Design of Masonry Structures

BY

Vivek P. Patel

11MCLC12

DEPARTMENT OF CIVIL ENGINEERING

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Design of Masonry Structures

Major Project

Submitted in partial fulfillment of the requirements

For the degree of

Master of Technology in Civil Engineering
(Computer Aided Structural Analysis & Design)

By

Vivek P. Patel
11MCLC12

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Declaration

This is to certify that

a. The thesis comprises my original work towards the Degree of Master of Technology in Civil Engineering (Computer Aided Structural Analysis and Design) at Nirma University and has not been submitted elsewhere for a degree.

b. Due acknowledgement has been made in the text to all other material used.

Vivek P. Patel

Certificate

This is to certify that the Major Project entitled "**Design of Masonry Structures**" submitted by Vivek P. Patel (11MCLC12), towards the partial fulfillment of the requirements for the degree of Master of Technology in Civil Engineering (Computer Aided Structural Analysis and Design) of Nirma University, Ahmedabad is the record of work carried out by him under my supervision and guidance. In my opinion, the submitted work has reached a level required for being accepted for examination. The results embodied in this major project, to the best of my knowledge, haven't been submitted to any other university or institution for award of any degree or diploma.

Dr. P. H. Shah
Guide and Head,
Department of Civil Engineering,
Institute of Technology,
Nirma University, Ahmedabad

Dr K Kotecha
Director,
Institute of Technology,
Nirma University,
Ahmedabad

____
Examiner

____
Date of Examintion

Abstract

Masonry buildings are the most common type of construction used for all housing around the world.There are innumerable advantages of masonry construction such as thermal comfort,sound control,possibility of addition and alteration after construction,less formwork,easy and inexpensive repair,use of locally available materials,need of less skilled labours. Because of the merits mentioned above this type of construction is employed in the rural, urban and hilly regions up to its optimum, since it is flexible enough to accommodate itself according to the prevailing environmental conditions.

Although this type of construction is most oftenly preferred and most frequently employed yet it is not completely perfect regard to seismic efficiency. The past earthquake survey has proved that the masonry buildings are most vulnerable to and have suffered maximum damages in the past earthquakes.Moreover the plight is that even after gaining knowledge of earthquake engineering since last three decades,no proper method have been developed for seismic analysis and design of masonry buildings in the Indian curriculum in spite of the fact that 90 percent of the population lives in masonry buildings.

The present work is a step towards with regard to illustrate a procedure for seismic analysis and design of a masonry building. It gives detail procedure of the seismic analysis and design of a four storeyed masonry Residential building. The procedure is divided into several distinctive steps in order to create a solid feeling and confidence that masonry buildings may also be designed as engineered construction. It also include the study of different codes from a number of countries on the design of masonry structures with respect to the design philosophy.It also provides an overview of masonry as a sustainable construction material.

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- Vivek P. Patel
11MCLC12

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chapter 1

Introduction

1.1 General

Masonry is structures of individual units laid in and bound together by mortar.The common materials of masonry construction are bricks, stones i.e. marble, granite, limestone, concrete block, glass block, and tile. Even today, residential and other low-rise buildings are of masonry. Masonry is generally a highly durable form of construction. However, the materials used, the quality of the mortar and workmanship, and the pattern of units can strongly affect the durability of the overall masonry construction.

Masonry buildings of brick and stone are superior with respect to durability, fire resistance, heat resistance and formative effects. because of the easy availability of materials for masonry construction.Masonry can carry loads that can cause compression, but can hardly take loads that cause tension. Thus masonry buildings are brittle structures and one of the most vulnerable of the entire building stock under strong earthquake shaking. Masonry buildings have large mass and hence attract large horizontal forces during earthquake shaking. They develop numerous cracks under both compressive and tensile forces subjected during earthquake.With increase in the axial stresses due to overturning,the load may cause failure of the structure.

1.2 Need of Study

The traditional buildings were designed based on the "Rule of Thumb" and the tables given in building codes and regulation. Due to this very large thickness of wall above 3 to 4 stories is necessary and hence buildings were uneconomical compared with buildings constructed with RCC or Steel.

Masonry can carry loads that can cause compression, but can hardly take loads that cause tension. Thus masonry buildings are brittle structures and one of the most vulnerable of the entire building stock under strong earthquake shaking. Masonry buildings have large mass and hence attract large horizontal forces during earthquake shaking. They develop numerous cracks under both compressive and tensile forces subjected during earthquake..

In India, there has not been much progress in the construction of tall load bearing masonry structures, mainly because of poor quality of masonry workmanship and materials such as clay bricks that are manufactured even today having nominal strength of only 7 to 10MPa. However, recently mechanized brick plants are producing brick units of strength 17.5 to 25N/mm2 and therefore it is possible to construct 5 to 6 storeyed load bearing structures at costs less than those of RC framed structures.

1.3 Objective of Study

The main objective is to study the analysis and design procedure for masonry structures.

1.4 Scope of Work

To achieve above objectives the scope of work is decided as follows:

- To review design procedure for masonry structure and issues related to the masonry building including earthquake resistant design,sustainability, thermal comfort.etc.

- To analyze and design of G+4 storey reinforced and unreinforced masonry building

- To prepare worksheet for manual calculation for analysis and design of masonry building

- To study about the application of prestressed masonry in building components like slab, lintel.

1.5 Organization of Report

The Major Project is divided into five chapters. They are as follows:

Chapter 1 provides brief introduction, need of study, objective of study etc.

Chapter 2 covers general information on bricks, masonry construction, advantages and disadvantages of masonry construction, behaviour of masonry structures under earthquake forces, failure types in masonry walls and the earthquake improvement features in masonry structures

Chapter 3 covers in detail the basic concepts of analysis and design, the load transfer mechanism, failure modes for building, integration requirements for the building, bearing and shear wall concept, calculation of rigidity for shear walls building, analysis and design method

Chapter 4 covers the analysis and design of G+4 story masonry building.

Chapter 5 includes the summary of the study, conclusions and future scope of work.

chapter 2

A review of Literature on Masonry Structures

2.1 Introduction

Traditional masonry buildings were designed utilizing the weight of the floor and the massive walls to offset tensile stresses due to moments from eccentricity of vertical loads and from lateral loads. Achieving lateral stability by gravity limits the size of load bearing structures. This has lead to find out ways by which load bearing walls could be decreased in thickness while maintaining the stability.

The significant improvement in masonry materials and advancement in manufacturing have contributed to the growth of masonry construction as a competitive and cost-efficient contemporary building system. High strength units are available with different shapes, colour and textures with good moisture, sound and thermal characteristics. Various masonry materials are stone, clay units, calcium silicate units, concrete masonry units etc. Brick is one of the most commonly and widely used material due to its following advantages:

a. Economy

b. Durable

c. Structural strength

d. Fire resistance

e. Sound insulation

f. Low thermal conductivity

g. Resistance to adverse climatic conditions

h. Flexibility in application

i. Minimum maintenance.

2.2 History of Masonry construction

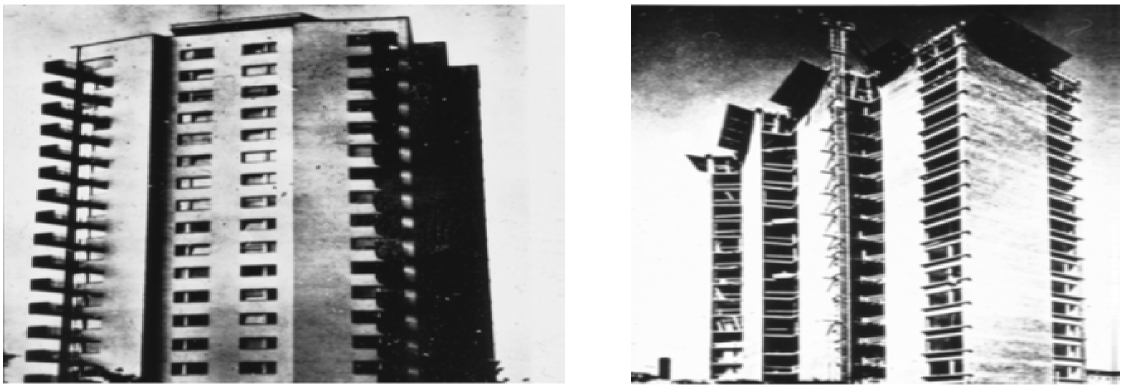
The history of masonry construction can be considered as the beginning of the history of civil Engineering. Stone is the oldest and most abundant raw building material of prehistoric times which resulted in wide use as a construction material. Then brick entered to human life as the man-made building material .It is the oldest manufactured building material, invented almost 10,000 years ago which has been used extensively as a result of its high strength and durability.Masonry bearing - wall structures have been used for centuries for all types of buildings from the small simple shelter to some of our magnificent monuments and public buildings.Some examples are: Temple at Gatewara in Mesopotamia (4500 B.C.), Palaces and Pyramids of Egypt (3500 B.C.),Remains of Indus Valley Civilisation (2500 B.C.)

In the year 1891, the 16-storey high Monadnock Building made up of traditional masonry construction fig.1 was designed by John Root in Chicago with 1.82m thick walls at the base.When it was completed, the Monadnock Building was the world's largest office building. It is generally cited as the last great building in the ancient

(a) (b)

Figure 2.1: Monadnock building

masonry architecture. The tallest 18-storey load-bearing building Fig. 2.2(a) supported on relatively thin walls (127 to 254mm) was built in 1957 in Switzerland. In 1965, a 16-storey building supported on 355-mm thick walls was built in Denmark Fig.2.2(b)



(a) 18-storey load bearing building in Switzerland (b) 16-storey masonry building in Denmark

Figure 2.2: Multistory load bearing masonry building

In India under the Experimental Projects Scheme of the National Buildings Organization, 50 residential units in 5 storeyed blocks, having one brick, that is 25.4 cm thick load bearing brick masonry walls in all the storeys were constructed at Manicktola, Calcutta in 1975 and construction of 20 residential units in 5 storeyed blocks, having one brick, that is, 22.9 cm thick walls, have been constructed in New Delhi.

Figure 2.3: 28-story Excalibur Hotel in Las Vegas, Nevada

Since 1924, numerous field and laboratory tests have been made on reinforced brick beams, slabs, columns, and on full-size structures. In the early 1900's concrete block masonry units were introduced to the construction industries. Use of steel reinforcement for concrete masonry began between 1930 and 1940. In the ensuing years, reinforced concrete masonry became a viable construction practice for single and multi-storey buildings such as schools, hospitals, hotels, apartment complexes, commercial. One of the tallest modern reinforced concrete masonry structures is the 28-story Excalibur Hotel in Las Vegas, Nevada fig 1.3**??**. The load-bearing walls of this four-building complex are built from concrete masonry of 4000 psi compressive strength.

2.3 Type of Masonry construction

2.3.1 Un reinforced masonry

Plain masonry refers to construction from natural or manufactured building units of burned clay, concrete, stone, glass, gypsum, or other similar building units. Unreinforced masonry has been commonly used in low and high rise areas of low seismic zone. Unreinforced masonry is simplest to construct because they do not contain any vertical reinforcement. The strength of plain masonry depends primarily on the high compressive strength of masonry units. The poor tensile strength of plain masonry makes it unsuitable for horizontal spanning structural elements such as beams and slabs, which resist loads in flexure and, thereby, are subjected to tensile stresses.

