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Management and quality control of construction materials standards, techniques, and challenges

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Abstract. Construction materials are crucial for the safety and longevity of structures, as they must withstand environmental conditions and be durable. Adherence to stringent standards and regulations is essential for materials like concrete, steel, wood, bricks, and composites. Common defects include manufacturing flaws, storage issues, non-compliance with standards, and variability in quality. To minimize quality problems, rigorous control techniques like material testing, visual inspections, performance testing, and certifications are applied. Proper finishing enhances aesthetics, durability, and performance, while surface preparation, installation, and maintenance are critical for plumbing and electrical systems.

Key words: material quality, structural durability, regulatory compliance, quality control techniques, defect impact, importance of finishes.

1. Introduction

Material quality is fundamental to ensuring that structures are safe, durable, and high-performing (Ramchandra and Gehlot, 2012; Allen and Iano, 2019). High-quality materials guarantee not only the robustness and longevity of constructions but also affect long-term maintenance and repair costs (Bijen, 2003). Conversely, defective or non-compliant materials can lead to severe failures, high repair costs, and safety hazards (Higham, Challender and Watts, 2022).

Quality control begins with the initial selection of materials and continues throughout the construction process, including procurement, storage, installation, and finishing (O'Brien, 2012, 2013). Standards, whether national or international, set specific criteria that materials must meet to ensure technical compliance. Effective management is crucial to minimize risks associated with materials and to optimize their performance and durability.

This review explores the key aspects of managing and controlling construction material quality. It examines applicable standards and certifications, methods for evaluating material quality, and common challenges in management. Through case studies and concrete examples, we will illustrate the importance of a rigorous approach to ensure reliable, safe, and high-quality constructions.

2. Importance of Material Quality

2.1. Safety and Durability of Structures

Construction materials directly impact structural safety. For example, poor-quality cement can compromise concrete strength, leading to cracks and structural failures (Whittle, 2012; Nagrockiene, Pundienė and Kicaite, 2013). Case studies, such as the 2018 Genoa Bridge collapse, demonstrate how inferior materials contributed to disasters (Rymsza, 2021). The bridge's collapse was due to material quality issues and maintenance neglect, highlighting the need to adhere to quality standards to prevent such tragedies (Rymsza, 2021).

2.2. Material Performance in Environmental Conditions

Materials must also withstand environmental conditions to which they are exposed (Chamasemani *et al.*, 2023). For instance, bricks in coastal areas must be resistant to moisture and salinity to prevent premature degradation (Sena da Fonseca, Simao and Galhano, 2013). Concrete used in seismic regions must have specific properties to handle seismic forces (Mendis and Panagopoulos, 2000). Evaluating the impact of environmental conditions on material performance can be done through experimental studies and on-site testing (Bentur and Mitchell, 2008).

2.3. Economic Implications

Material quality has significant economic implications. Using poor-quality materials can lead to additional costs due to repairs and increased maintenance, and a reduced building lifespan (Newton and Christian, 2006). Conversely, investing in high-quality materials can lower long-term maintenance costs and enhance the overall durability of the construction (Isaksson, 2005).

2.4. Compliance with Standards and Regulations

Construction materials must adhere to strict standards and regulations to ensure their quality and safety (Bubshait and Al-Atiq, 1999). International standards such as those from ISO and ASTM define the criteria materials must meet (Saba, Jawaid and Sultan, 2019). Compliance with these standards is crucial to ensure that materials used in construction are safe, reliable, and suited to project specifications.

3. Construction Materials and Quality Issues

3.1. Identification of Construction Materials

Concrete Composed of cement, water, aggregates, and sometimes additives, concrete is valued for its strength and durability. Problems can arise if the mix is improperly proportioned or if the materials used are of poor quality (Obla, 2014).

Steel Known for its strength and flexibility, steel is essential in modern construction. Quality issues can include corrosion, improper rolling, or impurities in the alloy (Knott, 2008; Pal, 2018).

Wood While natural and aesthetically pleasing, wood is susceptible to moisture, pests, and fire. Quality problems may include knots, warping, or defects from poor growth conditions or inadequate drying (Kesik, Lio and logement, 1996).

Bricks Valued for their strength and thermal insulation, brick quality issues can result from incorrect clay mixing, improper firing temperatures, or structural defects such as cracks or air bubbles (Ghoshal, 2008; Hossain, 2020; Räsänen *et al.*, 2022).

