Volume 15 • Issue 4 • 2023

sciendo

ISMSME International Society for Manufacturing, Service and Management Engineering

received: 26 June 2023
accepted: 15 November 2023

pages: 104-115



# Hierarchical risk communication management framework for construction projects

Mohammad A. Mansour
Nabil Beithou
Moh'd Alsqour
Sultan A. Tarawneh
Khalid Al Rababa'a
Sameh AlSaqoor
Ewa Chodakowska

**Sameh AlSaqoor**
Applied Science
Private University, Jordan
Middle East University, Jordan
Tafila Technical University, Jordan
ORCID 0000-0002-0552-8926
Corresponding author:
e-mail: sameh@ttu.edu.jo

**Mohammad A. Mansour**
Applied Science
Private University, Jordan
Middle East University, Jordan
ORCID 0000-0001-8701-4007

**Nabil Beithou**
Tafila Technical University, Jordan
ORCID 0000-0002-3283-1402

**Moh'd Alsqour**
Irbid National University, Jordan
ORCID 0000-0003-0167-3429

**Sultan A. Tarawneh**
Applied Science
Private University, Jordan
Middle East University, Jordan
Mutah University, Jordan
ORCID 0000-0001-6194-2833

**Khalid Al Rababa'a**
Tafila Technical University, Jordan
ORCID 0000-0001-7091-8587

**Ewa Chodakowska**
Bialystok University
of Technology, Poland
ORCID 0000-0003-1724-192X

ABSTRACT
Risk, as an effect of uncertainty, is associated with every human activity. Like any other industry, construction companies are eager to reduce the uncertainty of reluctant events. A well-planned risk communication system could contribute to the success of a construction project. A proper announcement protocol could be a mitigating lever for identified or unidentified risks during planning and monitoring processes. This research aims to present a risk communication management system (RCMS) for construction companies involved in large projects. The proposed model includes a step-by-step communication procedure considering the authority level within the organisational hierarchical structure. The model aims to remove the ambiguity of risk communications during the construction process under uncertain conditions. It leaves no or little room for the emergence of unplanned risks. The proposed communication structure has been implemented in GRC cladding construction projects, and the risk communication time and response have been significantly improved.

KEY WORDS
**risk, uncertainty, risk management, communication, project, risk response plan, construction, model**

**10.2478/emj-2023-0031**

## Introduction

Uncertainty and the resulting risks create challenges for decision-making managers in every sector and every process (Chodakowska, 2020; Sukwadi & Caesar, 2022). Construction is one of the activities that contribute the most to creating added value in countries worldwide; thus, the sector's problems translate into the global economy (Nazarko & Chodakowska, 2017; Urbański et al., 2019). On the other

Mansour, M. A., Beithou, N., Alsqour, M., Tarawneh, S. A., Al Rababa'a, K., AlSaqoor, S., & Chodakowska, E. (2023). Hierarchical risk communication management framework for construction projects. *Engineering Management in Production and Services, 15*(4), 104-115. doi: 10.2478/emj-2023-0031

hand, global economic fluctuations are expected to impact the construction sectors significantly. The present instability in the global economy is predicted to only worsen in the coming years (Lucchese & Pianta, 2020; Yu et al., 2022). Clients, investors, and funders are becoming more demanding, discerning, less willing to accept risks, and want to minimise risk exposure. Therefore, the accounting and project finance practice should be integrated with risk management (Zaleha Abdul Rasid et al., 2011). Large construction companies need to realise the shortage of funds for future projects. Meanwhile, high competition leads the construction industry to low profitability (Davila Delgado et al., 2019).

Driven by the desire to overcome the risks, large construction firms need to have a strategy to minimise costs and improve performance. Risk reduction contributes to long-term financial stability and, as such, should be one of the company's top goals (Ginevičius, 2020). The problem of identifying the sources of uncertainty and the probability and severity of the risks is one of the main impediments that construction companies must overcome. The risk management capability is important to ensure the achievement of goals and to gain a competitive advantage (Saeidi et al., 2019). This has led to increasing attention to risk analysis to guide decision-making in recent years (Drożyner, 2020; Shevchenko et al., 2019).

The research aims to present the risk communication management system (RCMS) for construction companies involved in large projects. The proposed model refers to the communication processes and considers the level of authorisation in the organisation's hierarchical structure. It can be treated as an operationalisation of ISO 310000 and such initiatives as integrated risk management (IRM) or enterprise risk management (ERP). This model allows for eliminating the ambiguity of communication and reducing risk in the context of uncertainty in construction processes. It leaves little to no room for emerging unplanned risks. RCMS supports the achievement of business goals by transparent risk identification and control. The proposed communication structure has been successfully implemented in GRC cladding construction projects.

The article is organised as follows. First, it presents the motivation for the research, the risks and their categories in construction projects. The role of risk communication in risk management is discussed next. Then, the RCMS is introduced. The article ends with conclusions.

## 1. Literature review

Construction companies must be increasingly aware of the problems related to accepting risks of highly vulnerable projects that are difficult to manage and control. Most insurance companies are no longer open to coverage that involves a disproportionate amount of risk (Liu et al., 2007; Roy & Gupta, 2020). The occurrence of risks can significantly hinder the implementation of plans and disturb the development of a construction company in the short, medium, and long term (Moorhead et al., 2022; Raza & Zhong, 2022). The risk management process in construction projects often has many deficiencies that reduce the efficiency and effectiveness of project management and the probability of success (Shevchenko et al., 2019). The inappropriate predominant practice of risk identification and analysis in the construction industry is mostly based on the assessments of individual experts and does not consider the subjectivity of individual perception (Bornschein et al., 2020).

Risks can occur in any construction process and at any level of the project life cycle. They influence project scope, schedule, budget, and quality (Mulholland & Christian, 1999). Large-scale construction projects involve a particularly high risk. Clients take significant financial risks due to their investments. Architects are responsible for design risks (Aksamija, 2016). Contractors take responsibility for the risks associated with construction implementation. Government agencies are responsible for ensuring that regulations and standards have been established at the minimum acceptable level. The insurance industry bears the transferable risk of failure of either party. Suppliers are responsible for the performance risk associated with delivered components and materials (Eriksson & Westerberg, 2011; Ritchie & Brindley, 2007). Besides, risks of hazards, negligence, maintenance, accidents or force majeure can affect everyone involved in the project and contribute considerably to the construction project's success (Jarkas & Haupt, 2015).

