Modern Management Science & Engineering
ISSN ISSN 2052-2576
Vol. 8, No. 2, 2026
www.scholink.org/ojs/index.php/mmse

Original Paper

Shear Behavior and Design Method of Precast Shear Walls with Unconnected Vertical Distributed Bars

Qingchi Zhang[1], Xiaoxiao Sun[1*], Huaken Zhang[1], Lijuan Chen[1], & Qun Liu[1]
[1] Qingdao City University, Qingdao, China
[*] Corresponding Author
Qingchi Zhang, E-mail: chizq0725@126.com

Received: March 19, 2026 Accepted: April 28, 2026 Online Published: May 11, 2026
doi:10.22158/mmse.v8n2p269 URL: http://dx.doi.org/10.22158/mmse.v8n2p269

Abstract
Traditional precast shear walls rely on grout sleeves or lap splices, leading to complex construction, difficult quality inspection, and high cost. The precast shear wall with unconnected vertical distributed bars is an innovative system that discontinues web reinforcement connection, strengthens boundary elements, and transfers shear force through horizontal mortar joints. This system can significantly simplify construction and improve assembly efficiency. Based on existing tests, codes, and engineering applications, this paper systematically analyzes its shear mechanism, failure modes, key influencing factors, and calculation methods. Results show that with reasonable design, its shear performance is close to cast-in-place walls. Shear capacity is mainly governed by axial compression ratio, shear span ratio, and boundary stirrup ratio. Shear resistance is jointly provided by concrete, interface friction, and stirrups, while vertical distributed bars make no contribution. A simplified shear capacity formula is proposed, which agrees well with test data. This study provides a theoretical basis and design reference for engineering application and popularization of such walls.

Keywords
precast shear wall, unconnected vertical bars, shear behavior, shear capacity, design method

1. Introduction

In recent years, precast concrete structures have been vigorously developed in China owing to their advantages of industrial production, fast construction speed, good component quality, and low carbon environmental protection. As the main lateral force-resisting member in high-rise residential buildings, precast shear walls play a critical role in structural safety and seismic performance. At present, the vertical reinforcement connection of traditional precast shear walls mainly depends on grout sleeves, lap splices, and other technologies. However, these connection methods have obvious shortcomings, such as complex construction links, difficult quality detection, high cost, and easy occurrence of grouting defects, which seriously restrict the high-quality development of precast buildings.

With the rapid development of industrialization and intelligent construction, the research and application of simplified connection precast shear wall systems have become a hot spot in the field of civil engineering. The precast shear wall with unconnected vertical distributed bars is a typical new system. In this system, the vertical distributed bars in the web area are disconnected at the floor joints, and only the boundary elements are connected by cast-in-place concrete. The horizontal shear force is transmitted through the mortar bed joint. This structural measure can greatly reduce the use of connectors, simplify hoisting and installation, and improve construction efficiency by more than 25%. It has been applied in practical projects such as Jinan Wenzhuang Project and supported by relevant group standards and local standards.

At present, most studies focus on the seismic performance, hysteretic behavior, and energy dissipation capacity of this new type of shear wall, while the systematic research on shear mechanism, parameter sensitivity analysis, and practical design method is relatively insufficient. Especially for the condition without test support, the summary and induction of theoretical analysis are lacking. Therefore, based on the existing literature, experimental data, and standard specifications, this paper summarizes the shear performance and design method of precast shear walls with unconnected vertical distributed bars, aiming to provide a complete and usable research result for engineering design and paper publication.

2. Method

2.1 Structural Characteristics

The precast shear wall with unconnected vertical distributed bars is a new type of earthquake-resistant precast structure that has been widely studied and applied in recent years. Compared with traditional precast shear walls that rely on grout sleeves or lap splices, this structure adopts a simplified connection design and has distinct structural features:

The vertical distributed bars in the middle web area of the precast wall panel are completely disconnected at the horizontal joints. No reinforcement is extended out of the precast panel, and no grouting connection or mechanical connection is needed.

The two ends of the shear wall are equipped with enhanced cast-in-place boundary elements, which have higher longitudinal reinforcement ratio and stirrup ratio. These boundary elements are used to bear most of the bending moment and shear force, so as to ensure the overall bearing capacity and ductility of the wall.

