Study on Seismic Behaviour of Ferrocement Shearwall by Using ETABS and ABAQUS Software

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***Abstract*— The seismic performance evaluation of Reinforced Cement Concrete (FERROCEMENT) shear walls is vital for designing resilient structures capable of withstanding earthquake forces. This study utilizes ETABS and Abaqus software to conduct comprehensive analyses, focusing on key parameters such as material properties, wall thickness, aspect ratio, and reinforcement ratios. Time history analysis is employed to assess the dynamic behaviour of Ferrocement shear walls under seismic loading.**

In ETABS, the analysis evaluates structural displacements, natural frequencies, and mode shapes, identifying critical factors influencing performance. Abaqus further investigates the seismic loading response by simulating dynamic earthquake patterns, capturing nonlinear material behaviours like strain rate effects and fatigue damage. Key metrics include structural displacements, energy dissipation, joint acceleration, and compressive and tensile behaviour. The findings provide insights into the durability and seismic resilience of Ferrocement shear walls

***Index Terms*— Ferrocement, reinforced concrete, ABAQUS, Shearwall , ETABS, Time History Analysis.**

I. INTRODUCTION

Shear walls, or structural walls, play a critical role in enhancing a building's resistance to lateral forces from earthquakes and winds, especially in tall structures, by reducing bending stresses on columns. According to Fintel (1991), constructing earthquake-resistant buildings without shear walls is not feasible. Meanwhile, ferrocement, an older yet increasingly utilized material, is gaining recognition for its high tensile strength, ductility, and crack resistance due to the presence of wire mesh reinforcement. Unlike traditional reinforced concrete, ferrocement offers better crack control, making it ideal for high-quality, durable, and cost-effective construction. Its applications span marine, terrestrial, and housing sectors, including roofing, tanks, shelters, and rehabilitation works. Economically, ferrocement roofs are found to be more durable and stable than other low-cost alternatives, offering a reliable solution for affordable housing.

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. SHEAR WALL

Shear walls come in various forms, including simple rectangular, coupled, non-rectangular (T, C), and box-type configurations. Rectangular walls with boundary elements offer greater strength and ductility, and should be designed to fail in bending rather than brittle shear. Coupled shear walls, connected by short spandrel beams, enhance energy dissipation during earthquakes by yielding the beams instead of damaging the primary walls. Box-type shear walls often form the building's core around services like elevators. Shear wall behavior depends on geometry, with slender walls (aspect ratio > 2) typically failing in flexure, squat walls (aspect ratio < 1) in shear, and intermediate walls showing a combination. Failure modes include flexural failure (steel yielding and crushing), shear failure (diagonal cracking or crushing), and sliding shear failure (loss of shear transfer across widened cracks due to cyclic loading).

IV. DIMENSIONS

WALL SEC.	SHEAR WALL (h*w*t)	BASE SLAB (l*b*t)
1.	1.5m*0.45m*0.08m	0.28m*0.65m*0.8m

V. REINFORCEMENT DETAILING

Wall Sec.	Horizontal Reinforcement	Vertical Reinforcement	Cover
SW	8mm φ 128mm c/c	8mm φ 125mm c/c	20mm
SWB	8mm Φ 74mm c/c	8mm Φ 46mm c/c	20mm

The reinforcement data of the shear wall is calculated by the procedure mention in IS: 13920 – 2016.

1) Data Collection: Gather necessary information for the shear wall design process.
2) Section Classification: To find the type of shear wall to be designed [As per IS: 13920 – 2016 (Cl – 10.1.2)]

   Squat walls, $(h/w) \leq 1$

   Intermediate walls, $1 < (h/w) \leq 2$

   Slender walls, $(h/w) > 2$

3) Design of Shear reinforcement (Horizontal)

   As per IS: 13920 – 2016 (Cl – 10.1.7)

   If $\tau_v > 0.25\sqrt{f_{ck}}$ or $t_w > 200$ mm

Diameter of bars > $t_w/10$as per IS: 13920 – 2016

(Cl – 10.1.8)

