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A Comparative Study of G+10 Structure with Various Materials Masonry, Concrete and Glass Fiber Reinforced Gypsum Panel (GFRG)

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Abstract: Glass fiber reinforced gypsum plasterboard (GFRG) is an environmentally friendly product. They are made of modified plaster and reinforced with fiberglass strips. Its main use is in the construction of walls, but it can also be used in combination with reinforced concrete on floors and roofs. The panels have voids that can be filled with concrete or reinforced with steel bars to increase strength and ductility. These panels can be used as an alternative building material to replace bricks and concrete blocks. IIT Madras has conducted several research studies and developed a structural design manual for designing buildings constructed by GFRG. Phosphor gypsum is a by-product of the fertilizer industry. In addition to its use as a fertilizer, building material, and soil stabilizer, approximately 85% of phosphor gypsum is disposed of near phosphate plants, which require large disposal sites. Phosphorus from gypsum can be effectively removed by creating glass fiber reinforced gypsum plasterboard (GFRG), also known as fast wall. They may or may not be used as support structures. In this research work we design three different models of G+10 in 5th zone of earthquake as on IS code. The lateral load such as earthquake is to be classified as live horizontal forces acting on the structure depending on the structure's geographic location, height, shape and structural material. In this study, a multi-story Glass fiber reinforced panel and Brick-infill and concrete block infill wall building has been shown and performed by using software ETABS constructed on a plan ground having G+10 stories.
Keywords: GFRG Panels, Concrete Blocks, Clay Bricks, Lateral Loading, Light weight Construction and Masonry etc.

I. INTRODUCTION

For use in creating buildings that GFRG will construct, IIT Madras has created a building design. A by-product of the fertilizer business is phosphor gypsum. About 85% of phospho gypsum is disposed of at nearby phosphate facilities, which need large disposal sites in addition to using it as fertilizer, building material, and soil stabilizer. By producing glass fiber reinforced gypsum plasterboard (GFRG), also known as quick wall, phosphorus from gypsum may be successfully eliminated. They might or might not be utilized as support.

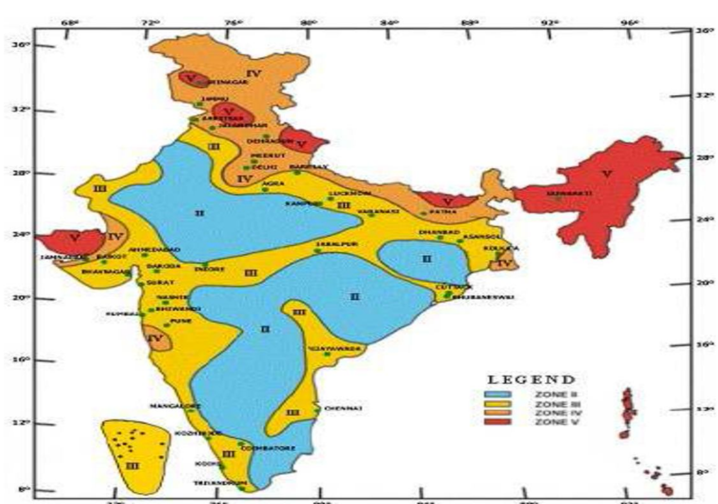

Figure 1 Seismic zone map of India as per IS: 1893 (Part 1) – 2002 [29]

A. Damages during Past Earthquakes in Hilly Region

1) Uttarkashi in Western Himalayas
2) The Chamoli in Central Himalayas (Chamoli (Himalaya, India))
3) 3 Assam in eastern Himalayas

B. Glass Fiber Reinforced Gypsum

Rapid wall, commonly referred to as glass fiber reinforced gypsum plasterboard (GFRG), is an architectural panel constructed of calcined gypsum and reinforced with glass fiber. Since 1990, these panels have been employed in large-scale buildings in Australia. They were first created by GFRG Building Systems Australia. The technology is now used and manufactured in India for these panels. According to the structural requirements, the panels, which have a thickness of 124 mm, a length of 12 m, and a height of 3 m, leave the cavity empty or are partially or fully covered with reinforced concrete. It is possible to totally fill a cavity. Research and trials conducted in Australia, China, and India have demonstrated the great strength and versatility of GFRG plates filled with regular reinforced concrete, allowing them to be used not only as load-bearing parts but also as load-bearing walls that can withstand side impacts. It can withstand wind, earthquakes, and loads.

