Application and Study of Notched Over-Beams Based in Masonry

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Abstract. In building engineering, the pipelines in indoor strong and weak electricity boxes are dense. After the construction of autoclaved aerated concrete blocks, the secondary slotting usually leads to serious cracks in the masonry, which causes great inconvenience to the subsequent construction.In order to effectively deal with the common cracking problem of autoclaved aerated concrete block masonry during construction, an innovative fabrication method, i.e., notched over beams, was introduced. Through in-depth analysis, we explored the specific causes of cracks in autoclaved aerated concrete block masonry and found that the notching of the wall during the installation of wires and pipes was one of the causes of the cracks, especially in the indoor location of the electrical box where the installation of wires and pipes was more intensive and complex, the cracking of the masonry was particularly serious. After rigorous problem analysis and optimization, it was decided to make this part of the standard construction process. It effectively enhances the stability, durability, seismicity and integrity of the masonry structure, thus saving a lot of time and cost for the construction of the building.

Keywords: masonry cracking, notched over beams, prefabricated, line pipe trenching

1 Introduction

With the rapid development of the social economy and the fast-paced advancements in construction technology, new building materials are increasingly gaining prominence in the construction industry. These materials not only expand the possibilities for architectural design but also significantly improve construction efficiency, lower project costs, and contribute to environmental sustainability. Among these, autoclaved aerated concrete (AAC) blocks have quickly become a preferred choice due to their many advantages, such as being lightweight, energy-efficient, thermally insulating, fire-resistant, soundproof, cost-effective, and eco-friendly[4]. These attributes have made AAC blocks one of the most popular building materials in recent years.

However, like any material, AAC blocks are not without their drawbacks. One prominent issue is the tendency for masonry structures built with AAC to develop cracks, particularly during the installation of electrical wiring and the slotting of strong and

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weak electrical boxes indoors. Such cracks can compromise the overall structural stability of the building, reduce its strength, and significantly affect its energy efficiency. Addressing these issues is therefore critical to ensuring the successful adoption and broader application of autoclaved aerated concrete blocks.

2 Analysis of Masonry Cracking in Autoclaved Aerated Concrete Blocks

2.1 Factors Contributing to Masonry Cracking

Through a comprehensive investigation of the construction industry, particularly in projects utilizing autoclaved aerated concrete (AAC) blocks, it has become evident that masonry cracking is a common issue and not an isolated phenomenon. The occurrence of these cracks is linked to several factors, including defects in the masonry process, uneven foundation settlement, insufficient material strength, disruptions caused by mechanical and electrical installations, and the overall quality of the building materials (Figure 1).

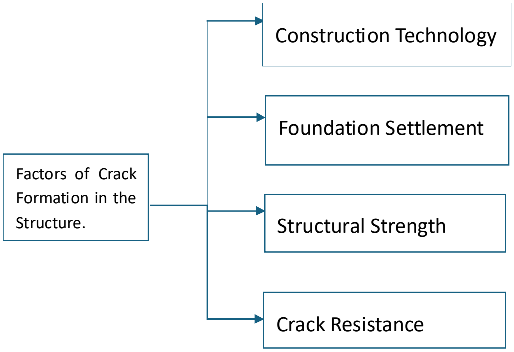

Fig. 1. Factors Contributing to Masonry Cracking

One of the critical contributors is the disruption caused during mechanical and electrical installations, particularly trenching. This process often compromises the continuity of the masonry surface, resulting in cracks. Additionally, the quality of the AAC blocks plays a significant role; low-quality blocks are more prone to cracking and have a reduced service life.

From a structural standpoint, cracks are most found in specific areas:

- Masonry-Shear Wall Junctions: These areas are highly susceptible to cracking due to the concentration of forces.
- Junctions of Frame Beams and Columns: Cracks in these regions often result from the impact of gravity and potential construction errors[5].
- Middle Wall Mortar Joints: Humidity changes and temperature fluctuations can lead to wet expansion and dry contraction, making this another common site for cracks[1].

- Around Window and Door Openings: These areas, exposed to wind and rain over time, tend to experience reduced stability and are vulnerable to cracking.
- Wiring and Tubing Trenches: The stress concentration in newly trenched areas often results in localized cracks.

These factors highlight the importance of addressing both material quality and construction techniques to minimize cracking in AAC block masonry.

2.2 Masonry Cracking Response Initiatives

According to survey research, during the project's construction phase, particularly in the use of autoclaved aerated concrete (AAC) blocks, different factors contribute to varying degrees of masonry cracking. These factors also affect the controllability and difficulty of addressing the cracks. Among the leading causes, line pipe trenching and uneven foundation settlement account for over 57% and 61% of the observed masonry damage, respectively. Trenching for pipe installations poses a challenge as it involves significant mechanical disturbance to the masonry, often requiring extensive repairs, leading to a more complex response to the cracking issue (as shown in Fig. 2).

