Experiment on RC Frame with Different Infill Walling Materials against Lateral Load

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Abstract:- Masonry infill wall RC structures are the most vulnerable against earthquake load because of rapid degradation of stiffness, strength, and energy dissipation capacity that lead to the brittle failure of the masonry infill walls. In Bangladesh commonly seen most of the RC structures have open the ground floor uses for parking and other purposes that causes the soft story problem. This study concentrates on the laboratory tests to assess the safety and performance of masonry infilled (clay brick, sand-cement hollow block and hollow clay block) RC frames due to seismic loads as well as to develop practical and cost-efficient techniques for the seismic retrofit and repair of these structures using indigenous materials. Cyclic load is applied by means of Reverse Loading Hydraulic Jack (capacity 60 tons) mounted on the Reaction Frame. At the time of applying cyclic load the behavior of the test model specimens is observed by means of Data Acquisition System. After the application of cyclic load, the damaged specimens are retrofitted with ferrocement laminates for observing their behavior under same load. This study provides a justified and cost-effective preventive and retrofit measure to protect "soft-story" or "weak-story" problem for infill wall RC frame structures.

Keywords:- *Cyclic Load, Hydraulic Jack, Infill wall, RC Frames, Retrofit, Ferrocemet, Soft -Story.*

I. INTRODUCTION

Bangladesh already known is an earthquake prone country. In this country there are majority of old buildings built without following any proper codes, land use planning and earthquake resistant guidelines. Moderate to severe earthquakes may result in devastation in this country especially in the cities where multi-storeyed masonry infill buildings with soft ground stories are commonly seen. Recent earthquakes have demonstrated that those are the most vulnerable structures because of rapid degradation of stiffness, strength, and energy dissipation capacity that lead to the brittle failure of the masonry infill walls. Again, when there is insufficient stiffness in the frame, the non-load bearing partitions participate as shear walls as they become loaded by the deformation of the frame. If the ground floor is diaphanous, undivided and has higher columns, a classic "soft-story" results with stiffer than expected mass over a very weak (soft) ground floor. In such buildings, the upper floors drift over the ground floor causing plastic hinges and permanent deformations. In fact, use of infill walls have long been disallowed by modern codes of developed countries unless special precautions have been taken to ensure that they do not interact with the structural lateral load resisting system. Here, neither the possible extents of seismic damage of existing buildings are known nor there any guideline for their strengthening measure. Even the performance of the engineered buildings under a seismic event is questionable. It is, therefore, efficient and reliable upgrading methods are needed in order to mitigate the expected seismic loss.

II. METHODOLOGY

The proposed experimental research scheme involves testing of Model Infill RC frames against cyclic load with a test setup Which is being constructed in Housing and uilding Research Institute (HBRI) workshop. The test setup has different components like 'Strong Beam', 'Reaction Frame, the 'Test Model Frames with infill', 'Anchor Bolts' etc. Cyclic load shall be applied by means of Reverse Loading Hydraulic Jack (capacity 60 tons) mounted on the Reaction Frame. At the time of applying cyclic load the behavior of the test model specimens shall be observed by means of Data Acquisition System. Displacement transducers or deflectometers shall be fitted at selected locations of the frame to measure the deflections. Strain gauges shall be used for measuring deformations. After application of cyclic load, the damaged specimens shall be retrofitted with ferrocement laminates for observing their behavior under same load.

III. TEST SPECIMEN FRAMES

Table 1 list the number and types of frames have been tested, by application of cyclic load the damaged specimens are retrofitted with ferrocement laminates for observing their behavior under same load.

Table 1 Test Specimen Frames

Sl. No.	Description of specimen frame type	Number of Specimens for each type of infill	Frame designations
1	Bare Frame	2	I, J
2	Bare Frame Laminated with Ferrocement	2	K, L
3	Brick infilled Frame	1 + 1 trial	B, A (trial)
4	Brick infilled Frame Laminated with Ferrocement	2	C, D
5	Frame with Hollow clay ceramic infill	2	G, H
6	Frame with Hollow clay ceramic infill laminated with Ferrocement	2	E, F
7	Frame with lift core brick infill	2	M, N
8	Frame with lift core brick infill laminated with Ferrocement	2	O, P
9	Total Number Of Frame	15 + 1 trial	
10	Retrofitted damaged infilled frames of Sl.No.1,3,5,7	8	