Figure 2 Construction of GFRG panel house

C. Concrete Block in Building

Concrete blocks are "bricks" made exclusively of concrete that are linked together with mortar to form a magnificent, long-lasting building. Blocks can be "hollow" or "solid" and built of thick or lightweight concrete in a number of standard sizes, depending on the requirements. These concrete blocks can be used to build ceiling walls, partition walls, and load-bearing walls. It is employed when bricks or stones of the required quality and strength are difficult to procure but a sufficient aggregate is readily available.

1) Solid Concrete Blocks
2) Hollow Concrete Blocks

D. Clay Bricks

Clay bricks are one of the most commonly employed for building purposes. This style of manufactured brick can be utilized for a variety of home and commercial applications. Clay tiles are commonly used for walls, roofing, patios, landscaped spaces, and facades, among other things. Because of their excellent characteristics, pavers and bricks can be utilized for a variety of reasons. Recent advancements in brick manufacture have resulted in bricks with wider holes that provide improved flexural strength and water resistance. Many brick makers are attempting to reduce resource use and employ very cost-effective and practical techniques for creating clay bricks.

II. PROBLEM STATEMENT

1) The concept and use of the GFRG panel building presents challenges that must be accounted for in its design and use.
2) These challenges arise because in modern present/future time many of the building are constructed with different type of infill in regular and irregular pattern resting on plan or sloping ground.
3) Large irregularities in vertical and horizontal configurations, ground conditions or using different type of infill material can create serious problems of displacement, torsion and stress concentration that will result in distortions and drifts beyond those that the building can accommodate.
4) Scrutiny of these conditions is necessary at an early design stage to ensure that the structure is not faced with conditions that may be almost impossible to make safe.

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III. OBJECTIVES

1) The main purpose of this research is to provide insights and consequences about the seismic performance of GFRG panels and brick buildings.
2) To determine the optimum masonry building material.
3) Recognize how brick, GFRG, and concrete block react to seismic loads.
4) Investigate how various materials affect joint displacements, bending moments, and foundation reaction forces.
5) To evaluate the outcomes for brick walls, concrete block walls, and all GFRG panels.

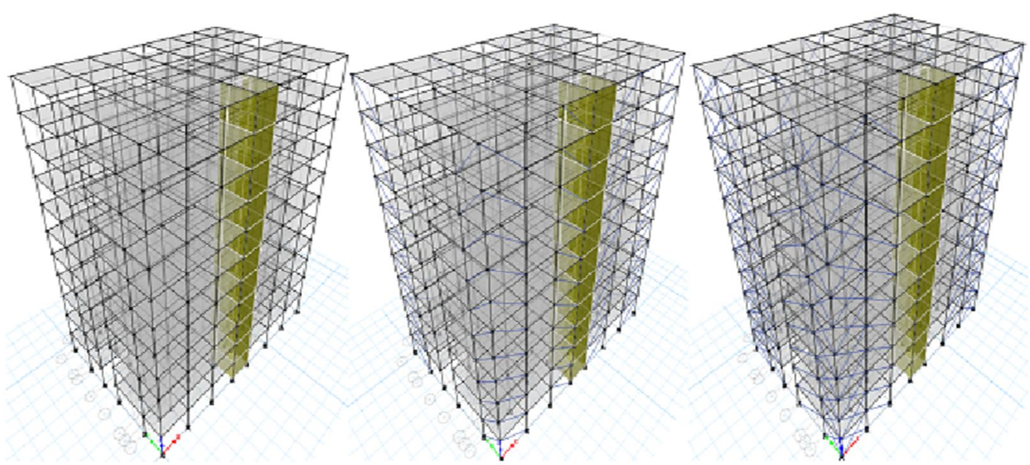
IV. METHODOLOGY

In this research work we prepare three different models of G+10 in 5th zone of earthquake as per IS code using Etabs 2016 software. The model 1 considered as RCC structure, model 2 considered as GFRD structure and model 3 considered as masonry structure.

