iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 **Issue:** III **Month of publication:** March 2022

DOI: https://doi.org/10.22214/ijraset.2022.40967

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue III Mar 2022- Available at www.ijraset.com

Dynamic Analysis of Confined Masonry Structures for Residential Buildings under Seismic Conditions

Ahmad Qazi[1], Ashish Kumar[2]
[1]*Student of Engineering, Department of Civil Engineering, RIMT University, Punjab, India,*
[2]*Assistant Professor, Department of Civil Engineering, RIMT University, Punjab, India*

Abstract: In India, unreinforced brick masonry and reinforced cement concrete are the go-to technologies when it comes to construction of modern residential buildings, with the design applications ranging from one-story nuclear family houses to multi-story apartment buildings housing several families. However, each major natural disaster in India has exposed several 'chinks in the armour' linked to both of these widely employed construction techniques. Enter confined masonry. Confined masonry offers a substitute to both, unreinforced brick masonry and reinforced concrete framed residential buildings for applications in disaster prone areas of the world while keeping the cost under check and optimizing the structural performance. Confined masonry has evolved over the last century through an informal process based on its satisfactory performance in past, mostly in countries with high seismic activity like Indonesia, Mexico and Turkey. It is used for both non-engineered and engineered construction as its field applications range from one-story single-family dwellings to six-story apartment buildings. Some countries have even adopted design provisions and construction guidelines for confined masonry in their building codes. The success and implementation of building technologies is totally dependent on the local conditions like the availability and cost of building materials, the skill level of construction labour and the availability of construction tools and equipment. The fact that confined masonry construction looks similar to reinforced frame construction with masonry infill walls and that it uses the same components, i.e., masonry infills, tie-beams and tie-columns, helps in an easy transition to adopt confined masonry. Although confined masonry construction practice doesn't require any advanced construction equipment or an extra skillset, it is necessary to lay emphasis on the quality of the construction for its satisfactory performance. Hence, to optimize the quality of confined masonry structures, this thesis employs the use of a modern easy-to-learn-and-use structural software known as ETABS.

Keywords: Confined Masonry, RCC Frame, Unreinforced Brick Masonry, ETABS, Seismic Performance.

I. INTRODUCTION

A. General

In this post-modern era, brick masonry construction is becoming obsolete at an alarming rate, the upcoming metropolitan smart cities being a testimony to it, because of our tendency to construct reinforced concrete structures instead. In fact, it wouldn't be an exaggeration to say that brick masonry construction will become extinct in the coming decade. In the minds of today's populace, many civil engineers included, brick masonry is just an archaic and primitive construction practice. Most people disregard the fact that masonry has many advantages over reinforced concrete structures for low rise residential building construction as it is relatively cheaper, more easily accessible and available, better at thermal insulation and fire resistance, low in maintenance and easy to repair. It requires comparatively less sophisticated technology and skill and thus, these brick masonry buildings are constructed without much engineering supervision. That being said, reinforced concrete structures still hold one major advantage over brick masonry: seismic resistance, which is of monumental consequence especially in India where a considerable population is still residing in masonry structures in earthquake prone areas. This study is an effort to prove the superiority of confined masonry construction over reinforced cement construction and traditional unreinforced brick masonry. However, it is still possible to develop simple empirical design guidelines for confined masonry construction just like unreinforced masonry construction. In this respect, this study compares the seismic/static/dynamic performances of confined masonry, reinforced concrete and unreinforced brick masonry structures under various loads detailed by Indian Standard Codes. Confined masonry is an innovative construction technique that, whenever constructed correctly, performs significantly well in seismic tremors. It utilizes similar essential materials of cement and brick that constitute unreinforced masonry construction and in reinforced concrete construction with brick work infill walls, however with a subsequently altered construction sequence.

In confined masonry construction, the masonry walls convey the seismic loads and the RCC is used to confine the walls, as opposed to RCC framed structures where the concrete frames need to convey the various loads. Confined masonry construction consists of unreinforced masonry walls confined with reinforced concrete tie-columns and tie-beams. In Mexico, along with low-rise development for single-nuclear families, confined masonry is utilized for structures up to seven stories high. For this situation, the initial two stories are built with RCC structural walls as the lateral load-resisting system framework; the upper floors are developed distinctly with confined masonry walls. In India in general, most residential buildings fall under the classification of low-rise structures. Since, the populace in urban areas is developing dramatically and the land is restricted, there is a need of vertical development of structures in these urban areas. Thus, for the satisfaction of this reason countless medium to tall structures are coming up nowadays. For these structures it has been discovered that the taller the building, the more it is susceptible to seismic failure. Here comes the role of civil engineers and a structure analyzing software called ETABS.

