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SEISMIC PERFORMANCE OF SHEAR WALL RETROFITTED WITH HYBRID STEEL AND FIBER REINFORCED POLYMER

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Abstract—Steel shear walls are used in high rise structures in developed countries such as USA,Germany as they provide major saving in wall thickness and weight of the building and as a result decline in foundation and inertia loads.But when buildings are subjected to seismic loading damage to steel shear walls occur.Therefore to recover the initial strength & stiffness, fibers of Carbon Fiber Reinforced Polymer(CFRP) and Glass fiber Reinforced Polymer(GFRP) can be applied to steel shear walls.This study explores the result of analytical investigation for enhancing strength by application of fiber reinforced polymers.Three Shear models of 1025mm height and 1090mm width were prepared using ANSYS software for steel,hybrid steel CFRP and hybrid steel GFRP shear wall each. In case of hybrid shear walls both Carbon and Glass fibers are applied at 45^0 angle to steel plate.It is found that in retrofitted models the increase in ultimate load values are up 16% and 20% for hybrid steel carbon and glass shear wall respectively.

Keywords— CFRP,GFRP,shear wall,seismic loading,ANSYS

I.INTRODUCTION

Every structure built by humans undergoes some form of deterioration over the course of time due to both natural reasons such as flood,cyclones,tsunami and artificial reasons.Deterioration caused by this wear and tear causes reduction in original strength and stiffness of structure.Therefore In order for the structure to continue its service it is essential to retrofit the structure and update its strength.

Steel shear walls have been widely used in various parts of the world especially Japan and USA.Despite possessing qualities such as high strength to weight ratio,corrosion resisitance,high fatigue resisitance,durability,versatility they also have some drawbacks.One of such drawbacks is difficulty in repairing them after the event of earthquake.Possible solution for such problem could be use of steel plate coated with carbon and glass fiber reinforced polymer.Shear wall mainly consists of steel boundary elements comprising two steel columns and an overhead beam.Two steel columns are enclosed by steel plate.In case of hybrid steel CFRP and GFRP walls steel plate is laminated with CFRP and GFRP fibers to provide additional strength and stiffness.

II.PRAPOSED WORK

This paper is focussed on evaluating effects of use of hybrid steel CFRP and GFRP fibers to recuperate original strength and stiffness of the structure.Ultimate load carrying capacity of hybrid steel Carbon Fiber Reinforced Polymer and Glass Fiber Reinforced Polymer walls is compared with that of steel wall to analyse the impact of fiber wrapping.Energy dissipation capacities of hybrid steel Carbon Fiber Reinforced Polymer and hybrid steel Glass Fiber Reinforced Polymer walls is also compared.

III.METHODOLOGY

A. Description of model

Shear wall model of height 1025mm and width 1090mm are prepared using ANSYS software.Shear wall model consists of steel infill plate of E300A grade and steel frame of E350A grade from IS:2062.Thickness of the plate is 0.8mm.Unidirectional CFRP and GFRP fibers are laminated on plate at relative to the loading direction for hybrid CFRP and GFRP models.

.TABLE1
PROPERTIES OF FRP MATERIALS

Properties	CFRP	GFRP
Density(kg/m3)	1.7X10^6	2.6X10^6
Shear modulus(Pa)	5.8X10^9	3.3X10^9
Young’s modulus(Pa)	165X10^9	65X10^9
Poisson’s ratio	0.319	0.311
Tensile strength(Pa)	2800X10^6	2000X10^6

TABLE 2
PROPERTIES OF STEEL

Grade Designation	Tensile strength(Mpa)	Yield Stress(MPa)	Percentage Elongation
E300A	440	300	22
E350A	490	350	22

B. Modelling of shear wall in ANSYS

Process of modelling is as follows:

1) Define material
2) Geometry creation
3) Meshing of model (Coarse/finer)
4) Application of loading
5) Solution

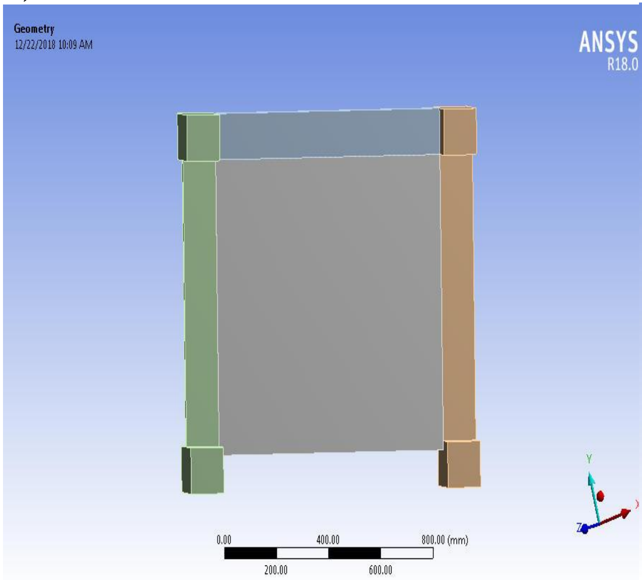

Figure 1 Shear wall model

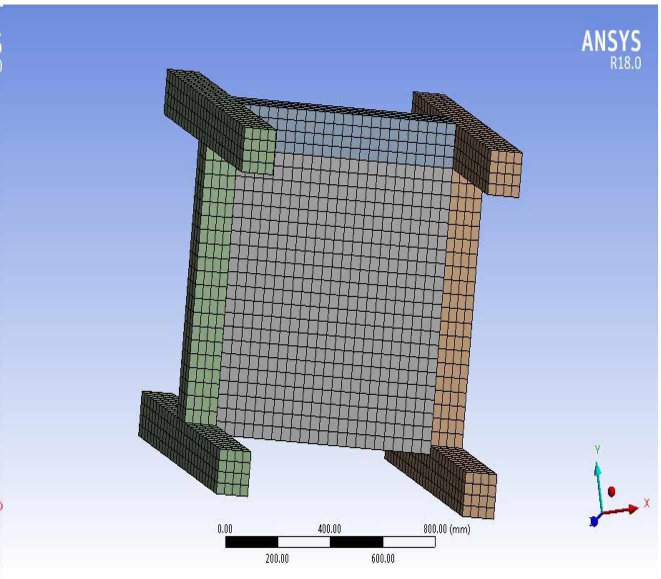

Figure 2 Meshed model of shear wall

Both the fibers of CFRP and GFRP are fixed to the steel plate to avoid delamination between steel plate and fibres.

