Proceedings of the 7th African International Conference on Industrial Engineering and Operations Management
Cape Town, South Africa, May 13-15, 2026

Proceedings of the International Conference on Industrial Engineering and Operations Management

Publisher: IEOM Society International, USA DOI: 10.46254/AF07.20260454
Published: May 13, 2026

The analysis of the cost related to poor quality in the Construction of Transmission Line Towers

Elelwani Beauty Ndou
Department of Industrial Engineering and Engineering Management
University of South Africa
Johannesburg, South Africa
39572471@mylife.unisa.ac.za

Kemlall Ramdass
Department of Industrial Engineering and Engineering Management
University of South Africa
Johannesburg, South Africa
ramdakr@unisa.ac.za

Kgabo Mokgohloa
Department of Industrial Engineering and Engineering Management
University of South Africa
Johannesburg, South Africa
mokgok@unisa.ac.za

Kajingulu Malandala
Department of Industrial Engineering and Engineering Management
University of South Africa
Johannesburg, South Africa
malank@unisa.ac.za

Abstract

The construction of transmission tower lines incurs financial losses and operational challenges due to poor quality, resulting in project delays, structural failures and rework. This study analyses the costs associated with poor quality in the construction of transmission tower lines. Quantitative approach was adopted, using secondary data from archival rework reports on completed transmission tower lines over three years. The findings interpret the cost related to poor quality in the construction of transmission tower lines. Quantitative validation and development were supported by qualitative findings, which provided the specific variables and context. The descriptive statistics were used to analyse the frequency of rework events and the total cost of rework percentage as per the Transmission Tower. The results proved that construction design-related factors is the main drivers of COPQ. This study contributes to the limited body of knowledge on quantifying the COPQ in transmission line tower construction.

Keywords
Construction, Causes of Poor-Quality, Poor-Quality Cost, Poor Quality Measurements

1. Introduction
Despite efforts and energy invested, the construction of the transmission tower line project performance in Company XYZ has fallen significantly due to the high re-work rate, construction waste, and errors in tower designs, which contribute to the cost of poor quality. The company has seen financial losses in the construction of the transmission line project, which are associated with poor quality and productivity losses. (Sucala et al.2025) stated that the construction industry plays an important role in the development of the economy and continuous improvement to execute the construction projects successfully. (Mahmood 2014) alluded to the fact that COPQ remain hidden and cannot be captured correctly as COQ, identified, traced in any accounting reports system that is currently active and auditing system, since construction projects are activities that are executed based on the project scope and budget, depending on the project size.

The study analyses the cost of poor quality in the construction of transmission line towers, identifies the major cost-related factors, namely: construction design-related factors, construction waste, management-related factors and poor quality. The study aimed to quantify the poor-quality costs, evaluate the performance of the project and the impact to provide insights on how quality-related defects affect time, cost, and reliability in transmission infrastructure projects. The goal is to propose strategic recommendations for improving quality management practices and reducing COPQ in future projects. (Zhang et al.2023) classified the hidden costs, which include transportation, labour, materials and equipment as the expenses that are documented during the construction process. However, the definition of hidden costs is not accurate. The project manager does not focus on controlling and identifying the hidden costs and risks to optimise the project costs.

1.1 Objectives
Analysis of the cost related to the poor quality in the construction of Transmission Line Towers.

2. Literature Review
Table 1 depicts the evolution of the Cost of Poor Quality (COPQ) in the construction industry by various researchers in different years from 1951 to 2024. The table depicted the main contributions by providing an overview of how COPQ concepts have developed over time.

Table 1: Evolution of COPQ by different researchers

Author	**Year**	**E**volution of the Cost of Poor Quality (COPQ)
Jurah	1951	Emphasised that the COPQ and its impact on the construction quality, to include the financial impact due to rework costs and company revenue loss due to customer complaints and poor-quality work (Gil-Vilda et al.2021)
Harrington	1987	Defines COPQ products as determined by the output of the product that satisfies the customer's needs and expectations.
Feigenbaum	1998	He was the First researcher to classify the COPQ (Gil-Vilda et al.2021)
Gryna	1999	Indicated that the visibility of COPQ is three or four times the visible cost and divided the COPQ into ten categories.
Sorqvist	2001	Define the COPQ of the product not conforming to the standards and procedures (Gil-Vilda et al.2021)
Krishnan	2006	Highlighted that COPQ can be visible and invisible, where a small amount of cost can be visible, and the rest are hidden (Srivastava 2008).
Bergman and Klefsjo	2010	Stated that quality cost is not a good terminology, as it gives the wrong impression, and advises COPQ as the right terminology that will give a good impression(Gil-Vilda et al.2021).