B. Confined Masonry

In confined masonry construction, confining elements are not designed to act as a moment-resisting frame. As a result, detailing of reinforcement is simple. In general, confining elements have smaller cross-sectional dimensions than the corresponding beams and columns in a reinforced concrete frame building. It should be noted that the most important difference between the confined masonry walls and infill walls is that infill walls are not load-bearing walls, while the walls in a confined masonry building are load bearing walls. There is a fine line between confined masonry and reinforced concrete construction practices. Some reinforced concrete buildings use smaller column sizes and inadequate reinforcement detailing for effective moment transfer between the various components of the structure i.e., columns and beams.

C. Objective

To design three models of the same residential building by modeling it with confined masonry, reinforced concrete construction and unreinforced brick masonry construction technique respectively in ETABS under IS CODES to compare their results like story shear, story drift, story displacement and story overturning moments under severe seismic conditions.

II. LITERATURE REVIEW

'Seismic Design and Behaviour of Confined Masonry Buildings' posted by Dr. Vaibhav Singhal of Department of Civil and Environmental Engineering, Indian Institute of Technology Patna in 24th June 2016 provides brief diagrammatic description of confined masonry construction. Ajay Chourasia of Central Building Research Institute published 'Design Guidelines for Confined Masonry Buildings' in February 2017 detailing the namesake in comparison to unreinforced masonry. 'Confined Masonry-Analysis, Design and Comparison' by Kushal J. Desai, Professor S.B. Patel and Professor V.V. Agrawal of Department of Structural Engineering, Birla Vishvakarma Mahavidyalaya, Vallabh Vidyanagar, Gujarat, India published a journal in 2017 which considered the analysis, design and comparison of confined masonry wall with unreinforced masonry wall. 'Modelling of confined masonry structure and its application for the design of multi-story building' by Made Sukrawa, Gede Pringgana, and Putu Ayu Ratih Yustinaputri in 2018 of the Department of Civil Engineering, Universitas Udayana, Denpasar, Indonesia numerically investigates the behaviour of confined masonry and its application for use as the main structure of multi-story buildings subjected to seismic loading. 'Seismic Analysis of Confined Masonry Building and RCC Building' by Arle Pratibha, Kubhar G. and Shirsath M. Published in May 2019 compared equivalent RCC frame to confined buildings. Using software like ETABS and manual calculation has been done as well.

III.METHODOLOGY

In this study, three residential buildings of similar architectural layout were modelled with confined masonry, reinforced concrete construction and unreinforced brick masonry construction technique respectively. The three aforementioned models were designed on ETABS software. First one is a confined masonry structure, the second one is a reinforced concrete structure, and the third and the last one is the unreinforced brick masonry structure. Keeping in view the various IS Codes for loading details and load combinations including the seismic load; the models were analyzed in ETABS under Indian Standard Code provisions to assess their performance under a given set of conditions. The results are generated such as maximum deflection analysis, story drift analysis, story shear analysis & maximum axial force analysis. A comparative analysis is then done between the outcomes to determine the relatively better design for ultimate earthquake resistance.

A. *Confined Masonry Model*

TABLE I
CONFINED MASONRY MODEL DETAILS

Type of construction	Confined Masonry
Purpose of structure	Residential Building
Number of stories	5 i.e. (G + 4)
Floor Height	3 m
Grade of concrete (fck)	M20
Grade of reinforcement (fy)	Fe500
Thickness of outer load-bearing masonry walls	230 mm
Thickness of inner partition masonry walls	100 mm
External tie-column dimensions	230 mm x 150 mm
Internal tie-column dimensions	100 mm x 100 mm
Tie-beam dimensions	230 mm x 230 mm
Sill-beam dimensions	230 mm x 100 mm
Slab thickness	125 mm

TABLE 2
CONFINED MASONRY MODEL MATERIAL DETAILS

Material List by Object Type		
Object Type	Material	Weight (kN)
Inner tie-column	M20	253.4626
Beam	M20	937.3058
Outer tie-column	M20	504.4135
Brick Wall	Masonry	4603.4519
RCC Floor	M20	1918.5802
Total Weight of the Components		8217.214

