

Research on Structural Design and Optimization of Intermittent Cement-Concrete Mixing Equipment

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Abstract: This paper conducts an in-depth study on the design and structural optimization of intermittent cement-concrete mixing equipment, mainly including improved design for blade structure, power system, and body structure. Computational Fluid Dynamics (CFD) technology is adopted to optimize blade design, which effectively improves mixing efficiency and mixing uniformity and reduces material accumulation. Frequency converter technology and an adaptive speed-regulation system are introduced for power-system optimization, which significantly enhances energy efficiency and mixing performance. High-strength materials and improved sealing systems are applied in body-structure improvement to boost the durability and stability of the equipment. These optimization measures not only raise mixing efficiency but also cut maintenance costs and strengthen environmental adaptability, providing important technical support for modern construction projects.

Keywords: Intermittent; Cement-concrete mixing equipment; Structural design; Performance optimization

Online publication: October 21, 2026

1. Introduction

With the arrival of the 15th Five-Year Plan, higher quality requirements have been put forward for the civil-engineering industry, and performance requirements for cement-concrete mixing equipment are growing day by day. Traditional mixers have certain limitations in mixing efficiency, energy consumption, and equipment durability, which drives the construction-machinery industry to solve these problems through technological innovation. Structural optimization of cement-concrete mixing equipment is a critical approach to improve mechanical performance and economic benefits. Through systematic analysis and technological innovation, this study discusses the optimization of mixer blade structure, efficient configuration of the power system, and stability improvement of the body structure, aiming to enhance the overall performance and operational efficiency of mixers via scientific design.

In recent years, domestic and foreign scholars have carried out comparative experimental research on the performance of various cement-based materials such as cement concrete, manufactured-sand concrete, self-compacting concrete, recycled concrete, fiber-reinforced concrete and ultra-high-performance concrete, focusing on vibratory mixing technology and ordinary forced mixing technology. Research results show that vibratory mixing has remarkable advantages in cement-consumption saving, improvement of concrete workability, promotion of mechanical properties, and enhancement of durability^[1-3].

Wang Bo et al. conducted comparative tests with ordinary mixing and found that vibratory mixing can reduce cement consumption by up to 10% while guaranteeing equivalent performance^[4]. Xue Shaoqing et al. explored the improvement effect of vibratory mixing on cement-stabilized macadam performance^[5]. The research results indicate that under identical cement dosage, vibratory mixing can increase strength by 8.5%–18% and significantly reduce drying shrinkage strain and average drying shrinkage coefficient; on the premise of meeting strength requirements, vibratory mixing can save 11% of cement consumption.

In terms of concrete strength-formation mechanism, Zhao Shun from Chang'an University studied the influences of ordinary mixing and vibratory mixing under different forming methods^[6]. Test results demonstrate that vibratory mixing can raise concrete compressive strength by 16%–25%, remarkably refine internal pores, and optimize pore gradation. Liu Shanshan et al. analyzed the strengthening mechanism of vibratory mixing through experiments and proposed an optimized scheme combining vibratory mixing and staged-mixing technology^[7]. Studies show that the slump of concrete prepared by staged vibratory-mixing rises with the increase of vibration acceleration; meanwhile, vibratory mixing can greatly improve concrete strength and reduce the strength variation coefficient.

For manufactured-sand concrete, Zhao Wu et al. tested the influences of vibratory mixing and forced mixing on indicators including slump, compressive strength, emptying time, air content, and electric flux through comparative experiments^[8]. The results reveal that under vibratory-mixing conditions, each indicator has a small deviation coefficient, the plastic viscosity of materials drops significantly, and workability, durability, and compressive-strength performance are all improved.

Based on the vibratory-mixing mechanism, Jia Baodong from Chang'an University optimized vibratory-mixing parameters via orthogonal tests and obtained the optimal parameter combination for self-compacting-concrete preparation: amplitude 1.12 mm, mixing time 120 s, vibration frequency 40 Hz^[9]. Test results indicate that compared with forced mixing, vibratory mixing can greatly improve mechanical properties, workability, and air-content performance of self-compacting concrete.

