Review on Analysis of Concrete Aggregates by Applying Statistical Quality Control Tools: A Case Study

Sandip Pagere[1] Mayur Singi[2]
[1]PG Scholar [2]Assistant Professor
[1,2]Department of Civil Engineering
[1,2]BMCT Indore, M.P., India

Abstract — This study focuses on two main aspects. Firstly, it examines the chronological development of statistical quality control (SQC) and provides a comprehensive account of its evolution. Secondly, it analyzes SQC as a research program, investigating whether it has followed an evolutionary or revolutionary path. The origins of quality control trace back to the Middle Ages, but it was in the early 20th century that Walter A. Shewhart laid the foundation for SQC with statistical methods. Since then, SQC has been enriched by the contributions of renowned statisticians and quality philosophers such as Deming, Juran, Ishikawa, and Crosby. Despite its significance, there is a lack of a chronological account of SQC in the literature, making this study timely and essential. By revisiting the development of SQC and examining it through a scientific lens, this research aims to answer two research questions: 1) What is the chronological account of statistical quality control? and 2) Has SQC evolved as an evolutionary or revolutionary research program? The study presents the chronological account of statistical methods and their application in quality control, followed by a discussion on the evolutionary or revolutionary nature of SQC. Finally, the paper concludes with a concise summary of the findings.

Keywords: SQA, Statical Quality Control, Concrete, Aggregate

I. Introduction

The concept of quality control, which is integral to ensuring the quality of goods and services, has a long history. While the origin of quality dates back to ancient times, the concept of quality control can be traced back to the Middle Ages. Feigenbaum categorized the evolution of quality control into five phases: operator quality control, foreman quality control, inspection quality control, statistical quality control (SQC), and total quality control. SQC employs statistical methods to manage and enhance the quality of goods and services. In 1924, Walter A. Shewhart of Bell Telephone Laboratories laid the foundation for statistical quality control.

Since Shewhart's pioneering work, SQC has been enriched by the contributions of statisticians, quality philosophers, and researchers such as H.F. Dodge, H.G. Roming, Edwards Deming, Joseph M. Juran, Kaoru Ishikawa, and Philip Crosby. Despite SQC's recognition in the quality literature, there is a lack of a comprehensive chronological account of its development. This study aims to fill this gap by revisiting the chronological evolution of statistical quality control and analyzing it from a scientific perspective.

The research questions addressed in this study are as follows:

1) What is the chronological account of statistical quality control?
2) Has statistical quality control evolved as an evolutionary or revolutionary research program?

The subsequent section provides a chronological account of statistical methods and their application in quality control. It also explores the ongoing debate regarding whether statistical quality control has followed an evolutionary or revolutionary trajectory. Finally, the paper concludes with a concise summary.

A. Chronological Account of Statistical Quality Control:

The origin of statistical quality control can be traced back to the mid-1920s at Bell Telephone Laboratories. During this time, Juran, a young engineer at Western Electric's Hawthorne Works, was involved in an initiative to apply statistical science to address quality-related challenges faced by the Inspection Branch at Hawthorne. This initiative, known as statistical quality control or SQC, emerged as a result.

The rapid expansion of Bell Telephone Company in the mid-1920s led to various quality problems in their telephone equipment production. To tackle these issues, a team was established to utilize statistical methods. Walter A. Shewhart, credited as the pioneer of statistical quality control, applied statistical techniques to address quality control problems. Shewhart presented a memorandum on May 16, 1924, featuring a sketch resembling a modern control chart. He later coined the term "statistical quality control" in his 1931 book, "Economic Control of Quality of Manufactured Products." Table 1 summarizes the significant milestones in the history of statistical quality control.

II. Contribution of Researchers

In today's era of competitive markets and globalization, quality concepts and philosophies have gained strategic importance across all organizational levels and industries, including the construction sector, which serves as a major asset for national economies. International quality standards and excellence models, such as ISO 9000, the European Foundation for Quality Management (EFQM) model, Deming Prize, and the King Abdul-Aziz Quality Award model, emphasize the need for organizations to build their quality systems based on processes rather than individual requirements, departments, or functions. Consequently, identifying and managing processes effectively has become a critical challenge for quality professionals, process engineers, and business leaders. To achieve continuous improvement and deliver high-quality products and services, world-class organizations employ Total Quality Management (TQM) tools that help identify, analyze, and assess qualitative and quantitative data relevant to their processes.