Composite Materials These materials, often made from two or more substances, are designed to combine the properties of their components. Quality issues can include manufacturing defects, adhesion problems between layers, or inconsistent performance (Thomson, 2020).

3.2. Common Quality Problems

Quality issues in materials can have severe impacts on safety, durability, and costs of construction projects. Common problems include manufacturing defects, storage issues, non-compliance with standards, and variability in quality(Allen and Iano, 2019). Manufacturing errors can introduce defects such as cracks in concrete, imperfections in bricks, or irregularities in steel (Ahzahar *et al.*, 2011). Improper storage can lead to degradation, such as concrete exposed to moisture losing its strength, or wood deteriorating from poor storage (Reinprecht, 2016a). Using non-compliant materials can compromise the overall project quality, and variability in materials can affect the consistency and reliability of structures (Kockal and Turker, 2007).

3.3. Quality Control Techniques

To minimize quality problems, rigorous control techniques are applied throughout production and construction (Dux, 1990; Gulghane and Khandve, 2015). Quality control includes testing materials to verify their compliance with specifications, such as strength, adhesion, durability, and other specific properties. Visual inspection of materials before and after installation helps detect obvious defects, such as cracks in bricks or irregularities in wood beams (Tezel, Koskela and Tzortzopoulos, 2013, p. 13). Performance testing of materials under simulated conditions predicts their behavior in real situations, and certifications ensure materials meet performance and safety requirements (Pargaonkar, 2023)

3.4. Case Studies

Case studies provide concrete examples of how quality issues in materials have affected construction projects. The 2018 Genoa Bridge collapse is a case where material quality issues and inadequate maintenance led to a failure. Corrosion problems in steel bridges, often due to insufficient protection or poor-quality steel, and material failures in residential buildings caused by manufacturing defects illustrate the serious consequences of quality issues (Bijen, 2003; Ahzahar *et al.*, 2011).

4. Finishes and Installation

4.1. Finishing Process

The finishing phase is critical for the final appearance and functionality of constructed structures. It includes all steps needed to complete a project, from wall coverings to floor finishes (Allen and Iano, 2019). Proper finishing not only enhances aesthetics but also improves material durability and performance (Brodetskaia, Sacks and Shapira, 2011; Son and Van Tien, 2024). Wall coverings, whether painted, wallpapered, or plastered, are crucial for the aesthetics and protection of walls. Common errors include air bubbles under paint, misaligned joints in plaster, or tears in wallpaper (Atkinson, 1998). Floor finishes include various types such as tiling, hardwood, and carpets, each requiring specific surface preparation, installation, and maintenance (Binggeli, 2008; Cheever and Association), 2014). Proper finishing of plumbing and electrical systems is essential for functionality and safety, requiring rigorous inspections and performance tests to ensure compliance with standards (Organization and Council, 2006).

4.2. Installation Techniques

Proper installation of materials and equipment is essential for the longevity and performance of a building (Allen and Iano, 2019). Adequate surface preparation is a preliminary step necessary for good adhesion and a uniform finish (DE FEHER, 1956, p. 10; Ebnesajjad, 2011). Installation methods vary by material type, such as tiling requiring a well-leveled subfloor and plumbing installations needing precise alignment of pipes and fittings (Silvestre and De Brito, 2011). Rigorous quality control during installation helps identify and correct issues before they become permanent defects (Bhattacharjee, 2018).

4.3. Challenges and Solutions

Finishing and installation can present various challenges, such as adapting to changing site conditions, managing materials, and coordinating between different trades (Merritt and Ricketts, 2001; Allen and Iano, 2019). Solutions include creating detailed finishing plans, implementing strict quality control procedures, and providing ongoing training for installation teams to ensure they are up-to-date with best practices and new technologies (Musarat *et al.*, 2024).

5. Construction Material Management

5.1. Planning and Procurement

Material management in construction involves careful planning and procurement to ensure that the right materials are available when needed (Zeb *et al.*, 2015). This process includes selecting appropriate materials based on project requirements, sourcing from reliable suppliers, and managing inventory to avoid shortages or delays (Said and El-Rayes, 2011; Ahmadian *et al.*, 2014; Ramabodu, 2014; Sarode and Bhangale, 2020) (Morris et al., 2022). Effective planning and procurement help mitigate risks associated with material quality and availability (Dyili *et al.*, 2018; Hong, Lee and Zhang, 2018).