IV. CONDUCTING THE TESTS

Carrying out of the actual test is a long, time consuming and laborious jobs. Each of the test specimens weighs more than 3.0 ton. Need more than five workers for two days for moving such a heavy object in to the test setup position before testing as well as removing it from the test setup. After placing a test specimen, it was required to firmly affix it to the base by means of anchor bolts. In order to prevent horizontal slippage of the test specimen at the time of loading, special anti-slip blocks were installed on the base at two ends of the test specimen. Tripod stands and bracket arrangements were placed adjacent the frame specimens to facilitate mounting of the sensors. Delicate electrical wiring was required to connect the sensors (Displacement and pressure transducers) to the data logger. To ensure continuous and uninterrupted supply of electricity during testing, a diesel fuelled power generator as well as several UPS units was used. After setting up all these it was required to verify that the whole system is set up properly. All these setup procedures required careful supervision of several days.

Testing of each specimen began by applying constant compression load to the two columns by means of hydraulic jacks placed atop each column. The magnitude of the load was approximately 50% of the pure axial capacity of the columns. There after cyclic horizontal load was applied to the frame by means of hydraulic jacks mounted on the bracket attached to the reaction frame. Load was applied at an increment of 3 ton in each cycle for the

Infilled specimens. For the bare frame models, the load increment was much smaller. After each cycle of loading the specimen frame was carefully observed for appearance of cracks. When a crack is observed it was immediately marked and traced on the specimen using permanent marker pen. Photographs were also taken at intervals when significant growths of cracks were observed till failure.

Actual testing started with Frame-A specimen. Testing of this specimen was conducted mainly as a trial to verify the effectiveness of the test procedure and setup as well as to identify problems associated with the testing and data acquisition procedure. After conducting the test of Frame-A the acquired data was analysis in the computer to cheek for consistency and some problems in the test procedure were identified. Based on these findings test procedure of the subsequent specimens was adjusted and rectified. Therefore, results of Frame-A is not included in this report.

Of the tested specimen mention above, eight specimens were not strengthened with ferrocement initially. It was planned that these shall not be discarded after testing; instead, these shall be repaired using ferrocement technology. After that, these repaired samples shall be tested again as was done before

V. TEST RESULTS

Through testing and data processing, cyclic load vs. displacement diagrams are obtained corresponding to each deflectometer. Such diagrams for all the tested frames are presented as follows.