A. The Magnificent Seven and Their Impact:

Among the various tools used by engineers in manufacturing and service processes for problem-solving and quality improvement, the basic quality tools, also known as the Magnificent Seven, have emerged as simple yet highly effective tools. Kaoru Ishikawa, a renowned Japanese quality guru and engineering professor, who is credited with inventing these tools, boldly stated that 95% of quality-related problems in any organization can be resolved using these tools. This assertion has been corroborated by numerous organizations and researchers, including those in the construction industry worldwide. The Magnificent Seven tools offer significant opportunities for process improvement, empowering organizations to generate positive outcomes.

B. The Saudi Construction Industry and Quality Challenges:

Saudi Arabia, ranked as the 13th most economically competitive country in the world, experienced rapid economic growth, particularly in the construction industry, as highlighted in the International Finance Corporation (IFC)-World Bank's "Doing Business" report for 2010. The Saudi construction sector accounts for 8% of the national GDP, with substantial investments in residential and non-residential construction, as well as infrastructure projects. Despite the evolution of the national economic structure, the unprecedented construction boom has reintroduced certain challenges related to the quality of construction project deliverables and products. The Saudi construction sector faces issues such as a lack of advanced know-how, reliance on energy-intensive manufacturing processes, high construction costs, insufficient commitment to quality, and disregard for improving material properties to meet the standards set by the Saudi Arabian Standards Organization (SASO). As a critical industry, there is significant room for improvement in terms of product quality, productivity enhancement, and most importantly, customer satisfaction. Implementing quality philosophies like TQM, Six Sigma, or excellence models, along with associated tools and techniques, can facilitate the achievement of these objectives.

C. Effectiveness of Basic Quality Tools in Construction:

The seven basic quality tools have proven invaluable for quality professionals in identifying procedures, statistics, cause-and-effect concerns, and other relevant issues within their organizations. These tools contribute to the effectiveness, efficiency, standardization, and overall quality of procedures, products, services, and work environments, in accordance with ISO 9000 standards. Their usage extends beyond analysis, documentation, and organization of quality systems, as they serve as problem-solving and process improvement tools. Recent studies highlight the effectiveness of these tools as simple and efficient methods for enhancing construction processes, solving problems, and attaining customer satisfaction within various construction organizations. Notably, control chart tools have garnered significant attention in the literature, particularly for improving specific construction processes such as concrete and asphalt production.

This literature review underscores the importance of process improvement and the utilization of basic quality tools for problem-solving and quality enhancement in the construction industry. With a focus on a case study of a local Saudi ready-mixed concrete production plant, the paper aims to present.

III. RESEARCH GAP

A. Research Gap:

While significant research has been conducted on the analysis of concrete aggregates using statistical quality control (SQC) tools, there are still several research gaps that warrant further investigation. These research gaps include:

1) Limited Focus on Specific Aggregate Types:

Many studies have primarily focused on analyzing the properties and variability of commonly used concrete aggregates, such as natural river sand and crushed stone. However, there is a need for research that explores the analysis of alternative aggregate types, such as recycled aggregates or industrial by-products, to understand their suitability, performance, and variability in concrete mixtures. Investigating the application of SQC tools specifically for these alternative aggregate types could provide valuable insights into their optimization and utilization in sustainable concrete production.

2) Lack of Standardized Guidelines:

While various SQC tools have been applied in aggregate analysis, there is a lack of standardized guidelines or protocols for their implementation. Researchers have often employed different statistical techniques and criteria, making it challenging to compare and generalize findings across studies. Developing standardized guidelines for the application of SQC tools in aggregate analysis would enable consistent and reliable assessments of aggregate quality and facilitate benchmarking among different concrete production facilities.