Wang Xinxin from Chang'an University found that vibratory mixing improves air content, pore structure, and mechanical properties of recycled concrete. Compared with ordinary mixing, it raises bulk density, slump, and air content, and effectively repairs defects of recycled aggregates. Xia Ji from Yangzhou University prepared recycled concrete by vibratory mixing and ordinary forced mixing and tested its performance^[10]. The results prove that the mechanical properties and durability of both ordinary concrete and recycled concrete are improved to varying degrees when ordinary forced mixing is replaced by vibratory mixing. Zheng et al. combined vibratory-mixing technology with steel-fiber volume fraction for the first time and systematically studied performance changes of steel-fiber-reinforced concrete^[11]. The research results show that the strength-improvement effect of vibratory-mixing on concrete presents an increasing-then-decreasing trend; the most prominent strength gain occurs when steel-fiber volume fraction is less than 1%. Among them, the maximum improvement of cubic compressive strength reaches 14.94%,

axial compressive strength rises by up to 10.87%, and flexural strength increases by up to 23.97%. Xiong et al. adopted vibratory-mixing technology to prepare lightweight high-strength concrete, made comparisons with non-vibratory mixing, and analyzed differences in structure and performance ^[12]. Meanwhile, comprehensive digital-image-processing technology was used to quantitatively analyze homogeneity of lightweight aggregates as well as orientation and distribution of steel fibers under different mixing modes. The results show that compared with ordinary mixing, vibratory mixing can effectively improve homogeneity of lightweight high-strength concrete, optimize internal micro-structure, enhance mechanical properties, and raise steel-fiber dispersion efficiency.

2. Basic design objectives of cement-concrete mixing equipment

The core design objective of cement-concrete mixing equipment is to fully mix construction raw materials, including cement, sand-aggregate, clean water, and various admixtures, according to preset proportions, relying on mechanical structural devices, so that finished concrete can meet engineering-design standards. The whole mixing process mainly consists of three key links: feeding, mixing, and discharging. During construction, various concrete raw materials are sequentially fed into the mixing drum in accordance with set proportions. Then, mixing blades keep rotating and exert shearing, extruding, and other forces on materials to promote full blending of each component. After mixing for the specified duration, concrete mixtures with qualified fluidity, bonding performance, and structural strength are finally formed. Based on mechanical-dynamics principles, the equipment realizes all-round material mixing through continuous motion of mixing blades, and guarantees uniformity and stability in concrete mixing processes.

Various cement-concrete mixing equipment on the market are classified according to their structural forms and mixing modes. Widely-used types include gravity-drop mixers, forced mixers and planetary mixers. Gravity-drop mixers complete mixing by means of free fall of materials by their own gravity inside the mixing drum, and are more suitable for mixing concrete with large-size coarse aggregates. Forced mixers rely on high-speed-rotating mixing blades to conduct multi-directional forced mixing of materials. They can produce concrete with high uniformity and stable viscosity and fit high-standard construction scenarios. Planetary mixers greatly improve mixing efficiency through complex motion trajectories of blades, and are mainly applied to concrete-mixing operations with special performance requirements.

Overall, the core working principle of cement-concrete mixing equipment is to realize uniform blending of diverse raw materials by mechanical external force, so as to guarantee that various performances of finished concrete satisfy requirements of building-structure construction. Key parameters such as mixing duration, structural shape of mixing blades, and rotational speed of the mixing drum exert direct influences on material-mixing uniformity and constitute important factors determining the construction quality of finished concrete.