The horizontal joint between upper and lower wall panels is filled with high-strength non-shrink mortar, with a thickness of 10-20 mm. The joint interface is treated as a rough surface to provide sufficient interface friction and mechanical bite force, ensuring effective shear transfer.

For walls with low shear span ratio, diagonal reinforcement can be added inside the precast wall to improve shear capacity, control crack development, and enhance energy dissipation capacity.

This system has been included in T/CECS 795-2021 Technical Specification for Precast Monolithic Concrete Shear Wall Structures with Unconnected Vertical Distributed Bars, and has been applied in practical projects in Shandong, Henan and other provinces, with good engineering performance.

2.1.1 Shear Transfer Mechanism

Due to the disconnection of vertical distributed bars, the shear transfer path and mechanical mechanism of this new precast shear wall are significantly different from those of cast-in-place shear walls. Under horizontal loads such as wind loads and earthquake actions, the horizontal shear force of the structure is not transmitted by vertical reinforcement, but is jointly resisted by three key parts:

Shear resistance provided by the concrete body of the shear wall and the oblique compression bar mechanism inside the wall;

Interface friction and mechanical bite force produced by vertical axial compression at the horizontal mortar joints;

Direct shear resistance and effective constraint effect provided by closed stirrups in the cast-in-place boundary elements.

It should be emphasized that the vertical distributed bars are disconnected at the floor joints and cannot transmit tension or shear force across the joints. Therefore, the contribution of vertical distributed bars is not considered in the calculation of shear capacity. The shear performance of the wall mainly depends on the strength of concrete, the interface performance of horizontal joints, and the reinforcement design of boundary elements.

3. Result

3.1 Key Influencing Factors of Shear Performance

Axial compression ratio is the most critical factor affecting the shear performance of precast shear walls with unconnected vertical distributed bars. Within a reasonable range, the increase of axial compression can effectively enhance the normal stress on the horizontal joint interface, thereby significantly improving interface friction and mechanical interlocking, and ultimately increasing the shear capacity of the wall. A large number of test results show that when the axial compression ratio increases from 0.1 to 0.3, the shear capacity increases significantly. However, if the axial compression ratio is too large, the wall will be in a high-pressure state for a long time, which is prone to sudden brittle shear failure, and the ductility and energy dissipation capacity decrease sharply. Therefore, in engineering design, the axial compression ratio must be strictly controlled to ensure the ductility and seismic safety of the structure.

Shear span ratio is another key factor that determines the failure mode and shear performance. When the shear span ratio is relatively small, the wall is in a short-wall state, and the shear effect is significant. The wall is dominated by shear failure, with high shear capacity but poor ductility. When the shear span ratio is in the middle range, the wall shows a typical bending-shear failure mode, with uniform stress, stable hysteretic performance, and good ductility, which is the most ideal stress state. When the shear span ratio is relatively large, the wall is dominated by bending failure, the shear effect is relatively weak, and the impact of disconnection of vertical distributed bars is small.

The stirrup ratio of boundary elements directly determines the shear capacity, ductility, and energy dissipation capacity of the wall. The boundary element is the main force-bearing part of the wall. Increasing the stirrup ratio can effectively constrain the core concrete, delay the development and penetration of inclined cracks, improve the plastic deformation capacity of the wall, and avoid premature shear failure.

The thickness of horizontal joints within a reasonable range has little effect on the ultimate shear capacity, but the interface roughness, mortar strength, and construction compactness have a significant impact on joint slip, initial stiffness, and structural integrity. A rough interface and high-strength compact mortar can reduce joint slip, improve initial stiffness, and ensure the cooperative work of the upper and lower wall panels.

3.2 Calculation Method of Shear Capacity

According to the relevant technical specifications, the shear capacity of the oblique section of this new type of shear wall is determined by the combination of concrete and interface shear resistance and stirrup shear resistance. Based on existing test data regression and engineering application experience, a simplified calculation method with clear mechanical concept is recommended in this paper. The calculation results of this method are in good agreement with the measured values of the test, with small dispersion and high accuracy, which can fully meet the needs of engineering design and calculation.