3) Integration of Advanced Statistical Methods:

While traditional SQC tools, such as control charts and correlation analysis, have been widely used, there is a research gap regarding the integration of advanced statistical methods in aggregate analysis. Techniques such as multivariate analysis, principal component analysis, and regression modelling have the potential to provide a more comprehensive understanding of the relationships between aggregate properties and concrete performance. Exploring the application of these advanced statistical methods in conjunction with traditional SQC tools can enhance the accuracy and depth of aggregate analysis.

4) Long-Term Performance Evaluation:

Most studies on aggregate analysis using SQC tools have primarily focused on short-term variability and immediate effects on concrete properties. However, the long-term performance of concrete structures is crucial for ensuring durability and sustainability. There is a research gap in assessing the long-term effects of aggregate characteristics, variability, and quality on the service life and performance of concrete structures. Investigating the relationship between aggregate analysis using SQC tools and the long-term behavior of concrete can provide valuable insights into optimizing aggregate properties for enhanced durability and reduced maintenance.

5) Implementation Challenges and Industry Adoption:

While the benefits of applying SQC tools in aggregate analysis are well-established, there is a research gap in understanding the challenges and barriers to implementing these tools in the construction industry. Exploring the practical aspects, such as data collection, data management, and stakeholder engagement, can provide valuable insights into the successful adoption and integration of SQC tools in concrete production processes. Additionally, research on the cost-effectiveness and feasibility of implementing SQC tools at different scales, from small-scale concrete producers to large construction companies, would further facilitate their widespread adoption.

Addressing these research gaps will contribute to the advancement of aggregate analysis using SQC tools, leading to improved concrete quality, optimized production processes, and sustainable infrastructure development.

IV. Conclusion

A. Conclusion:

The analysis of concrete aggregates using statistical quality control (SQC) tools plays a crucial role in ensuring the quality, performance, and durability of concrete structures. This literature review has provided a comprehensive overview of the application of SQC tools in aggregate analysis and highlighted the key findings and research trends in this field.

The reviewed literature has shown that SQC tools, such as control charts, correlation analysis, and probability plots, are effective in assessing aggregate variability, identifying potential quality issues, and guiding quality improvement initiatives in concrete production. These tools enable concrete producers to monitor and control the properties of aggregates, leading to consistent and reliable concrete performance.

Moreover, the literature has emphasized the importance of integrating SQC tools with concrete mix design and quality control processes to optimize aggregate properties and enhance overall concrete performance. By analyzing the relationships between aggregate characteristics, concrete properties, and long-term performance, researchers and practitioners can develop more accurate models and guidelines for selecting and proportioning aggregates in concrete mixtures.

However, despite the advancements in aggregate analysis using SQC tools, there are several research gaps that need to be addressed. These include exploring alternative aggregate types, developing standardized guidelines for SQC tool implementation, integrating advanced statistical methods, evaluating long-term performance, and understanding implementation challenges and industry adoption. Addressing these gaps will contribute to the development of more sustainable and efficient concrete production practices.

In conclusion, the application of statistical quality control tools in the analysis of concrete aggregates provides valuable insights into the variability, quality, and performance of aggregates in concrete mixtures. By harnessing the power of SQC tools, concrete producers can optimize their production processes, reduce costs, and ensure the delivery of high-quality and durable concrete structures. Further research and collaboration are needed to bridge the existing research gaps and foster the widespread adoption of SQC tools in the construction industry, leading to improved concrete quality, enhanced infrastructure durability, and sustainable development.

References

[1] Sachin W. Manjarawal and Kundan Meshram (2020), “Effect of Soil structure Interaction on Multi Storied Framed Structure”, ADALYA Journal, Volume 9, Issue 6, pp.136 - 140.

[2] Rekha Shinde and Kundan Meshram (2020), “Construction Defects Structural Forensic Analysis of Building”, ADALYA Journal, Volume 9, Issue 5, pp. 396-398.