3. Structural analysis of cement-concrete mixing equipment

The overall structure of cement-concrete mixing equipment mainly comprises core components: mixing pan, mixing blades, mixing arms, rotor, inner-wall and outer-wall scraping blades, feeding inlet, discharging outlet, and protective cover plates (**Figures 1 and 2**). The turbine-type forced mixer is high-efficiency mixing equipment specially adapted for preparation scenarios of high-quality concrete, and is widely

applied in high-standard construction projects. Seen from the equipment-structural layout, the mixing pan is installed at the bottom of the equipment and serves as the main working surface for material mixing. Mixing blades are fixedly mounted on mixing arms and driven by rotors to run at high speed for concrete-material mixing. As the power core of the whole mixing system, the rotor directly determines mixing efficiency and material-mixing uniformity of the equipment.

Inner-wall and outer-wall scraping blades equipped on the equipment can effectively clean materials attached to the inner wall of the mixing drum, so that all materials inside the drum can fully participate in mixing, avoid material accumulation and bonding, and guarantee concrete-mixing uniformity from the perspective of structural design. The feeding inlet is used for input of various raw materials, and the discharging outlet is for output of finished concrete after mixing. The whole operation is simple with high working efficiency. The cover plate on the top of the equipment mainly plays a dust-proof and protective role: it can prevent splashing and leakage of materials in mixing processes and block external impurities from entering the mixing drum to avoid contamination of concrete raw materials, so as to practically guarantee finished-product quality.

In the design phase, turbine-type forced mixers fully take mixing efficiency and mixing quality into account. Through accurate calculation of blade mounting angle and rotational speed as well as reasonable optimization of arrangement mode for mixing arms, fast, uniform and high-efficiency mixing effects are achieved. Meanwhile, core components of the equipment are all manufactured from wear-resistant materials, which can withstand long-term high-load and high-intensity continuous operation and effectively extend the service life of the equipment. With optimized structural design and stable operating performance, turbine-type forced mixers can continuously produce high-quality concrete and act as critical core equipment in modern construction-engineering practices.

