Seismic Design and Behaviour of Confined Masonry Building

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Abstract **-** Confined masonry buildings have performed very well in damaging earthquakes in many countries, including Mexico, Chile, Peru, Indonesia and Iran. The unreinforced masonry building during the earthquake condition has resulted into significant damages in buildings and subsequent life loss. This study has considered the analysis design and comparison of confined masonry wall with unreinforced masonry wall. Confined masonry is a construction technology which offers a safer alternative to both RC frames with masonry infill's and unreinforced masonry construction in seismically prone areas.

Keywords: *Confined masonry, Shear behavior, Seismic design, and Sensitivity analysis.*

I. INTRODUCTION

Confined masonry (CM) consists of RC restricting vertical and horizontal elements that are thrown in-situ around URM wall segments built in small heights. Confined masonry construction consists of masonry walls and horizontal and vertical reinforced concrete ties. This structural system provides an alternative to unreinforced masonry. The key point about a CM building is the sequence of its construction. The first step is to build masonry building with toothed age; then tie columns and tie beams are cast in place. This in-situ concrete fills all gaps and covers vertical bars protruding out from the foundation. On hardening of concrete, the RC elements hold the masonry wall segments without any gap between them. This construction sequence provides a stiff connection between the masonry panel and the ties and plays an important role in the lateral resistance of CM walls.

Earthquake performance is good of confined masonry construction. While CM work sustained damages in past seismic tremors, total fall has not been seen in this typology of development. In CM construction, the masonry walls convey the seismic burdens and RC confining elements are utilized to restrict the wall. This is in contrast to RC frame buildings with infill where the concrete frames are needed to carry the load. RC frame structures are significantly more complex to plan and design. RC confining elements are critical for the seismic safety of a confined masonry building. These elements are effective in enhancing the stability, integrity, and ductility of the masonry walls and lead to better seismic performance of confined masonry buildings compared to other forms of masonry construction. There are some specific rules with respect to placement and spacing of these RC confining elements in a confined masonry building that contribute to its better seismic performance.

The structural components of a CM building are:

1. *Masonry walls* – The walls distribute the gravity load from the slab above down to the foundation; these walls act as bracing panels, which resist horizontal earthquake forces. The walls must be confined by concrete tie-beams and tie-columns to ensure satisfactory earthquake execution.
2. *Confining elements* – The tie column and tie beam provide restraint to masonry walls and protect them from complete disintegration even in major earthquakes; these elements resist gravity loads and have vital role in ensuring vertical stability of a building in an earthquake.
3. *Floor and roof slabs* – These elements transmit both gravity and lateral loads to the walls. In an earthquake, slabs act as like horizontal beams and are called diaphragms.
4. *Plinth band* – The band transmits the load from the walls down to the foundation. It also protects the ground floor walls from unreasonable settlement in soft soil conditions.
5. *Foundation* – Foundation transmits the loads from the structure to the ground.

In CM construction, confining elements are not designed to behave as a moment resisting frame; so that, detailing of reinforcement is simple. In general, confining elements have smaller cross sectional dimensions than the corresponding beams and columns in a RC frame building. It should be observed that the most important difference between the confined masonry walls and RC walls is that RC walls are not load-bearing walls, while the walls in a confined masonry building are.

II. LITERATURE REVIEW

Vishnu J, Mathew C.S.et.al.(2016) stated that the performance of seismic engineering is a modern approach to earthquake resistant design. it is building technology that uses the basic materials found in unreinforced masonry construction and RC frame construction with masonry infill's.It is wide spread that use of good quality materials

and proper construction practices can render a building safe. Improving the quality of materials and efficiency of workmanship will increase the load carrying capacity.

R.K. L. Su, J.C.M.Ho.et.al.(2011) stated that the seismic measures that are stipulated in seismic design codes are very effective for increasing the strength and integrity, but not the ductility of masonry buildings. The ductility design approach is preferable for the design of medium and high rise buildings. Rare earthquake loads could be used directly in the design of masonry building to achieve the objective of "no collapse in rare earthquakes".

shghi,B.Sarrafi.et.al.(2016) stated that confined masonry is popular in Iranian construction but code provision have not been improve during recent year and it is similar to old provision proposed for unconfined masonry building. The main advantage of this system is that it is cheaper than other building system such as reinforced concrete or steel.