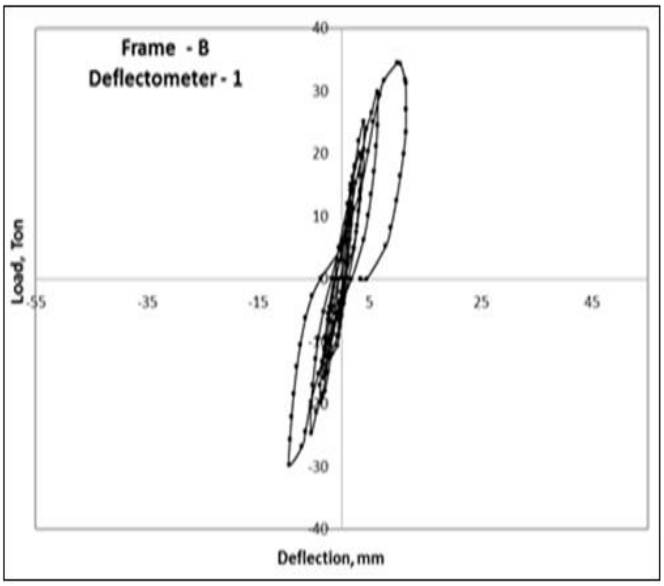

Fig 1 Loads vs. Deflection for Frame B

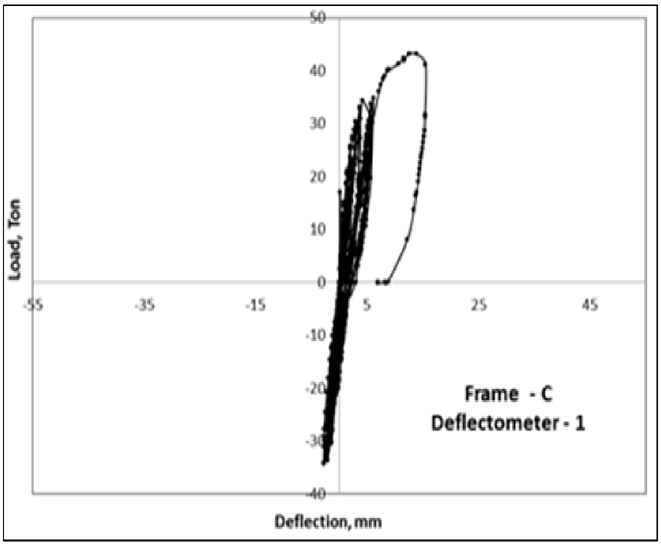

Fig 2 Loads vs. Deflection for Frame C

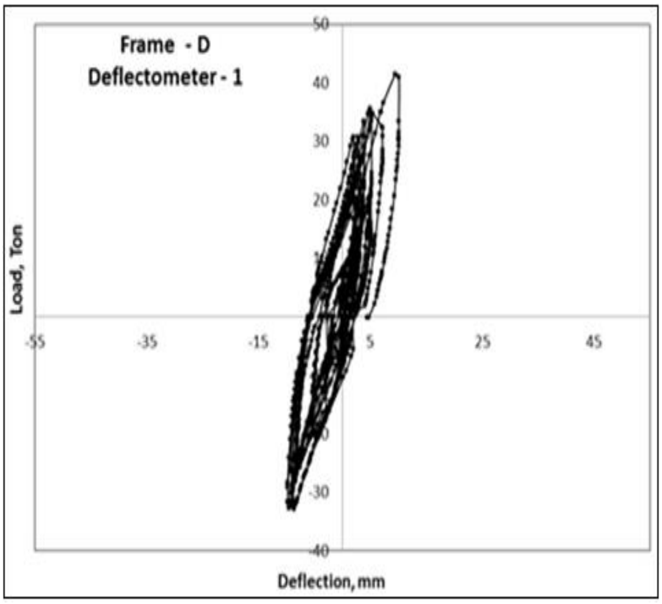

Fig 3 Loads vs. Deflection for Frame D

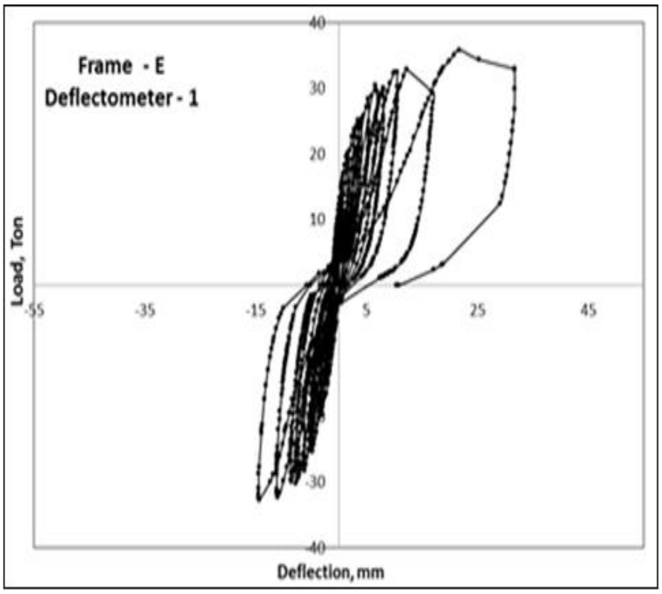

Fig 4 Loads vs. Deflection for Frame E

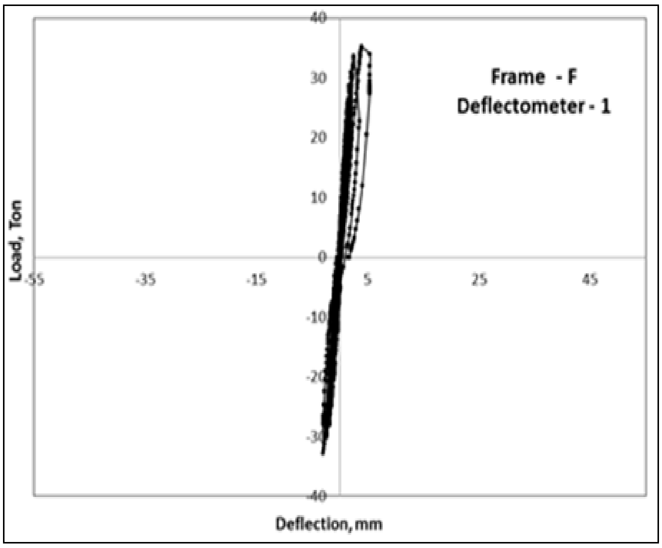

Fig 5 Loads vs. Deflection for Frame F

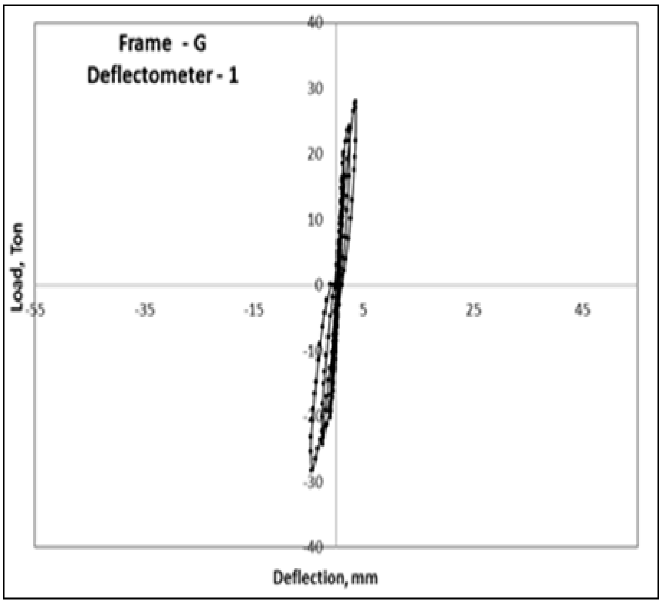

Fig 6 Loads vs. Deflection for Frame G

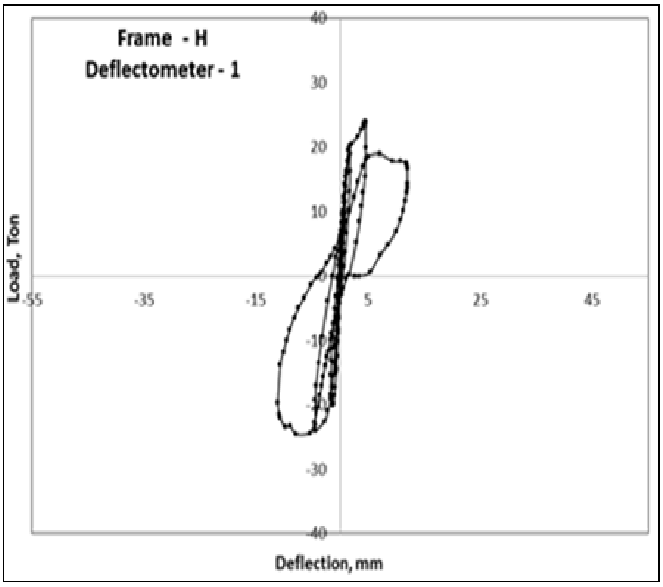

Fig 7 Loads vs. Deflection for Frame H