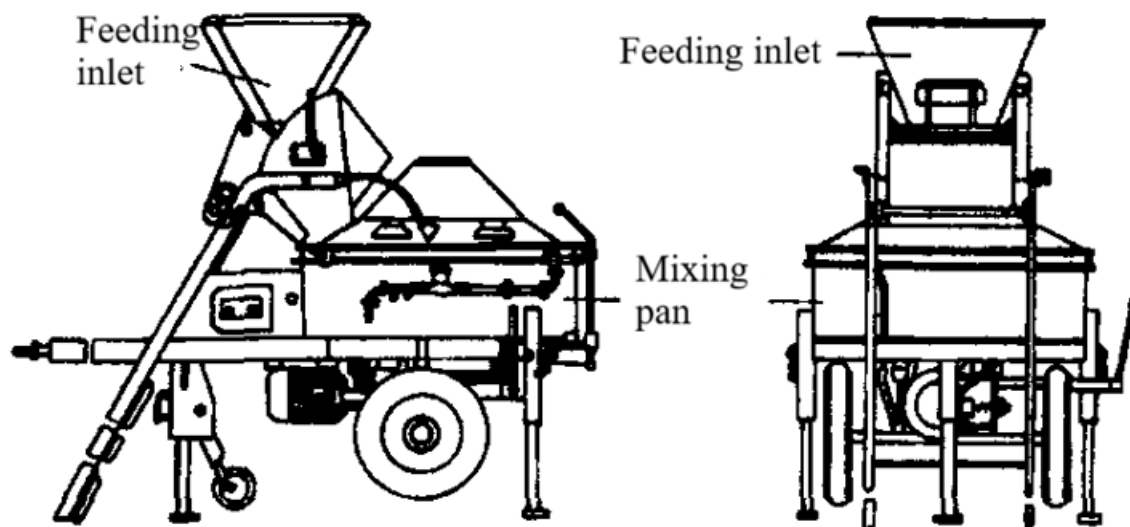


Figure 1. Turbine-Type Forced Mixer

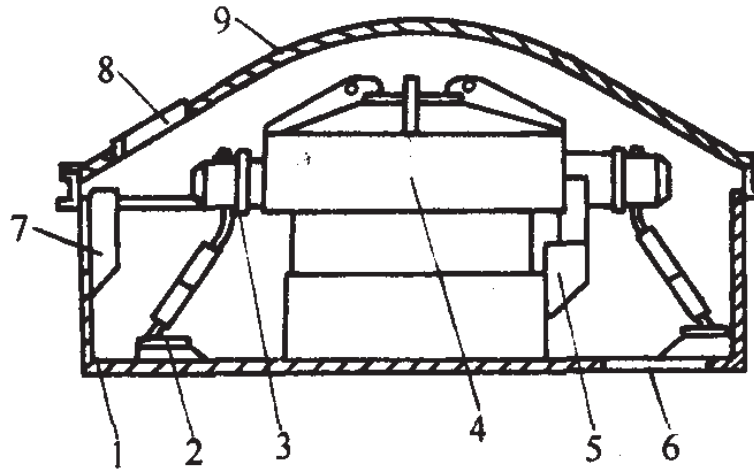


Figure 2. Structural diagram of turbine-type forced mixer. 1-Mixing pan; 2-Mixing blade; 3-Mixing arm; 4-Rotor; 5-Inner-wall scraping blade; 6-Discharging outlet; 7-Outer-wall scraping blade; 8-Feeding inlet; 9-Cover plate

4. Structural optimization design of cement-concrete mixing equipment

4.1. Blade-structure optimization

Blades are core working components of mixing equipment. Their optimization and reconstruction mainly adjust blade profile, mounting angle, and overall arrangement mode to practically raise mixing efficiency and material-mixing effects. In research processes, Computational Fluid Dynamics (CFD) simulation can be adopted to accurately reproduce flow variations of concrete inside the mixing drum, accurately analyze contact, friction, and disturbance rules between blades and materials, and accordingly determine the most reasonable geometric dimensions and structural parameters of blades. This optimization method can effectively solve common problems such as material accumulation and local mixing dead zones in mixing operations, and realize sufficient and uniform mixing of all materials inside the drum. Besides, blades manufactured from high-strength wear-resistant materials can significantly improve the wear resistance of components, extend service life, greatly reduce daily maintenance and part replacement costs, and fully meet long-term, continuous, and high-intensity industrial construction working conditions. The overall optimization of blade structure not only enhances the service performance of single components, but also comprehensively raises the operating stability and comprehensive working capacity of the whole mixing equipment.

4.2. Power-system optimization

Optimization and reconstruction of the power-system focus on improving energy-utilization efficiency of the equipment and accelerating working-condition response speed. By matching high-performance motors and optimizing transmission structures, power-transmission procedures are effectively simplified, energy loss in transmission processes is reduced, and power output becomes more efficient and stable. Meanwhile, combined with modern intelligent-control technology, functional modules including load sensing and adaptive speed regulation are installed. The equipment can real-time adjust operating rotational speed and torque according to actual on-site working conditions, material proportions, and mixing states, and always maintain optimal working status. Among them, frequency-conversion regulation technology can flexibly

adjust mixing speed in accordance with actual concrete consumption, slurry viscosity, and construction requirements, further optimize mixing effects, and guarantee stable quality of finished concrete. The optimized power-system not only comprehensively improves the operating performance of the equipment, but also realizes energy-saving and consumption-reduction, effectively lowers equipment-operation costs, and extends the service life of the whole machine. Intelligent control modes also greatly improve operation flexibility and accuracy of the equipment, and can adapt to construction standards and application requirements of various projects.

4.3. Improved design for body structure

Reconstruction of the body-structure mainly solves problems such as insufficient operating stability and weak environmental adaptability of the equipment, and comprehensively improves structural strength and durability performance. By optimizing the overall layout of the machine body and upgrading high-strength, corrosion-resistant raw materials, the anti-seismic and anti-corrosion performance of the equipment is effectively enhanced to better adapt to outdoor complex, dusty, and highly-corrosive construction environments. At the same time, the sealing structures and shock-absorbing devices of the equipment are improved and upgraded. It can not only avoid material waste and equipment contamination caused by cement-slurry leakage in mixing processes, but also mitigate component wear induced by mechanical vibration and lower equipment-failure probability. The whole equipment adopts a modular assembly design. Each functional component is easy to disassemble and assemble, which greatly simplifies daily maintenance and inspection work and reserves sufficient space for subsequent equipment performance upgrading and structural reconstruction. After structural improvement, the mixing equipment can maintain stable operation for a long time, effectively cut construction-operation-and-maintenance costs, and bring better economic benefits and user experience for construction projects.