In unreinforced masonry structures, the lateral stability is provided by gravity. Because masonry is weak in tension, no tension can be allowed to develop at the base of the structure. This requires unreinforced masonry structures to be sufficiently massive (meaning large base width) that the resultant of all forces acting on the structure does not fall outside the middle third of the base. This requirement imposes an economic limit on the height of the masonry structures that can be built.

2.3.2 Reinforced masonry

Reinforced masonry is a construction system where steel reinforcement in the form of reinforcing bars or mesh is embedded in the mortar or placed in the holes and filled with concrete or grout. By reinforcing the masonry with steel reinforcement, the resistance to seismic loads and energy dissipation capacity can be improved significantly.

a. Reinforcement surrounded by mortar

- In bed joints or collar joints

- In pockets formed by the bond pattern of units
- In pockets formed by special units

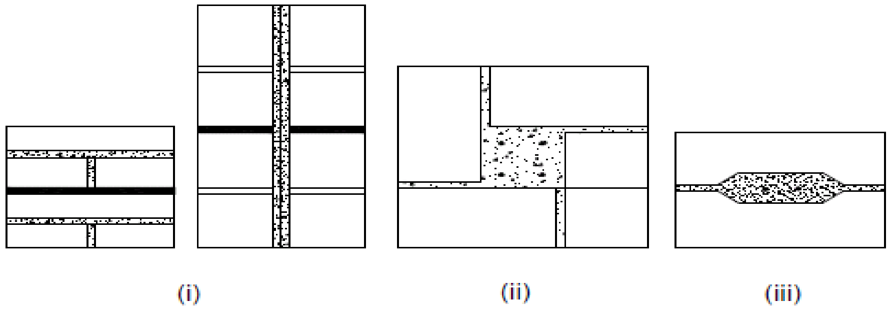


Figure 2.4: Reinforcement surrounded by mortar

b. Reinforcement surrounded by concrete:

- In cavity between masonry leaves
- In pockets formed in the masonry
- In the cores of hollow blocks
- In U shaped lintel units

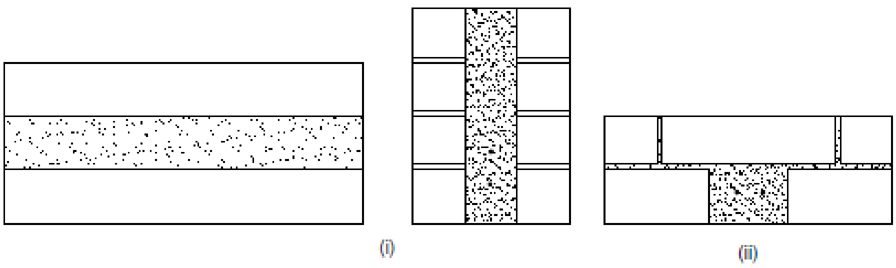


Figure 2.5: Reinforcement surrounded by concrete

2.3.3 Prestressed Masonry

Masonry is very strong in compression, but relatively very weak in tension. This limitation can be overcome by reinforcing or prestressing.Prestressing of masonry is achieved by applying pre compression to counteract, to a desired degree, the tension that would develop under service loading. As a result, prestressing offers several advantages over reinforced masonry, such as the following:

a. Effective Utilization of materials: In reinforced masonry elements, only the area above the neutral axis in compression will be effective in resisting the applied moment, whereas in a prestressed masonry element the whole section will be effective. Further in reinforced masonry, the steel strain has to be kept low to keep cracks within acceptable limit; hence high tensile steel cannot be used to its optimum.

b. Increased Shear Strength : The shear strength of a fully prestressed brickwork beam with bonded tendons is much higher than one of reinforced brickwork.

c. Improved service and overload behavior: By choosing an appropriate degree of prestressing, cracking and deflection can be controlled. It may, however, be possible to eliminate both cracking and deflection entirely, under service loading in case of a fully prestressed section

d. High fatigue resistance: In prestressed masonry, the amplitude of the change in steel strain is very low under alternating loads; hence it has high fatigue strength.

Methods of Prestressing: The technique and methods of prestressing of masonry are similar to those of concrete.

1 Pre tensioning:In this method, the tendons are tensioned to a desired limit between external anchorages and released slowly when both the masonry and its concrete infill have attained sufficient strength. During this operation, the forces in the tendons are transferred to the infill then to the masonry by bond

2 Post tensioning : In this method, the tendons are tensioned by jacking against the masonry element after it has attained adequate strength. The tendons forces are then transmitted into the masonry through anchorages provided by external bearing plates are set in concrete anchorage blocks.

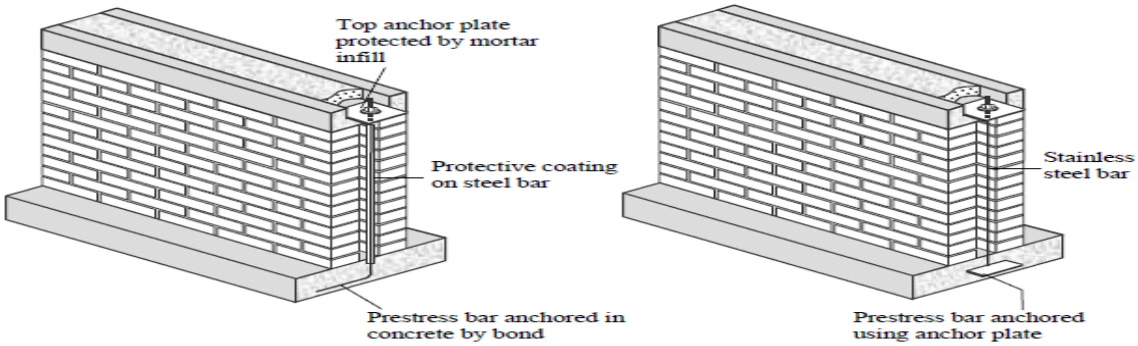


Figure 2.6: prestressed brickwork

2.3.4 Confined Masonry

Confined masonry construction consists of masonry walls (made either of clay brick or concrete block units) and horizontal and vertical RC confining members built on all four sides of a masonry wall panel. Vertical members, called tie-columns or practical columns, resemble columns in RC frame construction except that they tend to be of far smaller cross-section. Horizontal elements, called tie-beams, resemble beams in RC frame construction.

Confined masonry walls can be constructed using different types of masonry units. Figure 2(a) shows construction from Slovenia built using hollow clay tiles and confined masonry construction from El Salvador built using burnt clay bricks, while Figure 2(b) shows a confined masonry building from Indonesia built using concrete blocks.In confined masonry, the reinforcement is concentrated in vertical and horizontal confining elements whereas the masonry walls are usually free of reinforcement.

Figure 2.7: confined masonry construction

2.4 Advantages and disadvantages of Masonry building

The durability of masonry, when used correctly, is excellent. However, the advantages of masonry when used with other materials, depends on its proper usage, requires an understanding of its physical characteristics, its strengths and weakness, the method of construction and availability of various shapes and textures together with relative costs. It is notoriously difficult to determine comprehensive cost of building, as it is a combination of short-term cost of erecting the building and long-term cost incurred for building life. Following are the areas of concern, which lifts masonry over the conventional systems.

2.4.1 Advantages

- Cost :

  a. In steel and concrete structures, partition, staircase and corridor walls if made from masonry can be used to carry loads and hence beams and columns can be dispensed.

b. Steel and other structures require more skilled workers as compared to that required for masonry structures.

c. Faster erection of masonry buildings results in lower site overhead costs

d. Maintenance cost is minimum.

- Speed of Erection : Because of Prefabricated frames masonry structure building can be erected to higher level in a short time. Moreover masonry structure also permits other construction work during the erection period. Time taken to fix reinforcement, erect shuttering, cast concrete, cure, prop and shutter striking in concrete columns is saved in masonry structures.

- Aesthetics : Masonry provides the human scale, is available in vast range of colours and textures and due to small module size bricks and blocks is extremely flexible in application in that it can be used to form a great variety of shapes and sizes of walls, piers, arches, domes, chimneys etc. Masonry structures tend to wear well and mellow with time.

- Durability : Excellent durability of masonry is obviously a great advantage of properly designed masonry structures are designed and build with competence and care; they should last much longer than the required life.

- Sound insulation : Majority of noise intrusion is by air born sound and the best defense against this is masonry structures, as they reduce the additional cost for sound insulation that is required to be done separately.

- Thermal insulation : The good thermal properties of brick and cavity walls have long been recognized and more recently have become critical in the attempts to conserve energy.

- Fire resistance and accidental damage : Masonry structures are more resistant to fire compared to all other structures.

- Repair and Maintenance : Properly designed masonry requires little or no maintenance and therefore it is extremely economical in terms of maintenance. With reference to its use in areas of possible high deformation, such as mining areas, a well-designed building will contain majority of damage within mortar and movement joints, and repointing of the masonry will repair most of the defects.

- Availability of material and labour : The normal module size of bricks and blocks and the readily availability of their raw materials means that they can be mass produced in many locations and stocked in standard sizes. Modern transportation and packing enables speedy delivery of bricks and blocks, and reduce the damages. Moreover being widely used material skill labour are easily available.

2.4.2 Disadvantages

a. Lack of education : Masonry was mainly designed based on the experience and rule of thumb. The many uses to which masonry can be put, the wide range of materials and material behaviour, and the great strides forward in the structural use of masonry, require the backing of good sound education to prevent misuse and to ensure the maximum economy and efficiency in design and construction. Unfortunately, education has been lagging behind the developments, and this has been left the construction industry in a situation where it cannot fully exploit masonrys capabilities until it is geared up to the new techniques and applications.

b. Increase in obstruction area over steel and reinforced concrete : Although masonry units can be obtained with extremely high crushing strengths, the design compressive strengths of masonry walls are generally lower than for steel or reinforced concrete. Thus for a particular loading conditions masonry will require greater cross sectional area.

c. Problems with some isolated details : Like many other materials, masonry can give rise to problems in the achievement of satisfactory isolated details. For example tolerance on manufacture of bricks makes acceptable fair face each side very difficult.

d. Foundations : One of the major advantage of masonry is that it does not require expensive shuttering like concrete but in situations like foundations where the soffit and sides of the excavations form, in effect, the majority of the shuttered faces. Thus in these type of situations concrete foundations are better.

e. Large openings : In situations where large openings are to be formed and a level soffit is required, reinforced concrete or steel beams are generally found to be the most economical means of support. But in cases where the soffit can be in the form of arch, and where the horizontal reactions from such a form can be accommodated, masonry may prove more economical.

