LANDSLIDE MITIGATION USING STONE CONCRETE BLOCKS IN RETAINING WALL

A Thesis

Submitted in partial fulfillment of the requirements for the award of the degree of

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in

CIVIL ENGINEERING

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STRUCTURAL ENGINEERING

Under the supervision

of

Dr. Tanmay Gupta

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by

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to

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HIMACHAL PRADESH, INDIA

May-2023

STUDENT'S DECLARATION

I hereby declare that the work presented in the M.Tech Thesis entitled **"Landslide mitigation using stone concrete blocks in retaining wall"** "submitted for partial fulfillment of the requirements for the degree of Master of Technology in Civil Engineering, with specialization in Structural Engineering at **Jaypee University of Information Technology, Waknaghat,** is an authentic record of my work carried out under the supervision of **Dr. Tanmay Gupta, Assistant Professor.** This work has not been submitted elsewhere for the reward of any other degree/diploma. I am fully responsible for the contents of my M.Tech Thesis.

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CERTIFICATE

This is to certify that the work which is being presented in the thesis titled "**Landslide mitigation using stone concrete blocks in retaining wall**" in partial fulfillment of the requirements for the award of the degree of Master of Technology in Civil Engineering with specialization in "Structural Engineering" and submitted to the Department of Civil Engineering, **Jaypee University of Information Technology, Waknaghat** is an authentic record of work carried out by **Manish Kumar(212654)** during a period from July 2022 to May 2023 under the supervision of **Dr. Tanmay Gupta, Assistant Professor**, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of our knowledge.

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ABSTRACT

. In general, all hilly terrain construction on sloped ground needs some kind of earth retaining structure, most popular of which are retaining walls. Design of earth retaining structures like retaining walls, breast walls, bridge abutments, mechanically stabilized wall, bulkheads, braced excavations etc. depend upon varying load and environmental conditions and also on country specific codal provisions Rapid urbanization and chaotic climate change has resulted in an increased number of landslides in hilly terrains due to which retaining wall failure is quite commonly seen. Thus, careful design of retaining walls becomes of paramount importance. It shall be designed considering the predominant parameters like lateral earth pressure and horizontal displacements resulting from the supported backfill in addition to its own weight. There are different types of materials used to create the retaining wall like concrete blocks, stones, wood, boulders, rocks, treated timber etc. which depends upon loading and environmental conditions. In present research work stone concrete blocks were created with varying percentage of stone and concrete and tested under static conditions for various grade such as M15, M20, M25. These stone concrete blocks were used to construct a retaining wall and were checked under static and dynamic loading conditions. Bhuj and chile earthquake were given to the wall, to check the performance of wall under these earthquake at various simulated intensities. Performance of the wall was also tested under sinusoidal loading at varying frequencies and amplitude. The failure mechanism of the wall under these conditions were observed which was found to be superior then in case of random rubble stone masonry wall. Thus these walls can better mitigate the impact of landslide then normal retaining walls.

Keywords: Stone concrete blocks, Retaining wall, static testing, dynamic testing.

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LIST OF ABBREVIATIONS

OPC	Ordinary Portland cement
CA	Coarse Aggregates
CS	Compressive Strength
NCB	Normal concrete blocks
SCB	Stone concrete blocks
FA	Fine Aggregates
RCC	Reinforced cement concrete
SG	Specific Gravity
SST	Sine sweep Test
PCC	Plain cement concrete
UTM	Universal testing machine
CTM	Compressive testing machine
BW	Breast wall
RW	Retaining wall
AAC	Autoclaved aerated concrete
IS	Indian standard

CHAPTER 1
INTRODUCTION

1.1 General

Globalization, privatization and liberalization plays an important role in today's world. This has led to the construction of many major infrastructure projects like expressways, Airports, Railways stations, complex, malls, multiple storeys building, highways, Auditorium, nuclear plants, earth retaining structures etc. worldwide in every years. Huge Quantity of natural resources gets consumed every year for such development activities. This results depletion of natural resources very quickly and has put impact on the construction cost of structures which has a serious issue for the construction sector and mostly for all countries which are in developing stage like India etc.

Materials are considered as the most vital component of any type of construction works. In which stone masonry is considered to be one of the best forms of construction because it has existed since the very beginning of civilization. The history of stone architectures dates back to the prehistoric era when it was used as a shelter of cavemen. In modern days, there are many buildings, walls, retaining structures, hospitals etc. are constructed by stones masonry structures. There are different types of materials which is used to construct the earth retaining structures like concrete blocks, stone masonry, Plain and reinforced concrete, Rocks etc. As we know concrete is a composite construction material which is a mixture of three basic conventional component like (cement, fine aggregate and course aggregate and water).

In general, all hilly terrain construction on sloped ground needs some kind of earth retaining structure, most popular of which are retaining walls. Rapid urbanization and chaotic climate change has resulted in an increased number of landslides in hilly terrains due to which retaining wall failure is quite commonly seen. Thus, careful design of retaining walls becomes of paramount importance. It shall be designed considering the predominant parameters like lateral earth pressure and horizontal displacements resulting from the supported backfill in addition to its own weight. Generally there are different types of materials like concrete blocks, stones, boulders, treated timber etc. that are used to construct a retaining wall. In this research work we are used stone concrete blocks for construct a retaining wall and checked performance under static and dynamic loading.

1.2 What is Concrete Blocks?

Concrete blocks are most common and vital used in earth retaining structures or building construction works. It is widely used as a construction material in the commercial and residential construction industries, these can be produces in manually or mechanically way. It may be different shape and sizes. The most obtainable size of these type of blocks is length 40cm, height 20cm, and width of 8,10,15,20 cm. These concrete blocks are produced in different shapes that can hollow and solid concrete blocks.

In solid blocks have no cavities or voids whereas hollow block have one or more holes opened at both sides. Advantage of solid concrete blocks are that they have good stability, good compressive strength fire resistance and resistance to weathering impact or abrasion.

The advantage of hollow concrete blocks are they can be made heavy and biiger in size than solid block, also lighter in weight, wall can construct quickly, easily good thermal insulation is provided by the air space.

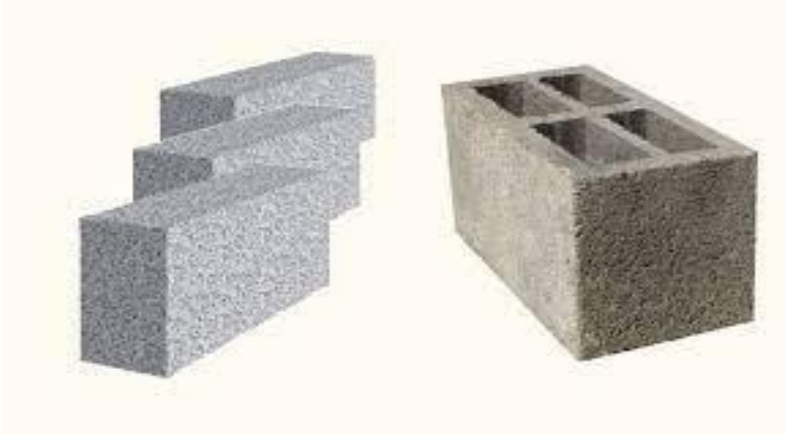


Figure 1.1 Solid concrete block and hollow concrete block

1.2.1 AAC (Autoclaved Aerated Concrete) Blocks

AAC blocks is that type of block which is made with fine aggregates, cement, and an expansion agent that causes the fresh mixture to rise like bread dough. These type of blocks contains 80 percent air. In the industry where it is created, the material is molded and cut in to precisely according to units of dimensions. The weight of AAC blocks is 80 percent less than the traditional red bricks. It contains reduction of cement and steel, thus it is cheapest. AAC blocks ensure they have better durability and improved heat insulation and sound.

Fig.1.2 AAC BLOCKS

1.2.3 Precast Stone Masonry blocks

Some places, abundance of stone is available and popular forms a major walling material. Generally walls are normally constructed as random rubble masonry with the different thickness of 380 to 450 mm and at stone places, 300 mm walls are also made with slightly higher cost due to skilled labor required and time. Thickness of these blocks is huge depends upon practical and structure requirement. A study was carried out by Central Building Research Institute (CBRI) which mainly focused on reducing the thickness and level of skilled required for the construction of random rubble walls. This study resulted the in developing the precast stone masonry blocks using stone spalls and lean concrete mix with a natural stone texture on one side of the blocks. Stone concrete blocks are good alternative that depends upon the local materials in its place of bricks that are brought from long distance and this is known as "**Pre-cast concrete Block**".

1.3 Retaining wall

A retaining wall is structure which is created to retain or hold the soil, stones, water or rocks behind it or in their real position so that erosion of material cannot take place is called retaining wall. Different types of materials is used to construct a retaining wall like concrete blocks, stones, wood (treated timber), boulders, rocks etc. it is depend upon varying load and environmental conditions. In generally all hilly terrain where slope is so heavy ground need some kind of earth retaining structure whereas retaining wall is used to resist the lateral earth pressure.

Due to rapid urbanization and chaotic climate change has resulted in an increased number of landslides in hilly terrains due to which retaining wall failure is quite commonly seen. Thus careful design of retaining walls becomes of paramount importance. It shall be designed considering the predominant parameters like lateral earth pressure and horizontal displacements resulting from the support backfill in addition to its own weight. As the retaining wall holds the earth pressure of backfill soil, a translation failure mechanism is assumed in current design. For Design of retaining walls there are many theories, investigations, experimental as well as numerical studies, and established mathematical relations have been obtained to calculate the static and dynamic behavior of retaining wall system. In some cases, where soil is quiet steep, unstable soil, heavy weight, run off occurs these retaining structure help to stem erosion. Failure takes place, whether by overturning, by sliding, by tilting or any other mechanism creates permanent deformation of retaining wall.

