

## Portable Small-Scale Concrete Mixer Designs: A Review

Ovundah King Wofuru-Nyenke <sup>1\*</sup> 

<sup>1</sup> Department of Mechanical Engineering, Rivers State University, Port Harcourt, Rivers State, Nigeria.

\*Correspondence: [ovundah.wofuru-nyenke@ust.edu.ng](mailto:ovundah.wofuru-nyenke@ust.edu.ng)

Received: 1 May 2025 / Accepted: 29 May 2025 / Published: 2 June 2025

© The Author(s) 2025.

### Abstract

The growing requirement for adaptable construction equipment has led to the need for a review of compact yet efficient concrete mixers. Portable concrete mixers offer a workable option that might completely transform the development of small-scale infrastructure, particularly on isolated and difficult-to-reach construction sites. By examining the activities in construction sites, transport and mobility limitations in current concrete mixer models were found. In order to address this issue in this research, a review of portable mixers intended for small-scale construction projects was conducted evaluating earlier studies on concrete mixer designs. The goal of this research is to highlight machines that overcome the transport and mobility limitations by putting utility and portability first in their design. From the research, there is a need for more concrete mixers that can rotate in multiple directions; create homogeneous mixtures with less waste; and possess detachable components for easier maintenance. This is in order to reveal the research gap posed by the need for concrete mixers that are portable, mobile, efficient, durable, and have excellent overall performance for small-scale concrete mixing. This work significantly advances the need for more adaptable construction tools in contemporary building and construction practices.

**Keywords:** Portable concrete mixer, Design, Building, Construction, Engineering, Review.

### 1. Introduction

The need for contemporary concrete mixing equipment is growing as the construction industry evolves. Conventional concrete mixer designs frequently have issues with mobility, effectiveness, and maintenance. To address these issues, our study focuses on creating a revolutionary concrete mixer that prioritizes mobility and utility. Concrete mixers used on construction sites are large and stationary, which restricts their capacity to meet a range of project needs. Because of their size and weight, they are difficult to move and transport, especially in remote and hard-to-reach locations. Ineffective merging processes may also result in higher labour and time expenditures, which reduces project efficiency overall (Rudyk & Kuzub, 2022).

Concrete mixers that achieve both mixing efficiency and operational convenience have been the focus of research and engineering efforts. Concrete mixing device technology has advanced significantly as a result of the various approaches that have been explored to achieve this delicate equilibrium. One such method that enables a more effective and complete blending of all the concrete components is high-speed. Improving drum geometry, such as adding specific shapes or angles, also contributes to better mixing results. To improve the mixing process, variable-speed mixing devices and asymmetrical drum rotation have been used.

Compact and agile designs were designed with utilitarian comfort in mind. Concrete mixers with wheeled and tracked bases are more mobile, and their parts can be detached or rolled up for simpler transit and storage (McLoughlin et al., 2017). Investigated various blade angles and produced non-porous, streamlined areas that are easier to maintain and less likely to accumulate residue. Angled surfaces and drainage systems can make cleaning processes go more easily. Additionally, some designs use brushes and high-pressure water nozzles for efficient cleaning, and self-cleaning

mechanisms have been developed to automate this process. This paper includes a thorough analysis of the body of research on concrete mixer design techniques. This thorough analysis highlights possibilities for future innovation and provides insightful remarks about the state of the art today. Understanding consumer demands and preferences is essential for creating a competitive product, and this analysis helps with that.

Concrete's performance is greatly impacted by its microstructure, which is determined by its composition, the curing conditions, and the particular mixing method used (Aitcin, 2003). This blending process includes components that are essential to controlling the workability of concrete, such as the type of mixer, the order in which materials are introduced, and the energy that is used. This analysis explores commercially available mixers, describing their methods, benefits, drawbacks, and uses. Prioritizing quality, the choice of mixing technique depends on factors such as site location, concrete volume, timetable, and cost. Mixer efficiency is still crucial, depending on material feed, mixer type, and energy input, even in the absence of standardized quality assessment techniques.