A. *Model Geometry*

Table 1 Model input data

Cases	Case 1	Case 2	Case 3
Case name	G+10 structure with RCC concrete	G+10 structure with GFRG panel	G+10 structure with brick masonry
Data	**Value**		
Grade of steel	HYSD 415		HYSD500
Materials	M30	Masonry	GFRG
No. of storeys	G+10		
No. of bay along X-direction	5		
No. of bay along Y-direction	5		
Span along X-direction	5m		
Span along Y-direction	5m		
Floor height	3m		
Column size (mm)	500X500mm		
Beam size (mm)	500X400mm		
Masonry (Brick strut)	481x230mm		
GFRG (strut)	612x124mm		
Depth of Slab	150mm		
Dead load	13 kN/ m		
Live load	2.5kN/m2		
Software	ETABS 2016 Ultimate V 16.2.1		
Response spectrum RS-X	1106.26		
Response spectrum RS-Y	1073.38		
Response Reduction R	5		
Earthquake Load	IS code 1893:2002		
Seismic zone X-dr. coefficient, Z	0.36		
Seismic zone Y-dr. Coefficient, Cp	0.36		
Importance factor	1		



a) RCC structure **b) GFRG structure** **c) Masonry structure**

Figure 3 3D view of Structure with different materials

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V. RESULTS AND DISCUSSION

A. Results of Storey Displacement

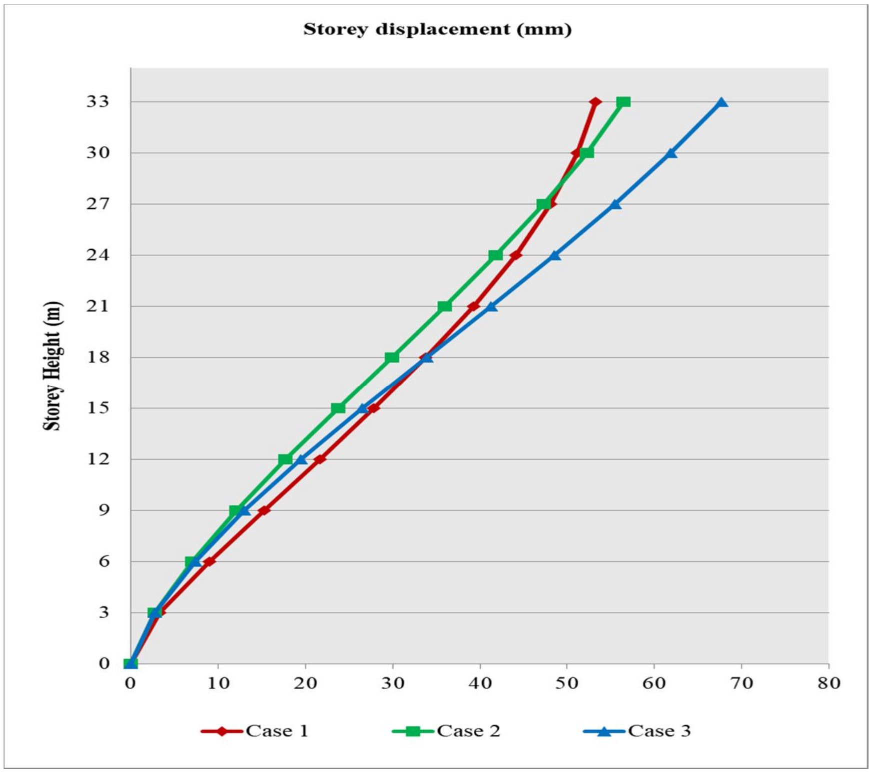

Figure 4 Storey displacement in G+10 storey building model in varying type of cases cause from load combination 1.2 (DL+LL+EQL-X)

