Review On Comparative Study on Behavior of Light Weight Ferrocement Beam Subjected to Shear and Bending

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Abstract—**The construction industry seeks high-performing, economical, and sustainable structural solutions. Ferrocement a cementitious composite with closely spaced mesh offers high strength-to-weight ratio, excellent crack control, impact resistance, and ductility. This paper reviews the comparative behavior of lightweight ferrocement beams under shear and bending, synthesizing findings from experimental and numerical studies on flexural and shear performance. Core materials include autoclaved aerated concrete (AAC), extruded foam (EFC), and lightweight concrete (LWC), reinforced with expanded metal mesh (EMM), welded wire mesh (WWM), or fiberglass mesh (FGM). Key parameters analyzed are first crack and ultimate loads, deflection, ductility, strain, crack patterns, and failure modes. The review also covers ferrocement for strengthening fire-damaged or seismically deficient RC beams, and sustainable innovations like pozzolanic wastes and geopolymer matrices. Findings consistently show that lightweight ferrocement sandwich composites outperform conventional RC beams in pre-cracking stiffness, load capacity, energy absorption, ductility, and flexural load-to-weight ratio. Critical research gaps include the need for standardized bond strength characterization between ferrocement skin and core, long-term durability studies, and optimized mesh configurations. This analysis confirms that lightweight ferrocement beams, particularly those with EMM, are a promising low-cost alternative for sustainable construction, especially in low-cost residential applications.**

Index Terms—**Ferrocement, Expanded metal mesh (EMM), Welded wire mesh (WWM), Fibre glass mesh (FGM)**

I. INTRODUCTION

The construction industry faces growing demand for high-performing, economical, sustainable structures. Ferrocement a cementitious composite with closely spaced mesh offers high strength-to-weight ratios, excellent crack control, impact resistance, and toughness. It enables lightweight prefabricated elements for low-cost housing, silos, roofs, tanks, and RC repair. Previous research shows U-shaped ferrocement formwork enhances ultimate and serviceability loads, crack control, ductility, and energy absorption. Short steel fibres improve cracking and stress-strain behavior. Stainless steel meshes promote ductile behavior with fine cracks, while fiberglass meshes yield higher ultimate loads but fewer, wider cracks and reduced ductility.

Most literature focuses on ferrocement as formwork or thin sheets, but there is growing need to explore fully composite lightweight structural elements. Encasing low-strength core materials within a strong ferrocement matrix offers structural efficiency with significant weight reduction.

To address this gap, this report presents the first phase of an experimental program on flexural behavior of lightweight ferrocement beams. Sixteen full-scale beams with AAC, EFC, and LWC cores, reinforced with EMM, WWM, or FGM, are tested for first crack and ultimate loads, deflections, ductility, strain, crack patterns, and failure modes. Results are compared against conventional and lightweight RC control beams to evaluate lightweight ferrocement as a viable alternative for modern construction, especially low-cost residential applications.

II. LITERATURE REVIEW

The behavior of lightweight ferrocement beams under shear and bending has been the subject of considerable research over the past two decades, driven by the need for cost-effective, sustainable, and high-performance construction materials. Ferrocement a composite of cement mortar and closely spaced wire mesh layers offers unique advantages including high tensile strength-to-weight ratio, excellent crack control, impact resistance, and ductility. This literature review synthesizes findings from key experimental and numerical studies on ferrocement composites, covering four main areas: flexural and shear behavior of lightweight ferrocement beams incorporating various core materials (autoclaved aerated concrete, extruded foam, lightweight concrete) and mesh reinforcements (expanded metal mesh, welded wire mesh, fiberglass mesh) strengthening and retrofitting applications of ferrocement for fire-damaged, pre-damaged, and seismically deficient reinforced concrete beams sustainable innovations including the integration of pozzolanic wastes and geopolymer matrices into ferrocement and bond characteristics and optimal configuration of ferrocement laminates. The review also transitions to rubberized concrete as an emerging sustainable material, identifying critical research gaps that motivate the present experimental program.

