Utilization and Testing of materials using Concrete block Technology

A

PROJECT REPORT

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

of

MASTER OF TECHNOLOGY

in

CIVIL ENGINEERING

With specialization in

STRUCTURAL ENGINEERING

Under the supervision

of

Dr. Tanmay Gupta & Dr. Saurav Kumar

(Assistant Professor)

by

ABHISHEK KAPIL (192653)

to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT, SOLAN – 173234

HIMACHAL PRADESH, INDIA

May 2021

STUDENT'S DECLARATION

I hereby declare that the work presented in the Project report entitled **"Utilization and Testing of materials using Concrete block Technology"** submitted for 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 and** co-supervisor **Dr. Saurav Kumar, 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 project report.

Signature

Name: Abhishek Kapil

Roll No: 192653

Department of Civil Engineering

Jaypee University of Information Technology, Waknaghat

CERTIFICATE

This is to certify that the work which is being presented in the thesis titled "**Utilization and Testing of materials using Concrete block Technology**" in 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 **Abhishek Kapil (192653)** during a period from July 2020 to November 2020 under the supervision of **Dr. Tanmay Gupta, Assistant Professor** and co-supervisor **Dr. Saurav Kumar, Assistant Professor**, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

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

Date: - …26. May. 2021…

HOD
CE DEPT

Signature of Supervisor
Dr. Tanmay Gupta
Assistant Professor
Department of Civil Engineering
JUIT, Waknaghat

Signature of HOD
Dr.Ashok Kumar Gupta
Professor and Head
Department of Civil Engineering
JUIT, Waknaghat

Signature of Co- Supervisor
Dr. Saurav Kumar
Assistant Professor
Department of Civil Engineering JUIT, Waknaghat

ACKNOWLEDGEMENT

I take this opportunity to acknowledge all who has been great sense of support and inspiration thought the report work successful. First of all I would like to thank almighty God, my parents and lots of people who inspired me and helped, worked for me in every possible way to provide the details about various related topics thus making thesis and report work success. My gratitude goes to our Head of the Department Prof. (Dr.) Ashok Kumar Gupta for his guidance, encouragement and support.

I am very grateful to Dr. Tanmay Gupta, Assistant Professor and co-supervisor Dr. Saurav Kumar, Assistant Professor for all their diligence, guidance, encouragement and help throughout the period of thesis, which has enabled me to complete the thesis work in time. I also thank them for the time that they spared for me, from their extreme busy schedule. Their insight and creative ideas are always the inspiration for me during the dissertation work.

Abhishek Kapil
(192653)

ABSTRACT

In developing countries such as India, because of growing industrialization and urbanization, including the construction of infrastructure and other facilities, the consumption of natural resources is very common. In regards of this people have began to realize different appropriate substitute of materials for concrete in order that the conventional resources that are existing these days may be preserved for the longer term generations. This article aims at studying and analyzing but diffusing the literature on utilization of different materials and their testing using concrete block technology, highlight its recent trends or work in research, its uses in the industries and in field works and to suggest or recommend future areas of research and development which can be done in this field. Different materials are used in concrete blocks and a discussion is done and review is made on the basis of research works done earlier. The advantages and disadvantages of different materials that are utilized and tested are discussed according to present or new case studies. The particular prominence is given to the concrete stone block where stones are extracted from local demolition wastes. On staadpro, a live retaining wall structure was analysed using software. First, using data and calculations, software modelling was performed on a live counterfort retaining wall structure, and then a comparison was made with a counterfort retaining wall built with precast stone masonry blocks and regular blocks, using data derived from experimental testing of blocks designed on staadpro. Compressive strength, resilience, workability, compaction factor, cost analysis, and a assessment between rcc counter fort retaining wall and counterfort retaining wall using precast stone masonry blocks were investigated using a software tool named Staadpro. The recent work is highlighted and developments are discussed. The results and data are formulated for the entire year.

Keywords: concrete, blocks, demolition waste, disposable waste, mud concrete, stone-crete, rice husk, textile waste, mix proportions, blast furnace, waste glass cullet.

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LIST OF ABBREVIATIONS

CDW	Construction and Demolition Waste
RHA	Rice Husk Ash
SSC	Steel slag concrete
CBRI	Central Building Research Institute
OPC	Ordinary Portland Cement
GBFS	Granulated Blast Furnace Slag
GP	Glass Powder
GC	Glass Cullet
MPa	Mega Pascal

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CHAPTER 1

INTRODUCTION

1.1GENERAL

In today's environment, globalisation, liberalisation, and privatisation are important. This has resulted in the growth of numerous major infrastructure projects in India each year, including airports, expressways, railways and stations, complex malls, multi-story houses, nuclear power plants, and so on. Every year, a large amount of essential natural capital is depleted for such construction activities. This has resulted in rapid depletion of natural resources, as well as an impact on structure construction costs, posing a serious problem for the construction sector, especially in developing countries like India.[1]

Materials are considered as the most important aspect of any construction project. With the need for alternatives which consume lesser energy and have a less effect on surroundings are being considered.. With the rising cost of materials, an alternative that promotes sustainable and affordable construction is being considered [2].

As a result, people have begun searching for other appropriate materials that can be used as an additive or substitute for the traditional concrete ingredients so as to preserve current conventional ingredients for upcoming generations. Various materials or unwanted materials from the industry, such as fly ash, waste aggregate, broken bricks, demolition stones, broken glass waste, ceramic waste, blast furnace slag, tile waste, and so on, have been successfully used as viable alternatives to the normal materials in concrete.

Cement, sand, coarse aggregate, and water are the three basic traditional components of concrete, which is a composite building material. Due to its generation of clinkers, cement, as the most basic component of concrete, causes environmental issues. It produces a lot of carbon dioxide and pollutes the environment. To reduce reliance on cement, different substitute materials available locally can be used as reinforcing cementitious materials, as well as other low-carbon materials. [3].

Construction and demolition waste is a serious issue, not only on a local or regional level, but also on a global scale. To minimise waste dumping and the use of primary resources, it is essential to efficiently use building and demolition waste, as well as its application in reusable structural elements. This is critical in terms of environmental considerations and responsible long-term management.

1.2 CONSTITUENTS OF CONCRETE BLOCKS

Concrete blocks are widely used and needed in construction. It is commonly used as a building material in residential and commercial buildings. Blocks of concrete can be made either by machines or by hand. They come in a variety of shapes and sizes. The most popular sizes are 40cm in length, 20cm in height, and 8/10/15/20cm in width [4].

These concrete blocks come in a variety of sizes, including Solid blocks and Hollow blocks. Hollow blocks have one or more gaps on both sides, while solid blocks have no voids or cavities. Strong blocks have high compressive strength, good durability, good fire resistance, and resistance to weathering effect or abrasion, among other benefits. Hollow blocks have the following advantages: they can be made larger than solid blocks, are lighter in weight, walls can be built easily and quickly, the air space provides strong thermal insulation, voids can be filled with concrete or steel bars for high earthquake resistance, and cavities can be used for plumbing and electrical installation.

The materials used to make concrete blocks are ordinary Portland cement, sand or gravel with a maximum particle size of 10 mm. The typical aggregate-cement ratio is 1:6 or 1:8, and the water-cement ratio is 0.5. Depending on the required strength, the casting and curing time is 7 or 28 days.

In today's environment, sustainable development is extremely relevant. Construction and demolition waste dumped on the ground has become a big issue. So, in order to save the nature and to address problem of excavated waste disposal, numerous research studies have been conducted in which various materials have been tested by mixing them or using them in concrete blocks, and their strengths have been noted and reviewed for long-term and cost-effective construction.

1.3 DIFFERENT TYPES OF MATERIAL USED IN CONCRETE BLOCKS

1.3.1 PLASTIC BOTTLES:

Since 1950, the use of plastic has increased rapidly, with an estimated 9 billion tonnes of plastic produced. Until 2015, only 9% of plastic was recycled, 12% was burned, and 79% was disposed of in landfills. It is produced in large quantities all over the world, and disintegration of plastic is thought to take thousands of years. We use plastic bottles on a regular basis. They're used to keep cold beverages, water, and other liquids cool. There has been a rapid increase in their use, which has exacerbated the disposal problem. To solve this problem, many ways are being employed, as well as their application in construction as a concrete material. The thermal insulation provided by these plastic bottles decreases the amount of electricity used in the cooling process. They can be used to make hollow concrete blocks, which are a popular masonry unit with an ever-increasing number of applications [5]. The aim of using plastic bottles in concrete blocks was to create voids that were evenly spaced. Bottles are contained in a masonry unit, which is surrounded by concrete.

1.3.2 RICE HUSK ASH:

It is produced by burning rice paddy husks as a byproduct of the rice milling industry. Rice husks are burned at 500 to 800 degrees Celsius to create non-crystalline amorphous. Amorphous silica accounts for 90-95 percent of the total. Rice husk ash has become a concern because it needs a significant amount of space for disposal and has an effect on the environment. There have been research on using rice husk ash as a 15-25 percent concrete substitute. RHA lowers the weight density of concrete by 72-75 percent while also lowering the material cost by 8-12 percent. It also improves the compressive strength and work-ability of concrete by reducing water absorption. [6]

1.3.3 COCONUT SHELL:

Green technology is developed as a result of the use of waste products. Coconut shells are discarded by businesses and households. They can be found in large numbers in Indonesia and parts of India's south. The coconut shell is used as a concrete material, which lowers the cost and provides environmentally friendly concrete blocks that can be used in paving and making them more durable by absorbing water. These pavement blocks can be used on sidewalks, parking lots, and pedestrian areas, among other things. The benefits of using coconut shell as a concrete-mixture material include its high strength and longevity, as well as its high modulus of elasticity. It also provides a close bond with cement due to its fibre texture. [7].

1.3.4 STEEL SLAG:

Steel slag is a solid waste output of the steelmaking process. Depending on the form of steel, it may be known as steel slag or carbon steel slag, as well as a pretreatment slag. Steel slag is created when scrap iron or iron ore is converted into steel. Waste steel slag can be used to make construction products like cementitious pastes and bricks. In developing countries, the rising amount of steel slag is causing environmental issues, so it is vital for utilizing these so as to protect our environment. When utilized as aggregate that is is fine in the process of material mixing, steel slag improves the ultimate expansion ratio and hardness, and when mixed with concrete, it increases the energy absorption potential [8].

1.3.5 TEXTILE WASTE CUTTINGS:

In recent years, global population growth and rising living standards have resulted in increased demand for textile products. Thanks to fast fashion trends, it has also resulted in resource overconsumption. Textiles are primarily used to shield our bodies from temperature changes and UV rays, and they have evolved into a reflection of personality and interest in fashion. Textiles are also used for a variety of purposes other than clothing, thanks to technical advances. During the industrial revolution in the United Kingdom in the 1700s and 1800s, the concept of recycling textile items arose. They are combined with cement which are used in
place of a binder, resulting in concrete that can be cut and nailed like wood. [9].

1.3.6 BLAST FURNACE SLAG:

Blast furnace slag forms from the production of iron and steel industry, produced by blast furnaces that manufacture iron. It is widely used as a popular Portland cement substitute, offering numerous advantages such as longevity, workability, high strength, environmental benefits, and cost effectiveness. In today's environment, sustainable development is a critical factor. A by-product of one industry may be used as a by-product of another industry, according to the industrial ecology scheme. With this in mind, concrete technologies are developed with expense, durability, and environmental preservation in mind. Studies have been done previously in which it was found that the blast furnace slag can be employed in place of fine aggregate in concrete [10].

1.3.7 RECYCLED AGGREGATE CONCRETE BLOCKS:

Recycled aggregates are the products of the future. The use of these aggregates has begun in a number of developing countries. The use of recycled aggregate will aid in environmental protection. Currently, in countries such as Spain, the use of such materials is being encouraged in order to protect the environment, taking into account the progress of international standardisation such as EHE-08, BS-8500, RILEM, and DIN-4226.10. This advantage contributes to the reduction of the load on natural resources derived from riverbeds and quarries. Recycled aggregate concrete is primarily used in sub-base or granular base applications, soil construction, and embankment construction, though it is also used in structural construction is insignificant. Since construction and excavated waste are shown as an excellent source of aggregate for concrete manufacturing, numerous studies have shown that concrete produced with such aggregates can have mechanical properties comparable to conventional concrete. Concrete with recycled aggregate has also been shown to have a 40% reduction in concrete strength, according to studies. Furthermore, because of presence of higher content of cement, recycled aggregate concrete has greater carbonation resistance and demonstrates better resilience than traditional aggregate concrete. Natural aggregate is the key substitute for recycled aggregate, and it is still a relatively low-cost material [11].