Non-industry or sector-specific standard ISO 31000:2018 Risk management — Guidelines (International Organisation for Standardisation, 2018) proposes to express risk in terms of risk sources, potential events, consequences, and likelihood. It introduces a high-level set of principles for effective risk management and establishes a framework for dealing with risk that needs to be adapted to each

sector (Almeida et al., 2019; Moraes et al., 2021). Also, it proposed a generally structured approach to risk management (Howlett et al., 2022).

In recent years, several studies have analysed risk factors and explored the key success factors in risk management. Risks can be classified into categories according to various criteria, e.g., macrolevel, mesolevel, and microlevel (Yang et al., 2020). Furthermore, risk factors can be grouped into six categories related to project, government, client, design, contractor, consultant, and market risks (Shen et al., 2006). There are categories such as technical, social, economic, ecological, and political (Kodym et al., 2020) or contractual, environmental, financial, economic, market, logistical, design, construction, and operational risks (Shen et al., 2006). In a hierarchical risk structure for construction projects, external, operational, project management, engineering, and financial categories are distinguished (Rezakhani, 2012). The main risks to a construction project's performance in terms of quality, time and cost are technical, schedule, and financial (cost and funding risks). Technical risks result from incomplete design, inadequate site investigation, and uncertainty about the source or availability of materials and appropriateness of specifications. In particular, logistics risks significantly impact construction projects since they concern the sufficient availability of such resources as construction equipment, spare parts, fuel, labour, and transportation facilities. Risk is sometimes shared among organisational units in the supply or production chain. Risk may be shifted downwards through contractual terms and penalties. Flexible supply chain strategies are often the way to overcome the logistics risk. Construction risks also involve the uncertain productivity of resources, weather or seasonal implications, and industrial relations problems.

Proper communication is believed to be one of the key project success factors. The most common definition of risk communication has been developed by Covello (1992) as "the process of exchanging information among interested parties about the nature, magnitude, significance, or control of a risk" (Gentili et al., 2020). Risk communication is also defined as "any two-way communication between stakeholders about the existence nature, form, severity, or acceptability of risk" (Canadian Standards Association, 1997). Risk communication is traditionally associated with natural disasters, public health, and food safety. The literature emphasises the evolutionary and interdisciplinary character of risk communication (Balog-Way et al., 2020). Risk communications should be viewed as an important business process since there is a need to share information about risks with stakeholders: employees, customers, or the public. The necessity for a practical and effective risk communication model, rather proactive than reactive, should be among the top priorities for risk management, as the way the risk is announced determines a message reception (Freudenstein et al., 2020). Risk communication encourages accountability and ownership of risk and should be a key part of any company's risk management strategy (International Organisation for Standardisation, 2018).

A good communication system in large construction projects should involve all people associated with the construction projects directly or indirectly. At the same time, rules and responsibilities should be comprehensible, and risk communication must consider the actual public concerns (Doyle & Becker, 2022). The risk communication model is intended to clarify ambiguities and provide appropriate guidance to be applied from risk identification to the risk monitoring and control process (Tufano, 1996). The threat of miscommunication during risk management affects the performance and costs of the all-project's aspects. However, these costs can be avoided if a proper and clear communication model is launched and introduced to all team members associated with construction projects (Ceric, 2014).

Analysing the relationship between risk management and risk communication according to ISO 31000:2018, the risk management process starts from context establishment and consists of risk assessment (risk identification, risk analysis, and risk evaluation); the output of the process is risk treatment. Monitoring and review, communication and consultation are related to the entire process (Fig. 1). According to the standard, communication is a continuous and iterative process of providing, sharing, or obtaining information regarding risks and takes place at all stages of the risk management process. The relationship between risk management, risk assessment, and communication could also be viewed as presented in Fig. 2 (Yoe, 2019). From this perspective, risk assessment is a science-based process of describing the character, likelihood, magnitude, and consequences. Risk management is a policy-based process of problem identification, information gathering, evaluation and implementation of actions to reduce the impact and likelihood of problems, shift the unacceptable risk to the tolerable/acceptance level, and monitoring. Risk communication means exchanging infor-

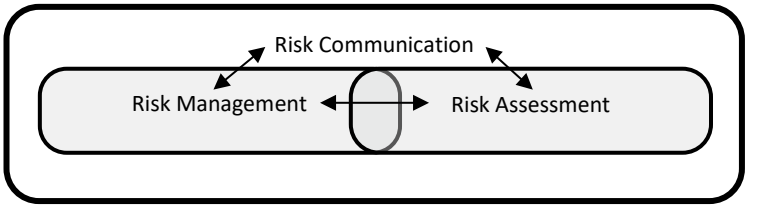


Fig. 1. Risk analysis framework
Source: adapted from Yoe, 2019.

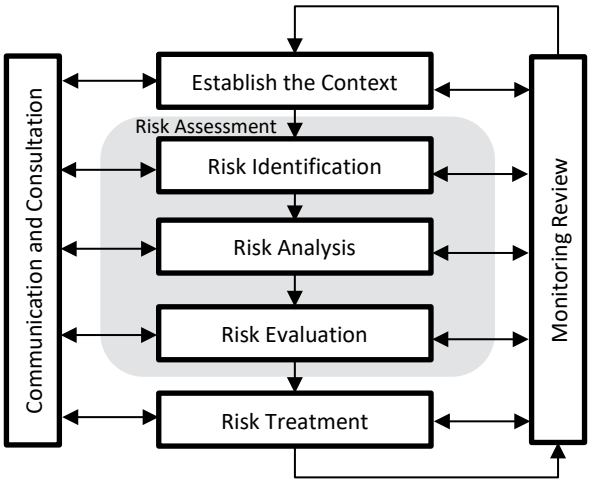


Fig. 2. Risk management process
Source: adapted from the International Organisation for Standardisation, 2018.

mation about risk to better understand it and make improved decisions (Yoe, 2019). Regardless of the approach, it is widely recognised that effective risk communication is a vital and integral part of the risk management process and risk assessment.