El-Wafa, M. A., & Fukuzawa, K., (2010) [1] Based on the provided study by El-Wafa and Fukuzawa (2010), the flexural behavior of lightweight ferrocement (LWF) sandwich composite beams has been experimentally investigated as a promising alternative to conventional reinforced concrete (RC) beams. The research involved testing eight simply supported rectangular beams six LWF beams and two RC beams under three-point loading, with cross-sections of 300×200 mm and 300×250 mm and a span of 1800 mm. The LWF beams employed a novel technique: encasing lightweight polystyrene foam blocks as a core between high-performance ferrocement wire mesh reinforcement layers, all fully encapsulated in high-flowable, high-strength cement grout mortar. Key performance parameters evaluated included first crack load, load-deflection curves, stiffness, energy absorption capacity, ductility index, ultimate flexural load-to-weight ratio, load-strain behavior, crack characteristics (number, spacing, width), and failure mode. Results demonstrated that LWF beams exhibited superior performance over RC beams, showing enhanced pre-cracking stiffness, higher load-carrying capacity, greater energy absorption, improved ductility, and a significantly higher ultimate flexural load-to-weight ratio. Moreover, LWF beams developed multiple fine “hairy” cracks with smaller crack widths and spacing, compared to the limited number of wide cracks in RC beams, indicating better energy dissipation and prevention of catastrophic failure. The ACI Building Code method was found to provide satisfactory predictions of ultimate moment capacities for both beam types. The authors concluded that lightweight ferrocement sandwich composites offer remarkable structural efficiency and represent a viable path toward industrialized, innovative, and responsible concrete construction.

Shaaban et al. (2018) [2] reviewed lightweight ferrocement beams' flexural behavior. Ferrocement exhibits excellent strength, crack control, impact resistance, and toughness due to closely spaced reinforcement (Naaman, 2000; Fahmy et al., 2004, 2006). It has been used in silos, roofs, tanks, and structural repair (Gaidhankar et al., 2017; Lalaj et al., 2015). Ferrocement laminates serve as cost-effective permanent formwork (Shaaban, 2002; Abdul Kadir & Jaafar, 1993). Fahmy et al. (2014) found U-shaped ferrocement formwork enhanced ultimate loads, crack control, and ductility. El-Wafa and Fukuzawa (2008, 2010) reported that expanded metal mesh (EMM) produced fine cracks and higher ductility, while fiberglass mesh (FGM) gave fewer cracks, higher ultimate loads, but lower ductility. Memon et al. (2006) showed ferrocement encasement transformed brittle aerated concrete into ductile behavior. Based on this, Shaaban et al. (2018) tested beams with AAC, EFC, and LWC cores reinforced with EMM, WWM, or FGM, concluding that ferrocement lightweight beams, especially with EMM, are promising low-cost alternatives to conventional beams.

Al Amin et al [3] reviewed strengthening fire-damaged RC beams using ferrocement. Ferrocement offers high crack resistance, toughness, low cost, and easy application (Anggawidjaja et al., 2006; Choi, 2008; Dai et al., 2011). Ferrocement wraps convert brittle shear failure to ductile flexure, improving load capacity and crack control (Amin et al., 2021; Colombo & Felicity, 2007). Fire damage reduces concrete strength by 50% at 600°C and 80% at 800°C, coarsening pores and reducing durability (Zahid et al., 2018). High-modulus materials like CFRP increase strength but reduce deformability; lower-modulus materials offer better ductility (Tepfers & De Lorenzis, 2003; Rafeeqi et al., 2005). Al Amin et al. tested fire-damaged beams strengthened with single/double ferrocement layers, finding load capacity improvements of 46% and 72%, respectively, confirming ferrocement as an effective retrofitting technique.