1.3.8 MUD-CONCRETE BLOCK:

Owing to concerns about strength and durability, earthen construction systems were not considered to be part of engineering in the past. While mud-house construction was very common in ancient times, it only became well-known in the 1930s after the United States established a written standard for adobe. The mud-concrete mixture can be compacted by its own weight. It would not need any compaction and, once set, would conform to the shape of the mould [12].

The mud concrete principle was first used to incorporate concrete's strength and resilience into mud-based structures. It was the first to implement an inexpensive, bearing of load wall arrangement with simple design methods. It aids in the reduction of environmental effects. It aids in the reduction of environmental effects. Mud concrete comprises of clay, cement, and water that is used to make concrete. Here, soil serves as aggregate, a small amount of cement serves as a stabiliser, available gravel provides compressive strength, and a large amount of water ensures cement hydration and improves self-compaction.

1.3.9 PRECAST STONE MASONRY BLOCKS:

Stone is abundant in some areas, and it is often used as a walling material. Walls are typically constructed of random rubble masonry in thicknesses ranging from 380 to 450mm, though 300mm walls are sometimes built at a slightly higher cost due to the need for skilled labour and time. Depending on the functional and structural requirements, these walls can be extremely thick. thirteenth

The CBRI conducted a study with the aim of reducing the thickness of random rubble walls and the degree of ability needed to create them. This study resulted in developing Precast stone masonry blocks using stone spalls and lean concrete mix with a natural stone texture on one side of the block [14].

Stone-crete blocks, also known as "Pre-cast Stone Blocks," are a good alternative to bricks that are shipped in from a long distance since they rely heavily on local materials. These blocks are created by putting stones in concrete lesser of 100mm to 125mm in diameter. The stone utilization outcomes in substantial concrete savings. Stone-crete Blocks usually measure 300x200x150 mm in size, resulting in walls that are 200mm thick. These blocks are used in the same way as solid blocks of concrete which are used in the manufacturing of masonry walls to ensure that the structure is hazard-resistant. If stones are available on site, stone-crete blocks are less expensive than brick walls. [15].

1.4 RETAINING WALLS:

Early engineers in certain countries were masters of creativity and investigation, discovering what worked and what didn't specifically through intuition and trial-and-error. We are fascinated by their accomplishments. Even the most casual observer is fascinated by the impressive buildings constructed by them and which remained robust for many years, which have numerous retaining walls. They cut and constructed joints with stones with such finesse that they seemed almost invisible. The ingenuity and achievements of those early engineers astonish every student of ancient building methods [23].

Retaining walls are the supporting structure that supports the soil or excavated portion of the hills to prevent from falling on the area of live moment. These are basically rigid structures standing to prevent soil from falling at different levels. These walls are designed to prevent soil or retain soil from falling from the elevations of undesirable slopes or in areas where landscapes may occur and needs to be engineered for purposes like farming in hilly areas or roadside where moment is more often. Construction of retaining walls is done to withstand the
lateral soil pressure or wedge of soil.

Retaining wall contains three major parts:

a) Stem Wall

b) Heel slab

c) Toe slab

The stem is vertical. Cantilever retaining wall's vertical stem can bear the pressure of earth from backfill side and bend as of cantilever. Slab for foundation. The retaining wall's foundation is built by the base slab.

1.4.1 TYPES OF RETAINING WALLS:

a) CANTILEVER RETAINING WALLS:

Self-supporting retaining wall is the most popular and recognized form of retaining wall [24]. The vertical rods of the self-supporting retaining wall bear the earth pressure from the backfill side. The thickness of the board is greatest at the bottom of the trunk and gradually reduces the buoyancy of the soil. The pressure decreases with depth. The foundation of the retaining wall consists of foundation slabs. It consists of two panels: heel and toe. Under the combined effect of supporting the weight of the floor, the heel acts as a horizontal cantilever. Overlap the printed surface and ceiling. The toe cover can also enhance friction from the bottom up. The integrity and weight of the structural elements of the retaining wall are supported by the weight of the floor. Lining and heel. Cantilever retaining walls are ideal for backfilling depths of up to 5 meters.

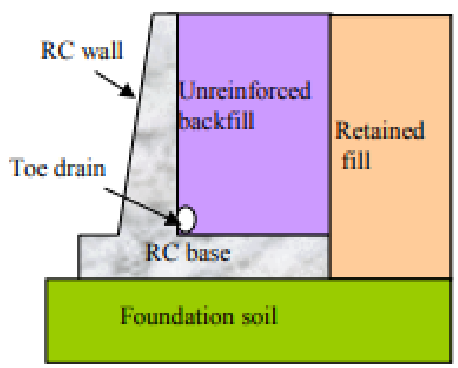


Figure 1.1. Cantilever Retaining Wall

b) COUNTER-FORT OR BUTTRESS RETAINING WALL:

Cantilever walls with counterforts recommending with a back wall slab and foundation slab are known as counterfort walls. The counter-forts bind the wall slab and the foundation, acting as tension stiffeners to minimise bending and shearing stresses. Counterforts, spaced at distances equal to or little bigger than half the height, are used to minimise moments in walls of large height. For high walls of more than 8 to 12 metres, counter forts are used.

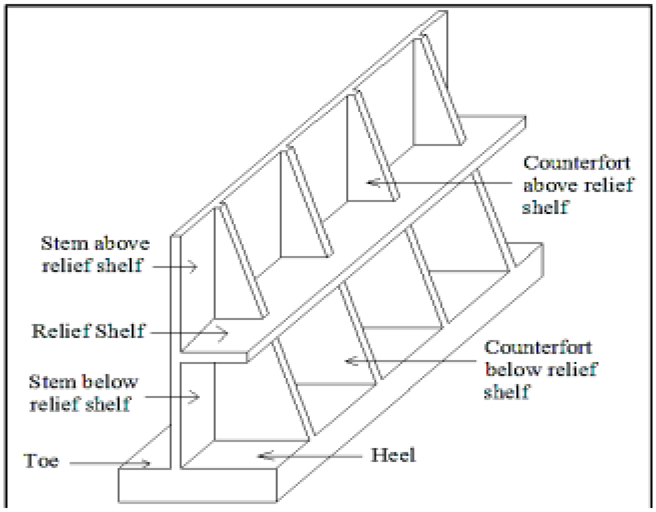


Figure 1.2 Counterfort Retaining wall

c) ANCHORED RETAINING WALL:

It requires additional strength in the form of cables which can be anchored behind rock or soil. Anchors are usually bored and then cables end are extended mechanically or by pouring pressurized concrete forming a bulb. Although technically challenging, this method comes in handy when heaver loads are required or when slender walls are to be constructed..

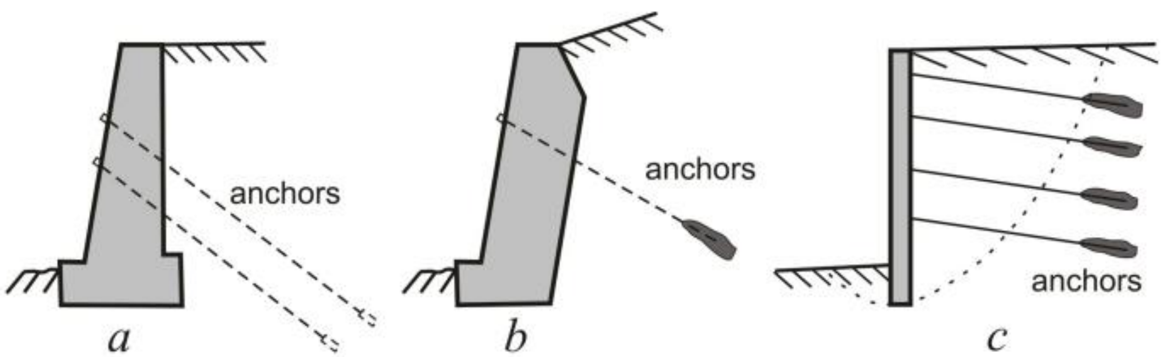


Figure 1.3 Anchored Retaining Wall

Retaining walls prevent soil or strata from collapsing. These walls are vertical structures that provide protection for the backfill or seawater. These are critical structures built along the hilly section of the road to prevent the excavated portion of the mountain from collapsing on the road. These walls are built with the topography of the area in mind and are constructed for the form of retaining that will be used. These walls can resist the pressure which is due to the backfill of the soil or the sea water.

1.5 NEED TO STUDY

Concrete blocks are essential in the building industry. When placed under a load in a testing lab, these blocks aid in determining compressive strength. Concrete blocks are less expensive since they require locally available materials or can be easily manufactured on the construction site, lowering both the in-situ and transportation costs. To gain power, locally available material is used, which makes it much cheaper or more economical.

To meet the demands of environmental management, construction and demolition waste (CDW) must be utilised. It aids in the resolution of dumping issues and eliminates the need for primary capital. CDW waste is a very real problem for local communities, as well as a major global issue. Dumping of these wastes has become a global problem, so by using CDW waste, we can address dumping issues while still contributing to environmental conservation. It can be used to replace natural aggregates, reducing the need for natural resources while also helping to protect the environment. Locally accessible demolition stone can be used to make the blocks, and their strength can be specified; additionally, there isn't much research on the topic. By adding a stone to a concrete block, we can see how the strength of the block varies and whether it adds more strength or not. It must be determined if the stone fails before or after the concrete up to the ultimate load. Other disposable waste can be used to create an environmentally friendly concrete block while also solving waste disposal issues. As a result, in today's world, an alternative to dumping or disposing of waste is needed.

Retaining walls supports the soil or back of strata from falling. These walls are vertical structures providing support to the backfill or water on the sea. These are very important structures and are constructed along the hilly portion of the road to stop the excavated portion of the mountain from falling on to the road. These walls are designed considering to the topography of the place and accordingly designed for the type of retaining that is needed to be used. The demolition waste can be mend within the concrete blocks and can be used in construction of retaining walls. Demolition or excavated stones are easily available on the sites and this would help in lowering the cost of construction of these walls. Disposable waste or the dumping of disposable waste has become a major problem so these wastes can be used to reform the structures by reusing and recycling these waste items.

1.6 AIM AND OBJECTIVE:

This study focuses on construction industry about the different materials that are being utilized using the concrete block technology to solve the disposal problems and to check for the replacement of natural resources that are used as coarse aggregates, see the advantages and disadvantages of using different materials and measure their strength and check them for construction use. The aim is supported by the objectives stated below:

- To check the effectiveness of Utilization of stone in various grades of concrete blocks.
- Assessment of strength of various configuration of stone placement in concrete blocks.
- To check for the analysis of various properties of retaining walls using software tools like Staadpro.
- To check and differentiate the properties of reinforced concrete retaining walls and retaining wall using concrete blocks by software designing.
- To check strength, compaction factor, durability of these retaining walls and compare them.
- Utilization of local materials and plastic bottles.
- Perform cost analysis of various blocks casted.

CHAPTER 2
LITERATURE REVIEW

2.1 GENERAL

This chapter focuses on the literature of the influence of Utilization of different materials using concrete block technology and then, the software analysis of the retaining walls using software tools like Staadpro. Different materials were used in concrete blocks and their properties were discussed. A live counterfort retaining wall was taken and its design was studied and then using the concrete blocks a similar counterfort retaining wall was structured and the comparisons of their properties were studied. The advantages and disadvantages of using different materials in concrete blocks and their measures were examined. The following chapter gives the complete knowledge of the literature alongside the ways for further research worksfor the future generations.