The best concrete mixing technique for a particular project depends on a number of variables, including the required volume of concrete, delivery time, cost, and distance to the batching plant, with a primary focus on concrete quality (Trejo & Prasittisopin, 2016). Even if it takes more energy, making sure everything is thoroughly mixed is the most important thing. Long-term mixing improves the efficacy of concrete. This study aims to provide a review of concrete mixers that are excellent at handling different types of concrete mixing tasks for small-scale building and construction projects.

## 2. Review of Concrete Mixer Designs

Arashpour et al. (2014) addressed a critical issue related to concrete mixer performance: maintaining optimal temperature conditions within mixer drums. They developed innovative thermal insulation systems that prevent excessive heat loss during cold weather and minimize heat gain in hot climates. Proper temperature control ensures consistent concrete quality and extends the lifespan of mixer components. The limitation of their work is that they had limited access to advanced testing facilities, which made it difficult to thoroughly evaluate the performance and durability of their design under various conditions.

Yao et al. (2016) developed advanced blade designs to optimize mixing efficiency and reduce mixing time by 20%. Unlike the conventional straight or slightly curved blades; they designed blades with complex geometric shapes. These new blades were tested to create more turbulence within the mixer drum, ensuring that the concrete mix was more uniformly distributed. This improvement was critical for achieving a higher quality mix. The new design allowed the mixer to achieve the desired consistency in a shorter amount of time, thereby cutting down on energy usage and operational costs. This reduction in mixing time by twenty percent was a notable achievement, considering the importance of time efficiency on construction sites. The limitation of their work was manufacturing the blades with complex geometries also proved challenging. Conventional manufacturing techniques were inadequate, and the team had to explore advanced manufacturing methods such as 3D printing and CNC machining. These methods increased production costs and required specialized equipment, further complicating the project. Once the blades were designed and manufactured, field testing was crucial. The team needed to test the new blades under various conditions to ensure they performed as expected. Collecting feedback from field operators and making necessary adjustments based on real-world performance data was an iterative and time-consuming process.

Labiapari et al. (2021) proposed wear-resistant materials for mixer drums; enhancing durability and reducing maintenance costs. Traditional steel drums, although strong, tend to wear down quickly when exposed to the abrasive nature of concrete mixtures. The team researched and tested various materials to find those that could withstand this harsh environment more effectively. One of their significant achievements was the identification and application of composite materials that offered superior wear resistance compared to conventional steel. These materials were not

only more durable but also lighter, which contributed to reduced energy consumption during the mixing process. The lighter drums required less power to operate, leading to lower operational costs and improved energy efficiency. The limitation of their work was identifying suitable materials that could provide the desired level of wear resistance while also being cost-effective required extensive testing and experimentation. The team had to balance the need for durability with the practical considerations of cost and manufacturability. Also, the integration of these new materials into existing mixer drums designs. Traditional manufacturing processes were not always compatible with the new materials, necessitating modifications to production techniques. The team had to work closely with manufacturers to develop new processes that could accommodate the advanced materials without significantly increasing production costs.

Chang (2004) focused on designing high-performance concrete mixers specifically tailored for rapid mixing. Their mixers feature optimized blade configurations, motor power, and drum geometry to achieve faster and more efficient mixing cycles. Increased output rates benefit large-scale construction projects with tight schedules. The limitation of their work was incorporating advanced features such as automated controls and sensors increased the design complexity, leading to numerous iterations and redesigns and ensuring the mixer met industry standards and safety regulations posed an additional layer of complexity, necessitating more rigorous testing and certification processes.

Faridmehr et al. (2024) explored the integration of artificial intelligence (AI) into concrete mixer operations. They developed AI algorithms that optimize mixing parameters (such as rotation speed, water content, and aggregate proportions) based on real-time data. The AI-enhanced mixers achieve precise consistency and minimize material waste. The limitation of their work was scaling the design from prototype to a manufacturable product presented difficulties, including the need for specialized manufacturing processes and quality control measures and introducing innovative features required substantial research and experimentation, which was time-consuming and resource-intensive.