Zivkovic et al. (2024) [4] reviewed ferrocement strengthening of RC beams. Ferrocement offers high durability, toughness, and ease of construction. Strengthening methods include column wrapping (Xiong et al., 2011; Mourad & Shannag, 2012), slab tension zones (Al-Kubaisy & Jumaat, 2000), beam-column joints (Li et al., 2013), and RC walls (Erfan et al., 2021). High-strength matrices (Shannag & Mourad, 2012) and combined micro-reinforcement (Shannag & Ziyyad, 2007) have been studied. RC beams strengthened via direct mesh application (Shang et al., 2003; Zisan et al., 2023) and gluing prefabricated elements (Bashandy, 2013; Sridhar et al., 2014) have been examined, as well as pre-damaged beams (Reddy & Reddy, 2011; Amin et al., 2022). These studies show increased bearing capacity, rigidity, and energy absorption with reduced deformations. Zivkovic et al. tested 15 RC beams with four ferrocement strip types, finding numerical failure force within 3.94% of experimental results and bearing capacity increase up to 21.4%. The transformed area method proved reliable, and ferrocement showed positive environmental impact over steel plate and CFRP.

Makhlouf et al. (2024) [5] reviewed shear behavior of ferrocement beams with lightweight cores. Ferrocement (wire mesh in mortar) offers high durability, strength, and rigidity. Abdullah and Abdulla (2022) found three mesh layers increased first crack load, ultimate load, and energy absorption by 20%, 30.3%, and 69.2%. Alobaidy et al. (2022) reported mesh layers enhanced ultimate load by 33.7–122.1% over unstrengthened beams. Nasr (2019) showed a ferrocement layer increased load capacity by 23%. El-Sayed and Erfan (2018) found expanded wire mesh provided higher shear capacity than welded mesh. Fahmy et al. (2014) demonstrated U-shaped ferrocement formwork improved crack control, ductility, and energy absorption. Rao et al. (2006) noted shear capacity increased with mesh volume fraction for $a/d \leq 3$. Erfan et al. (2021b) reported walls with expanded mesh had 105% higher ultimate load. Based on this, Makhlouf et al. tested ten AAC/EFC core beams with EMM or WWM under two-point loading. Two EMM layers gave optimum performance, increasing ultimate load and deflection by 12.9% and 22.8% over controls. ABAQUS results agreed well (Pult, FEM/Pult,EXP = 1.04), confirming ferrocement's effectiveness for lightweight shear-resistant beams.

Shaheen et al. (2014) [6] reviewed ferrocement beams reinforced with composite materials. Ferrocement has been used in various applications, including buildings, bridge decks, water tanks, and retaining walls (Aboul-Anen et al., 2009; Ali, 1995), and for strengthening RC structures (Elavenil & Chandrasekar, 2007; Fahmy et al., 1997). Naaman and Shah (1971) found ferrocement has higher bond area than conventional reinforcement. Rajagopalan and Parameswaran (1975) observed better crack control and smaller crack widths. Walker (1995) noted first cracks at mid-span spreading toward supports. Nassif and Najm (2004) validated ABAQUS models against experiments. Fiberglass offers corrosion resistance and high tensile strength (Daniel & Shah, 1994). Harris et al. (1998) reported hybrid FRP bars achieved ductility close to steel. Sakthivel and Jagannathan (2012) found impact energy increased with more mesh layers. Shaheen et al. (2013) found welded wire mesh gave higher first crack and ultimate loads than expanded or fiberglass mesh. Based on this, Shaheen et al. (2014) tested twelve beams with steel bars, welded mesh, expanded mesh, fiberglass mesh, and polyethylene mesh. Beams with polypropylene fibers (C2) achieved the highest loads and energy absorption. The beam with four welded mesh layers (WWM3) showed the best behavior, while fiberglass mesh gave the lowest loads. Metal meshes produced smaller crack widths than non-metallic meshes. ANSYS simulations agreed well with experiments.