2.2 LITERATURE SURVEY

Rajendra Desai, Rupal Desai, Pawan Jain, R.K. Mukerji and Harshad Talpada [15] discussed about the stonecrete blocks that are dependent on local materials that can be a alternative for the bricks which are brought from a distance. These blocks are made by placing a stone of 100mm to 125mm size inside a mould of size 300x200x150mm and then surrounded by a concrete mix or concrete slurry. This option was first developed by CBRI. It is discussed that to make the building resistant, the blocks should be of moulded of superior quality as specified by CBRI. It must be ensured that in the cold places like hilly regions wall insulation is important. So, a wall with 200mm and 225mm thickness will have lower insulations, so in winters it won’t provide warmness inside the house with stone walls. As, the walls made by this method is 200mm thick lesser than the rubble masonry walls of 450mm, a house made by this method can save 25% floor area. Places where stones are easily available there stonecrete blocks can be preferred.

Indian Standards IS-12440 (1998) [13] specifies the dimensions that are required to make a stonecrete block. Its dimensions are as follows: length is 300mm, height is 150mm and its width varies from 200mm, 150mm and 100mm in size. The methodology to make these stonecrete blocks is specified in this code. Material required, the stone size with 100 to 125mm is specified in the code. The mould size is given, the casting method and demoulding techniques are all specified in this code. Compressive strength values for 7days and 28 days are given and also the testing method is given in the code.

Sina Safinia & Amani Alkalbani [5] conducted a study on the implementation of plastic bottles in concrete blocks. Voids were created using plastic bottles at equal distances in a masonry unit and concrete was placed around them. This study utilized 500ml plastic bottles in a masonry unit and compressive strength was also analyzed. The results showed a difference of 57% in strength in comparison to the locally available concrete. This study approves that further study can be done on other properties as well.

F.R. Arooz, R.U. Halwatura [12] showed that the mud concrete blocks can be established to load bearing wall system which also ensures indoor comfort and minimizes the impact on environment. Here soil was used as aggregate and cement with low quantity will act as a stabilizer. High quantity of water was used for hydrating process. The Experimental testing found that in a mix proportion of these blocks has cement=4%, fine aggregate 10%, sand 55-60%, gravel 30-35% and water to be 18 to 20% from the mix of dry.

S.D. Nagrale, Dr. Hemant Hajare and Pankaj R. Modak [6] confirmed that how distinctive contents of RHA introduced to concrete can affect the bodily and mechanical properties. They confirmed that RHA may be used as a alternative for concrete through 15 to 25%. Sample cubes have been examined with unique chances of RHA and w/c ratio. It become discovered that with the addition of RHA weight density of concrete decreased through 72-75%. This suggests that RHA concrete may be efficaciously used as a mild weight concrete. The fee of 1m three concrete works out to Rs. 1157 while of RHA concrete become Rs. 959. Thus, using RHA in concrete facilitates in making low-cost concrete. Also, the compressive power of concrete become discovered out to be growing with the assist of RHA.

Ridwan, S. Mudjunararko, A. Limantrara, E. Gardjito, A. Sari [7] demonstrated the use of coconut shell scraps in mixed concrete materials, which reduces the cost and makes the concrete blocks of the sidewalk environmentally friendly. ...The use of coconut shells on concrete blocks helps to absorb runoff to the ground, indicating that the pavement is more durable. The main purpose of his research is to use fine aggregates and coconut shells as coarse aggregates to determine the compressive strength of concrete. They made 5 15×15×15 cm coconut shell tubes with powder shell content of 0%, 20%, 25% and 30%, and tested them for 28 days. The results showed that the compressive and absorption resistance after 28 days was 18.5 MPa and 22%, the change was 0%, 11.4 MPa and 16%, the deviation is 20%, 7.6 MPa and 14%, the deviation is 25%, 6.7 MPa and 12%, the deviation is 30%. These results indicate that the coconut shell mixed concrete has reduced compressive strength and absorbency.

Guo, J. Xie, J. Zhao, K. Zuo [8] showed in their research that untreated steel slag can be used as a fine-grained aggregate in concrete compaction. They use two types of concrete and eight percentages of fine aggregates (such as steel slag) (0%, 10%, 20%, 30%, 40%, 60%, 80% and 100%) as test parameters. Axial compression test. The influence of steel slag percentage on the relationship between ordinary and high-strength concrete tensile and elongation, expansion ratio, compressive strength, elastic modulus and impact strength. Their results show that with the increase of steel slag, the compressive strength of SSC is not monotonous, and the use of steel slag as a fine aggregate has a positive effect on the energy absorption capacity. SSC with the best steel slag has better compressive strength than conventional concrete.

Aspiras, J. Manalo [9] uses textile waste as a binder with cement to form concrete that can be cut or nailed like wood. They pointed out certain physical and mechanical properties of concrete, indicating that it is light in weight and inexpensive. They used 2 cm and 6 cm pieces of cloth and mixed them with OPC to form a cloth-to-ash ratio of 1:3, 1:4, and 1:5. The bending, stretching and compression of different blocks of 9.5 x 14.5 x 2 cm, 1.5 x 5.5 x 22.5 cm and 5 x 5 x 5 cm were tested. These samples were immersed in water for 8 days, cured and analyzed for 28 to 30 days. The test results show that the compression test sample does not show brittle fracture even when the breaking load is exceeded, which indicates its high energy absorption capacity. They also found that even though the fabric was highly flammable, the samples showed no signs of burning after 30 minutes of burning under an open flame. These results indicate the potential of using textile waste concrete as roof walls to replace wood boards or as cheap concrete blocks.

I Yuksel, O Ozkan, Turhan Bilir [10] geared toward analyzing the feasible utilization of backside ash and GBFS in manufacturing of concrete elements. They produced sure quantity of blocks containing GBFS and backside ash as high-quality combination in lab and examined a few the blocks for sturdiness and mechanical residences of those specimens. They took specimens (i) examined unit weight, compression power and freeze thaw for briquette specimen (ii) Compression power, freeze thaw, water absorption and floor abrasion assessments had been performed for paving blocks. Results confirmed that at the same time as the compressive power reduced the sturdiness elements freeze thaw and abrasion had been increasing.

Lu Henghui, Yang Shipeng, He Pengfei [16] tried to use glass waste to develop environmentally friendly precast concrete parts. These glass fragments are used as fine pellets and used as part of the binder in the form of glass powder (GP) in the form of blocks. Their results showed that despite the increase in glass waste (GC), the electrical resistance remained constant. They also showed that the combined use of GP and GC helps to reduce water absorption and prevent shrinkage during drying. Within the acceptable range.

Ozturk T., Bayrakl M. [17] studied the possibility of using tobacco waste to produce lightweight concrete. They used different percentages of tobacco waste in lightweight concrete containing pumice, and found that lightweight concrete made from tobacco waste pumice could be used as a cladding and insulation material in building materials. It has been found that lightweight concrete containing tobacco waste has low thermal conductivity (0.194-0.220 W/mK), which is lower than most masonry materials (for example, bricks and tiles). B. Brick (0.45 to 0.6 W/mK), briquettes (0.7 to 1).0 W/mk), Pumice (0.29 W/mk) and Ytong (0.23 W/mk).

Senthil, M. Iqbal and Amit Kumar [25] used software tools such as ABAQUS/Standard to check the 3D finite element modeling to study the performance of Counterfort retaining walls and cantilever retaining walls subjected to lateral ground pressure. ...Retaining walls with different geometric configurations, and analyzed where three cantilever retaining walls and one retaining wall were removed. In their research, they found that the displacement and stress of the cantilever wall increase with height. When the heel is larger and the toes are smaller, the maximum horizontal displacement is larger; when the heel is smaller and the toes are larger, the maximum tension is larger. In their research, they also found that the greatest compression force occurs near the shaft and finger joints, while the greatest tension occurs near the nail and heel joints and shear force and toe joints.

G. Madhavi and MM Mahajan [26], did a essential look at on counterfort keeping wall through thinking about six one-of-a-kind fashions of various load instances and combinations. Those six fashions have been as follows a) Conventional counterfort Retaining wall with out shear key,b) Conventional Counterfort Retaining wall With shear key. c) Conventional counterfort Retaining wall with buttress. d) Conventional counterfort Retaining wall with shear key and buttress. d) 8m counterfort keeping wall with 1 remedy shelf e) 8m counterfort keeping wall with 2 remedy cabinets. Their experiments determined that the effects they've got specifies that in place of non-cohesive soil across the wall, cohesive soil across the wall will increase the pass segment of the wall. They additionally determined that having a shear key withinside the counterfort keeping wall reduces the quantity of concrete used. In their test additionally they determined that it's miles feasible to expect that through the use of buttresses withinside the counterfort keeping wall, we are able to lessen the quantity of concrete used. They additionally determined that the impact of the shear secret's advanced to the impact of the buttress and the blended impact of the shear key and buttress. The impact of 1 shelf is advanced to the impact of the shear key. One shelf at 2/third peak of stem is greater effective than cabinets at one-of-a-kind positions for an 8m counterfort keeping wall. Their test recommended that the shelf be positioned at 2/third peak from the pinnacle of the wall. They determined that for a 10m counterfort keeping wall, cabinets at one-of-a-kind heights are greater green than one shelf on the stem 2/third peak. Their conclusions determined that having cabinets is useful for partitions with a peak of greater than 8m.

2.3 RESEARCH GAPS

a) Most of the literatures are concerned about utilizing different materials in concrete blocks and checking their properties so that these materials can be used for further practical uses in the physical world and help to build a environment friendly block and also solve the disposing or dumping problem.

b) There is a need to utilize the local demolition waste and to check the strength of these demolition waste in a concrete block so as to get the required strength and durability and also solve the dumping problem.

c) Limited literature is available which provide use stone spalls in a concrete block. Not much study has been done in this concept.

d) Retaining walls with construction and demolition waste has been experimented earlier but there isn't any proper information or research work that specifies the strength, durability and other factors of the pre- cast stone masonry blocks.

e) Is codes for precast stone masonry blocks have not been revised since 1994.

f) Properties of pre cast stone masonry blocks have not been found on the retaining walls

g) Cost analysis have not been done in prior studies of the precast stone masonry blocks.

h) There is very limited research work or literature is available there in this topic and there is need to explore the study on pre cast stone masonry blocks.

i) The literature on the use of the precast stone masonry blocks, their economical variability and different parameters like strength, durability, compaction factor, crushing failure and shear failure is not available.

2.4 RESEARCH OBJECTIVES

a) Utilization of Construction & demolition waste is done to solve the disposal problem and to promote sustainable development.

b) Concrete blocks with waste and demolition material are more cost effective than the normal concrete block.

c) Agro waste like Rice husk ash shows 20% high workability and reduces material cost by 8-12% and concrete blocks with agro waste shows high durability and high cost effectiveness.

d) Industrial waste in concrete blocks shows high compressive strength, solves disposal problem, are much cheaper, durable and workable.

e) To analyze different parameters like strength, durability, compaction factor, crushing failure and shear failure.

f) Study the design of a live Counter-fort retaining wall using software tool like Staadpro and check for the strength and moment factors.

g) Comparing the design of live reinforced concrete counter-fort retaining wall with design of counter-fort retaining wall using precast stone masonry blocks.

h) Cost analysis of the reinforced counter-fort retaining wall and the same retaining wall using precast stone masonry blocks and making their comparison.

i) Limited literature and experimental study is provided in this topic.

CHAPTER 3
MATERIALS AND RESEARCH METHODOLOGY

UTILIZATION OF DEMOLITION STONE IN A CONCRETE BLOCK

3.1GENERAL

Different material properties, as well as a detailed experimental programme and procedure, are discussed in this chapter. Cement, aggregate fine in texture, and aggregate coarse in texture were all subjected to tests. Cement has been checked for normal quality, initial, and final setting times. Fine aggregate specific gravity and grading Water absorption and specific gravity on coarse aggregate were measured in accordance with Indian Standards codes. Various factors that influence the properties of concrete, either directly or indirectly, are addressed so that an experimental programme can be designed to investigate the use of demolition stone in a concrete block. The procedure of the experiment is discussed in detail and then mix design has been done from M30 grade and above. Software analysis has been done of a live retaining wall structure on staadpro. First software modeling was done on a live councterfort retaining wall structure by using the data and calculations and then comparison was made with counterfort retaining wall constructed with precast stone masonry blocks and normal blocks by using the data formed with the experimental testing of blocks designed on staadpro. The studies were made on the compressive strength, durability, workability, compaction factor, cost analysis and a comparison is studied between rcc counterfort retaining wall and counterfort retaining wall using precast stone masonry blocks on software tool like Staadpro.