This work is related to risk communication that results from the technical and managerial complexity of construction projects and can be linked to the decision-making process in project management tasks in risk management. In this paper, a High Hierarchical Risk Communication Model associated with a Risk Communication Management System is proposed to remove the ambiguity of risk communications in the construction process in uncertain conditions. The main advantages of this risk communication model are (i) consistency and standardisation of procedures, (ii) clear division of responsibilities, and (iii) no or little room for unplanned risks to emerge.

## 2. Risk communication model

The basic steps of risk communication are identifying the risks, the stakeholders and their concerns, and forming and delivering messages (Ndlela, 2019). It can be expanded to assessing the impact of the risk, implementing mitigation activities, and monitoring and reporting the effectiveness of the communication efforts. The communication tasks can be divided into the initiation (identifying stakeholders and scope of issue), preliminary analysis, risk estimation, risk evaluation, risk control, implementation (communication), and monitoring stages (Canadian Standards Association, 1997).

The proposed High Hierarchal Risk Communication (HHRC) for construction consists of twelve steps, starting from risk identification and ending with risk publication. In each step, the responsibility

is assigned to the right person. HHRC and the associated Risk Communication Management System (RCMS) are illustrated in Fig. 3 and 4, respectively.

The required input, the detail of the process and the output of each step are as follows:

### 2.1. Risk identification

The RCMS contains the Risk Title, Initiator Name, Date Submitted, Risk Description and Major Areas that might be affected, and Risk Response Action. The risk identification process is a continuous ongoing task throughout the project life cycle and involves anyone, as shown in Fig. 5.

### 2.2. Risk validation

The Risk Manager (RM) should review the candidate risk with the Initiator, as illustrated in Fig. 6., to guarantee that the initial information is correct and complete. The RM clusters the risks into categories and assigns a unique identifier. The consultation should also be carried out with a Subject Matter Expert (SME). The RM determines the validation of