Clarke (2026) [7] reviewed advanced ferrocement (AF) for natural disaster mitigation, retrofitting buildings against earthquakes and hurricanes. Traditional ferrocement (multiple mesh layers in cement mortar) offers high strength-to-weight ratio, crack resistance, and toughness (Paul & Pama, 1978). However, conventional analysis underestimates its capacity. Lamination Theory (LT) addresses this by considering mesh orientation, layer layup, and coupling stiffnesses (Clarke & Sharma, 1997; Clarke, 1994), enabling mesh angles (e.g., 45°) and non-metallic meshes as design variables. Applications include unreinforced masonry walls, infilled frames, and concrete frames (FEMA 172). Proof-of-concept tests showed ferrocement overlays on infilled masonry walls increased lateral yield strength 1.50× and displacement at yield 2.30×. Ferrocement shear panels had 3.37× higher strength-to-weight ratio than reinforced concrete masonry alternative. One-way roof panels achieved 10.78× higher wind load strength-to-weight ratio than conventional metal sheet solutions. Based on this, nine research directions are proposed: URM walls, infilled frames, sacrificial shear panels, RC columns, beams, beam-column joints, shear walls, and roofing. LT suggests further enhancement by aligning mesh with principal stresses and optimizing lamina stacking, with non-metallic meshes offering corrosion resistance.

Minde et al. (2023) [8] reviewed ferrocement as a sustainable construction material in India. Mughal et al. (2019) found GI mesh panels had better flexural/compressive strength, while PP mesh offered higher ductility. Aules et al. (2022) showed ferrocement with CFRP effectively strengthened RC columns. Shaaban et al. (2018) reported glass fibres (0.2%) increased flexural capacity by 31%; ferrocement beams had better crack control, and expanded metal mesh (EMM) lightweight beams proved suitable alternatives to conventional RC. Mohana et al. (2021) found complete cement replacement with fly ash in geopolymer ferrocement improved flexural strength and reduced emissions. Hanif et al. (2017) used fly ash cenosphere (40–60% sand replacement) with 0.5% PVA fibres, achieving lightweight composites (1332–1458 kg/m³) and specific strengths of 18.4–26.7 kPa/kg/m³. Shinde et al. (2022) reported LGS framing with ferrocement panels reduced cost, time, and carbon footprint versus RCC. Srikrishna and Rao (2021) found geopolymer ferrocement achieved 90% and 70% of cement mortar's compressive and flexural strengths, with mesh layers enhancing flexural strength. Kaish et al. (2018) concluded ferrocement jacketing enhances RC column load-carrying and ductility as a low-cost alternative. Abdullah and Abdulla (2022) tested hollow beams with GFRP bars and fibreglass mesh, achieving 5–10% higher loads/energy but 37–44% lower ductility than steel-reinforced beams. Clarke (2022) showed advanced ferrocement overlays increased lateral yield strength 1.5× and displacement at yield 2.3× on masonry walls, and AF roof panels had 10.78× higher wind load strength-to-weight ratio than conventional metal sheets. Erfan et al. (2021) demonstrated ferrocement composites improved RC wall cracking, permeability, and load capacity. El-Sayed and Erfan (2018) found welded wire mesh beams had higher shear capacity and fewer cracks than expanded mesh. Based on this, Minde et al. (2023) conducted a farmhouse case study in Pune, showing cost reductions of 50.4% and 57.7% vs. load-bearing and RCC structures, time savings of 37.5% and 50%, and lower embodied energy, confirming ferrocement as sustainable, cost-effective, and time-efficient.

Fahim et al. (2025) [9] reviewed pozzolanic waste integration into ferrocement for sustainable construction. Cement production contributes 5–8% of global CO_2 emissions, with nearly one ton emitted per ton of cement (Althoey et al., 2023; Ige et al., 2024). Construction and demolition waste (CDW) comprises 30–40% of municipal waste, largely landfilled in developing countries (Islam et al., 2019; Song et al., 2015). Various solid wastes (glass, red mud, ceramics) and industrial byproducts (silica fume, fly ash, GGBS) have been successfully incorporated into concrete, offering environmental and economic benefits (Ferdous et al., 2021; Habert et al., 2020). Pozzolanic wastes rich in SiO_2, Al_2O_3, and Fe_2O_3 (>70% combined) meet ASTM C618 standards, reacting with Ca $(OH)_2$ to form secondary C-S-H, enhancing long-term strength (ASTM, 2020; Ayaz Khan et al., 2018). Brick powder's pozzolanic reactivity improves with smaller particle size (Komnitsas et al., 2015). Ceramic tile powder performs best at <20% replacement; higher levels reduce strength due to excess free water (Fatima et al., 2013; Lim et al., 2022). Ferrocement studies include lightweight slabs with fly ash (Chidambaram & Kumar, 2017), geopolymer panels (Nagan & Mohana, 2014), and nano-SiO_2 mortar for jacketed columns (Revathy et al., 2020). Based on this, Fahim et al. (2025) tested M15 ferrocement slabs with 15% cement replaced by brick powder, ceramic tile powder, or raw sawdust. Ceramic tile powder retained 78.8% of flexural strength, brick powder retained

