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Optimum analysis of seismic retrofitting in G+5 building by bracing and shear wall

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***Abstract*— In the RC building, bracing and shear wall techniques are used to provide stiffness, strength and energy dissipation to resist the lateral loads imposed by seismic zone. In this research study demonstrates the optimum analysis of seismic retrofitting in G+5 building with comparison of shear wall and bracing techniques by equivalent static load method with the help ofETABS15software. The structure which is to be analysed is symmetrical G+5 hospital building by shifting III to V seismic zones. Comparison of response of shear wall and bracing system of hospital building will have to be done in future scope of this research work. We have design it for zone III and suddenly seismic zone V was created. All the data required for earthquake resistance structure is to be taken from IS code i.e. IS 1893 (part 1): 2002.The main objective of this study is to check the kind of performance a building can give when designed as per Indian Standards and also to determine the effect of providing shear wall and Bracing to building frame. In order to minimize the damages due to sudden change of seismic zone, bracing are efficient in terms of cost and effectiveness analysis. On the other side bracings can absorb huge degree of energy which is exerted by trembling. Structural performances of both systems are significant, but their effect shows unequal variations and behaviour against earthquake load.**

***Keywords*— Shear wall; ETABS; Steel bracing; Seismic load; Optimisation; Linear analysis**

I. INTRODUCTION

Earthquake frequently occurs all over the world and now-a-days it is great issue. After the Nepal earthquake 25 April 2015, there has been a mutual effort throughout India to provide more awareness with respect to earthquake resistant design of structures. Many unexpected damages have been caused due to earthquake in different domains. At present scenario India moving toward become the developed country through economy and humanity for that infrastructure places an important role [1]. The estimation of time, location and intensity of tremor is very difficult to understand. It is required to identify the damage of a structure caused due to varying ground motion intensities. This identification results will help an engineer to take necessary action against the after-effects of an earthquake. So it is very necessary to adopt the suitable rules before design by keeping in mind the dangerous effects of earthquake. Mostly, structures are designed only for dead load, live load, wind load, etc. which is susceptible to severe damages due to earthquake. Different countries have a variety of provisions of providing such system with a view to dissipating the energy of seismic zone [2]. The design adopted in the Indian Code IS 1893(Part 1): 2002 Criteria for Earthquake Resistant Design of Structure to ensure that structure withstand major earthquake without collapse. Damages caused by earthquake can be prevented by adding such structural elements like shear wall and bracing systems. Shear wall and steel bracing systems are most efficient means to adopt for add more stiffness in frames. Bracings have less stiffness as comparing with shear wall; there is an important concern that is the self-weight of bracings are to a small amount as comparing with concrete shear wall. In this research paper one model for bare frame, with bracing and other with shear wall technique for hospital building are generated with the help of ETABS software and its economic analysis has been tested [3].

II. METHODOLOGY

It desires to adopt the exact procedure to analyze a certain structural frame considering its parallel characteristics related to earthquake as seismic analysis was very complicated portion in the field in structural engineering. In this research work Static methods is used for earthquake analysis. This method is also known as equivalent static force method. It calculates base shear from the weight of building or frame. Live loads and dead loads are considered according to the norms and distributed along in each storey [4-7]. Properties of concrete material as shown in table 1.

TABLE 1
PROPERTIES OF CONCRETE MATERIAL

Sr. No.	Property	M20 (Beam)	M25 (Column)	M30 (Shear Wall)
1	Mass per unit volume	25000 kg/m^3	25000 kg/m^3	2500 kg/m^3
2	Weight per unit volume	25 kN/m^3	25 kN/m^3	25 kN/m^3
3	Poisson's ratio	0.21	0.21	0.21
4	Young's modulus	22360.68 MPa	25000 MPa	27386 MPa
5	Shear modulus	9316.95 MPa	10416.67 MPa	11410.83 MPa

A. Preliminary Data

- G + 5 Storey R.C hospital building having plan dimensions 18 × 12 m
- Floor to floor height = 3 m
- Beams dimension = 300 × 300 mm
- Column size = 400 × 400 mm
- Shear wall thickness = 115 mm

B. Dead Load

The dead load on structure includes all the permanent loads attached with structure i.e. self-weight of structure, slab, floor finish, wall and partition load. The loading pattern is trapezoidal or triangular depending upon the panel size in floor slab. The wall loads have been calculated based on wall thickness and same applied on beam members as UDL. Following are the permanent loads which have been considered in design & analysis. Self-weight of structure members has been considered on the basis of the following criteria:

- Density of reinforced concrete = 25kN/m^3
- Density of steel = 78.5 kN/m^3
- Density of plain concrete = 24 kN/m^3
- Density of finishes = 20 kN/m^3

