# Analytical study on hollow core ferrocement slab using partial replacement of recycled fine aggregate

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***Abstract*—The construction industry is one of the largest consumers of natural resources, particularly river sand used as fine aggregate in concrete production. Excessive extraction of natural sand has resulted in severe environmental degradation and depletion of available resources. Simultaneously, the generation of construction and demolition waste has increased significantly due to rapid urbanization, creating disposal and environmental challenges. Recycling fine aggregate obtained from demolished concrete provides a sustainable alternative for reducing environmental impacts while conserving natural resources. Ferrocement, a thin composite material consisting of cement mortar reinforced with closely spaced wire mesh, offers excellent strength-to-weight ratio, crack resistance, and structural efficiency. Incorporating recycled fine aggregate into ferrocement members can further enhance sustainability without significantly compromising structural performance. The present analytical investigation evaluates the structural behaviour of a hollow core ferrocement slab prepared using partial replacement of natural fine aggregate with recycled fine aggregate. The study primarily focuses on reducing slab self-weight while maintaining adequate structural performance. A hollow core configuration is adopted to improve structural efficiency by reducing dead load without substantially affecting load-carrying capacity. The analytical investigation was carried out using ABAQUS finite element software to evaluate deformation characteristics, stress distribution, and overall structural response under loading. Load calculations were performed in accordance with relevant Indian Standard provisions for dead and live loads. The analytical results include deformation behaviour, stress–strain response, load–deflection relationship, time–displacement characteristics, and interaction behaviour of the slab. The analytical observations indicate that hollow core ferrocement slabs incorporating recycled fine aggregate demonstrate satisfactory structural performance while offering significant advantages in sustainability, reduced material consumption, and lower self-weight. The study confirms that recycled fine aggregate can be effectively utilized in ferrocement structural members, thereby promoting environmentally responsible construction practices and encouraging the circular utilization of construction and demolition waste in modern infrastructure development.**

***Index Terms*—Ferrocement, Hollow Core Slab, Recycled Fine Aggregate, ABAQUS Analysis, Sustainable Construction, Finite Element Analysis, Construction and Demolition Waste.**

## I. INTRODUCTION

Concrete continues to be the most extensively used construction material because of its versatility, durability, and economic feasibility. However, the increasing demand for natural aggregates, particularly river sand, has resulted in serious environmental concerns including riverbed degradation, ecological imbalance, and depletion of natural resources. Simultaneously, the rapid expansion of infrastructure has generated enormous quantities of construction and demolition waste, much of which is disposed of in landfills, creating significant environmental challenges.

One sustainable solution to these issues is the utilization of recycled fine aggregate (RFA) obtained from construction and demolition waste. The use of recycled aggregates reduces landfill disposal, conserves natural resources, minimizes transportation requirements, and supports circular economy principles. Numerous researchers have demonstrated that recycled fine aggregate can successfully replace a portion of natural sand in concrete production while maintaining acceptable engineering properties.

Ferrocement is a thin composite structural material consisting of cement mortar reinforced with multiple layers of closely spaced wire mesh. Due to its high tensile resistance, crack control capability, impact resistance, and excellent strength-to-weight ratio, ferrocement has found widespread application in slabs, shells, tanks, roofs, marine structures, and rehabilitation works. The present research investigates the analytical behaviour of hollow core ferrocement slabs incorporating recycled fine aggregate as partial replacement of natural fine aggregate. Finite Element Analysis (FEA) using ABAQUS software is adopted to evaluate structural response under loading conditions. The study examines deformation characteristics, stress distribution, interaction behaviour, and load–deflection performance to assess the feasibility of sustainable ferrocement slabs utilizing recycled construction materials.