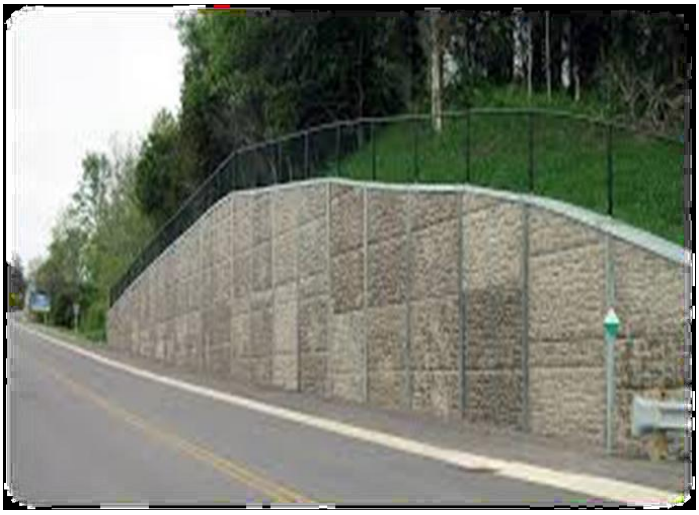


Fig.1.3 Retaining wall

1.3.1 Types of Retaining wall

There are different types of retaining walls, which are classified on the basis of shapes, materials and uses that are given below;

- Gravity retaining wall
- Cantilever retaining wall
- Buttress/ Counterfort retaining wall
- Piled retaining wall

- Anchored retaining wall
- Gabion retaining wall
- Soil nailing retaining wall

1.3.2 Gravity Retaining wall

A gravity retaining wall is that type of wall which is depends upon its own weight to resist the active earth pressure or passive earth pressure. Generally, materials that are used to create a gravity retaining wall are stones, rocks, boulders, concrete, brick masonry etc. A gravity retaining wall is enormous because it involves substantially gravity load to counter act with soil pressure. All failure shall be taken into considering the predominant parameters like sliding, overturning bending, bearing forces etc. It should be designed by specific code provision. Gravity retaining wall is uneconomical over the height of 6m.

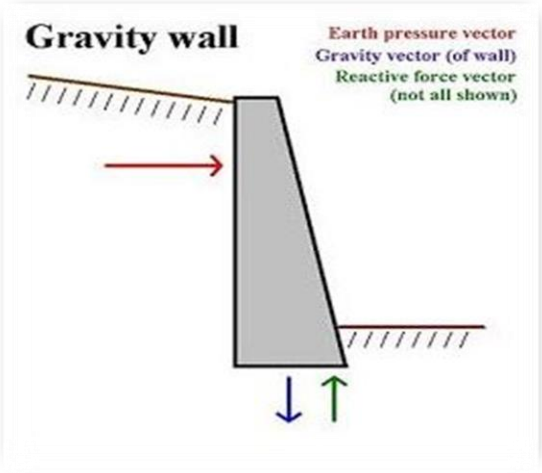


Fig.1.4 Gravity retaining wall

1.3.3 Cantilever retaining wall

Cantilever retaining walls are constructed in the principle of mechanics of cantilever to provide support laterally to earth, soil or other material. It is typically constructed of reinforced concrete to resist the pressure of soil. The shape of the cantilever retaining wall is inverted T. At the top of the cantilever wall horizontal beam is known as the stem which extend the vertical face of wall. It is generally used in bridge abutment or highways or residential and commercial development.

- Cantilever wall is economical at height of 3-8mm.
- Cantilever are usually constructed by reinforced or concrete.

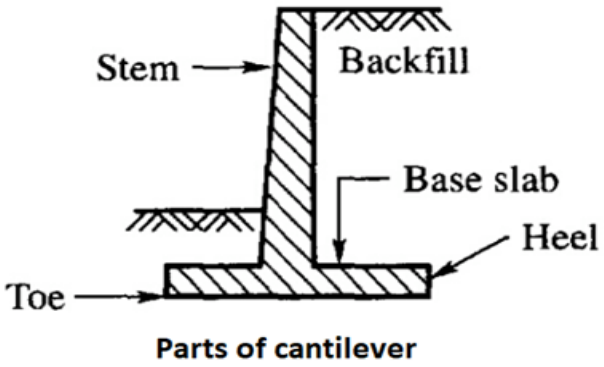


Fig. 1.5 Cantilever retaining wall

1.3.4 Counter-fort/Buttress retaining wall

A counterfort retaining wall is a particular kind of retaining wall that is strengthened and supported by a sequence of vertically concrete or masonry walls called counterforts. A lateral concrete structure known as a tie beam joins the counterforts to the main wall and is positioned at regular times throughout the length of the retaining wall. The height of counter-fort retaining wall ranges from 8-12m.

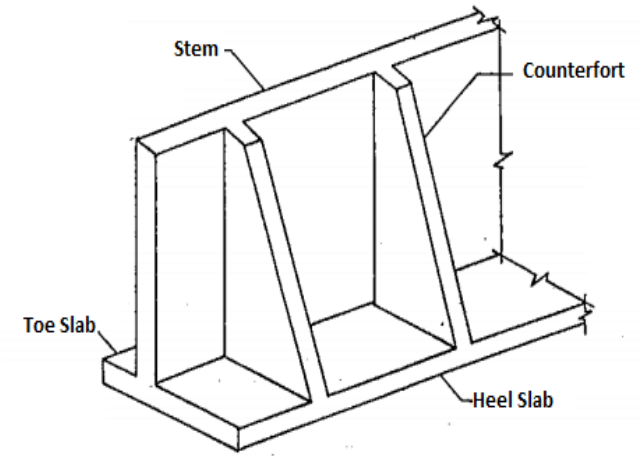


Fig. 1.6 Counter-fort/Buttress retaining wall

1.3.5 Piled retaining wall

An example of a retaining wall that uses vertical piles driven into the ground to support the structure or wall is a piled retaining wall. To create a solid foundation for the retaining wall,

long, slender, cylindrical piles made of wood, concrete, steel, or other materials are driven deeply into the ground.

Fig. 1.7 Pilled retaining wall

1.3.6 Gabion retaining wall

A retaining wall that uses wire baskets filled with rocks, gravel, or other materials is known as a gabion retaining wall. To build a sturdy and solid retaining wall, pebbles or other materials are placed inside wire baskets, or gabions, which are commonly composed of galvanised steel or steel wire mesh that has been PVC coated.

Fig1.8 Gabion retaining wall

1.3.7 Soil nailing retaining wall

This retaining wall is Utilising sheet sections with interlocking edges, this wall pilling is an earth retention and excavation support technique that can retain soil. Driving piles into a slope or excavations acts as a temporary certificate wall to prevent soil that is soft from collapsing from high below ground. High driving stress resistance and weight reduction.

Fig.1.9 Soil nailing retaining wall

1.4 Purpose of retaining wall

The main purpose of retaining wall is given below;

- Prevents erosion by holding the backfill soil and prevents it from rainy season or flooding.
- Supporting materials that would otherwise slide or collapse owing to gravity or other natural forces are soil, rocks, and other materials that are supported by retaining walls.
- Retaining structures are designed to resist the backfills or grounds and other outside loads applied their forces securely the foundation.
- It is designed to restrain soil, or engineering field at an angle steeper than the earth or materials angle of repose.

1.5 Application of retaining wall

- Construct in basement below ground level in buildings.
- In the bridges, abutment or wing walls.
- Maintain slope in hilly terrain.
- Approach roads as lateral walls of bridge.
- Providing horizontal slopes for the embankment.
- Protect erosion from the soil.

1.6 Organization of this thesis

This dissertation shows how much beneficial or what is the difference between normal concrete block and stone concrete block or dynamic analysis of wall with construction of stone concrete block.

Chapter 1 is basically introduction about concrete blocks and retaining wall or its types. It is also discuss about purpose and application of retaining wall briefly.

Chapter 2 introduce the literature survey is explanation of theory behind the construction of stone concrete blocks and dynamic analysis of retaining wall, or different materials used in construction of retaining wall.

Chapter 3 shows the research methodology of work.

Chapter 4 shows the experimental investigation of present work or test conducted in this work.

Chapter 5 shows the results and discussion.

Chapter 6 shows the conclusion and future scope.

CHAPTER 2
LITERATURE REVIEW

2.1 General

This chapter deals with the review of literature about the influences of utilization of different materials like stone using in concrete blocks and construct it with retaining wall. Different materials were used in concrete blocks or retaining wall and their properties were discussed. The advantages and disadvantages of using different materials in concrete blocks and retaining wall and their measures were discussed. Also this chapter discuss the previous researches conduct by various researcher to study the different methodology used in understanding of tests result and setup. This chapter gives a complete review of the finding along with directions for future explorations.

2.2 Literature survey

Rajendra Desai, Rupal Desai, Pawan Jain, R.K Mukerji and Harshad Talpada studies about the stone-concrete-blocks which are depend upon local materials that can be alternative for the bricks which are brought from distance. In this blocks stone is place 100mm to 125mm size inside a mould of size 300x200x150mm and then surrounded by mixed concrete slurry. This was developed by CBRI. It must be ensure that in the hilly terrain where cold takes place wall insulation is necessary. So, a wall with 200mm and 225mm by thickness will have lower insulation, so in winters warmness is not provided inside the house with the stone walls. As, the wall made by this method is 200mm thick lesser than the other random rubble masonry walls of 450mm, a home made by this method can save 25% area of floor. Some places where stones is easily available there stone concrete wall is preferred.

Indian Standards IS-12440 (1998) specifics the dimensions that are required to construct a stone concrete block. The dimensions of these blocks as follow as; length is 300mm, height is 150mm and its width varies from 200mm, 150 mm, 100 mm dimensions. The methodology to make these types of blocks is specified in this code. The materials requirement, the stone size width 100 to 125mm is specified in code. The mould size is given, the casting method and demoulding techniques are specified in code. The

compressive strength values for 7 days and 28 days are given and also testing method specified in code.

F.R Arooz, R.U Halwatura studies that the mud concrete blocks can used to introduce a low-cost, load bearing wall system which ensures indoor comfort and minimize the impact on environment. Soil was fulfilling the role of cement in low quantity and aggregate will act as stabilizer. Excess amount of water used for hydration of cement and to keep the material. Experimental testing found that in a mix proportion of mud concrete block has 4% cement, gravel 30-35%, fine aggregate < 10% and water 18 to 20% from the mix. Also specifies the durability of mud concrete blocks is according to standard levels.

Ankit C. Mahure and Prof. M.N Umare studies dynamic structural response of the retaining walls at different level of heights. In this research the main problem is instability of retaining walls depends upon the backfill soil pressure distribution upon the wall and the behavior of retaining wall beside backfill soil or different materials under dynamic loading condition. The studies shows the suitable height of retaining wall at different level of height.

Hua Wn, Jiu-jiang Wu, Jia-li Zou, Xin Luo, Min Zhang, and chengzhuang Gu[7] This studies shows retaining wall constructed with GEOBAGS filled with waste construction material (concrete waste). This studies shows the eco-friendly with environment with cheapest in cost and supports reuse of concrete waste materials by filling it in geo bags. This concept is used from ancient time of egypt. They use this method model test of wall on different slopes and different dimension (length) of geobags. The main conclusion they got by their research is failure of retaining wall, failure of slopes, and load carrying capacity of wall.