3.2 MATERIALS USED

Concrete is a dense substance with a cementitious medium in which aggregates are embedded. The degree of compaction has a significant impact on the potential consistency and strength of concrete of a given mix proportion. The materials used in concrete planning are examined in the parts that follow.

3.2.1 AGGREGATES

Aggregates are the building blocks of concrete. They offer the concrete body and help to reduce shrinkage. Aggregates have a significant impact on the consistency, longevity, and dimensional stability of concrete. Aggregates are responsible for more than 75% of the volume of concrete [18]. The aggregates are represented in terms of weight and height. The aggregates that make up concrete cannot outperform the aggregates that make up the concrete. In any case, there is no way to measure total's consistency directly. Maintaining the dimensional integrity of concrete under load requires absolute firmness. Direct-quality aggregate with a high modulus of elasticity, on the other hand, can be used to withstand volume changes in concrete caused by thermal or expansive forces. To suit like a fiddle, aggregates are angular or round. The smoothness of aggregates is defined by their surface.

Aggregate with a rough texture can have a stronger cement-aggregate bond, so it is preferred. Aggregates are graded as follows based on their weight

a) Aggregate having normal weight

b) Aggregate having light weight

c) Aggregate having heavy weight

Natural and artificial aggregates are of two types of normal weight aggregate. Sand, for example, is a natural aggregate, while broken concrete, air-cooled slag and other artificial aggregates are not. Aggregates may also be classified according to their scale.

a) Coarse aggregate (> 4.75mm)

b) Fine aggregate (< 4.75mm)

The cornerstone is the starting point for all common aggregates. There are three types of rocks: igneous rocks, sedimentary rocks and metamorphic rocks. These three volcanic rocks are strong, thick and hard, making the concrete very attractive [18]. The size of the aggregate is also important because it affects the workability of concrete. For a given water/cement ratio, circular units are preferable to angular units in terms of the economic requirements of cement. Surface measures the degree to which the molecular surface is washed or opaque, smooth or rough. The contact area becomes narrower as the surface smoothness increases, and the particles of deep purity hardly hold the area with the matrix more firmly than the coarse particles of the same volume. The amount of coarse aggregate seems to affect the workability and finish of concrete.

Concrete's workability and finish are influenced by the amount of fine aggregate used. Grading is an important property of aggregate used to make concrete because it affects the packing of particles, which reduces voids. This, in turn, has an effect on the amount of water required and the cement content of concrete. Figure 3.1 depicts the behaviour of IS sieves for study. Evaluating is done in the form of total %age of weights that move through a specific IS sieve [19].

IS 383-1970 explains the classification limits of coarse and fine aggregates. Small aggregates are connected to the scale module, which is a broad measure of aggregate rating[20]. This takes into account throughout the blend's proportioning. It's calculated by dividing the total percentage of weight retained on a regular collection of sieves by 100. Table 3.1 shows how fine aggregates are classified based on their fineness modulus.

Table 3.1 FM for fine aggregates [IS 383-1970] [23]

Type	**(FM)**
Fine aggregate	2.3-2.6
Medium aggregate	2.6-2.9
Coarse aggregate	2.9-3.2

Figure 3.1: Sieve Analysis method.

3.2.2 BINDER
ORDINARY PORTLAND CEMENT

Clinker is important cement manufacturing. Clinker is a kind of artificial stone, which is obtained by heating limestone and other raw materials to extremely high temperatures in a special furnace. Portland cement is a hydraulic cement that is made by finely grinding calcined clinker into a mixture of clay and limestone materials in the early stages of calcination. BIS divides (OPC) into three grades for the production of different types of concrete to meet the requirements of the construction industry. [20][21].

- Grade 33 OPC
- Grade 43 OPC
- Grade 53 OPC

The project shows, a single-source 43-grade cement (ACC cement) is used. The cement grade represents compressive strength of the mortar cube at 28 days in MPa. Clinker, which is made from lime stone, is the basic raw material used to make cement.

Figure.3.2 Ordinary Portland Cement

3.2.3 WATER

Without water, concrete would be tough to imagine. Water, after cement, is that the most significant element within the manufacturing of concrete. Using water carelessly may result in poor-quality concrete. A close investigation for quantity of water needed to provide high-quality of concrete is crucial during this case. The water is also wont to mix or cure the concrete. A association reaction happens when water is added, leading to the formation of the C-S-H gel. It is generally believed that if water is safe to drink, it is also safe to use in concrete production. The pH level of water is also a factor in determining its suitability for concrete production. If the pH level is between 6 and 8, and there are no organic additives, it is suitable for producing concrete.

The proportion of water to cement affects the consistency of concrete as well. With w/c proportions of 0.2, 0.3, and 0.5, Figure 3.4 depicts a schematic representation of cement gel hydration. It's worth noting that only a small amount of water is needed to hydrate cement. To grease up the blend, more water is needed [22]. Capillary pores can form when there is too much water in the body. Excess water increases concrete's workability but compromises value to some extent. The amount of water necessary find desired workability is usually higher to be required to completely hydrate the cement.

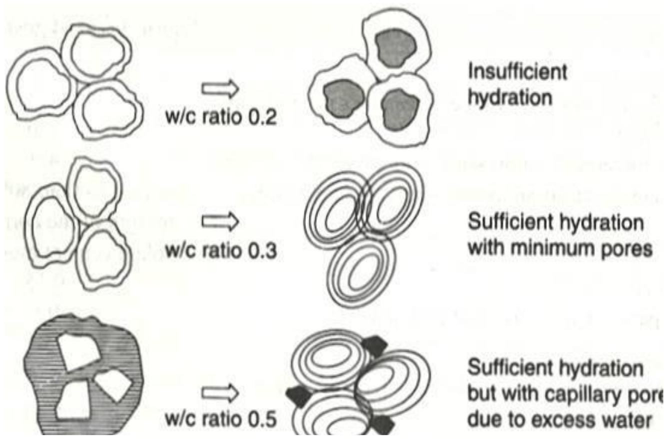


Figure 3.3: Insufficient, adequate, and excess water for hydration are depicted schematically.

3.3 TESTING OF MATERIALS

3.3.1 CEMENT

i) NORMAL CONSISTENCY

The consistency is used to find out how much water, expressed as a %age of cement weight, should be applied to achieve normal or natural consistency.

Figure 3.4: Normal Consistency

It's the amount of water that, when mixed with cement, penetrates 5-7 mm from the Vicat Mould's bottom or 33-35 mm from the Vicat Mould's top. The water essential for various cement tests is determined by cement's usual consistency, which is determined by the compound composition and fineness of the cement. Vicat's apparatus was used in accordance with IS: 4031 Part 4:1988. The cement's Standard Consistency was found to be 35%. [21].

ii) INITIAL SETTING TIME

The primary setting time of cement is described as the moment when the cement begins to set and loses its plasticity. During this time, the cement can be made into any preferred shape while remaining solid. This is the time required to obtain a 1mm square cross section. The distance between the needle and the bottom of the Vicat's mold is 5mm to 7 mm, so the cement slurry will not penetrate after adding water. It is important to know the initial setting time, because if mortar or concrete is placed in the mold after this time, the beneficial properties of the cement will be lost. The initial setting time is 90 minutes.

iii) FINAL SETTING TIME

The final setting duration of cement is the factor at which it has absolutely misplaced its plasticity and has come to be strong. Final putting time is defined because the time among while water is brought to cement and while a 1 mm needle makes an impact at the paste withinside the mildew however a five mm hyperlink does not. The final setting time is valuable because it allows the moulds to be removed.

The total setting time was 4 hours and 30 minutes.

iv) SPECIFIC GRAVITY

If the temperature is kept constant, the specific gravity of cement is the ratio of the density of cement to the density of water. Excessive exposure to moisture can impair the workability and strength of cement. For the nominal composition of the mixture, the basic density of the cement should be 3.15 g/m3. When exposed to high humidity due to bad weather, the specific gravity of cement increases to 3.19. When the basis weight of cement is 3.19, moisture will fill the pores. Premature wetting of the cement occurred. The bottle density method is used to determine the specific gravity of cement.Water is usually used to measure the specific gravity of a substance. However, in the cement industry, we use kerosene to determine real gravity. In the presence of water, cement hydrates. When kerosene is mixed with cement, there is no reaction or shift. The basic gravity of OPC cement was found to be 2.91 in a lab experiment.

Figure 3.5: Specific gravity of cement

3.3.2SAND

SPECIFIC GRAVITY

To measure the specific gravity of sand, a density bottle was used. Basic gravity of quartz sand particles ranges from 2.65 to 2.80.

Empty bottle weight (W1)

Weight of bottle and soil (W2)

Weight of bottle, soil and water (W3)

Weight of bottle and water (W4)

Specific Gravity $= \frac{W2-w1}{(W4-W1)-(W3-W2)}$

Specific gravity with density bottle for sand = 2.7

Zone = III

3.3.3 COARSE AGGREGATES

WATER ABSORPTION

Concrete's coarse aggregate has a propensity to draw water out of the mix. Cement hydration would be insufficient if this drop in water content is not taken into account.

Water absorption = (A-B/B) × 100

Sample weight

Saturated surface dried sample weight (A)

Oven dried sample weight (B)

Absorption of water for aggregates = 1.5%

3.4 PRECAST STONE MASONRY BLOCKS

The CBRI conducted a work with an aim of reducing the thickness and degree of ability needed to create random rubble walls. Precast stone masonry blocks using stone spalls and a lean concrete mix with a natural stone texture on one side of the block were developed as a result of this research [14].

Stone-crete blocks, also known as "Pre-cast Stone Blocks," are a good alternative to bricks that are shipped in from a long distance since they rely heavily on local materials. These blocks are created by putting stones in concrete which are not larger than 100 to 125mm in diameter. The use of stone results in substantial concrete savings. Stone-crete Blocks usually measure 300x200x150 mm in size, resulting in walls that are 200mm thick. If stones are available on site, stone-crete blocks are less expensive than brick walls [15].

Figure 3.6: Stone-crete blocks

3.4.1 SIZE OF BLOCKS

For ease of use and other features, the nominal length and height of the block are kept at 300mm & 150mm, respectively, and have 3 widths: 200mm, 150mm and 100mm. The actual size of the block should be 10mm shorter to fit the mortar line. These blocks have a weight range of 90 to 180 N. The blocks are cast in such a way that the bottom face is revealed when they are laid in the wall, i.e. the width of the block is kept the same as the height of the moulds, and the height of the block is kept the same as the width of the moulds. By placing different textures on the top face during casting, such as exposed pebble or crushed aggregate, different textures may be created on one face.

Figure 3.7: Moulds for blocks

Figure 3.8: Placing stone in Mould

3.4.2 MATERIALS

The stone blocks are made of lean cement concrete and stone pieces ranging in length from 50 to 250 cm, collected by breaking boulders so that at least one face is smooth. The stones should be hard, sound, long-lasting, and impurity-free. Crushed stones or natural aggregate with a diameter of 10mm or less, free of impurities, and conforming to IS 383-1970 should be used. Sand should have fine particles, 15-20% passing IS Sieve No 300 micron and 5-15% passing IS Sieve No 150 micron, since the concrete used is lean and lacks fine particles, resulting in a loss of plasticity and workability.

If such sand is not sufficient, the proportioning of sand and aggregate should be modified appropriately through a few trials to achieve good workability and plasticity at the green level. This could be used to replace the fine sand particles. The fineness modulus of the cumulative aggregate should be between 3.6 and 4 when graded. Ordinary portland cement or Portland Pozzolona cement that meets applicable Indian standards should be used. To prevent efflorescence, water should be free of toxic chemicals and salts.

3.4.3 CONCRETE MIX

For manufacturing blocks with compressive strengths greater than 6Okg/cm2, the concrete mix should be lean, with a slump of 15 to 20 mm and a quantity of 1:5:8. We used various grades of concrete in this experiment, including M7.5, M10, M15, M20, and M25. To give the blocks a better finish, a slightly over sanded concrete mix is recommended. It should be remembered that using stone spalls saves money on cement because they have a higher compressive strength and lower drying shrinkage.

