SEISMIC PERFORMANCE OF FLYASHED CONCRETE BUILDING WITH FLYASH BRICK AND BURNT CLAY BRICK MASONRY INFILL

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Abstract- This paper presents the seismic performance of a flyashed concrete space framed building with two different types of masonry infills namely, clay brick masonry and flyash brick masonry using pushover analysis. Cement is replaced with flyash in concrete in the proportion of 30 %, 40 % and 50 % by weight of cement. The modeling and analysis of frames are carried out using the software SAP 2000. The lateral loads are calculated as per Indian Seismic code IS 1893:2002. The modal analysis shows that the fundamental frequency of the frames with flyash brick masonry is more than that of frames with clay brick masonry. The capacity curves obtained from the analysis reveal that the performance of frames with flyash brick masonry infill is superior to frames with clay brick masonry infill. The performance point is obtained for all the frames; moreover the spectral displacement is lower in the case of frames with flyash brick masonry. The results of this analysis would encourage the end users to switch over to the usage of flyash leading to a sustainable and greener environment.

Keywords- Clay Brick Masonry, Flyash Brick Masonry, Flyashed Concrete, Performance Point, Pushover Analysis.

I. INTRODUCTION

The seismic behaviour of space framed buildings has been the subject of extensive study over the last several decades. In many countries infilled frames are the most common form of construction in high rise buildings. Low and medium-rise reinforced concrete frame buildings with clay brick masonry infills are common in urban India. Engineers and builders are trying with supplementary cementing materials to reduce the cost of construction and CO_2 emission into the atmosphere. To replace larger proportion of cement in the concrete industry the most available supplementary cementing material is fly ash, a byproduct of thermal power plants. As per Indian Code, upto 30 % of flyash is allowed in concrete mixtures and the rest of flyash is just dumped in the filling yard. Many researches revealed that the high volume flyash could effectively be used in building construction and proved that the incorporation of high volume of fly ash in concrete reduces the water demand, improves the workability, minimizes cracking due to thermal and drying shrinkage, and enhance durability to reinforcement corrosion, sulphate attack, and alkali-silica expansion.

Shake table tests conducted on framed buildings suggested that flyash can be utilized to reduce the cost of construction; can be recycled and diverted from landfills, thereby moving towards greener construction. From seismic point of view, the presence of masonry infills increase the stiffness of the building, decrease the fundamental period and therefore the base shear due to seismic action is increased. Part of the seismic action is carried by the infills, thus relieving the structural system. The energy dissipation capacity of the building is considerably increased. In order to reduce the lateral force acting on the structure the self weight of the structural elements should be reduced. Now-a-days the traditional brick masonry walls are being replaced by lighter infill materials like, flyash bricks, aerated concrete blocks, etc. In this research an attempt has been made to study the seismic performance of space framed building with flyash concrete and flyash brick masonry using pushover analysis. The performance is compared with concrete frame building with traditional clay brick masonry and bare frame.

II. ANALYTICAL INVESTIGATION

A. Modeling of Spaced Framed Building

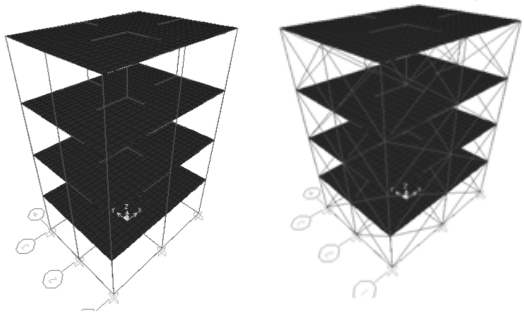
Modeling of space framed building with infill is done in SAP 2000 software. The space frame is a two bay by two bay four-storeyed building. The beams and columns are modeled as frame elements. The size of beam and column is taken as 0.25 m x 0.50 m and 0.30 m x 0.30 m, respectively. The slab is modeled as shell element and its thickness is taken as 0.120 m. The infill walls are modeled as equivalent strut elements and its width is approximately taken as ¼ of the diagonal length. End offsets are assigned to all beams and columns to make the frame rigid. Diaphragm action is assigned at each floor level and the base of the frame is fully fixed.