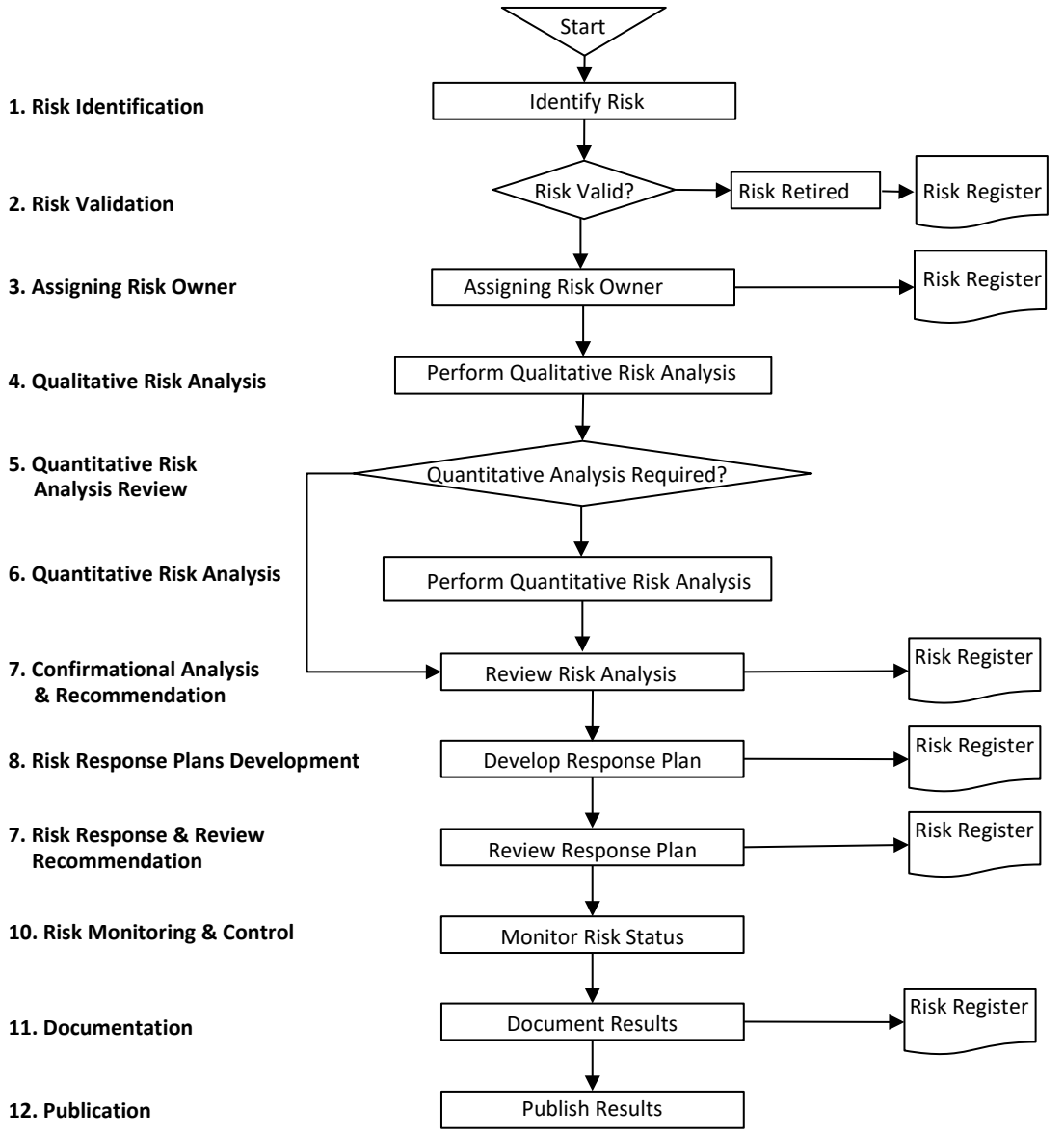


Fig. 3. Flowchart of the High Hierarchical Risk Communication Model

| Risk Communication Management System | | | |
|---|---|---|---|
| I | 1. Risk Identification | (1) | Risk Title |
| | | (2) | Initiator Name |
| | | (3) | Date Submitted |
| | | (4) | Risk Description |
| | | (5) | ☐Schedule ☐Budget ☐Scope ☐Quality<br>Primary Risk Area: |
| | | (6) | Risk Response Action (if any): |
| RM | 2. Risk Validation | (7) | Risk ID #: |
| | | (8) | Risk Validity: ☐Yes ☐No |
| | | (9) | Validation Done by: |
| | | (10) | Validation Date: |
| PM | 3. Assigning Risk Owner | (11) | Risk Owner Name: |
| | | (12) | Risk Assigned: |
| RO | 4. Qualitative Risk Analysis | (13) | Risk Probability Ranking: |
| | | (14) | Risk Impact: |
| | | (15) | Risk Exposure Rating: |
| | | (16) | Risk Priority: |
| RM | 5. Qualitative Risk Analysis Review | (17) | Required Risk Qualitative Analysis: ☐Yes ☐No |
| RO | 6. Quantitative Risk Analysis | (18) | When Risk Will Be Effective: |
| | | (19) | Effect on Critical Path: |
| | | (20) | Contingency Time Reserve: Min… Max… Most likely… Average… Standard deviation… |
| | | (21) | Contingency Cost Reserve: Min… Max… Most likely… Average… Standard deviation… |
| RM<br>TM | 7. Conformational Analysis & Recommendation | (22) | Analysis Approval: ☐Yes ☐No |
| | | (23) | Risk Critical: ☐Yes ☐No |
| | | (24) | Risk Status: ☐Active ☐Not Active |
| | | (25) | Team Member Name: |
| | | (26) | Team Member Recommendation: |
| RO | 8. Risk Response Plan | (27) | ☐Eliminate ☐Mitigate ☐Accept ☐Transfer<br>Select Risk Response Strategy:<br>Describe: |
| | | (28) | Identify Residual Risk: |
| | | (29) | Contingency Trigger: |
| | | (30) | Contingency Plan: |
| | | (31) | Fallback Plan Trigger: |
| | | (32) | Fallback Plan: |
| RM | 9. Risk Response Review & Recommendation | (33) | Risk Response Plan Approval: ☐Yes ☐No |
| RO | 10. Risk Monitoring & Control | (34) | Current Status: |
| RM | 11. Documentation | (35) | Create an Issue Report: |
| PM | 12. Publication | (36) | Publish Risk Status To: |
| I: Initiator, RM: Risk Manager, RO: Risk Owner, PM: Project Manager, TM: Team Member | | | |

Fig. 4. Risk Communication Management System (RCMS)

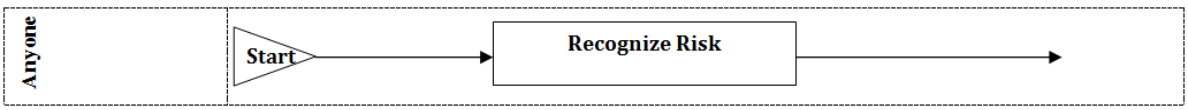


Fig. 5. Risk identification

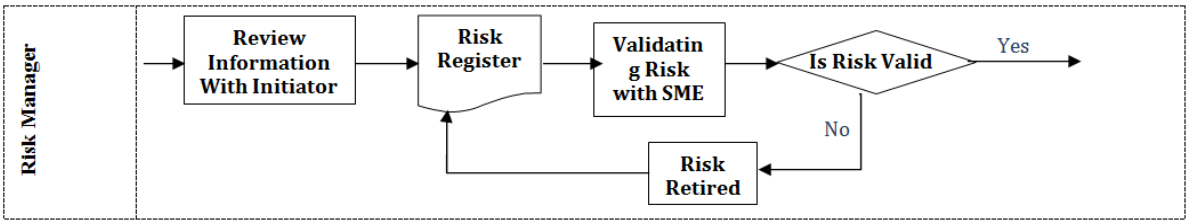


Fig. 6. Risk validation

the candidate risks and determines whether any concern or action is warranted.

### 2.3. Assigning risk owner

When the candidate risk is determined to be unfounded, the risk is withdrawn. If the candidate risk is determined to be valid, the Project Manager (PM) assigns the risk to the Risk Owner (RO) according to RCMS. The RM should meet the RO (and SME) to review the risk, as shown in Fig. 7. The RM delivers the Risk Response Plane Form (RRPF) to the RO and updates the Risk Register.

### 2.4. Qualitative risk analysis

Qualitative risk analysis is a subjective process. This process clears the ambiguity about the risk and sets the roadmap for further investigation and planning. During this process, the Risk Owner can be assisted by a Team Member or SME. The risk probability should be investigated to evaluate the frequency and the impact of the occurring risk according to RCMS, as depicted in Fig. 8.