1) *Wall Load*: *230 mm thick brick wall*

Height of wall = 3 m
Self-load = 0.23×18= 4.14 kN/m^2
Plaster (12+15mm) =
0.027×22 = 0.594 kN/m^2
Total = 4.734 kN/m^2
Effective height of wall = 3 - 0.12 = 2.88 m

Thus, 230 mm thick wall load applied on floor = 2.88×4.734 = 13.6 kN/m

115 mm thick brick wall

Height of wall = 3 m
Self-load = 0.115×18 = 2.07 kN/m^2
Plaster (12+15mm) = 0.027×22 = 0.594 kN/m^2
Total = 2.56 kN/m^2
Thus 115mm thick Wall load applied on floor = 2.88×2.56 = 6.8 kN/m

2) *Slab loads (120 mm thick floor slab)*

Dead load: self-weight = Incorporated by software
Plaster = Incorporated by software
Floor finish = 0.75 kN/m^2
Total = 4.5 kN/m^2

C. Live Load

The live load has been taken as per IS 875 (part 2) acting on the floor slab. Live load is shown in table 2.

TABLE 2
LIVE LOAD VALUS

Area		Live load kN/m^2
Living Room		2
Corridor , Lobbies		3
Toilets		2
Kitchens		2
Utility Area		2
Balconies		3
Stair Case		3
Terrace	Usable	3
	Non usable	1.5
Basement Parking		5

D.Earthquake Load

EQX = Static EQ Load in X direction with "User Defined" Time Period
EQY = Static EQ Load in Y direction with "User Defined" Time Period
Time period in x direction = $0.09h/d^{0.5}$ (as per IS 1893: 2002 clause no. -7.6.2) = $0.09 \times 18/18^{0.5}$=0.47sec.
Time period in y direction = $0.09h/d^{0.5}$ (as per IS 1893: 2002 clause no. -7.6.2)
= $0.09 \times 18/12^{0.5}$ = 0.57sec.
Earthquake load calculations parameters shown in given blow:

Zone	3	5
Importance factor	1.5	1.5
Response reduction	5	5
Zone factor	0.16	0.36
Soil type	2	2

Service Load Combinations	Static Analysis	Gravity Load Analysis
DL+LL+FT	1.5 DL+1.5 EQX	1.5 (DL+LL+FT)
DL+0.5LL+FT	1.5 DL - 1.5 EQX	1.5 (DL+0.9LL+FT)
DL+EQX	1.5 DL + 1.5 EQY	1.5 (DL+0.8LL+FT)
DL-EQX	1.5 DL - 1.5 EQY	1.5 (DL+0.7LL+FT)
DL+EQY	0.9 DL + 1.5 EQX	1.5 (DL+0.6LL+FT)
DL-EQY	0.9 DL - 1.5 EQX	1.5 (DL+0.5LL+FT)
DL+0.8LL+0.8EQX	0.9 DL + 1.5 EQY	
DL+0.8LL - 0.8EQX	0.9 DL - 1.5 EQY	
DL+0.8LL+0.8EQY		
DL+0.8LL-0.8EQY		

III. MODELLING IN ETABS

The following assumptions were made before the start of the modelling procedure so as to maintain comparable conditions for all the three models [8-14]:

- Only the major block of the building is measured. The staircases are not measured in the design method.
- The building is to be used for hospital, but no walls are provided as the study focuses only on the response of frame construction.

- The beams are latent centrally on the columns so as to avoid the conditions of eccentricity. This is obtained automatically in ETABS.
- The footings are not considered. Supports are assigned in the form of fixed supports.
- Seismic loads are considered in the horizontal direction only (X & Y) and the loads in vertical direction (Z) are supposed to be insignificant.

A. *Steps used in Modelling*

- Gathering of structural information (sizes, material, orientation etc.).
- Model initialization (grid dimension, storey dimension and structural objects).
- Defining of material properties (mass/vol., E, shear modulus).
- Creating the structural model.
- Replicating or creating upper floors.
- Assigning old with new sections and material properties.
- Checking the model for geometry warnings.
- Assigning the structural load.
- Analyse gravity loads and checks shall be made.
- Earthquake loading shall be applied as per IS 1893-2002.
- Load combinations to be defined.
- Assign all slabs to be a rigid diaphragm.
- Assign restraints to the base points.
- Assign pier labels to shear walls
- Final "run analysis" to be performed
- Check for Base Shear calculation is to be performed.
- After analysis design is performed.
- Check if any element fails then take remedial measure accordingly.