2.1 Causes of Poor Quality in the Construction of Transmission Line Towers

The construction waste is the most contributing factor to the cost of poor quality in the Nigerian construction industry due to poor management of material by the construction practitioners, that result in project delays caused by late delivery of materials, environmental impacts on regulatory issues and rework (Albert, et al.2021) Furthermore, (Hijazi 2021) affirms that subcontractors experience challenges in moving and storing the construction material from one location to another that result in extra costs of material handling and delays in project execution. The design and construction phase of the project quality-related issues are not taken into consideration during the initial phase of the project, resulting in main stakeholders' suspension, such as the architect, due to the impact of time wasted and lack of project integration, effective communication and coordination between the project managers (Khan et al.2021).

Therefore, there is a lack of an effective framework to manage the design challenges and a lack of coordination among the designers, that lead to modifications and changes resulting in project delays. According to (Olanrewaju and Lee 2022), Management avoid to share the causes of poor quality in the industry, resulting in a lack of knowledge sharing across the construction industry. According to (Shoar and Chileshe 2021), omissions, value engineering and errors in designs are major causes of poor quality in construction projects, leading to design changes during project execution, resulting in rework and an increase in labour costs. (Olatunji et al.2025)classified three types of design errors that cannot be recorded, and not conforming to the quality standard, namely: imperfections, non-conformance, and omissions.

2.2 Cost of Poor Quality in the Construction Projects (COPQ)

(Shuko and Yaakub 2025) indicated that the Cost of Poor Quality (COPQ) had a negative impact as it plays an important role in reducing company revenue and delaying the operational performance. (Cheshmberah et al.2019). (Albert 2021) and (Walston et al.2025) to reduce the COPQ in construction projects, it is essential to identify and measure quality costs, as quality is the primary goal for continuous improvement. There is a lack of research studies conducted on the operational level to determine the defects that cause poor quality and hidden quality costs; therefore, there is a need to research hidden quality costs calculations.

(Henriques and Silva 2009)and (Cheshmberah et al.2019) presented the Cost of Poor-quality Costs in Figure 1 and confirmed that the prevention cost forms part of the organisation's investment since it can improve the COPQ and focus on activities that prevent quality errors and defects. These costs are aimed at avoiding problems before they occur, which can result in significant long-term savings and other benefits within the organisation, such as reducing inspection and testing costs, process efficiency improvement, enhancing employee skills and competency and reducing rework.

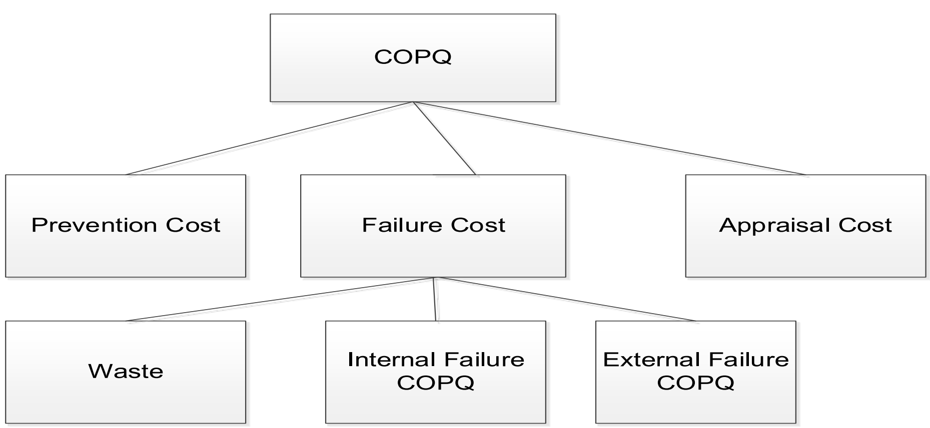

Figure 1: Cost of Poor-quality Costs Source

(Oakland 2024) highlighted the challenges in applying COPQ models due to the project's complexity, which involves various project stakeholders, subcontractors, making it difficult to identify quality-related costs accurately, a lack of a COPQ framework to measure the cost of poor quality in the construction industry and hidden COPQ, which is difficult to measure.

(Mahmood and Kureshi 2015) indicated that COPQ is a hidden cost not measured or documented in any accounting system. Therefore, further postulates that if the work is executed as per the project schedule, the COPQ always disappears. Lack of management in understanding the hidden losses of poor quality makes it difficult to get involved in corrective actions to address poor quality costs divided into 2 failures, namely: internal and external failure costs.