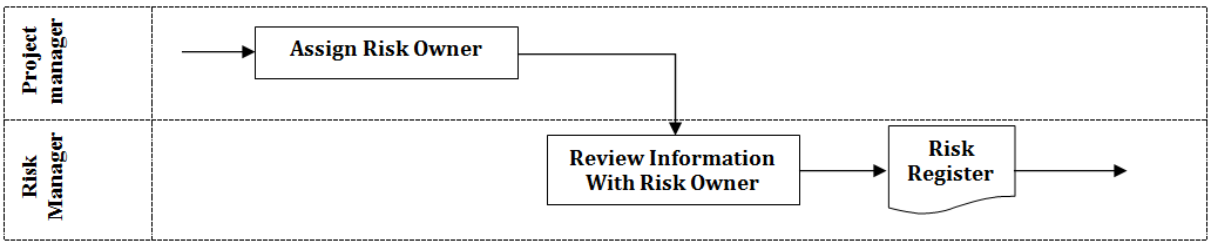


Fig. 7. Assigning risk owner

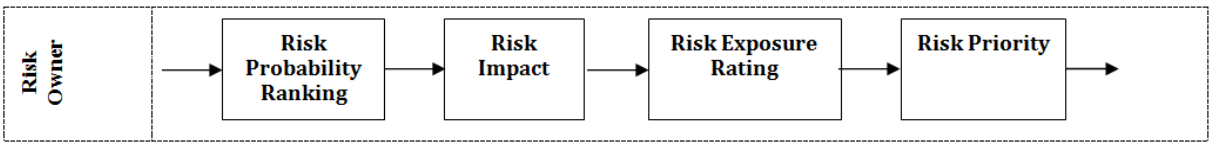


Fig. 8. Qualitative risk analysis

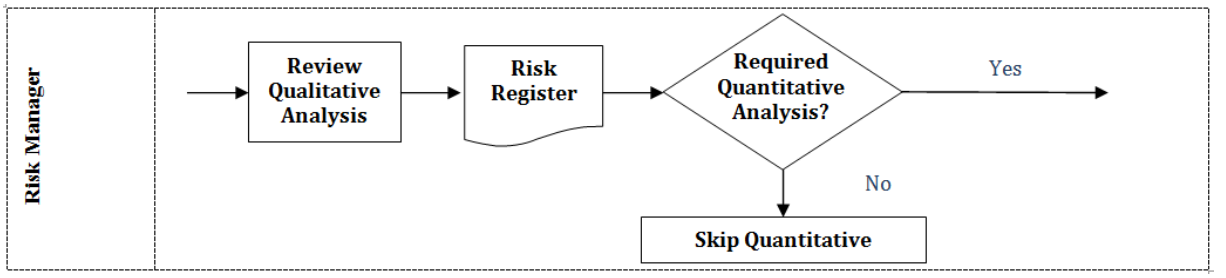


Fig. 9. Qualitative risk analysis review

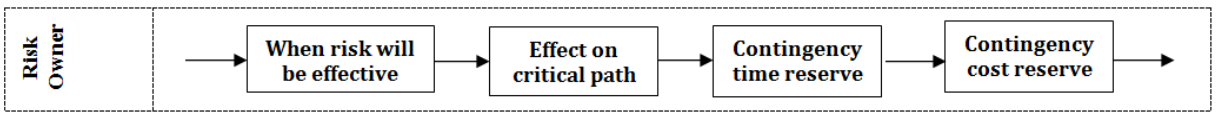


Figure 10. Quantitative risk analysis

### 2.5. Qualitative risk analysis review

The Risk Manager should review the qualitative risk analysis, as illustrated in Fig. 9. The Risk Manager should address and discuss results and findings at the project team meeting. The Risk Register is updated according to the assessment. The Risk Manager is expected to address the need for quantitative analysis.

### 2.6. Quantitative risk analysis

As shown in Fig. 10, the quantitative risk analysis addresses at what time risk is effective, the impact of risk on the critical path, the contingency time, and the cost reserve. Data can be used to extract some statistical scales and parameters for assessment.

### 2.7. Confirm risk analysis and recommendations

The Risk Manager must review and confirm the output from the risk analysis process and address them in the project meetings, as depicted in Fig. 11. If the risk is active, a recommendation from the project Team Members is required for a better risk response plan. The recommendation should follow the RCMS platform. A critical risk should be on the watch list, and the Risk Register must be updated.

### 2.8. Risk response plan

As input from the risk confirmation analysis process, the RO, the RM, and the Team Members should decide upon the best strategy that corresponds