B. *The Plan and Elevation of the Building Model are given below*

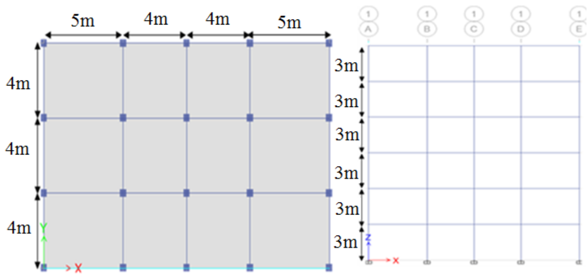

Fig.1Building with its elevation and plan view

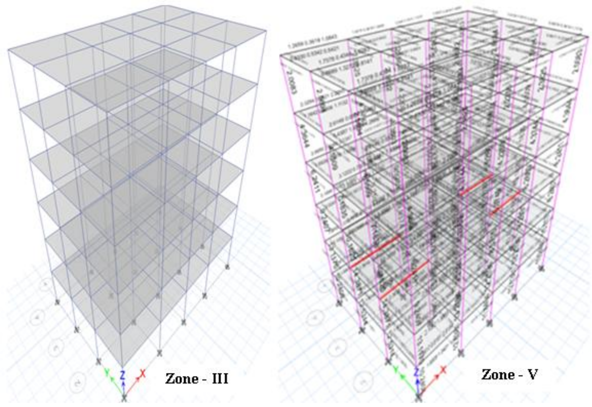

Fig. 2 Three dim. View of Models with seismic zone III and beam failure in zone V

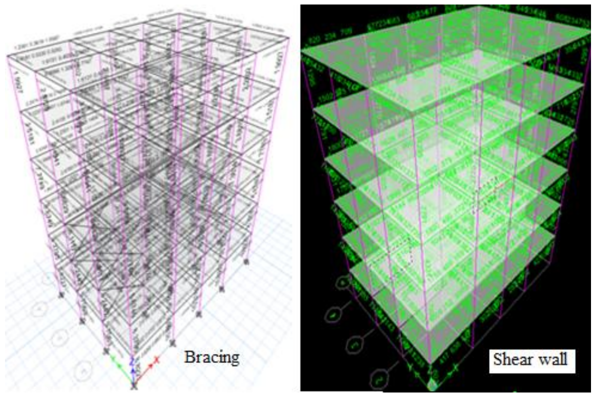

Fig. 3 Retrofitted Structures with Bracing and Shear Wall

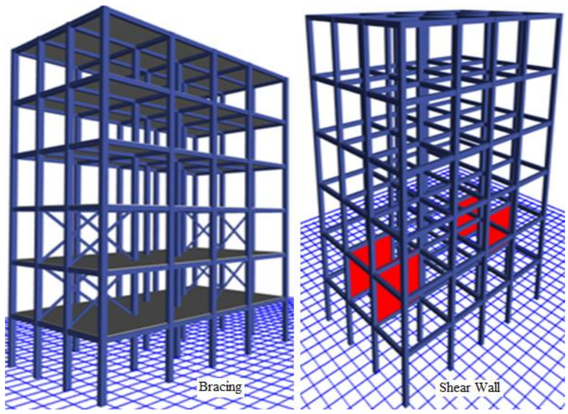

Fig. 4 Rendered view of structure with bracing and shear wall.

IV. ECONOMIC ANALYSIS

- **Cost for bracing system**
  - Section used= ISLC 200
  - Weight per meter = 20.6 Kg
  - Length of bracing section = 5.90 m
  - Weight of section used
    = 20.6×5.9 = 123.6kg
  - Number of sections used = 16
  - Rate of one section of bracing
    = Rs. 48/kg (Acc. to market rates)

  Total Cost of bracing system
  = 16×123.6×48 = Rs. 94,924

- **Cost for shear wall system**
  - Concrete used per wall
    = 0.115x3x5=1.725 m^3
  - Number of walls used = 4
  - Cost of concrete
    = Rs.4000/m^3 (Acc. to market rates)
- Total cost of concrete = 4×4000×1.1725 = Rs.27,600
- Steel area required = 0.018366 m^2 /wall
- Total weight of steel = 0.018366 × (3+5) × 7850 × 4 = 4613.5 Kg (7850 Kg/m^3 being density steel)
- Cost of steel = 4613.5×48 = Rs.221448

Total Cost of shear wall system = Rs. 221448

V. Conclusion

In the present research work, (G+5) storied R.C.C building models with bare frame, frame with shear wall, frame with bracing was analyzed for gravity and lateral loads. From the above analysis following general conclusions were drawn:

- Due to the shifting of higher seismic zone, the earthquake hazard will also increase. In such cases, use of bracing and shear walls becomes mandatory for achieving safety in design.
- The frame with Shear Walls clearly provides more safety to the designers and although it proves to be a little costly, they are extremely effective in terms of structural stability.
- It was inferred that shear walls were more resistant to lateral loads in structure. The moments in the columns got reduced when shear wall was introduced in the structure.
- The structure of using steel bracings was additional helpful which can use to strengthen or retrofit the existing structure.
- After economic analysis it was found that X bracing technique more cost efficient as compared to shear wall used in structure.

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