TABLE 3
CONFINED MASONRY MODEL SEISMIC DETAILS

Seismic Zone	V
Seismic Zone Factor, Z	0.36
Importance Factor	1
Soil Type	II
Response Reduction Factor	3
Function Dampening Ratio	0.05

B. RCC Frame Model

TABLE 4
RCC FRAME MODEL DETAILS

Type of construction	RCC Frame
Purpose of structure	Residential Building
Number of stories	5 i.e. (G + 4)
Floor Height	3 m
Grade of concrete (fck)	M20
Grade of reinforcement (fy)	500
Column dimensions	300 mm x 450 mm
Beam dimensions	300 mm x 450 mm
Slab thickness	125 mm

TABLE 5
RCC FRAME MODEL MATERIAL DETAILS

Material List by Object Type		
Object Type	Material	Weight (kN)
Column	M20	809.7608
Beam	M20	1696.8707
Floor	M20	1918.5802
Total Weight of the Components		4425.2117

TABLE 6
RCC FRAME MODEL SEISMIC DETAILS

Seismic Zone	V
Seismic Zone Factor, Z	0.36
Importance Factor	1
Soil Type	II
Response Reduction Factor	5
Function Dampening Ratio	0.05

C. Unreinforced Brick Masonry Model

TABLE 7
UNREINFORCED BRICK MASONRY MODEL DETAILS

Type of construction	Unreinforced Brick Masonry
Purpose of structure	Residential Building
Number of stories	5 i.e. (G + 4)
Floor Height	3 m
Grade of concrete (fck)	M20
Grade of reinforcement (fy)	500
Thickness of load bearing walls	230 mm
Slab thickness	125 mm

TABLE 8
UNREINFORCED BRICK MASONRY MODEL MATERIAL DETAILS

Material List by Object Type		
Object Type	Material	Weight (kN)
Unreinforced Masonry Wall	Masonry	6657.41
Floor	M20	1918.58
Total Weight of the Components		8575.99

TABLE 9
UNREINFORCED BRICK MASONRY MODEL SEISMIC DETAILS

Seismic Zone	V
Seismic Zone Factor, Z	0.36
Importance Factor	1
Soil Type	II
Response Reduction Factor	3
Function Dampening Ratio	0.05

IV. COMPARISON

A. Maximum Story Shear

TABLE 10
MAX STORY SHEAR COMPARISON

Maximum Story Shear (kN)							
S.no	Load Combinations	Confined Masonry		RCC Frame		Unreinforced Brick Masonry	
		Value	Location	Value	Location	Value	Location
1	DL + LL + EQX	6.687 x 10^9	Base	0	Base	1.083 x 10^7	Story 3
2	DL + LL - EQX	921.8	Base	693.5	Base	953.088	Between Story 3 & 4
3	DL + LL + EQY	0	Story 3	0	Base	0	Base
4	DL + LL - EQY	921.8	Base	693.5	Base	953.088	Base

B. Maximum Story Drift

TABLE 11
MAX STORY DRIFT COMPARISON

Maximum Story Drift (Unitless)							
S.no	Load Combinations	Confined Masonry		RCC Frame		Unreinforced Brick Masonry	
		Value	Location	Value	Location	Value	Location
1	DL + LL + EQX	0.000234	Story 2	0.002396	Story 2	0.000314	Story 2
2	DL + LL - EQX	0.000234	Story 2	0.002392	Story 2	0.000315	Story 2
3	DL + LL + EQY	0.000288	Story 2	0.002271	Story 2	0.000405	Story 2
4	DL + LL - EQY	0.000241	Story 2	0.001948	Story 2	0.000406	Story 3

C. Maximum Story Displacement

TABLE 12
MAX STORY DISPLACEMENT COMPARISON

Maximum Story Displacement (mm)							
S.no	Load Combinations	Confined Masonry		RCC Frame		Unreinforced Brick Masonry	
		Value	Location	Value	Location	Value	Location
1	DL + LL + EQX	2.693	Story 4	27.477	Story 5	3.445	Story 5
2	DL + LL - EQX	2.711	Story 4	27.418	Story 5	3.459	Story 5
3	DL + LL + EQY	3.484	Story 5	26.426	Story 5	4.889	Story 5
4	DL + LL - EQY	2.657	Story 5	21.978	Story 5	5.731	Story 5

