Seismic Analysis of Symmetric RC Frame with AAC and Masonry Infill Using Response Spectrum Method

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***Abstract** - In the History of Civil Engineering, the structures were usually designed considering only Static load factor. Later due to research in the civil engineering field it was explored that the structures are also acted upon by several other loads which included Seismic loads, Wind loads, Snow loads, etc, depending upon the dimensions of the structure, location of the structure, type of the ground profile, etc. Hence this brought in the process of analyzing a structure for different types of loads and designing the structure for the critical load case of which Dynamic load is considered as one of the important load for which the structure should be analyzed and designed. In the present work an attempt has been made to study the dynamic behavior of multistoried building frame (Symmetric) using IS1893-2002 code recommended response spectrum method. Analysis has been carried out using the STAAD software. Here we compare two materials of infill i.e., AAC and conventional Bricks.*

***Keywords:** RC Frame, RC Bare Frame, RC masonry infill, RC AAC infill, Earthquake Analysis, Response Spectrum Analysis, dynamic comparisons.*

1. INTRODUCTION

Structural design of buildings for seismic loading is primarily relate with structural safety against major earthquakes, but serviceability and the potential for economic loss are also of concern. Seismic loading requires an understanding of the structural behavior under large inelastic deformations. Behavior under this loading is fundamentally different from wind or gravity loading, requiring much more detailed analysis to assure acceptable seismic performance beyond the elastic range. Some structural damage can be expected when the building experiences design ground motions because almost all building codes allow inelastic energy dissipation in structural systems.[1] The first step in dynamic analysis is to develop a mathematical model of the building, through which estimates of strength, stiffness, mass, and inelastic member properties (if applicable) are assigned. In general, for a multistory building it is necessary to take into account contributions from more than one mode.

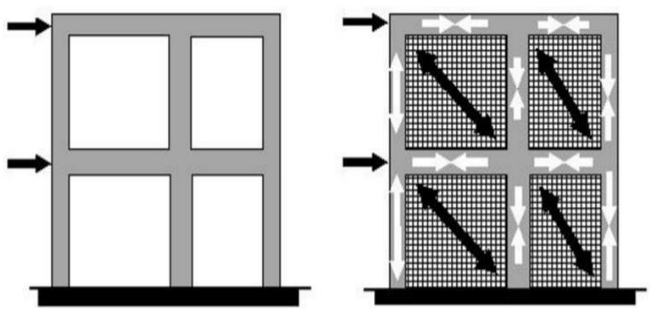
For high-rise buildings, it may be necessary to consider more than three modes. The significant modes that contribute to response may be determined by selecting the number of modes such that their combined participating mass is at least 90% of the total effective mass in the structure. [2]

1.3 INFILL WALL

In India, Masonry wall are used as infill wall for both interior and exterior R.C. frames. Material of the masonry infill is ranging from natural stones like granite, laterite or sand stones to man-made bricks and blocks.

Masonry infill walls should not be used unless they are specifically designed to:

- Remain isolated from frame.
- Work in conjunction with the frame to resist the lateral loads.



(a) Frame action(bare) (b) Truss action (infill)

Role of infill's in altering the behavior of moment resisting frames and their participation in the transfer of loads has been established by decades of research. The survey of buildings damaged in earthquakes further reinforces this understanding.

Infills in reinforced concrete buildings cause several undesirable effects under seismic loading: short-column effect, soft-storey effect, torsion, and out-of-plane collapse. Hence, seismic codes tend to discourage such constructions in high seismic regions. However, in several moderate earthquakes, such buildings have shown excellent performance even though many such buildings were not designed and detailed for lateral forces.

1.3 AAC BLOCK

Autoclaved aerated concrete (AAC) is a lightweight, precast, concrete building material invented in the mid-1920s that simultaneously provides structure, insulation, and fire- and mold-resistance. AAC products include blocks, wall panels, floor and roof panels, cladding (facade) panels and lintels.

AAC was perfected in the mid-1920s by the Swedish architect and inventor Dr. Johan Axel Eriksson, working with Professor Henrik Kreüger at the Royal Institute of Technology. AAC production in Europe has slowed down considerably, but the industry is growing rapidly in Asia due to strong demand in housing and commercial space. China, Central Asia, India, and the Middle-East are the biggest markets in terms of AAC manufacturing and consumption.