Ganesh C, Chikute, Ishwar P. Sonar [9] This research work shows, cases study of how the gabion wall is good as comparison to the other type of Techno-Economical Analysis of the gabion retaining wall against the other type of Conventional retaining walls. This study material needed and work procedure for the gabion retaining wall, Bank erosion at ordinary factory, Kirki, Pune. This study also shows the comparative analysis of gabion retaining wall with other conventional retaining wall in term of speed of construction, cost of construction, material requirement of wall. The construction cost of gabion retaining wall as

compare with Rubble masonry walls, RCC Cantilever, RCC counterfort, Gravity retaining wall are 0.3%, 54.12%, 10.72%, 9.56% les.

Anjali diwalkar This research work, studied the design and result outcomes of retaining wall. The failure of retaining wall either by sliding or either by overturning or bending is investigated in this research work. Both method is used (Rankine and Coulomb's methods of earth pressure theory) to evaluate the lateral soil pressure on retaining wall in static state condition. Active and Passive earth pressure or its application plays an important role in its failure.

Karthik Babu C and Keerthi Gowda B S [10] This studies is depend upon the counterfort retaining walls with gross pressure or without any type of pressure shelf using soft computing techniques (SAP2000). They gives a brief introduction and method used in SAP2000 software. They designed a counterfort retaining wall in this software SAP2000 with conventional method. The counterfort retaining wall with earth pressure relief shelf of 2h/3 place is well suitable for design. SAP 2000 is very best software for structure engineering for analyzing the behavior of retaining wall. It prevents time.

Dr. Dhamdhere, Dr. V.R. Rathi and Dr. P.K Kolase This research work studies about the design method of the counterfort retaining wall and cantilever wall with pressure relieving wall. The bending moment in heel or toe is comparative less for retaining wall with relieving wall than cantilever retaining wall. Area of steel for heel and toe comparative less for retaining wall with relieving platform than other type of cantilever retaining wall.

HAN Shang Yu, LI Kai Ren and Qiu Fang The aim of the this research is study on construction techniques about the Concrete retaining walls with reinforced adjacent displacement repairing. This repairing of techniques is very useful in retaining wall if wall is displaced from one place to another place. This studies also describes the material requirement and cost analysis of repairing of retaining wall. They describes the quality of concrete, of points, and quality measures taken before, after and during of the repairing of Reinforced concrete retaining wall.

2.3 Research Gaps

- Retaining walls with construction and demolition waste has been experimented earlier but there is not any proper information of research work that specifies the durability, strength and life span.
- Most of the literatures are concerned about utilizing different types of materials in blocks for construct the retaining walls like geo bags filled with concrete waste materials etc. But few Limited Literatures are available which provide use of stone spalls in concrete blocks.
- Need to utilize the local demolition waste stone and check the strength in concrete blocks or as well as retaining wall to get the required strength and durability.
- As per Literature review and best author knowledge, behavior of retaining wall or stone concrete blocks has not checked under dynamic loading condition.

2.4 Research Objective

- Testing on stones, concrete blocks and stone concrete blocks to find out there mechanical and chemical properties.

- To analyse stability of gravity retaining wall created with stone concrete blocks via as shake table experiment modelling and validation with ABAQUS.

- Field implementation of stone concrete blocks in gravity retaining wall to compare its behavior with random rubble gravity retaining wall.

CHAPTER 3
METHODOLOGY

3. 1 Research methodology

To achieve the research objectives that are explained in chapter 2, a successive methodology was suggested. The design methodology is given in this figure in below;

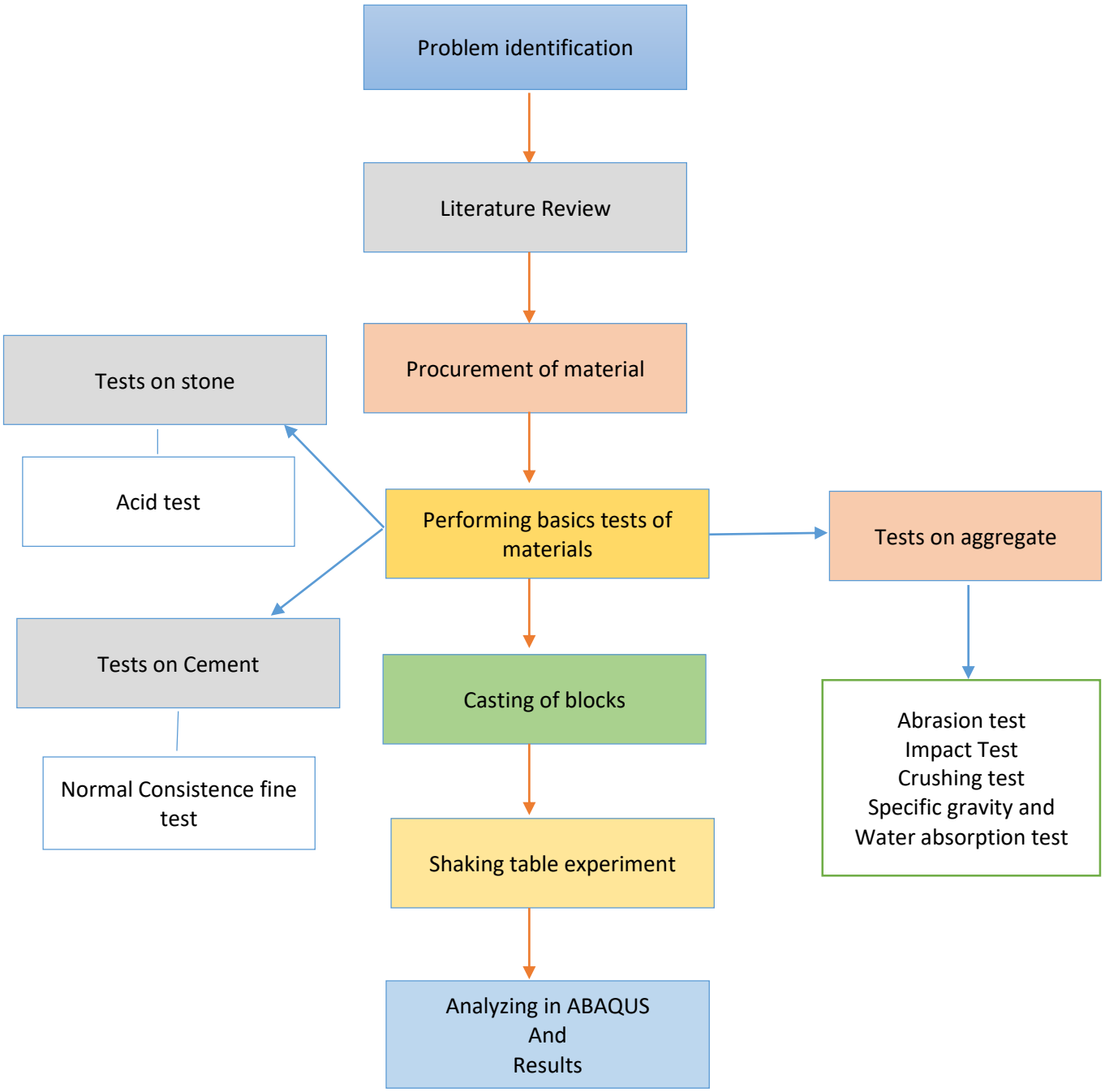


Fig 3.1 Methodology

CHAPTER 4
EXPERIMENTAL INVESTIGATION

4.1 General

In this chapter different materials properties and details of experimental work and procedure has been discussed. Tests of cement, coarse aggregate and fine aggregate, tests on stones, static and dynamic tests on concrete blocks were performed. Initial and final setting time, normal consistency have been done on cement and Specific gravity or grading of fine aggregate. Whereas water absorption and specific gravity on coarse aggregate has completed according to their Indian standards code. Wall is constructed by stone concrete blocks (SBC) and check their dynamic response on shaking table experimentally. Procedures of the experiment is discussed in details and nominal or mix design has been done from M15 grade and above.

4.2 Materials used

As we know concrete is a hard material that includes cementious medium inside which aggregates are implanted. Strength of concrete or potential quality of mix proportion are particularly subjected to its compaction level.

4.2.1 Aggregates

Aggregates plays a vital role in concrete. It provides body to the concrete and helps in decreasing shrinkage. Aggregates gives large effect on quality, durability and good life span of concrete. It takes at least 75% of the volume of concrete. Coarse aggregate are angular or round in shape.

Aggregates are classified on the basis of weight as follow as;

1) Light weight aggregate
2) Normal weight aggregate
3) Heavy weight aggregate

Natural aggregate	Non-natural aggregate
Gravel, Sand, Crushed	Damaged brick
Rock i.e. granite	Air-cooled slag
Basalt	Sintered fly ash

Table 4.1 Ordinary weight aggregate

Based on size of aggregate;

1) Fine aggregate
2) Coarse aggregate

Aggregates which has size more than 4.75 mm is categorized as rough aggregate and aggregate and aggregate whose size is less than or equal to 4.75mm is carried as fine aggregate. Its form has their significant characteristics, which impact as workability of concrete. More than 40mm in size is employed for coarse aggregate in construction uses.

All type of Regular aggregates comes from the bedrock. The mainly used aggregates comes from igneous rock, metamorphic rock and sedimentary rocks which is typically dense and tough in nature. The igneous rock and sedimentary rocks determined by heavy pressure and temperature which has resulted as metamorphism that affect the structure or stone surface.