3.4.4 CASTING OF BLOCK

i) Clean the platform and mould properly with grease or oil and place the moulds individually or near to one another so as to make it easier to demould.

ii) Place wide stone spalls at the bottom of the moulds with a minimum gap of 15mm between any two stones and the mould to ensure proper concrete filling..

iii) Fill the gaps in the mould with the lean concrete with the help of trowel or tamping rod.

iv) Vibrate the concrete mix properly with the table vibrator on the top surface and demould the block after 10mins of manufacture.

v) 30 samples of different grades and 6 samples of each grade were made out of which 15 blocks have been cured for 7 days and 15 blocks were cured for 28 days.

Figure 3.9: Placing of two stones in mould

Figure 3.10: Filling gaps around stone with concrete

3.4.5 TESTING OF SAMPLES

Thirty samples were made in total, out of which six samples were made for each grade out of which two blocks contained only the concrete mix, two blocks contained one big stone and the other two contained two small stones. These blocks were examined after 7 days of curing and 28 days of curing and their compressive strengths were checked accordingly. The main aim of this test is to see the benefit of adding stone to the block whether it provides more strength to the block and shows required results or not. Testing was done with the help of a UTM machine of 1000KN load.

Figure 3.11: Testing of blocks in UTM machine

According to the testing done on the blocks following data was specified, which is shown in the graphs below and the data of the test is shown accordingly in the tables below:

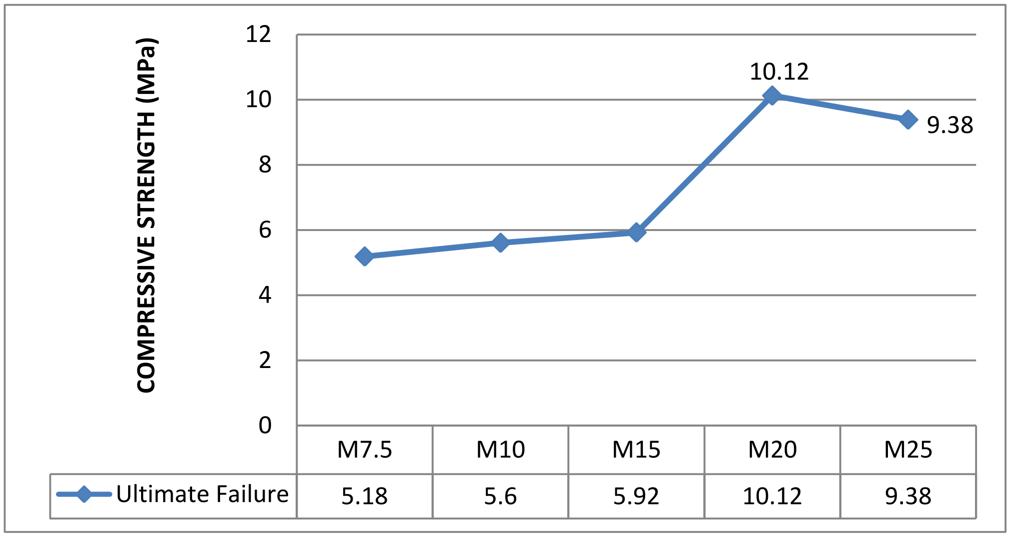


Figure 3.12: Compressive strength of Simple concrete block cured for 7 days

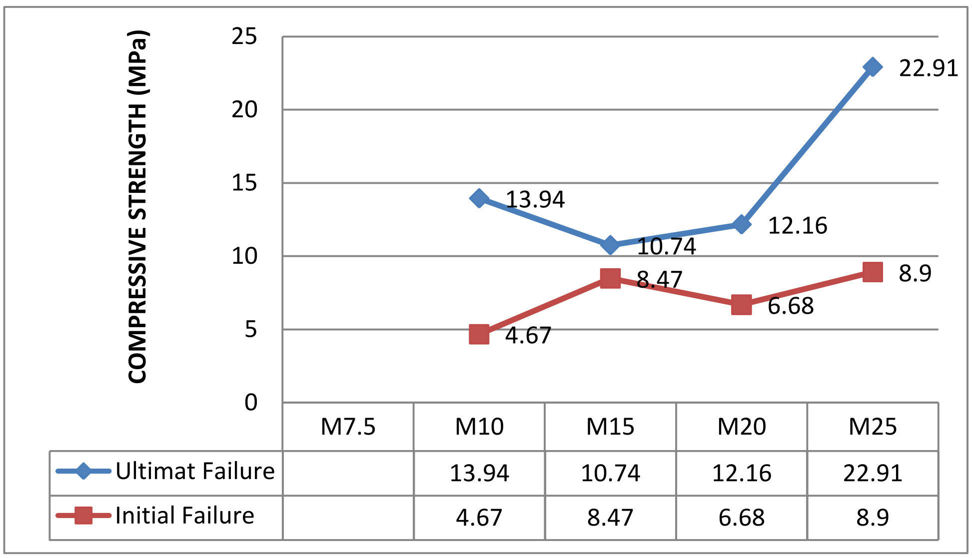


Figure 3.13: Graph showing compressive strength of Single Big stone concrete block cured for 7 days

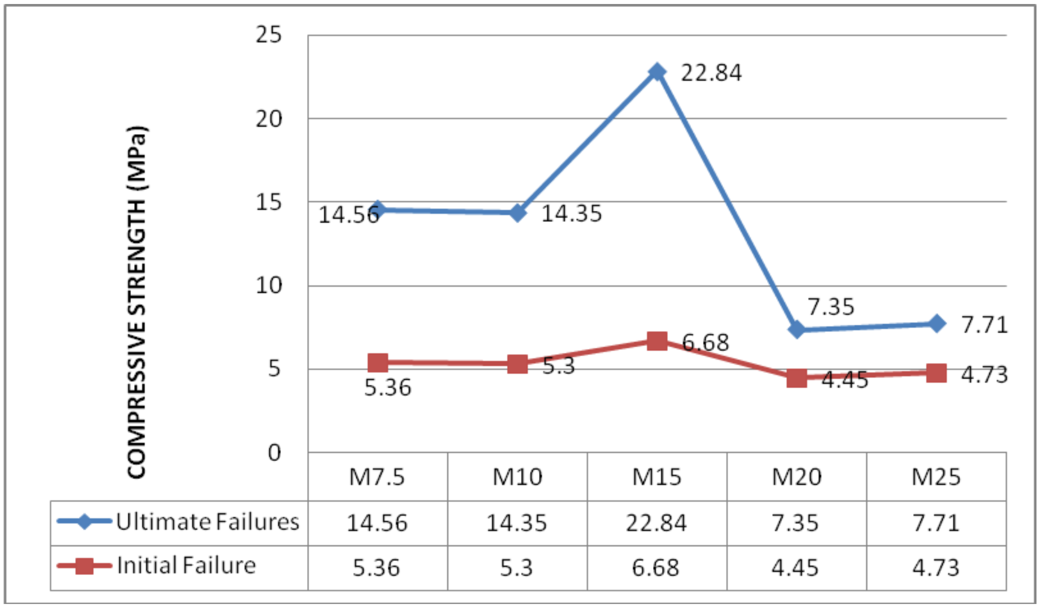


Figure 3.14: Graph showing compressive strength of two small stones concrete block cured for 7 days

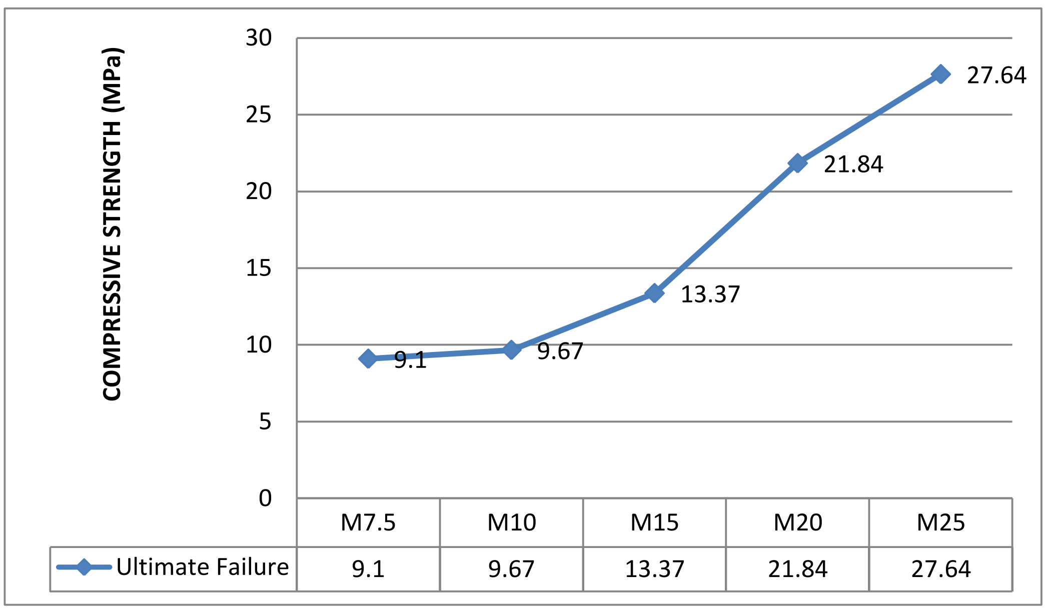
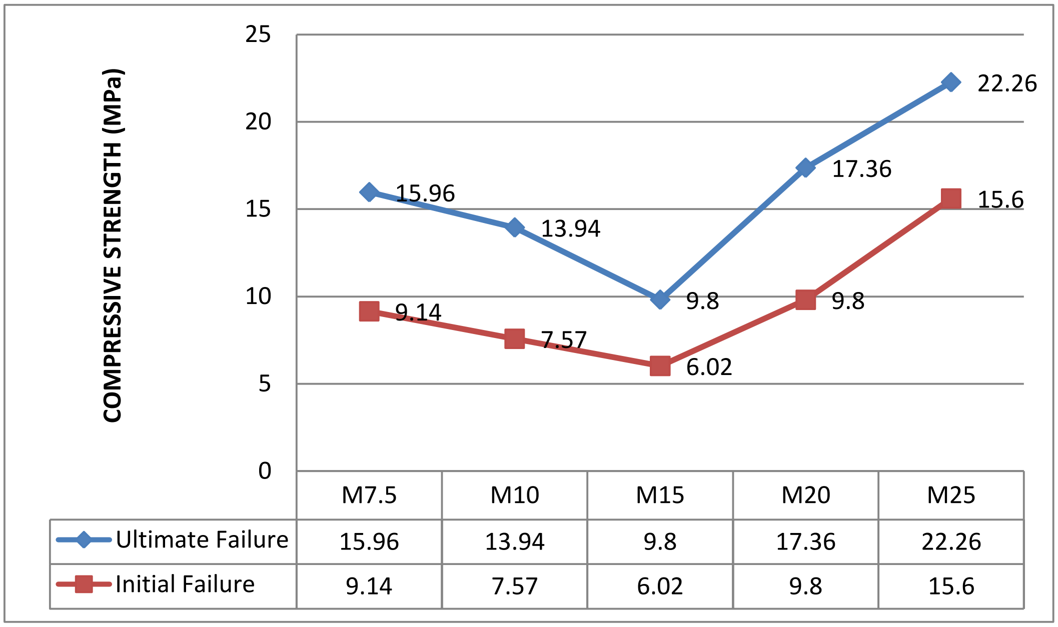
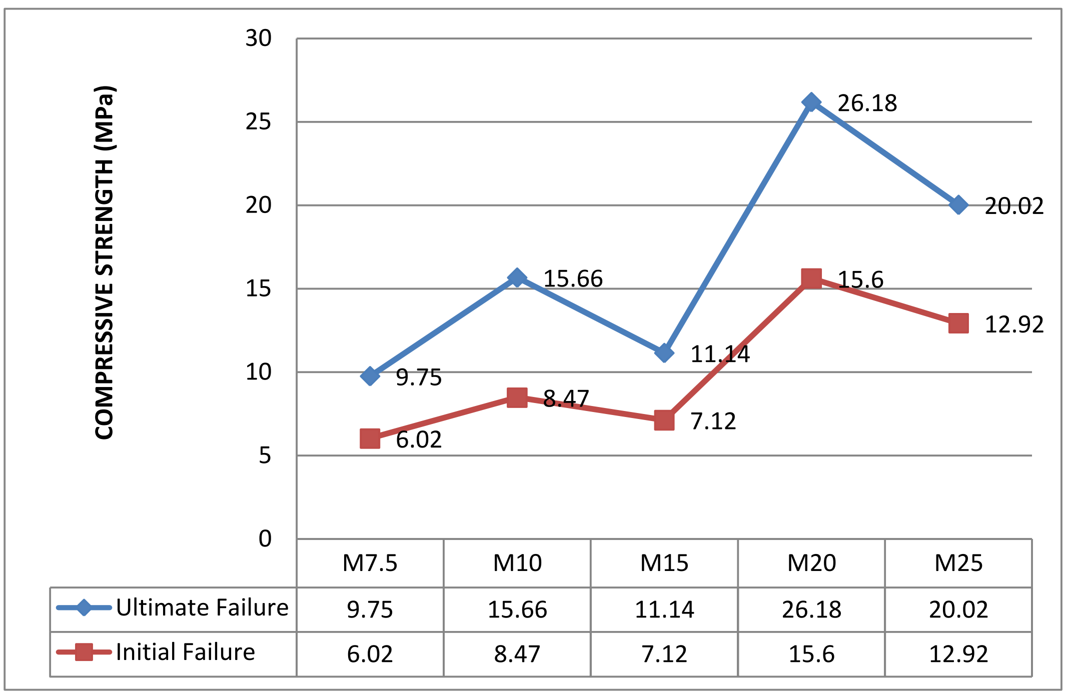