Lines et al. (2016) focused on developing automated control systems that ensured precise mix proportions and improved the overall quality of concrete. The team's primary innovation was the development of automated control systems for concrete mixers. These systems were designed to handle precise measurements and mix proportions, ensuring that each batch of concrete met the required specifications. The automated control systems utilized sensors and software to monitor and adjust the mixing process in real-time. One significant achievement was the integration of advanced sensors within the mixer drums. These sensors could accurately measure the quantities of each component—cement, water, aggregates, and admixtures—being added to the mix. The data collected by the sensors were fed into a central control unit, which used algorithms to determine the optimal mixing parameters. The limitation of their work was the development and implementation of automated control systems for concrete mixers presented several challenges. One of the primary obstacles was the integration of advanced sensors and control units into existing mixer designs. Traditional mixers were not designed with automation in mind, so the team had to retrofit the new systems into these older models. This required significant modifications and testing to ensure compatibility and reliability. Another challenge was the accuracy and reliability of the sensors. The harsh environment within a concrete mixer drum, characterized by dust, moisture, and vibrations, posed challenges for sensor performance. The team had to select sensors that could withstand these conditions while maintaining accuracy. Extensive testing and calibration were necessary to ensure the sensors performed reliably over time.

Zheng et al. (2022) tackled operator comfort and equipment longevity by developing vibration reduction systems for concrete mixers. These systems dampen vibrations transmitted to the operator's cabin, reducing fatigue and improving safety. Additionally, they protect sensitive components from excessive wear.

Elaydi and Al-Roos (2017) emphasized safety enhancements in concrete mixer design. They introduced features such as enhanced braking systems, emergency stop mechanisms, and improved operator visibility. These safety measures

reduce accidents and protect both operators and bystanders. The limitation of their work was conducting comprehensive prototype testing under various environmental conditions was resource-intensive and logistically complex. Also, designing for ergonomics to ensure ease of use and operator safety required extensive human factors research and iterative design adjustments.

Desai and Kalathingal (2020) designed a portable concrete mixer, focusing on the selection of proportions for cement, water, and aggregates, and verified the safety of the design through deformation analysis, that is considering specific boundary conditions. It also addresses the need for small- volume works or projects. The limitation of their work was choosing materials that could withstand the abrasive nature of concrete, resist corrosion, and endure frequent loading and unloading was critical. The mixer's components, especially the drum and blades, needed to be robust; ensuring the structural integrity of the mixer to support the expected load was a significant challenge. This included the design of the yoke, base frame, and hand wheel. Verifying the safety of the design by analysing specific boundary conditions and observing the deformation of each part was essential to ensure that the mixer would be safe for use.

Kaitukov et al. (2018) investigated the selection of reliable concrete mixers for high-quality concrete production. Their work likely involved analysing design parameters, mixing efficiency, and the behaviour of concrete components during the mixing process. By optimizing mixer internals and operational parameters, they aimed to improve the quality and consistency of concrete mixtures. The limitation of their work was adapting and transferring technologies from different regions posed challenges in ensuring compatibility and efficiency, also, navigating different regulatory environments and standards added complexity to the design and compliance processes.

González-Fonteboa et al. (2021) addressed mobility challenges associated with concrete mixers. They developed lightweight mixer designs using advanced materials (such as high-strength composites or aluminium alloys). These lightweight mixers are easier to transport and manoeuvre on construction sites. The limitation of their work was adapting the design to meet diverse market needs and preferences across different regions was challenging

Macdonald (2017) analysed mechanical stresses in mixer drums, leading to more robust structural designs. Their research focused on developing advanced safety mechanisms to protect operators and reduce accidents on construction sites. The system incorporated Automatic Shutoff Mechanisms to shut of the mixer drum if any part of the operator's body came too close to the mixing drum or other hazardous components and Enhanced Guarding and Barriers for preventing accidental contact with dangerous components, such as the mixing blades and the drum. The limitation of their work was integrating the new safety systems into existing mixer designs. The team had to retrofit the safety features into traditional mixers, ensuring that they did not interfere with the primary functions of the machine. This required careful design and engineering to achieve seamless integration and ensuring the reliability and accuracy of the sensors used in the automatic shutoff mechanisms.