B. Results of Storey drift

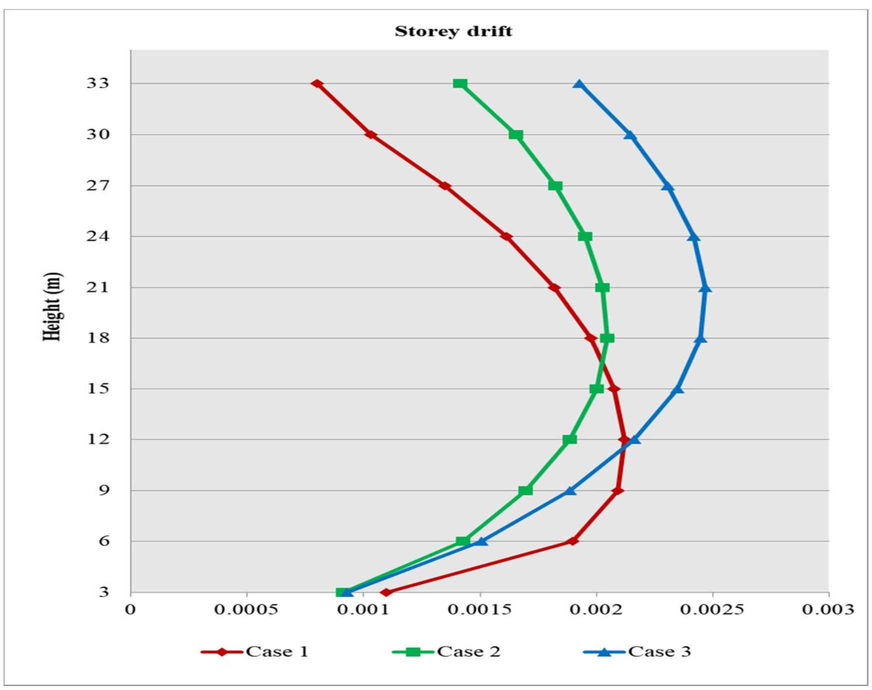

Figure 5 Storey drift in G+10 storey building model in varying type of cases cause from load combination 1.2 (DL+LL+EQL-X)

C. Results of Storey Stiffness

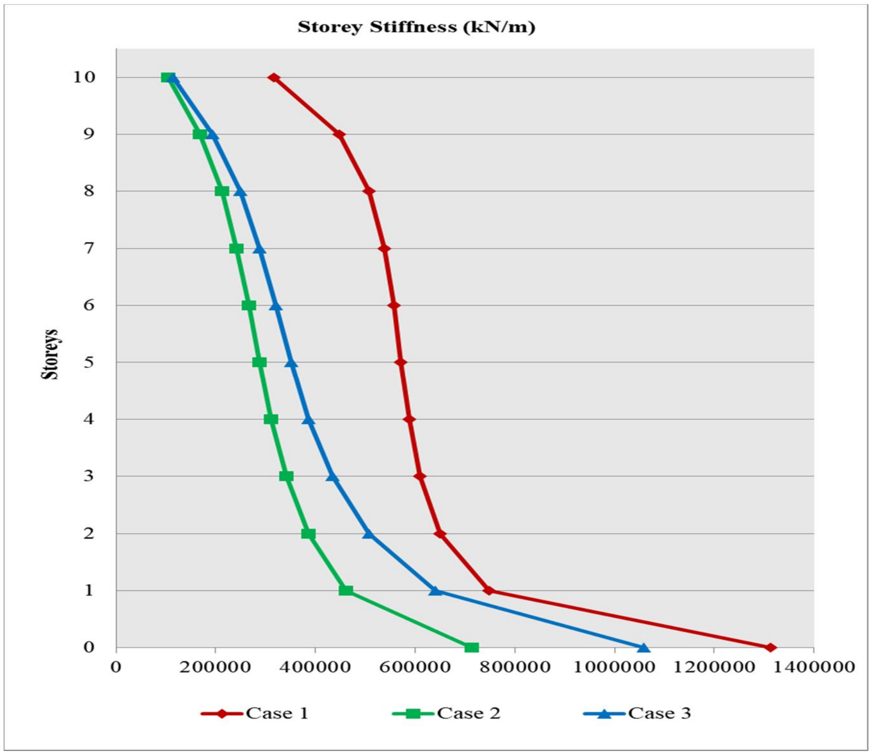

Figure 6 Storey stiffness in G+10 storey building model in varying type of cases cause from earthquake load (EQL-X)