## II. LITERATURE REVIEW

1) Evangelista and de Brito (2007): investigated the environmental life cycle assessment of concrete incorporating recycled fine concrete aggregates. Their study concluded that recycled fine aggregate substantially reduces environmental impacts associated with natural sand extraction while promoting sustainable waste management practices. The authors emphasized that recycling demolished concrete contributes to landfill reduction and supports sustainable construction. Subsequently, Evangelista and de Brito (2013) presented an extensive review on concrete incorporating recycled fine aggregates. Their research summarized existing production techniques, treatment methods, engineering properties, and available international standards. The review concluded that recycled fine aggregate possesses considerable potential for replacing natural sand in structural concrete, provided appropriate quality control measures are implemented.
2) J. M. Khatib (2004) : investigated the mechanical behaviour of concrete containing crushed concrete and crushed brick as recycled fine aggregates. Experimental observations revealed that although compressive strength may reduce by approximately 15–30% depending upon replacement percentage, continued hydration contributes to long-term strength development. The study also reported higher shrinkage and expansion characteristics compared to conventional concrete.
3) Changming Bu et al. (2022): studied durability characteristics of recycled fine aggregate concrete. Their investigation demonstrated that higher recycled aggregate replacement ratios influence shrinkage, carbonation, permeability, and water absorption. However, the incorporation of supplementary cementitious materials and improved mixing techniques significantly enhanced durability performance.
4) Minkwan Ju et al. (2019) :evaluated the mechanical performance of recycled fine aggregate concrete with high workability. Their research concluded that recycled aggregate concrete generally achieves approximately 70–90% of the mechanical performance of conventional concrete. Higher strength mixes exhibited better structural performance, indicating the suitability of recycled aggregate for structural applications.
5) Fernando Rodrigues et al. (2019) :emphasized the importance of physical, chemical, and mineralogical characterization of recycled fine aggregates obtained from construction and demolition waste recycling plants. Proper characterization was considered essential to ensure consistent concrete quality and reliable engineering performance.
6) Subhadip Pramanik et al. (2025) : critically reviewed the effective utilization of construction and demolition waste through recycled aggregates. The study highlighted recent advancements in aggregate treatment techniques capable of improving water absorption characteristics and overall aggregate quality, thereby expanding the application of recycled aggregates in structural engineering.

## III. EXPERIMENTAL INVESTIGATION

The experimental investigation was planned to evaluate the structural performance of hollow core ferrocement slabs incorporating recycled fine aggregate (RFA) as a partial replacement for natural fine aggregate. The investigation aimed to study the behaviour of the slab under static loading and compare its performance with that of a conventional ferrocement slab. Although the present study primarily focuses on finite element analysis using ABAQUS, the following experimental procedure is proposed for future validation of the analytical results.

## IV. RESULTS

The finite element analysis of the hollow core ferrocement slab with partial replacement of recycled fine aggregate was carried out using ABAQUS to evaluate its structural response under applied loading conditions. The analytical results indicate that the proposed slab exhibits stable structural behaviour with a uniform stress distribution over the majority of the slab surface. Localized stress concentrations were observed near the support regions and around the hollow core openings, which is expected due to geometric discontinuities.

The deformation contour revealed that the maximum displacement occurred at the mid-span of the slab, while the supports experienced negligible displacement because of the applied boundary conditions. The deflected shape demonstrated a smooth deformation profile, indicating adequate stiffness and effective load transfer throughout the slab.

The stress–strain response obtained from the analysis showed an initial linear elastic behaviour followed by gradual nonlinear deformation as the applied load increased. The closely spaced wire mesh reinforcement effectively controlled tensile stresses and improved the ductility of the ferrocement slab. The load–deflection curve exhibited a continuous increase in deflection with increasing load, confirming satisfactory flexural behaviour without sudden structural instability.

The incorporation of recycled fine aggregate and the hollow core configuration resulted in a reduction in the overall self-weight of the slab. The reduced dead load contributes to lower bending moments, reduced reactions on supporting members, and improved structural efficiency. Overall, the analytical results confirm that the proposed hollow core ferrocement slab possesses adequate strength, stiffness, and stability for lightweight structural applications while promoting sustainable utilization of construction and demolition waste.