In this anaslysis, finer type of meshing is applied because it provides more accuracy.

Load is applied at one edge as in the case of earthquake.

For getting same amount of displacement of 5mm,10mm,15mm,20mm,25mm,30mm different magnitude of loading required for steel,hybrid steel CFRP,hybrid steel GFRP shear walls is noted.Therefore their ultimate load carrying capacities can be compared.Then for same amount of displacements energy absorbed by each steel,hybrid steel CFRP and hybrid steel GFRP shear wall is obtained.In this way energy dissipated by each wall can be compared.

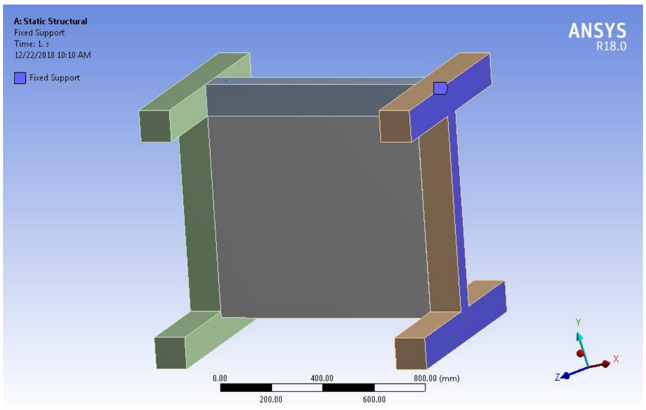

Figure 3 Fixed edge 1

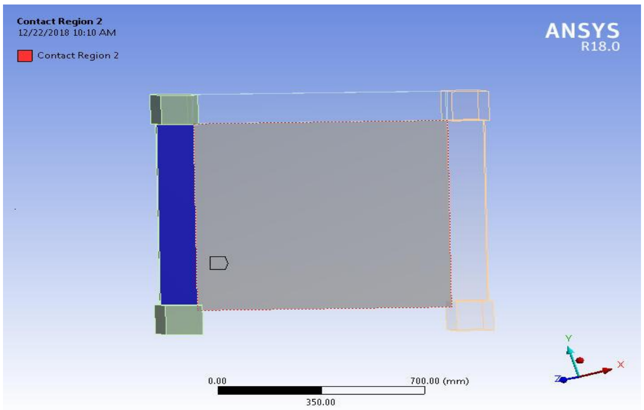

Figure 4 Fixed edge 2

IV.TEST RESULTS AND DISCUSSION

A. Load displacement result

The load displacement behaviour of pristine and retrofitted models is compared to investigate the possibility of structural repair of steel shear walls after the seismic event.

1) Steel plate model:

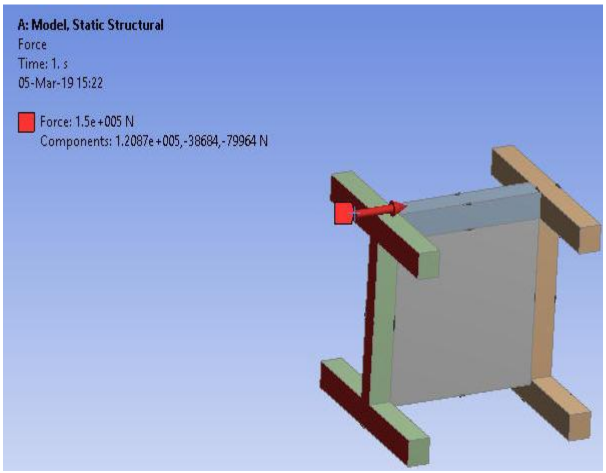

Figure 5 steel model loading

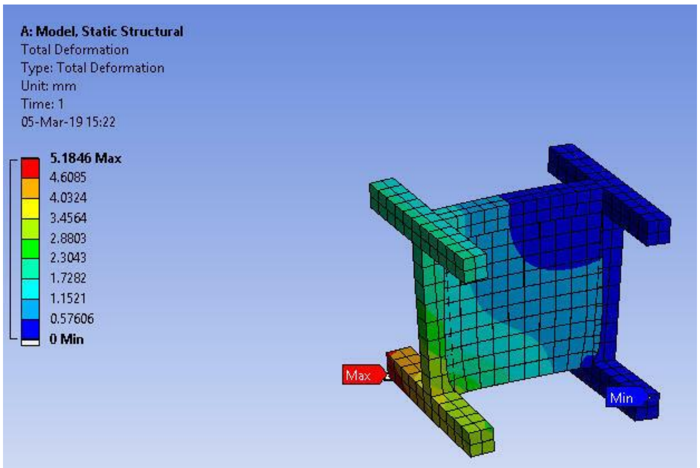

Figure 6 steel model deformation

2) Hybrid steel CFRP model:

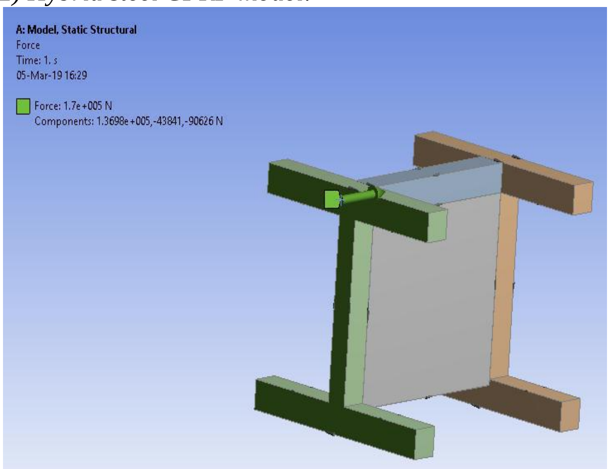

Figure 7 Hybrid steel CFRP model loading

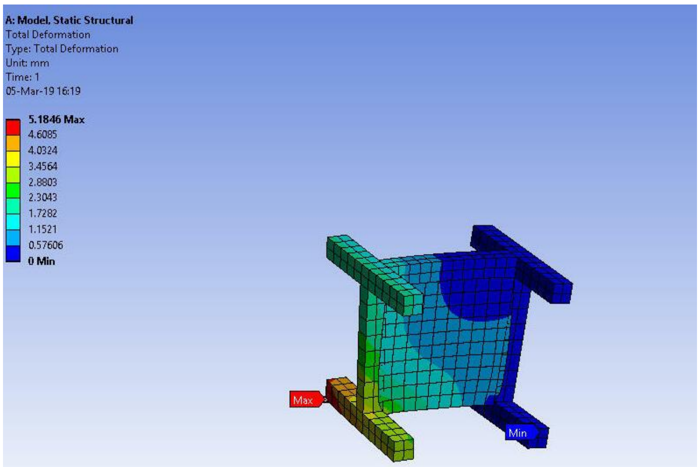

Figure 8 Hybrid steel CFRP model deformation

3) Hybrid steel GFRP model:

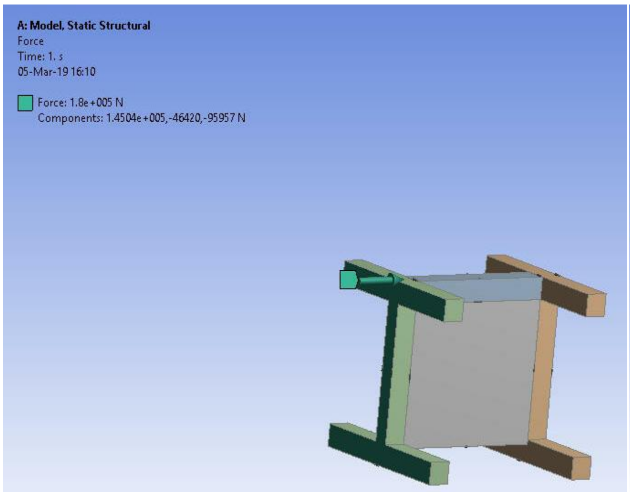

Figure 9 Hybrid steel GFRP model loading

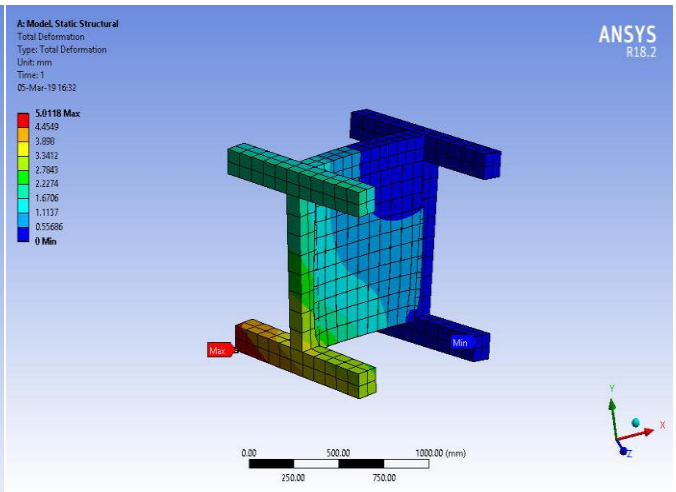

Figure 10 Hybrid steel GFRP model deformation

B. Energy dissipation results

1) Steel plate model:

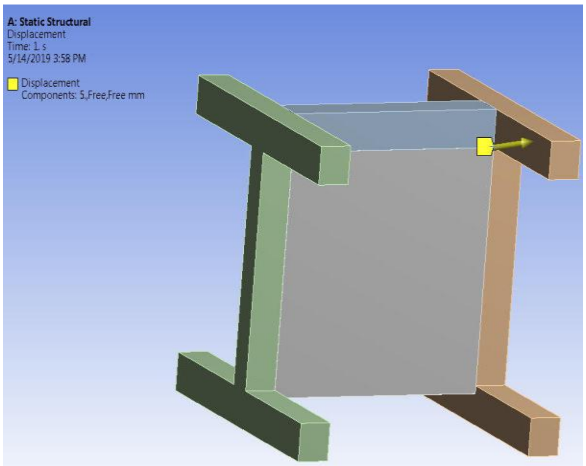

Figure 11 steel model displacement

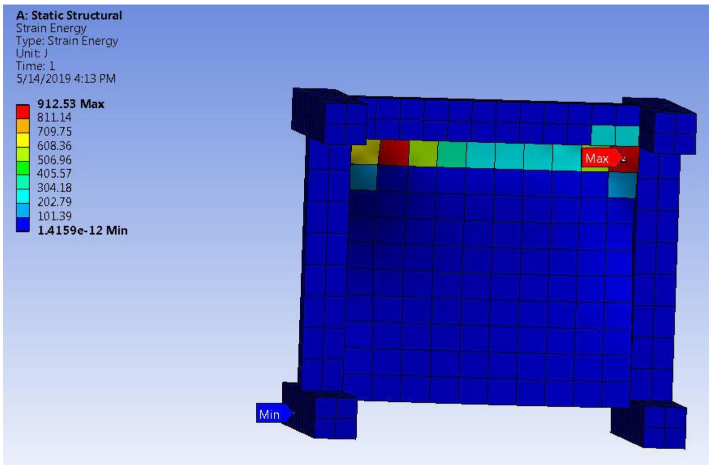

Figure 12 steel model energy absorption

2) Hybrid Steel CFRP model:

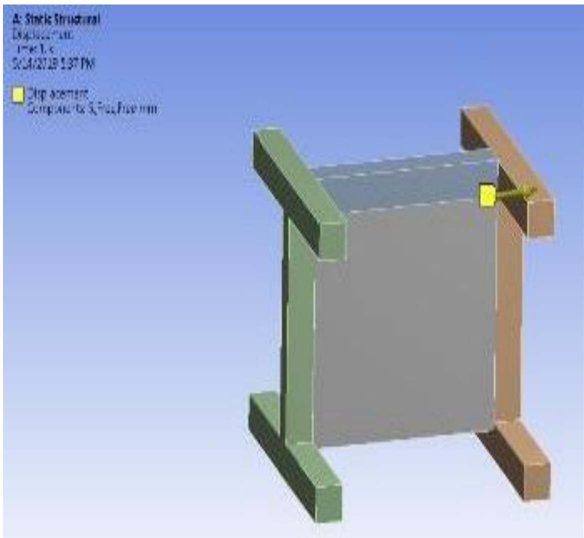

Figure 13 Hybrid steel CFRP model displacement

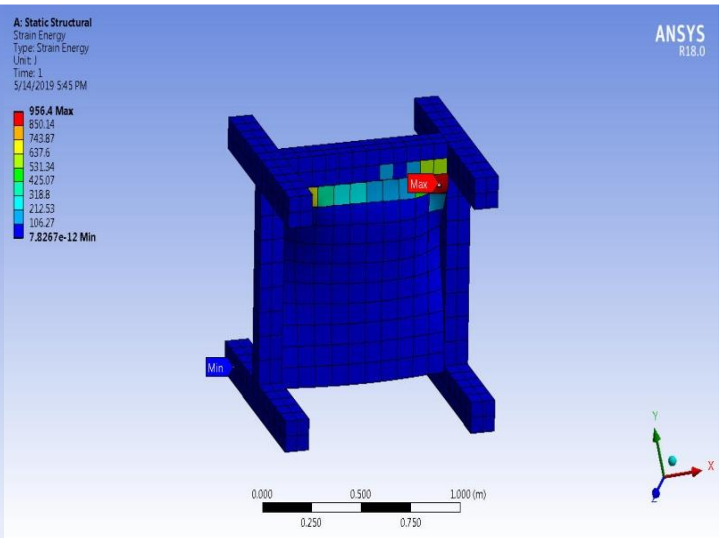

Figure 14 Hybrid steel CFRP model energy absorption

3) Hybrid steel GFRP model:

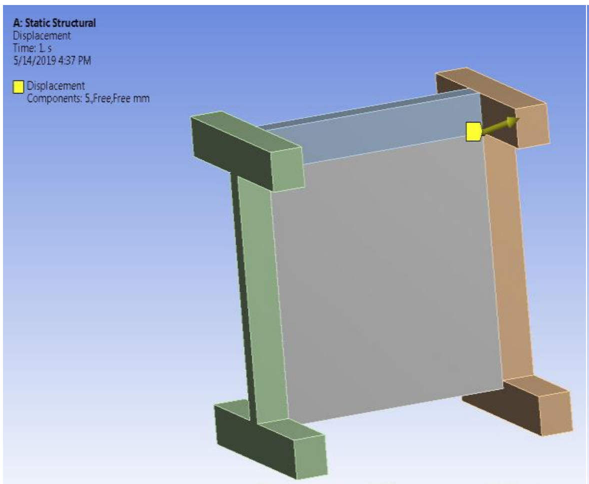

Figure 15 Hybrid steel GFRP model displacement

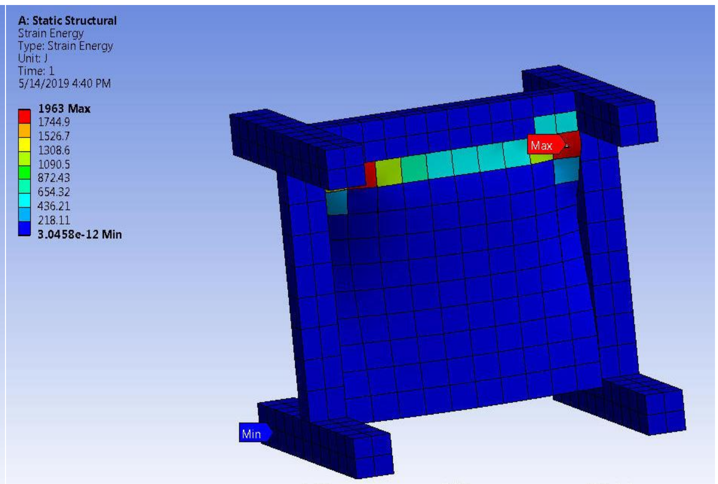

Figure 16 Hybrid steel GFRP model energy absorption

C. Graphical representation of load vs displacement results

1) Steel shear wall:

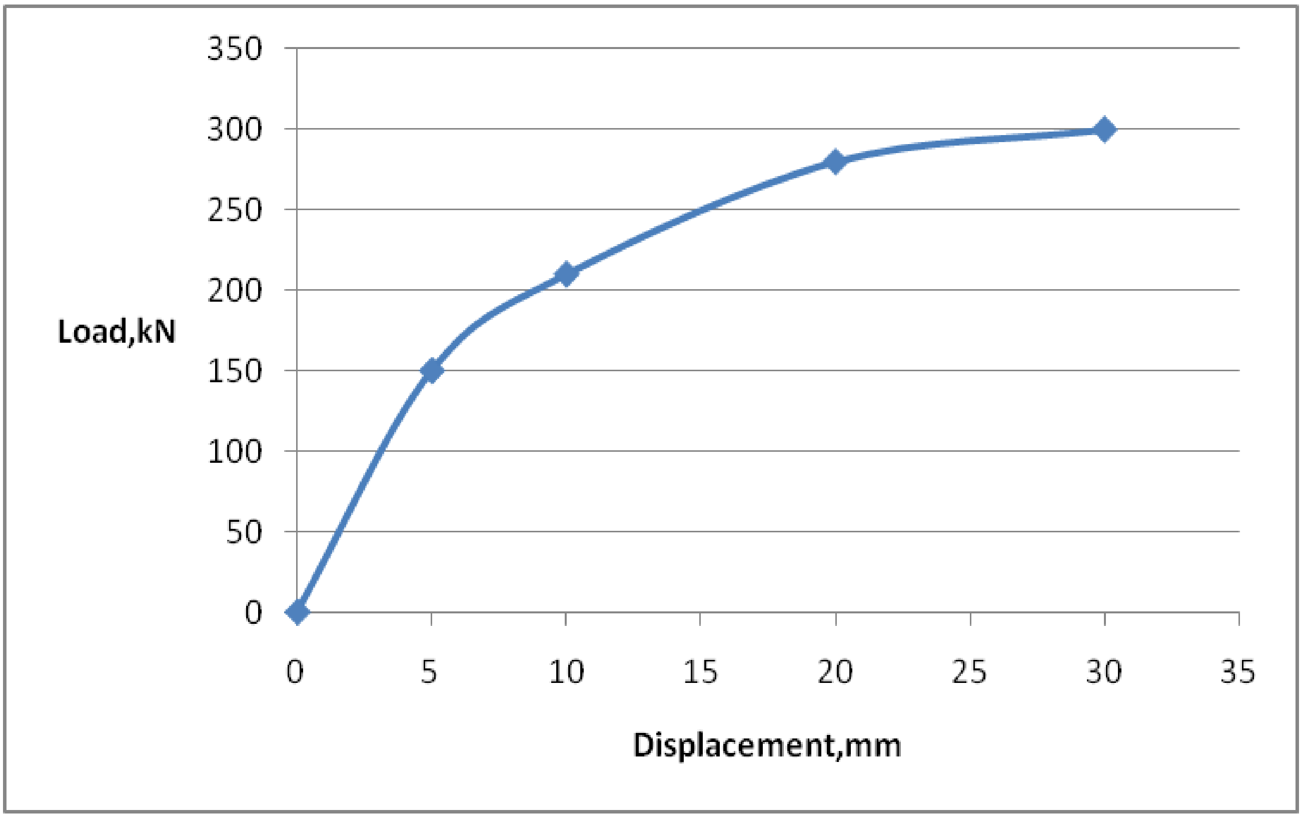

Figure 17 steel shear wall load vs displacement result

2) Hybrid steel CFRP shear wall:

