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Ferrocement to Strengthen Brick Masonry Walls and Beams: A Review

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***Abstract*— Ferrocement is an efficient and economical strengthening material that has gained significant attention for improving the performance of brick masonry walls and beams. This review presents a comprehensive overview of the use of ferrocement composites for retrofitting and strengthening masonry structures subjected to structural deficiencies, aging, and seismic or lateral loads. Ferrocement, consisting of rich cement mortar reinforced with closely spaced wire mesh, offers high tensile strength, crack control, ductility, and improved load-carrying capacity. The review discusses various strengthening techniques such as surface wrapping, jacketing, and overlay systems applied to masonry walls and beams. Experimental and analytical studies reported in the literature demonstrate notable improvements in compressive strength, flexural capacity, shear resistance, and energy absorption of strengthened members. Additionally, ferrocement is highlighted as a cost-effective, lightweight, and easy-to-apply solution suitable for both new construction and retrofitting of existing masonry structures, particularly in developing regions. The review concludes that ferrocement-based strengthening systems provide a promising and sustainable approach for enhancing the durability and seismic performance of brick masonry walls and beams.**

***Keywords*— Ferrocement, Brick masonry, Strengthening, Retrofitting, Structural performance, Durability.**

I. INTRODUCTION

Brick masonry structures are widely used across the world due to their simplicity of construction, availability of materials, and cost-effectiveness. In many developing and developed regions, brick masonry walls and beams form a major portion of residential, commercial, and heritage buildings[1]. However, despite their widespread use, brick masonry structures inherently suffer from low tensile strength, brittle behavior, poor ductility, and limited resistance to seismic and lateral loads. Over time, factors such as aging, environmental exposure, poor construction practices, material degradation, increased service loads, and changes in usage further reduce their structural performance[2]. As a result, many existing masonry buildings are vulnerable to cracking, excessive deflection, and even sudden failure, especially during earthquakes and extreme loading conditions.

Strengthening and retrofitting of brick masonry walls and beams have therefore become essential to enhance structural safety, extend service life, and meet modern design requirements. Conventional strengthening techniques such as reinforced concrete jacketing, steel plate bonding, and fiber-reinforced polymer (FRP) systems have been explored extensively. While these methods can be effective, they often involve high costs, skilled labor, increased dead weight, corrosion issues, or limited compatibility with masonry substrates[3]. In this context, there is a growing demand for strengthening materials and techniques that are economical, durable, lightweight, and easy to apply, particularly for large-scale retrofitting of existing buildings[4].

Ferrocement has emerged as a promising alternative material for strengthening brick masonry structures. Ferrocement is a thin composite material consisting of rich cement mortar reinforced with one or more layers of closely spaced wire mesh or small-diameter steel reinforcement[5]. Due to its high surface-area-to-volume ratio of reinforcement, ferrocement exhibits superior crack control, enhanced tensile strength, improved ductility, and excellent energy absorption capacity compared to conventional concrete. These properties make ferrocement particularly suitable for applications where thin overlays and minimal increase in member size are required[6].

When applied to brick masonry walls and beams, ferrocement can significantly improve flexural strength, shear resistance, stiffness, and overall load-carrying capacity. Strengthening techniques such as ferrocement jacketing, surface plastering, wrapping, and overlay systems have been successfully used to confine masonry elements and delay crack propagation[7]. The compatibility of ferrocement mortar with masonry units ensures good bonding behavior, which is critical for effective stress transfer between the existing structure and the strengthening layer. Moreover, ferrocement systems are relatively easy to apply using locally available materials and semi-skilled labor, making them highly suitable for retrofitting applications in low- and medium-income regions[8].

Another important advantage of ferrocement is its adaptability to different structural configurations and damage conditions. It can be used for strengthening both load-bearing and non-load-bearing masonry walls, as well as masonry beams subjected to flexure and shear[9]. Ferrocement retrofitting has also shown promising results in improving seismic performance by enhancing ductility and energy dissipation capacity, thereby reducing the risk of sudden brittle failure. In addition, ferrocement can be combined with other strengthening approaches, such as confinement bands or anchors, to further enhance structural performance[10].