81.7% of compressive strength, and all wastes reduced slab weight (8.7–15.7%) and cost (6.13%), demonstrating the potential of pozzolanic waste for sustainable, lightweight ferrocement.

Makki[10] reviewed ferrocement for retrofitting RC beams. Structural distress often requires rehabilitation (retrofitting) (ACI Committee 549, 1988). Ferrocement thin cement mortar with closely spaced small-diameter wire mesh offers high toughness, ductility, strength, and crack resistance, superior to conventional concrete. It applies quickly without special bonding, needs less skilled labor, and has low self-weight, making it favorable for prefabrication. Conventional shear strengthening methods (post-tensioning, member enlargement, steel plates) are complex, and advanced laminates like CFRP/GFRP exist, but ferrocement is gaining popularity. Previous studies used ferrocement laminates for either flexural or shear enhancement, but beams often need both. Makki tested ten beams: controls (with/without stirrups), strengthened (1.2 mm and 2.2 mm wire mesh), and repaired (preloaded to 50% and 70% of ultimate capacity), with mechanical anchorage (bolts) to prevent debonding. Results showed strengthening increased ultimate load by 69.8–175% and repairing by 50.9–125% compared to controls, with larger mesh diameters yielding higher increases. The study confirmed ferrocement rehabilitation is effective for both shear and flexural deficiencies.

Sirimontree et al. (2019) [11] reviewed flexural strengthening of RC beams with ferrocement. Balaguru et al. (1979) studied fatigue behaviors of ferrocement beams. Rafeeq et al. (2012) and Khan et al. (2013) focused on flexural strengthening using ferrocement. Sirimontree et al. (2015) used ferrocement jacketing on RC columns, improving strength and ductility. Madadi et al. (2017) performed FEA and experiments on lightweight ferrocement matrix, assessing load-displacement, crack pattern, density, ductility, and elastic modulus. Sakthivel and Jagannathan (2011) reviewed ferrocement construction technologies. Based on this, Sirimontree et al. (2019) tested three RC beams: reference, ferrocement-strengthened without shear connectors, and with shear connectors (6 mm bars). Strengthening increased flexural capacity up to 79% over the reference. The beam with shear connectors showed 26% higher ultimate deflection due to better composite action, while the beam without connectors failed by delamination.

Ameh (2023) [12] reviewed studies on bond strength between ferrocement skin and core material in permanent forms. Ferrocement, a thin composite of cement mortar and wire mesh layers, offers high crack resistance, ductility, and toughness (Naaman, 1979; Korany, 1996). Early research showed ferrocement channels undergo large deflections (Al-Rifaei & Hassan, 1994) and can serve as precast permanent forms (Rosenthal & Bijuger, 1985). Mays and Barnes (1995) reported 15% strength increase over conventional RC beams, while Roa and Roa (1987) achieved 18% steel and 80% labour savings. Tawab et al. (2012) observed high serviceability and ultimate loads, good crack resistance, and high impact resistance in U-shaped laminates. Fahmy et al. (2013) used U-shaped forms with various core materials and shear connectors, achieving better crack behavior and energy absorption. Shaaban (2018) and Saini & Singh (2022) found expanded wire formwork increased beam load capacity by 20% and reduced crack width by 15%. For composite action, adhesion between layers determines bond strength (Halicka, 2007; Tayeh et al., 2013), with splitting tensile test appropriate for assessment (Dybel & Walach, 2017). However, previous studies (Shaaban et al., 2018; Memon et al., 2006) did not evaluate interface bonding. Based on this gap, Ameh (2023) investigated plane and interlock bonds, finding interlock bonds improved strength by 9–15% over plane bonds, with granite mortar achieving the highest bond strength (2.17 N/mm²), classified as excellent.