D. Results of Shear Force

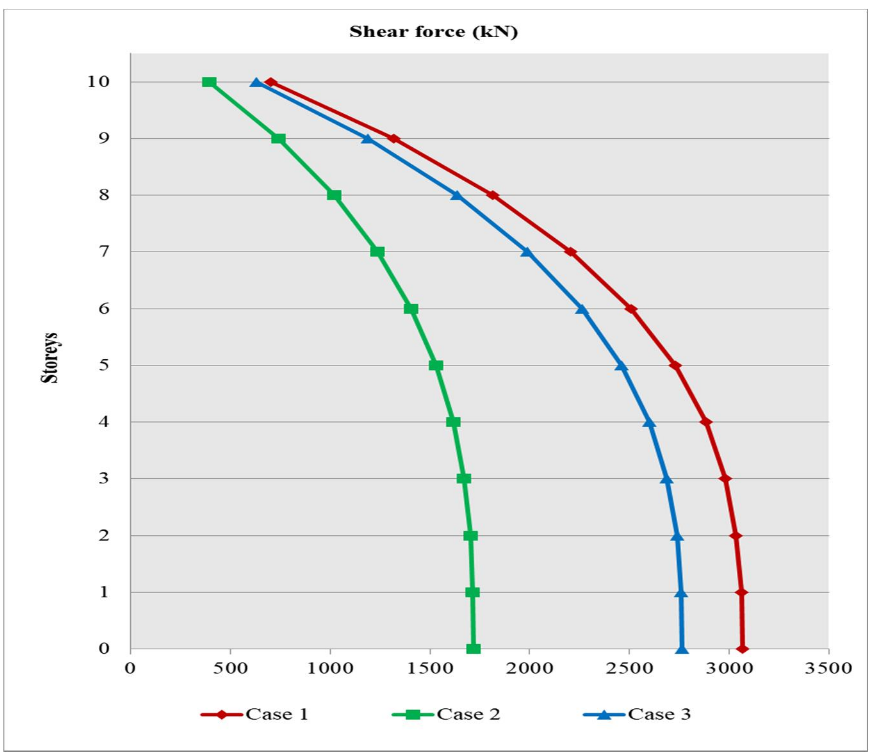

Figure 7 Shear force in G+10 storey building model in varying type of cases cause from earthquake load (EQL-X)

E. Results of Bending Moment

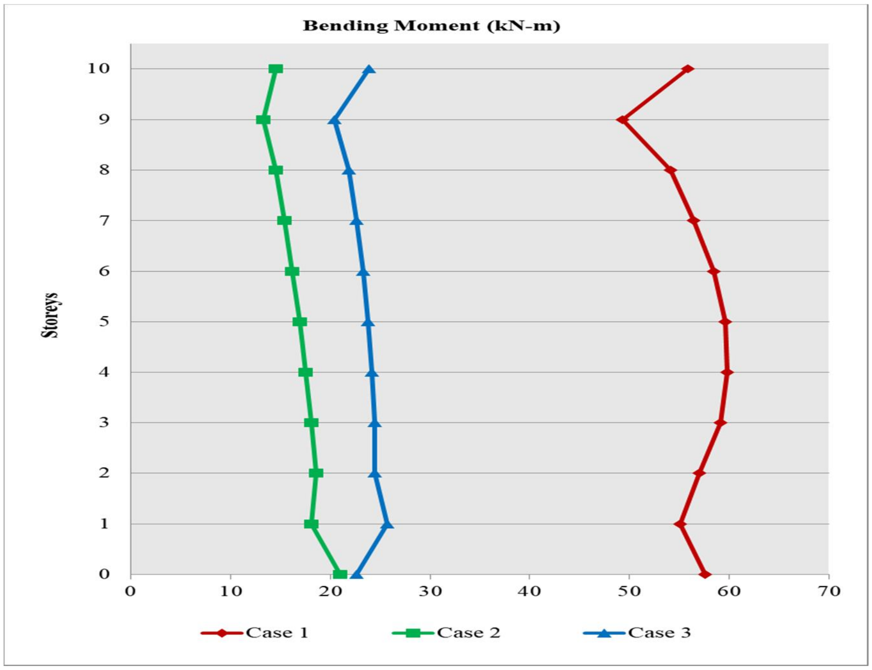

Figure 8 Bending moment of G+10 storey building model in varying type of cases cause from load combination 1.2 (DL+LL+EQL-X)