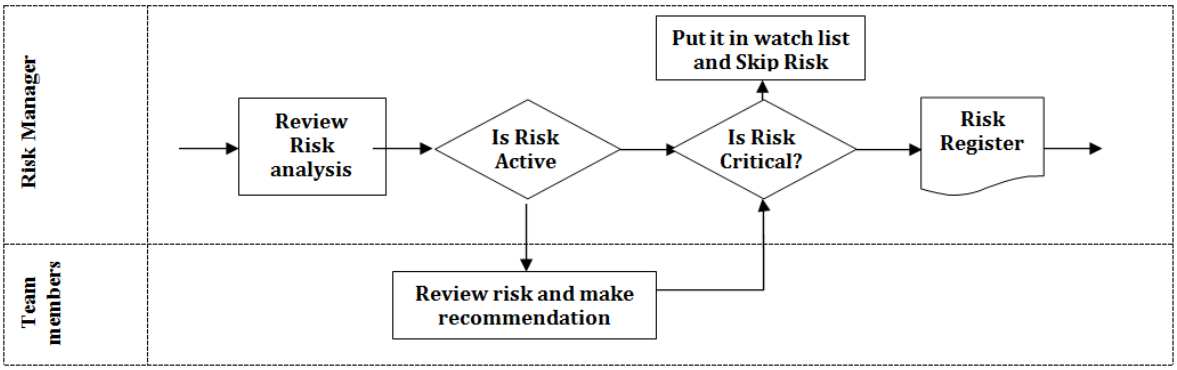


Fig. 11. Confirm risk analysis and recommendation

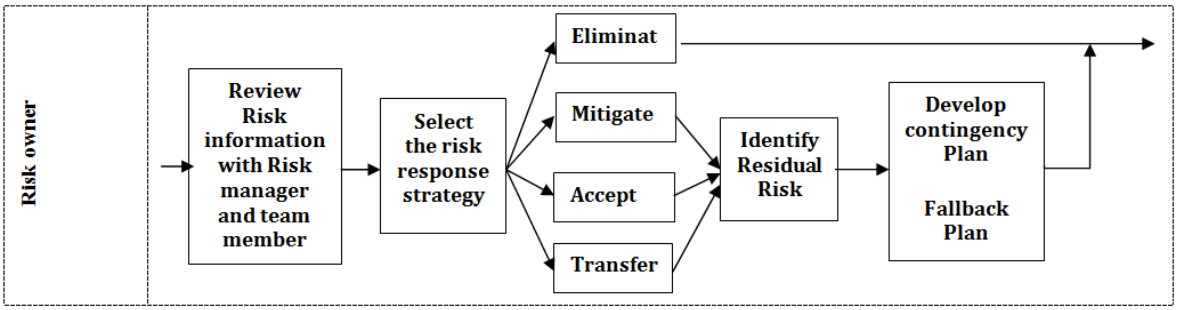


Fig. 12. Risk response plan

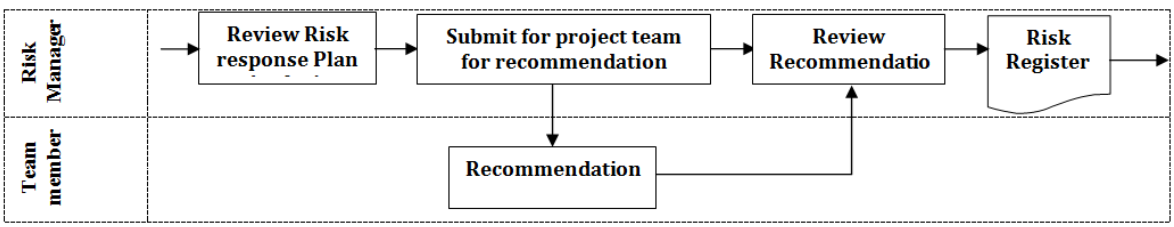


Fig. 13. Risk response review and recommendation

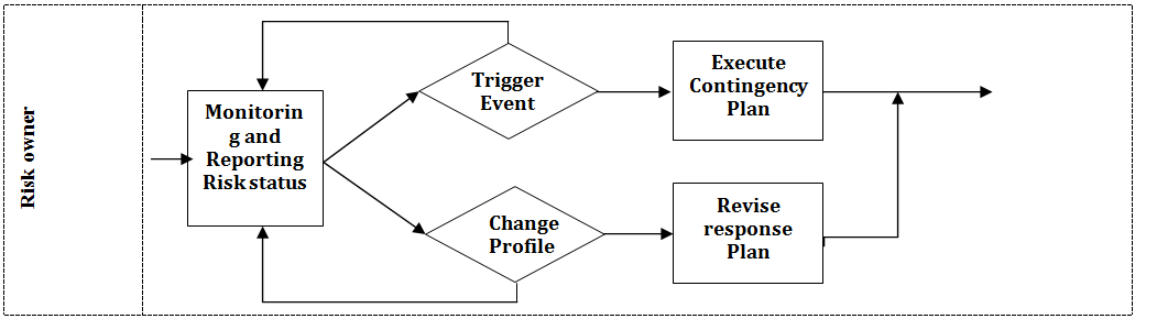


Fig. 14. Risk monitoring and control

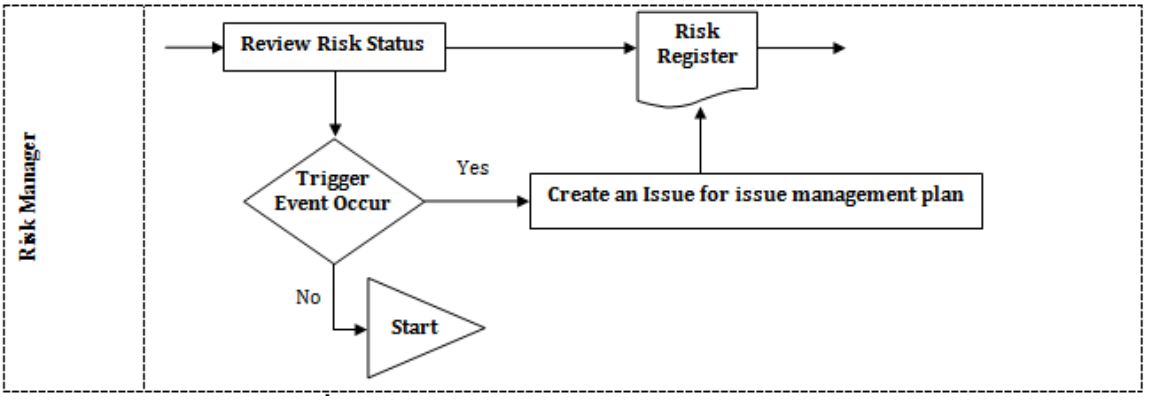


Fig. 15. Risk documentation

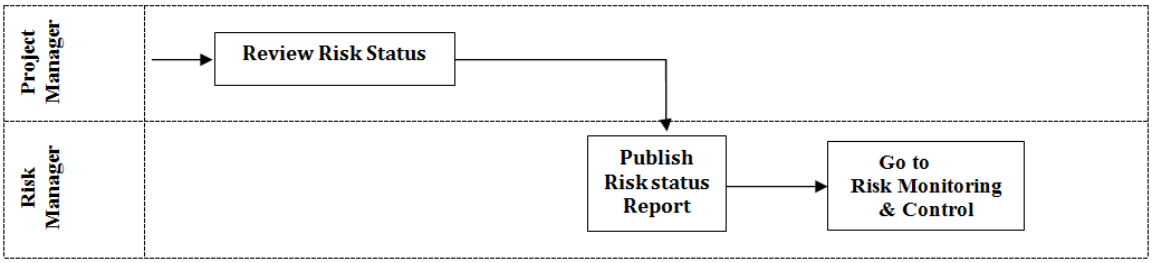


Fig. 16. Risk Publication

to the particular risk. The process is illustrated in Fig. 12. The risk can be eliminated, mitigated, accepted, or transferred to a third party. Based on the selected strategy, the residual risk and risk triggers must be identified to develop a contingency and/or a fallback plan.

### 2.9. Risk response plan review and recommendation

The Risk Manager reviews the risk response plan. A recommendation analysis from the Team Members might be significant to implement the strategy effectively, as illustrated in Fig. 13. As a result, Risk Manager should review the recommendations and update the Risk Register with the proposed suggestions and actions as per the RCMS.

### 2.10. Risk monitoring and control

The risk status should be updated in the RCMS regularly. If a trigger event is recognised, the contingency plan must be executed. On the other hand, if the risk changes its profile or characteristic, the risk response plan must be revised, as shown in Fig. 14.

### 2.11. Risk documentation

The Risk Manager must review the risk status, whether a trigger event occurs, and update the risk

register. In addition, the Risk Manager should create a concern for an issue of a management plan if the need emerges, as shown in Fig. 15. The required information of this level should be addressed in the RCMS.

### 2.12. Risk publication

The Risk Manager should review the risk status to take the best advantage of the risk communications system, as shown in Fig. 16. The Project Manager communicates to the Risk Manager the need to publish the risk status report according to the RCMS. Risk monitoring is an ongoing process until the project's closure.

## 3. Research results

Poor communication is one of the leading causes of project failure, which also applies to risk communication. ISO 31000 has introduced a set of principles and paradigms in risk management. It emphasises that effective communication is essential to managing risk and understanding the decision made; however, the guidelines are very general and need to be customised. The proposed model addresses the issue of defining risk communication procedures. The proposed High Hierarchal Risk Communication model includes a detailed plan with the necessary forms compliant with the requirements of ISO and, as such, can be used directly when implementing ISO standards. It makes the process of risk communication transparent and visible to all stakeholders. It clearly defines tasks and responsibilities by describing roles such as Initiator, Risk Manager, Risk Owner, Project Manager, and Team Member. The risk register enables proper collection and archiving of data for further processing, thus facilitating effective risk management.

