables. Now few risks have been identified or highlighted by participants from all three original projects. Delay payments by owners/clients are the challenge faced in most of the engineering projects. When the payments are not released on time and financial issues are present, it can easily lead to schedule delays and cost overruns, as indicated by the participants in this study.

Similarly, changes in the scope of the project are another frequent risk in engineering projects. One of the reasons behind this the clients are not exactly aware of their requirements and once the project is initiated, they ask to make changes in the scope of the project, and incorporating those changes is a challenge, that sometimes leads to project delays or cost overrun.

Another issue is fluctuation in prices of material that is also very common in engineering projects. As the prices of material are already defined in the initial budget, so any fluctuation in the price of material means deviating from the actual budget and this issue is one of the most frequent challenges faced.

Availability and late delivery of materials and equipment is also very frequently faced risks in engineering projects. Especially high-quality material and high-tech equipment are either not easily available or they are not delivered to the site on time, which leads to schedule delays and costs associated with that. Quality compromise is also identified as a risk in all projects.

Coordination between the parties involved is one risk identified in all projects. These two risks are not taken very seriously but are leading factors for the failure of many projects. Obtaining no objection certificates (NOCs)/permit from regulatory authorities and flaws in the initial design are also identified as frequently occurring risks in these projects. Table 1 shows the RII of risks in original projects.

Table 1 RII of risks in original projects

<i>No.</i>	<i>Risk indicator</i>	<i>Code</i>	<i>RII</i>
1	Delay payments by owners	DPO	0.90
2	Changes in the scope of the project	CSP	0.77
3	Communication b/w parties	CBP	0.73
4	Inaccurate time and cost estimates	ITC	0.73
5	Coordination b/w parties	COO	0.70
6	The fluctuation of prices of materials	FPM	0.67
7	Late delivery of material and equipment	LDM	0.67
8	Mistakes in design	MID	0.67
9	Obtaining NOCs/permits	ONP	0.63
10	Availability of material/skilled personnel	AMP	0.57
11	Quality compromised	QC	0.53

Figure 2 Frequent risk indicators in original projects using RII (see online version for colours)

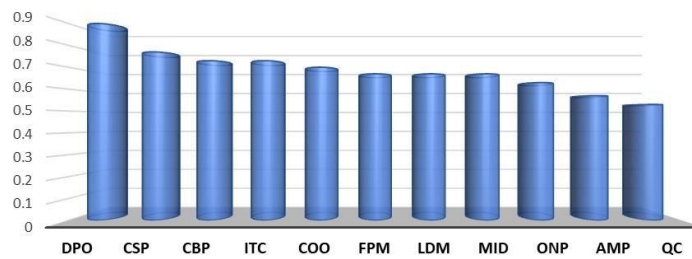


Figure 2 shows frequent risk indicators in original projects using RII.

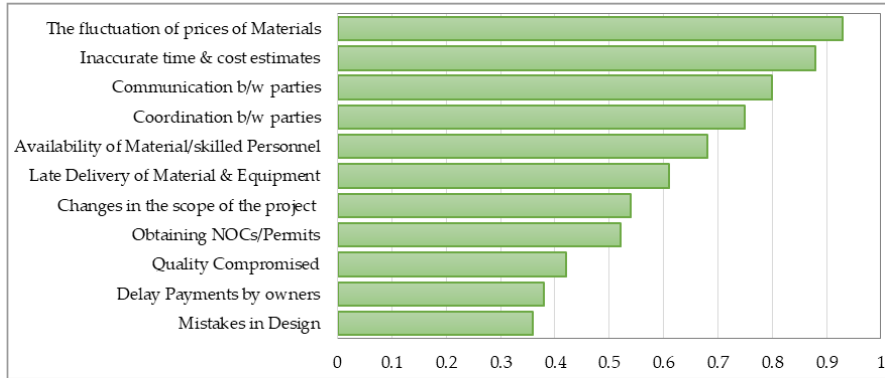
Figure 3 Frequent risk indicators in original projects using NVivo (see online version for colours)

Figure 3 shows frequent risk indicators in original projects using NVivo.