5.2. Storage and Handling

Proper storage and handling of construction materials are critical to maintaining their quality and performance (Gulghane and Khandve, 2015; Johnston, 2016). Materials must be stored in conditions that prevent degradation, such as protecting concrete from moisture or keeping wood in a dry environment (Reinprecht, 2016a, 2016b). Handling procedures should prevent damage during transportation and installation (Brown, 2022).

5.3. Waste Management

Efficient waste management practices help reduce the impact of construction waste on the environment and project costs (Ortiz, Castells and Sonnemann, 2009, 2009, 2009). Implementing recycling programs, reducing material wastage, and properly disposing of construction debris are essential for sustainable construction practices (Gangolells *et al.*, 2004; Huang *et al.*, 2018; Blaisi, 2019). Effective waste management contributes to overall project efficiency and environmental responsibility (Blaisi, 2019; Wu *et al.*, 2019).

6. Conclusions

The management and quality control of construction materials are pivotal to ensuring the durability, safety, and economic viability of construction projects. This review has highlighted the critical importance of adhering to strict standards and employing rigorous quality control techniques to mitigate material defects and their adverse impacts. From proper planning and procurement to the application of advanced testing methods and certifications, each step of material management contributes significantly to the overall performance and longevity of structures.

Furthermore, the emphasis on proper finishing and installation underscores the role of these processes in enhancing both the functionality and aesthetic appeal of completed projects. The integration of sustainable practices, including efficient waste management and adherence to environmental standards, further underscores the industry's responsibility toward ecological stewardship.

By addressing challenges through innovative solutions, improved coordination among stakeholders, and the adoption of new technologies, the construction sector can achieve higher standards of quality and sustainability. This proactive approach ensures not only the integrity of individual projects but also the advancement of construction practices as a whole.

Conflicts of Interest

The authors state that they have no conflicts of interest related to the publication of this paper.

References

Ahmadian, F.F.A. *et al.* (2014) 'Importance of planning for the transport stage in procurement of construction materials', in *ISARC. Proceedings of the International Symposium on Automation and Robotics in Construction*. Citeseer, p. 1. Available at: https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=f57c41499f18ca05d779f4c825 53af3b60c23ca9 (Accessed: 14 August 2024).

Ahzahar, N. *et al.* (2011) 'A study of contribution factors to building failures and defects in construction industry', *Procedia Engineering*, 20, pp. 249–255.

Allen, E. and Iano, J. (2019) *Fundamentals of Building Construction: Materials and Methods*. John Wiley & Sons.

Atkinson, A. (1998) 'Human error in the management of building projects', *Construction Management and Economics*, 16(3), pp. 339–349. Available at: https://doi.org/10.1080/014461998372367.

Bentur, A. and Mitchell, D. (2008) 'Material performance lessons', *Cement and Concrete Research*, 38(2), pp. 259–272. Available at: https://doi.org/10.1016/j.cemconres.2007.09.009.

Bhaskaran, B. and Petchikkan, M. (2023) 'Overview of construction materials.' *Multidisciplinary International Conference on Innovations in Engineering Science and Technology*, Pune, 26 November.

Bhattacharjee, J. (2018) 'Quality control and quality assurance in building construction', *International Research Journal of Management Science & Technology*, 9(4), pp. 10–16.

Bijen, J. (2003) *Durability of Engineering Structures: Design, Repair and Maintenance*. Elsevier.

Binggeli, C. (2008) *Materials for Interior Environments*. John Wiley & Sons.

Blaisi, N.I. (2019) 'Construction and demolition waste management in Saudi Arabia: Current practice and roadmap for sustainable management', *Journal of Cleaner Production*, 221, pp. 167–175. Available at: https://doi.org/10.1016/j.jclepro.2019.02.264.

Brodetskaia, I., Sacks, R. and Shapira, A. (2011) 'A workflow model for systems and interior finishing works in building construction', *Construction Management and Economics*, 29(12), pp. 1209–1227. Available at: https://doi.org/10.1080/01446193.2011.647829.

Bubshait, A.A. and Al-Atiq, T.H. (1999) 'ISO 9000 Quality Standards in Construction', *Journal of Management in Engineering*, 15(6), pp. 41–46. Available at: https://doi.org/10.1061/(ASCE)0742-597X(1999)15:6(41).

Chamasemani, N.F. *et al.* (2023) 'Environmental Impacts of Reinforced Concrete Buildings: Comparing Common and Sustainable Materials: A Case Study', *Construction Materials*, 4(1), pp. 1–15. Available at: https://doi.org/10.3390/constrmater4010001.