The finite element analyses of the walls are used to verify material test result and properties.

Ajay Chourasia,Navratarn M.Bhndari.et.al.(2013) stated that influential aspects like sequence of construction, properties and type of masonry material, structural configuration, reinforcement detailing in tie column and beam and masonry, panels aspect ratio etc. The aspects of influencing performance of confine masonry under seismic events and solutions could be incorporate to overcome.

Dr.R.P.Arora,Yamini Upadhyay.et.al.(2017) stated that modern reinforced concrete building technology consisting of frames with masonry infill walls when adequate design expertise and construction quality assurance are not available. Good seismic performance release on two key features, namely confinement and bond between masonry walls and reinforced concrete confining elements that enclosed this wall.

The adaptation of confine masonry technology for building construction will lead to safer at lower construction cost compare to alternative options.CM is attractive because it is less expensive than RC frame.

III. MATERIALS

A. Building materials used in confined masonry construction are same as in masonry and reinforced concrete buildings.

1. Brick: Brick is building materials used to make walls and other elements in masonry construction, Traditionally, the term brick referred to unit composed of clay, but now used to denote any rectangular units laid in mortar. Brick can be composed of clay bearing soil, sand and lime or concrete material. Two basic categories fired and non fired bricks.

2. Mortar: Mortar is a workable paste used to bind building blocks such as stones, bricks, concrete masonry units, fill and seal the irregular gap between them and some time add decorative color or pattern in masonry walls. Mortar comes from Latin mortarium meaning crushed.

3. Concrete: Concrete is a composite material made out of fine and coarse aggregate. Concrete mix provides adequate workability. Size of coarse aggregate less than 12.5mm and minimum grade of concrete M15.

4. Steel: Most construction is done with steel called mild steel. The main advantage of steel is it can be bend without cracking. The characteristic of steel is plasticity or ductility. Steel is better in earthquake and failure in steel frames is not sudden and is really collapsed.fe415 grade steel used for tie-column and tie-beam.

B. Material Properties

The materials used are 1st class burned bricks, mortar, steel having following engineering properties:

Table 3.1 . Materials engineering properties

Material	Young's Modulus (Mpa)	Poisons Ratio
Steel	2.10×10^5	0.22
Brick	3.02×10^5	0.09
Mortar	3.65×10^5	0.17

IV.METHODOLOGY

This research has the following methodologies; Stage1: Detailed study of confined masonry

In this stage the detailed study of the confinement of the masonry.

Stage2: Select the required data for analysis.

Here, assume the data which are required for problem statement for analysis.

Stage3: Analysis of confined masonry and unconfined masonry with ETABS.

In this stage, we will analyze both confined and unconfined masonry building on ETABS software.

Stage4: Study of results

After analysis, the study of the confinement of the masonry failure will obtain in terms of:

i. Deformation
ii. Stress
iii. Strain

Stage 5: Conclusion

In this final stage the best masonry is by comparing the results from ETABS analysis.

IV. CASE STUDY

CONFINED MASONRY IIT GANDHINAGAR

In the main occurrence, the ground breaking strategy of the IITGN Permanent Campus at Palaj Village, Gujarat, imagined the development of 36 limited brick work structures. This venture, building both understudy inns and staff and personnel lodging, includes the main utilization of designed kept brick work development in India for a huge scale venture including open structures. The grounds is on a real estate parcel on the banks of Sabarmati River estimating around 163 Hectares (399 Acres). The Institute held various rumored counseling firms to complete the arranging and plan of understudy lodgings, workforce and staff homes, and scholastic structures. Development started in June 2013 and was executed by an undertaking group of the Central Public Works Department (CPWD).

The site is situated in Seismic Zone III per the Indian seismic code IS: 1893, which infers a shaking force of VII (MSK Scale). Gujarat has encountered annihilating seismic tremors in late history, incorporating into January 2001 when the Bhuj quake (greatness 7.7; most extreme shaking force X) struck the Kutch locale of Gujarat and caused immense human and monetary misfortunes. The loss of life was 13,805. Around 130 RC outline structures in Ahmadabad fallen prompting a loss of life of 805. Proof from various quakes in different nation shows that great seismic execution can be accomplished with kept brick work even without an abnormal state of building, gave the nature of development is kept up. Thus it was chosen that private structures at the IITGN Permanent Campus would be developed in restricted brick work.