Gadner et al. (2019) unveiled its new truck mixer series with a fully electric drum drive, marking a significant milestone in pioneering concrete technology. Liebherr has been a pioneer in the concrete mixer industry with several innovations. In 2020, they developed the first fully electric concrete mixer trucks with 10- or 12-m<sup>3</sup> drums on a five-axle chassis. These trucks are part of their ETM series and are designed for urban use, offering an environmentally friendly solution. Additionally, Liebherr's modular concrete mixing plants feature a modular design that allows for different configurations and efficient assembly, catering to the changing market needs. Liebherr's development of a new generation of concrete mixing plants required a shift from previous models to a more modular design was a limitation. This approach allows for individual modules, such as the mixer or scale module, to be planned, manufactured, and combined independently or with other modules. The challenge here was to create a system that could adapt to various customer requirements and changing market situations, particularly in response to rising costs and logistical challenges. The modular system introduced by Liebherr also aimed to address logistical challenges by significantly reducing the number of parts that had to be manually packed and shipped. The uniform basic dimensions

due to the modular design simplified vehicle planning. However, ensuring efficient and high-performance material supply and production in the face of these logistical hurdles was a complex task.

Harris (2022) innovated ultrasonic mixing technology to enhance homogeneity and reduce mixing time. They aimed to revolutionize the design and construction of concrete mixers by incorporating advanced automation technologies. Their goal was to create mixers that could operate with minimal human intervention while maintaining high standards of efficiency and consistency. This system used sensors and programmable logic controllers (PLCs) to monitor and adjust the mixing parameters in real-time. The automated system ensured precise control over the mixing time, speed, and ingredient proportions, leading to consistent and high-quality concrete. The limitation of their work was integrating the various automation technologies into a cohesive system. The team had to ensure that the sensors, PLCs, actuators, and control software worked seamlessly together. This required extensive testing and fine-tuning to achieve reliable and efficient operation. They also developed fail-safes to handle potential system failures.

Fiorineschi et al. (2020) developed an innovative cycloidal gearbox for concrete mixers. The work aimed to identify innovative solutions for power transmission gearboxes, aligning with company specifications. Specifically, she developed an original cycloidal gearbox by merging classical cycloidal drives with the planetary gearbox. This novel concept offers high reduction rates and exceptional overload capacity, paving the way for more robust and compact concrete mixer designs. The research demonstrates a tailored design approach that can be adapted by other designers working on similar tasks. The impact of the work extends beyond gearboxes, influencing the entire field of concrete mixer engineering. The study did not perform in-depth evaluations typically done in the detail design phase due to the scope defined by the company.

Mulki et al. (2020) developed self-cleaning systems to increase operational efficiency and reduce labour costs. Their research focused on reducing the environmental impact of concrete mixer operations through the use of sustainable materials, energy-efficient technologies by using Electric Motors designed to deliver optimal performance while consuming less electricity compared to traditional motors, and waste minimization strategies. They integrated water recycling system for the mixers. This system collected and treated water used in the mixing process, allowing it to be reused for subsequent batches of concrete. The limitation of their work is that sourcing high-quality recycled materials that met the performance and durability requirements for mixer components and achieving a balance between performance and sustainability was crucial. The team had to ensure that the use of sustainable materials and energy-efficient technologies did not compromise the performance and efficiency of the mixers.

Basu et al. (2024) undertook a detailed conceptual and embodied design for a commercial concrete mixer, focusing on sustainability and energy consumption. The mixer drum was required to rotate at 16 rpm and accelerate to this speed within 0.5 seconds, achieving this acceleration while maintaining safety and stability posed a challenge. The mounting frame had to support the entire mixer structure, including the motor, gearbox, and drum ensuring structural integrity while minimizing weight was a delicate balance. The team considered the reduction of energy consumption and the CO<sub>2</sub> footprint. Their design aimed to protect the environment and contribute to global sustainability goals. Achieving this balance required innovative solutions and material choices.

Wu et al. (2021) designed mobile concrete mixers for remote construction sites, enhancing on-site mixing capabilities. The limitation of their work is that integrating knowledge from previous projects while innovating posed challenges in balancing tried-and-tested methods with new approaches and ensuring seamless integration of various system components like motors, mixers, and control units required meticulous planning and testing.