Based on shape of aggregate;

1) Rounded shape aggregate
2) Irregular shape aggregate
3) Angular shape aggregate
    a) Elongated aggregate
    b) Flaky aggregate

Sr. No.	Type of Test	IS Standard	Results
1	Water absorption	IS-2386-P-3	1.513%
2	Specific Gravity	IS-2386-P-3	2.75
3	Bulk density test	IS-2386-P-3	1436

Table4.2 Physical properties: coarse aggregate (20mm)

Sr. No.	Type of Test	IS Standard	Results
1	Specific Gravity	IS-2386-P-3	2.67
2	Water absorption	IS-2386-P-3	7%

Table 4.3 Physical properties: FA (Fine aggregate)

Sieve analysis of coarse aggregate

Coarse Aggregate = 20mm				
Total Weight of Aggregate =1000g				
IS Sieve Size (mm)	Weight of Aggregate Retained	% age of Total Weight Retained	Cumulative %age of Total Weight Retained	Cumulative %age Passing
20	0	0	0	100%
16	47.3	4.73	4.73	95.27%
12.5	494	49.40	54.13	45.87%
10	347.7	37.47	91.60	8.40%
4.75	76.0	7.60	99.20	0.80%
pan	8.0	0.80	100%	Zero%

Table 4.4 Sieve analysis of coarse aggregate

IS Sieve Designation	Specification (IS-383:1970)					
	%age Passing For Single Size Aggregate of Nominal Size (mm)					
	63	40	20	16	12.5	10
80mm	100	-	-	-	-	-
63mm	85-100	100	-	-	-	-
40mm	0-30	85-100	100	-	-	-
20mm	0-5	0 - 20	85-100	100	-	-
16mm	-	-	-	85-100	100	-
12.5mm	-	-	-	-	85-100	100
10mm	0-5	0-5	0-20	0-30	0-45	85-100
4.75mm	-	-	0-5	0-5	0-10	0-20
2.36mm	-	-	-	-	-	0-5

4.4.1 Sieve analysis of coarse aggregate (CA)

Total weight of fine aggregate = 1000gm					Specification (IS: 383-1970) Percentage Passing For			
IS Sieve Size	Weight Retained	Cumulative Weight Retained	Cumulative %age Retained	Cumulative % age Passing	Zones I	Zones II	Zones III	Zones IV
10mm	0	0	0	100	100	100	100	100
4.75mm	13.3gm	13.3gm	13.3	99.86	90-100	90-100	90-100	95-100
2.36mm	49.1gm	62.4gm	62.4	99.38	60- 95	75-100	85-100	95- 100
1.18mm	118.4gm	180.8gm	1.80	98.2	30-70	55-90	75-100	90- 100
600µ	91.7gm	272.5gm	2.72	97.28	15-34	35-59	60-79	80-100
300µ	174.7gm	446.2gm	44.6	55.4	20-5	30-8	12-40	15-50
150µ	453.7gm	901.1gm	90.1	9.9	0-10	0-10	0-10	0-15
Pan	98.9gm	1000gm	98.9	0				
Total	1000gm	Fineness modulus = 2.46						

4.5 Sieve analysis of fine aggregate

4.2.2 Binder

Ordinary Portland cement (OPC)

Cement plays a vital role in concrete. It act as a binding material in concrete. It can be characterized as the adhesive and cohesive properties of bonding material which authorized to join the different building materials. Generally, most usable or utilized type of cement is ordinary Portland cement. The basic constituents used to produce this type of cement is Lime, alumina, iron oxide and silica are the main materials. Its production process consists crushing of raw materials, take them in a furnace at temperature between 1300 and 1500˚C in which sinters material is produced, fused in the form of clinkers. Clinkers is milled with fine powder with adding of 3 to 5% of gypsum on it.

Fig.4.1 Ordinary Portland cement

The ordinary Portland cement has classified by Indian Standards (BIS) to generate different grades of concrete (M15, M20, M25 etc.). These different grades of concrete depends upon 28-days compression forces as mentioned below:

1. IS 269:1989 Grade 33
2. IS 8112: 1989 Grade 43
3. IS 12269: 1987 Grade 53

OPC (Ordinary Portland Cement of grade 43 (Ambuja Cement) is used in this research work. The properties of cement in this work complaint to IS 8112-1989 are showed in below the Table 4.6.

Property	Average Value	Standard Value as per IS 8112-1989
Specific gravity	3.129	
Normal Consistency	32%	
Initial setting time	40	>30min
Final setting time	460	<600min
Fineness	5% retained	
Compressive Strength		
3-days	24 N/mm^2	>23
7-days	35N/mm^2	>33
28-days	46N/mm^2	>43

Table 4.6 Physical properties of ordinary Portland cement

4.2.3 Water

Water plays a vital role in the process of concrete mix. It provides mainly workability of concrete and bonding in concrete mix.

In concrete mix water is also depends upon its PH value of water. It varies from 6 to 8 is free from organic compound. Strength is also depends upon water-concrete ratio Hydration of cement gel is shown in fig. 4.2 given below with ratio. A less amount of water is used to hydrate the cement and for lubrication extra water is required.

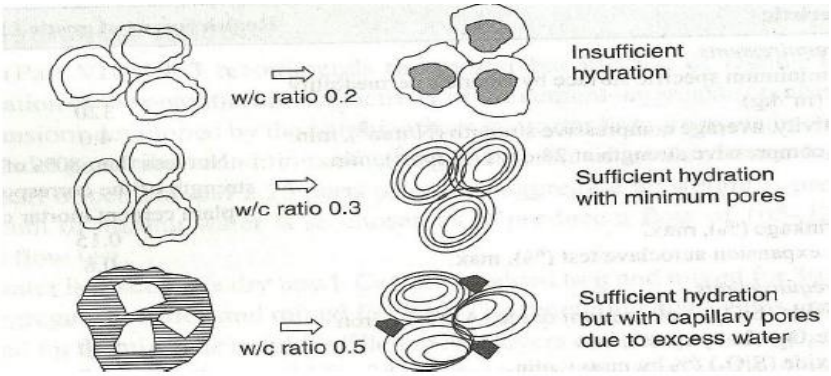


Fig. 4.2 Hydration based upon amount of water

4.2.4 Stones

Stone is a hard material which is founded by nature and it is non-metallic mineral or matter which is made from crushing of rocks by weathering effect, by mechanically way and by man-made is known as stone. Stone is normally used for construction work like buildings, retaining structures etc. In ancient times, the use of stone is considered as the best material used in construction of buildings and walls. Stone can cut into different size according to dimensions need for a structure. Basically it is used in rectangular shape with 40cm, height 20cm, and width of 8,10,15,20 cm. Now days, stones can be cut by mechanically ways as the shape of blocks and in previous time it was cut by man-made sources.

Fig. 4.3 Stones

4.2.5 Mortar

Mortar is a mixture of cement and fine aggregate with different proportions as the need in structure. Water is added to provide bonding in mortar. There are different ratios used in mortar mix like (1:2, 1:3, 1:4) etc. In which 1 represent the quantity of cement and 2, 3, 4 represent the quantity of fine aggregate. Mortar is used to fix the bond between one block to another block or one stone block to another stone block and one brick to another brick in walls either it is building wall or retaining wall.

Fig. 4.4 Mortar mix

4.3 Nominal mix

The Concrete mix ratios are proportion of different type of components i.e. cement, sand, aggregate and water. Mix ratios are categorical which kind of construction is carried and mix design.

There are different grades of nominal mix of concrete provide by IS (Indian Standards Codes) for all types of construction work which is depend upon performance, experience and testing.IS 456-2000 has been elected the concrete mixes into the various number of grades such as: M10, M15, M20, M25, M30, M35 and M40. In this M represents the mix and numbers specified the 28 days cube strength of mix in N/mm^2.

Grade of concrete	Mix ratio
M5	1:5:10
M7.5	1:4:8
M10	1:3:6
M15	1:2:4
M20	1:1.5:3

Table 4.7 nominal mix grades and ratios

4.4 Materials testing

4.4.1 OPC cement

a) Normal consistency

Normal consistency is defined as the percentage of water from cement weight that creates a consistency in which plunger with diameter10mm penetrate to a thickness of 5 mm to 7mm over vicat's plunger mold. This device was utilized from IS: 4031 Part 4: 1988[60]. The normal consistency of OPC cement is 35.5%. The initial setting time (IST) is 40 minutes and final setting time is 460 minutes.

Fig **4.5 Normal consistency with vicat's plunger**

b) Specific gravity

Specific gravity is also mentioned as relative density, it is that portion of density of a substance to the density of a reference substance; it equates with the portion of the mass of substance into used reference substance for the specific and same quantity. The jar density procedure is used to calculate the specific gravity of cement.

Fig. 4.6 Specific gravity of cement

In this we have used water and kerosene in cement to calculate the specific gravity. Because cement is sterile and it produce calcium when answered it with water. There has no response when it mixed with kerosene. It is tested as SG is 3.129 as shown in figure 4.6.

4.4.2 Concrete blocks

Concrete blocks are most common and vital used in earth retaining structures or building construction works. It is widely used as a construction material in the commercial and residential construction industries, these can be produces in manually or mechanically way. It may be different shape and sizes. In this research work we used the size of concrete block is 300x200x150 mm which is 9000000 mm^3 in volume. In this research work, we had used different grades of concrete blocks (M15, M20, and M25) for made these blocks to check their static and dynamic response. In Static test, we had done compressive strength tests of blocks with different ratio.

Fig. 4.7 Concrete Blocks

4.4.3 Stone concrete blocks

In ancient times, uses of stones plays a vital role in construction work it is a hard material which is founded by nature and it is non-metallic mineral or matter which is made from crushing of rocks by weathering effect, by mechanically way and by man-made is known as stone. Stone is normally used for construction work like buildings, retaining structures etc. In this research work we had cut stones in 250x150x100 mm in size by mechanically way with the help of stones cutter machine and kept it inside the block. The size of Mould is 300x200x150mm in rectangular shape. In stone concrete block stones kept inside the block along with concrete with different grades of concrete to check their static and dynamic response. To check the dynamic response of stone concrete block we used shaking table to complete this experiment.

Fig. 4.8 Stone concrete blocks

4.6 Stone cutter

Stone cutter is equipment or machine for cutting the stone properly with 250x150x100 mm in size by mechanically way. Cutting stones plays a vital role in stone concrete block because it mainly effect on compressive strength of Stone concrete block. In Stones, there should not be any cracks take place for increasing the strength and durability.

Fig. 4.9 Stone cutter

4.7 Casting of Normal concrete blocks (NCB) and Stone concrete blocks (SCB)

4.7.1 Normal Concrete blocks

Normal concrete blocks is that type of block in which concrete is made by nominal mix and mix design according to grade M15 and M20, by nominal mix and M25 by design mix. In this Process firstly we have to prepare mould with size of 300x200x150 mm. Then we have to prepare concrete by nominal mix, such as M15 in which ratio is 1:2:4 (1 represents cement, 2 represent the fine aggregate and 4 represents the coarse aggregate). Calculate the materials required in concrete, then prepare the concrete.