Figure 3.15: Graph showing compressive strength of Simple concrete block cured for 28 days



	M7.5	M10	M15	M20	M25
Ultimate Failure	15.96	13.94	9.8	17.36	22.26
Initial Failure	9.14	7.57	6.02	9.8	15.6

Figure 3.16: Graph showing compressive strength of Single Big stone concrete block cured for 28 days



	M7.5	M10	M15	M20	M25
Ultimate Failure	9.75	15.66	11.14	26.18	20.02
Initial Failure	6.02	8.47	7.12	15.6	12.92

Figure 3.17 Graph showing compressive strength of two small stones concrete block cured for 28 days

Stone-crete blocks for 7 days curing are given in the following table below:

S.No.	Date of construction of blocks	No. of Days for Curing	No. of stones	Grade of Concrete	Weight of Concrete block	Specific Weight (KN/m3)	Load at Initial Failure	Load at Ultimate Failure
1	22/9/2020	7	0	M7.5	18.94kg	21.04	118.4KN	118.4KN
2	22/9/2020	7	1 BS	M7.5	19.40kg	21.55	71.5KN	Failed
3	22/9/2020	7	2 SS	M7.5	21.16kg	23.51	120.5	327KN
4	22/9/2020	7	0	M10	19.60kg	21.78	125.7KN	125.7KN
5	22/9/2020	7	1 BS	M10	20.21kg	22.45	105KN	313KN
6	24/9/2020	7	2 SS	M10	19.44kg	21.60	119KN	119KN
7	24/9/2020	7	0	M15	17.49kg	19.43	64.3KN	64.3KN
8	29/9/2020	7	1 BS	M15	20.66kg	22.95	190KN	240.9KN
9	29/9/2020	7	2 SS	M15	21.70kg	24.11	150KN	513.6KN
10	29/9/2020	7	0	M20	19.18kg	21.31	110KN	227.2KN
11	29/9/2020	7	1 BS	M20	20.15kg	22.38	150KN	272.9KN
12	29/9/2020	7	2 SS	M20	21.58kg	23.97	100KN	165KN
13	29/9/2020	7	0	M25	19.49kg	21.65	100KN	210.5KN
14	29/9/2020	7	1 BS	M25	20.30kg	22.55	200KN	514KN
15	30/9/2020	7	2 SS	M25	20.19kg	22.43	73.8KN	242.4KN

Table 3.2: Data representing the initial and ultimate failure loads for blocks cured for 7 days.

S.No.	Date of construction of blocks	No. of Days for Curing	No. of stones	Grade of Concrete	Weight of Concrete block	Specific weight (kN/m3)	Load at Initial Failure	Load at Ultimate Failure
1	22/9/2020	28	0	M7.5	20.270kg	33.78	205KN	205KN

2	26/9/2020	28	1 BS	M7.5	21.310kg	35.51	205KN	359.4KN
3	26/9/2020	28	2 SS	M7.5	19.820kg	33.03	135KN	219KN
4	22/9/2020	28	0	M10	20.270kg	33.78	125KN	125KN
5	28/9/2020	28	1 BS	M10	20.210kg	33.68	170KN	312.9KN
6	29/9/2020	28	2 SS	M10	21.340kg	35.56	190KN	351.5KN
7	29/9/2020	25	0	M15	19.270kg	32.11	162KN	162KN
8	29/9/2020	28	1 BS	M15	20.420kg	34.03	135KN	220KN
9	29/9/2020	28	2 SS	M15	21.720kg	36.20	160KN	250KN
10	29/9/2020	28	0	M20	19.720kg	32.86	232KN	232KN
11	29/9/2020	28	1 BS	M20	20.520kg	34.20	220KN	390KN
12	29/9/2020	28	2 SS	M20	21.220kg	35.36	350KN	590KN
13	30/9/2020	28	0	M25	20.320kg	33.86	350KN	350KN
14	30/9/2020	28	1 BS	M25	20.920kg	34.86	350KN	500KN
15	30/9/2020	28	2 SS	M25	21.320kg	35.53	290KN	450KN

Table 3.3: Data representing the initial and ultimate load failure of blocks for 28 days curing

Here, 1 BS = 1 Big Stone

2 SS = 2 Small stones

0 = No stone (Normal Concrete block)

Weight of 1 single stone is taken to 6.35kg

Considering the shape of the stone to be polygonal having 3 sides:

Depth of stone d = 50 mm

Length of stone L = 100mm

Weight of small stone = 4.5kg

Volume = $(1/4.\ n\ L^2 \cot(\pi/n)).d = 0.0002165\ m^3$

Density = 287.4 KN/m^3

Compacting of concrete is done with the chisel rod due to which values of few blocks vary.

In the next table compressive strength of blocks were formed using the data of the tables above:

S No.	No. of days of curing	No. of stones in block	Grade of concrete	Pressure (kg/m^2)	Compressive strength (KN/m^2)
1	7	0	M7.5	315.66	5.18
2	7	1 BS	M7.5	323.33	-
3	7	2 SS	M7.5	352.66	14.56
4	7	0	M10	326.66	3.6
5	7	1 BS	M10	336.83	13.94
6	7	2 SS	M10	324.80	14.35
7	7	0	M15	291.5	5.92
8	7	1 BS	M15	344.33	10.74
9	7	2 SS	M15	361.66	22.84
10	7	0	M20	319.66	10.12
11	7	1 BS	M20	335.83	12.16
12	7	2 SS	M20	359.66	7.35
13	7	0	M25	324.83	9.38
14	7	1 BS	M25	338.33	22.91
15	7	2 SS	M25	336.5	7.71
16	28	0	M7.5	337.8	7.1
17	28	1 BS	M7.5	355.1	15.96
18	28	2 SS	M7.5	330.3	9.75
19	28	0	M10	337.8	9.67
20	28	1 BS	M10	336.8	13.94
21	28	2 SS	M10	355.6	15.66
22	28	0	M15	321.1	13.37
23	28	1 BS	M15	340.3	9.8
24	28	2 SS	M15	362.0	11.14
25	28	0	M20	328.6	21.84

26	28	1 BS	M20	342.0	17.36
27	28	2 SS	M20	353.6	26.18
28	28	0	M25	338.6	27.64
29	28	1 BS	M25	348.6	22.26
30	28	2 SS	M25	355.3	20.02

Table 3.4 Compressive strength of the blocks

To find the compressive strength of the blocks the IS code is.12440.1988 is used whose values are shown in figure below:

TABLE 1 COMPRESSIVE STRENGTH OF CONCRETE STONE MASONRY BLOCKS

(*Clauses* 4.1 *and* 7.3)

CLASS DESIGNATION	MINIMUM AVERAGE* COMPRESSIVE STRENGTH OF BLOCKS N/mm^2	MINIMUM STRENGTH OF INDIVIDUAL BLOCKS N/mm^2
5	5·0	3·5
6	6·0	4·2
7	7·0	5·0
9	9·0	6·3
10	10·0	7·5

*For 100 mm wide blocks (for 100 mm thick walls), the minimum strength may be 3·5 N/mm^2.

Figure 3.18 Compressive strength of concrete stone masonry blocks [27]

3.5 MIX DESIGN

The properties required in the fresh and solidified state are expressed by concrete mix proportioning. Plastic concrete's properties are important for proper compaction. Hardened concrete has the strength and toughness of a conclusive framework. The proportion of water to cement is fundamentally linked between the two. The art of proportioning a concrete blend for a particular design therefore ensures that the various elements of appropriate concrete are in optimal proportion with the required properties at the lowest cost. The minimum cement content should be a properly proportioned concrete blend with specific criteria for workability, strength and durability to make the blend generally economical.

The method of selecting required concrete elements to achieve the least strength and durability while at the same time being as cost-effective is known as mixing design and determining their relative proportion. There are two explanations for planning, as can be seen from the definitions above. The key objective is to have as little strength and endurance as possible. The second objective is to produce concrete as quickly as possible. All grades of concrete, in terms of cost, are primarily determined by two variables: material cost and labor cost. For good and poor concrete, labor costs are almost identical due to formwork, bunching, mixing, transporting, and curing. As a result, the cost of materials receives the most publicity. Since cement is so much more expensive than other materials, the focus is on using as less cement as possible while still maintaining strength and durability.

3.5.1 MIX PROPORTIONING FOR A CONCRETE OF M30 GRADE

1. **DESIGN SPECIFICATIONS**

a) Grade = M30

b) Cement = Ordinary Portland cement 43grade

c) Size of aggregate = 20mm angular

d) Workability = 75mm (slump)

e) Supervision = Good

f) Exposure = Severe(for reinforced concrete)

g) Chemical admixture = superplasticizer

2. **TEST DATA FOR MATERIALS**

a) Cement = Ordinary Portland cement 43grade as per IS 8112

b) Specific gravity for cement = 2.91

c) Specific gravity for coarse aggregate = 2.65

d) Specific gravity for fine aggregate = 2.7

e) Water absorption for coarse aggregate =1.5%

f) Target mean strength:

TMS= f_{ck} +1.65s = 30 + 1.65x5 = 38.35 N/mm^2

g) Water content = 186 Kg/m^3 (from IS: 10262 for 20mm nominal size of aggregate)

For 75mm slump, Water content = 186 x (3/100 x186) = 192 Kg/m^3

Water content = 192 x .77 = 148kg/m^3

h) Cement content = W/ (w/c) = 148/0.45 = 329 kg/m^3

i) According to IS:10262 Table 3 for Zone III:

Volume of CA = 64%

Volume of FA = 1- 0.64 = 0.36

Volume of cement = 342/2.91 x 1/1000 = 0.117 m^3

Volume of water = 0.148m^3

Mass of FA => 1000(1- 0.02) = 329/2.91 + 148 + (F_a/2.7x0.36) = 716 kg/m^3

Mass of CA => 1000(1-0.02) = 329/2.91 + 148 + (C_a/2.67x0.64) = 1259 kg/m^3

Table 3.5 Design Mix Proportions

Water/cement ratio : 0.45			
Water(kg/m^3)	Cement(kg/m^3)	Fine aggregate (kg/m^3)	Coarse aggregate (kg/m^3)
148	329	716	1259

Final mix design – 1:2.17:3.82

3.5.2 MIX PROPORTIONING FOR A CONCRETE OF M35 GRADE

1. **DESIGN SPECIFICATIONS**

a) Grade = M35

b) Cement = Ordinary Portland cement 43grade as per IS 8112

c) Size of aggregate = 20mm angular

d) Workability = 100mm (slump)

e) Degree = Good

f) Exposure = Severe (for reinforced concrete)

g) Chemical admixture = superplasticizer

2. **TEST DATA FOR MATERIALS**

a) Cement = Ordinary Portland cement 43grade

b) Specific gravity for cement = 2.91

c) Chemical admixture = superplasticizer

d) Specific gravity for coarse aggregate = 2.65

e) Specific gravity for fine aggregate = 2.7

f) Water absorption of coarse aggregate =1.5%

g) Volume of cement = 0.120m^3

h) Volume of CA = 0.64

i) Volume of FA = 0.34

Table 3.6: Mix Design Proportions

Water to cement ratio : 0.45			
Water (kg/m^3)	Cement (kg/m^3)	Fine aggregate (kg/m^3)	Coarse aggregate (kg/m^3)
158	351	699	1229

Mix design – 1:1.99:3.5

3.6 DESIGN OF RETAINING WALL

A retaining wall is any structure that holds soil or other materials in place at a point where the elevation changes abruptly. Retaining walls are the supporting structures that keep the soil or excavated part of the hill from collapsing on the area where people are currently living. These are essentially rigid structures that are in place to prevent soil from collapsing at various levels. These walls are built to prevent or maintain soil from dropping from the elevations of unfavourable slopes or in areas where landscapes may occur, and they must be engineered for purposes such as farming in hilly areas or along highways where moment is more common. Retaining walls are designed to withstand the lateral pressure of soil or a wedge of soil [28].