2.5 Improving the earthquake resistance of masonry structures

Nearly 55 to 60 percent of the area of the country is prone to natural hazards of different types thereby leading to damage and destruction of a large number of houses every year by one or the other type of hazard.Recognising the high vulnerability of the existing housing stock and the related infrastructure and risk due to natural hazard like earthquakes, following recommendations on several aspects of masonry structures is given below:

2.5.1 Building type

The details of earthquake resistant design and construction given below are applicable to those buildings using fired bricks and other rectangular masonry units such as solid blocks of mortar, concrete or stabilized soil or hollow blocks of mortar or concrete, having adequate compressive strength. The compressive strength of the masonry units on the gross area should be a minimum of 3.5N/mm2 for ordinary 1 to 1 storeyed buildings and 5N/mm2 or more for important and/or taller buildings. The required strength will depend on number of storeys and wall thickness adopted.

2.5.2 Building categories for earthquake resisting features in masonry and earthen buildings

2.5.3 Size And Position of Openings In Bearing Walls

Door and window openings in walls reduce their lateral load resistance and hence, should preferably be small and more carefully located. The guidelines on the size and position of opening are given in table 2.2 and figure.Openings in any storey shall preferably have their top level same so that a continuous band can be provided over them, including the lintel throughout the building.

2.5.4 Vertical Reinforcement

Vertical steel for corners and junctions of walls, which are up to 340mm thick, shall be provided as specified in the table 2.4. For walls thicker than 340mm the area of the bars shall be proportionally increased. No vertical steel need to be provided in category A buildings. The figure shows the details of the brick work for the vertical bars by creating 115 x 115mm pockets and filling them with M15 cement concrete for good bond with brick work and corrosion resistance of the bars.

The vertical reinforcement shall be properly embedded, with minimum length equal to 55 diameters, in the plinth masonry of foundation and roof slab or roof band so as to develop its tensile strength in bond. It shall be passing through the lintel band and floor slabs or floor level bands in all storeys. Bars in different storeys may be welded or suitably lapped to develop full tensile strength, preferably above the lintel band.

M .Bhasker Matey[?] studied the slenderness ratio parameters for hollow block wall panels under uniformly distributed compressive load , ratio of wall strength to block strength,relation between the stress reduction factor and slenderness ratio with the value in IS.The block dimensions were 39x20x20 cm with double hollow core.The thickness of the wall was one brick thick 200 mm with cement mortar of 1:6. The wall panels height vary from 1.25 m to 2.5 m having slenderness ratio from 4.70 to 9.53.The test results shows that the ratio of wall strength to block strenght varies from 0.93 to 0.55. The ratio of experimental ultimate compressive laod to theoretical permissible load (IS Code)varies from 6 to 9.47. From the test results it was found that the relation between the slenderness ratio and stress reduction factor in IS code were higher than the experiment.

Range of a_h	Building Category
Less than 0.05	A
0.05 to 0.06(both inclusive)	B
More than 0.06 and less than 0.08	C
0.08 to less than 0.12	D
Equal to or more than 0.12	E

Figure 2.8: Building Categories for Earthquake Resisting Features in Masonry and Earthen Buildings

Sr. No	Position of Opening	Details of Opening for Building Category		
		A & B	C	D & E
1.	Distance b5 from the inside corner of outside wall minimum	0mm	230mm	450mm
2.	For total length of openings, the ratio (b1+b2+b3)/l1 or (b6 + b7)/l2 shall not exceed			
	a. one-storeyed building	0.60	0.55	0.50
	b. two-storeyed building	0.50	0.46	0.42
	c. 3 or 4 storeyed building	0.42	0.37	0.33
3.	Pier width between consecutive openings b4, minimum	340mm	450mm	560mm
4.	Vertical distance between two openings one above the other h3, minimum.	600mm	600mm	600mm
5.	Width of Ventilator b8, maximum	900mm	900mm	900mm

Figure 2.9: Size and Position of Openings in Bearing Walls

No of Storeys	Storey	Diameter of HSD Single Bar in mm at Each Critical section			
		Category B	Category C	Category D	Category E
One		Nil	Nil	10	12
Two	Top	Nil	Nil	10	12
	Bottom	Nil	Nil	12	16
Three	Top	Nil	10	10	12
	Middle	Nil	10	12	16
	Bottom	Nil	12	12	16
Four	Top	10	10	10	Four storeyed
	Middle	10	10	12	Building not
	Second	10	12	16	Permitted
	Bottom	12	12	20	

Figure 2.10: Size and Position of Openings in Bearing Walls

chapter 3

Design consideration of Masonry Structures

3.1 Introduction

Load bearing masonry residential buildings in the range of four to five storeys is found to be highly economical when compared to reinforced concrete frame and masonry infill construction and, therefore such constructions are preferred in urban areas. IS: 4326 1993 recommends reinforced construction in earthquake zones III, IV and V if the masonry bearing walls are of height greater than 15m, subject to maximum of four storeys. However there is great need for five storeyed load-bearing buildings in metropolitan cities.

Thus it becomes very much necessary that one understands the behaviour of masonry and designs the masonry building accordingly in order to have economic designs and alternative. This chapter deals with the basic concepts of masonry and its behaviour, the other factors affecting the stability of masonry structures and the method used for analysis and design of the load bearing brick masonry building.

3.2 Basic concept-Analysis and design

3.2.1 Vertical Load Transfer

The most effective way to transfer the vertical load to the foundation is to align the load bearing walls vertically below each other as shown in the figure 3.1. The load from the top floor gets transferred to the lower walls and so on. If there is opening in the walls than the load is distributed to the two piers or columns that are formed due to opening and then to foundation.

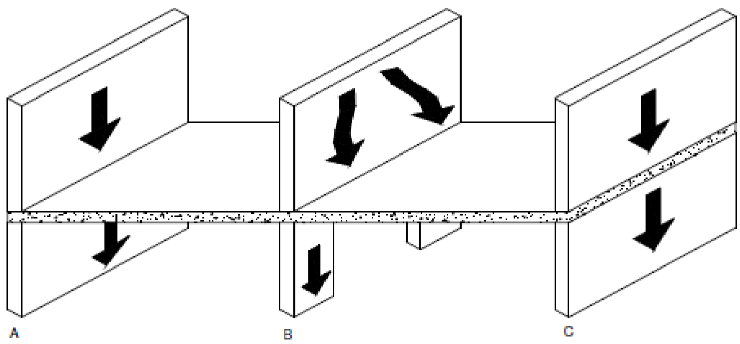


Figure 3.1: Deformation Response Spectrum for El Centro ground motion ($\zeta = 0.02$)

3.2.2 Lateral Load Transfer

Design of lateral loads in multi storey buildings involve use of rigid floor and roof diaphragms to transfer the loads to the shear walls, which in turn carry these forces to the foundation as shown in fig.**??**. It is essential to provide shear walls in two orthogonal directions of the building to resist the lateral load from any direction. It is also very necessary to provide proper connection between the floor and the walls to transfer the shear forces to the walls.

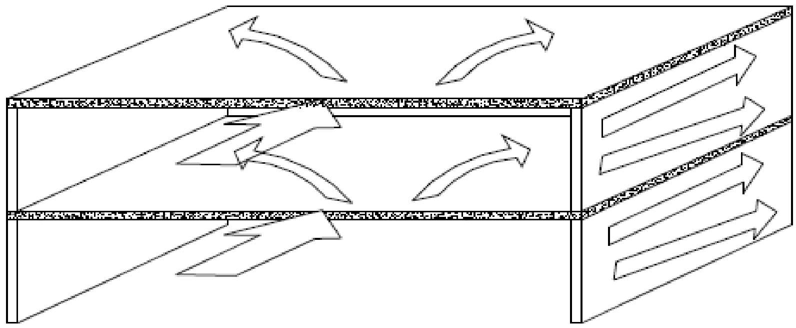


Figure 3.2: Pseudo-velocity Response Spectrum

3.3 Analysis and design procedure

In order to ensure uniformity of loading, openings in walls should not be too large and these should be of hole in wall type as far as possible;bearings for lintels and bed blocks under beams should be liberal in size;heavy concentration of the load should be avoided by judicious planning and sections of load bearing masonry should be varied where feasible with the loadings so as to obtain more or less uniform stress in adjoining parts of members. One of the commonly occurring causes of cracks in masonry is wide variation in stress in masonry in adjoining parts.

3.3.1 Compressive Stress Due To Dead Load And Live Load

Determination of Effective height, length, thickness and slenderness ratio:

- Effective Height : The actual height of the wall for the purpose of working out the effective height should be taken as the center-to-center distance between the supports. The effective height of the wall shall be found out by multiplying the appropriate coefficient that is given in table 4 of IS: 1905 depending on the support conditions.

In case of columns the effective height shall be taken as the actual height for the direction in which it is laterally supported and twice the actual height for the direction it is not laterally support. Refer Cl 4.3 of IS: 1905[21]

- Effective Length : The effective length of the wall shall be taken as the actual length multiplied by the coefficient that is given in the table 5 of IS: 1987[21].

- Effective Thickness : For solid walls, faced walls and columns the effective thickness shall be equal to the actual thickness. Where as for solid walls adequately bonded in the piers/buttress, effective thickness shall be 49 multiplied with the stiffening coefficient given in table 6 of IS: 1905[21] (where SR is based on effective height) and also in case where the wall is supported by the cross walls. Refer Cl 4.5 of IS: 1905.

- Slenderness ratio : Load carrying capacity of a masonry member depends upon its slenderness ratio. As these ratio increases, crippling stress of the member gets reduced because of limitations of workmanship and elastic instability. A masonry member may fail, either due to excessive stress or due to buckling. For slenderness ratio less than 30, the load carrying capacity of a member at ultimate load is limited by stress and for slenderness ratio higher than 30, failure is initiated by buckling.

In case of walls the slenderness ratio shall be effective height divided by the effective thickness or effective length divided by the effective thickness, which ever is less. In case of load bearing wall, slenderness ratio shall not exceed the value given in table 7 of IS: 1905.

- Design Loads : Following are the loads that are to be taken into consideration for determining the stresses.
  - Dead load of walls, columns, floors and roof :
    - Dead Load due to walls, columns, floors and roof is calculated in KN/m.The slab load is calculated in KN/m as per following formulas for triangular and trapezoidal portions of the two-way slab.
  - Live load on floors and roof :
    - Live load on floors is higher than the roof and is to be considered only in vertical stresses.
  - Imposed loads and finishing loads :
    - Finishing load due to floor finish and other finishes are to be taken in kN/m. In addition to finishing load, load due to waterproofing is to be added for the roofs.
- Stresses : Stresses in walls due to the summation of the above mentioned loads are worked out by dividing the load by the wall thickness, taking into consideration the openings in the walls as percentage opening (ratio of area of opening to the area of the wall) and the various factors viz. Stress reduction factor, shape modification factor and area reduction factor.

  - Stress Reduction Factor ks: This factor takes into consideration the slenderness ratio of the element and also the eccentricity of the loading as given in table 9 of IS: 1905 .
  - Area Reduction Factor ka: This factor takes into consideration smallness of the sectional area of the element and is applicable when the sectional area of the element is less than 0.2 m2. The factor $ka = 0.7 + 1.5A$. A being the area of section in m$^2 . Shape modification Factor kp$:

$Thisfactortakesintoconsiderationtheshapeoftheunit, thatis, heighttowidthratioasgi$
1905.

– Permissible Stresses :

Permissible compressive stress in masonry shall be based on the value of basic compressive stress fb given in table 8 of IS: 1905 and multiplying this value by factors known as stress reduction factor k, area reduction factor ka and shape modification factor kp.