D. Story Overturning Moments

TABLE 13
STORY OVERTURNING MOMENTS COMPARISON

Story Overturning Moment (kN-M)							
S.no	Load Combinations	Confined Masonry		RCC Frame		Unreinforced Brick Masonry	
		Value	Location	Value	Location	Value	Location
1	DL + LL + EQX	166487	Base	168501	Base	172942	Base
2	DL + LL - EQX	166587	Base	168501	Base	172942	Base
3	DL + LL + EQY	175072	Base	176648	Base	181651	Base
4	DL + LL - EQY	157901	Base	160354	Base	164233	Base

V. DISCUSSIONS

To understand the result, we need to establish the relation between the outputs. To put it simply; base shear is equal to the story shear at the bottom of the building. If a structure is expected to be subjected to high seismic forces, its design base shear would be high. As seen by the result, in most cases the value of maximum story shear is at their bases with confined masonry having the highest value of them all. As per IS 1893, story drift shall not exceed 0.004 times the story height. The story height of the model in consideration is 3 meters. So, maximum allowable drift for each floor would be 0.012 meters i.e., 12 millimetres. All the results of the given limit as the story fall below the aforementioned value as determined by ETABS. The relation between story drift and story displacement is as simple as this: story drift is the difference of story displacements between two consecutive stories divided by the height of that story. Story drift is caused by the accumulated deformations of each structural element or member, such as column and/or beam. The greater the story drift, the lesser stiff the structure is. If the drift is greater in X-direction than the Y-direction, it means that the Y-direction is stiffer. As seen by the results, surprisingly the RCC frame undergoes maximum story displacement. That is because of the absence of the shear walls or cross-bracing systems which becomes almost a necessity for a heavily reinforced high-rise structure. Had the cross-bracings or shear walls been added to this RCC frame, it would exhibit lesser story drift, however the cost of the residential building would have marginally increased due to the extra materials, equipment and skill required to construct it. In contrast, confined masonry shows the least the story displacement despite requiring lesser skill and equipment for construction. Given the fact that the three models had identical layouts and somewhat similar seismic inputs, the story overturning moments of the three structures via the aforementioned load combinations don't vary much in general. That being said, confined masonry structures experience the least amount of overturning moment out of the three models. All in all, the analysis of the given theorized data and the result indicate that confined masonry is as efficient, if not better than, as the RCC frame structures for G+4 residential buildings in a severe seismic zone

VI. FUTURE SCOPE

Residential buildings have been, are and will always be a necessity of the human civilization. For the Indian subcontinent, it is safe to assume that the graph of rising income has miles to go before it catches up with the graph of the exponentially growing population. There is an urgent need to address this issue while keeping in mind the growing shortage of the available land for housing when almost 59% of the Indian area falls under moderate to severe seismic zones. Low-cost high-rise residential building will soon become the need of the hour and this study was an attempt to address the issue which will arise in the near future.