Mostafaei et al. (2023) contributed to the understanding of the environmental impacts of concrete mix design. In 2023, they published a study investigating the effects of concrete mix design on the environmental impacts of reinforced concrete structures. The limitation of their work is that incorporating cutting-edge technology while ensuring

reliability and user-friendliness was a primary challenge and adhering to increasingly stringent environmental regulations influenced material and design choices.

McLoughlin et al. (2017) introduced a modular design concept that enhanced the versatility and adaptability of concrete mixers. Modular components such as interchangeable drums and mixing blades allowed for easy customization based on project requirements. This flexibility improved operational efficiency and minimized downtime during maintenance and component replacement. They recognizing the environmental impact of traditional diesel-powered mixers, the team developed hybrid power systems. These systems combined electric and alternative fuel sources such as biodiesel or compressed natural gas (CNG). The hybrid approach reduced greenhouse gas emissions and operational costs while maintaining the necessary power and mobility for construction site applications.

Zhao et al. (2009) focused on enhancing energy efficiency in concrete mixer systems. They achieved this by integrating hybrid power systems that combine traditional energy sources (such as diesel engines) with renewable energy sources (such as solar panels or wind turbines). The hybrid approach optimizes energy consumption during mixing operations, leading to reduced fuel costs and environmental impact. Keeping up with rapid technological advancements and integrating them effectively into the mixer design posed ongoing challenge and ensuring the design was intuitive and user-friendly for operators of varying skill levels required significant research and testing. These researchers and industry contributors have focused on improving the mechanical components and integrating advanced technologies to enhance the performance and safety of concrete mixers. Their work lays the groundwork for future innovations in concrete mixer design.

### 3. Conclusion

While the current study effectively outlines the design, modelling, and analysis of a concrete mixer, it leaves several areas unexplored. There is a need for detailed experimental testing of the selected materials under various operational conditions to ensure optimal performance and durability. The study does not delve deeply into optimizing the mixing process itself, such as investigating different paddle designs, drum shapes, and mixing speeds to improve the homogeneity and quality of the mixed concrete. Additionally, the analysis of energy consumption patterns over extended periods and the exploration of energy-saving technologies and alternative power sources are not covered. Furthermore, the environmental impact of the mixer's construction and operation is not addressed, highlighting the need for future research in these areas to develop more sustainable and efficient concrete mixing solutions.

Considering the need for large scale production of mixed concrete and concrete mixing equipment, the researchers therefore recommended that the following should be put in to consideration:

- i. This research should be used to improve the knowledge on the extent of research on various concrete mixer designs for various applications.
- ii. There is the need for developing more portable concrete mixers for small-scale domestic activities, to reduce drudgery while carrying out these activities.
- iii. It is important to carry out regular maintenance practices in order to avoid sudden failure of the concrete mixer system, and to ensure its longevity and optimal working condition.

### Acknowledgement

The author appreciates Lisa Oluchi Nwabuike, a student of the Department of Mechanical Engineering, Faculty of Engineering, Rivers State University, for her contributions to the research.