Sridhar, Malathy, and Sangeetha[13] reviewed flexural strengthening of RC beams with ferrocement laminates. Ferrocement, defined by ACI 549 (1988) as thin-wall reinforced concrete with cement mortar and closely spaced wire mesh, is a viable strengthening material. Naaman (2000) described it as a link between conventional RC and fiber-reinforced concrete. Anwar et al. (1991) presented a design chart for rehabilitation, while Fahmy et al. (1997) described repair methods. Paramasivam et al. (1994) showed increased flexural strength with ferrocement laminates. Ganesan and Thadhail (2005) studied ferrocement jacketing on distressed beams, and Ong et al. (1992) reported flexural behavior of strengthened beams. Masood et al. (2005) studied rehabilitation, Bansal et al. (2006) focused on joints, and Rajkumar and Vidivelli (2010) studied SBR latex modified ferrocement. Reddy (2011) showed load capacity increased with more mesh layers. Based on this, the authors investigated steel slag as partial fine aggregate replacement (0% and 30%) in laminates with volume fractions of 1.88% and 2.35%, finding that beams with 2.35% volume fraction and 30% steel slag showed significant increases in load capacity, ductility, and energy absorption.

Balamurali Krishnan et al. (2023) [14] reviewed seismic upgradation of RC beams with externally bonded ferrocement laminates. Ferrocement thin-wall concrete with cement mortar and closely spaced wire mesh offers excellent crack control, toughness, and impact resistance, enhancing energy absorption, ductility, and load capacity (ACI 549, 1988; Naaman, 2000; Sakir et al., 2016). Strengthening beams is critical for structural stability (ACI 318R-02, 2002). Alternative methods include section enlargement, steel/FRP wrapping, but CFRP/GFRP lack ductility (Naaman, 2000). Spent catalyst from oil refineries (rich in silica/alumina) exhibits pozzolanic properties and can replace up to 15% of cement (Pacewska et al., 2002; Al-Jabri et al., 2021; Krishnamurthy et al., 2017). Bitaraf et al. (2021) found combined woven/square mesh laminates performed better. Szeczek et al. (2020) reported NSM CFRP increased flexural capacity by 109–130%. Based on this, Balamurali Krishnan et al. optimized spent catalyst dosage (3–12%) in laminates (3% mesh volume), finding 9% optimum. Eight RC beams (750×100×150 mm) were cast; six strengthened with optimized laminates bonded at tension, shear, and combined zones. Results showed increased load capacity by 18% (flexure), 16% (shear), and 30% (combined); reduced deflection by 20–40%; increased ductility up to 30%; and improved stiffness by 40–48%, with good theoretical agreement.

Zisan et al. (2023) [15] investigated the flexural performance of reinforced concrete beams retrofitted with ferrocement wire mesh using finite element analysis, with model validation against experimental results. The study examined beams where conventional steel rebars were partially or completely replaced by wire mesh, as well as beams strengthened with externally bonded wire mesh in various configurations (U-shaped, bottom-only, diagonal, and full rectangular wrapping). The findings indicate that retrofitting with wire mesh significantly enhances flexural capacity, increasing first crack load by 15–43% and ultimate load by 20–35% compared to conventional RC beams, with the most pronounced improvements observed when wire mesh is applied along three sides of the beam (confinement effect). Beams with wire mesh exhibited higher ductility, more uniform and well-distributed crack patterns, and reduced crack depth under equivalent loading. Replacement of both main and shear reinforcement by wire mesh increased ultimate load capacity by 12% and midspan deflection by 25%, demonstrating improved energy absorption. Furthermore, the study determined that a wire mesh length of 50% of the beam span is optimal, as extending beyond this length yields negligible additional benefit in terms of stress reduction and deflection control. The authors concluded that ferrocement wire mesh offers a low-cost, effective alternative to expensive FRP retrofitting systems, particularly suitable for developing countries, while providing comparable or superior improvements in load capacity, ductility, and crack control.