The maximum spacing of vertical or horizontal reinforcements shall not exceed smaller of, as per IS: 13920 – 2016 (Cl – 10.1.9)

a) 1/5th horizontal length Lw of wall;

b) 3 times thickness tw of the web of the wall;

c) 450mms

4) Design of Longitudinal Reinforcement (Vertical)

Minimum area of reinforcement bars is indicated in table 1 shall be provided along horizontal and vertical direction, IS: 13920 – 2016 (Cl – 10.1.6)

Spacing Sv = A_min 〖X 1000〗 /A_max

VI.FREQUENCIES OF FERRO CEMENT SHEARWALL

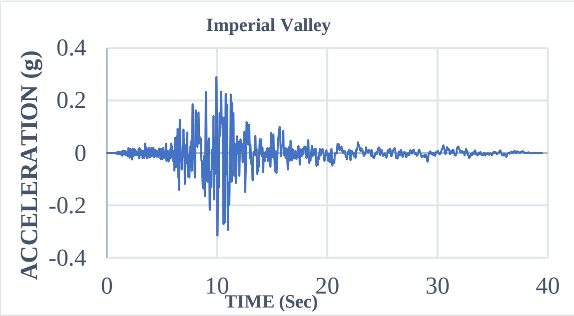

Figure 1.Imperial Valley Frequency

Case	Mode	Period sec	Frequency cyc/sec	CircFreq rad/sec	Eigenvalue rad²/sec²
Modal	1	0.07	14.194	89.1822	7953.4703
Modal	2	0.015	66.715	419.1814	175713.0842
Modal	3	0.012	83.082	522.0212	272506.1566
Modal	4	0.001	1891.505	11884.6742	141245481
Modal	5	0.0002587	3865.12	24285.2681	589774244
Modal	6	0.0001664	6009.277	37757.4037	1425621537