## References

- Aıtcın, P. (2003). The durability characteristics of high performance concrete: a review. *Cement and concrete composites*, 25(4-5), 409-420.
- Arashpour, M., Wakefield, R., Blismas, N., & Lee, E. (2014). Analysis of disruptions caused by construction field rework on productivity in residential projects. *Journal of construction engineering and management*, 140(2), 04013053.
- Basu, D., Mushtaq, S. M., Sharma, S., & Tripathi, S. (2024). Enhancing Quality Control in the Mix Design of High-Strength Concrete Using a Capacity-Based Approach. *International Journal of Concrete Structures and Materials*, 18(1), 78.
- Chang, P.-K. (2004). An approach to optimizing mix design for properties of high-performance concrete. *Cement and Concrete Research*, 34(4), 623-629.
- Desai, P., & Kalathingal, A. (2020). Fresh and hardened properties of pastes and concretes with LC3 and its economic viability: Indian ready mix industry perspective. *Calcined Clays for Sustainable Concrete: Proceedings of the 3rd International Conference on Calcined Clays for Sustainable Concrete*,
- Elaydi, H. A., & Al-Roos, S. I. A. (2017). Concrete Batch Process Quality Control Using Controller Self Parameter Tuning. *Journal of Automation and Control*, 5(1), 7-15.
- Faridmehr, I., Azarsa, M., Varjavand, I., & Valerievich, K. A. (2024). Artificial Intelligence-Driven Optimization of Ready-Mix Concrete for Enhanced Strength, Cost Efficiency, and Carbon Dioxide Emission Reduction.
- Fiorineschi, L., Papini, S., Pugi, L., Rindi, A., & Rotini, F. (2020). Systematic design of a new gearbox for concrete mixers. *Journal of Engineering, Design and Technology*, 18(6), 2017-2042.
- Gadner, S., Pifko, A., Brehmer, U., & Stockbauer-Muhr, D. (2019). Electric Truck Mixer for the Future Urban Construction Site. *ATZheavy duty worldwide*, 12(1), 14-21.
- González-Fonteboa, B., González-Taboada, I., Carro-López, D., & Martínez-Abella, F. (2021). Influence of the mixing procedure on the fresh state behaviour of recycled mortars. *Construction and Building Materials*, 299, 124266.
- Harris, J. (2022). *Non-destructive Evaluation of Concrete using Electrical Resistivity and Ultrasonic Wave Propagation*. The University of Maine.
- Kaitukov, B., Stepanov, M., & Kapyrin, P. (2018). The choice of concrete mixers for the concrete preparation. MATEC Web of Conferences,
- Labiapari, W., Gonçalves, R., De Alcântara, C., Pagani, V., Di Cunto, J., & De Mello, J. (2021). Understanding abrasion-corrosion to improve concrete mixer drum performance: A laboratory and field approach. *Wear*, 477, 203830.
- Lines, B. C., Sullivan, K. T., & Wiesel, A. (2016). Support for organizational change: Change-readiness outcomes among AEC project teams. *Journal of construction engineering and management*, 142(2), 04015062.
- Macdonald, P. (2017). Finite element analysis and structural optimisation of a concrete mixer.
- McLoughlin, C., Metzger, N., Szychowski, N., & Bustard-Gustafson, M. (2017). Human-Powered Concrete Mixer.

- Mostafaei, H., Badarloo, B., Chamasemani, N. F., Rostampour, M. A., & Lehner, P. (2023). Investigating the effects of concrete mix design on the environmental impacts of reinforced concrete structures. *Buildings*, 13(5), 1313.
- Mulki, H., Sabti, D., Almuhanha, H., Alhajiri, K., & Alrasheedi, A. (2020). Designing a Movable and Portable Concrete Mixer.
- Rudyk, R., & Kuzub, Y. (2022). Justification of new equipment development for preparing concrete solutions. *Academic journal Industrial Machine Building Civil Engineering*, 1(58), 11-16.
- Trejo, D., & Prasittisopin, L. (2016). Effects of mixing variables on early-age characteristics of portland cement systems. *Journal of Materials in Civil Engineering*, 28(10), 04016094.
- Wu, C., Shang, G., Wu, L., & Zhao, M. (2021). Design of Control System for Concrete Mixing Plant. 2021 4th International Conference on Electron Device and Mechanical Engineering (ICEDME),
- Yao, Y., Feng, Z., Chen, S., Li, B. Q., Zhao, L., & Zhao, W. (2016). A double-blade mixer for concrete with improved mixing quality. *Arabian Journal for Science and Engineering*, 41(12), 4809-4816.
- Zhao, J., Liu, X., Xin, Z., & Han, Y. (2009). Research on the energy-saving technology of concrete mixer truck. 2009 4th IEEE Conference on Industrial Electronics and Applications,
- Zheng, Y., Zhou, Y., Huang, X., Min, Y., Luo, H., Chen, Y., & Li, W. (2022). Study on performance improvement of ultra-high performance concrete by vibration mixing. *Construction and Building Materials*, 327, 126823.