(Mashwama et al.2017) identified COPQ quality as a crucial factor in understanding the expenses of producing high-quality products. The COPQ poses significant challenges in the construction industry due to waste during the construction process and failure to prevent errors and failures. COPQ poses a significant risk in the construction industry due to the failure to prevent construction waste and defects during the construction process. In addition, (Oluyemi et al. 2022) indicated that poor quality standards are one of the major challenges experienced in the industry. The challenges are common in Construction projects; failure to comply with the quality standards has an impact on project costs. Therefore, the quality cost (Non-conformance) contributed 12% in the USA.

The COPQ is the related cost of delivering poor-quality products due to nonconformance to quality standards. COPQ is defined as the acquired quality-related costs for the company due to noncompliance with the quality specification. "*Quality is free; it's not a gift, but it is free*. Poor-quality products cost money and not doing the job right the first-time results in poor products. The poor quality cost is divided into internal and external failure costs (Nadeem et al. 2014) and (Connor 2023).

2.2.1.1 Internal failure costs

Internal failure costs are costs related to the failure of products before being delivered to the external customers, waste of materials, waste of labour, scrap costs, production overheads, quality issues due to downtime, failure analysis and product downgrades (Nadeem et al.2014)and(Connor et al.2023) Cost of Poor Quality (COPQ) drives organisations to implement Lean Six Sigma, continuous improvement to reduce poor quality costs and process inefficiency.

2.2.1.2 External failure costs

External failure costs are costs related to failure after the products that are still within the warranty have been delivered to the customer. Examples include repair complaints, nonconforming to quality standards, defective parts replacement, liability costs of the products, recollection of products, payments, and changes in customer complaints. Furthermore, external failure costs include indirect and direct costs such as customer complaints and warranty inspection (Nadeem et al.2014) and (Connor et al.2023)

Cost of Poor-Quality Measurements

(Hwang et al.2009). The COPQ has been measured differently in construction projects, and seven measurements of quality are relevant to construction projects, namely: conformance, strength, dependability, and serviceability determination of quality measurement is more applicable and suitable for measuring different levels of quality. Calculating quality from a building life cycle cost (BLCC) viewpoint, considering the quality design, materials used, and workmanship. This quality measurement is complete with special effects of quality on maintenance and operational costs, which differ from construction costs. (Hwang et al. 2009) indicate that the quality cost calculation method is complicated and has been defined and experienced by capitalising on stopping non-compliance requirements, assessing compliance, and the requirements of service and product failure to meet the requirements. However, the quality definition leads directly to an equation of COQ, which equates non-conformance and conformance costs to the cost of conformance plus the non-conformance cost (Hwang et al. 2009).

(Krishnan et al.2008) highlighted the benefits of measuring poor quality cost as an initial phase of continuous improvement in construction projects. Poor quality cost measurement enables project managers to highlight areas of improvement, eliminate rework, and improve productivity improvement and helps project managers benchmark their results with the best practices in construction projects to come up with an improvement strategy. (Nouman et al.2023) stated that there is no standard approach for measuring COQ in the construction industry; every construction project develops its own standard to measure the cost items. There is limited research on measuring the COQ in construction projects, resulting in the loss of valuable resources. Furthermore, it is important to create a cost measurement system in construction projects throughout the project execution phase to support the project managers in understanding the root cause of the COPQ failure, which will benefit in completing the project on time. (Nouman et al.2023) furthermore indicated that the organisations measure COPQ in production differently and argue that it is effective to calculate contributing factors of COPQ; however, it is important to focus on solving the problems rather than doing many measurements since organisations invest in measurements rather than solving problems. (Hendriques and Silva 2009) indicated that it is important to identify what to measure and have a common understanding of the cost factors before making the actual improvements to ensure that the company does not lose the important information that adds value to production operations.

(Oluyemi et al.2019) (Mashwama et al. 2017), affirm that the most critical factors influencing project quality in the industry are poor quality of materials, inexperienced leadership, construction errors, lack of commitment to leadership, poor quality inspection and lack of coordination between the design engineers, project managers and construction managers during the design changes. (Mashwama et al.2017)recommended that quality should be taught as a subject in higher education institutions to enable the graduates entering the industry to apply their knowledge.

2.3 Gaps in the Literature

The literature review highlighted the comprehensive COPQ overview related to poor quality reviews; several gaps still need to be addressed. The COPQ framework for measuring the cost of poor quality in the construction sector has yet to be implemented, particularly for assessing hidden COPQ, which is challenging to quantify due to the complexity of construction projects (Krishnan et al. 2008). Moreover, the literature needs a thorough exploration of accounting systems to measure hidden costs that are not measured or documented. Management involvement in any actions related to poor-quality corrective actions is limited. Addressing these gaps is important for developing a holistic understanding of how the construction industry can reduce the cost of poor quality. There is no standard approach for measuring COQ in the construction industry; every construction project develops its own standard to measure the cost items and affirm there is limited research on measuring the COQ in construction projects, resulting in the loss of revenue (Mahmood et al.2014*)*.

