

STUDY ON SEISMIC BEHAVIOUR OF FERROCEMENT BOX SHEARWALL BY USING ETABS AND ABAQUS SOFTWARE.

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Abstract— This paper presents a comprehensive analytical and preparatory study of ferrocement box shear walls intended for seismic application, integrating numerical analysis with practical specimen casting. The seismic behaviour of ferrocement, recognized for its high ductility and resilience, is explored through extensive ETABS and ABAQUS simulations complemented by detailed, quality-controlled casting processes. The numerical investigation determines the wall's natural frequencies, time-history responses, and dynamic characteristics under representative earthquake loading. Simultaneously, the preparation and curing of wall specimens provides a physical basis for future experimental validation. While laboratory load testing is yet to be performed, the results establish a robust foundation for ongoing development and deployment of ferrocement shear walls in high-risk seismic environments

Index Terms— Ferrocement, Box Shear Wall, Seismic Analysis, ETABS, ABAQUS, Dynamic Response, Earthquake Resistance, Numerical Modelling, Casting .

I. INTRODUCTION

Achieving structural safety in earthquake-prone regions is a central challenge for civil engineers. Among the most effective strategies for controlling lateral movement and transferring seismic loads within buildings, shear walls play a foundational role. Conventional reinforced concrete shear walls, while strong, are often limited by their susceptibility to brittle failure and constrained ductility under the repeated reversals that earthquakes impose.

Driven by the need for greater performance and adaptability, research and practice have increasingly gravitated toward ferrocement—a material defined by its tightly spaced steel mesh reinforcement fully

embedded in a thin, strong cementitious matrix. Ferrocement's high reinforcement surface area, fine crack control, and improved energy dissipation make it exceptionally well-suited to the construction of thinner, lighter shear walls, particularly in the box configuration. The box geometry itself brings multidirectional stability, confining the vertical and horizontal panels while resisting both in-plane and out-of-plane forces with notable efficiency. These traits are critical for earthquake-resistant structures in urban environments, where higher performance standards and space efficiency are essential.

The present study undertakes a rigorous analytical and physical exploration of the seismic response of ferrocement box shear walls. By combining advanced numerical models in ETABS and ABAQUS with hands-on casting processes, the work aims to both predict and physically underpin the effectiveness of ferrocement as a lateral load-resisting system. The absence of experimental load testing at this phase emphasizes the importance of meticulous preparation, ensuring that future physical results can be meaningfully compared to current predictions. Thus, this project forms a comprehensive prelude to both full-scale validation and practical implementation in seismic design

II. LITERATURE REVIEW

- 1) Edosa Megarsa (2022): This study focused on the shear performance of reinforced concrete (RC) beams enhanced with ferrocement composites. It revealed that increasing the diameter of wire mesh significantly improves the ultimate load failure, shear capacity, and stiffness of RC beams. However, increasing the

spacing between wires results in a decline in performance. The optimal number of mesh layers was found to be three, beyond which no significant improvement in shear performance was observed. Hence, using three layers of mesh is considered the most efficient and cost-effective solution for improving RC beam shear behavior.

- 2) Yousry B.I. Shaheen (2021): An experimental investigation into ferrocement box shear walls with and without webs (ribs) under vertical loads demonstrated that ribs substantially improve the structural performance of these walls. The study compared walls reinforced with double layers of welded and expanded wire meshes, concluding that welded mesh offers superior results. The walls were analyzed using ANSYS simulation, which showed good agreement with experimental data, confirming that the presence of ribs and the type of reinforcement significantly influence strength, ductility, and crack behavior.
- 3) G.V. Rama Rao (2016): This research investigated the factors affecting the ductility of shear walls using nonlinear finite element modeling in ABAQUS with the Concrete Damaged Plasticity model. The study emphasized that ductility is influenced by aspect ratio, axial load level, and reinforcement percentages. To ensure a ductile seismic response, it was recommended that the axial load on a shear wall should not exceed 30% of its ultimate axial capacity. The findings led to valuable recommendations for modifying codal provisions to enhance ductile design practices in seismic zones.
- 4) N. Gopala Krishnan (2016): The nonlinear behavior of medium aspect ratio shear walls was analyzed under monotonic and cyclic loading conditions. Using both experimental testing and a layer-based analytical model, the study assessed plastic rotation, stiffness degradation, and ductility. Results showed distinct differences between monotonic and cyclic behavior, highlighting the importance of including cyclic load effects in design. The analytical pushover curves closely matched experimental ones, validating the modeling approach and reinforcing the significance of axial load influence on flexural response.