The permissible compressive stress can be increased for eccentric vertical loads and lateral loads for certain conditions.Also the permissible compressive stress can be increased for a concentrated load as given in Cl 5.4.1.4 and 5.4.1.5 of IS: 1905 . The compressive stresses due to dead load, live load and other loads should be less than the permissible stress.

3.4 Review of the design codes

In India, there has not been much progress in the construction of tall load bearing masonry structures, mainly because of poor quality of masonry workmanship and materials such as clay bricks that are manufactured even today having nominal strength of only 7 to 10MPa. However, recently mechanized brick plants are producing brick units of strength 17.5 to 25 N/mm2 and therefore it is possible to construct 5 to 6 storeyed load bearing structures at costs less than those of RC framed structures.

Use of reinforcement in masonry can further improve its load carrying capacity and most importantly its flexure and shear behavior under earthquake loads. Masonry units are being manufactured in shapes and sizes that make reinforcement embedding in masonry less cumbersome. With these developments, structural design of load bearing masonry buildings has been undergoing considerable modification as evidenced by changes that are taking place in the masonry design codes throughout the world.

A brief description and major highlights of the various codes that have been reviewed is presented below.

- **Building Code Requirements For Masonry Structures (ACI 530-02/ASCE 5-02/TMS 402-02) :**

  a. The code provides minimum requirements for the structural design and construction of masonry units bedded in mortar using both allowable stress design as well as limit state design (strength design) for unreinforced as well as reinforced masonry.In strength design, more emphasis is laid on reinforced masonry than unreinforced masonry.

- **International Building Code 2000 :**

  – The International Building Code 2000 (ICC 2000) is designed to meet the need for a modern, up-to-date building code addressing the design of building systems through requirements emphasizing performance.The provisions of this code for the design of masonry members have been heavily borrowed from ACI 530-02/ASCE 5-02/TMS 402-02.

- **New Zealand Standard Code of Practice for the Design of Concrete Masonry Structures (NZS 4230: Part 1:1990)** :

  – The content of this Code is largely dictated by seismic considerations and is intended to provide a satisfactory structural performance for masonry structures during a major earthquake. Minimum reinforcing requirements for different structural systems and the reinforcing and separation of non-structural elements will limit non-structural damage during moderate earthquakes. The design philosophy adopted throughout this code is strength design using reinforced masonry only.

- **Eurocode 6: Design of Masonry Structures (DD ENV 1996-1-1: 1996) :**
  - This code specifies a general basis for the design of buildings and civil engineering works in unreinforced and reinforced masonry made with clay and concrete masonry units laid in mortar.Limit state design method has been adopted throughout this code. However, Eurocode 6 does not cover the special requirements of seismic design.
- **Indian Standard Code of Practice for Structural Use of Unreinforced Masonry (IS: 1905-1987) :**
  - The Indian Standard on masonry design was first published in 1960 and later on revised in 1969, 1980 and 1987. The current third version, published in Review of Design Codes for Masonry Buildings IITK-GSDMA-EQ10-V1:1987, was reaffirmed in 1998. The provisions of this code are very similar to those of BS 5628: Part 1:1978. A separate handbook to this code, SP 20(ST): 1991, is also available. This Indian Standard provides recommendations for structural design aspect of load bearing and non-load bearing walls using unreinforced masonry only. Design procedure adopted throughout the code is allowable stress design, along with several empirical formulae.

No of Storeys	Storey	Diameter of HSD Single Bar in mm at Each Critical s			
		Category B	Category C	Category D	Cate
One		Nil	Nil	10	
Two	Top	Nil	Nil	10	
	Bottom	Nil	Nil	12	
Three	Top	Nil	10	10	
	Middle	Nil	10	12	
	Bottom	Nil	12	12	
Four	Top	10	10	10	Four s
	Middle	10	10	12	Build
	Second	10	12	16	Per
	Bottom	12	12	20	

chapter 4

Design of G+4 Residential building

4.1 General

This part contains the anlaysis and design of G+4 Reinforced Masonry building. Following are the details of the problems :

Type of the building : Reinforced masonry building

- No of storey : 4
- Storey Height: 3 m
- Slab Thickness: 0.115 m
- Wall Thickness: 200 mm
- Parapet height: 1.05 m
- Plinth Level: 0.6 m
- Thickness of raking on both sides: 0.01 m
- Sunk Depth in W.C.: 0.4 m

Material Properties :

- Density of Brick: 20 kN/m3
- Density of Concrete: 25 kN/m3
- Modulus of Elasticity of Masonry: 200 MPa

Design Loads :

- Floor Finish: 0.75 kN/m2
- Water Proofing on terrace: 0.5 kN/m2
- Live Load: 2 kN/m2
- Live Load on Terrace: 1.5 kN/m2

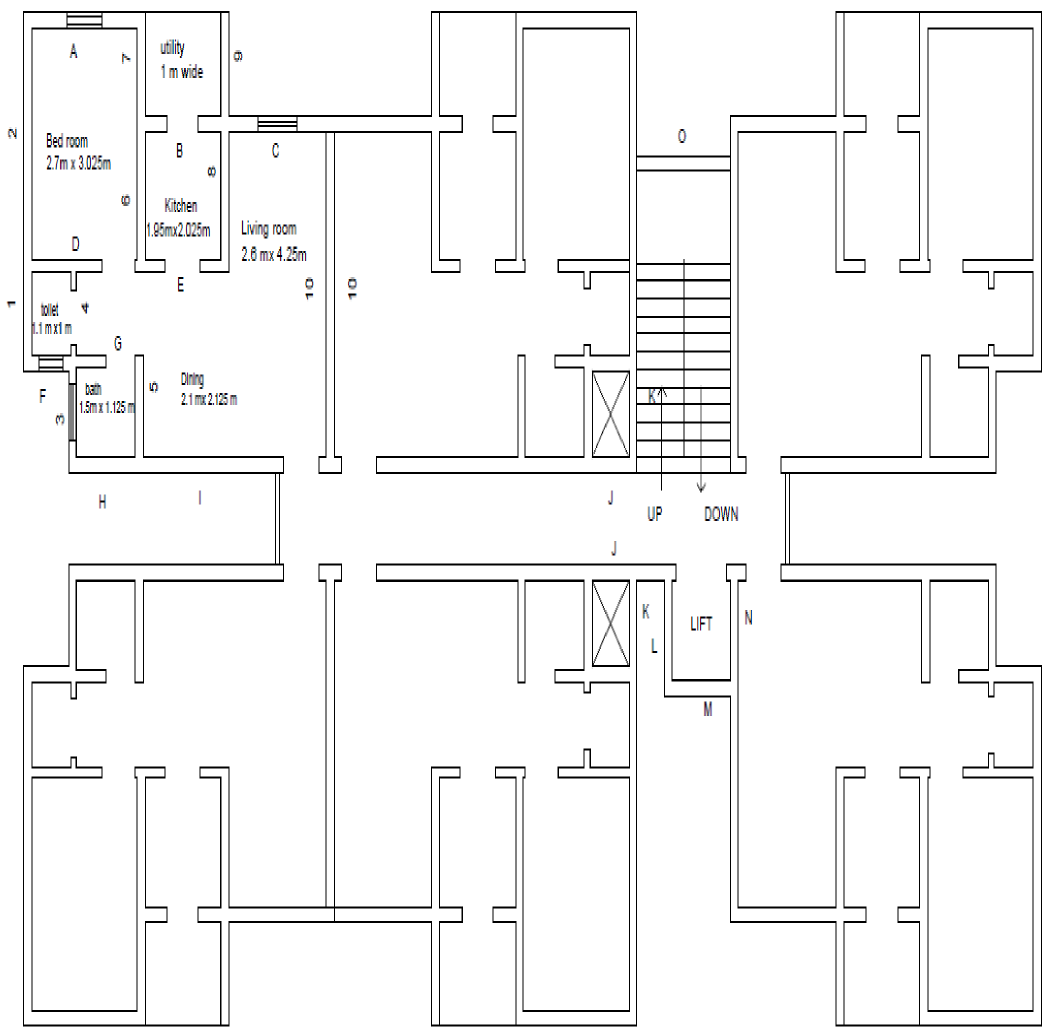


Figure 4.1: G+4 reinforced masonry building

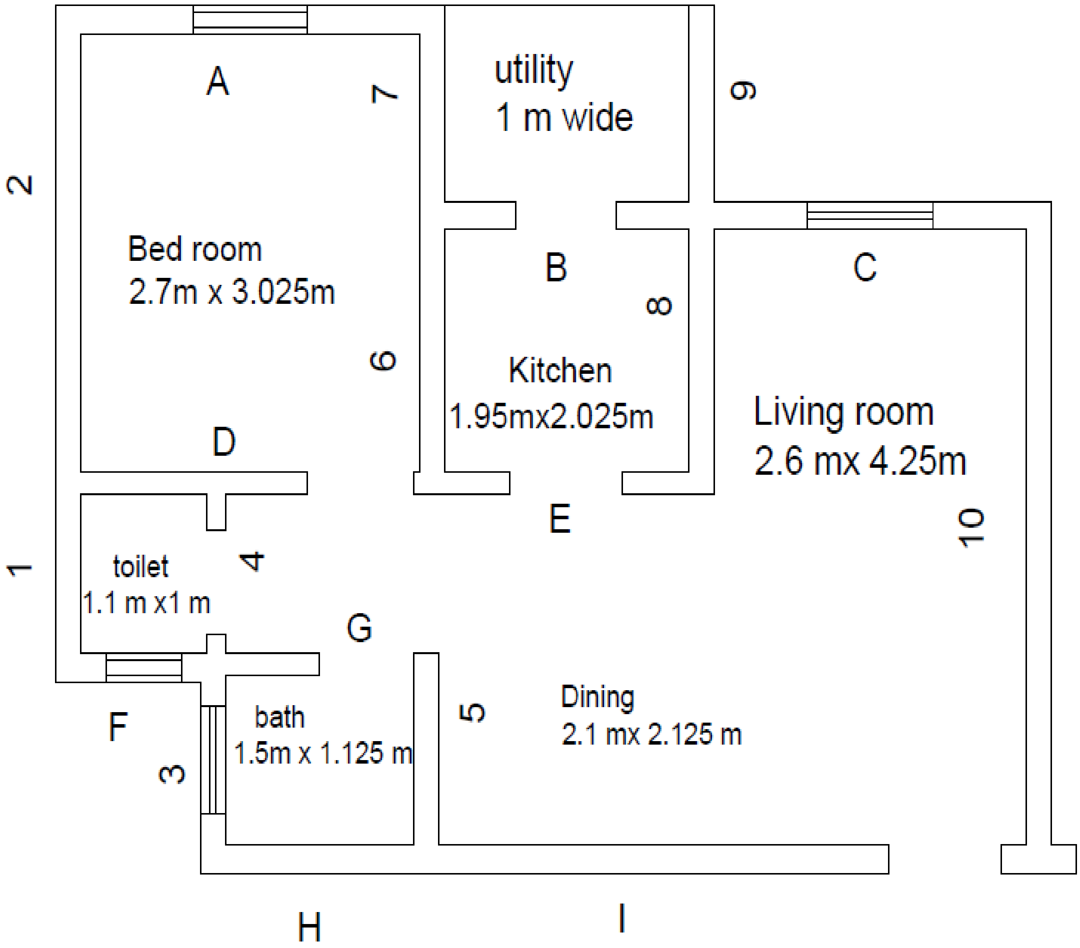


Figure 4.2: G+4 reinforced masonry building

DESIGN OF G+4 REINFORCED MASONRY BUILDING :