5. Conclusion

This paper carries out systematic structural optimization and improved design for cement-concrete mixing equipment. Performance upgrading is completed from three core dimensions: blade structure, power system, and machine-body frame, which significantly improves operating efficiency and running stability of the equipment. Optimization of blade structure effectively eliminates mixing dead zones, raises concrete-mixing uniformity and reduces material waste; improvement of the power-system realizes precise speed regulation and energy-saving operation, greatly boosts equipment-response speed and energy-utilization efficiency; reconstruction of the body-structure strengthens overall strength of the equipment and enhances its stability and durability under complex working conditions. This optimized design can not only satisfy construction requirements for high-efficiency, high-quality, and durable mixing equipment in current construction projects, but also provide reliable practical references for structural design, process improvement, and manufacturing of similar mixing equipment. Overall, this structural optimization effectively improves the engineering applicability and economic practicality of concrete-mixing equipment, and conforms to the technical-development trend of refinement, high efficiency, and long service life for modern construction machinery.

Disclosure statement

The author declares no conflict of interest.

References

- [1] Chen K, Sun F, Liang S, et al., 2021, Experimental Study on Freeze-Resistance and Crack-Resistance of Base Course in Alpine Regions Based on Vibratory Mixing Technology. *Materials Reports*, 35(S1): 291–296.
- [2] Dong W, Xie SY, Zhao LJ, et al., 2019, Influence of Vibration on Mixing Process and Performance of Cement-Stabilized Macadam. *China Journal of Highway and Transport*, 32(5): 181–190.
- [3] Wang HG, Su JZ, Zhang M, et al., 2021, Research on Influence of Vibratory Mixing on Cement-Stabilized Macadam Mixture Mixed with Iron-Tailings Sand. *Bulletin of the Chinese Ceramic Society*, 40(12): 4209–4216.
- [4] Wang B, 2014, Mechanism and Experimental Research on Improving Concrete Performance by Vibratory Mixing, thesis, Chang'an University.
- [5] Xue SQ, 2016, Experimental Research on Influence of Vibratory Mixing on Performance of Cement-Stabilized Macadam, thesis, Chang'an University.
- [6] Zhao S, 2018, Research on Influence of Vibratory Mixing and Vibratory Forming on Concrete Performance Indicators, thesis, Chang'an University.
- [7] Liu SS, 2020, Experimental Research on Concrete Vibratory-Mixing Technology, thesis, Chang'an University.
- [8] Zhao W, Yang ZW, Song RL, et al., 2021, Research on Influence of Vibratory Mixing on Manufactured-Sand Concrete Performance. *New Building Materials*, 48(7): 71–74.
- [9] Jia BD, 2022, Research on Vibratory-Mixing Technology and Equipment-Parameter Optimization for Self-Compacting Concrete, thesis, Chang'an University.
- [10] Xia J, 2023, Experimental Research on Performance of Reinforced Recycled Aggregate and Its Vibratory-Mixed Concrete, thesis, Yangzhou University.
- [11] Zheng Y, Wu X, He G, et al., 2018, Mechanical Properties of Steel-fiber-reinforced concrete by Vibratory Mixing Technology. *Advances in Civil Engineering*, 2018(1): 9025715.
- [12] Xiong G, Wang C, Zhou S, et al., 2022, Study on Dispersion Uniformity and Performance Improvement of Steel-fibre-Reinforced Lightweight Aggregate Concrete by Vibrational Mixing. *Case Studies in Construction Materials*, 2022(16): e01093.

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