- 5) Rohit et al. (2013): This research derived expressions for the ultimate moment of resistance in RC walls based on equilibrium and strain compatibility without assuming secondary compression failure. The study challenged the overstrength moment capacity ratio of 1.4 provided by IS 13920, demonstrating that it was conservative across all axial load ratios. Furthermore, the research accounted for concrete confinement effects on the P-M interaction curve, indicating a need to revise IS 13920 to reflect more realistic moment capacities, ultimately aiming for safer and more economical wall design.

III. FERROCEMENT SHEAR WALL

The essence of ferrocement lies in the synergistic combination of thin steel mesh layers and high-quality mortar. This configuration generates a composite with superior mechanical properties, notably enhanced tensile strength, ductility, and resilience against high-cycle and large-displacement loading. In the context of seismic engineering, such characteristics allow ferrocement box shear walls to engage in stable, energy-absorbing deformation, forming densely distributed micro-cracks rather than fewer, catastrophic failures.

Adopting a box wall form further amplifies these benefits. The closed geometry resists lateral loads equally in orthogonal directions, while the interaction between its faces provides robustness against local buckling and torsional demands. The distributed mesh acts as a net, actively containing cracks and limiting their propagation, even under extensive cyclic motion. This crack-arrest mechanism, vital for seismic applications, not only protects the wall's overall structural integrity but also mitigates repair needs and improves post-earthquake serviceability.

Ferrocement as a construction material offers several practical advantages: it supports prefab and modular construction methods, allows thinner wall sections than traditional reinforced concrete, and makes efficient use of high-strength mortar and lower-diameter steel mesh. This efficiency leads to lighter seismic masses, further reducing the inertial demands earthquake events impose on a structure. By addressing both safety and constructability, ferrocement box shear walls represent a highly promising avenue for contemporary seismic design.

IV. DIMENSIONS

A critical aspect of the design is dimensional planning, as it directly influences both analytical predictions and the actual constructability of the wall. For this study, the primary wall specimen is designed with a height of 1000 mm, a width of 500 mm, and a thickness of 60 mm. These proportions provide a balance between stiffness and slenderness, suitable for laboratory-scale testing and realistic in terms of field applications. The wall is anchored at the base by a reinforced concrete slab measuring 800 mm by 800 mm with a thickness of 100 mm, while the top is capped with a similar slab measuring 800 mm by 800 mm and 50 mm thick. Reinforcement arrangement consists of vertical mesh bars of 6 mm diameter placed at 100 mm spacing across the wall, and horizontal mesh (stirrups) of 4 mm diameter at 50 mm spacing along its height, ensuring an even and dense distribution of steel. For durability and corrosion protection, a concrete cover of 10 mm is maintained for the wall itself and 20 mm at the slabs, following code requirements and best construction practices.

V. REINFORCEMENT DETAILING

The hallmark of ferrocement technology is its meticulous reinforcement detailing. The principal vertical reinforcement comprises 6 mm diameter bars aligned along the wall's height at 100 mm spacing, intersected by 4 mm diameter horizontal mesh at 50 mm intervals. This fine grid is secured firmly at every intersection using binding wire, and mesh overlaps are staggered by at least 100 mm to avoid plane weaknesses. Reinforcement cages are purposefully anchored into the top and bottom slabs, typically with a minimum cover of 10 mm in the wall and 20 mm in the slabs, as per standard codes and durability requirements. The precision and uniformity of mesh placement are stringently checked prior to casting, as any deviation can influence crack trajectory and seismic performance. This arrangement not only suppresses the formation of wide, brittle cracks but also provides ductility by allowing a controlled pattern of numerous micro-cracks, enabling the wall to withstand significant cyclic deformations without sudden failure.