Assumed data :

No of storeys	4		
clear height of each storey	2.885	m	clht
Slab Thickness of F4	0.115	m	f4sbtk
Slab Thickness of F3	0.115	m	f3sbtk
Slab Thickness of F2	0.115	m	f2sbtk
Slab Thickness of F1	0.115	m	f1sbtk
Slab Thickness of F0	0.115	m	f0sbtk
ht of parapet	1.05	m	prptht
plinth height	0.6	m	plht
wall thickness at F4 ll to x	0.2	m	f4wthx
wall thicknessat F4 ll to y	0.2	m	f4wthy
wall thickness at F3 ll to x	0.2	m	f3wthx
wall thickness at F3 ll to y	0.2	m	f3wthy
wall thickness at F2 ll to x	0.2	m	f2wthx
wall thickness at F2 ll to y	0.2	m	f2wthy
wall thickness at F1 ll to x	0.2	m	f1wthx
wall thickness at F1 ll to y	0.2	m	f1wthy
wall thickness at F0 ll to x	0.2	m	f0wthx
wall thickness at F0 ll to y	0.2	m	f0wthy
ht of top of footing below gl for 200 mm wall	0.8	m	dpth200
ht of top of footing below gl for 150 mm wall	0.9	m	dpth150
thickness of racking on both side	0.01	m	rakthk
Density of brick	20	KN/m^3	brikdns
Density of concrete	25	KN/m^3	condns
Characteristic Strength of Steel	415	Mpa	
Live Load	2	KN/m^2	llf
LL on terrace	1	KN/m^2	llt
Floor Finish	0.75	KN/m^2	ff
Water Proofing on terrace	0.5	KN/m^2	wp
Thickness of plaster on both sides	0.02	m	plasthk
Sunk depth in W.C.	0.4	m	sdpth
Compressive Stress of brick unit	10	Mpa	csbrik
modulas of elasticity of brick	5500	Mpa	

Figure 4.3: G+4 reinforced masonry building

Floor	Wall	Actual Height	Cond. No.	Effective Height	Actual Length	Cond. No.	Effective Length	Actual Thickness	Effective Thickness	sp/wp	tp/tw	kn	SR
fourth	A	3	1	2.25	2.9	3	2.9	0.19	0.17	15.26316	3	1.189	11.13145
	B	3	1	2.25	2.15	2	1.935	0.19	0.17	11.31579	3	1.347	11.38235
	C	3	1	2.25	2.8	1	2.24	0.19	0.17	14.73684	3	1.21	13.17647
	D	3	1	2.25	2.9	2	2.61	0.19	0.17			1	13.23529
	E	3	1	2.25	2.15	2	1.935	0.14	0.12			1	16.125
	F	3.4	1	2.55	1.275	3	1.275	0.19	0.17			1	7.5
	G	3	1	2.25	1.7	5	3.4	0.14	0.12			1	18.75
	H	3.4	1	2.55	1.7	2	1.53	0.19	0.17	8.947368		1	9
	I	3	1	2.25	5	5	10	0.19	0.17			1	13.23529
	J	3	1	2.25	1.2	3	1.2	0.19	0.17	6.315789		1	7.058824
	K	3	1	2.25	1.1	3	1.1	0.19	0.17	5.789474		1	6.470588
	L	3	1	2.25	0.9	3	0.9	0.19	0.17	4.736842		1	5.294118
	M	3	1	2.25	1.4	3	1.4	0.19	0.17	7.368421		1	8.235294
	N	3	1	2.25	1.6	3	1.6	0.19	0.17	8.421053		1	9.411765
	O	3	1	2.25	2.4	3	2.4	0.19	0.17	12.63158		1	13.23529
	1	3.4	1	2.55	1.175	2	1.0575	0.19	0.17	6.184211	3	1.9724	6.220588
	2	3	1	2.25	3.2	2	2.88	0.19	0.17	16.84211	3	1.326	9.981368
	3	3.4	1	2.55	1.3	3	1.3	0.19	0.17			1	7.647059
	4	3	1	2.25	1.175	3	1.175	0.14	0.12			1	9.791667
	5	3	1	2.25	1.5	5	3	0.19	0.17			1	13.23529
	6	3	1	2.25	2.2	3	2.2	0.19	0.17			1	12.94118
	7	3	1	2.25	1.1	3	1.1	0.19	0.17			1	6.470588
	8	3	1	2.25	2.2	3	2.2	0.19	0.17			1	12.94118
	9	3	1	2.25	1.1	5	2.2	0.19	0.17			1	12.94118
	10	3	1	2.25	4.45	5	8.9	0.19	0.17			1	13.23529

Figure 4.4: G+4 reinforced masonry building

third	A	3	1	2.25	2.95	3	2.95	0.19	0.17	15.52632	3	1.189	11.13145
	B	3	1	2.25	2.2	2	1.98	0.19	0.17	11.57895	3	1.347	11.64706
	C	3	1	2.25	2.8	1	2.24	0.19	0.17	14.73684	3	1.21	13.17647
	D	3	1	2.25	2.9	2	2.61	0.19	0.17			1	13.23529
	E	3	1	2.25	2.15	2	1.935	0.14	0.12			1	16.125
	F	3.4	1	2.55	1.275	3	1.275	0.19	0.17			1	7.5
	G	3	1	2.25	1.7	5	3.4	0.14	0.12			1	18.75
	H	3.4	1	2.55	1.7	2	1.53	0.19	0.17	8.947368	3	1	9
	I	3	1	2.25	5	5	10	0.19	0.17			1	13.23529
	J	3	1	2.25	1.2	3	1.2	0.19	0.17	6.315789		1	7.058824
	K	3	1	2.25	1.1	3	1.1	0.19	0.17	5.789474		1	6.470588
	L	3	1	2.25	0.9	3	0.9	0.19	0.17	4.736842		1	5.294118
	M	3	1	2.25	1.4	3	1.4	0.19	0.17	7.368421		1	8.235294
	N	3	1	2.25	1.6	3	1.6	0.19	0.17	8.421053		1	9.411765
	O	3	1	2.25	2.4	3	2.4	0.19	0.17	12.63158		1	13.23529
	1	3.4	1	2.55	1.175	2	1.0575	0.19	0.17	6.184211	3	1.9724	6.220588
	2	3	1	2.25	3.2	2	2.88	0.19	0.17	16.84211	3	1.326	9.981368
	3	3.4	1	2.55	1.3	3	1.3	0.19	0.17			1	7.647059
	4	3	1	2.25	1.175	3	1.175	0.14	0.12			1	9.791667
	5	3	1	2.25	1.5	5	3	0.19	0.17			1	13.23529
	6	3	1	2.25	2.2	3	2.2	0.19	0.17			1	12.94118
	7	3	1	2.25	1.1	3	1.1	0.19	0.17			1	6.470588
	8	3	1	2.25	2.2	3	2.2	0.19	0.17			1	12.94118
	9	3	1	2.25	1.1	5	2.2	0.19	0.17			1	12.94118
	10	3	1	2.25	4.45	5	8.9	0.19	0.17			1	13.23529

Figure 4.5: G+4 reinforced masonry building

second	A	3	1	2.25	2.95	3	2.95	0.19	0.17	15.52632	3	1.189	11.13145
	B	3	1	2.25	2.2	2	1.98	0.19	0.17	11.57895	3	1.347	11.64706
	C	3	1	2.25	2.8	1	2.24	0.19	0.17	14.73684	3	1.21	13.17647
	D	3	1	2.25	2.9	2	2.61	0.19	0.17			1	13.23529
	E	3	1	2.25	2.15	2	1.935	0.14	0.12			1	16.125
	F	3.4	1	2.55	1.275	3	1.275	0.19	0.17			1	7.5
	G	3	1	2.25	1.7	5	3.4	0.14	0.12			1	18.75
	H	3.4	1	2.55	1.7	2	1.53	0.19	0.17	8.947368	3	1	9
	I	3	1	2.25	5	5	10	0.19	0.17			1	13.23529
	J	3	1	2.25	1.2	3	1.2	0.19	0.17	6.315789		1	7.058824
	K	3	1	2.25	1.1	3	1.1	0.19	0.17	5.789474		1	6.470588
	L	3	1	2.25	0.9	3	0.9	0.19	0.17	4.736842		1	5.294118
	M	3	1	2.25	1.4	3	1.4	0.19	0.17	7.368421		1	8.235294
	N	3	1	2.25	1.6	3	1.6	0.19	0.17	8.421053		1	9.411765
	O	3	1	2.25	2.4	3	2.4	0.19	0.17	12.63158		1	13.23529
	1	3.4	1	2.55	1.175	2	1.0575	0.19	0.17	6.184211	3	1.9724	6.220588
	2	3	1	2.25	3.2	2	2.88	0.19	0.17	16.84211	3	1.326	9.981368
	3	3.4	1	2.55	1.3	3	1.3	0.19	0.17			1	7.647059
	4	3	1	2.25	1.175	3	1.175	0.14	0.12			1	9.791667
	5	3	1	2.25	1.5	5	3	0.19	0.17			1	13.23529
	6	3	1	2.25	2.2	3	2.2	0.19	0.17			1	12.94118
	7	3	1	2.25	1.1	3	1.1	0.19	0.17			1	6.470588
	8	3	1	2.25	2.2	3	2.2	0.19	0.17			1	12.94118
	9	3	1	2.25	1.1	5	2.2	0.19	0.17			1	12.94118
	10	3	1	2.25	4.45	5	8.9	0.19	0.17			1	13.23529