Table 2: Gaps in the previous studies

Author	COPQ Gaps identified in previous studies
(Mahmood *et al.2014*)	The lack of knowledge of hidden losses in COPQ, it makes it difficult to document and measure in the accounting system, which makes it difficult to quantify.
(Nouman *et al.2023)*	The main problem in construction projects is the lack of a complete system for classifying and tracking quality costs.
(Axelsson and Skogum 2016)	There is no model to classify and quantify COPQ. The organisations operate differently, which results in challenges in generalising the COPQ parameters.

3. Methods

This research study adopted a quantitative method. The main research study was based on the analysis of archival rework data, rework flash reports on the construction of Transmission line Towers sourced from XYZ Construction Company to understand and quantify the cost of poor quality (CoPQ). These documents were collected over three years from completed Transmission line Projects. The descriptive statistics were used to analyse the frequency of rework events and the total cost of rework percentage as per the Transmission Tower.

4. Data Collection

The secondary data was used from the archived project documentation of the tower construction project. The extracted data template was designed in Excel to compile rework data from the sources, including flash reports, quality inspection logs, and financial records, detailing all the rework activities.

5. Results and Discussion

5.1 Numerical Results and Graphical Results

This section presents the rework analysis values derived from archival data related to Transmission line tower construction. The results are grouped under four key themes of poor quality: Construction Design-Related Factors, Construction Waste, Management-Related Factors, and Poor Quality in Construction. Each theme analyses the significant risks impacting project performance and cost management.

Theme 1: Construction Design-Related Factors

The results illustrated in Figure 2 shows that Tower 72 has the highest rework value of R260 116.63 for the construction of design-related factor, then followed by Tower 194 LM Leg B/C with has accounted the total cost of R217541.79, Tower 314 DM Leg B and D accounted for the total cost of R186 790.20, Tower 137 SM Leg B, which has accounted for the total cost of R160 128.72. Tower 156 Columns, Tower 143 SM Leg D, Tower 138 SM Leg A and C accounted for the lowest cost, ranging between R38,487.51 and R86,393.36. These costs are related to design changes, lack of communication between the design team, deviations between tower drawings and site conditions. These findings are consistent with those of Love et al.2003), Identified 79% of rework in construction projects due to design-related issues. This highlighted the need for validation of tower design drawings before project execution.

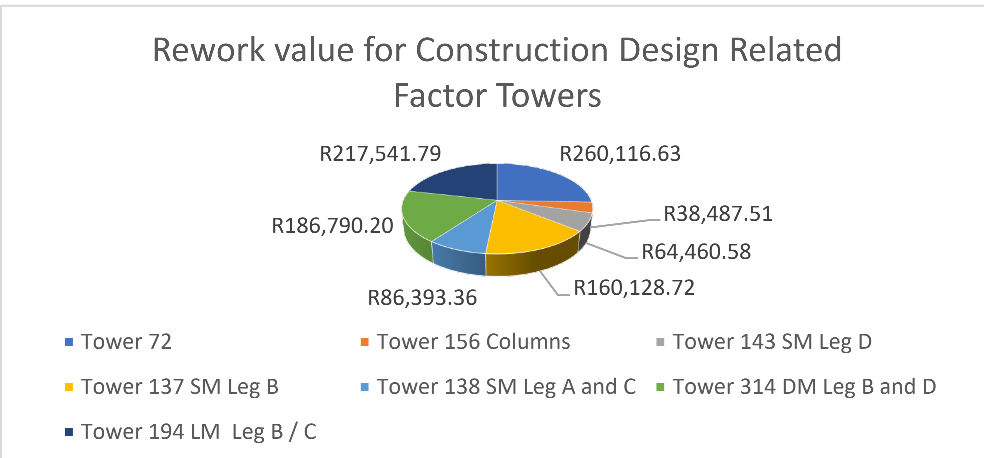

Figure 2: Graphical Representation of Rework Values for Construction Design Related Factor

Theme 2: Construction Waste

As shown in Figure 3, construction waste accounted for the highest rework costs in Tower 169 Columns with a rework value of R315,126.91. Other high-cost towers include Tower 175 LM Leg D and B (R297,982.58), Tower 315 DM Leg A, B, and D (R217,107.45), and Tower 159 Leg E (R217,541.79).