Calculation for materials requirement of concrete blocks

Assume we are casting M15 grade (1:2:4) of three blocks

Step-1:

Volume of block = 9000cm^3 (For 3 blocks 0.009x3=0.027 m^3)

Step-2:

For dry concrete= 0.027x1.5

= 0.041m^3

Step-3:

Add all ratio 1+2+4= 7

Step-4:

Put values in formula (Calculation for cement)

$\frac{1}{7}$ x volume of concrete x density of cement

$\frac{1}{7}$ x 0.041 x 1440

=8.43 Kg (approx. 8.5 kg)

After calculating the value for all materials the results out comes for 3 block is:

Quantities

Cement = 8.5 kg

Fine aggregate= 17 kg

Coarse aggregate= 34.5 kg

Apply these all steps for calculation of materials required in blocks with different grades.

Fig. 4.10 shows during casting of concrete blocks

Fig.4.10 Casting of normal concrete blocks

4.7.2 Stone concrete blocks

The casting of SCB (stone concrete blocks) is as similar as normal concrete block but the mainly difference is we kept stone inside the block. At least, 42% of stone is kept inside along with concrete in mould. Stone is cut in size of 250x150x100mm with the help of stone cutter machine. The weight of stone concrete block is almost 17-19 kg. We checked, the compressive strength of stone concrete blocks and compare it with normal concrete block. After made the stone concrete block, kept it inside the water for curing for 28 days.

Fig.4.11 Casting of stone concrete block

4.8 Cutting of stones

Cutting of stone also played a very important role in stone concrete blocks. In this research work, we cut stone in the size of 250x150x100 mm properly. This is 41-42% of whole block. Fig. 4.5 shows during or cutting method we used in this research work.

Fig. 4.12 Cutting of stones

4.9 Construction of wall with help of Stone concrete blocks

We construct a wall with the help of stone concrete blocks for checking the dynamic and seismic response of that wall in laboratory. Shaking table is used to perform this experiment. We had drilled hole in the blocks by concrete drilling machine to make the fix boundary conditions from ground side. The ratio we used construct this wall was (1:4) in which 1 represents the cement and 4 represents the fine aggregate. In this wall we used full and half blocks for construct this wall for proper bonding. As shown in figure 4.13 construction of retaining wall.

Fig. 4.13 Drilling holes in blocks

Fig. 4.14 Stone concrete block wall

CHAPTER 5
RESULTS AND DISCUSSIONS

General

In this chapter, final results outcomes of compression test, carried out normal concrete blocks and stone concrete blocks. After that compressive test results of stone concrete blocks and normal concrete blocks of all three grades (M15, M20, and M25) was compared. The compression test is checked by universal testing machine by applying load on blocks. The compressive test results are checked with normal concrete blocks and stone concrete block in 3, 7, and 28 days. The blocks are kept on inside the water tank for curing in those days. Experimental study of testing of stones which we kept inside to blocks is also done in this chapter. The research covers in this chapter focus on static and dynamic testing of blocks and wall. The next part of this chapter works with dynamic response under seismic load of stone concrete blocks and wall with comprehensive experimental study is done.

Also, this chapter presents all the dynamic response of wall and stone concrete wall. Dynamic testing of stone concrete blocks of all three blocks (M15, M20, and M25) was done in shaking table by giving natural frequency and amplitude to the stone concrete block. In this test we turn hole on stone concrete block by drilling machine and fix it on shaking table. Then we fixed accelerometer in block and checked their response for all grades of stone concrete block. Also we construct the wall upon shaking with the help of mortar with (1:4) and check their dynamic response on seismic load.

5.2 Tests conducted

5.2.1 Tests conducted on stones (1121-1974)

a) **Acid test**
b) **Crushing strength test**
c) **Water absorption test**
d) **Abrasion test**
e) **Impact test**

a) **Acid Test** – In acid test 50 to 100gm stone and 1% of NACL is required for performing this test to confirm the power of weathering or gases effect. Sample of stone is dissolved in water with 1% of NACL.

Fig. 5.1 Acid test on stone

The corner remains sharp the stone is good resistance to effect of weather.

b) **Crushing strength**- This test is used to find the compressive strength of stone in CTM. Stone is absorbed in water for 72 hours with dimension of 40 mm x 40mm. After that 5mm thick ply wood is placed on the top and bottom surface then apply load on CTM 14N/mm2 axially for 1 minute.

c) **Water absorption test**- In this test 50gm of three specimen is required to perform this test. Put this sample in oven at 105 degree Celsius.

$$\text{AOW} = \frac{W2-W1}{W1} \text{x} 100$$

d) **Abrasion Test-** This test is carried out on stones that are used as aggregates for road construction. Following tests could be conducted to discover out the suitability of aggregates as follow:

1. **L**os angles abrasion test
2. Deval abrasion test

3. Dorry's abrasion test

After performing experiments on stones, the results shows stone is strong and durable.

5.2.2 Compression test

In concrete blocks with size 300x200x150 mm is used to make the blocks with ratio M15, M20, and M25. The compressive strength of blocks is checked by 3, 7, and 28 days. For same stone concrete block (SBC) has also checked in same days and compares the results between normal concrete block and stone concrete block. In stone concrete block stone is kept inside the mold with 250x150x100 mm along with concrete. Universal testing machine (UTM) is used to check the compressive strength of these different types of blocks. The volume of stone is 375000 mm^3 and volume of block is 9000000 mm^3. The volume of stone which is kept inside the block is around 41-42% of whole block. The weight of one block is near 17 to 18 kg was founded. Compressive strength plays a vital role for failure of structure.. In this load is applied gradually applied on Blocks, Cylinder, and Cubes with the help of machine.

Fig. 5.2 Universal Testing machine (UTM)

As we know concrete is hard in nature, so compression evaluation plays a vital role or most common test that could be conducted, it provides more practical usable of normal concrete block and stone concrete block. It is given concerning the characteristic compressive strength of block and cube with 150mm in size cube tests as 3, 7, and 28 days (fck). The strength of block must figure the strength of structure.

To protect with any effect on compressive strength test, both type of blocks are poured into the moulds and kept on a table to reduce air entrapped inside the moulds. Then remove the blocks into mould after one day and the specimen were engaged for healing in room temperature before the test conduct. For the Compressive valuation, we have ready 9 blocks of every grade either it is stone concrete blocks or it is normal concrete blocks of every grade. Total 54 blocks were tested as shown in fig. 5.3.

Fig. 5.3 Testing of blocks in UTM

In next part calculated quantity of all type of materials used in blocks is given below:

1. **Normal M15 concrete blocks-** Materials required for three concrete blocks has given below quantities:

- Cement 8.5 kg
- Fine aggregate 17 kg
- Course aggregate 34 kg

2. **Stone concrete blocks-** Materials required for three concrete blocks has given below quantities::

- Cement 7 kg
- Fine aggregate 14 kg
- Course aggregate 28 kg

3. **Normal M20 concrete blocks-** Materials required for three concrete blocks has given below quantities::

- Cement 9 kg
- Fine aggregate 19 kg
- Course aggregate 27 kg

4. **Stone concrete blocks-** Materials required for three concrete blocks has given below quantities::

- Cement 8 kg
- Fine aggregate 17 kg
- Course aggregate 24 kg

5. **Normal M25 concrete blocks-** Materials required for three concrete blocks has given below quantities::

- Cement 14 kg
- Fine aggregate 14 kg
- Course aggregate 28 kg

6. **Stone concrete blocks-** Materials required for three concrete blocks has given below quantities:

- Cement 12.5 kg

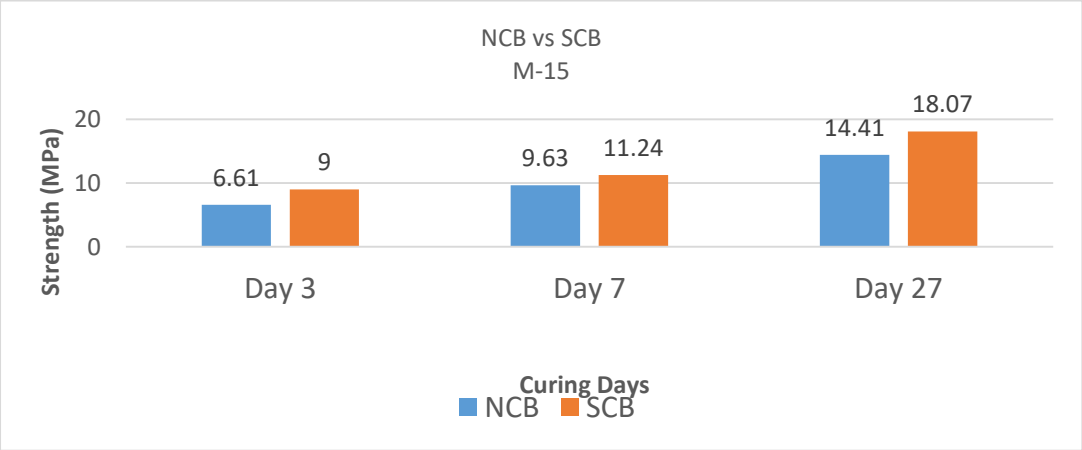
- Fine aggregate 12.5 kg
- Course aggregate 25 kg

5.2.3 Results Comparison average compressive strength of concrete blocks and stone concrete blocks with M15, M20, and M25 are:

M15 NCB and SCB:

No. of Days	M-15 (NCB)	M-15 (SCB)
3	6.61	9.0
7	9.63	11.24
28	14.41	18.07

Table 5.1 Compressive strength between NCB and SCB of M15 blocks

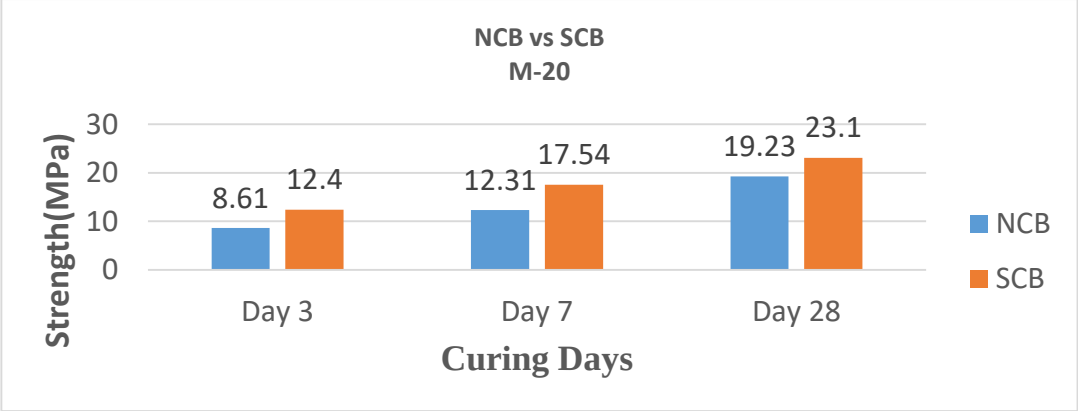


Graph shows compressive strength between NCB and SCB

M20 NCB and SCB:

No. of Days	M-20(NCB)	M-20(SCB)
3	8.61	12.4
7	12.31	17.54
28	19.23	23.1

Table 5.2 Compressive strength between NCB and SCB of M20 blocks

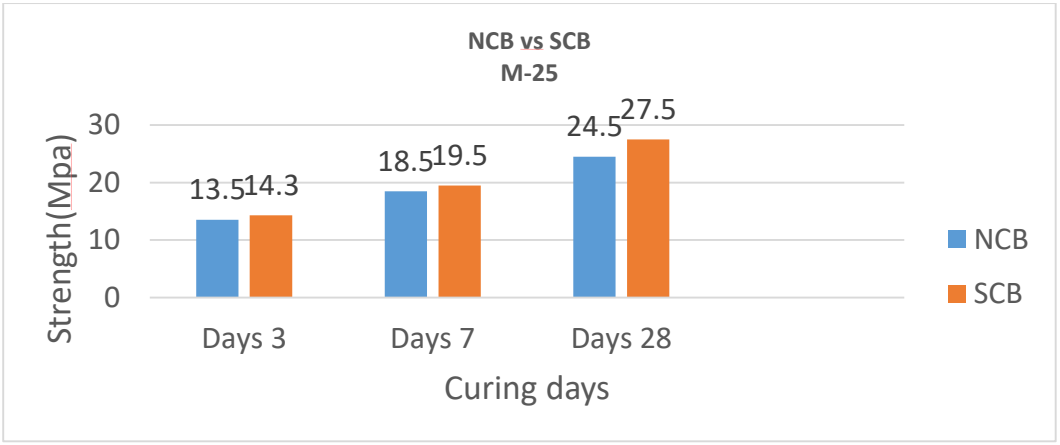


Graph shows compressive strength between NCB and SCB

M25 NCB and SCB

No. of Days	M-25(NCB)	M-25(SCB)
3	13.5	14.3
7	18.5	19.54
28	24.5	27.5

Table 5.3 Compressive strength between NCB and SCB of M25 blocks



Graph shows compressive strength between NCB and SCB

5.3 Dynamic testing

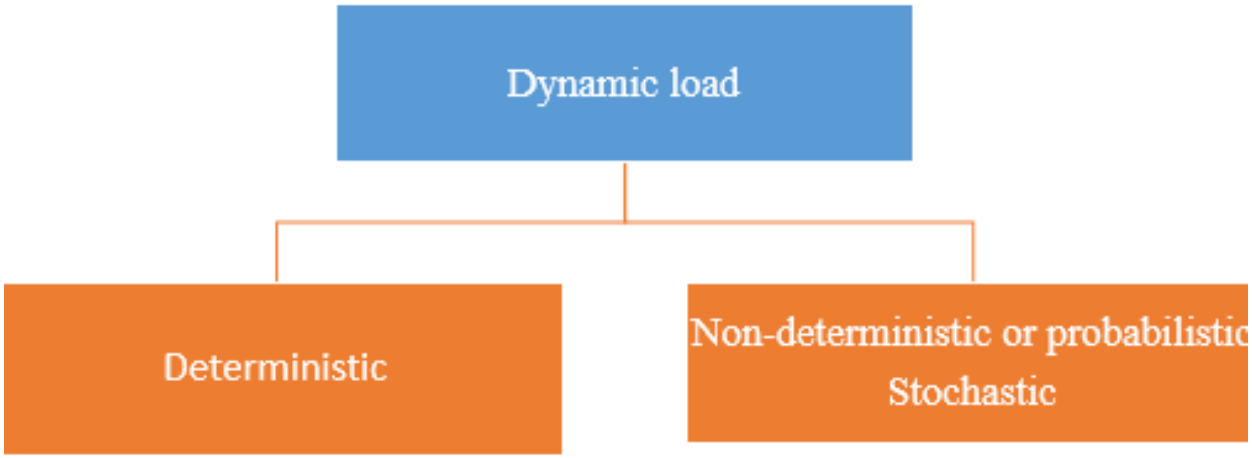


Fig. 5.4 Types of Dynamic load

The main objective of dynamic analysis is to determine the time-displacement history, time-velocity history and time-acceleration history, and internal force of member- time history due to force-time history. Time history provides the following information as given below:

- Mean value
- Peak value
- Nature of change
- Oscillation with respect to its original position.

Deterministic

If given parameters is known and there are not any uncertainties near by the values of parameter is known as deterministic.

Non deterministic

If a given parameters is not known and there are uncertainties near by the value of parameters is known as non-deterministic.

5.4 Testing under earthquake

This test is used to dynamic testing of any structure or blocks in which we used to evaluate the frequency response of any system, it may be mechanical system or electrical system. It involves sinusoidal input signal which is applied by system with increasing the frequency to the specific range, and it measures the response of system at each frequency.

During a sine sweep test, the input signal frequency of system is increasingly over a specified range of frequency, in the form of low frequency to a high frequency. The amplitude of the input signal which gave through the system is kept to be constant while performing this test. The response of system is measured at each frequency, in this we used sensor (accelerometer) instrument to record or measure the output signal.

The result of this sine sweep test are typically plotted as in excel sheet which shows the LVDT data and acceleration in each second, also it shows the results in the form of curves. It shows the how to system responds to different frequencies of the input signal. The curves provides the information about the system's damping ratios, resonant frequency and natural frequencies, or other valuable characteristics which are important for optimizing and considerate its performance.

This test is commonly used in the design or testing of mechanical and structural system, for e.g. (automobiles, bridges, aircraft etc.) By analyzing the all frequencies values and curves given by system Structural engineers can identify the potential design of system, optimize the system frequency and ensures the requirement of system and specifications.

5.4.1 Amplitude

Amplitude is defined as it the maximum value of a periodic system such as, velocity, displacement, acceleration, and force is known as amplitude.

5.4.2 Frequency

Depending on the context, the word "frequency" can signify several things, but generally speaking, it refers to how frequently an event or phenomena occurs over a period of time.

5.5 Sine sweep test on stone concrete block

In this test, stone concrete blocks involves the sinusoidal excitation which varies in frequency. The main purpose of this test is to investigate the SCB response under the dynamic condition with different frequencies of excitation.

During this test a sine wave changes the response of block is measured or recorded in the system. This test is done on shaking table, its response can be measured in system which is in the form of excel sheet or graph. When frequency increases, the amplitude of the vibration is increased till reaches its peak position. The stone concrete block of sinusoidal loading is measured by sensor (strain gauge, accelerometer).

In this test, stone concrete blocks with different ratio (M15, M20 and M25) is fixed in shaking table by drilling hole in the blocks. Then the accelerometer is fixed on the block and then gave dynamic loading in the form of sine wave by system and measure the response of block under the sinusoidal loading under different frequencies or amplitude until reach its peak ground acceleration. This test was performed to know the natural frequency of stone concrete blocks with different grades.

Fig. 5.5 Sine sweep test on block

5.5.1 Cross couplet test

Cross couplet test is used to check the shear strength parameters of blocks, bricks or other materials. This method involves the set of two blocks which intersects each other at the center of block.

In this test, two stone concrete blocks are intersect together at the center of block and joins together with the help mortar. The ratio we used to perform this test is 1:4 because this ratio is also used to construct the wall. Total 3 sample we used to perform this test. This test is used to check the bond strength of mortar. As shown in figure

Fig. 5.6 Cross Couplet test

Im n this test, 4mm PMM and ratio of cement and sand mortar is 1:4. This test is mainly used to evaluate the tensile bond strength and ASTM standard were followed 1991.

The tensile bond strength of the mortar was computed as:

$$\zeta_t = \frac{(Pt)max}{A}$$

Whereas, P_{max} at the point failure.

5.6 Dynamic test on wall

In this test, we know the wall response under dynamic loading in which frequency or amplitude crack is generated on the wall or wall will fail. This test is similar than the sine sweep test on block.

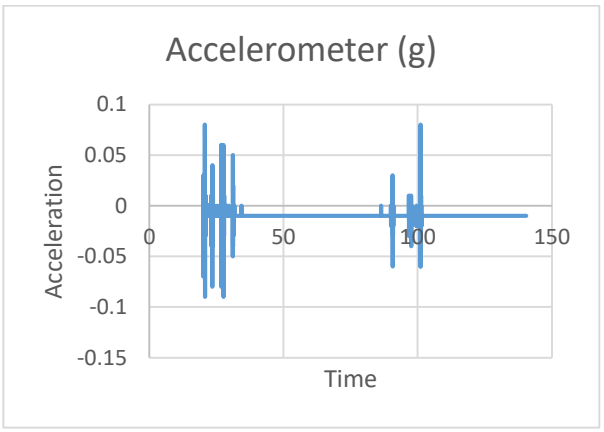
In wall, we apply the different earthquakes happened in world such as chile earthquake 1960, bhuj earthquake 2001 with different amplitude and check the response under these type of earthquakes. In this test wall is constructed upon shaking table with 92x62 cm with the help of mortar. The ratio of mortar is 1:4 which we used upon that wall. The inner blocks of wall is fixed by drilling holes in blocks and bolting on that blocks. This test is done on two sides of wall. Firstly, we construct wall by vertical side of shaking table than horizontal side of shaking table. In this test accelerometer is fixed on the top side of wall and then check the dynamic response of that wall.