Figure 4.6: G+4 reinforced masonry building

first	A	3	1	2.25	2.95	3	2.95	0.19	0.17	15.52632	3	1.189	11.13145
	B	3	1	2.25	2.2	2	1.98	0.19	0.17	11.57895	3	1.347	11.64706
	C	3	1	2.25	2.8	1	2.24	0.19	0.17	14.73684	3	1.21	13.17647
	D	3	1	2.25	2.9	2	2.61	0.19	0.17			1	13.23529
	E	3	1	2.25	2.15	2	1.935	0.14	0.12			1	16.125
	F	3.4	1	2.55	1.275	3	1.275	0.19	0.17			1	7.5
	G	3	1	2.25	1.7	5	3.4	0.14	0.12			1	18.75
	H	3.4	1	2.55	1.7	2	1.53	0.19	0.17	8.947368	3	1	9
	I	3	1	2.25	5	5	10	0.19	0.17			1	13.23529
	J	3	1	2.25	1.2	3	1.2	0.19	0.17	6.315789		1	7.058824
	K	3	1	2.25	1.1	3	1.1	0.19	0.17	5.789474		1	6.470588
	L	3	1	2.25	0.9	3	0.9	0.19	0.17	4.736842		1	5.294118
	M	3	1	2.25	1.4	3	1.4	0.19	0.17	7.368421		1	8.235294
	N	3	1	2.25	1.6	3	1.6	0.19	0.17	8.421053		1	9.411765
	O	3	1	2.25	2.4	3	2.4	0.19	0.17	12.63158		1	13.23529
	1	3.4	1	2.55	1.175	2	1.0575	0.19	0.17	6.184211	3	1.9724	6.220588
	2	3	1	2.25	3.2	2	2.88	0.19	0.17	16.84211	3	1.326	9.981368
	3	3.4	1	2.55	1.3	3	1.3	0.19	0.17			1	7.647059
	4	3	1	2.25	1.175	3	1.175	0.14	0.12			1	9.791667
	5	3	1	2.25	1.5	5	3	0.19	0.17			1	13.23529
	6	3	1	2.25	2.2	3	2.2	0.19	0.17			1	12.94118
	7	3	1	2.25	1.1	3	1.1	0.19	0.17			1	6.470588
	8	3	1	2.25	2.2	3	2.2	0.19	0.17			1	12.94118
	9	3	1	2.25	1.1	5	2.2	0.19	0.17			1	12.94118
	10	3	1	2.25	4.45	5	8.9	0.19	0.17			1	13.23529

Figure 4.7: G+4 reinforced masonry building

ground	A	4.4	1	3.3	2.95	3	2.95	0.19	0.17	15.52632	3	1.189	17.35294
	B	4.4	1	3.3	2.2	2	1.98	0.19	0.17	11.57895	3	1.347	11.64706
	C	4.4	1	3.3	2.8	1	2.24	0.19	0.17	14.73684	3	1.21	13.17647
	D	4.5	1	3.375	2.9	2	2.61	0.19	0.17			1	15.35294
	E	4.5	1	3.375	2.15	2	1.935	0.14	0.12			1	16.125
	F	4.4	1	3.3	1.275	3	1.275	0.19	0.17			1	7.5
	G	4.5	1	3.375	1.7	5	3.4	0.14	0.12			1	28.125
	H	4.4	1	3.3	1.7	2	1.53	0.19	0.17	8.947368	3	1	9
	I	4.4	1	3.3	5	5	10	0.19	0.17			1	19.41176
	J	4.4	1	3.3	1.2	3	1.2	0.19	0.17	6.315789		1	7.058824
	K	4.4	1	3.3	1.1	3	1.1	0.19	0.17	5.789474		1	6.470588
	L	4.4	1	3.3	0.9	3	0.9	0.19	0.17	4.736842		1	5.294118
	M	4.4	1	3.3	1.4	3	1.4	0.19	0.17	7.368421		1	8.235294
	N	4.4	1	3.3	1.6	3	1.6	0.19	0.17	8.421053		1	9.411765
	O	4.4	1	3.3	2.4	3	2.4	0.19	0.17	12.63158		1	14.11765
	1	4.4	1	3.3	1.175	2	1.0575	0.19	0.17	6.184211	3	1.9724	6.220588
	2	4.4	1	3.3	3.2	2	2.88	0.19	0.17	16.84211	3	1.326	16.94118
	3	4.4	1	3.3	1.3	3	1.3	0.19	0.17			1	7.647059
	4	4.5	1	3.375	1.175	3	1.175	0.14	0.12			1	9.791667
	5	4.4	1	3.3	1.5	5	3	0.19	0.17			1	17.64706
	6	4.4	1	3.3	2.2	3	2.2	0.19	0.17			1	12.94118
	7	4.4	1	3.3	1.1	3	1.1	0.19	0.17			1	6.470588
	8	4.4	1	3.3	2.2	3	2.2	0.19	0.17			1	12.94118
	9	4.4	1	3.3	1.1	5	2.2	0.19	0.17			1	12.94118
	10	4.4	1	3.3	4.45	5	8.9	0.19	0.17			1	19.41176

Figure 4.8: G+4 reinforced masonry building

LOAD CALCULATIONS DUE TO DEAD LOAD :

Floor	Wall	Room Dimensions on the left/ bottom of the wall m lx	m ly	Slab load + LL +FF KN/m²	condition 1 - trinag 2 - trapz	Slab load KN/m	Room Dimensions on the right / top of the wall m lx	m ly	Slab load + LL +FF KN/m²	condition 1 - trinag 2 - trapz	Slab load KN/m	Total slab load KN/m	Parapet load KN/m	Total load KN/m	Self wt of wall KN
fourth	A	2.9	3.2	5.125	1	4.954	0	0	5.125	2	0	4.95	4.41	9.36	33.06
	B	1.1	2.15	5.125	2	2.573	2.15	2.2	5.125	1	3.673	6.25	4.41	10.66	24.51
	C	2.8	4.45	5.125	1	4.783	0	0	5.125	2	0	4.78	4.41	9.19	31.92
	D	2.9	3.2	5.125	1	4.954			5.125	1	0	4.95		4.95	33.06
	E	2.15	2.2	5.125	1	3.673	2.2	2.3	5.125	1	3.758	7.43		7.43	18.06
	F	1.175	1.275	5.125	2	2.159	0	0	5.125	1	0	2.16	4.41	6.57	16.47
	G	1.15	1.7	5.125	2	2.497	1.3	1.7	5.125	2	2.682	5.18		5.18	14.28
	H	1.3	1.7	5.125	2	2.682	0	0	5.125	1	0	2.68	4.41	7.09	21.96
	I	2.2	2.3	5.125	1	3.758	2.8	4.45	5.125	1	4.783	8.54	4.41	12.95	57.00
	J	1.2	0	5.125	1	2.050	0	0	5.125	1	0	2.05		2.05	13.68
	K	0.7	1.2	5.125	1	1.196	0	0	5.125	1	0	1.20		1.20	12.54
	L	0.9	1.2	5.125	1	1.538	0	0	5.125	1	0	1.54		1.54	10.26
	1	1.175	1.275	5.125	1	2.007	0	0	5.125	1	0	2.01	4.41	6.42	15.18
	2	2.9	3.2	5.125	2	5.397	0	0	5.125	1	0	5.40	4.41	9.81	36.48
	3	1.3	1.7	5.125	1	2.221	0	0	5.125	1	0	2.22	4.41	6.63	16.80
	4	1.175	1.275	5.125	1	2.007	1.15	1.7	5.125	1	1.965	3.97		3.97	9.87
	5	1.3	1.7	5.125	1	2.221	2.2	2.3	5.125	2	3.918	6.14		6.14	17.10
	6	2.9	3.2	5.125	2	5.397	2.15	2.2	5.125	2	3.755	9.15		9.15	25.08
	7	1.1	2.15	5.125	1	1.879	0	0	5.125	1	0	1.88		1.88	12.54
	8	2.15	2.2	5.125	2	3.755			5.125	1	0	3.76		3.76	25.08
	9	1.1	2.15	5.125	1	1.879	0	0	5.125	1	0	1.88		1.88	12.54
	10	2.8	4.45	5.125	2	6.228	2.8	4.45	5.125	2	6.228	12.46		12.46	50.73

Figure 4.9: G+4 reinforced masonry building

third	A	2.9	3.2	5.625	1	5.438	0	0	5.625	2	0	5.44		5.44	33.63
	B	1.1	2.15	5.625	2	2.824	2.15	2.2	5.625	1	4.031	6.86		6.86	25.08
	C	2.8	4.45	5.625	1	5.250	0	0	5.625	2	0	5.25		5.25	31.92
	D	2.9	3.2	5.625	1	5.438			5.625	1	0	5.44		5.44	33.06
	E	2.15	2.2	5.625	1	4.031	2.2	2.3	5.625	1	4.125	8.16		8.16	18.06
	F	1.175	1.275	5.625	2	2.369	0	0	5.625	1	0	2.37		2.37	16.47
	G	1.15	1.7	5.625	2	2.741	1.3	1.7	5.625	2	2.944	5.68		5.68	14.28
	H	1.3	1.7	5.625	2	2.944	0	0	5.625	1	0	2.94		2.94	21.96
	I	2.2	2.3	5.625	1	4.125	2.8	4.45	5.625	1	5.250	9.38		9.38	57.00
	J	1.2	0	5.625	1	2.250	0	0	5.625	1	0	2.25		2.25	13.68
	K	0.7	1.2	5.625	1	1.313	0	0	5.625	1	0	1.31		1.31	12.54
	L	0.9	1.2	5.625	1	1.688	0	0	5.625	1	0	1.69		1.69	10.26
	1	1.175	1.275	5.625	1	2.203	0	0	5.625	1	0	2.20		2.20	15.18
	2	2.9	3.2	5.625	2	5.923	0	0	5.625	1	0	5.92		5.92	36.48
	3	1.3	1.7	5.625	1	2.438	0	0	5.625	1	0	2.44		2.44	16.80
	4	1.175	1.275	5.625	1	2.203	1.15	1.7	5.625	1	2.156	4.36		4.36	9.87
	5	1.3	1.7	5.625	1	2.438	2.2	2.3	5.625	2	4.300	6.74		6.74	17.10
	6	2.9	3.2	5.625	2	5.923	2.15	2.2	5.625	2	4.122	10.05		10.05	25.08
	7	1.1	2.15	5.625	1	2.063	0	0	5.625	1	0	2.06		2.06	12.54
	8	2.15	2.2	5.625	2	4.122			5.625	1	0	4.12		4.12	25.08
	9	1.1	2.15	5.625	1	2.063	0	0	5.625	1	0	2.06		2.06	12.54
	10	2.8	4.45	5.625	2	6.836	2.8	4.45	5.625	2	6.836	13.67		13.67	50.73

Figure 4.10: G+4 reinforced masonry building

second	A	2.9	3.2	5.625	1	5.438	0	0	5.625	2	0	5.44		5.44	33.63
	B	1.1	2.15	5.625	2	2.824	2.15	2.2	5.625	1	4.031	6.86		6.86	25.08
	C	2.8	4.45	5.625	1	5.250	0	0	5.625	2	0	5.25		5.25	31.92
	D	2.9	3.2	5.625	1	5.438			5.625	1	0	5.44		5.44	33.06
	E	2.15	2.2	5.625	1	4.031	2.2	2.3	5.625	1	4.125	8.16		8.16	18.06
	F	1.175	1.275	5.625	2	2.369	0	0	5.625	1	0	2.37		2.37	16.47
	G	1.15	1.7	5.625	2	2.741	1.3	1.7	5.625	2	2.944	5.68		5.68	14.28
	H	1.3	1.7	5.625	2	2.944	0	0	5.625	1	0	2.94		2.94	21.96
	I	2.2	2.3	5.625	1	4.125	2.8	4.45	5.625	1	5.250	9.38		9.38	57.00
	J	1.2	0	5.625	1	2.250	0	0	5.625	1	0	2.25		2.25	13.68
	K	0.7	1.2	5.625	1	1.313	0	0	5.625	1	0	1.31		1.31	12.54
	L	0.9	1.2	5.625	1	1.688	0	0	5.625	1	0	1.69		1.69	10.26
	1	1.175	1.275	5.625	1	2.203	0	0	5.625	1	0	2.20		2.20	15.18
	2	2.9	3.2	5.625	2	5.923	0	0	5.625	1	0	5.92		5.92	36.48
	3	1.3	1.7	5.625	1	2.438	0	0	5.625	1	0	2.44		2.44	16.80
	4	1.175	1.275	5.625	1	2.203	1.15	1.7	5.625	1	2.156	4.36		4.36	9.87
	5	1.3	1.7	5.625	1	2.438	2.2	2.3	5.625	2	4.300	6.74		6.74	17.10
	6	2.9	3.2	5.625	2	5.923	2.15	2.2	5.625	2	4.122	10.05		10.05	25.08
	7	1.1	2.15	5.625	1	2.063	0	0	5.625	1	0	2.06		2.06	12.54
	8	2.15	2.2	5.625	2	4.122			5.625	1	0	4.12		4.12	25.08
	9	1.1	2.15	5.625	1	2.063	0	0	5.625	1	0	2.06		2.06	12.54
	10	2.8	4.45	5.625	2	6.836	2.8	4.45	5.625	2	6.836	13.67		13.67	50.73