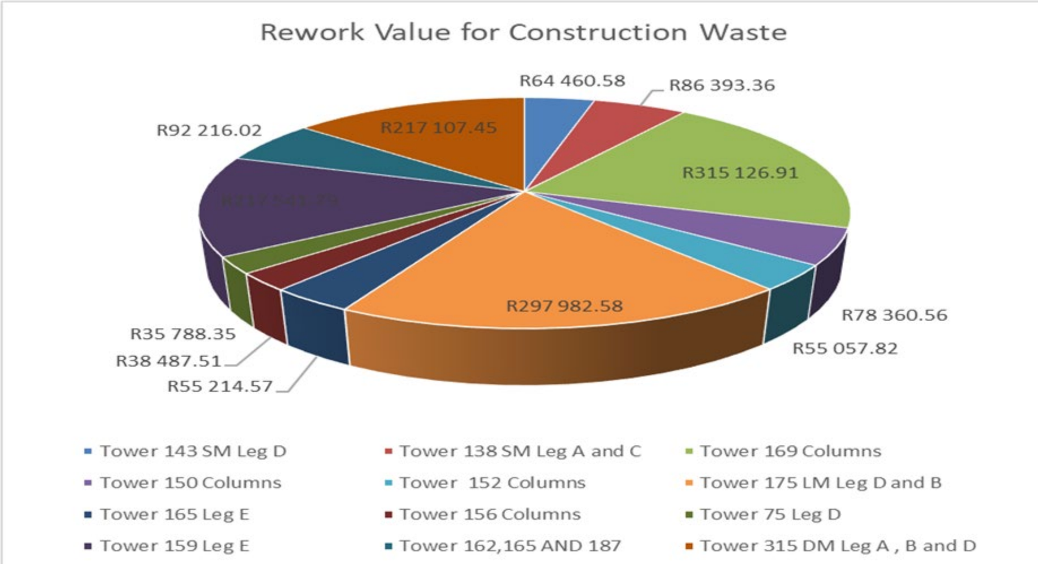

Figure 3: Graphical Representation of Rework Value for Construction Waste

Theme 3: Management-Related Factors

There are no quantitative values for this theme, but the Management failures—such as a lack of supervision during the construction process, a lack of communication between the project stakeholders ─played a critical role in quality failures. The indirect costs of these errors are rework across towers, where a lack of supervision was reported.

Theme 4: Poor Quality in Construction

Figure 4 illustrates that Tower 169 Columns again recorded the highest overall rework, under this theme at R315,126.91, followed by Tower 75 Leg D (R217,107.45), and Tower 165 Leg E (R78,360.56). Lower-cost rework cases were noted in Towers 156, 150, 152, and particularly Tower 51 & 53, which had the lowest rework cost of R27,911.02. These defects resulted from insufficient quality control, poor concrete work and inadequate designs.

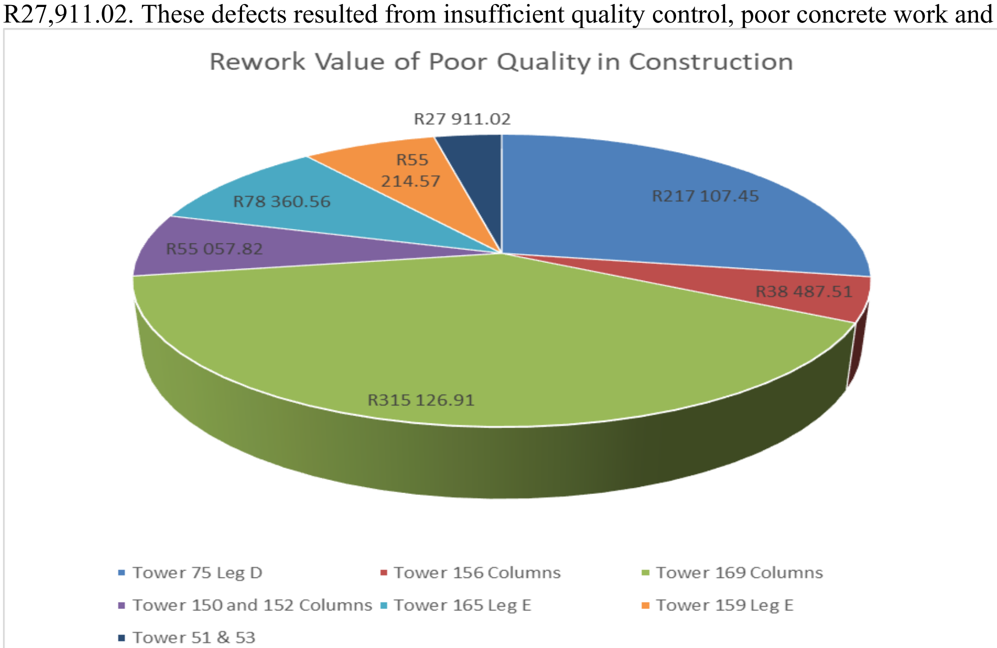

Figure 4: Graphical Representation of Poor Quality in Construction

5.3 Proposed Improvements

Based on the findings and the results of the research study, the researcher recommended the following improvements to reduce the COPQ in future construction projects :