4.2.2 Risk common in rework projects

This is the most important section as one of the main objectives of the study was to identify risks in rework projects. Time urgency is the most critical risk faced in all rework projects. Because the rework projects are already behind schedule, so there is so much pressure to press timelines and complete the project as soon as possible, which leads to other challenges such as compromise on quality or resources overburdening.

Table 2 RII of risks common in rework projects

No.	Risk indicator	Code	RII
1	Schedule delays – time urgency	SDT	0.87
2	Mobilisation of contractors	MOC	0.80
3	Equipment old – technology changes	EOT	0.77
4	Contractual claims with cost claims	CCC	0.77
5	Inaccurate time and cost estimates	ITC	0.77
6	Inappropriate documentation gap	IDG	0.73
7	Coordination b/w parties	COO	0.73
8	Communication b/w parties	CBP	0.70
9	Resources overburdened	RO	0.67
10	Working rates changed	WRC	0.67
11	Obtaining NOCs/permits	ONP	0.63
12	Quality compromised	QC	0.63
13	The fluctuation of prices of materials	FPM	0.57

One of the main risks identified is the mobilisation of contractors. Because the work is stopped at some stage in the rework project and then reinitiated again, the mobilisation of contractors is a challenge as they involve their resources in other projects. The technology used in rework projects get outdated and needs to be upgraded or maintained, so it is also a challenge in rework projects. Similarly, the work rates that were agreed in

initial contract change, and this risk is very much obvious in the rework project. Inappropriate documentation or rudimentary gaps/missing documentation is another challenge frequently faced in rework projects. Coordination between the parties involved is one risk identified in all projects. One similar risk is communication between different parties involved in the project. These two risks are not taken very seriously but are leading factors for the failure of many projects. Obtaining NOCs/permit from regulatory authorities and flaws in the initial design are also identified as frequently occurring risks in these projects. Contractual claims for the cost associated with idle manpower or equipment during the work stoppage is also an issue identified in both rework projects.

Figure 4 Frequent risk indicators in rework projects using RII (see online version for colours)

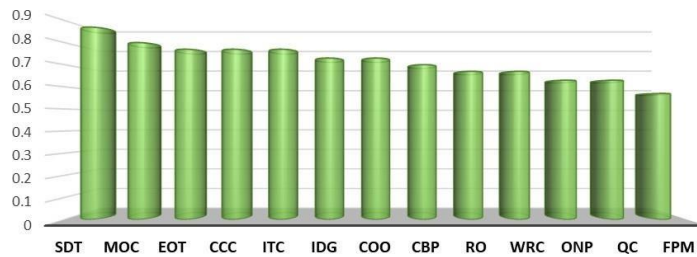


Figure 4 shows frequent risk indicators in rework projects using RII.

Figure 5 Frequent risk indicators in original projects using NVivo (see online version for colours)

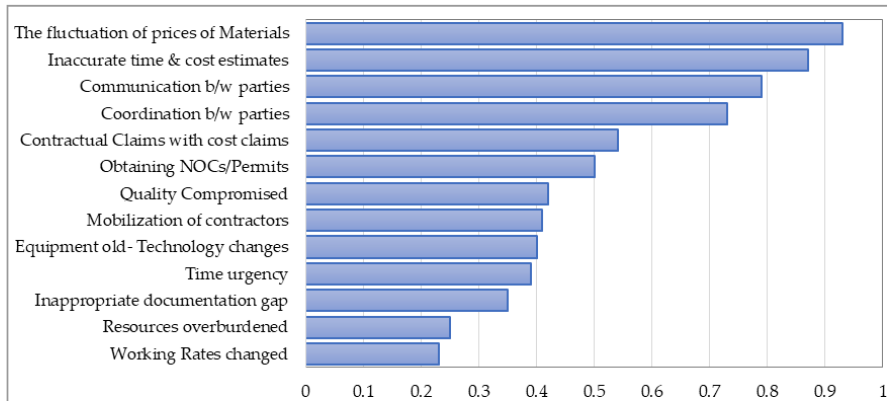


Figure 5 shows frequent risk indicators in rework projects using NVivo.