The risk management policy should include corporate governance objectives in relation to risk. The organisation's strategies should reflect the attitude and risk-aware culture. Each time, the risk acceptance level (based on risk attitude, appetite, and tolerance) must be included to describe and assess the risks. The proposed HHRC risk assessment mechanism has been designed to facilitate risk identification, assessment, and prioritisation.

The presented risk communication structure has been deployed in GRC cladding projects for two years. It significantly improved the communication level. Emerging risks have been identified and reported through the right channels properly. It was estimated that the risk communication model improved the communication time efficacy by 40%. In addition, the proposed communication model proactively identified the status, progress, variance, and trend and reported the risks. The communications occurred internally and externally, vertically and horizontally in all construction activities as outlined by the High Hierarchal Risk Communication plan.

## Conclusions

Large construction organisations are capturing a narrow market and facing risks that are difficult to assess and manage. The proposed Risk Communication Management System is a useful risk management tool throughout the lifecycle of a construction project. The twelve-level, high-hierarchy structure details the communication responsibilities and sequence of steps necessary to effectively manage risk communication to solve conflict issues during the risk management process. The presented procedures transfer the authorisations regarding the risks to the appropriate person directly or indirectly involved in the project to implement the assigned tasks and goals.

The risk communication model eliminates ambiguities, reduces the necessary response time, and minimises the effect of uncertainties. In addition, the communication model provides a tool for controlling project meetings by addressing risk regularly during project implementation. Risk communication protocol recognises the significance of involving all people associated with construction projects in identifying, analysing, and designing an effective response plan for risks. By following the presented procedures, monitoring the risk profile and status can be ensured. The proposed communication model positively affects the project's success within scope, budget, time, quality, and essential requirements. In future research, the presented approach is worth verifying in other sectors.

## Acknowledgements

This research was carried out within the framework of the project No. WZ/WIZ-INZ/2/2022 of the Bialystok University of Technology and financed

from the subsidy granted by the Minister of Science and Higher Education. The authors appreciate the financial support provided by Applied Science Private University and Tafila Technical University, Jordan.

## Literature

Aksamija, A. (2016). *Integrating innovation in architecture: Design, methods and technology for progressive practice and research*. Wiley.

Almeida, R., Teixeira, J. M., Mira da Silva, M., & Faroleiro, P. (2019). A conceptual model for enterprise risk management. *Journal of Enterprise Information Management*, *32*(5), 843-868. doi: 10.1108/JEIM-05-2018-0097

Balog-Way, D., McComas, K., & Besley, J. (2020). The Evolving Field of Risk Communication. *Risk Analysis*, *40*(S1), 2240-2262. doi: 10.1111/risa.13615

Bornschein, R., Schmidt, L., & Maier, E. (2020). The Effect of Consumers' Perceived Power and Risk in Digital Information Privacy: The Example of Cookie Notices. *Journal of Public Policy & Marketing*, *39*(2), 135-154. doi: 10.1177/0743915620902143

Canadian Standards Association. (1997). *CSA-Q850 Risk Management: Guidelines for Decision-Makers*.

Ceric, A. (2014). Minimizing Communication Risk in Construction: A Delphi Study of the Key Role of Project Managers. *Journal of Civil Engineering and Management*, *20*(6), 829-838. doi: 10.3846/13923730.2013.802739

Chodakowska, E. (2020). A Hybrid Approach in Future-Oriented Technology Assessment. In K. Arai, R. Bhatia, & S. Kapoor (Eds.), *Proceedings of the Future Technologies Conference (FTC)* 2019, Vol. 1069 (pp. 512-525). Springer International Publishing. doi: 10.1007/978-3-030-32520-6_38

Covello, V. T. (1992). Risk Communication: An Emerging Area of Health Communication Research. *Annals of the International Communication Association*, *15*(1), 359-373. doi: 10.1080/23808985.1992.11678816

Davila Delgado, J. M., Oyedele, L., Ajayi, A., Akanbi, L., Akinade, O., Bilal, M., & Owolabi, H. (2019). Robotics and automated systems in construction: Understanding industry-specific challenges for adoption. *Journal of Building Engineering*, *26*, 100868. doi: 10.1016/j.jobe.2019.100868

Doyle, E. E. H., & Becker, J. S. (2022). Understanding the Risk Communication Puzzle for Natural Hazards and Disasters. In E. E. H. Doyle & J. S. Becker, *Oxford Research Encyclopedia of Natural Hazard Science*. Oxford University Press. doi: 10.1093/acrefore/9780199389407.013.208

Drożyner, P. (2020). Risk analysis in maintenance processes. *Engineering Management in Production and Services*, *12*(4), 64-76. doi: 10.2478/emj-2020-0028

Eriksson, P. E., & Westerberg, M. (2011). Effects of cooperative procurement procedures on construction project performance: A conceptual framework. *International Journal of Project Management*, *29*(2), 197-208. doi: 10.1016/j.ijproman.2010.01.003

Freudenstein, F., Croft, R. J., Wiedemann, P. M., Verrender, A., Böhmert, C., & Loughran, S. P. (2020). Framing effects in risk communication messages – Hazard identification vs. Risk assessment. *Environmental Research*, *190*, 109934. doi: 10.1016/j.envres.2020.109934

Gentili, D., Bardin, A., Ros, E., Piovesan, C., Ramigni, M., Dalmanzio, M., Dettori, M., Filia, A., & Cinquetti, S. (2020). Impact of Communication Measures Implemented During a School Tuberculosis Outbreak on Risk Perception among Parents and School Staff, Italy, 2019. *International Journal of Environmental Research and Public Health*, *17*(3), 911. doi: 10.3390/ijerph17030911

Ginevičius, R. (2020). Managerial decisions on the nature and scale of corporate activity diversification in the construction sector. *Engineering Management in Production and Services*, *12*(3), 7-17. doi: 10.2478/emj-2020-0015

Howlett, M., Leong, C., & Sahu, S. (2022). Managing internal policy risk: Australia, the UK and the US compared. *Policy Design and Practice*, *5*(2), 152-163. doi: 10.1080/25741292.2022.2065716

International Organization for Standardization. (2018). *ISO 31000:2018. Risk Management – Guidelines*.