Building Material:

Building materials utilized on the task were commonplace for RC and stone work development in India: concrete, sand and coarse total, blocks, and fortifying steel.

1. Brick: Earth blocks and FALG blocks utilized on the IIT GN venture,FALG blocks with a class assignment 9.0 MPa according to CPWD Specifications and a most extreme 12% water assimilation were utilized for above level development, while establishments underneath the plinth level were built utilizing consumed earth blocks with a base compressive quality of 5.0 MPa and a greatest 15% water ingestion. FALG block properties were in consistence with IS 12894:2002.
2. Mortar: Block stone work development was performed utilizing 1:1:6 bonds: lime: sand mortar, which is Type M1 mortar as indicated by the IS: 1905 standard. Hydrated Lime Class 'C 'as a fine dry powder complying with IS: 712 standards were utilized on the undertaking. Portland Pozzolana Cement (PPC) adjusting to IS: 1489 (Part I) with a fly fiery remains substance of 28% or more was utilized on the task.
3. Concrete: Cement of review M25 fitting in with IS: 456 was utilized on the venture. The trademark compressive quality was 25 MPa dependent on 15 cm 3D square examples tried at 28 days.
4. Steel: High quality TMT bars (Fe500D level) consenting to the IS: 1786 standard was utilized for the strengthened solid development (500 MPa yield quality). Littler bar sizes (8 mm) were utilized for ties in tie-shafts and tie-segments, while 10, 12, and 16 mm bars were utilized for longitudinal fortification (Figure 26). The steel was conveyed to the site in mass supply (100 tons or more). The steel was sourced from essential makers who fabricate rebar from ingots.

Fig.5.1.IIT Gandhinagar (Boys Hostel)

Fig.5.2.Construction of IIT Gandhinagar

Construction Progress and Costs:

Table.5.1 Construction schedule and material

Building Type	Concrete (m^3)	Steel (tons)	Bricks (m^3)
Faculty and staff housing	15,266	1,968	21,417
hostels	13,047	1,602	15,100
Academic buildings	39,000	5,210	6,500

Table.5.2. Construction cost for buildings at IIT Gandhinagar campus

Building type	Structural system	Built up area (m2)	Structural cost (Rs. Crore)	Cost of structure (Rs.per m2)	Total cost (Rs. Crore)	Unit cost (Rs.per m2)
Faculty and staff housing	Confined masonry	49,270	42.5	8,626	127	25,776
hostels	Confined masonry	35,943	32	8,903	79	21,979
Academic buildings	RC frames	45,200	71	15,708	192	42,478

Note:

1. Rs. 1 Crore = Rs. 10 Million

The above expense is comprehensive, i.e., building + MEP administrations including HVAC and detached cooling framework and ELV framework in the structures and advancement of its appurtenant arrive. Be that as it may, it does exclude grounds level advancement works like primary streets, trunk sewer, water and waste lines, water and sewage treatment plants, electric sub-stations and cost of electric, water and PNG supply lines to the grounds.

Fundamental evaluations show that selection of kept stone work innovation brought about a cost sparing over RC outline development. This depends on the unit cost (Rs. per m^2), as appeared Table 2. The expense investment funds are because of a littler measure of cement and steel as a result of littler part sizes in limited brick work structures contrasted with RC outline structures. For instance, the required measure of steel in restricted workmanship structures was 85 kg for each m^3 of cement, when contrasted with 130 kg of steel for every m^3 of cement for RC outline structures. In any case, it ought to be noticed that the correlation was made dependent on various structures as far as size and capacity (lodging versus scholarly structures).

VI. CONCLUSION

- As per above, we will say that the confined masonry have greater deformation capacity than unreinforced masonry. Confined masonry is less costly and requires less labour.
- In confined masonry, Masonry walls are the main load bearing elements and are expected to resist both gravity and lateral loads.
- Confined masonry is rigid and wall should be stiff under seismic loading while unconfined masonry is ductile and frame should be flexible under seismic loading.

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