Improvement in site Management and Supervision by assigning clear roles and responsibilities for quality assurance and quality control (QA/QC) at each construction phase of the projects to avoid project delays and rework. Frequency and effectiveness improvement of site inspections and toolbox talks for project stakeholders has been recommended before the project execution phase to understand the project scope and identify the project hazards to improve the project compliance with safety standards to ensure continuous improvement.

Implementation of the design review engagement session between the project stakeholders before the procurement process to ensure the design's alignment with the construction project standard.The Implementation of Preventive Quality Systems to comply with the quality management system standard across the industry, including contractors and stakeholders, to ensure compliance. Development of a Standardised COPQ tool to quantify, track project performance, and Monitor Continuous Improvement in Construction Projects. Implementation of lean construction to reduce waste and rework to improve project efficiency.

6. Conclusion

The study investigated the Cost of Poor Quality (COPQ) in the construction of transmission tower lines at XYZ Construction Company, utilising archival rework data from multiple tower sites. The results revealed that poor quality results in significant financial losses, with one tower's rework costs reaching as high as R315,126.91.

The analysis identified four major themes contributing to COPQ:

Construction Design-Related Factors – Design errors were found to be the leading contributors to rework, primarily in Towers 72, 194, and 314.

Construction Waste – Poor handling and project site inefficiencies resulted in high waste-related rework costs, especially in Tower 169 and Tower 175. (Khandim et al. 2023) supported the view that construction waste in construction projects contributed to the hidden COPQ, quantifying the cost based on the base of the Ice iceberg in construction projects.

Management-Related Factors – There is no directly quantified cost of poor quality. The analysis shows poor supervision, lack of communication between the project stakeholders, and poor-quality control lapses as indirect causes of recurring rework, (Love et al. 2003) Identified lack of communication between the project stakeholders, inadequate design specifications, and inadequate management as the main contributing factors to the cost COPQ.

Poor Quality in Construction –Highlighted the construction errors resulted in poor quality checks, also led to costly rework, with Tower 169 being the most affected tower, with the highest cost of poor quality.

The repetition of high rework values in specific tower lines proposes systemic weaknesses in quality planning, integration design, and execution practices on-site. The study confirms that both hidden quality failures and visible quality failures have increased the project costs and project delivery timelines. The contributing factors to the cost of poor quality in construction projects, according to (Oakland 2012), in the construction projects are as follows: rework, poor performance, customer dissatisfaction and legal issues. The study concluded that the most severe factors affecting project quality in XYZ construction company are Construction design-related factors, Poor quality factors, Construction waste industry and Construction management-related factors.

References

Abd Shukor, S., and Yaakub, S.“The influence of continuous improvement on cost of poor quality and Operations in turbine Generation Manufacturing Industry,” Int. J. Innov. Ind. Revolut., vol. 7, no. 22, pp. 653–674, Sep. 2025.

Albert, I. Shakantu, W. and Ibrahim, S. “The effect of poor materials management in the construction industry: A case study of Abuja, Nigeria,” Acta Structilia, vol. 28, no. 1, pp. 142–167, Jun. 2021.

Axelsson, L. and Skogum, S. “Cost of Poor Quality-Development of a tool for identification and quantification of CoPQ,” Chalmers University of Technology, 2016.

Cheshmberah,M . Savadjani,Y. Karbasian, A. and M. “Identifying, refining, measuring and analysing the cost of quality (CoQ) (real case: a manufacturing firm),” *International. Journal. Engineering. Technology,* vol. 11, no. 6S, pp. 148–156, Dec. 2019.

Connor, C.O. and McDermott, O. “Cost of Quality in Construction,” IFIP Adv. Inf. Commun. Technol., vol. 668 IFIP, pp. 307–317, 2023.

Dorcas, B. Elkanah, O. and John, O .“Most Critical Factors Responsible for Poor Project Quality Performance in Building Construction Industry (A Case Study of Three Major Cities in Nigeria),” Eur. Int. J. Sci. Technol., vol. 8, no. 2, pp. 1–14, 2019.