The material properties of concrete with 30 %, 40 % and 50 % of flyash by weight of cement are obtained from the experimental work. The properties of different masonry infill such as clay brick masonry and fly ash brick masonry are taken from the experimental work carried out by Freeda et al. The brick size is 230 mm x 110 mm x 70 mm. The unit weight, poisson's ratio and Elastic modulus of flyash

brick masonry are taken as 16.7 kN/m^3, 0.15 and 420x10^3 kN/m^2, respectively. The different models are designated as shown in Table I and the typical 3-D view of the bare and infilled frame is shown in Fig.1 (a) and (b), respectively.

TABLE I FRAME MODELS USED

Sl.No	Model	Description
1	M0-Clay Brick	Frame with conventional concrete and clay brick masonry
2	M30-Clay Brick	Frame with 30 % flyash concrete and clay brick masonry
3	M40-Clay Brick	Frame with 40 % flyash concrete and clay brick masonry
4	M50-Clay Brick	Frame with 50 % flyash concrete and clay brick masonry
5	M0-Flyash Brick	Frame with conventional concrete and Flyash brick masonry
6	M30-Flyash Brick	Frame with 30 % flyash concrete and Flyash brick masonry
7	M40-Flyash Brick	Frame with 40 % flyash concrete and Flyash brick masonry
8	M50-Flyash Brick	Frame with 50 % flyash concrete and Flyash brick masonry



(a) Bare Frame **(b) Masonry Infilled Frame**

Fig.1. Typical 3-D Model of the frames

B. Modal Analysis

Modal analysis is carried out to determine the dynamic characteristics of the frames such as fundamental frequency, mode shapes, etc. The seismic weight of each floor is calculated and is lumped at the centre of mass. The fundamental frequency of the frames with flyash brick masonry is nearly 17 % more than the frames with clay brick masonry as shown in Figs 2 and 3. This shows that the flyash masonry infills increase the stiffness of the frames. Stiffness is slightly reduced when the percentage of flyash is increased in concrete. The fundamental frequency of the frames with clay brick masonry and flyash brick masonry is around two times more than that of the bare frame.

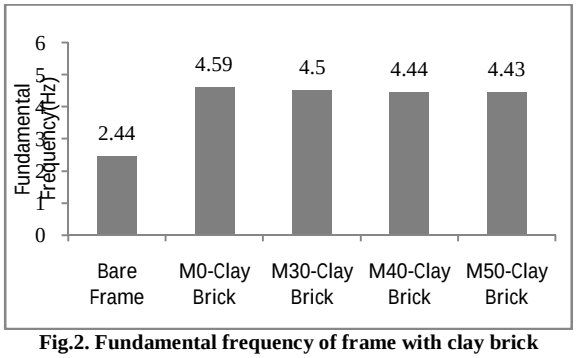


Fig.2. Fundamental frequency of frame with clay brick masonry

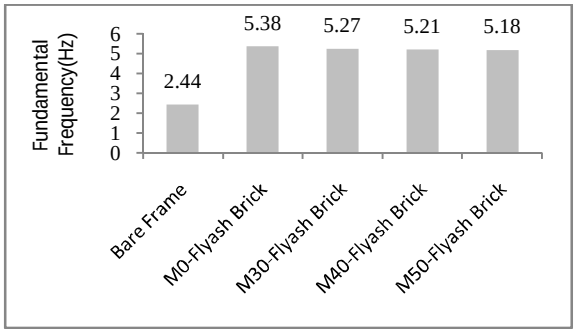


Fig.3. Fundamental frequency of frame with flyash brick masonry

III. PUSHOVER ANALYSIS

Pushover analysis verifies the adequacy of the frames against lateral load due to earthquakes. The lateral load acting at different floor levels are calculated as per IS 1893:2002 by considering that the building is located at Chennai City, Tamilnadu, India which lies in seismic zone III. The soil condition is assumed as medium soil and the building is designed only for gravity loading. Tables II and III give the details of seismic weight and lateral load at different floor levels for frame with clay brick masonry and frame with flyash brick masonry, respectively. The lateral loads are assigned at the centre of mass at each floor level. The beams and columns are assigned with P-M3 and P-M2-M3 hinge properties. The axial P hinge properties are assigned to masonry infills. Pushover analysis is run along the longitudinal and transverse directions after gravity push. The capacity curves for all the frames under study are obtained and the spectral displacement is noticed from ATC- 40 response spectrum.