AAC BLOCKS

ACC is a highly thermally insulating concrete-based material used for both internal and external construction. Besides AAC's insulating capability, one of its advantages in construction is its quick and easy installation, because the material can be routed, sanded, or cut to size on site using standard carbon steel power tools. Even though regular cement mortar can be used, most of the buildings erected with AAC materials use thin bed mortar in thicknesses around ⅛ inch, depending on the national building codes. AAC materials can be coated with stucco or plaster compound to guard against the elements, or covered with siding materials such as brick or vinyl.

2. OBJECTIVE OF STUDY

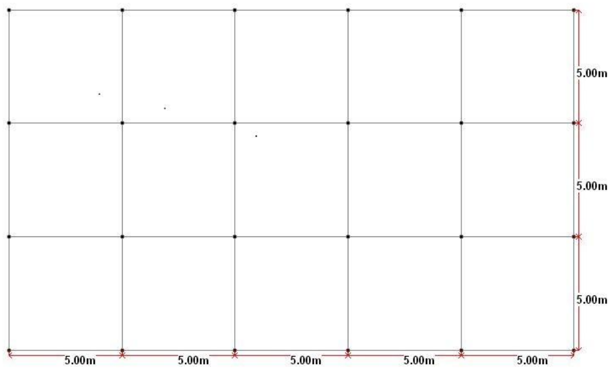
In the present study, work has been divided into two phases. The phases are as follows:-

Phase1-R.C.C. Frame with Infill Masonry Wall

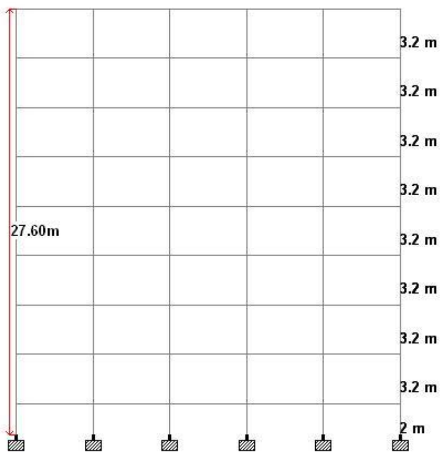
Phase2- R.C.C. Frame with Infill A.A.C. (Autoclaved Aerated Concrete) Wall.

3. DESCRIPTION OF BUILDING

- Type of structure: Multi-storey RC frame structure
- Number of stories: 9 (G+8)
- Ground storey height: 3.2 m
- Intermediate storey height: 3.2 m
- Depth of foundation: 2 m
- Type of soil: Hard soil
- Plan and elevation of the building is given in fig:



PLAN OF RC BUILDING



ELEVATION OF THE BUILDING

Materials

- Grade of concrete: M20
- Density of concrete: 25kN/m2
- Modulus of elasticity of concrete: 5000√fck (As per IS 456:2000[15], pp16)

Member dimensions

- Beam Size: 450mm x 300 mm
- Column Size: 6000mm x 300 mm
- Slab Thickness: 125 mm
- Wall Thickness: 230 mm

3.1 SEIMIC DESIGN FACTORS USED FOR ANALYSIS

(i)Response Reduction Factor : - The response reduction factor (*R*) for the building in the present study is taken as 5 i.e. special RC moment resisting frame (SMRF) has been considered.

(ii)Importance Factor: - The importance factor (*I*) for the general building is taken as 1.5.

(iii)Zone Factor: - the seismic zone Factor (*Z*) for the selected building is taken as 0.36 as the structure is located in seismic zone V.

(iv)Damping Ratio: - The critical damping for the RC frame structure is assumed to be 5 % as specified for concrete in IS: 1893-2002 (part I).

(v)Soil Type : - The soil type assumed is Type I soil i.e. Hard Soil.

(vi) Percentage reduction of imposed load for Earthquake: - the design imposed load for earthquake has been taken to be 50 % as per the codal provisions.

3.2 METHODS OF SEISMIC ANALYSIS OF STRUCTURES

- Static analysis
- Dynamic Analysis

3.2.1 Response Spectrum Method

The Response Spectrum is a method of estimation of maximum responses (acceleration, velocity and displacement) of a family of SDOF systems subjected to a prescribed ground motion. The RSM utilizes the response spectra to give the structural designer a set of possible forces and deformations a real structure would experience under earthquake loads.