Jarkas, A. M., & Haupt, T. C. (2015). Major construction risk factors considered by general contractors in Qatar. *Journal of Engineering, Design and Technology*, *13*(1), 165-194. doi: 10.1108/JEDT-03-2014-0012

Kodym, O., Kubáč, L., & Kavka, L. (2020). Risks associated with Logistics 4.0 and their minimization using Blockchain. *Open Engineering*, *10*(1), 74-85. doi: 10.1515/eng-2020-0017

Liu, J., Li, B., Lin, B., & Nguyen, V. (2007). Key issues and challenges of risk management and insurance in China's construction industry: An empirical study. *Industrial Management & Data Systems*, *107*(3), 382-396. doi: 10.1108/02635570710734280

Lucchese, M., & Pianta, M. (2020). The Coming Coronavirus Crisis: What Can We Learn? *Intereconomics*, *55*(2), 98-104. doi.: 10.1007/s10272-020-0878-0

Moorhead, M., Armitage, L., & Skitmore, M. (2022). Risk management processes used in determining project feasibility in the property development process early stages by Australia/New Zealand property developers. *Journal of Property Investment & Finance*, *40*(6), 628-642. doi: 10.1108/JPIF-08-2021-0071

Moraes, L. F. B., Rampasso, I. S., Anholon, R., Lima, G. B. A., Santa-Eulalia, L. A., Mosconi, E., & Yparraguirre, I. T. R. (2021). Assessing risk management in Brazilian social projects: A path towards sustainable development. *International Journal of Sustainable Development & World Ecology*, *28*(5), 451-460. doi: 10.1080/13504509.2020.1867251

Mulholland, B., & Christian, J. (1999). Risk Assessment in Construction Schedules. *Journal of Construction Engineering and Management*, *125*(1), 8-15. doi: 10.1061/(ASCE)0733-9364(1999)125:1(8)

Nazarko, J., & Chodakowska, E. (2017). Labour efficiency in construction industry in Europe based on frontier methods: Data envelopment analysis and stochastic frontier analysis. *Journal of Civil Engineering and Management*, *23*(6), 787-795. doi: 10.3846/13923730.2017.1321577

Ndlela, M. N. (2019). A Stakeholder Approach to Risk Management. In M. N. Ndlela (Ed.), *Crisis Communication* (pp. 53-75). Springer International Publishing. doi: 10.1007/978-3-319-97256-5_4

Raza, M. H., & Zhong, R. Y. (2022). A sustainable roadmap for additive manufacturing using geopolymers in construction industry. *Resources, Conservation and Recycling*, *186*, 106592. doi: 10.1016/j.resconrec.2022.106592

Rezakhani, P. (2012). Classifying Key Risk Factors in Construction Projects. *The Bulletin of the Polytechnic Institute of Jassy, Construction. Architecture Section*, *58*(2), 27-38. Retrieved from http://www.bipcons.ce.tuiasi.ro/Archive/292.pdf

Ritchie, B., & Brindley, C. (2007). An emergent framework for supply chain risk management and performance measurement. *Journal of the Operational Research Society*, *58*(11), 1398-1411. doi: 10.1057/palgrave.jors.2602412

Roy, S., & Gupta, A. (2020). Safety investment optimization in process industry: A risk-based approach. *Journal of Loss Prevention in the Process Industries*, *63*, 104022. doi: 10.1016/j.jlp.2019.104022

Saeidi, P., Saeidi, S. P., Sofian, S., Saeidi, S. P., Nilashi, M., & Mardani, A. (2019). The impact of enterprise risk management on competitive advantage by moderating role of information technology. *Computer Standards & Interfaces*, *63*, 67-82. doi: 10.1016/j.csi.2018.11.009

Shen, L.-Y., Platten, A., & Deng, X. P. (2006). Role of public private partnerships to manage risks in public sector projects in Hong Kong. *International Journal of Project Management*, *24*(7), 587-594. doi: 10.1016/j.ijproman.2006.07.006

Shevchenko, G., Ustinovichius, L., & Walasek, D. (2019). The Evaluation of the Contractor's Risk in Implementing the Investment Projects in Construction by Using the Verbal Analysis Methods. *Sustainability*, *11*(9), 2660. doi: 10.3390/su11092660

Sukwadi, R., & Caesar, A. (2022). An integrated approach for supply chain risk management. *Engineering Management in Production and Services*, *14*(1), 38-48. doi: 10.2478/emj-2022-0004

Tufano, P. (1996). Who Manages Risk? An Empirical Examination of Risk Management Practices in the Gold Mining Industry. *The Journal of Finance*, *51*(4), 1097-1137. doi: 10.1111/j.1540-6261.1996.tb04064.x

Urbański, M., Haque, A. U., & Oino, I. (2019). The moderating role of risk management in project planning and project success: Evidence from construction businesses of Pakistan and the UK. *Engineering Management in Production and Services*, *11*(1), 23-35. doi: 10.2478/emj-2019-0002

Yang, M., Chen, H., & Xu, Y. (2020). Stakeholder-Associated Risks and Their Interactions in PPP Projects: Social Network Analysis of a Water Purification and Sewage Treatment Project in China. *Advances in Civil Engineering*, 2020, 1-14. doi: 10.1155/2020/8897196

Yoe, C. E. (2019*). Primer on risk analysis: Decision making under uncertainty (Second edition)*. CRC Press.

Yu, Z., Razzaq, A., Rehman, A., Shah, A., Jameel, K., & Mor, R. S. (2022). Disruption in global supply chain and socio-economic shocks: A lesson from COVID-19 for sustainable production and consumption. *Operations Management Research*, *15*(1-2), 233-248. doi: 10.1007/s12063-021-00179-y

Zaleha Abdul Rasid, S., Rahim Abdul Rahman, A., & Khairuzzaman Wan Ismail, W. (2011). Management accounting and risk management in Malaysian financial institutions: An exploratory study. *Managerial Auditing Journal*, *26*(7), 566-585. doi: 10.1108/02686901111151314