VI. CASTING

Casting of the ferrocement box shear wall is carried out with strict adherence to dimensional and reinforcement specifications. The process begins with the assembly and cleaning of custom plywood formwork, into which the steel mesh cage—fabricated with precision to match the design—is carefully placed. Plastic or concrete spacers are used to maintain exact mesh cover and prevent displacement during mortar placement. The mortar, typically mixed to achieve M30 grade quality, is poured or pressed into the formwork in incremental layers. Careful vibration is applied at each stage to eradicate air pockets and ensure the continuous encapsulation of the mesh. The top and bottom slabs are cast either monolithically with the wall panel or in sequence, integrating seamlessly with the wall's vertical reinforcement. After casting, the specimen is subjected to minimum 28 days of moist curing, using methods such as water spraying or wet coverings, essential for achieving strength and minimizing cracking. All steps—from placement of reinforcement and mortar to demolding and curing—are thoroughly documented and monitored, ensuring that the finished specimen aligns with analytical models and is ready for subsequent experimental loading.

VII. NUMERICAL ANALYSIS

Advanced numerical modeling underpins the assessment of the ferrocement box shear wall's anticipated seismic performance. Using ETABS, the composite wall system is modeled as a shell structure, with equivalent isotropic properties reflecting both mortar and mesh reinforcement. Modal analysis in ETABS predicts a fundamental frequency of about 14.2 Hz, indicating high global stiffness and a reduced risk of resonance during earthquakes. ABAQUS, with its capacity for non-linear, three-dimensional finite element analysis, provides additional insights into local stress distributions and potential crack initiation zones. The detailed mesh, reinforcement geometry, and boundary conditions used in ABAQUS mirror the actual specimen, giving high fidelity between analytical prediction and physical construction. Both platforms consistently indicate that, due to optimal reinforcement and careful dimensioning, the wall will exhibit limited lateral displacement and efficient stress dispersion even under strong ground motion, affirming

its suitability for future experimental and real-world applications.

VIII.RESULTS

The results obtained from the numerical analyses of the ferrocement box shear wall provide compelling evidence for its outstanding seismic performance even before any experimental testing is undertaken. Simulations conducted in ETABS and ABAQUS reveal that the well-detailed reinforcement and precise wall dimensions result in a structure with significant lateral stiffness. The fundamental frequency values, determined to be around 14.2 Hz in ETABS and approximately 17.3 Hz in ABAQUS, clearly place the designed wall outside the resonance range typically associated with damaging earthquake ground motions, effectively minimizing the risk of dynamic amplification. Under simulated time-history seismic loading, the maximum predicted lateral displacement at the top of the wall is contained to less than 0.055 mm, a testament to the structure's rigidity and the mesh's capacity to restrain excessive movement. Stress distribution results further demonstrate that the close spacing and secure placement of mesh reinforcement prevent stress concentrations, distributing forces widely throughout the wall body and avoiding the formation of dominant cracks. The reinforcement grid ensures that even under intense simulated ground motions, the wall as a whole responds in a ductile manner, with stresses well below the ultimate limits of both the reinforcing mesh and the mortar. These outcomes collectively validate the high analytical expectations for ferrocement box shear walls and signal their readiness for physical testing and, ultimately, for practical application in earthquake-resistant design.

IX.CONCLUSION

The analytical and preparatory work presented demonstrates that ferrocement box shear walls, when constructed with rigorous attention to dimensions, reinforcement detailing, and casting processes, hold significant promise for earthquake-resistant structures. The combination of fine mesh reinforcement and a robust box configuration imparts exceptional ductility, control over crack development, and resistance to seismic forces. Numerical analysis confirms that the design achieves the desired dynamic properties and stress management, while the detailed

construction procedures ensure that the physical wall will faithfully replicate the predicted performance. With experimental testing forthcoming, this integrated approach provides a strong foundation for the further adoption of ferrocement technology in regions facing considerable seismic risk.

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