Figure 4.11: G+4 reinforced masonry building

first	A	2.9	3.2	5.625	1	5.438	0	0	5.625	2	0	5.44		5.44	33.63
	B	1.1	2.15	5.625	2	2.824	2.15	2.2	5.625	1	4.031	6.86		6.86	25.08
	C	2.8	4.45	5.625	1	5.250	0	0	5.625	2	0	5.25		5.25	31.92
	D	2.9	3.2	5.625	1	5.438			5.625	1	0	5.44		5.44	33.06
	E	2.15	2.2	5.625	1	4.031	2.2	2.3	5.625	1	4.125	8.16		8.16	18.06
	F	1.175	1.275	5.625	2	2.369	0	0	5.625	1	0	2.37		2.37	16.47
	G	1.15	1.7	5.625	2	2.741	1.3	1.7	5.625	2	2.944	5.68		5.68	14.28
	H	1.3	1.7	5.625	2	2.944	0	0	5.625	1	0	2.94		2.94	21.96
	I	2.2	2.3	5.625	1	4.125	2.8	4.45	5.625	1	5.250	9.38		9.38	57.00
	J	1.2	0	5.625	1	2.250	0	0	5.625	1	0	2.25		2.25	13.68
	K	0.7	1.2	5.625	1	1.313	0	0	5.625	1	0	1.31		1.31	12.54
	L	0.9	1.2	5.625	1	1.688	0	0	5.625	1	0	1.69		1.69	10.26
	1	1.175	1.275	5.625	1	2.203	0	0	5.625	1	0	2.20		2.20	15.18
	2	2.9	3.2	5.625	2	5.923	0	0	5.625	1	0	5.92		5.92	36.48
	3	1.3	1.7	5.625	1	2.438	0	0	5.625	1	0	2.44		2.44	16.80
	4	1.175	1.275	5.625	1	2.203	1.15	1.7	5.625	1	2.156	4.36		4.36	9.87
	5	1.3	1.7	5.625	1	2.438	2.2	2.3	5.625	2	4.300	6.74		6.74	17.10
	6	2.9	3.2	5.625	2	5.923	2.15	2.2	5.625	2	4.122	10.05		10.05	25.08
	7	1.1	2.15	5.625	1	2.063	0	0	5.625	1	0	2.06		2.06	12.54
	8	2.15	2.2	5.625	2	4.122			5.625	1	0	4.12		4.12	25.08
	9	1.1	2.15	5.625	1	2.063	0	0	5.625	1	0	2.06		2.06	12.54
	10	2.8	4.45	5.625	2	6.836	2.8	4.45	5.625	2	6.836	13.67		13.67	50.73

Figure 4.12: G+4 reinforced masonry building

ground	A	2.9	3.2	5.625	1	5.438	0	0	5.625	2	0	5.44		5.44	49.32
	B	1.1	2.15	5.625	2	2.824	2.15	2.2	5.625	1	4.031	6.86		6.86	36.78
	C	2.8	4.45	5.625	1	5.250	0	0	5.625	2	0	5.25		5.25	46.82
	D	2.9	3.2	5.625	1	5.438			5.625	1	0	5.44		5.44	49.59
	E	2.15	2.2	5.625	1	4.031	2.2	2.3	5.625	1	4.125	8.16		8.16	27.09
	F	1.175	1.275	5.625	2	2.369	0	0	5.625	1	0	2.37		2.37	21.32
	G	1.15	1.7	5.625	2	2.741	1.3	1.7	5.625	2	2.944	5.68		5.68	21.42
	H	1.3	1.7	5.625	2	2.944	0	0	5.625	1	0	2.94		2.94	28.42
	I	2.2	2.3	5.625	1	4.125	2.8	4.45	5.625	1	5.250	9.38		9.38	83.60
	J	1.2	0	5.625	1	2.250	0	0	5.625	1	0	2.25		2.25	20.06
	K	0.7	1.2	5.625	1	1.313	0	0	5.625	1	0	1.31		1.31	18.39
	L	0.9	1.2	5.625	1	1.688	0	0	5.625	1	0	1.69		1.69	15.05
	1	1.175	1.275	5.625	1	2.203	0	0	5.625	1	0	2.20		2.20	19.65
	2	2.9	3.2	5.625	2	5.923	0	0	5.625	1	0	5.92		5.92	53.50
	3	1.3	1.7	5.625	1	2.438	0	0	5.625	1	0	2.44		2.44	21.74
	4	1.175	1.275	5.625	1	2.203	1.15	1.7	5.625	1	2.156	4.36		4.36	14.81
	5	1.3	1.7	5.625	1	2.438	2.2	2.3	5.625	2	4.300	6.74		6.74	25.08
	6	2.9	3.2	5.625	2	5.923	2.15	2.2	5.625	2	4.122	10.05		10.05	36.78
	7	1.1	2.15	5.625	1	2.063	0	0	5.625	1	0	2.06		2.06	18.39
	8	2.15	2.2	5.625	2	4.122			5.625	1	0	4.12		4.12	36.78
	9	1.1	2.15	5.625	1	2.063	0	0	5.625	1	0	2.06		2.06	18.39
	10	2.8	4.45	5.625	2	6.836	2.8	4.45	5.625	2	6.836	13.67		13.67	74.40

Figure 4.13: G+4 reinforced masonry building

Stress calculations due to dead load :

Floor	wall	load KN/m	compressive stress without opening KN/m2	% opening	ompressiv stress with opening KN/m2	Stress Reduction Factor	ompressiv stress with SRF KN/m2	Shape modification factor	compressive stress with SMF Mpa	SR	permissible . compr.stress Mpa	check
fourth	A	19.80	116.46	1.08	117.73	0.861	136.73	1.00	0.14	11.13	1.183875	Safe
	B	22.10	130.02	1.68	132.24	0.856	154.58	1.00	0.15	11.38	1.1763125	Safe
	C	22.51	132.41	1.3	134.16	0.805	166.74	1.00	0.17	13.18	1.106325	Safe
	D	16.65	97.97	1.89	99.85	0.802	124.50	1.00	0.12	13.24	1.10275	Safe
	E	15.31	127.62	1.89	130.08	0.86	151.96	1.00	0.15	16.13	1.177	Safe
	F	19.07	112.16	0.36	112.57	0.96	116.95	1.00	0.12	7.50	1.3234375	Safe
	G	8.37	69.74	1.68	70.93	0.80	88.44	1.00	0.09	18.75	1.10275	Safe
	H	20.92	123.08	0	123.08	0.92	133.79	1.00	0.13	9.00	1.265	Safe
	I	16.99	99.91	2.1	102.05	0.80	127.25	1.00	0.13	13.24	1.10275	Safe
	J	13.05	76.76	0	76.76	0.95	81.23	1.00	0.08	7.06	1.299375	Safe
	K	12.36	72.72	0	72.72	0.99	73.68	1.00	0.07	6.47	1.357125	Safe
	L	12.64	74.34	0	74.34	1.00	74.34	1.00	0.07	5.29	1.375	Safe
	1	20.38	119.89	0	119.89	0.995	120.49	1.00	0.12	6.22	1.347603125	Safe
	2	21.42	126.00	0	126.00	0.89	141.58	1.00	0.14	9.98	1.22375	Safe
	3	19.12	112.46	0.45	112.96	0.958	117.92	1.00	0.12	7.65	1.31725	Safe
	4	11.60	96.64	1.575	98.19	0.977	100.50	1.00	0.10	9.79	1.343375	Safe
	5	10.64	62.60	0	62.60	0.80	78.24	1.00	0.08	13.24	1.1	Safe
	6	18.77	110.39	0	110.39	0.81	135.98	1.00	0.14	12.94	1.116225	Safe
	7	12.91	75.96	0	75.96	0.99	76.88	1.00	0.08	6.47	1.3585	Safe
	8	14.42	84.84	0	84.84	0.81	104.74	1.00	0.10	12.94	1.11375	Safe
	9	7.21	42.43	0	42.43	0.81	52.38	1.00	0.05	12.94	1.11375	Safe
	10	15.73	92.50	0	92.50	0.80	115.63	1.00	0.12	13.24	1.1	Safe

Figure 4.14: G+4 reinforced masonry building

third	A	34.70	182.64	1.08	184.63	0.861	214.44	1.00	0.21	11.13	1.183875	Safe
	B	39.19	206.25	1.68	209.78	0.856	245.21	1.00	0.25	11.65	1.1763125	Safe
	C	40.14	211.28	1.3	214.06	0.805	266.05	1.00	0.27	13.18	1.106325	Safe
	D	32.83	172.76	1.89	176.09	0.802	219.57	1.00	0.22	13.24	1.10275	Safe
	E	29.90	213.60	1.89	217.72	0.86	254.34	1.00	0.25	16.13	1.177	Safe
	F	33.51	176.39	0.36	177.03	0.96	183.92	1.00	0.18	7.50	1.3234375	Safe
	G	16.23	115.94	1.68	117.92	0.80	147.04	1.00	0.15	18.75	1.10275	Safe
	H	37.18	195.67	0	195.67	0.92	212.68	1.00	0.21	9.00	1.265	Safe
	I	28.73	151.19	2.1	154.44	0.80	192.56	1.00	0.19	13.24	1.10275	Safe
	J	25.90	136.32	0	136.32	0.95	144.25	1.00	0.14	7.06	1.299375	Safe
	K	24.61	129.52	0	129.52	0.99	131.22	1.00	0.13	6.47	1.357125	Safe
	L	25.13	132.24	0	132.24	1.00	132.24	1.00	0.13	5.29	1.375	Safe
	1	36.16	190.30	0	190.30	0.995	191.25	1.00	0.19	6.22	1.347603125	Safe
	2	37.90	199.50	0	199.50	0.89	224.15	1.00	0.22	9.98	1.22375	Safe
	3	33.61	176.89	0.45	177.69	0.958	185.48	1.00	0.19	7.65	1.31725	Safe
	4	22.81	162.90	1.575	165.51	0.977	169.40	1.00	0.17	9.79	1.343375	Safe
	5	20.68	108.86	0	108.86	0.80	136.07	1.00	0.14	13.24	1.1	Safe
	6	36.64	192.84	0	192.84	0.81	237.55	1.00	0.24	12.94	1.116225	Safe
	7	25.64	134.96	0	134.96	0.99	136.60	1.00	0.14	6.47	1.3585	Safe
	8	28.48	149.89	0	149.89	0.81	185.05	1.00	0.19	12.94	1.11375	Safe
	9	14.24	74.96	0	74.96	0.81	92.54	1.00	0.09	12.94	1.11375	Safe
	10	30.24	159.14	0	159.14	0.80	198.92	1.00	0.20	13.24	1.1	Safe