4.2.3 Risk common in rework projects

Risks that are common in both original and rework project, as identified by participants from all projects are fluctuation in prices of materials, quality compromise, coordination between parties, inaccurate times and cost estimates, communication between parties, obtaining NOCs/permits. Fluctuation in the prices of material is one of the most frequent

risks, that is identified by the participants from all five projects, although the project was original or rework. The risk of fluctuation in prices of material is due to the high inflation rate in developing countries and the changes in the value of the currency. Similarly, the political and economic instability, the law and order situation also affect the prices of material.

Another risk that existed in all five projects was compromised on quality. In all engineering projects, even though the requirement is to have strong quality conformance to the standards, the actual situation is the other way around. People involved in the projects do not give quality much importance, and hence conformance to quality is poor.

Coordination between different parties involved in the project is also identified as another area of concern in these studies. There are rarely any meetings arranged between different stakeholders. One other similar risk identified in all projects is communication between these parties. Due to a lack of proper communication and proper coordination, different issues arise as a consequence.

Inaccurate time and cost estimates are also identified as one of the most frequent risks in all five projects, which is obvious from their names. When the cost and time estimates are not accurate, then it would be a great risk for project success. Unfortunately, this is again true for engineering projects in developing countries as mostly the initial estimates of time and budget are not accurate enough, and are mostly prepared in a hurry, without proper research and homework, which at a later stage of the project, creates challenges for the project team and the clients.

Similarly, one more risk that was surprisingly identified by participants from all projects is obtaining NOCs or permits from concerned authorities. In most of the cases, it is the responsibility of the owner to apply for these NOCs or permits from concerned authorities, but the owner/clients do not have enough involvement as they should have, and the project suffers as a consequence. This often results in delays in projects schedule or additional costs at the later stages. Table 3 shows the risks common in both types of projects.

Table 3 Risks common in both type of projects

Fluctuation in prices of materials
Quality compromise
Coordination between parties
Inaccurate times and cost estimates
Communication between parties
Obtaining NOCs/permits

4.2.4 Risk specific to rework projects only

Risks that are specific to rework projects only are mobilisation of contractors, working rates changes, old equipment or changes in technology, inappropriate documentation gaps. Resources overburdened, contractual claims with cost claims and time urgency.

Time urgency is the most critical risk indicator identified in rework projects. When projects are not successful in achieving targets in the first attempt, generally the top priority of clients/owners is to complete the rework project which is the second attempt in the shortest time possible. When there is time urgency, the project team feels pressurised and there are high chances of further errors and new risk can occur because of squeezing

the timelines. The usual practice observed is because of this time urgency, is to use additional costs and resources, or to compromise on quality, or in some case overburdening of resources, and those consequences are all new risks created by shortening the timeline. That is the reason why all participants ranked time urgency as the most critical risk indicator in rework projects.

The mobilisation of contractors is the second most important risk indicator in rework projects. When the rework is initiated after the first attempt to achieve the results of the objectives in failure, one of the biggest challenges is to mobilise the contractors, because they normally withdraw their human resources and equipment from that project and utilise it in other on-going projects. In such scenarios, a lot of time is wasted to mobilise the contractors, and as mentioned earlier, time is the most crucial constraint in the rework project. That is the reason why participants from rework projects have ranked it as the second most critical risk.

Technological changes are third most critical risk indicators in rework projects. When the project is failed in the first attempt, generally the work is stopped from some time. We are living in an era where technology is changing rapidly, so in such scenarios, the technology and equipment used in that projects get outdated and old and most often needs to be replaced with updated technology, which involves a lot of costs and also the time required for procurement on work site. Transitioning to new technology is also a challenge for the project team.

Contractual claims with cost claims are observed when the work is stopped as a result of the first attempt failing. The contractors claim many costs from the client/consultant for their human resources, equipment, and machinery, etc. because it all remained idle due to the work stoppage. Dealing with such scenarios effectively is indeed a big challenge in rework projects.