Cheever, E. and Association), N. (National K. and B. (2014) *Kitchen & Bath Products and Materials: Cabinetry, Equipment, Surfaces*. John Wiley & Sons.

DE FEHER, J. (1956) 'Surface Finishing Techniques 10', *Technical Aids for Small Business: Annual*, (1), p. 94.

Dux, J.P. (1990) 'Statistical Quality Control Techniques', in Dux, J. P., *Handbook of Quality Assurance for the Analytical Chemistry Laboratory*. Boston, MA: Springer US, pp. 31–46. Available at: https://doi.org/10.1007/978-1-4684-1458-5_3.

Dyili, N.F. *et al.* (2018) 'The influence of supply risk in the procurement of construction materials', *Journal of Contemporary Management*, 15(Special Edition1), pp. 18–36.

Ebnesajjad, S. (2011) 'Material surface preparation techniques', in *Handbook of adhesives and surface preparation*. Elsevier, pp. 49–81. Available at: https://www.sciencedirect.com/science/article/pii/B9781437744613100057 (Accessed: 14

August 2024).

Gangolells, M. *et al.* (2004) ‘Analysis of the implementation of effective waste management practices in construction projects and sites - ScienceDirect’, 93, pp. 99–111.

Ghoshal, P.K. (2008) *Prospects and Problems of Brick Industry*. Mittal Publications.

Gulghane, A.A. and Khandve, P.V. (2015) ‘Management for construction materials and control of construction waste in construction industry: a review’, *International Journal of Engineering Research and Applications*, 5(4), pp. 59–64.

Higham, A., Challender, J. and Watts, G. (2022) *Introduction to Built Asset Management*. John Wiley & Sons.

Hong, Z., Lee, C.K. and Zhang, L. (2018) ‘Procurement risk management under uncertainty: a review’, *Industrial Management & Data Systems*, 118(7), pp. 1547–1574.

Hossain, F. (ed.) (2020) *The Fundamentals of Brick Manufacturing*. Nova Science Pub Inc.

Huang, B. *et al.* (2018) ‘Construction and demolition waste management in China through the 3R principle’, *Resources, Conservation and Recycling*, 129, pp. 36–44. Available at: https://doi.org/10.1016/j.resconrec.2017.09.029.

Isaksson, R. (2005) ‘Economic sustainability and the cost of poor quality’, *Corporate Social Responsibility and Environmental Management*, 12(4), pp. 197–209. Available at: https://doi.org/10.1002/csr.85.

Johnston, J.E. (2016) *Site Control of Materials: Handling, Storage and Protection*. Elsevier.

Kesik, T., Lio, M. and logement, S. canadienne d’hypothèques et de (1996) *Construction de maison à ossature de bois--Canada*. Canadian Mortgage & Housing Corporation/Societe Canadienne d’Hpotheque et de Logement.

Knott, J.F. (2008) ‘Quantifying the quality of steel’, *Ironmaking & Steelmaking*, 35(4), pp. 264–282. Available at: https://doi.org/10.1179/174328108X301688.

Kockal, N.U. and Turker, F. (2007) ‘Effect of environmental conditions on the properties of concretes with different cement types’, *Construction and Building Materials*, 21(3), pp. 634–645.

Mendis, P.A. and Panagopoulos, C. (2000) ‘Applications of high strength concrete in seismic regions’. *World Conference on Earthquake Engineering (12WCEE),* Auckland, New Zealand. Available at: https://www.iitk.ac.in/nicee/wcee/article/0809.pdf.

Merritt, F.S. and Ricketts, J.T. (2001) *Building Design and Construction Handbook, 6th Edition*. Mcgraw-hill.

Musarat, M.A. *et al.* (2024) ‘Automated monitoring innovations for efficient and safe construction practices’, *Results in Engineering*, 22, p. 102057.

Nagrockiene, D., Pundienė, I. and Kicaite, A. (2013) ‘The effect of cement type and plasticizer addition on concrete properties’, *Construction and Building Materials*, 45, pp. 324–331. Available at: https://doi.org/10.1016/j.conbuildmat.2013.03.076.

Newton, L.A. and Christian, J. (2006) ‘Impact of Quality on Building Costs | Journal of Infrastructure Systems | Vol 12, No 4’, 12(4), pp. 199-206.

Obla, K.H. (2014) *Improving Concrete Quality*. CRC Press.

O’Brien, J.J. (2012) *Construction Inspection Handbook: Total Quality Management*. Springer Science & Business Media.