F. Results of Base Reaction

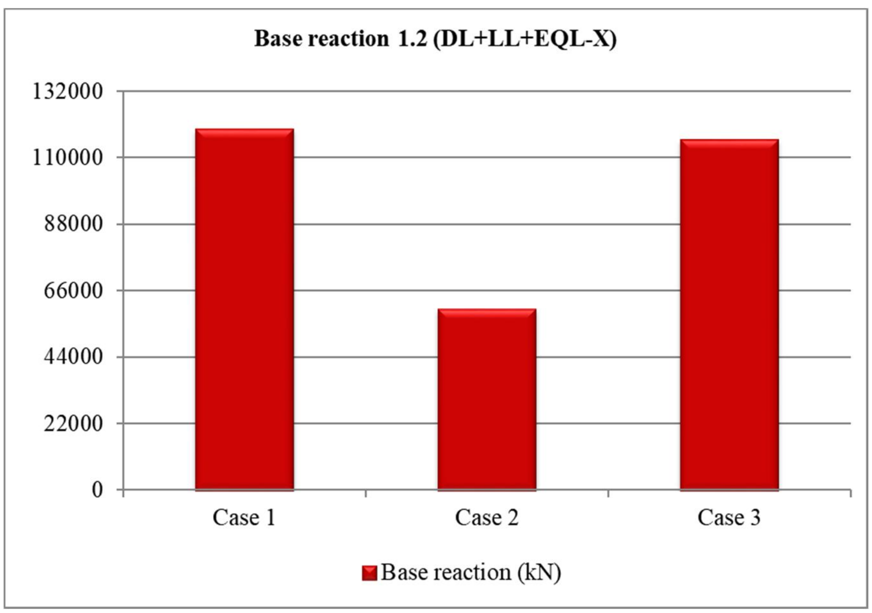

Figure 9 Base reaction of G+10 storey building model in varying type of cases cause from load combination 1.2 (DL+LL+EQL-X)

VI. CONCLUSIONS

1) Maximum value of Storey displacement of G+10 models having GFRG panel is 56.51mm and when model having brick wall on behalf of GFRG this storey displacement is 67.65mm that was becomes higher than models having GFRG panel and bare frame of G+10 building.
2) It noticed that use of GFRG panels in model increment of storey displacement was 6.08%. And when using brick masonry increment of storey displacement was 26.99%. So, it was self-explanatory that in GFRG panel displacement not becomes as high as use of brick masonry.

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3) Maximum value of Storey drift of G+10 models having GFRG panel is 0.002046 and when model having brick wall on behalf of GFRG this storey drift is 0.002469 that was becomes higher than models having GFRG panel and bare frame of G+10 building.
4) It noticed that use of GFRG panels in model decrement of storey drift was 3.58%. And when using brick masonry increment of storey drift was 16.35%. So, it was self-explanatory that in GFRG panel drift becomes as high as use of brick masonry.
5) Maximum value of Stiffness of G+10 models having GFRG panel is 713479.53 kN/m and when model having brick wall on behalf of GFRG this stiffness is 1057866.17kN/m that was becomes higher than models having GFRG panel and bare frame of G+10 building.
6) It noticed that use of GFRG panels in model decrement of stiffness was 45.62%. And when using brick masonry decrement of stiffness was 19.38%. So, it was self-explanatory that in GFRG panel stiffness not becomes as high as use of brick masonry.
7) Maximum value of Shear force of G+10 models having GFRG panel is 1719.66kN and when model having brick wall on behalf of GFRG this shear force is 2765.97kN that was becomes higher than models having GFRG panel and bare frame of G+10 building.
8) It noticed that use of GFRG panels in model decrement of shear force was 43.92%. And when using brick masonry decrement of shear force was 9.80%. So, it was self-explanatory that in GFRG panel shear force not becomes as high as use of brick masonry.
9) Maximum value of Bending moment of G+10 models having GFRG panel is 20.98kN-m and when model having brick wall on behalf of GFRG this bending moment is 25.69kN-m that was becomes higher than models having GFRG panel of G+10 building.
10) It noticed that use of GFRG panels in model decrement of bending moment was 64.93%. And when using brick masonry decrement of bending moment was 57.06%. So, it was self-explanatory that in GFRG panel bending moment not becomes as high as use of brick masonry.
11) Maximum value of Base reaction of G+10 models having GFRG panel is 59763.00kN and when model having brick wall on behalf of GFRG this base reaction is 115827.98kN that was becomes higher than models having GFRG panel of G+10 building.
12) It noticed that use of GFRG panels in model decrement of base reaction was 49.96%. And when using brick masonry decrement of base reaction was 3.02%. So, it was self-explanatory that in GFRG panel base reaction not becomes as high as use of brick masonry.

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