An inappropriate documentation gap is found to be another big challenge in rework projects. When rework projects are initiated after some time gap, there is a big challenge finding previous project plan, progress reports, budget, drawings, etc. so new project team or even old project team working on the same project finds it difficult to manage that situation and create linkage without those old documents. In some cases, documents are available, but those documents are not appropriate, which also creates challenges for the project team involved in rework projects. Resources overburdened are an issue already linked with time urgency. As completing the project as quickly as possible is the top priority of clients and they want to squeeze the timeline as much as possible, so one consequence of this is the project team involved in rework project is overburdened and are carrying out multiple tasks at the same time, which in itself is very risky and could lead to other potential errors or consequences

Working rates changes is also found as a contributing risk indicator in rework projects as the rates agreed in contractual agreement change over time because the first attempt couldn't succeed and the project work was stopped for some time, so now either contractors, sub-contractors or even consultants demand to make changes in working rates, incorporating factors such as inflation, etc. Effectively dealing in such situations is also a challenge. Table 4 shows risks specific to rework projects only.

Table 4 Risks specific to rework projects only

Time urgency
Mobilisation of contractors
Old equipment/changes in technology
Inappropriate documentation gaps
Contractual claims with cost claims
Resources overburdened
Working rates changed

5 Discussion

The risks indicator identified in both original projects were listed down and risk indicators for original projects were compared with the risk indicators of rework projects. In this study, we were able to identify risks that were unique to rework projects that have never been identified before. Following are the risk indicators that are specific to rework project, identified in this study:

5.1 *Time urgency*

Time urgency is the most critical risk indicator identified in rework projects. When projects are not successful in achieving targets in the first attempt, generally the top priority of clients/owners is to complete the rework project which is the second attempt in the shortest time possible. When there is time urgency, the project team feels pressurised and there are high chances of further errors and new risk can occur because of squeezing the timelines. The usual practice observed is as a result of this time urgency, is to use additional costs and resources, or to compromise on quality, or in some case overburdening of resources, and those consequences are all new risks created by shortening the timeline. That is the reason why all participants ranked Time urgency as the most critical risk indicator in rework projects.

5.2 *Mobilisation of the contractors*

The mobilisation of contractors is the second most important risk indicator in rework projects. When the rework is initiated after the first attempt to achieve the results of the objectives in failure, one of the biggest challenges is to mobilise the contractors, because they normally withdraw their human resources and equipment from that project and utilise it in other on-going projects. In such scenarios, a lot of time is wasted to mobilise the contractors, and as mentioned earlier, time is the most crucial constraint in the rework project. That is the reason why participants from rework projects have ranked it as the second most critical risk.

5.3 *Technological changes*

Technological changes are the third most critical risk indicators in rework projects. When the project is failed in the first attempt, generally the work is stopped from some time.

We are living in an era where technology is changing rapidly, so in such scenarios, the technology and equipment used in that projects get outdated and old and most often needs to be replaced with updated technology, which involves a lot of costs and the time required for procurement on work site. Transitioning to a recent technology is also a challenge for the project team.

5.4 Contractual claims with cost claims

Contractual claims with cost claims are observed when the work is stopped because of the first attempt failing. The contractors claim many costs from the client/consultant for their human resources, equipment, and machinery, etc. because it all remained idle due to the work stoppage. Dealing with such scenarios effectively is indeed a big challenge in rework projects.

5.5 Inappropriate documentation gap

An inappropriate documentation gap is found to be another big challenge in rework projects. When rework projects are initiated after some time gap, there is a big challenge finding previous project plan, progress reports, budget, drawings, etc. so new project team or even old project team working on the same project finds it difficult to manage that situation and create linkage without those old documents. In some cases, documents are available, but those documents are not appropriate, which also creates challenges for the project team involved in rework projects.

5.6 Resources overburdened

Resources overburdened are an issue already linked with time urgency. As completing the project as quickly as possible is the top priority of clients and they want to squeeze the timeline as much as possible, so one consequence of this is the project team involved in rework project is overburdened and are carrying out multiple tasks at the same time, which in itself is very risky and could lead to other potential errors or consequences.