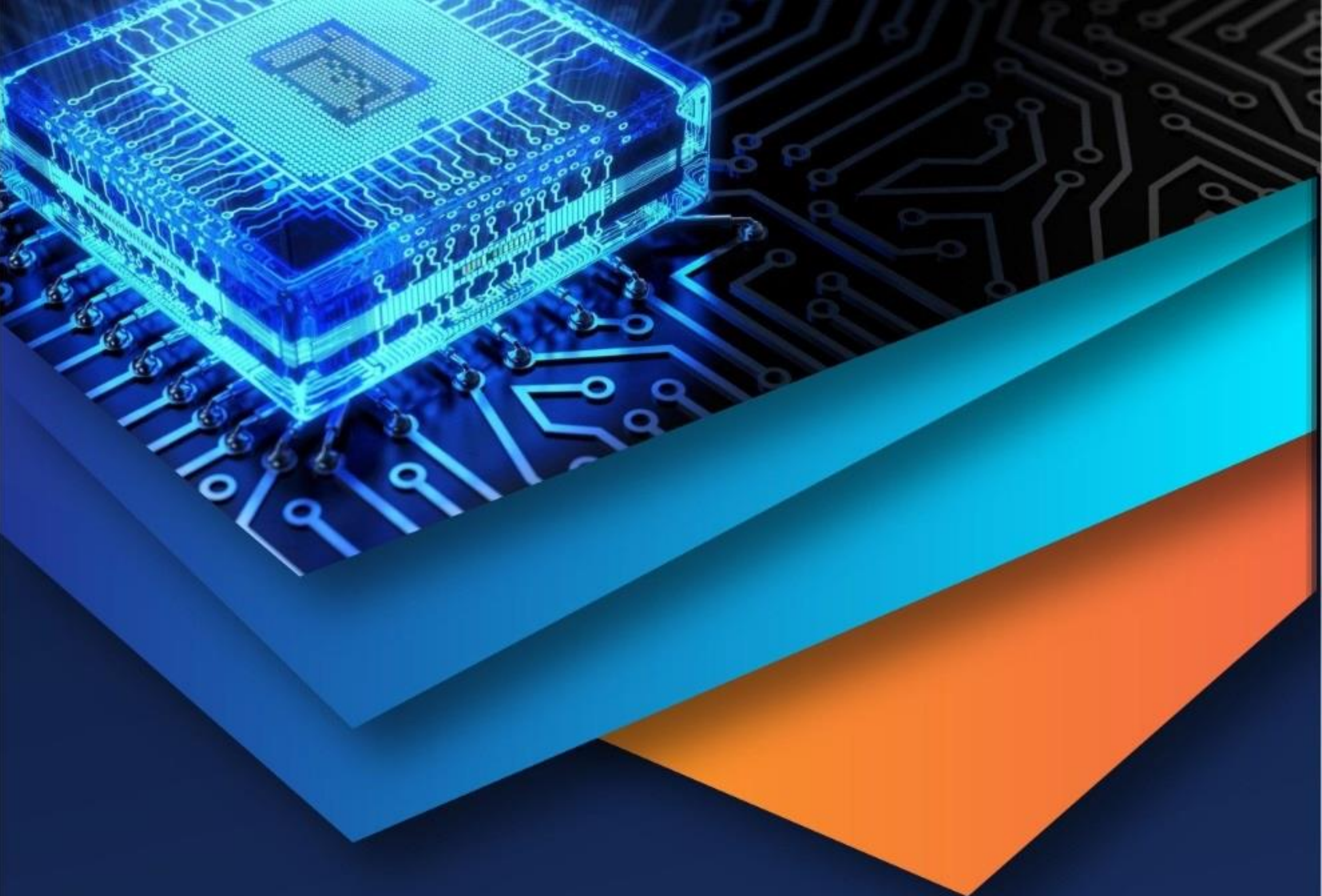
The population must be made familiar with alternatives to RCC frame structures and unreinforced brick masonry structure, especially since a large part of our society still live in joint families and invest their hard-earned money for construction of a family house.

VII. ACKNOWLEDGMENT

I would like to give my warmest thanks to my supervisor Professor Ashish Kumar who believed in me and was supportive when that was the need of the hour. I am really grateful to HOD Civil Department of RIMT University, Dr Sandeep Singla who managed to hold on to his duties even during the time of COVID. The completion of this study couldn't have been possible without the expertise of my dear friend, Er Sheikh Mutahar who was a source of inputs as well. A debt of gratitude is also owed to RIMT University for allowing the students easy access in times of a global pandemic.

REFERENCES

[1] Flores, L. E., & Alcocer, S. M. (1996, June). Calculated response of confined masonry structures. In Eleventh world conference on earthquake engineering.
[2] Brzev, S., & Mitra, K. (2007). Earthquake-resistant confined masonry construction. NICEE, National Information Center of Earthquake Engineering, Indian Institute of Technology Kanpur.
[3] Schacher, T. (2009). Confined Masonry. India: National Information Centre of Earthquake Engineering.
[4] Network, C. M. (2011). Seismic design guide for low-rise confined masonry buildings. Earthquake Engineering Research Institute (EERI).
[5] Jain, S. K., Basu, D., Ghosh, I., Rai, D. C., Brzev, S., & Bhargava, L. K. (2014, July). Application of confined masonry in a major project in India. In Tenth US National conference on earthquake engineering frontiers of earthquake engineering.
[6] Porst, C. F. (2015). Confined masonry for seismically resilient low-cost housing in India: a design and analysis method (Doctoral dissertation, Massachusetts Institute of Technology).
[7] Chourasia, A. (2017). Design guidelines for confined masonry buildings.
[8] Gujarat State Disaster Management Authority (GSDMA) (2012), 'Build a Safe House with Confined Masonry'.
[9] CSI (2011), CSI Analysis Reference Manual for SAP 2000®, ETABS®, SAFE® and CSiBridge™, Computers and Structures, Berkley, California, USA.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)