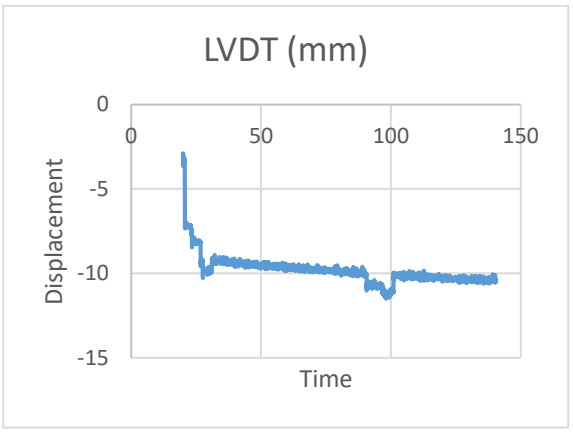
Fig. 5.7 Dynamic testing of wall

Some results outcomes after applying bhuj and chile earthquake is shown below:

NAME	EARTHQUAKE	PGA (g)	PGD(cm)	Duration(s)	Intensities (%)
Signal 1	Bhuj 2001	0.31-0.37	20	90	25, 50, 75, 100
Signal 2	Chile 1960	0.45	180	240	75, 100, 125, 150

Table5.4 Earthquake analysis





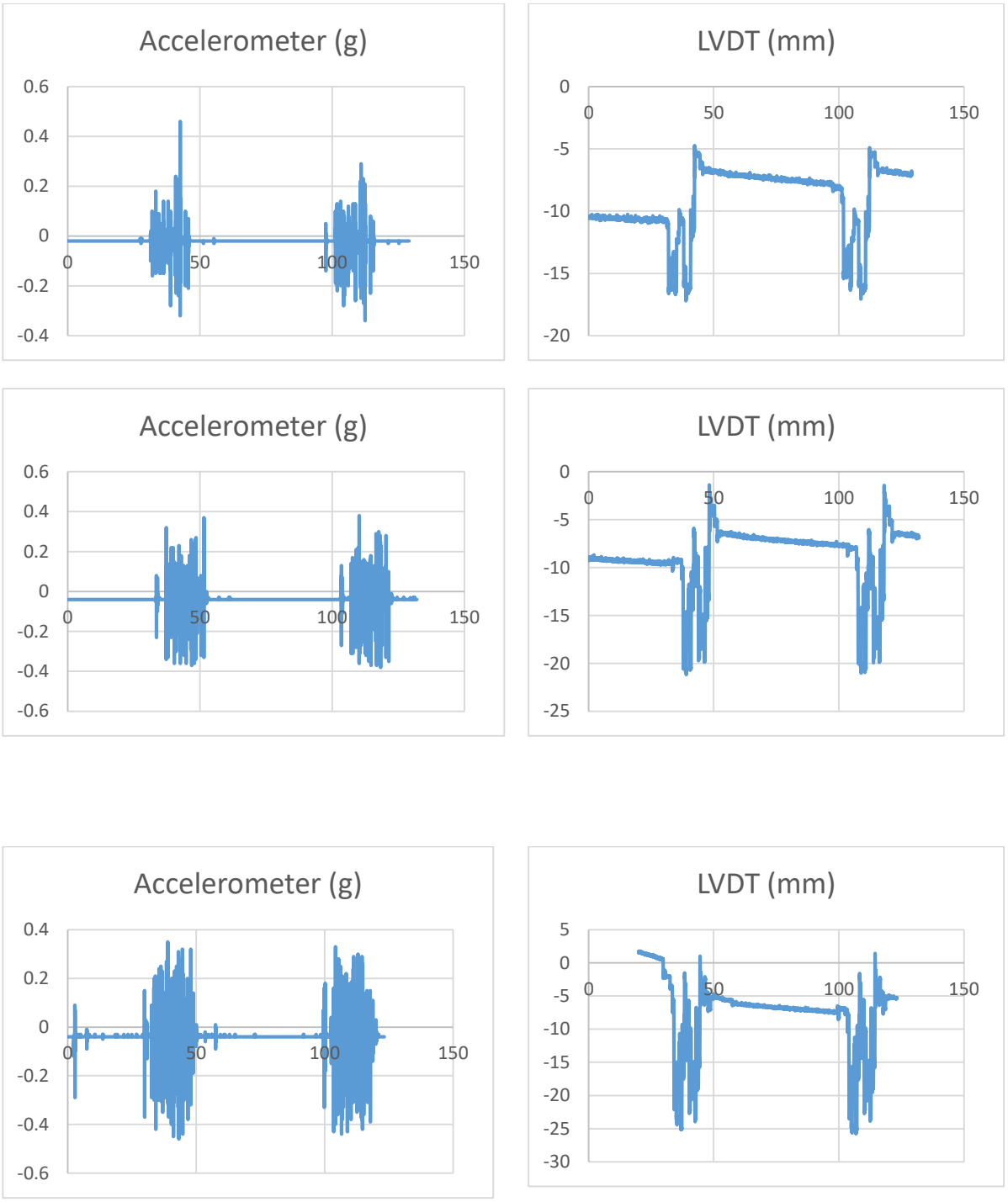


Fig.5.8 Dynamic response of wall under bhuj earthquake waves with different amplitude

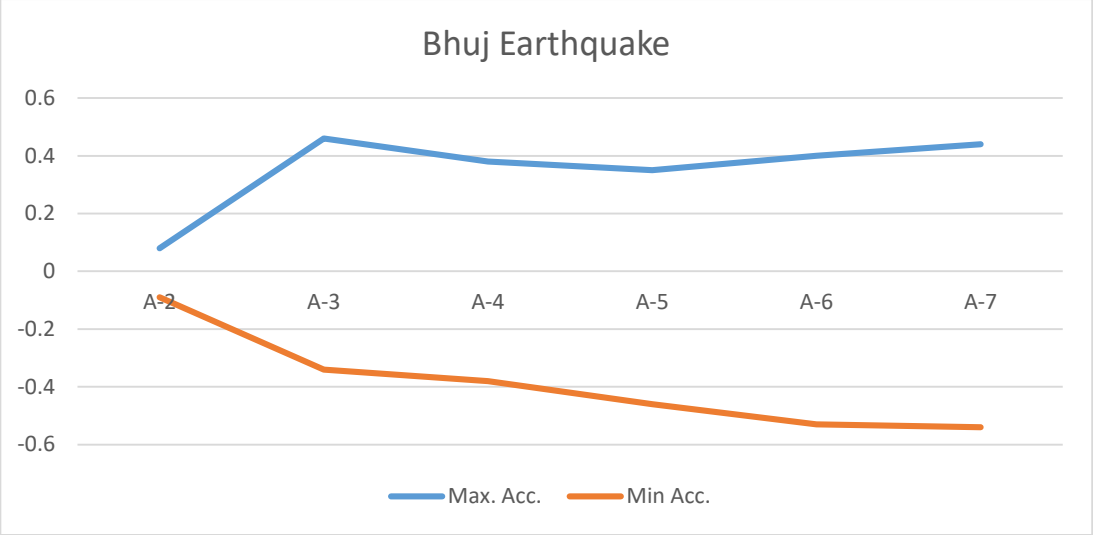


Fig. 5.9 Acceleration and time graph with different amplitude (Bhuj)

5.6.1 Failure mechanism of wall

By applying Bhuj earthquake 2001, with amplitude of 7 the failure mechanism of wall was as shown in fig. 5.8 below, as we know wall had a great mass around 182 kg, When the wall is subjected to earthquake with low amplitude with same frequency there was no sign of damage to be found on the wall surface. At last, the structure was subjected amplitude of (7 Vpp) with same frequency it achieve the high PGA and to absorb failure mode of wall under this excitation. Failure mode wall, the recorded acceleration and displacement time history shows the brittle failure of wall with last excitation.

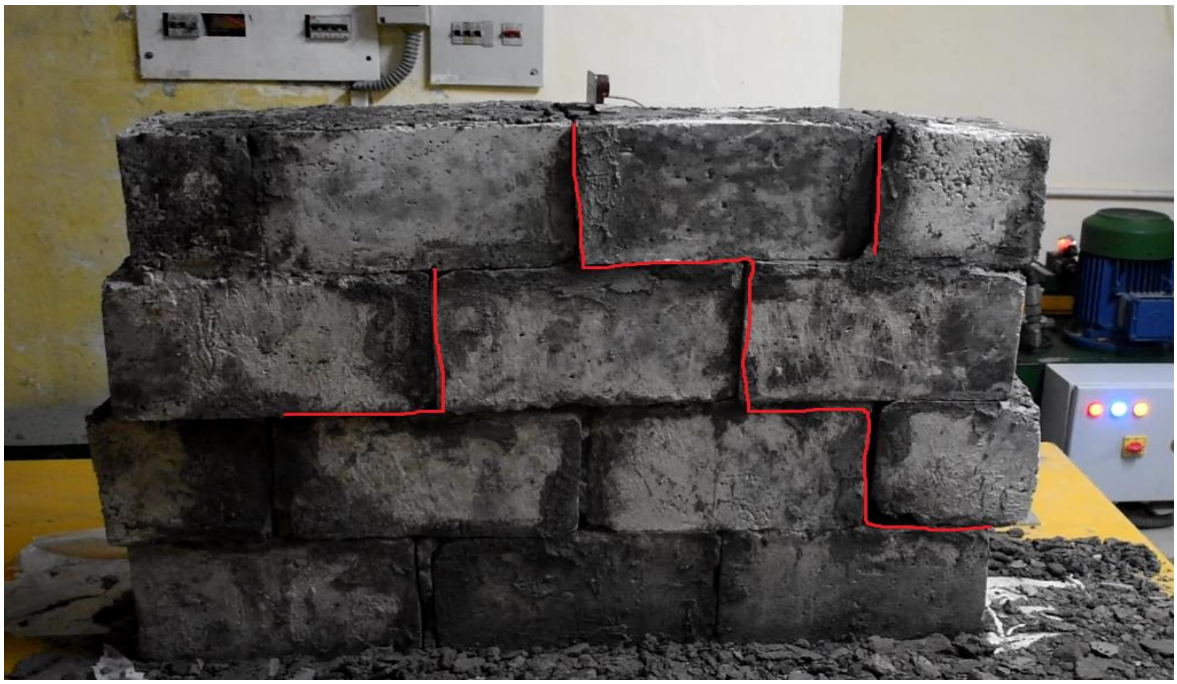
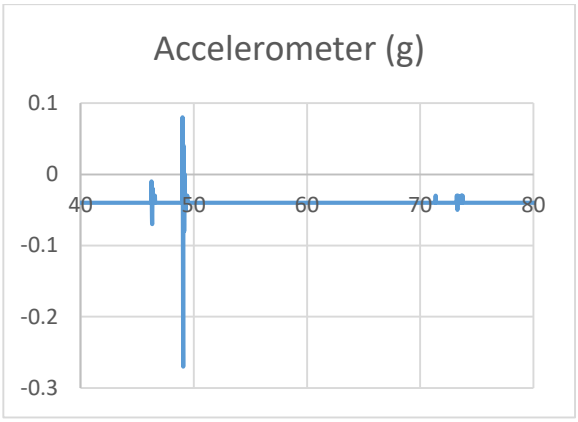