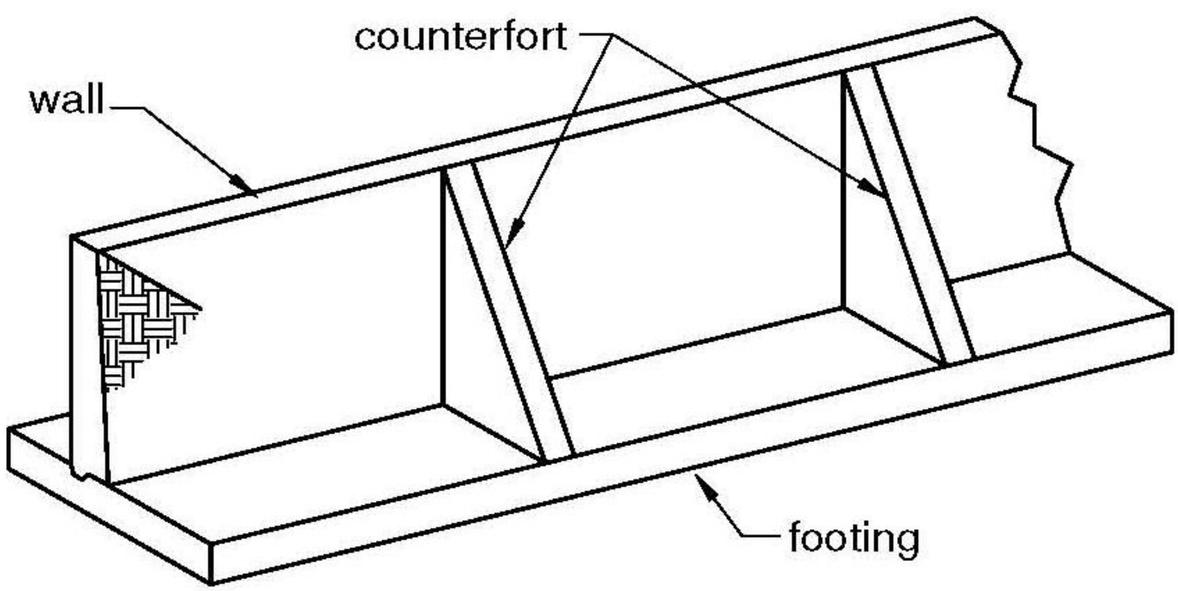


Figure 3.19 Counterfort Retaining Wall

3.6.1 DESIGN OF COUNTERFORT RETAINING WALL

Due to the extreme large number of components that must be designed differently than a conventional cantilevered vertical wall, the design of a counterfort wall can be difficult. The steps for building a rcc counterfort wall are as follows:

1. Choose a counterfort spacing that is one-half to two-thirds of the retained height after deciding the height. Determine the necessary foundation width and soil bearing at both the toe slab and heel slab for counterfort proportions, and then design considering the wall as a rcc cantilevered wall for stability calculations. As a longitudinal axial weight, you should apply the estimated weight of the counterforts..
2. Designing the wall that is fixed at the base and having a crossing at counterforts but keeping it free at the top just like the two way slab.
3. Create a cantilever from the wall with the footing toe.
4. 4. Make the heel a longitudinal beam that spans the counterforts.
5. 5. Build a counterfort. It will be a tension member with a tapered trapezoidal shape.
6. 6. Check for stability, overturning, slipping, and soil pressures in the final design.
7.

3.6.2 DESIGN OF A LIVE CONTERFORT RETAINING WALL

In this document a live counterfort retaining wall structure has been studied. The design was taken from the HPPWD Department for the analysis of this project. The design parameters are thoroughly studied on a counterfort retaining wall located at Shoghi-Mehli road. The design considerations are as follows:

Table 3.7: Data considered for design

Sr. No.	Specifications	Values
1	Unit Weight of backfill soil	20 KN/m^2
2	Safe bearing capacity of soil	270.00 KN/m^2
3	Internal friction	40.00 ^{0}
4	Wall friction	20.00 ^{0}
5	Angle representing back face of wall with the vertical	0.00 ^{0}

6	Slope of earthfill	$i = 0.00^{0}$
7	Unit weight of concrete	25.00 kN/m^3

a) CALCULATION OF HORIZONTAL AND VERTICAL SEISMIC CO-EFFICIENT

For relevant seismic data, the IS: 1893:2002 Part I is referred to. The horizontal seismic coefficient can be determined as follows:

$$\alpha_h = Z/2 \times I/R \times S_a/g$$

where, α_h = Horizontal seismic coefficient

Z = Seismic Zone factor

I = Importance factor

R = Response reduction factor

S_a/g= Spectral acceleration coefficient or flexibility factor

Seismic Zone of area = IV

Z, Seismic Zone factor = 0.26

I , Importance factor = 1.00

R, Response reduction factor = 1.50

Putting all these values in α_h,

$$\alpha_h = (0.26x1x1)/(2x1.5) = 0.09$$

The vertical acceleration coefficient, α_v= 2/3 x

$$\alpha_h = 0.06$$

b) PROPORTIONING OF WALL COMPONENTS

- Wall Height above base = H 9.37 m
- Base width, b = 0.6 H to 0.7 H i.e. 5.62 m to 6.56 m
- Take Base width, L = 5.00 m
- Toe Projection =b/4 = 1.25 m

Provide Toe Projection = 1.30 m

- Thickness of stem slab =0.06H = 0.56 m

Provide thickness of stem slab = 0.60 m

- Thickness of stem slab at top = 0.40 m
- Spacing of counterfort, = 2.90 m
- Provide spacing of counterforts = 2.875 m

- Assume thickness of counterforts = 0.40 m
- C/C spacing of counterfort = 3.275 m
- Thickness of base slab shall be nearly = i) 119.60 cm = 1.20 m

ii) 61.37 cm = 0.61 m

- Provide thickness of base slab = 0.63 m
- Length of heel slab = 3.10 m

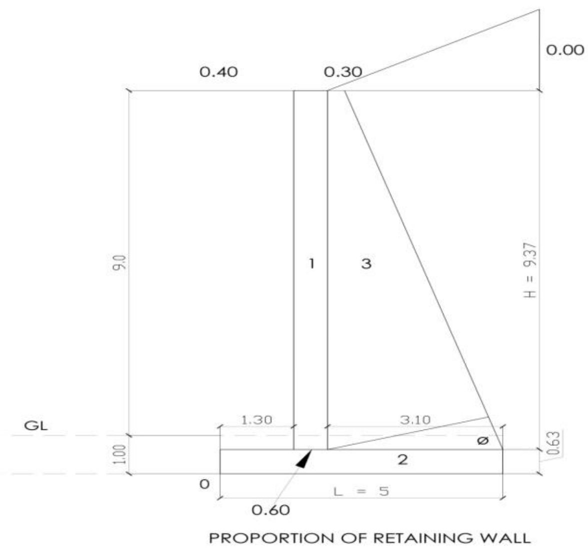


Figure 3.20 Proportioning of Retaining Wall

c) CALCULATION OF PRESSURES

- Active pressure = 175.07 kN/m
- Dynamic pressure = 232.83 kN/m
- Dynamic increment = 57.76 kN/m
- Horizontal Component Active Pressure,

$$P_a.\cos(i) = 175.08x\cos 0 = 175.07 \text{ kN/m}$$

- Vertical Component of Active Pressure,

$$P_a.\sin(i) = 175.08x\sin 0 = 0.00 \text{ kN/m}$$

- Horizontal Component of Dynamic increment

$$\Delta P_e.\cos(i) = 57.76x\cos 0 = 57.76 \text{ kN/m}$$

- Vertical Component of dynamic increment

$$\Delta P_e.\sin(i) = 175.08x\sin 0 = 0.00 \text{ kN/m}$$

- Horizontal componemnt of active pressure will act at H/3 from base and horizontal component of dynamic increment will act at H/2 from base.

d) CHECK STABILITY OF WALL

Calculation of weight

- *Section 1*
- Distance of C.G. From 'O' in horizontal direction 2.61

= 0.5x(0.6-0.4)x(9.37-0.63)x2/3(0.6-0.4)+0.4x(9.37-0.63)x(1.3+(0.6-0.4)+(0.4/2) = 109.25KN

0.5x(0.6-0.4)x(9.37-0.63)+(0.4x(9.37-0.63))

- Distance of C.G. From 'O' in vertical direction 7.10m

=0.5x(0.6-0.4)x(9.37-0.63)x(1+(1/3(9.37-0.63))+0.4x(9.37-0.63)x(0.63+1/2(9.37-0.63)

7.10 m 0.5x(0.6-0.4)x(9.37-0.63)+(0.4x(9.37-0.63)

= 78.75 KN

Section 2 = 78.75 kN

Distance of C.G. From 'O' in horizontal direction= 5/2 = 2.50 m

Distance of C.G. From 'O' in vertical direction= 0.32 m

Section 3:

Weight of soil = 3.1x(9.37-0.63)x20 = 541.88 kN

Distance of C.G. from O= - 5-(3.1/2) = 3.45 m

Section 4

Weight of triangular portion of soil = 0.5x0x3.1x20 = 0.00 kN

Distance of C.G. from O= 5-(1/3x3.1) = 3.97 m

- Bitmap Factor of safety against overturning = =2359.31/901.01 = 2.62 **SAFE**
- Co-efficient of friction of soil and wall at base = = 0.84
- Take value = 0.60
- Factor of safety against sliding= = 1.78 **SAFE**
- Net Moment ∑M= = 1458.29 kNm
- let x, distance from toe where the resultant R acts,
- x=∑M/∑W = 1.96 m
- ` Eccenticity ,e = 0.54
- No Tension will Occur

- Maximum pressure at toe = 744.88/5(1+6x0.55/5)= 245.91 kN/m^2 O.K.
- Minimum pressure at heel = 744.88/5(1-6x0.55/5)= 52.04 kN/m^2

e) DESIGN OF TOE SLAB

Grade of concrete = M20

- Moment factore R^u for M20 = 2.76
- Strength of Concrete f_{ck} = 20 kN/m^2
- Strength of Steel f_y = 415 kN/m^2
- Pressure Intensity at B = 195.51 kN/m^2

The forces acting on toe slab are:

i) Weight Downward of toe slab

ii) Soil pressure on length AB

- Moment at 'B =195.51x1.3^2/2+(245.92-195.51)x1.3(2/3x1.3) -20x1.3x0.63x1.3/2 = 208.69 kNm
- Factored Moment =1.5x208.69 = 313.03 kNm
- Depth required , = 336.77 mm
- Depth Provided = 590.00 mm

OK

- Area of steel required = 1555.29 mm^2
- Minimum area of steel required =0.12x1000x590/100 = 708.00 mm^2
- Use Dia of Bar = 16 mm
- Spacing required =201x1000/1555.3 = 129.24 mm
- Provide Spacing = 100 mm Area of steel provided = 2010 mm^2

f) CHECK FOR SHEAR

- The critical shear section is measured at a distance of d from the front of the stem, because of the pressure of the soil causing wall compression. 590 mm from the supporting side Pressure intensity =52.04+(245.92-52.04)x(3.7+0.59)/5 = 218.38 kN/m2
- Vertical Net Shear = Shear because of a lower force of 0.71 m in length, with the pressure between 218.38 and245.91 kN / m2 minus shear=218.39+245.92x0.71/2-(25x0.63x0.71) = 159.23 kN
- Factored shear force = 238.85 kN
- Shear stress, = 0.40 N/mm^2