Gil-Vilda, F. Yagüe-Fabra, J.A .and. Sunyer, A“From lean production to lean 4.0: A systematic literature review with a historical perspective,” Appl. Sci., vol. 11, no. 21, 2021.

Henriques, P. G. De, P. and Silva, F. “Implementation of Lean Construction Principles in Portugal: Adaptation of good practices from a Danish Case Study,” Jt. Int. Symp. 2009- Constr. facing World. challenges, pp. 396–405, 2009.

Hijazi, R.A. “Factors Hindering Quality Performance in Construction Projects: An Empirical Study,” J. Manag. Res., vol. 13, no. 2, p. 70, Apr. 2021.

Khadim, N. Agliata,R. Marino, A. Thaheem, M. J. and Mollo, L. “Critical review of nano and micro-level building circularity indicators and frameworks,” J. Clean. Prod., vol. 357, no. October 2021.

Khadim, N. Thaheem, M. J. Ullah, F., and Mahmood, M.N. “Quantifying the cost of quality in construction projects: an insight into the base of the iceberg,” Qual. Quant., vol. 57, no. 6, pp. 5403–5429, Dec. 2023.

Khan, S. Saquib, M., and Hussain, A. “Quality issues related to the design and construction stage of a project in the Indian construction industry,” Front. Eng. Built Environ., vol. 1, no. 2, pp. 188–202, Dec. 2021.

Liu, R, Sucala, V. I, Luis, M. and Soliman, L., “Systematic Review of Service Quality Models in Construction,” Buildings, vol. 15, no. 13, p. 2331, Jul. 2025.

Love P. E. D. and Irani, Z. “A project management quality cost information system for the construction industry,” Inf. Manag., vol. 40, no. 7, pp. 649–661, Aug. 2003.

Love, P. E. D. Irani, Z. and Edwards. J. “A Rework Reduction Model for Construction Projects,” IEEE Trans. Eng. Manag., vol. 51, no. 4, pp. 426–440, Nov. 2004.

Mahmood S. and Kureshi, N. I. “A Literature Review of the Quantification of Hidden Cost of Poor Quality in the Historical Perspective,” J. Qual. Technol. Manag., vol. XI, no. I, pp. 1–24, 2015.

Mahmood, S., Ahmed, S., Panthi, K. and Kureshi, N., “Determining the cost of poor quality and its impact on productivity. and profitability,” Built Environ. Proj. Asset Manag., vol. 4, no. 3, pp. 296–311, Jul. 2014.

Mahmood, S.Ahmeds. M. Pathak and Ishaque Kureshi, N. “Determining the cost of poor quality and its impact on productivity and profitability,” Built Environ. Project. Asset Management, vol. 4, no. 3, pp. 296–311, Jul. 2014.

Mashwama, N. Aigbavboa, C.and. Thwala, D.“An Assessment of the Critical Success Factor for The Reduction of Cost of Poor Quality in Construction Projects in Swaziland,” Procedia Eng., vol. 196, no. June, pp. 447–453, 2017.

Melnikovas,A. “Towards an explicit research methodology: Adapting the research onion model for futures studies,” J. Future. Stud., vol. 23, no. 2, pp. 29–44, 2018.

Oakland, J. S., on Quality Management, no. December. Routledge, 2012.

Olanrewaju, A., and Lee, H. J. A. “Analysis of the poor quality in building elements: providers’ perspectives,” Front. Eng. Built Environ., vol. 2, no. 2, pp. 81–94, Apr. 2022.

Olatunji, O. W. Ibidapo,O. I and Adedayo, L. Y. “Assessing the Impact of Design Errors in Construction Projects in Selected Construction Companies in Lagos State,” Int. J. Res. Innov. Soc. Sci., vol. IX, no. V, pp. 2543–2553, 2025.

Qiu, Z. Zhu, X., Liao, C., Shi, D. and Qu, W. “Detection of Transmission Line Insulator Defects Based on an Improved Lightweight YOLOv4 Model,” Appl. Sci., vol. 12, no. 3, p. 1207, Jan. 2022.

Sharma, N. and Laishram, B. “Understanding the relevance and impact of the cost of quality in the construction industry: a systematic literature review using PRISMA,” Constr. Innov., vol. 25, no. 6, pp. 1707–1726, Nov. 2025.

Shoar, S., and Chileshe, N. “Exploring the Causes of Design Changes in Building Construction Projects: An Interpretive Structural Modelling Approach,” Sustainability, vol. 13, no. 17, p. 9578, Aug. 2021.

Srivastava, S.K. “Towards estimating Cost of Quality in supply chains,” Total Qual. Manag. Bus. Excell., vol. 19, no. 3, pp. 193–208, Mar. 2008.