This review focuses on the application of ferrocement for strengthening brick masonry walls and beams. It presents an overview of material characteristics, strengthening techniques, and key findings from experimental and analytical studies reported in the literature. Emphasis is given to the structural performance improvements achieved through ferrocement retrofitting, including strength enhancement, crack control, ductility, and durability. The review also highlights the advantages, limitations, and practical considerations associated with ferrocement-based strengthening systems, aiming to provide a clear understanding of its potential as a sustainable and cost-effective solution for improving the safety and longevity of masonry structures.

II. LITERATURE SURVEY

Hamilton et al., [1] investigated the flexural behavior of concrete masonry walls strengthened using glass fiber–reinforced polymer (GFRP) systems. The study focused on improving out-of-plane flexural capacity of masonry walls subjected to bending loads. Experimental results showed a significant increase in ultimate load-carrying capacity and crack control after FRP application. Strengthened walls exhibited improved ductility and delayed failure modes compared to unstrengthened specimens. The research also highlighted the importance of proper bonding between masonry and composite layers. The findings demonstrated that externally bonded composites can effectively retrofit deficient masonry walls. This work laid foundational concepts later adopted in ferrocement-based strengthening techniques.

Bureau of Indian Standards, [2] IS 383 (2016) specifies requirements for coarse and fine aggregates obtained from natural sources for use in concrete. The standard defines grading limits, physical properties, and quality criteria to ensure strength and durability of cementitious composites. Proper aggregate selection plays a vital role in ferrocement mortar performance.

Compliance with this standard ensures uniformity, reduced voids, and enhanced bond strength with wire mesh reinforcement. The code also addresses deleterious materials that can affect long-term durability. In ferrocement applications, adherence to IS 383 improves compressive strength and crack resistance. This standard serves as a base guideline for material selection in strengthening works.

Bureau of Indian Standards, [3] IS 1489 (Part 1):2015 provides specifications for fly ash–based Pozzolana Portland Cement (PPC). The standard emphasizes improved workability, reduced heat of hydration, and enhanced durability. PPC is widely used in ferrocement applications due to its fine particles and better bonding characteristics. The inclusion of fly ash helps in reducing shrinkage and micro-cracking in thin ferrocement layers. This cement type also improves resistance against chemical attack and corrosion. The standard supports sustainable construction by encouraging industrial waste utilization. Its use contributes to long-term performance of masonry strengthening systems.

Bureau of Indian Standards, [4] IS 1905 (1987) outlines design and construction guidelines for unreinforced masonry structures. The code discusses permissible stresses, material properties, and construction practices. It highlights the inherent limitations of masonry in tension and seismic resistance. The provisions indirectly justify the need for strengthening techniques such as ferrocement overlays. This standard serves as a reference baseline to evaluate performance improvements after retrofitting. Researchers commonly compare strengthened masonry behavior against IS 1905 limits. Thus, the code plays a critical role in assessing safety enhancement achieved through ferrocement strengthening.

Khan, L. F., [5] Khan studied the effectiveness of shotcrete as a strengthening technique for brick masonry walls. The research demonstrated that thin cementitious overlays significantly increased wall stiffness and load capacity. Shotcrete application improved crack control and reduced lateral displacement under loading. The study emphasized surface preparation and proper curing to ensure bond integrity. Experimental results showed enhanced seismic resistance of strengthened walls. The work established early concepts of surface-applied cement-based retrofitting. These principles later evolved into ferrocement strengthening systems.

Khan Mahmud, [6] Khan Mahmud conducted an experimental investigation on the use of ferrocement laminates for repairing masonry structures. The study evaluated flexural and shear performance of masonry elements retrofitted with ferrocement layers.

Results indicated substantial improvement in strength, ductility, and crack distribution. Multiple layers of wire mesh were found to enhance load-carrying capacity. The research highlighted the importance of anchorage and mesh orientation. Ferrocement repair proved to be cost-effective and easy to apply. This study strongly supports ferrocement as a viable masonry rehabilitation technique.