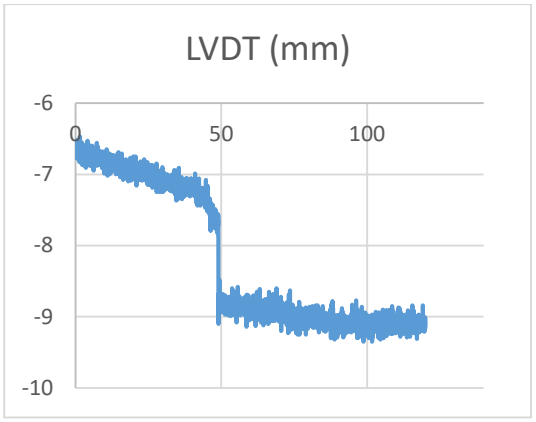
Fig. 5.10 Failure mechanism of wall

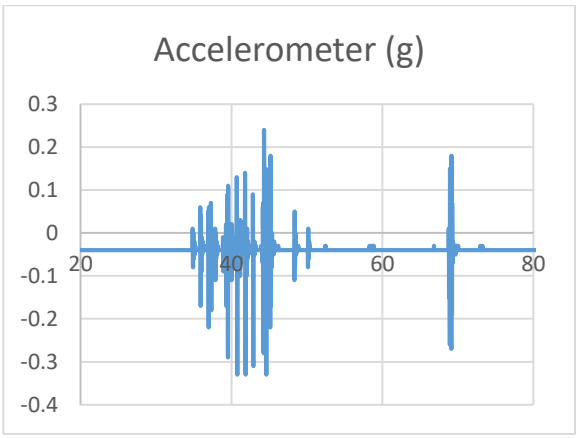
5.6.2 Chile earthquake

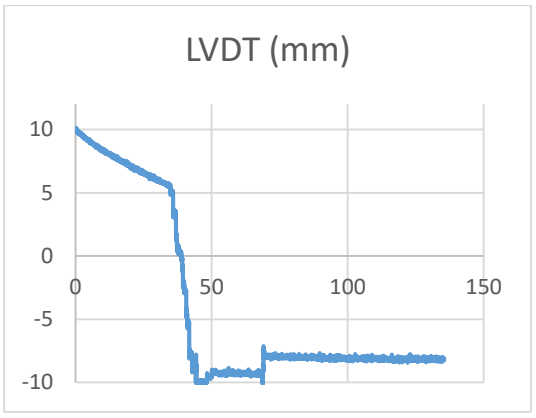
Chile's earthquake occurred in 1960. It was founded some largest devastating earthquake in chile's. The magnitude of this earthquake was 8.8 was recorded. It leased for about the 3 to 4 minutes was felt. It caused severeal damages of infrastructure like buildings, bridges, highways etc.

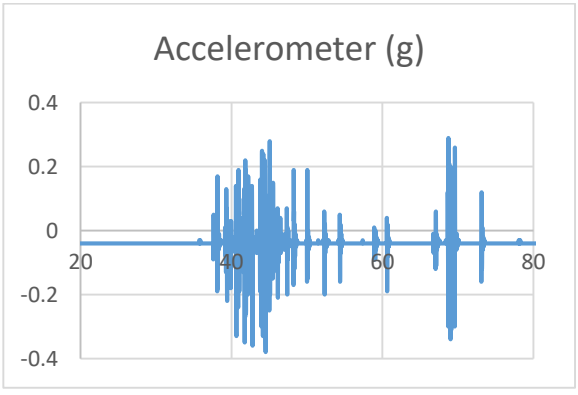
The LVDT and acceleration was found by shaking table by applying chile earthquakes waves with different amplitude was recorded as shown in graph below:

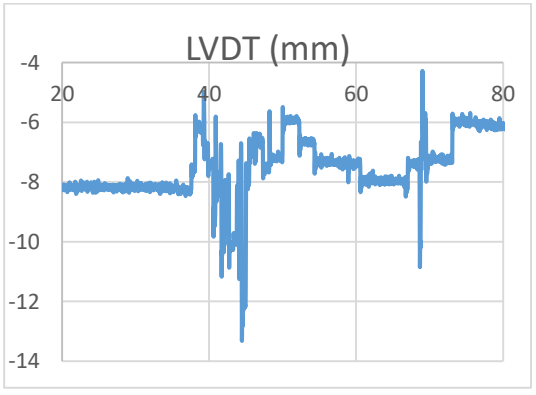












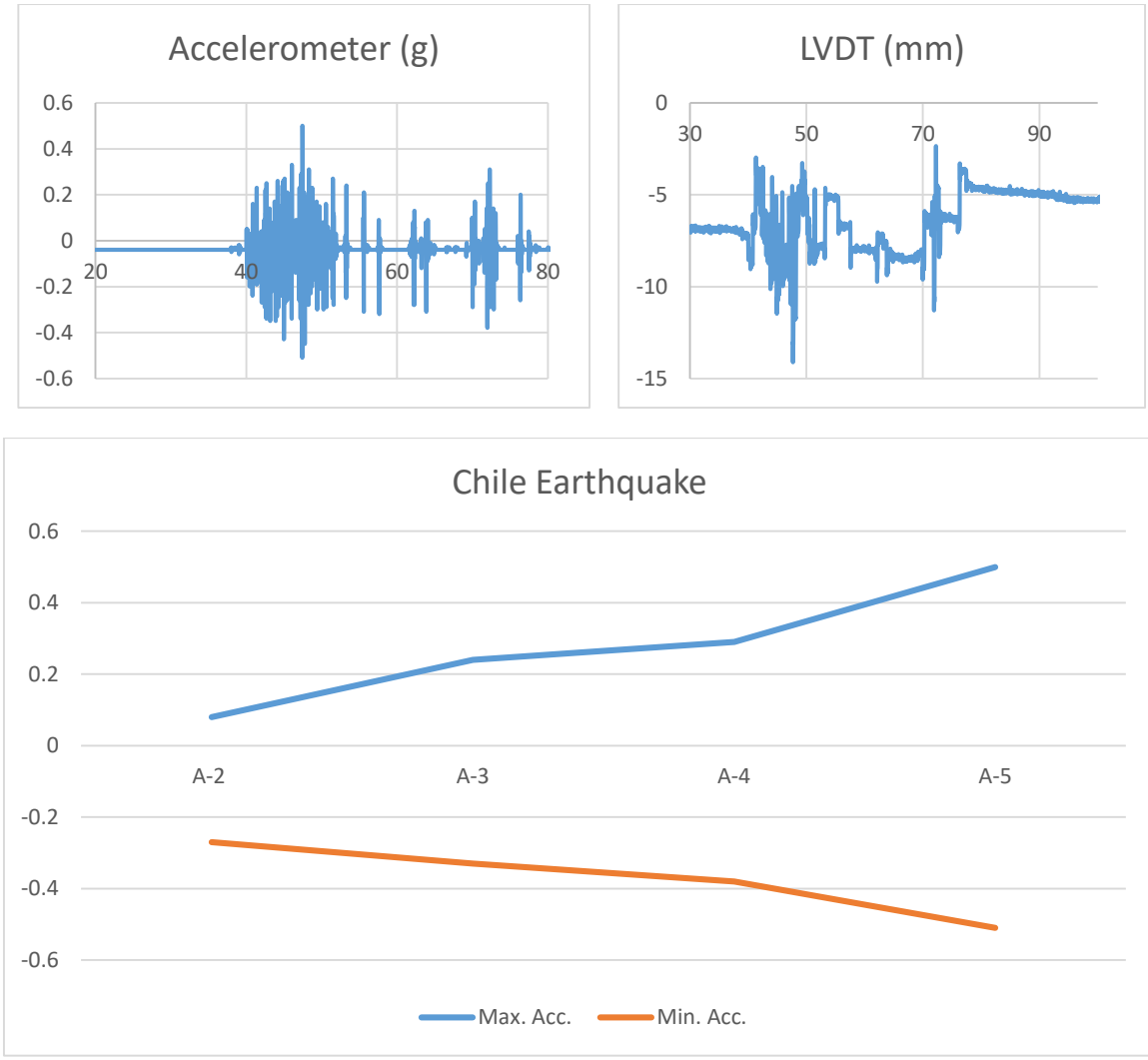


Fig. 5.11 Acceleration and time graph with different amplitude (Chile)

Peak ground acceleration was recorded in data of chile earthquake with different amplitude as shown in graph:

CHAPTER 6
CONCLUSIONS AND FUTURE SCOPE

6.1 General

The main objective of this research was to check the performance of static and dynamic analysis of concrete blocks or stone concrete blocks. In static test we used basic tests of stones as per IS: 1121-1974 code. In concrete blocks or stone concrete blocks compression test, cross couplet test, shear strength test had done on universal testing machine. Its results was compared with each other. In dynamic test, sine sweep test is done upon the shaking table on blocks or stone concrete wall. Bhuj earthquake or chile earthquake is done with different amplitude on wall to check the dynamic response of wall under dynamic loading.

The rareness of this thesis is the first time a complete study done on stone concrete blocks. It is checked upon different parameters with the help of shaking table by applying accelerometer upon stone concrete blocks or wall. The stone concrete blocks checked with different grades and researched related wall made by stone concrete blocks model are constructed. This chapters provides the ideas about works on future which will match in future and draw the conclusions.

5.2 Research outcomes

The final research results of this thesis contains the comparative study of normal concrete blocks or stone concrete blocks compression test results and dynamic testing of stone concrete blocks with different ratio. Stone concrete blocks with M15 grade are used to construct the wall for future reference or better implementation in structure results and outcomes of research are defined as follow:

- In this research work we have used Grade M15, M20, M25 grade of concrete for static and dynamic test compressive strength gains with grade of concrete.

- To find out the compressive strength of these grades total 9 cubes of each grade were casted such as 27 total cube casted for normal concrete blocks and 27 blocks are casted for stone concrete block. These samples were cured with different time period

such as 3days, 7 days, and 28 days. And results outcomes of these blocks are discussed on chapter 5.

- For checking the shear test of these stone concrete blocks cross couplet method or shear strength test results of mortar joints as shown in Chapter 5.

- The dynamic test results of different grades of concrete block or stone concrete block and wall with different earthquake and wall were fail at amplitude at 7 in bhuj earthquake.

6.3 Future recommendations

For future researches, the following points can be considered for other results outcomes upon dynamic testing of stone concrete blocks study:

- This study was carried out on dynamic study of M15, M20, M25 grades of concrete blocks. In future, this research can also done by different grades of blocks.
- In this work we have used M15 grade of stone concrete blocks to construct a wall but same can extend with other grades.
- Dynamic analysis of wall is done, only on bhuj earthquake or chile earthquake.
- In future work grade of cement can be replaced with other type of Geopolymer concrete.

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