Seismic Base Shear*:* The seismic base shear VB in a given direction shall be determined in accordance with the following equation

$$V_B = A_h W$$

A_h= the seismic response coefficient
W= the total dead load and applicable portions of other loads:

Calculation of Seismic Response Coefficient: The seismic response coefficient A_h shall be determined in accordance with the following equation:

$$A_h = \frac{Z}{2}\frac{S_a}{g}\frac{I}{R}$$

Z =Zone factor given in
Sa/g = average response acceleration coefficient
R = the response reduction factor

I = the importance factor depending up the functional use of structure

Period Determination: The fundamental period of the building, *T*, in the direction under consideration shall be established using the structural properties and deformational characteristics of the resisting elements in a properly substantiated analysis or, alternatively, it is permitted to be taken as the approximate fundamental period, *T,* determined in accordance with the requirements of Sec. The fundamental period, *T*, shall not exceed the product of the coefficient for upper limit on calculated period from and the approximate fundamental period *T.*

T=0.075h ¾ for R.C.frame building

T=0.085h ¾ for Steel frame building

Where

h=Height of building in meter

Vertical Distribution of Seismic Forces: The lateral force, *F* (kip or KN), induced at any level shall be determined from the following equations:

$$Q_i = V_B \frac{W_i h_j^2}{\sum_{j=1}^{n} W_i h_j^2}$$

Q_i= Design lateral force at floor i

W_i= Seismic Weight of floor i

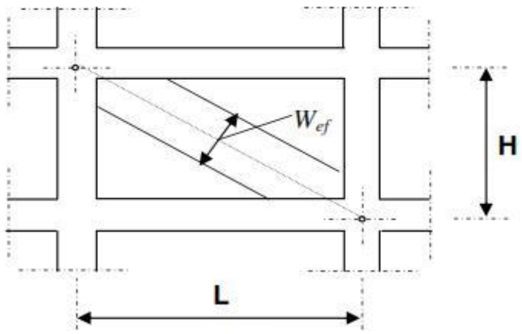
h_i= Height of floor i measured from base

n= Number of storey's in the building is the number of levels at which the masses are located

4. MODELLINNG OF INFILL WALLS

EQUIVALENT STRUT METHOD

In this method, the analysis is carried out by simulating the action of infills similar to that of diagonal struts bracing the frame. The infills are replaced by an equivalent strut of length D and width.

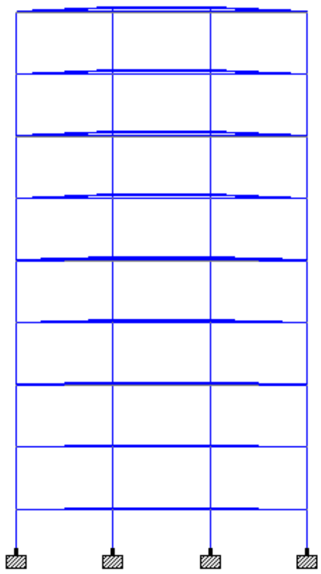


5. RESULT AND DISCUSSIONS

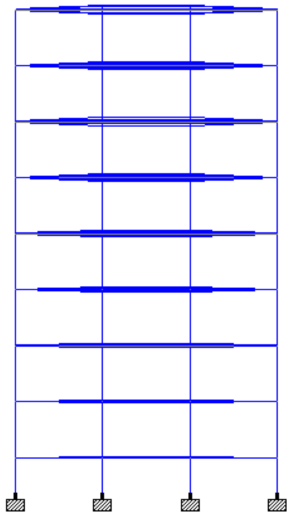
5.1 Modes Shape

There many number of Modes shapes depending upon the type and directions of the forces acting on it. The STAAD software shows the various mode shapes with respect to the cut off modes mentioned in the input. The first three are mentioned below along with their figures.

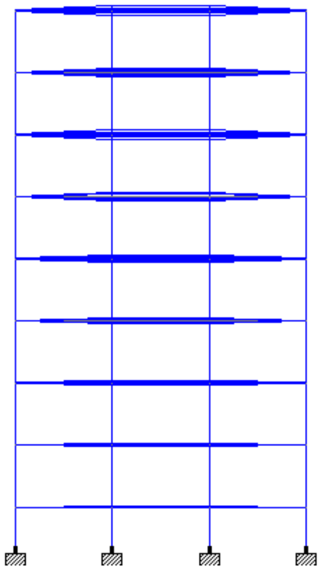
1. Mode Shape 1 - In X Direction.
2. Mode Shape 2 - In Z Direction.
3. Mode Shape 3 - Torsional Moment