Kolsch, H., [7] Kolsch proposed a carbon fiber cement matrix (CFCM) overlay system for strengthening masonry. The system combined high-strength fibers with cement-based matrices to enhance structural capacity. Experimental results showed notable improvement in tensile and flexural strength. The cement matrix ensured compatibility with masonry substrates. The study addressed durability concerns associated with epoxy-based FRP systems. Crack control and energy dissipation capacity were significantly improved. This research contributed to the development of advanced cementitious composite overlays similar to ferrocement.

Korkmaz et al., [8] assessed the seismic performance of reinforced concrete structures with masonry infill walls. The study emphasized the influence of infill walls on stiffness, strength, and failure mechanisms during earthquakes. Damage patterns revealed vulnerability of unstrengthened masonry infills. The authors suggested strengthening techniques to improve seismic behavior. Their findings highlighted the necessity of retrofitting masonry elements in seismic regions. Ferrocement overlays were identified as a potential solution due to their ductility. The research supports masonry strengthening for earthquake resilience.

Nayak, G. C., [9] Nayak investigated composite action between masonry and ferrocement using CGI sheet reinforcement. The study explored load transfer mechanisms and crack behavior in composite masonry systems. Experimental results showed improved bending resistance and stiffness. Ferrocement layers effectively controlled crack propagation. The research emphasized the lightweight nature of ferrocement composites. It demonstrated feasibility for low-cost housing applications. This early work contributed to understanding composite masonry–ferrocement behavior.

Plesu et al., [10] reviewed conventional strengthening and rehabilitation methods for masonry structures. The study compared techniques such as jacketing, shotcrete, and composite overlays. Advantages and limitations of each method were discussed. Cement-based methods were found to be compatible with historic masonry. The authors highlighted durability and constructability issues. Ferrocement-type solutions were recognized for their thin section and effectiveness.

The review provides a comprehensive background for selecting appropriate masonry strengthening techniques.

Table 1:
Summary of Literature review

Sr. No.	Author	Year	Work	Outcome
1	Hamilton III & Dolan	2001	Flexural capacity of GFRP-strengthened concrete masonry walls	Significant improvement in flexural strength, crack control, and ductility of masonry walls
2	Bureau of Indian Standards (IS 383)	2016	Specification for coarse and fine aggregates for concrete	Ensured quality aggregates leading to improved strength and durability of cementitious composites
3	Bureau of Indian Standards (IS 1489 Part 1)	2015	Fly ash–based Pozzolana Portland Cement specification	Enhanced workability, durability, and reduced shrinkage in mortar and ferrocement applications
4	Bureau of Indian Standards (IS 1905)	1987	Code of practice for structural use of unreinforced masonry	Provided baseline design limits highlighting need for strengthening of masonry structures
5	Khan, L. F.	1984	Shotcrete strengthening of brick masonry walls	Increased stiffness, load capacity, and crack resistance of masonry walls
6	Khan Mahmud	2007	Ferrocement laminates for masonry repair	Improved flexural and shear strength with better crack distribution and ductility
7	Kolsch, H.	1998	Carbon fiber cement matrix overlay for masonry strengthening	Enhanced tensile and flexural capacity with good substrate compatibility
8	Korkmaz et al.	2011	Earthquake assessment of RC structures with masonry infill walls	Identified seismic vulnerability of infill walls and need for strengthening
9	Nayak, G. C.	1981	Masonry and CGI sheet composite with ferrocement	Demonstrated improved composite action and bending resistance
10	Plesu et al.	2011	Review of conventional masonry strengthening methods	Highlighted effectiveness and limitations of cement-based and composite retrofitting techniques

III. CHALLENGES

Despite the proven effectiveness of ferrocement in strengthening brick masonry walls and beams, several challenges limit its widespread application in practice. These challenges are related to material durability, construction quality, design uncertainty, and long-term performance. Addressing these issues is essential to ensure reliable, safe, and durable ferrocement retrofitting solutions. The major challenges identified from the literature are discussed below.