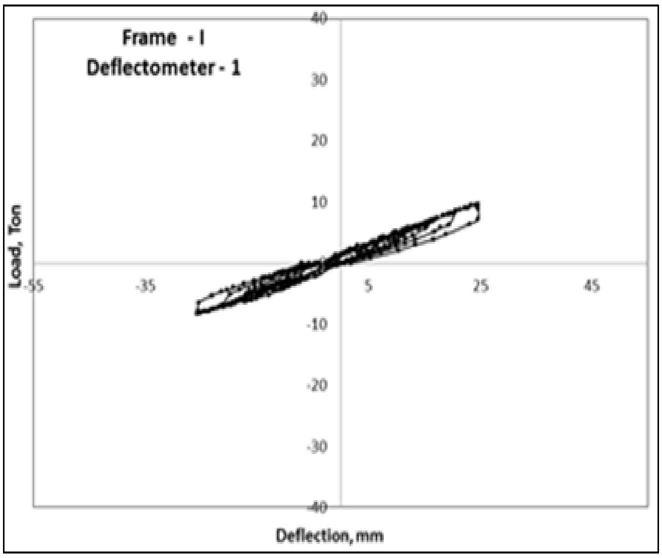

Fig 8 Loads vs. Deflection for Frame I

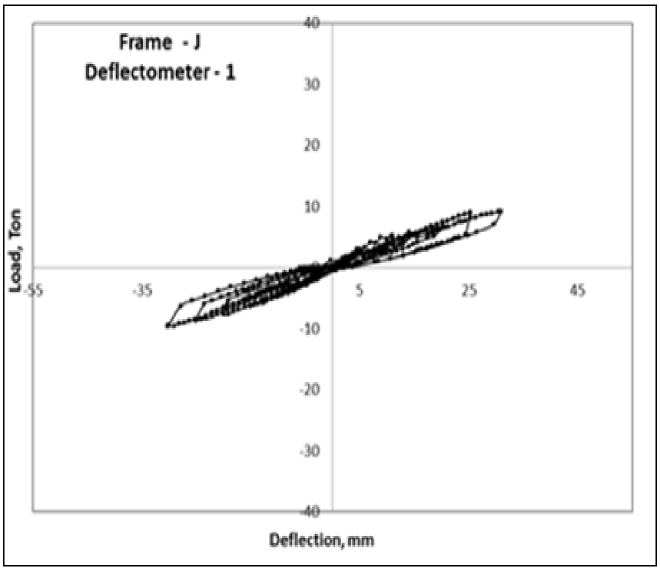

Fig 9 Loads vs. Deflection for Frame J

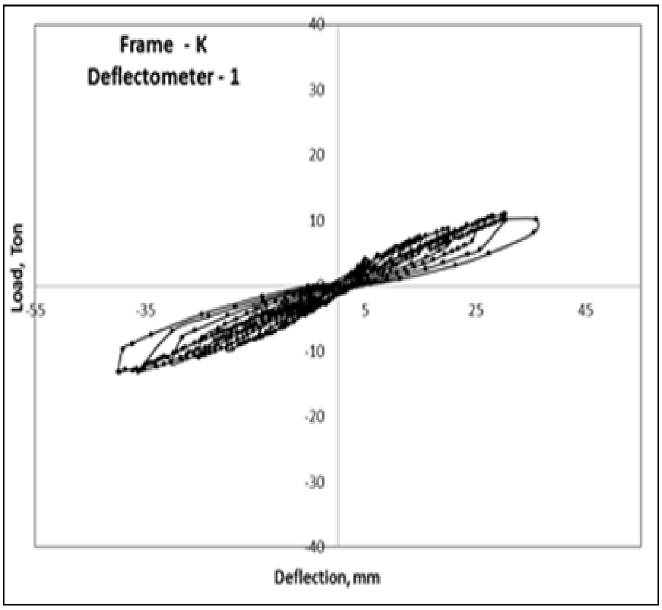

Fig 10 Loads vs. Deflection for Frame K

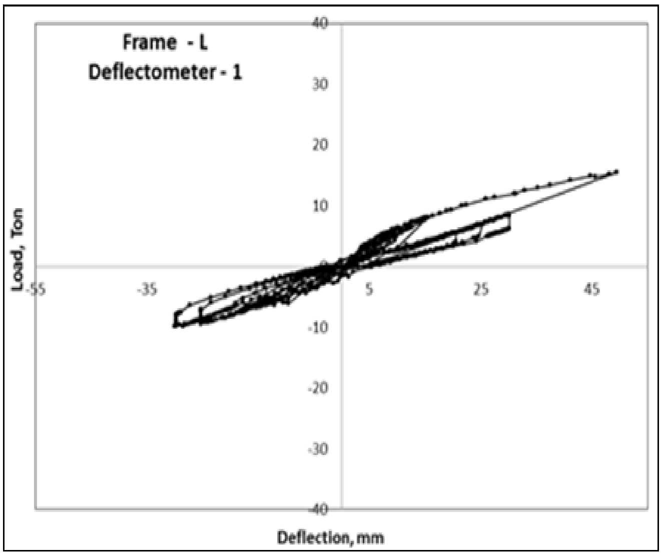

Fig 11 Loads vs. Deflection for Frame L

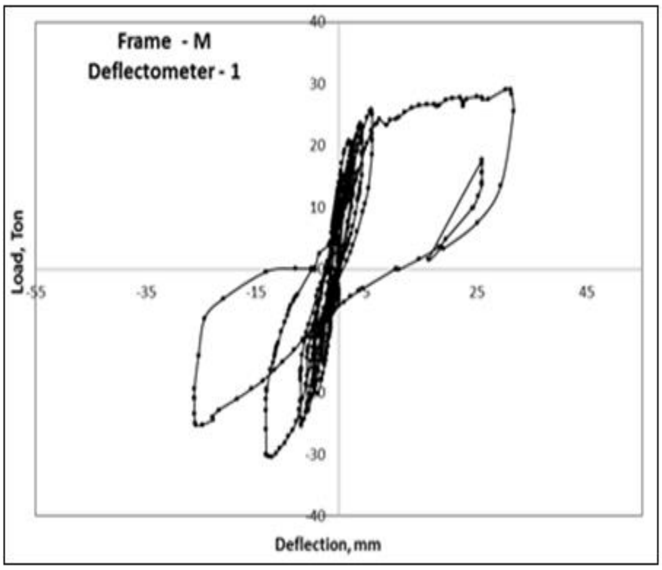

Fig 12 Loads vs. Deflection for Frame M

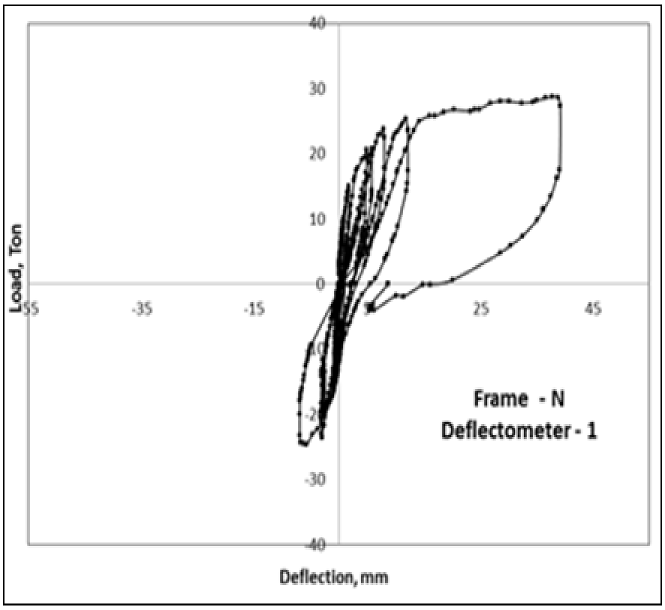

Fig 13 Loads vs. Deflection for Frame N

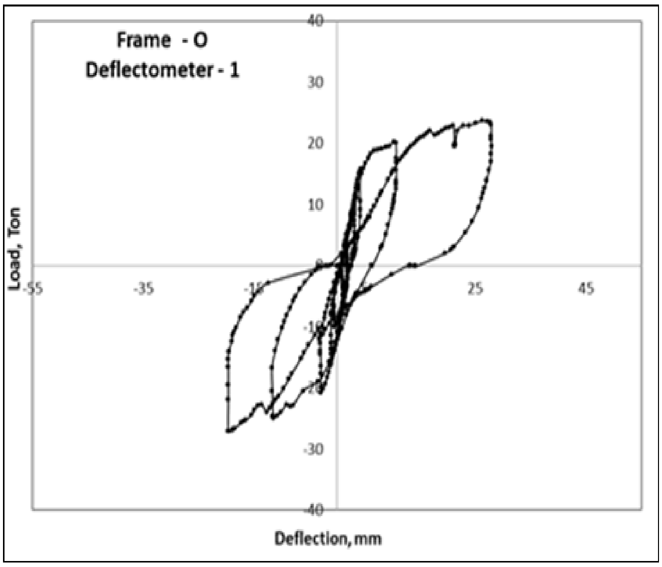

Fig 14 Loads vs. Deflection for Frame O