5.7 Working rates changes

Working rates changes is also found as a contributing risk indicator in rework projects as the rates agreed in contractual agreement change over time because the first attempt couldn't succeed and the project work was stopped for some time, so now either contractors, sub-contractors or even consultants demand to make changes in working rates, incorporating factors such as inflation, etc. Effectively dealing in such situations is also a challenge.

6 Recommendations and future works

Some important recommendations based on the findings of this research will help the organisations and project managers in better understanding the risk associated specifically to rework projects and hence, they would be in a better position to devise appropriate strategies to prioritise and manage those risks properly and leading the

rework projects to success after the pandemic is over. The recommendations are as follow:

6.1 Different between rework projects and original projects

Project managers need to understand that rework projects are different from normal/original projects. Some risk factors are specific only to rework projects, as identified in these studies, which means that while those risks may not be significant in ordinary projects, those risks become highly critical in rework projects.

6.2 Timelines

When initiating the rework project, both project consultants and clients/owners need to clarify the fact that pressing the timelines to complete the rework project as quickly as possible could again fail the project. It is very critical for the successful completion of the rework project that a very realistic schedule is developed that will not affect the performance of the project team. It is quite understandable that when the project is started for the second time, it has already missed the timelines, and completing the objectives as early as possible in the second attempt might be the top priority in most of the cases. One thing that both client and consultant can do to reduce timelines is to use additional resources and use cost as a weak constraint if time is considered as a primary constraint or top priority.

6.3 Renegotiate some clauses

It is very important to re-negotiate some clauses in the contract with contractors and sub-contractors and all the issues need to be clarified before the start of work to avoid any complication in the middle of the project, especially the risks identified in these studies such as contractors' mobilisation and cost claims.

6.4 Assessing upgradation of technology

Both the client and project team need to assess the need for upgradation of technology at the start of the rework project and allocate cost for the procurement of the latest technology. It should also be ensured that the team working on those advanced machines and technologies are fully trained and know how to operate them.

6.5 Check the appropriateness of projects

The project team needs to check the appropriateness of all project-related documents for the rework project and identify early if any documents are missing or inappropriate. The client should also support the consultants in recovering previous information about the project, especially when a new consultant is hired for the rework project.

6.6 Prioritise particular risks

The project managers need to prioritise those risks identified in this study in addition to other common risks to properly manage the rework project in the post-pandemic world.

7 Conclusions

When the COVID-19 pandemic is over, one of the biggest challenges in the engineering industry would be to re-initiate and manage the projects, which were halted during the pandemic. This would become even more challenging in developing countries due to their scarce resources. The effective and efficient use of these limited resources requires great efforts from all the stakeholders involved. A good project is one that is completed within the planned budget, schedule, and scope with expected quality. This becomes more critical for rework projects that failed to fulfil the objectives in the first attempt, so those projects must meet their goals in the second attempt. One of the best approaches to successfully lead the project to meet its targets is by proactively managing risks associated with the projects and devising strategies to mitigate or tackle those risks. The purpose of this research was to identify the risk indicators unique to the rework project and the intent was to make project managers aware of those risks and prioritise them to help them make appropriate risk management strategies in the post-pandemic world.

The study highlighted the risk indicators that were frequently occurring in five engineering projects already completed by Pakistan's largest engineering consultants NESPAK. Three of those projects were categorised as original projects as those engineering projects were completed in one go. Two projects were classified as rework projects as they were either abandoned at some stage or consultants were stopped from working on that project. In future, we can extend this study by studying more rework projects of different size and scope to have broad data set. For the future study, we will extend our work by employing some machine learning and optimisation approaches (Golilarz et al., 2017a, 2017b, 2018, 2019b, 2019c, 2020; Golilarz and Demirel, 2017a, 2017b, 2017c; Addeh et al., 2018; Ali et al., 2019a, 2019b, 2019c, 2020; Khan et al., 2019) to check and compare the performance analysis of various methods.

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