MODE 1



MODE 2



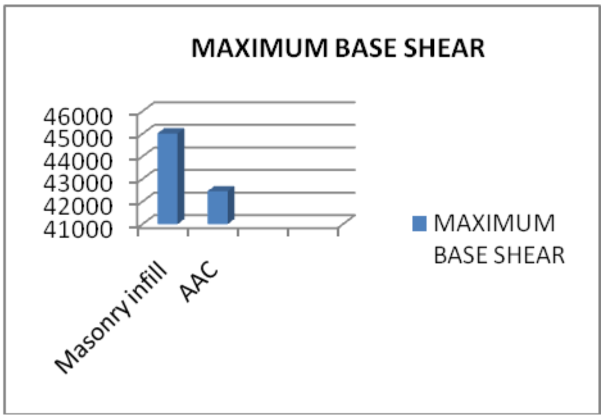
MODE 3

5.2 Base Shear:

Base shear is calculated by using IS 1893-2002 method for AAC and Conventional Brick the comparison of base shear using lateral load Equivalent method. The Conventional Brick base shear is higher than the base shear for AAC Infill. Lesser the lateral forces and lesser dead load will results in lesser member forces which ultimately results economical design.

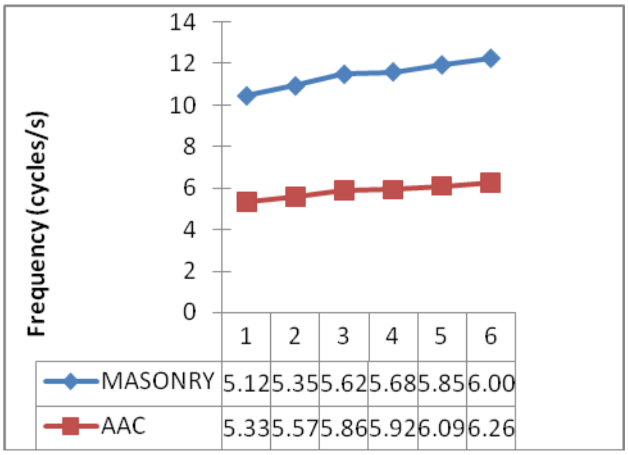
TABLE 1: Base shear for various models with Conventional clay brick masonry

BASE SHEAR	With Conventional Bricks	With AAC BLOCK
VBx	45020.56	42464.96
VBy	45020.56	42464.96



5.2 Natural Frequency

Natural frequency is the reciprocal of model natural period. The dynamic responses are vary according to different natural frequency because the number of modes to be considered is depend upon the natural frequency. If the natural frequency beyond 33Hz those modes are to be considered and model combination will be carried out only for modes up to 33Hz according to IS -1863-2002. The natural frequency for various modes for Conventional Brick and AAC infill as shown in the graph.



Graph 2: Variations in frequency of AAC and Conventional Brick infill

6. CONCLUSION

From the dynamic analysis of G+8 RCC frames with plan irregularity we have got the following conclusions.

1) Dynamic analysis of buildings requires careful structural modeling, understanding appropriate selection of ground motion records, and thorough knowledge and familiarity of the analyst with the procedures and computer software employed.

2) Seismic design of structures is typically based on the modal analysis with response spectrum that is generally considered a conservative approach.

3) Base shear is calculated by using IS 1893-2002 method for all four model s Graph illustrate the comparison of base shear using lateral load Equivalent method. The lower base shear is getting in model C and the higher base shear is getting in model A.

4) For higher and unsymmetrical buildings Response Spectrum Method should be used for symmetric building we can use lateral load equivalent method to the best way. But for unsymmetrical building requires more accurate analysis therefore Response Spectrum Method should be used.

7.REFERENCES

1.IS 1893: 2002, ―Code of Practice for Criteria for Earthquake Resistant Design of structures (part 1) General Provisions and Buildings, Bureau of Indian Standards, New Delhi.

2. IS 456: 2000, ―Code of Practice for Plain and Reinforced Concrete, Bureau of Indian Standards, New Delhi.

3. C. V. R. Murty Svetlana Brzev Heidi Faison Craig D. Comartin Ayhan IrfanogluC. V. R. Murty, Svetlana Brzev ,Heidi Faison ,Craig D. Comartin ,Ayhan Irfanoglu. (2006). *AT RISK: The Seismic Performance of Reinforced Concrete Frame Buildings with Masonry Infill Walls*. 1 (1), 11-37

4. Jaiswal, K., Sinha, R., Goyal, A., (2003),
Building with Masonry Infill WallsDesigned for Gravity Loads". WHEReport 19 (India), World Housing Encyclopedia (www.world-housing.net). Earthquake Engineering Research Institute and InternationalAssociation for Earthquake Engineering.