O’Brien, J.J. (2013) *Construction Inspection Handbook: Quality Assurance/Quality Control*. Springer Science & Business Media.

Organization, W.H. and Council, W.P. (2006) *Health Aspects of Plumbing*. World Health Organization.

Ortiz, O., Castells, F. and Sonnemann, G. (2009) ‘Sustainability in the construction industry: A review of recent developments based on LCA’, *Construction and Building Materials*, 23(1), pp. 28–39. Available at: https://doi.org/10.1016/j.conbuildmat.2007.11.012.

Pal, S. (2018) *Steel Quality Question And Answer*. Independently Published.

Pargaonkar, S. (2023) 'A comprehensive review of performance testing methodologies and best practices: software quality engineering', *International Journal of Science and Research (IJSR)*, 12(8), pp. 2008–2014.

Ramabodu, M.S. (2014) *Procurement guidelines for project success in cost planning of construction projects*. PhD Thesis. University of the Free State. Available at: https://scholar.ufs.ac.za/bitstream/handle/11660/1514/RamaboduMS.pdf?sequence=1&isAllowed=y (Accessed: 14 August 2024).

Ramchandra and Gehlot, V. (2012) *Design of Concrete Structures*. Scientific Publishers.

Räsänen, A. *et al.* (2022) 'Methods for evaluating the technical performance of reclaimed bricks', *Case Studies in Construction Materials*, 17, p. e01504.

Reinprecht, L. (2016a) *Wood Deterioration, Protection and Maintenance*. John Wiley & Sons.

Reinprecht, L. (2016b) *Wood Deterioration, Protection and Maintenance*. John Wiley & Sons. Available at: https://doi.org/10.1002/9781119106500.

Rymsza, J. (2021) 'Causes of the Collapse of the Polcevera Viaduct in Genoa, Italy', 11(17), p. 8098.

Saba, N., Jawaid, M. and Sultan, M.T.H. (2019) 'An overview of mechanical and physical testing of composite materials', in *Mechanical and Physical Testing of Biocomposites, Fibre-Reinforced Composites and Hybrid Composites*. Elsevier, pp. 1–12. Available at: https://doi.org/10.1016/B978-0-08-102292-4.00001-1.

Said, H. and El-Rayes, K. (2011) 'Optimizing Material Procurement and Storage on Construction Sites', *Journal of Construction Engineering and Management*, 137(6), pp. 421–431. Available at: https://doi.org/10.1061/(ASCE)CO.1943-7862.0000307.

Sarode, A.S. and Bhangale, P.P. (2020) 'Comparison of material procurement methods of a construction projects-case study', *International Research Journal of Engineering and Technology*, 7(6), pp. 4947–4951.

Sena da Fonseca, B., Simao, J.A.R. and Galhano, C. (2013) 'Effect of coastal environment in clay facing bricks and roof tiles'. *1st Annual International Interdisciplinary Conference*, Azores, Portugal.

Silvestre, J.D. and De Brito, J. (2011) 'Ceramic tiling in building façades: Inspection and pathological characterization using an expert system', *Construction and Building Materials*, 25(4), pp. 1560–1571.

Son, P.V.H. and Van Tien, P. (2024) 'Apply EZStrobe to simulate the finishing work for reducing construction process waste', *Scientific Reports*, 14(1), p. 349.

Tezel, A., Koskela, L.J. and Tzortzopoulos, P. (2013) 'Visual Management in industrial construction: A case study: 21st Annual Conference of the International Group for Lean Construction, IGLC 13', *21st Annual Conference of the International Group for Lean Construction 2013, IGLC 2013*. Edited by C.T. Formoso and P. Tzortzopoulos, pp. 675–684.

Thomson, N. (2020) *Composite Materials: Science and Engineering*. NY Research Press.

Whittle, R. (2012) *Failures in Concrete Structures*. 0 edn. CRC Press. Available at: https://doi.org/10.1201/b12674.

Wu, H. *et al.* (2019) 'A review of performance assessment methods for construction and demolition waste management', *Resources, Conservation and Recycling*, 150, p. 104407.

Zeb, A. *et al.* (2015) 'Factors affecting material procurement, supply and management in building projects of Pakistan: A contractor's perspective', in *Proceedings of 2015 International Conference on Innovations in Civil and Structural Engineering*, pp. 170–175. Available at: http://uruae.urst.org/siteadmin/upload/2209U0615309.pdf (Accessed: 14 August 2024).