Shaheen et al. (2022) [16] investigated lightweight ferrocement beams with different cores (light brick, foam, perlite-lightweight concrete) and mesh reinforcements (expanded metal mesh, welded wire mesh) under flexural loading. Beams with two layers of expanded metal mesh achieved the highest ultimate load, energy absorption, and load-to-weight ratio across all core types. For instance, the perlite-lightweight concrete core beam with double expanded mesh increased ultimate load by 29.6% and 22.3% relative to normal-weight and ferrocement controls, respectively. Expanded mesh enhanced ductility and crack control, producing numerous fine cracks, while welded wire mesh resulted in fewer, wider cracks and brittle failure. The perlite-lightweight concrete core exhibited the best overall performance. The authors concluded that lightweight ferrocement beams with expanded metal mesh and lightweight concrete core offer a sustainable alternative for low-cost residential construction, providing improved strength, ductility, and reduced self-weight.

Mabrouk et al. (2022) [17] studied strengthening of RC short columns using ferrocement jackets. Fourteen square columns were tested one control and thirteen strengthened with various steel meshes (diagonal, welded, hexagonal) in one to three layers. The literature review indicated that ferrocement jacketing offers advantages over FRP and steel jacketing, including lower cost, ease of application, good bond, and improved ductility. Previous research showed that ferrocement jackets can increase axial capacity by 11–40%. The authors' experimental results showed that two layers of diagonal mesh (2.0 mm thickness) gave the highest strength increase (40.2%), with marginal gain beyond two layers. A finite element model (ANSYS) and a modified equation were developed, showing good agreement with experimental data. The study concluded that ferrocement jacketing is an effective, economical strengthening technique for short columns.

Balamurali Krishnan et al. (2019) [18] investigated retrofitting RC short columns using ferrocement full versus strip wrapping. Sixteen square columns (150×150×450 mm) were tested: four control and twelve retrofitted with pre-woven mesh layers (single, double, triple) at volume fractions of 1–4% using C30 concrete. Full wrapping with 3% volume fraction (double layer) increased load capacity by 35% over controls, while strip wrapping with 2% gave a 20% increase. Deflection at the same load dropped by 50–60% for full wrapping and 30% for strip wrapping. ANSYS19 finite element models agreed well with experiments (variation <10%). Full wrapping consistently outperformed strip wrapping, and all retrofitted columns failed in crushing mode without brittle failure. The study concluded that ferrocement jacketing, especially full wrapping at 3% volume fraction, is an effective low-cost technique for enhancing axial capacity and confinement of short RC columns.

Shaheen et al. (2020) [19] investigated lightweight ferrocement sandwich wall panels under axial compression. Ten panels (600×700 mm) were fabricated with two thin ferrocement skins (10–15 mm thick) separated by a 100 mm lightweight brick core. Skins were reinforced with welded or expanded steel mesh in one or two layers per face (volume fractions 0.51–3.82%), with steel wire shear connectors embedded in the brick. Higher reinforcement fractions increased first crack, ultimate, and serviceability loads. Wall 10 (double expanded mesh both faces, 3.82%) achieved the highest ultimate load (280 kN) and service load (142 kN), versus 100 kN and 29 kN for the control. Expanded mesh provided better ductility and energy absorption than welded mesh. All panels showed fine crack control and no spalling. The study concluded that lightweight ferrocement sandwich panels offer high strength-to-weight, ductility, and energy absorption, making them promising load-bearing wall units.