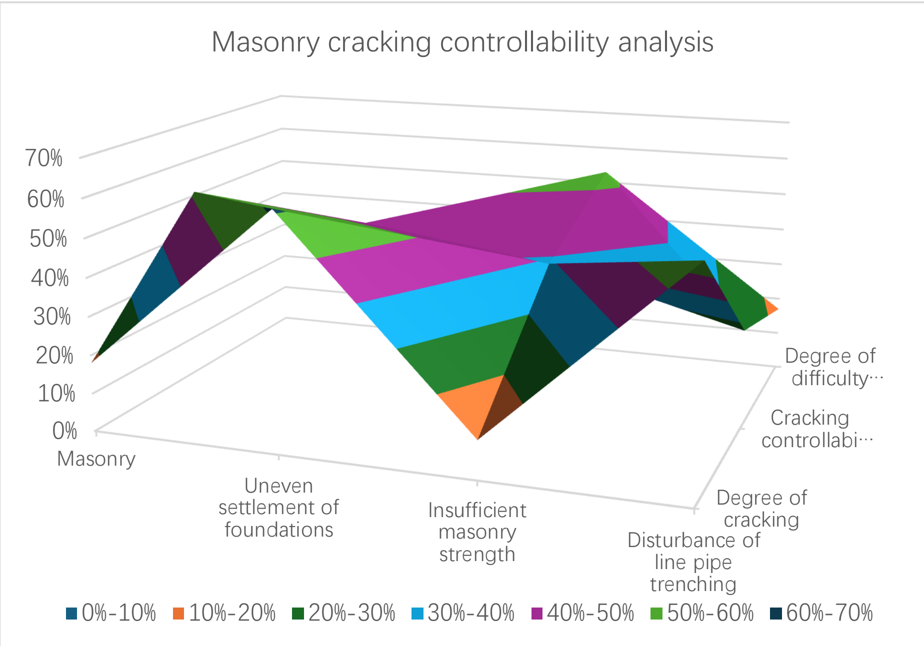

Fig. 2. Masonry Cracking Controllability Analysis

In modern construction, the masonry process is crucial for maintaining a building's structural integrity. While traditional methods often led to minor cracks at mortar joints[2], the adoption of digital and intelligent masonry techniques has greatly minimized this issue. By utilizing high-precision measuring equipment and data analysis, construction teams can accurately control the spacing between blocks, significantly reducing the likelihood of cracking.

2.2.1 Addressing Uneven Foundation Settlement.

Uneven foundation settlement is another common issue that leads to cracking in various parts of the building. The severity and pattern of these cracks are closely related to the extent of the settlement. To prevent this, exhaustive foundation exploration should be conducted before starting masonry work to ensure the foundation's stability and levelness. With advanced exploration tools, potential areas of settlement can be predicted, allowing for proactive measures such as installing temporary supports or employing new foundation reinforcement techniques.

2.2.2 Material Quality and Masonry Strength.

Inadequate material strength is also a significant factor in masonry cracking. To avoid this, high-quality construction materials should be selected according to building codes and material selection standards[3]. These materials must meet both physical property requirements and environmental and safety standards. By adhering to these standards, the durability and reliability of the masonry structure can be ensured.

2.2.3 Minimizing Trenching Impact.

Trenching during the installation of electrical and piping systems is another major contributor to masonry damage. At present, the slotting of autoclaved aerated concrete block masonry conduit is first cut with a cutting machine, and then it is chiseled manually. This method reduces the disturbance to masonry to a certain extent, but it is still insufficient. In masonry, the cutting machine can only cut off the masonry on both sides of the conduit, and the depth of the conduit is still connected with the masonry. Manual chiseling will still disturb the masonry, thus destroying the masonry.

Regardless of the tools used for grooving, some degree of disruption to the masonry is unavoidable. This issue is particularly pronounced in areas requiring dense conduit layouts, such as indoor strong and weak electrical boxes. Since the beams around electrical boxes are typically made from reinforced concrete, the cutting process is more difficult and results in greater disturbances to the masonry[5].

To mitigate this damage, the affected areas must undergo additional reinforcement or masonry re-laying to ensure the building's stability and safety. However, this secondary reinforcement or reconstruction work inevitably increases construction costs.

2.2.4 Optimizing Electrical Box Placement.

In order to carry out in-depth research, the field experiment method and the field investigation method of related housing construction projects are adopted. The field experiment method can flexibly adjust the experimental scheme according to the actual situation, and can make full use of the field resources; The field investigation method can reflect the actual situation and observe the details of the research object in depth.

According to the field experiment and field investigation, in order to reduce the damage of this problem to masonry, the cast-in-place concrete lintel at the location of masonry electric box is optimized. Using prefabricated notch lintel can make up for the deficiency of the disturbance of the existing pipeline slotting on masonry, improve the construction efficiency and improve the construction quality and economy.