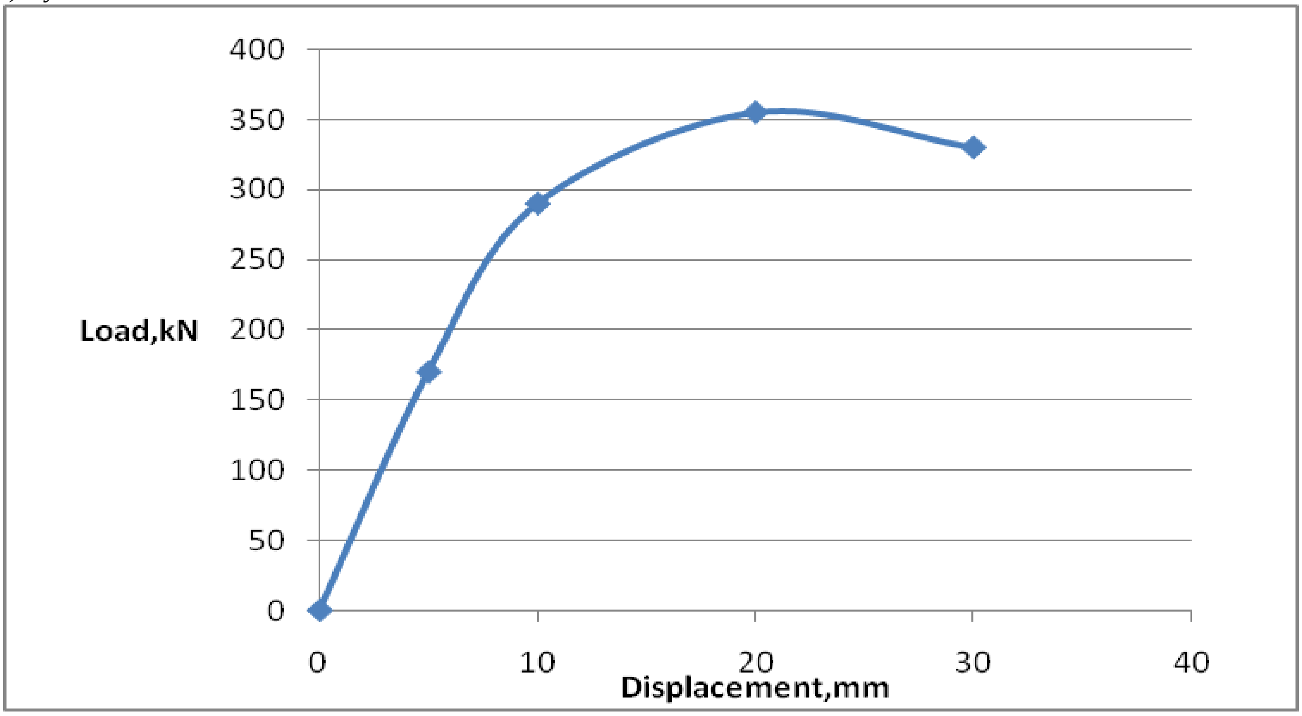

Figure 18 Hybrid steel CFRP shear wall load vs displacement result

3) Hybrid steel GFRP shear wall:

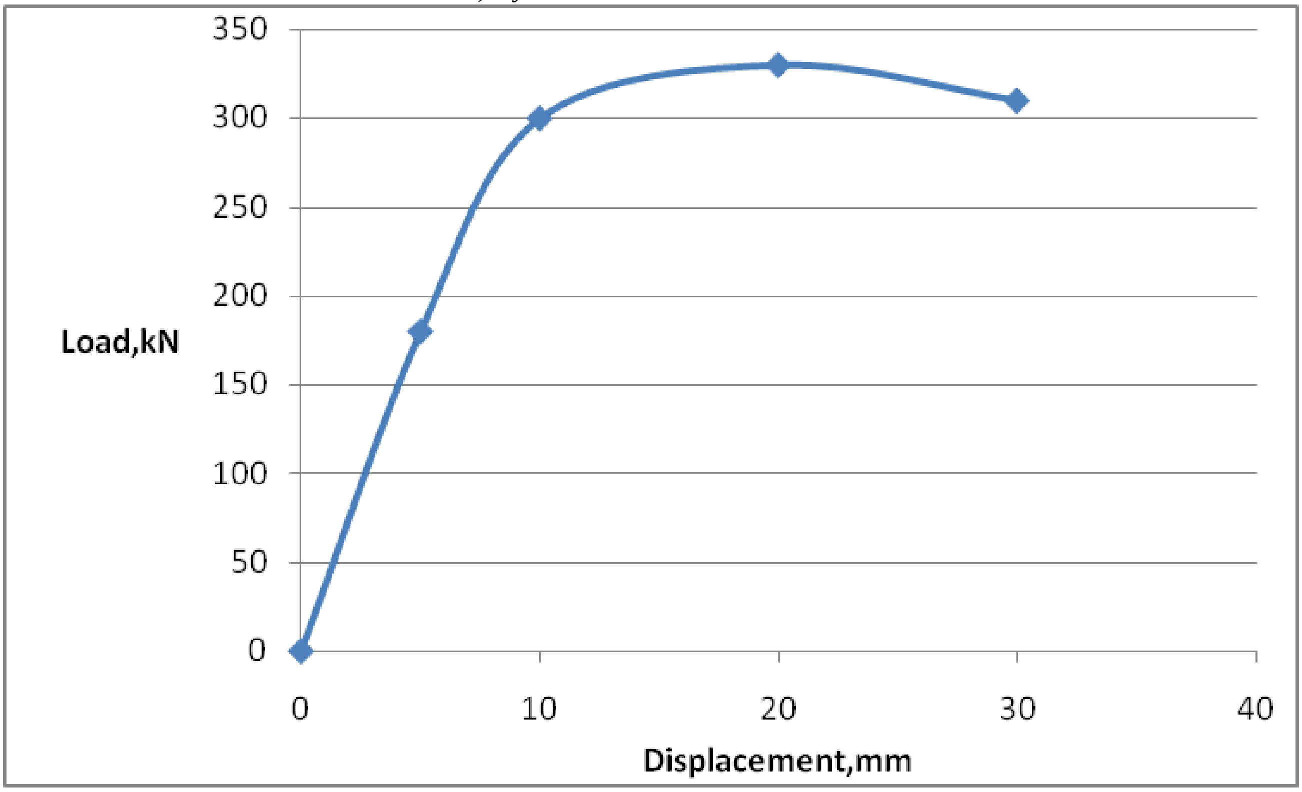

Figure 19 Hybrid steel GFRP shear wall load vs displacement result

4) Comparison of load vs displacement results:

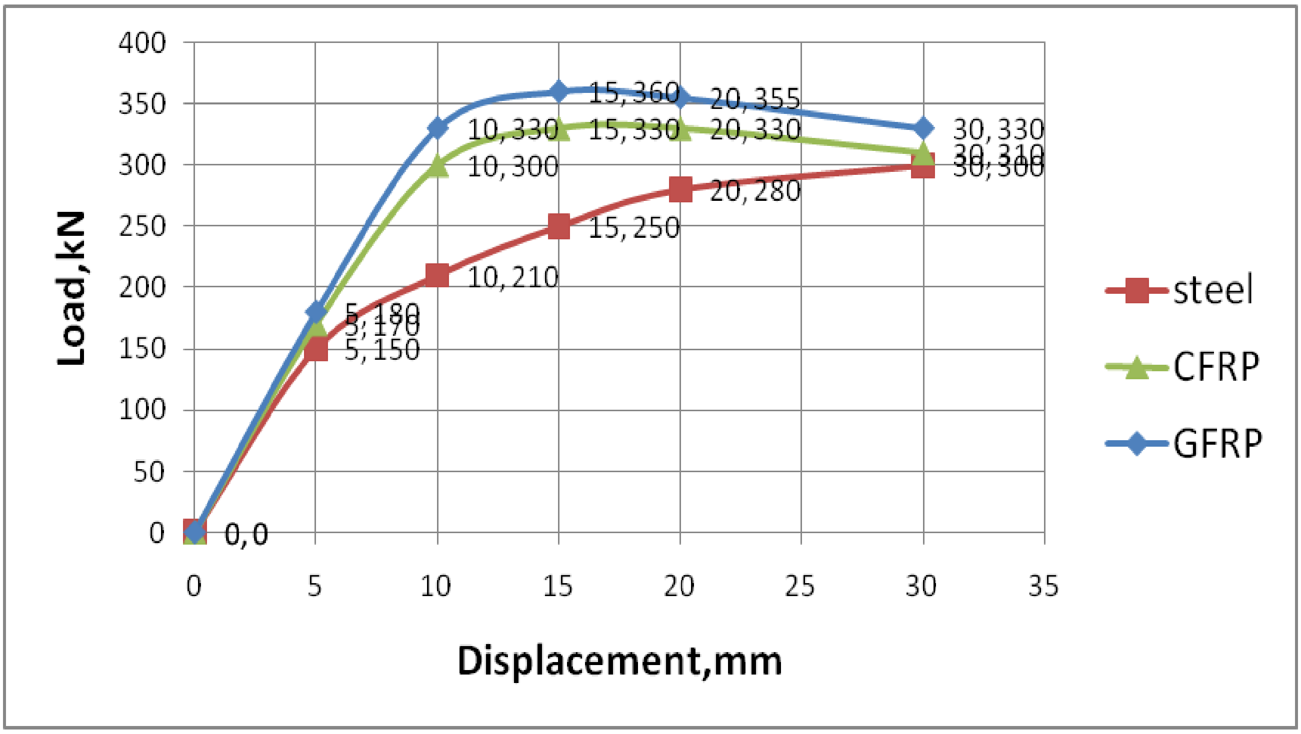

Figure 20 Comparative load vs displacement result

It is found that, the increases of load values are up to 16% higher for hybrid steel CFRP shear wall and up to 20% higher for hybrid steel GFRP shear wall as compared to steel shear wall.