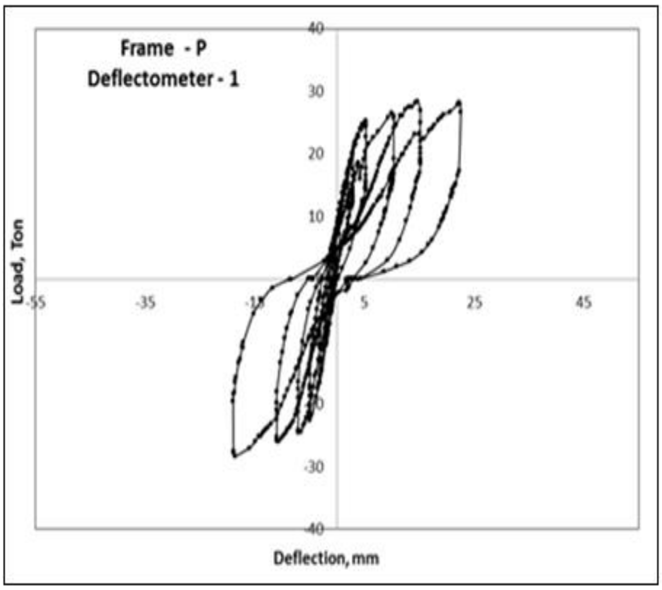

Fig 15 Loads vs. Deflection for Frame P

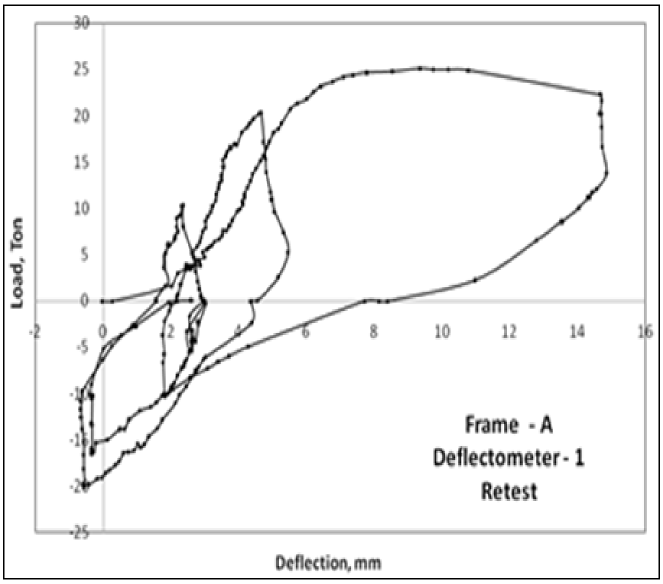

Fig 16 Loads vs. Deflection for Frame A-retest

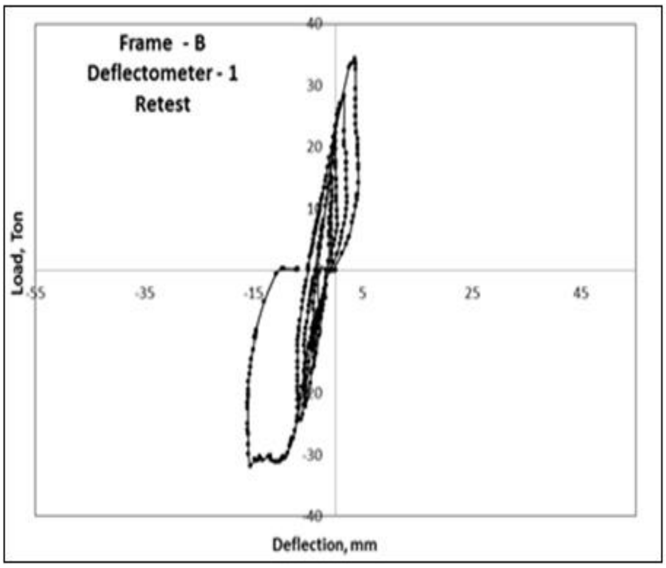

Fig 17 Loads vs. Deflection for Frame B-retest

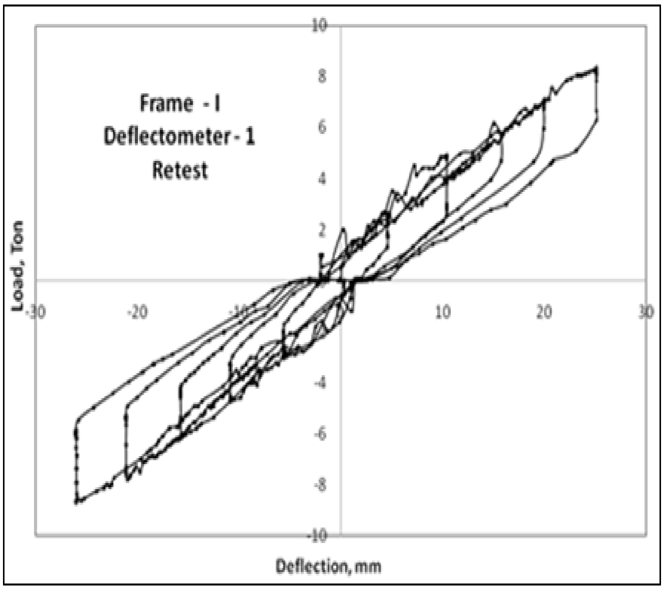

Fig 18 Loads vs. Deflection for Frame I-retest

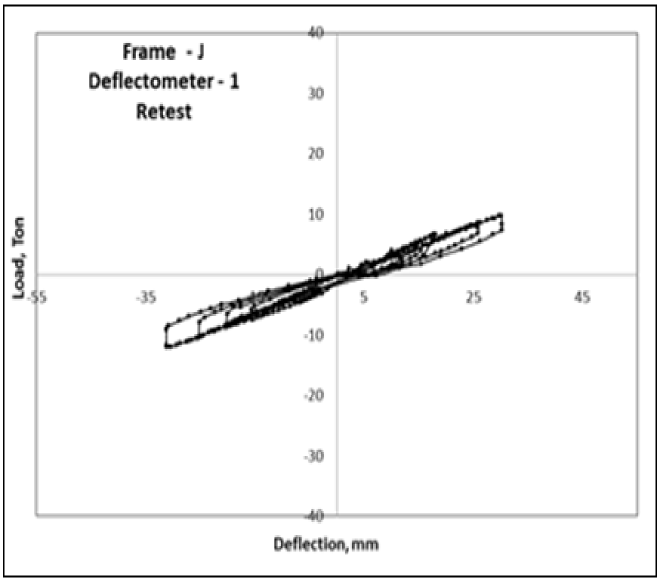

Fig 19 Loads vs. Deflection for Frame J-retest

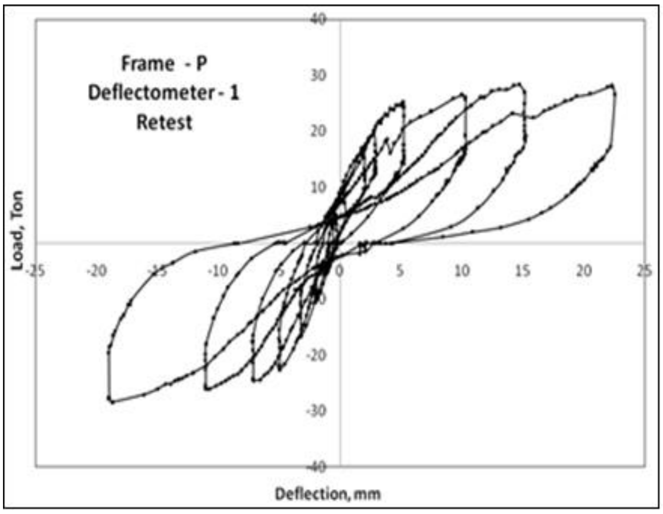

Fig 20 Loads vs. Deflection for Frame P-retest

VI. CONCLUSIONS