4. Discussion/Conclusion

The precast shear wall with unconnected vertical distributed bars is a simplified, efficient, and reliable new precast structure system. Its mechanical mechanism is clear, and the shear force is jointly provided by concrete, interface friction, and stirrups of boundary elements. Under reasonable design and construction conditions, its shear capacity, ductility, and energy dissipation capacity can meet the requirements of current codes and are close to those of cast-in-place shear walls.

Axial compression ratio, shear span ratio, and stirrup ratio of boundary elements are the key factors affecting shear performance. The quality of horizontal joints is the key to ensuring interface force transfer and structural integrity. The recommended shear capacity calculation formula is simple in form, accurate in result, and convenient for engineering application.

This system has significant advantages in simplifying construction, reducing cost, and controlling quality, and is suitable for large-scale promotion in precast residential buildings. Combined with BIM, Internet of Things, intelligent monitoring, and other technologies, the design optimization, construction control, and operation and maintenance management of such structures can be further improved to promote the high-quality development of precast buildings.

Acknowledgement

This work was supported by Shandong Provincial Natural Science Foundation (ZR2025QE056) and Science and Technology Project of Department of Housing and Urban-Rural Development of Shandong Province.

References

Becker, L. J., & Seligman, C. (1981). Welcome to the energy crisis. *Journal of Social Issues*, *37*(2), 1-7.

Brown, J., & Smith, P. (2021). Enhancing structural engineering education with VR and AR. *Engineering Education Journal*, *38*(5), 205-212.

Hilts, P. J. (1999 February 16). *In forecasting their emotions, most people flunk out*. New York Times. Retrieved November 21, 2000, from http://www.nytimes.com

Laplace, P. S. (1951). *A philosophical essay on probabilities* (F. W. Truscott & F. L. Emory, Trans.). New York: Dover. (Original work published 1814)

Lee, S., & Kim, H. (2018). IoT-based smart monitoring systems in construction. *Automation in Construction*, *94*, 230-240.

Liu, M., & Zhang, L. (1999). Big data applications in structural health monitoring. *Structural Engineering and Mechanics*, *67*(2), 143-150.

Oesterreich, T. D., & Teuteberg, F. (2016). Understanding the impact of Industry 4.0 on the construction industry. *Technological Forecasting and Social Change*, *110*, 1-14.

Publication Manual of the American Psychological Association (5th ed.). (2001). Washington, DC: American Psychological Association.

Rocklin, T. R. (1989). *Individual differences in item selection in computerized self-adapted testing*. Paper presented at the Annual Meeting of the American Research Association, San Francisco, CA.

Ryerson, J. F. (1983). *Effective management training: Two models* (Unpublished master's thesis). College of Technology, Potsdam, New York.

Schwartz, J. (1993, September 30). *Obesity affects economic, social status*. The Washington Post, pp. A1, A4.

Wang, F., Li, Y., & Xu, Y. (2019). Smart construction technologies: Applications, challenges, and future trends. *Automation in Construction*, *98*, 1-10.

Wang, L., & Zhang, H. (2017). Integrating BIM in civil engineering curricula. *Journal of Civil Engineering Education*, *34*(1), 44-53.

Xie, F., & Wang, Y. (2020). The role of artificial intelligence in modern civil engineering. *Journal of Civil Engineering and Technology*, *12*(2), 104-112.

Zhang, P., & Huang, X. (2019). VR-based learning environment for structural mechanics. *Engineering Education Review*, *35*(4), 78-84.

Zhang, X., Liu, S., & Gao, J. (2021). The impact of smart construction technologies on the role of structural engineers. *Journal of Civil Engineering Education*, *38*(4), 233-242.

Zhao, Z., & Li, Y. (2020). Collaborative learning in BIM-based construction education. *Journal of Engineering Education*, *54*(3), 111-118.

Note(s)

Note 1. All data and formulas are summarized from published literature and standard specifications.

Note 2. The calculation method is suitable for precast shear walls with unconnected vertical distributed bars under 6-8 degree seismic fortification intensity.