D. Graphical representation of energy dissipation results

1) *Steel shear wall:*

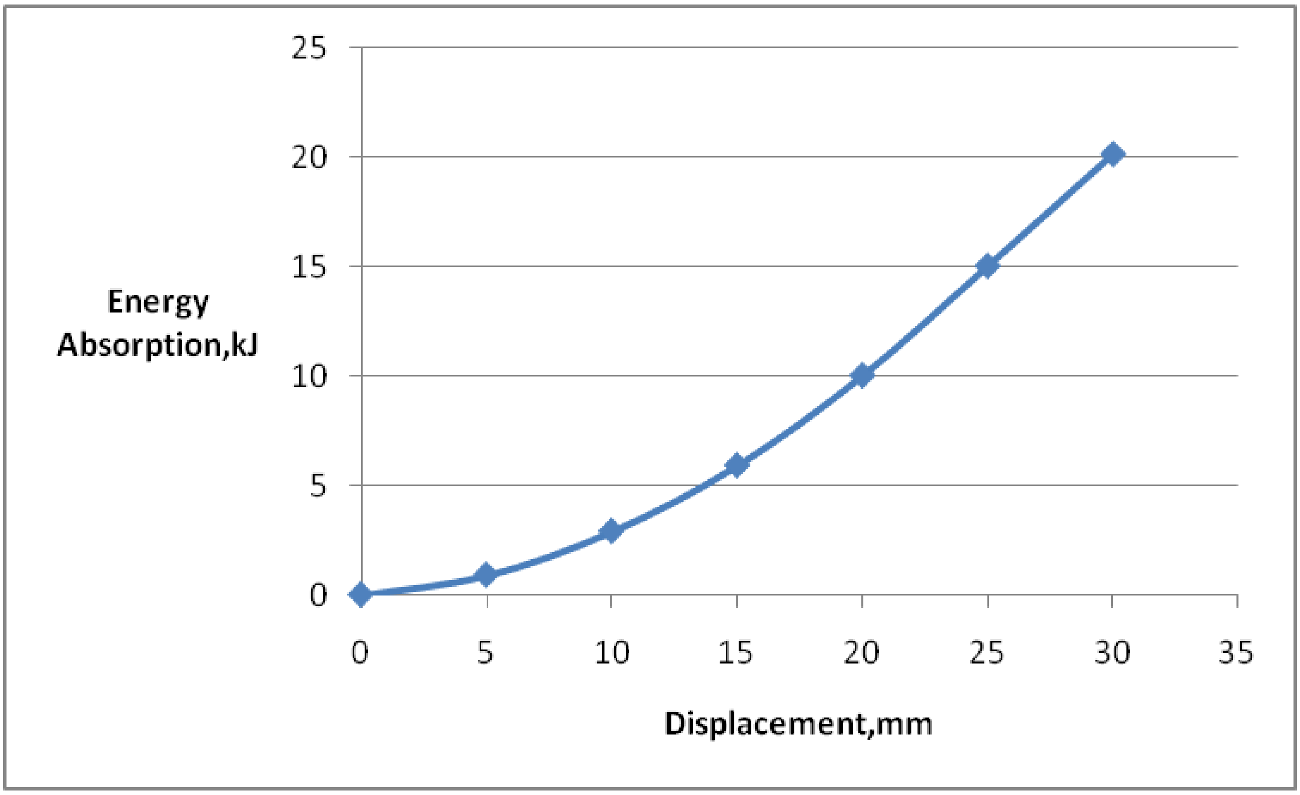

Figure 21 Steel shear wall energy absorption result

2) Hybrid steel CFRP shear wall:

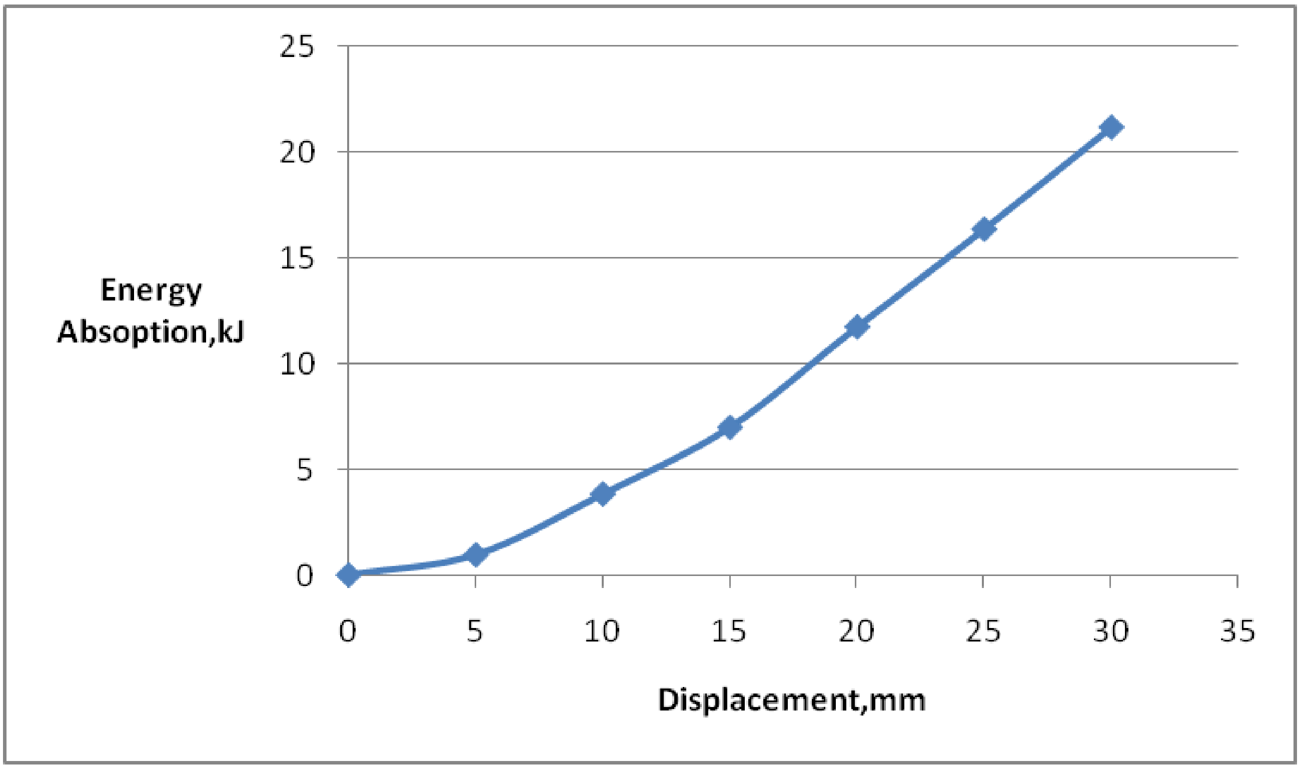

Figure 22 Hybrid Steel CFRP shear wall energy absorption result

3) Hybrid steel GFRP shear wall:

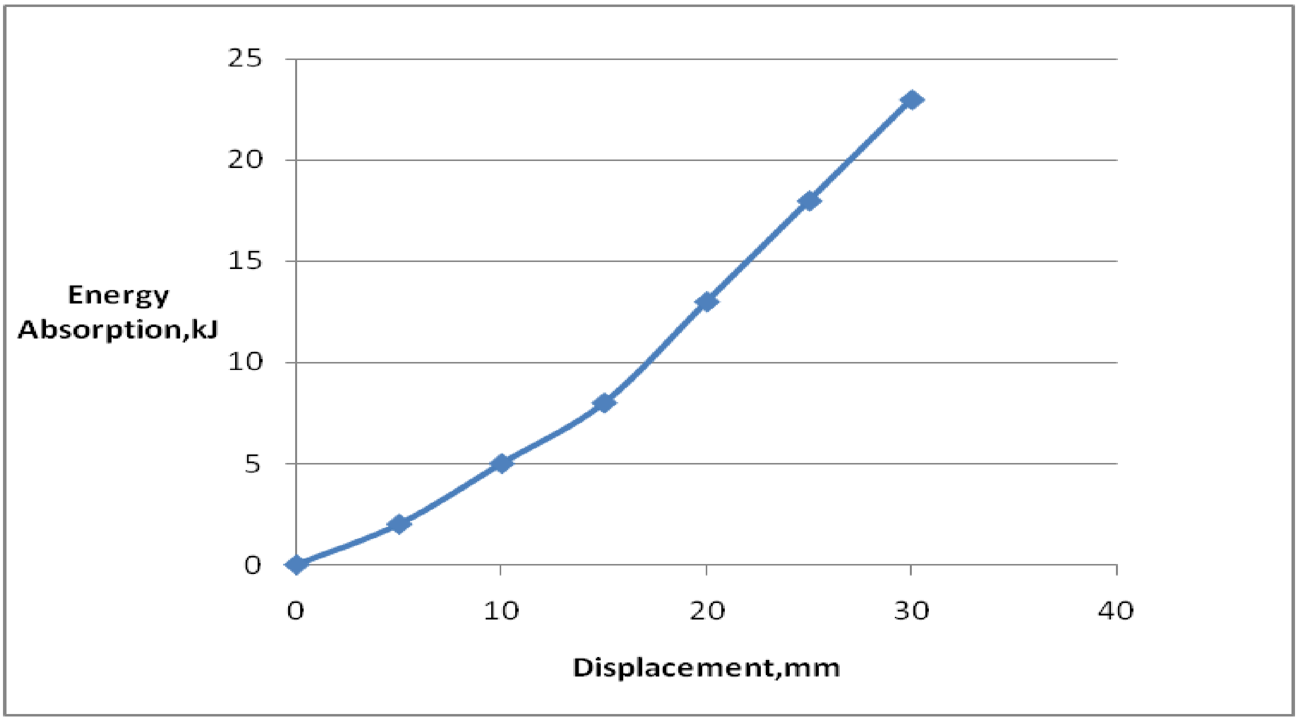

Figure 23 Hybrid Steel GFRP shear wall energy absorption result

4) Comparison of energy dissipation results:

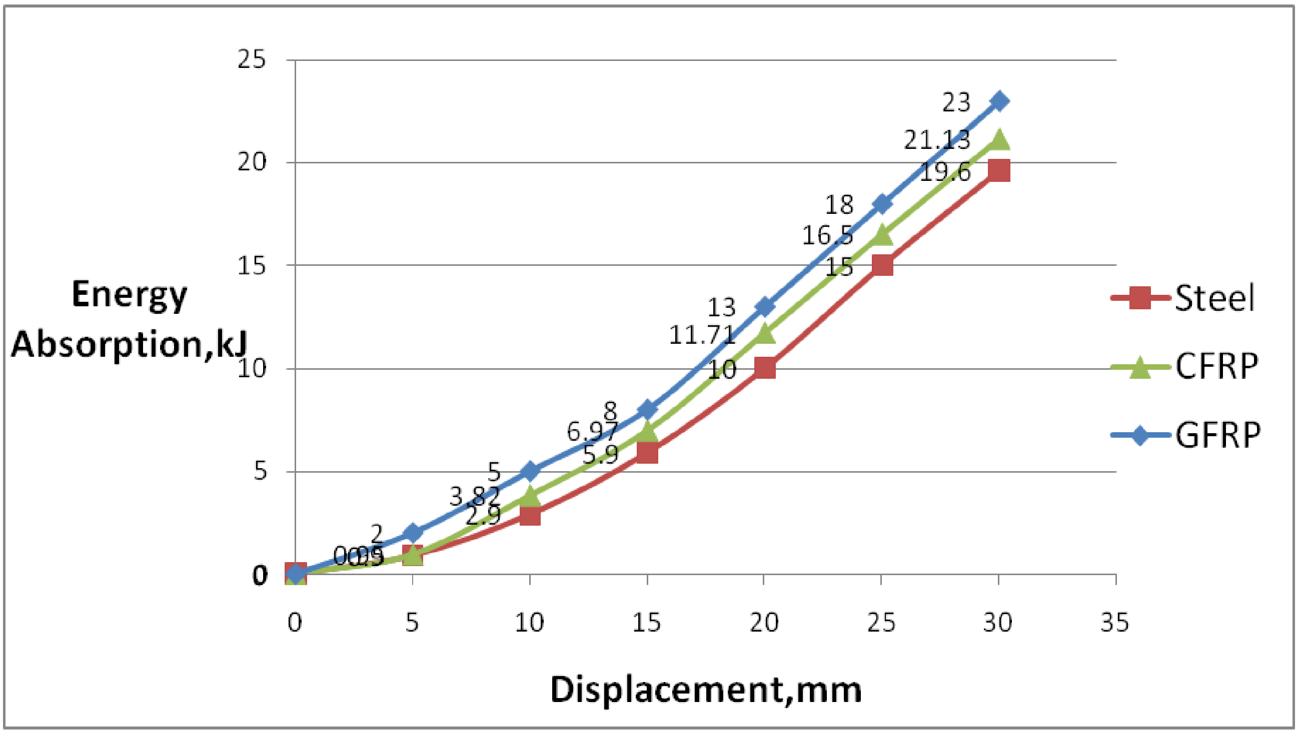

Figure 24 Comparison of energy absorption results

It is found that energy absorption capacity of steel shear wall increases by 10% and 14% due to application of CFRP and GFRP fibers respectively.

V.CONCLUSIONS

1) Use of the structural repair procedure, lead to in higher ultimate load in retrofitted models in comparison with original steel shear wall model.
2) It is found that, the surges of load values are up to 16% higher for hybrid steel Carbon Fiber Reinforced Polymer shear wall and up to 20% higher for hybrid steel steel Glass Fiber Reinforced Polymer shear wall as compared to steel shear wall.
3) It is found that energy absorption capacity of steel shear wall increases by 10% and 14% due to application of CFRP and GFRP fibers respectively.
4) Due to results of energy dissipation, it is known that, stiffness of hybrid shear walls is more than steel shear wall. Therefore it can be concluded that application of CFRP and GFRP fibers results in increment in stiffness of steel shear wall.

In summary it has been found that initial strength and stiffness of steel shear wall can be restored with the help of application CFRP and GFRP fibers in the case of earthquake.

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