Figure 4.15: G+4 reinforced masonry building

second	A	49.61	261.08	1.08	263.93	0.861	306.54	1.00	0.31	11.13	1.183875	Safe
	B	56.27	296.17	1.68	301.23	0.856	352.11	1.00	0.35	11.65	1.1763125	Safe
	C	57.78	304.09	1.3	308.09	0.805	382.91	1.00	0.38	13.18	1.106325	Safe
	D	49.00	257.87	1.89	262.84	0.802	327.73	1.00	0.33	13.24	1.10275	Safe
	E	44.49	317.81	1.89	323.93	0.86	378.43	1.00	0.38	16.13	1.177	Safe
	F	47.96	252.43	0.36	253.34	0.96	263.21	1.00	0.26	7.50	1.3234375	Safe
	G	24.10	172.11	1.68	175.05	0.80	218.27	1.00	0.22	18.75	1.10275	Safe
	H	53.43	281.21	0	281.21	0.92	305.66	1.00	0.31	9.00	1.265	Safe
	I	40.47	212.99	2.1	217.56	0.80	271.27	1.00	0.27	13.24	1.10275	Safe
	J	38.75	203.95	0	203.95	0.95	215.82	1.00	0.22	7.06	1.299375	Safe
	K	36.85	193.97	0	193.97	0.99	196.52	1.00	0.20	6.47	1.357125	Safe
	L	37.61	197.96	0	197.96	1.00	197.96	1.00	0.20	5.29	1.375	Safe
	1	51.93	273.33	0	273.33	0.995	274.70	1.00	0.27	6.22	1.347603125	Safe
	2	54.39	286.25	0	286.25	0.89	321.63	1.00	0.32	9.98	1.22375	Safe
	3	48.10	253.15	0.45	254.30	0.958	265.45	1.00	0.27	7.65	1.31725	Safe
	4	34.02	242.97	1.575	246.86	0.977	252.67	1.00	0.25	9.79	1.343375	Safe
	5	30.73	161.71	0	161.71	0.80	202.14	1.00	0.20	13.24	1.1	Safe
	6	54.51	286.91	0	286.91	0.81	353.43	1.00	0.35	12.94	1.116225	Safe
	7	38.37	201.95	0	201.95	0.99	204.40	1.00	0.20	6.47	1.3585	Safe
	8	42.54	223.87	0	223.87	0.81	276.38	1.00	0.28	12.94	1.11375	Safe
	9	21.27	111.95	0	111.95	0.81	138.21	1.00	0.14	12.94	1.11375	Safe
	10	44.75	235.51	0	235.51	0.80	294.39	1.00	0.29	13.24	1.1	Safe

Figure 4.16: G+4 reinforced masonry building

first	A	64.51	339.53	1.08	343.23	0.861	398.64	1.00	0.40	11.13	1.183875	Safe
	B	70.76	372.42	1.68	378.78	0.856	442.76	1.00	0.44	11.65	1.1763125	Safe
	C	75.41	396.89	1.3	402.12	0.805	499.78	1.00	0.50	13.18	1.106325	Safe
	D	65.17	342.98	1.89	349.59	0.802	435.90	1.00	0.44	13.24	1.10275	Safe
	E	56.43	403.04	1.89	410.80	0.86	479.91	1.00	0.48	16.13	1.177	Safe
	F	62.41	328.46	0.36	329.65	0.96	342.49	1.00	0.34	7.50	1.3234375	Safe
	G	30.06	214.73	1.68	218.40	0.80	272.32	1.00	0.27	18.75	1.10275	Safe
	H	69.68	366.75	0	366.75	0.92	398.64	1.00	0.40	9.00	1.265	Safe
	I	48.83	256.98	2.1	262.49	0.80	327.30	1.00	0.33	13.24	1.10275	Safe
	J	51.60	271.58	0	271.58	0.95	287.39	1.00	0.29	7.06	1.299375	Safe
	K	49.10	258.42	0	258.42	0.99	261.82	1.00	0.26	6.47	1.357125	Safe
	L	50.10	263.68	0	263.68	1.00	263.68	1.00	0.26	5.29	1.375	Safe
	1	67.71	356.35	0	356.35	0.995	358.14	1.00	0.36	6.22	1.347603125	Safe
	2	70.87	373.01	0	373.01	0.89	419.11	1.00	0.42	9.98	1.22375	Safe
	3	62.59	329.42	0.45	330.91	0.958	345.42	1.00	0.35	7.65	1.31725	Safe
	4	43.84	313.11	1.575	318.12	0.977	325.61	1.00	0.33	9.79	1.343375	Safe
	5	38.00	199.98	0	199.98	0.80	249.98	1.00	0.25	13.24	1.1	Safe
	6	69.73	367.00	0	367.00	0.81	452.09	1.00	0.45	12.94	1.116225	Safe
	7	51.10	268.95	0	268.95	0.99	272.21	1.00	0.27	6.47	1.3585	Safe
	8	56.59	297.85	0	297.85	0.81	367.72	1.00	0.37	12.94	1.11375	Safe
	9	28.30	148.95	0	148.95	0.81	183.89	1.00	0.18	12.94	1.11375	Safe
	10	50.45	265.51	0	265.51	0.80	331.89	1.00	0.33	13.24	1.1	Safe

Figure 4.17: G+4 reinforced masonry building

ground	A	84.73	445.97	1.08	450.84	0.861	523.62	1.00	0.52	17.35	1.183875	Safe
	B	91.16	479.77	1.68	487.97	0.856	570.39	1.00	0.57	11.65	1.1763125	Safe
	C	99.69	524.70	1.3	531.61	0.805	660.72	1.00	0.66	13.18	1.106325	Safe
	D	87.67	461.43	1.89	470.31	0.802	586.43	1.00	0.59	15.35	1.10275	Safe
	E	73.02	521.59	1.89	531.64	0.86	621.08	1.00	0.62	16.13	1.177	Safe
	F	80.65	424.50	0.36	426.03	0.96	442.63	1.00	0.44	7.50	1.3234375	Safe
	G	38.13	272.35	1.68	277.00	0.80	345.38	1.00	0.35	28.13	1.10275	Safe
	H	90.16	474.51	0	474.51	0.92	515.77	1.00	0.52	9.00	1.265	Safe
	I	59.85	314.97	2.1	321.73	0.80	401.16	1.00	0.40	19.41	1.10275	Safe
	J	69.77	367.21	0	367.21	0.95	388.58	1.00	0.39	7.06	1.299375	Safe
	K	66.67	350.87	0	350.87	0.99	355.49	1.00	0.36	6.47	1.357125	Safe
	L	67.91	357.41	0	357.41	1.00	357.41	1.00	0.36	5.29	1.375	Safe
	1	87.70	461.60	0	461.60	0.995	463.92	1.00	0.46	6.22	1.368125	Safe
	2	93.27	490.88	0	490.88	0.89	551.55	1.00	0.55	16.94	1.22375	Safe
	3	80.88	425.69	0.45	427.61	0.958	446.36	1.00	0.45	7.65	1.31725	Safe
	4	57.86	413.25	1.575	419.86	0.977	429.75	1.00	0.43	9.79	1.343375	Safe
	5	47.93	252.25	0	252.25	0.80	315.31	1.00	0.32	17.65	1.1	Safe
	6	90.27	475.10	0	475.10	0.81	585.24	1.00	0.59	12.94	1.116225	Safe
	7	69.15	363.94	0	363.94	0.99	368.36	1.00	0.37	6.47	1.3585	Safe
	8	75.97	399.83	0	399.83	0.81	493.62	1.00	0.49	12.94	1.11375	Safe
	9	37.99	199.94	0	199.94	0.81	246.84	1.00	0.25	12.94	1.11375	Safe
	10	63.21	332.69	0	332.69	0.80	415.87	1.00	0.42	19.41	1.1	Safe

Figure 4.18: G+4 reinforced masonry building

Seismic Analysis:

Floor area SF = 62.35 m^2

		Reference of 1893 (Part 1) : 2002
Zone	3	
Zone Factor (Z)	0.16	Tab. 2 pg 16
Importance Factor (I)	1	Tab. 6 pg 18
Response Reduction Factor (R)	3	Tab. 7 pg 23 *
Fundamental Natural Period (Ta)		Cl 7.6.2 pg 24
(Ta)-x	0.08	
(Ta)-y	0.12	
Avg. response acc. Coeff. (Sa/g)		Cl 6.4.5 pg 16
(Sa/g)-x	2.2	
(Sa/g)-y	2.5	

Figure 4.19: G+4 reinforced masonry building

Desing horizontal seismic coeffiecient (Ah) for force II to Y axis

Ah = (Z I / 2 R) * Sa/g (Cl 6.4.2 pg 14)
= **0.07**

Design Seismic Base Shear (Vb)

Vb = Ah * W
= **999.21** KN

Desing horizontal seismic coeffiecient (Ah) for force II to X axis

Ah = (Z I / 2 R) * Sa/g (Cl 6.4.2 pg 14)
= **0.06**

Design Seismic Base Shear (Vb)

Vb = Ah * W
879.30515 KN

Figure 4.20: G+4 reinforced masonry building

Seismic Weight of floors (according to Cl 7.4.1 pg 17 of IS 1893 (part 1) : 2002

Parapet Walls ll to Y	192.276	KN
Parapet Walls ll to X	348.39	KN

Loading from Slab :

Floor	slab load KN/m2	Slab Load KN	Wall load (Y KN (Y)	Wall load (X KN (X)	Total Weight (KN)
F0	4.125	257.188594	1768.354	2263.108	3667.001594
F1	4.125	257.188594	1226.922	1561.242	3045.352594
F2	4.125	257.188594	1226.922	1561.242	3045.352594
F3	4.125	257.188594	1226.922	1561.242	3041.932594
F4	4.125	257.188594	1226.922	1554.402	2188.516594

Total Weight = 14988.15597 KN

Floor	Weight (Wi) KN	Height (hi)	hi2	wihi2 (Y)	Qi (Y)	Vi (Y)	Qi (X)	Vi (X)
F0	3667.002	3	9	33003.01	24.98701	999.2104	21.98857	879.3052
F1	3045.353	6	36	109632.7	83.00434	974.2234	73.04382	857.3166
F2	3045.353	9	81	246673.6	186.7598	891.219	164.3486	784.2728
F3	3041.933	12	144	438038.3	331.6445	704.4593	291.8472	619.9242
f4	2188.517	15	225	492416.2	372.8148	372.8148	328.077	328.077
				1319764	999.2104		879.3052	

Figure 4.21: G+4 reinforced masonry building

———— Bibliography————