1. *Corrosion of Wire Mesh:* Steel wire mesh used in ferrocement is vulnerable to corrosion, especially in moist and aggressive environments. Due to the thin mortar cover, moisture can easily reach the reinforcement, leading to rusting. Corrosion weakens the mesh and causes cracking and delamination of the ferrocement layer, reducing its structural effectiveness.
2. *Bonding Issues with Existing Masonry:* Effective strengthening depends on strong bonding between the ferrocement layer and the masonry substrate. Poor surface preparation, weak mortar joints, or improper curing can result in debonding. This prevents proper stress transfer and significantly reduces the load-carrying capacity of the strengthened element.
3. *Absence of Standard Design Codes:* There is a lack of specific design guidelines or codal provisions for ferrocement strengthening of masonry structures. Most designs are based on experimental results or empirical methods. This creates uncertainty in design parameters such as thickness, mesh spacing, and safety factors.
4. *Construction Quality and Workmanship:* Ferrocement application requires careful mesh placement, uniform mortar thickness, and adequate curing. Variations in workmanship can lead to voids, uneven thickness, and poor compaction. Such defects adversely affect strength, durability, and crack resistance.
5. *Long-Term Durability Concerns:* The long-term behavior of ferrocement under environmental exposure such as temperature variations, moisture ingress, and chemical attack is not fully understood. These factors can degrade the mortar and reduce bond strength over time, affecting service life.
6. *Anchorage and Edge Detailing Difficulties:* Proper anchorage of wire mesh at edges, corners, and beam–wall junctions is critical. Inadequate detailing can cause peeling or premature failure under loading. Stress concentration at these locations reduces the effectiveness of the strengthening system.
7. *Limited Seismic Performance Evaluation:* Although ferrocement improves ductility, limited studies have evaluated its performance under cyclic and earthquake loading. The behavior of strengthened masonry during repeated load reversals remains uncertain, especially for seismic retrofitting applications.
8. *Requirement of Skilled Labor:* Successful ferrocement application depends on skilled labor for correct mesh fixing and mortar application. In many regions, lack of trained workers leads to improper installation, resulting in inconsistent performance and reduced reliability.

IV. CONCLUSION

Ferrocement has emerged as a promising and cost-effective technique for strengthening brick masonry walls and beams, offering significant improvements in strength, ductility, and crack control with minimal increase in weight and thickness. The reviewed studies indicate that ferrocement overlays and laminates enhance flexural and shear capacity and improve overall structural performance, particularly for retrofitting existing and deficient masonry structures. However, challenges such as corrosion of wire mesh, bonding issues, lack of standardized design guidelines, and uncertainties in long-term and seismic performance still restrict its large-scale adoption. With proper material selection, quality construction practices, improved detailing, and the development of codal provisions, ferrocement can be effectively utilized as a durable and practical solution for masonry strengthening. Further experimental and field-based research is recommended to establish standardized design methods and validate long-term performance under real service conditions.

REFERENCES

[1] Hamilton III, H. R. and Dolan, C. W. (2001). Flexural Capacity of Glass FRP Strengthened Concrete Masonry Walls , Journal of Composites for Construction, ASCE, 5(3): 170-178.

[2] IS - 383 (2016). “Specification for coarse and fine aggregates from natural sources for concrete.” BIS, New Delhi, India.

[3] IS –1489-2015(Part-1) . "Specification for Pozzolona Portland Cement Part-1 Fly Ash Based." BIS, New Delhi, India.

[4] IS – 1905 (1987). "Indian standard code of practice for structural use of unreinforced masonry (third revision)," BIS, New Delhi, India.

[5] Khan, L.F., (1984), "Shotcrete Strengthening of Brick Masonry Walls," Concrete International, July 1984, pp. 34-40.

[6] Khan Mahmud [2007]Experimental investigation of the use of ferrocement laminates for repairing masonry.

[7] Kolsch H (1998), Carbon fiber cement matrix (CFCM) overlay system for masonry strengthening. Journal of Composites for Construction p:105-109.

[8] Korkmaz et al. (2011), Earthquake assessment of R/C structures with masonry infill wall.

[9] Nayak, G.C., (1981), "The Study of Masonry and CGI Sheet Composite with Ferrocement," Report of Structural Engineering Section, Civil Engineering Department, University of Roorkee.

[10] RalucaPlesu, George Taranu, Daniel Covatariu and Ionut-Dan Gradinariu, Strengthening and rehabilitation conventional Methods for masonry structures", Bulletin of the Polytechnic Institute of Iasi - Construction & Architecture Section 10/2011; 61:165-176.