- *Based on Results Obtained from Testing of the Specimen Frame as Shown in the Preceding Sections Following Conclusion can be Drawn.*

- Ferrocement laminate can significantly increase the in-plane load carrying capacity of infilled RC frames.
- Ferrocement laminating can be successfully used to restore the in-plane load carrying capacity of a damaged infilled RC frame.
- Ferrocement laminate can significantly restored the load carrying capacity of the bare RC frame.
- Ferrocement laminating can significantly reduce visible cracking. Thus, it shall be very effective in protecting concrete from weather and increased durability.
- In-plane load capacity of hollow block infilled frames is lower than the same of solid brick infilled frames.
- Lift core type infilled frames show lower in-plane load capacity than corresponding normal infilled frame.

RECOMMENDATIONS

The experimental program and results presented in the preceding section provide us with some useful information towards construction of better earthquake resistant building frames using locally available materials. However due to limitations in scope of the experimental program it is nowhere near comprehensive and ample scopes for future investigation remain. Some are suggested bellow.

- The data presented in this report may be further analyzed and processed to evaluate material characteristics appropriate for earthquake resistant design of building using ferrocement laminate.
- Further experimental program may be conducted using automated actuators instead of manually operated hydraulic jacks.
- Further experimental program may be conducted for infills with opening.
- Effectiveness of locally available repair materials other than ferrocement laminate may be explored.

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