TABLE II. LATERAL LOAD ON FRAME WITH CLAY BRICK MASONRY

Storey Level	Seismic Weight (kN)	Lateral Load (kN)
1	775	7.96
2	775	31.85
3	775	71.66
4	455	74.79

TABLE III. LATERAL LOAD ON FRAME WITH FLYASH BRICK MASONRY

Storey Level	Seismic Weight (kN)	Lateral Load (kN)
1	711	7.28
2	711	29.13
3	711	65.53
4	423	69.31

IV. RESULTS AND DISCUSSION

Space framed flyash concrete buildings with clay brick masonry and flyash brick masonry are analysed using pushover technique. Capacity curves are obtained for all the infilled frame models and are shown in Fig. 4. It is observed that the capacity of the frames with flyash brick masonry is higher than that of with clay brick masonry. The strength and stiffness are reduced when percentage of flyash in concrete is increased. In order to determine the contribution of infill in the lateral load resistance, pushover analysis for bare frame is also carried out and the capacity is compared with frame with clay brick masonry infill and flyash brick masonry infill as shown in Fig.5. It can be seen that the strength and stiffness of the frame with clay brick masonry infill are 3.9 times and 2.2 times, respectively more than that of the bare frame. Similarly, the strength and stiffness of the frame with flyash brick masonry infill are 4.5 times and 2.5 times, respectively more than that of the bare frame.

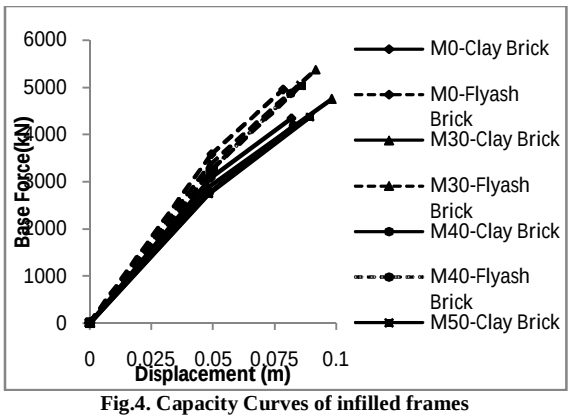


Fig.4. Capacity Curves of infilled frames

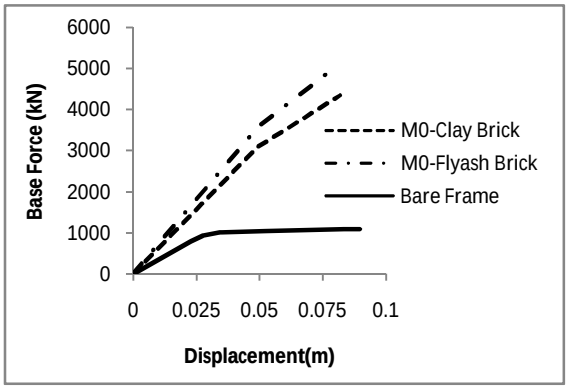


Fig.5. Comparison of capacity curves of infilled frames with bare frame

The performance point is obtained for all the models which reveal that both the types of frames are capable of resisting the applied intensity of earthquake and a typical Acceleration Displacement Response Spectrum (ADRS) format is shown in Fig.6. The hinge formation in bare and infilled frames is shown in Fig.7 and 8, respectively. It is observed that critical warning hinges are formed in the bare frame at ground floor level whereas in the masonry infilled frames the low damage hinges are seen throughout its height.