Thomas, B.G. Haas, C. T. and Caldas, C. H. “Measuring the Impact of Rework on Construction Cost Performance,” J. Constr. Eng. Manag., vol. 135, no. 3, pp. 187–198, Mar. 2009.

Zhang, J Wei, W., Chen, L. and Jiang, Z.“Evaluation of Hidden Cost Risk of Prefabricated Construction Based on SEM-MEECM,” Appl. Sci., vol. 13, no. 13, p. 7902, Jul. 2023.

Biographies

Elelwani Beauty Ndou is a PHD student graduating on the 30th June 2026 at the University of South Africa and is a Senior Technologist at the National Transmission Company of South Africa (Eskom), where she contributes to infrastructure development and operational performance within the power transmission sector. She is involved in the refurbishment of the transmission lines and substations to improve network performance. Her work focuses on project execution and continuous improvement within the transmission environment. Her academic and professional expertise focuses on quality management, process improvement, and lean implementation within large-scale engineering projects. She is professionally registered with the Engineering Council of South Africa (ECSA) as a Professional Engineering Technologist. Her work integrates engineering practice with research-driven solutions to improve efficiency and sustainable project delivery.

Professor Ramdass is widely recognised for his expertise in quality management, industrial engineering, operations management, process improvement, performance management, and organisational competitiveness. An active researcher, he has authored and presented approximately 120 journal articles and conference papers and serves as a reviewer for numerous academic publications. His professional achievements include Fellowship of the Southern African Institute for Industrial Engineering, membership of several professional bodies, and multiple prestigious awards, including the SAIIE President's Award, IEOM Best Conference Contributor Award, Risk Champion Award, and IEOM Industry 4.0 Award. He also serves on key national and international engineering bodies, including the Engineering Council of South Africa (ECSA) and the Federation of African Engineering Organisations, contributing significantly to engineering education, professional standards, and institutional transformation across Africa.

Professor Dr Kgabo Mokgohloa is a scholar, Ubuntu coach, strategist, and thought leader whose work bridges academia, leadership development, and organisational transformation. With extensive experience in higher education, research, and executive practice, he is committed to advancing knowledge and practice in systems thinking, systems engineering, systems dynamics, personal mastery, value management and value engineering, strategy formation and execution, sustainability, sustainable engineering, digital strategy, digital innovation, digital disruption, coaching, mentoring, and human-centred leadership. As an academic, Prof. Dr Mokgohloa has published extensively in journals and conference proceedings and has contributed significantly as a reviewer, editor, and researcher in the fields of technology, strategy, and sustainability. He has served as an Honorary Treasurer and Council Member of the Southern African Institute for Industrial Engineering (SAIIE) and as an Associate Editor of the *Technology Analysis & Strategic Management Journal*.

Beyond academia, he is the founder of Dr Kgabo Coaching Clinic, a practice grounded in Ubuntu philosophy that supports organisations, leaders, teams, postgraduate students, and individuals through coaching, facilitation, and foresight initiatives. His approach combines African wisdom traditions, including the symbolism of the baobab tree, with contemporary methodologies such as systems thinking, strategic foresight, and Sun Tzu's *Art of War*. Prof. Dr Mokgohloa is also the author of the novel *Unchained*, a speaker, and a respected advocate for leadership transformation. He holds qualifications in Chemical Engineering, Industrial Engineering, Environmental Engineering, and a PhD in Industrial Engineering, as well as an International Coaching Federation (ICF)-accredited Ubuntu Coaching Programme certification.

Malandala Kajingulu is an academic with extensive experience in teaching, research, and postgraduate supervision in the field of Statistics. He holds a Master of Science (MSc) degree in Statistics and is currently pursuing a Doctor of Philosophy (PhD) in Statistics. Over the course of his academic career, he has developed strong expertise in statistical theory, applied statistics, and advanced modelling techniques. He began his academic career at the University of Johannesburg, where he served as a lecturer from 2006 to 2015, contributing to undergraduate and postgraduate teaching, curriculum development, and student academic support. Since 2015, he has been a lecturer in the Department of Statistics at the University of South Africa (UNISA), where he continues to play a key role in teaching, research, and postgraduate supervision. He has acquired substantial experience in Mathematical modelling, copula-based dependence modelling, time-varying statistical methods, and other advanced statistical frameworks. His research output includes peer-reviewed journal publications and presentations at both local and international academic conferences. His academic contributions extend to postgraduate supervision, where he has successfully guided Honours and master's students in Statistics through their research projects. He remains actively engaged in collaborative research and is committed to advancing statistical science through rigorous research, innovative methodology development, and excellence in teaching and mentorship.