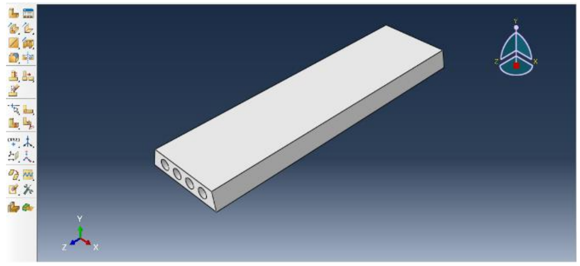

FIG 1: 3D VIEW OF HOLLOW SLAB

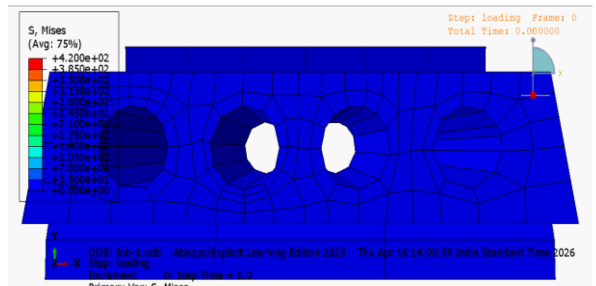


FIG 2: HOLLOW CORE SLAB MESH

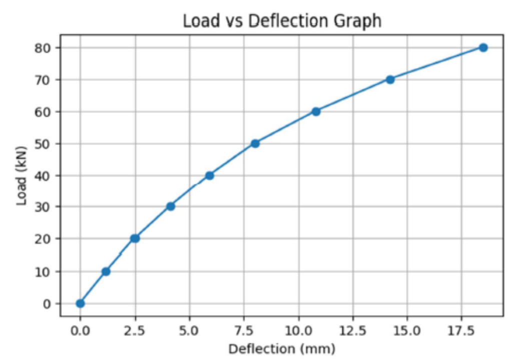


FIG 3: GRAPH RESULTS OF LOAD VS DEFLECTION

The above graph represents the load–deflection behavior of the conventional slab under two-point loading conditions.

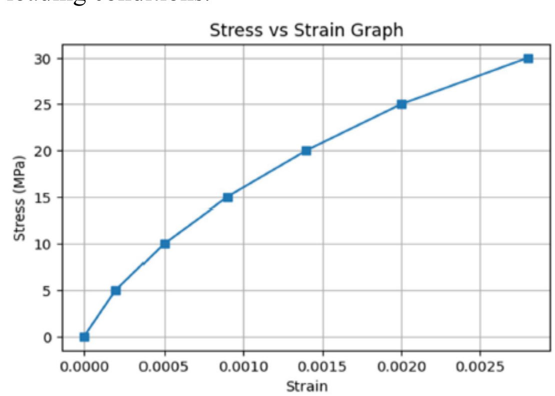


FIG 4: GRAPH RESULTS OF SRESS STRAIN CURVE

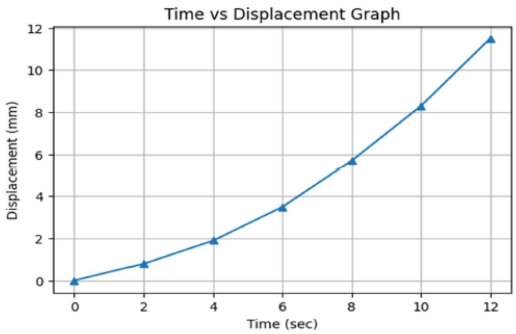


FIG 5: GRAPH RESULTS OF TIME VS DISPLACEMENT

## V. CONCLUSION

The present analytical investigation evaluated the structural behaviour of a hollow core ferrocement slab incorporating recycled fine aggregate as a partial replacement for natural fine aggregate. The study was undertaken to promote sustainable construction practices while reducing the self-weight of structural slab systems.A finite element model was successfully developed using ABAQUS software to investigate deformation characteristics, stress distribution, load–deflection response, stress–strain behaviour, and displacement characteristics under gravity loading. The analytical results demonstrate that the hollow core configuration effectively reduces the overall dead weight of the slab without significantly affecting its structural performance.

The reduction in density resulting from the incorporation of recycled fine aggregate contributes to lower self-weight and reduced dead loads acting on the supporting structural members. Consequently, beams, columns, and foundations experience reduced loading, leading to improved structural economy. The analytical stress contours indicate that stress concentrations remain localized near support regions and hollow core boundaries, while the majority of the slab exhibits uniform stress distribution. Similarly, deformation contours confirm stable structural behaviour under the applied loading conditions.

The load–deflection relationship indicates satisfactory flexural performance throughout the loading process. The stress–strain response demonstrates adequate stiffness and ductility of the ferrocement composite, while the time–displacement history confirms stable numerical convergence and structural stability. These observations indicate that the incorporation of recycled fine aggregate does not adversely affect the structural integrity of the hollow core ferrocement slab.

From an environmental perspective, the utilization of recycled fine aggregate significantly reduces the dependence on natural river sand while simultaneously providing an effective method for recycling construction and demolition waste. The proposed system therefore contributes to resource conservation, waste minimization, and sustainable infrastructure development.

Overall, the analytical investigation confirms that hollow core ferrocement slabs with partial replacement of recycled fine aggregate represent a structurally efficient, environmentally sustainable, and economically attractive alternative to conventional slab systems. The findings encourage the adoption of recycled construction materials in modern civil engineering applications and provide a strong foundation for future experimental and analytical research.

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