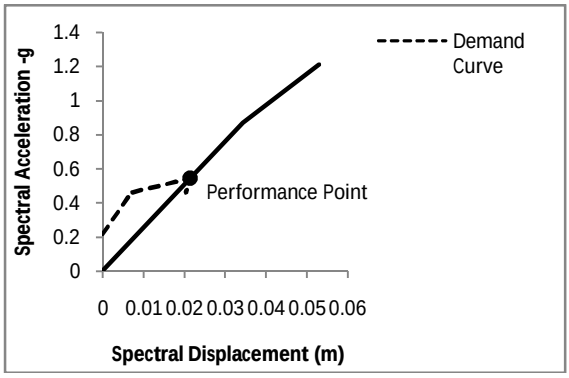


Fig.6. Typical ADRS format

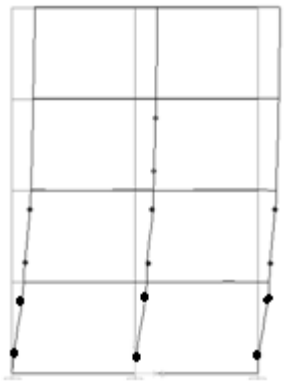


Fig.7. Location of hinges in bare frame

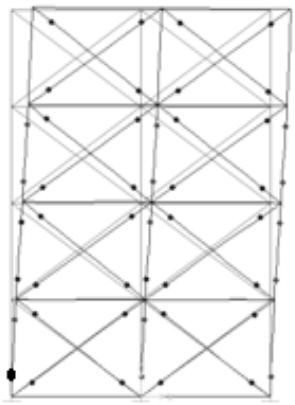


Fig.8. Location of hinges in masonry infilled frame

The spectral displacement of all the models are observed and shown in Fig 9 and 10, respectively. The spectral displacement of the frames with flyash brick masonry infill is nearly 40 % less than the frames with clay brick masonry infill. However, in both the frames

the spectral displacement is much lower than the permissible displacement as per IS Code (48 mm).

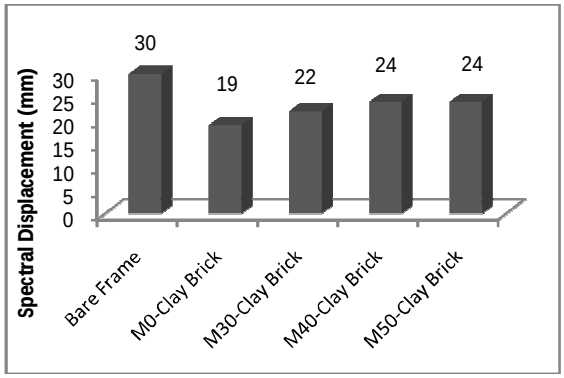


Fig.9. Spectral displacement of frames with clay brick masonry

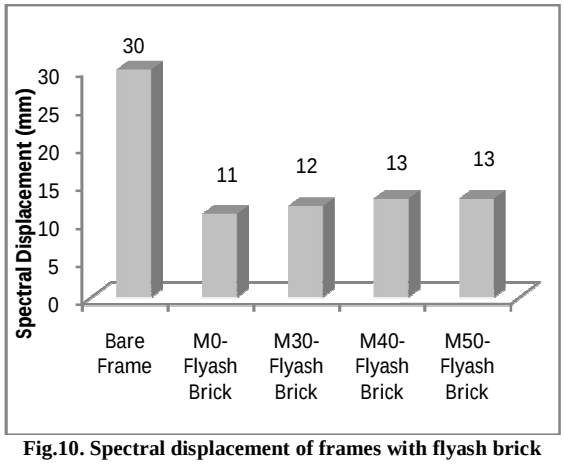


Fig.10. Spectral displacement of frames with flyash brick masonry

CONCLUSION

The masonry infills improve the seismic performance of the frame in terms of strength and stiffness. The space frames made of conventional concrete with flyash brick masonry infill behaves better than that with clay brick masonry infill. The analysis shows that the flyash concrete space frames are also capable of resisting lateral loads. Due to the above said advantages, high volume of flyash can be utilized for mass production of concrete and bricks. Incidentally, usage of high volume flyash also reduces the CO_2 emission in concrete thereby ensuring a green construction.

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