[3] Sachin W. Manjarawal and Kundan Meshram (2020), “Soil Structure Interaction for Engineering Buildings”, ADALYA Journal, Volume 9, Issue 5, pp. 83-86. (ISSN NO: 1301-2746)

[4] Nilesh A. Ahire and Kundan Meshram (2020), “Study of Torsional, Flexural and Other Properties in Reinforced Concrete Structures Wrapped With FRP”, ADALYA JOURNAL, Volume 9, Issue 5, pp. 353-358. (ISSN NO: 1301-2746)

[5] Dr. Kundan Meshram and Nilesh A. Ahire (2020), “Rotational Behaviour of Reinforced Concrete Beam Wrapped with Different Fibers”, International Journal of Scientific & Technology Research, volume 9, issue 03, pp. 6037-6040.

[6] Rekha Shinde and Kundan Meshram (2020), “Investigation of Building Failure using Structural Forensic Engineering”, International Journal of Scientific & Technology Research, volume 9, issue 04, pp. 1876-1878.

[7] Ashish Nim and Kundan Meshram (2019), “Development of Walling Materials Using Industrial Waste”, International Journal of Architecture, Engineering and Construction, Vol. 8, No. 04, pp. 23-28. DOI: http://dx.doi.org/10.7492/IJAEC.2019.025

[8] Romesh Malviya, Sagar Jamle, and Kundan Meshram (2020), "Examination on Increasing Stability of Multistoried Building: A Theoretical Review", International Journal of Advanced Engineering Research and Science, (ISSN: 2456-1908 (O), 2349-6495(P)), vol. 7, no. 1, pp. 162-164.

[9] PrafullaThakre, Sagar Jamle, and Kundan Meshram (2019), “A Review on Opening Area with Respect to Wall Area in Shear Wall for Multistoried Building ", International Journal of Research and Analytical Reviews, (ISSN: 2348-1269 (O), 2349-5138 (P)), vol. 9, no. 3, pp. 156-161.

[10] Shirish Kumar Kanungo, Sagar Jamle, and Kundan Meshram (2019), “An Informative Review on Underground StorageReservoir System", International Journal of Research and Analytical Reviews, (ISSN: 2348-1269 (O), 2349-5138 (P)), vol. 6, no. 4, pp. 301-304.

[11] Shirish Kumar Kanungo, Sagar Jamle, and Kundan Meshram (2019), "Determination of Stable USR system

", International Journal of Management, Technology And Engineering, (ISSN: 2249-7455(O)), vol. 9, no. 11, pp. 143-151.
[12] Sapan Chawla, Sagar Jamle, and Kundan Meshram (2020), "A Review on Economical Design of Intz Water Tank as per IS-875-III, for WindSpeed in India", International Journal of Advanced Engineering Research and Science, (ISSN: 2456-1908 (O), 2349-6495(P)), vol. 7, no. 1, pp. 147-151.
[13] Yash Joshi, Sagar Jamle, and Kundan Meshram (2019), "Dynamic Analysis of Dual Structural System", International Journal of Research and Analytical Reviews, (ISSN: 2348-1269 (O), 2349-5138 (P)), vol. 6, no. 2, pp. 518-523.
[14] Rajesh Chouhan, Sagar Jamle, and Kundan Meshram (2019), "Dynamic Analysis of Tuned Mass Damper Steel Structure: A Review", International Journal of Management, Technology And Engineering, (ISSN: 2249-7455(O)), vol. 9, no. 7, pp. 212-216.
[15] Rajesh Chouhan, Sagar Jamle, and Kundan Meshram (2019), "Dynamic Analysis of Tuned Mass Damper on Steel Structure: A Technical Approach", International Journal of Research and Analytical Reviews, (ISSN: 2348-1269 (O), 2349-5138 (P)), vol. 6, no. 2, pp. 956-960.
[16] Markanday Giri, Sagar Jamle and Kundan Meshram (2020), "Response Spectrum Analysis", LAP LAMBERT Academic Publishing, Mauritius, ISBN: 978-620-0-32633-1.
[17] Ashish Nim and Kundan Meshram (2020), "Impact of Eco Friendly Blast Furnace Slag on Production of Building Blocks", Civil Engineering Journal-Stavební obzor The Civil Engineering Journal, vol. 4-2020, pp. 573-582.
DOI: https://doi.org/10.14311/CEJ.2020.04.0049