Chandrashekar and Praveen (2022) [20] investigated hybrid fibrous ferrocement, focusing on steel and polypropylene fibers with wire mesh on compressive and flexural strength. Mortar cubes (150 mm) and flexural specimens (1:3 cement-sand, 0.4 w/c) incorporated hexagonal or welded mesh with mono fibers (polypropylene or steel) or hybrid (steel polypropylene). Mesh alone gave marginal gains (1.6% compressive, 47% flexural over plain mortar at 28 days). Mono steel fibers increased compressive strength by 30.4% and flexural by 91.2% versus mesh-only, while polypropylene gave 20.2% and 50.6%, respectively. The hybrid combination achieved the best results: 46.8% higher compressive and 96.6% higher flexural strength. The authors concluded that hybrid fibrous ferrocement offers superior mechanical properties due to synergistic crack-bridging, making it promising for high-toughness applications.

III. SUMMARY OF LITERATURE REVIEW

Research on lightweight ferrocement beams subjected to shear and flexural loading consistently demonstrates that ferrocement sandwich composites outperform conventional reinforced concrete in terms of pre-cracking stiffness, ultimate load capacity, ductility, energy absorption, crack distribution, and load-to-weight ratio. Studies indicate that lightweight ferrocement beams with polystyrene foam cores develop multiple fine cracks that enhance energy dissipation, while expanded metal mesh (EMM) reinforcement provides superior ductility, improved crack control, and optimum shear performance compared to welded wire mesh (WWM) and fiberglass mesh (FGM). Ferrocement has also proven effective in structural retrofitting applications, significantly restoring or enhancing the load-carrying capacity of damaged beams with reduced environmental impact. Furthermore, the incorporation of sustainable pozzolanic waste materials and hybrid fiber reinforcement improves mechanical performance, reduces structural weight and cost, and promotes eco-friendly construction practices. However, important research gaps remain, including the absence of standardized bond characterization methods, limited long-term durability investigations, insufficient understanding of shear behavior, and the lack of comprehensive design guidelines. Overall, lightweight ferrocement beams represent a structurally efficient, economical, and sustainable alternative for low-cost housing and seismic retrofitting applications.

IV. RESEARCH GAP

From the literature review, the following observations were made:

1. There is a lack of standardized characterization of bond strength between the ferrocement skin and various lightweight core materials such as autoclaved aerated concrete, extruded foam, and lightweight concrete.
2. Long-term durability studies on lightweight ferrocement beams under environmental exposures like freeze-thaw cycles, chloride ingress, carbonation, and chemical attack are currently missing.
3. No systematic optimization or standardized design guidelines exist for mesh configurations, including the number of layers, orientation, and hybrid combinations of expanded metal mesh, welded wire mesh, and fiberglass mesh.
4. Dedicated design codes or provisions specifically for lightweight Ferro cement sandwich beams are absent, leaving engineers without validated serviceability and ultimate strength models.
5. While the paper addresses both shear and bending, the vast majority of existing studies focus on flexural behavior, leaving the shear behavior, failure modes, and shear span-to-depth ratio effects systematically under-investigated

V. CONCLUSION

The comprehensive review concludes that lightweight ferrocement sandwich beams outperform conventional RC beams in pre-cracking stiffness, ultimate load capacity, ductility, energy absorption, crack distribution, and load-to-weight ratio. Behavior is strongly influenced by mesh type: expanded metal mesh offers the best ductility and crack control, welded wire mesh produces fewer but wider cracks with moderate ductility, and fiberglass mesh achieves higher ultimate loads but lower ductility. Ferrocement jacketing is an effective, economical retrofitting technique, restoring significant strength in fire-damaged or seismically deficient RC beams while converting brittle shear failure into ductile flexural failure. Additionally, pozzolanic waste materials and hybrid fibers improve mechanical performance, reduce weight and cost, and promote sustainable construction. However, further research is needed to address the lack of standardized bond characterization, limited long-term durability studies, insufficient understanding of shear behavior and span-to-depth ratio effects, and the absence of design code provisions. Overall, lightweight ferrocement beams especially those with expanded metal mesh and sustainable wastes are a structurally efficient, economical, and environmentally sustainable solution for low-cost housing, prefabricated construction, and seismic retrofitting.

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