3 The Application of Notched Over beam

The application of notched over beams plays a critical role in enhancing the overall stability of building masonry. This design strengthens the structure by increasing its durability and resilience while minimizing the disruptions caused by installing electrical wires and pipes. The notched over beam ensures that the integrity of the masonry is maintained, leading to a more robust and long-lasting structure.

3.1 Difference Between Cast-in-Place and Prefabricated Notched Over beams

There are notable differences between cast-in-place and prefabricated notched over beams, which influence their application in construction:

3.1.1 Production Mode.

Prefabricated beams are produced in a factory or a designated prefabrication site and then transported to the construction site for installation.

Cast-in-place beams, on the other hand, are created by pouring concrete directly on-site, forming the beam in place.

3.1.2 Construction Efficiency.

Prefabricated beams can be produced in a specialized area, unaffected by on-site construction conditions, allowing for greater efficiency in the building process.

Cast-in-place beams require building formwork, concrete pouring, and on-site curing, which can extend the construction cycle.

3.1.3 Quality Control.

The controlled environment of a prefabrication facility allows for better quality control of prefabricated beams.

The quality of cast-in-place beams, however, depends heavily on-site conditions and the skill level of workers, making it more variable.

3.1.4 Cost Considerations.

While the production costs of prefabricated beams might be lower, transportation and installation add to the overall expense.

Cast-in-place beams may incur higher costs in materials and labor, but savings on formwork and scaffolding can be factored in certain scenarios.

Due to the controlled production environment and construction efficiency, prefabricated notched over beams are widely used to meet the specific demands of different construction environments.

3.2 Production Process of Prefabricated Notched Over beams

The production process of prefabricated notched over beams involves several key steps:

3.2.1 Size Determination.

The first step is to determine the dimensions of the beam above the strong and weak electrical boxes, including the size and location of the embedded conduit. These measurements help define the overall size and notch dimensions of the over beam.

3.2.2 Prefabrication Environment Control.

Maintaining a clean and controlled environment is essential during prefabrication, as dust and debris can affect the quality of the final product. To mitigate this, plywood is used as the base material during the prefabrication process to prevent ground contamination and keep the work area orderly.

3.2.3 Formwork Setup.

Using the pre-measured dimensions, formwork is supported using plywood. Before pouring the concrete, a release agent is applied to the surfaces of the formwork that will met the concrete, ensuring easy removal later. Once the formwork is in place, it is reinforced with nails and other supports to prevent deformation during the pouring process.

3.2.4 Reinforcement and Concrete Pouring.

After formwork setup, reinforcing bars (rebar) are arranged according to the design specifications. This step is crucial for increasing the stability and load-bearing capacity of the beam. After rebar placement, concrete is poured into the formwork, and care is taken to avoid any deformation that could compromise the beam's structural integrity (as shown in Fig. 3).

After the reinforcement bars are properly positioned according to the design, fine stone concrete is poured into the formwork. The concrete strength must align with the specifications outlined in the drawings and meet design requirements. During the pouring process, it is essential to ensure that the concrete is densely packed. To achieve this, small vibrating rods are used to vibrate the fine stone concrete, ensuring that the concrete fills all gaps and voids, enhancing its structural integrity and durability (as illustrated in Figure 4).

Fig. 3. Reinforcement Arrangement of Prefabricated Notched Over beam

Fig. 4. Concrete pouring and forming of notched over beams

3.3 Installation of Prefabricated Notched Over beam

The installation of prefabricated notched over beams involves several critical steps to ensure structural integrity and proper alignment. First, the location and size of the electrical power boxes are determined based on the drawings and masonry layout. Mortar is then applied to create a uniform base, followed by the careful placement of the over beam, ensuring that the notched sections align with the pre-embedded conduits to avoid the need for additional cutting. An infrared laser is used to calibrate the perpendicularity and flatness of the over beam, ensuring it meets design and code requirements. Finally, joints between the over beam and the masonry are finished to enhance both stability and aesthetics (as illustrated in Figure 5).

Fig. 5. Prefabricated notched over beam installation

4 Conclusion

This paper has provided an in-depth analysis of the cracking issues observed in autoclaved aerated concrete (AAC) masonry walls, highlighting the key challenges associated with these problems. Through extensive research and practical application, it has been demonstrated that incorporating notched over beams in the design—particularly around indoor distribution boxes—significantly enhances the stability, durability, seismic performance, and overall integrity of the masonry structure. The use of notched over beams also minimizes the need for frequent maintenance, thereby reducing both time and costs associated with building upkeep. This approach not only underscores the importance of high construction quality but also aligns with the principles of sustainable development, making it a valuable technique for the construction industry. However, the subject involves multi-disciplinary fields, and it is inevitable that the study from the perspective of masonry cracking will be superficial and needs to be improved in the future.

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