Figure 2.Frequencies obtained in ETABS

VII.RESULTS

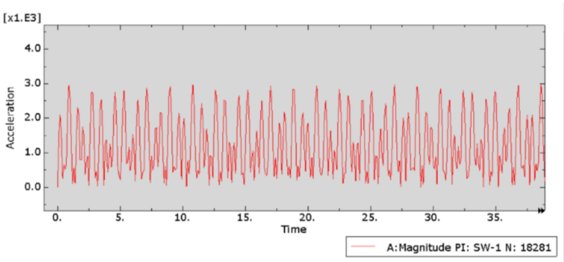

Figure 1 Acceleration of Ferrocement Shear Wall-Magnitude

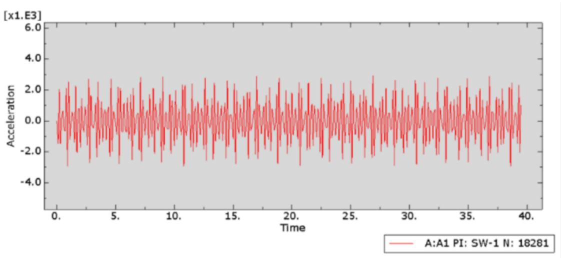

Figure 2 Acceleration of Ferrocement Shear Wall-A1

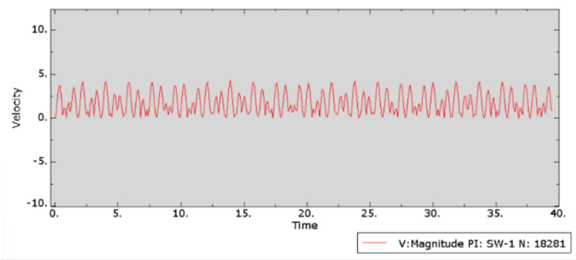

Figure 3 Velocity of Ferrocement Shear Wall Magnitude

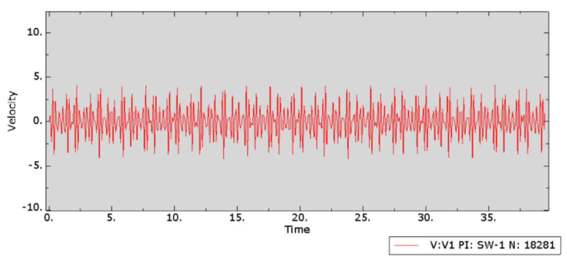

Figure 4 Velocity of Ferrocement Shear Wall-V1

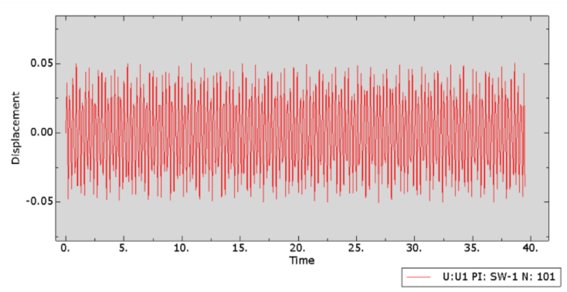

Figure 5 Displacement of Ferrocement Shear Wall-U1

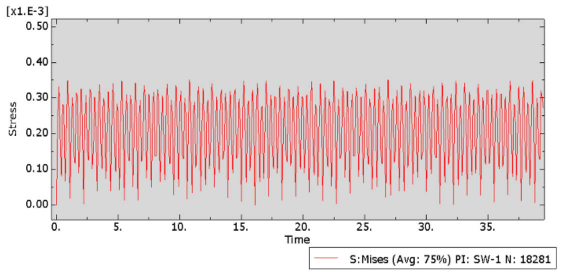

Figure 6 Stress of Ferrocement Shear Wall-Mises

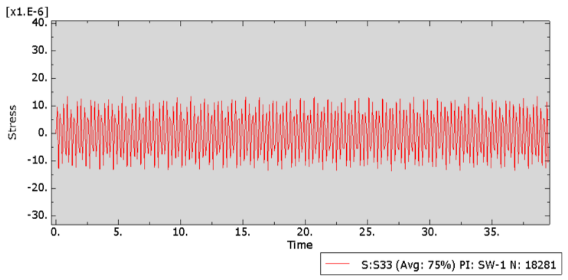

Figure 7 Stress of Ferrocement Shear Wall-S33

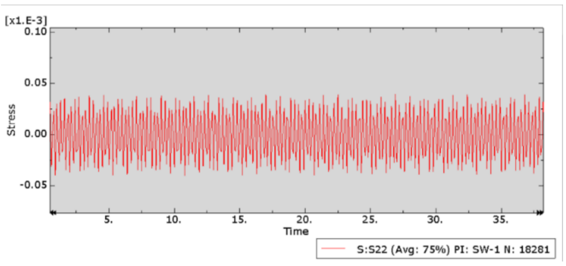

Figure 8 Stress of Ferrocement Shear Wall-S22

VIII.CONCLUSION

The Numerical Analysis of an Ferrocement Shear Wall using ETABS and ABAQUS software provide detailed insight into its dynamic behavior and seismic response. The key observation from the study is follows:

1. Frequency Comparison:

- The natural frequency of the Ferrocement Shear Wall was determined as 14.194 Hz using ETABS and 17.322 Hz using ABAQUS. The slight variation reflects the differences in modeling approaches and solver techniques used in the two software.

2. Displacement Comparison:

- Maximum Displacement: 0.05490 mm
- Minimum Displacement: -0.05590 mm

3. Acceleration Analysis:

- Maximum Acceleration: 2916.48 mm/sec2
- Minimum Acceleration: -2919.18 mm/sec2

4. Velocity Analysis:

- Maximum Velocity: 4.06521 mm/sec
- Minimum Velocity: -4.1755 mm/sec

The results indicate that both ETABS and ABAQUS are reliable tools for analysing the dynamics response of ferrocement shear walls. While ETABS efficiently estimates global frequencies, ABAQUS provides a detailed analysis of time-dependent displacement, velocity, and acceleration parameters, capturing the wall's seismic behaviour with higher resolution. This Study demonstrates the utility of using a combination of these software platforms to achieve accurate and comprehensive structural analysis.

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