- P_t =100x2010/1000x590 = 0.34
- Shear Strength of concrete, = 0.41 N/mm^2
- *No Shear Reinforcement Required*
- No. of legs of vertical stirrups = 4
- Dia of stirrups = 10.00 mm
- Area of stirrups, Asv = 314.16 mm2
- Spacing of stirrups required = -25602.48 mm
- Provide spacing 0 mm

g) DESIGN OF HEEL SLAB

• The heel plate is a permanent plate that is protected by reinforcements. At the edge of the plate the downward force is greatest, when the pressure on the soil is less intense. Take a 1 m broad band near the edge of D. The forces acting close to the edge are the following; i) Upward weight of soil of height; ii) Upward weight of soil = 174.80 kN/m

ii) Downward wieght of heel slab = 15.75 kN/m

iii) Upward soil pressure intensity at D = 52.04 kN/m

- Net Pressure, P = 138.51 kN/m
- Maximum moment = = 123.80 kNm
- Factored Moment = 185.70 kNm
- Area of steel required = = 900.73 mm^2
- Minimum area of steel required =0.12x1000x590/100 = 708.00 mm^2
- Use Dia of Bar = 16 mm Spacing required =201x1000/900.74 = 223.15 mm
- Provide Spacing = 100 mm
- Area of steel provided = 2010 mm^2

Provide 16mm dia bars @100 C/C

h) CHECK FOR SHEAR

- Maximum shear force 158.25 kN
- Factored shear force = 237.37 kN
- Shear stress, = 0.40 N/mm^2
- P_t =100x2010/1000x590 = 0.34
- Shear Strength of concrete, = 0.41 N/mm^2

No Shear Reinforcement Required

i) DISTRIBUTION STEEL

- A_{st} on each face =0.12x1000x590/2x100 = 354.00 mm^2
- Use Dia of Bar = 12 mm
- Spacing required =113x1000/354 = 319.21 mm
- Provide Spacing = 200 mm Area of steel provided = 565 mm^2

j) DESIGN OF STEM (VERTICAL SLAB)

- Between counterforts, the wall serves as a continuous slab. It is subjected to earth pressure that varies linearly and reaches its highest strength at the bottom.
- • At C, consider a 1 m wide strip at the last of the stem.
- • Earth pressure at the base of the stem slab = 0.27x20x(9.37-0.63) = 46.36 kN/m
- Horizontal component of earth pressure = 46.36 kN/m
- Moment, Maximum moment = = 31.93 kNm
- Factored Moment = 47.89 kNm
- Effective depth of stem slab = 540.00 mm
- Area of steel required = = 423.01 mm^2
- Minimum area of steel required =0.12x1000x/100 = 648.00 mm^2
- Use Dia of Bar = 12 mm
- Spacing required =113x1000/648 = 174.38 mm
- Provide Spacing = 100 mm
- Area of steel provided = 1130 mm^2

Provide 12mm dia bars @100 C/C

k) DISTRIBUTION STEEL

- A_{st} on each face =0.12x1000x314.159265358979/2x100 = 188.50 mm^2
- Use Dia of Bar = 12 mm 113.10
- Spacing required =113x1000/188.5 = 599.48 mm
- Provide Spacing = 200 mm
- Area of steel provided = 565 mm^2

Provide 12mm dia bars @200 C/C on each face

l) DESIGN OF COUNTERFORT

- The counterfort is 400mm thick.
- The counterforts have a C/C spacing of 2.875m.

- They are exposed to soil pressure and the downward reaction of heel.
- The horizontal earth pressure acting on the counterfort at any portion at any depth h below the top E.
- Base pressure strength = 46.36 kN/m
- Total Moment at base =0.5x46.36x8.74x2.875x8.74/3 = 1696.71 kNm
- Factored Moment = 2545.06 kNm
- Depth required , = 1518.32 mm
- Area of steel required = 2218.03 mm^2
- Minimum area of steel required = 1243.93 mm^2
- Use Dia of Bar = 20 mm
- No. of bars required = 7.06
- Bars Provided = 8
- Area of steel provided = 2512 mm^2

Provide 20mm dia bars

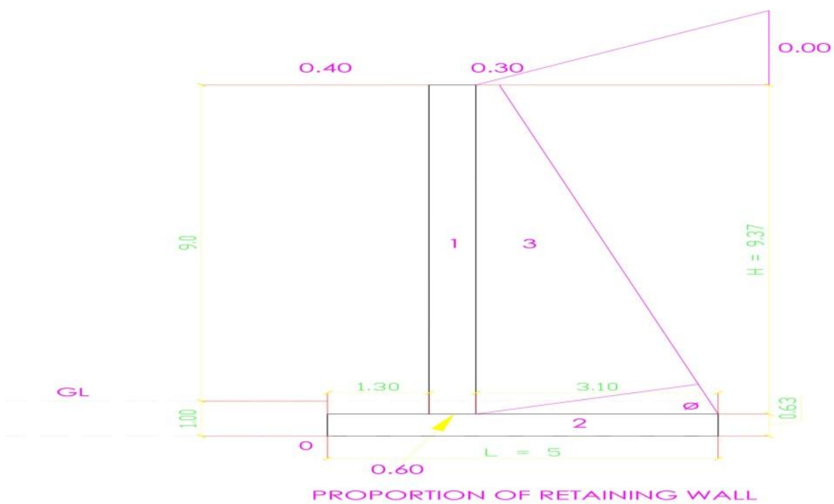


Figure 3.21 Retaining Wall design with counterforts

3.6.3 STAAD MODELLING OF COUNTERFORT RETAINING WALL

The design of the counterfort retaining wall has been studied through Staadpro and the design has been modeled on the Staadpro using the calculations and required specifications. Step by step methods has been followed to design the retaining wall on Staadpro.

Firstly, the geometry was considered of the model and using the surface meshing plates was formed by joining the nodes. Then, providing thickness to the walls as per the specifications in the design.

Thereafter, supports were applied to the bottom face of the base slab by assigning the loads to the nodes on the bottom face of the slab.

After the supports have been assigned to the structure concrete properties were defined for the structure.

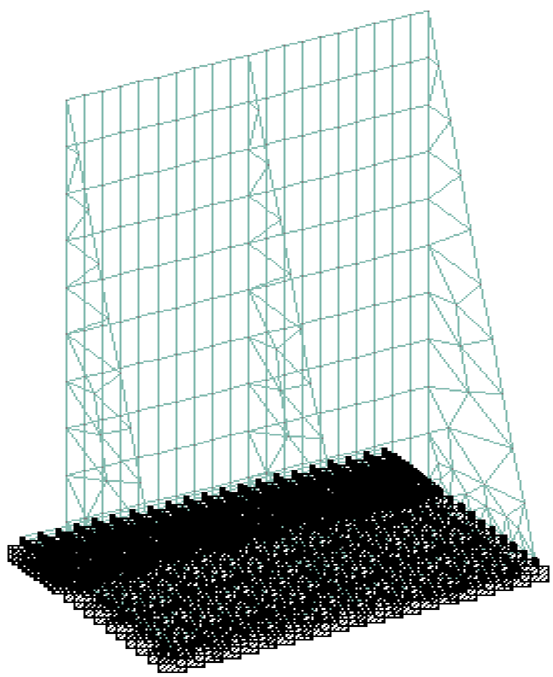


Figure 3.22 Providing Plates and Supports

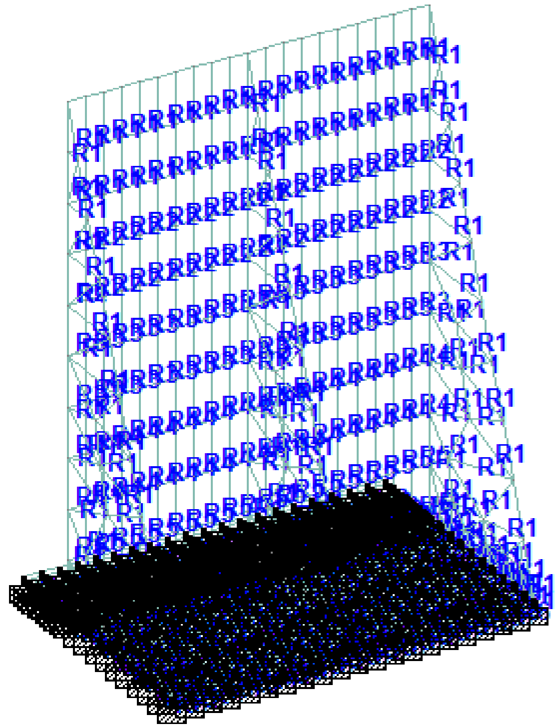


Figure 3.23 Providing concrete properties

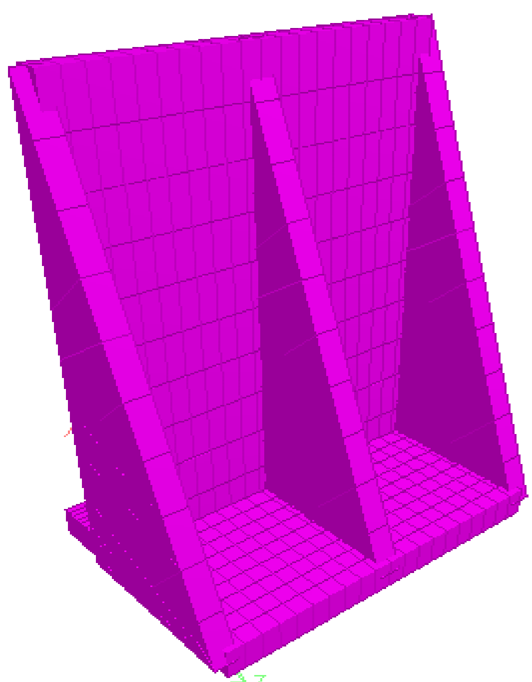


Figure 3.24 3d view of ret wall after providing thickness

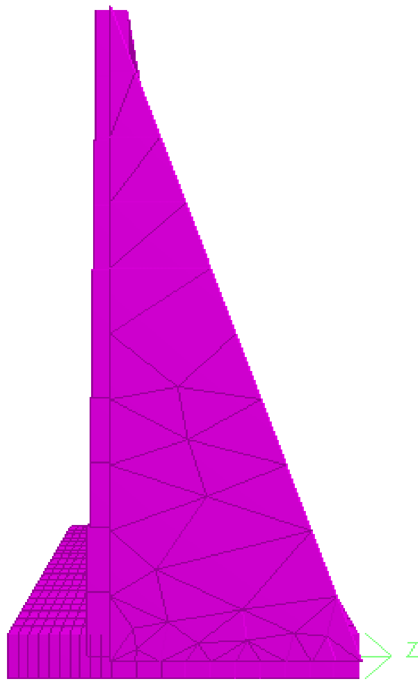


Figure 3.25 Providing thickness to the walls

Different set of load cases were applied on the retaining wall and their diagrams have been showed as follows:

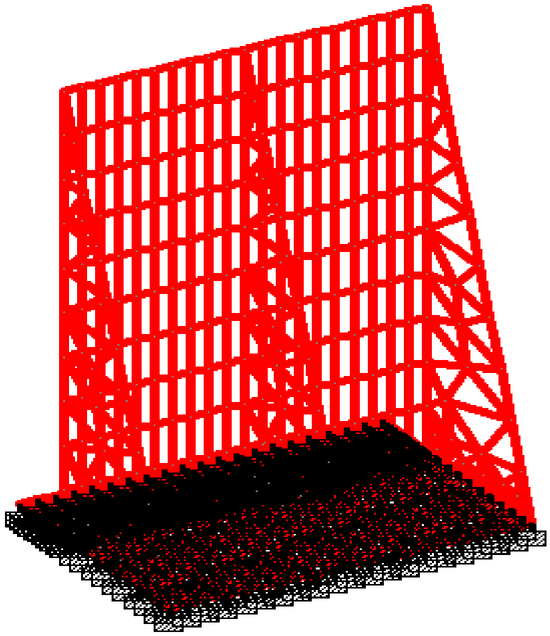


Figure 3.26 Load Case: Self Weight applied to the structure

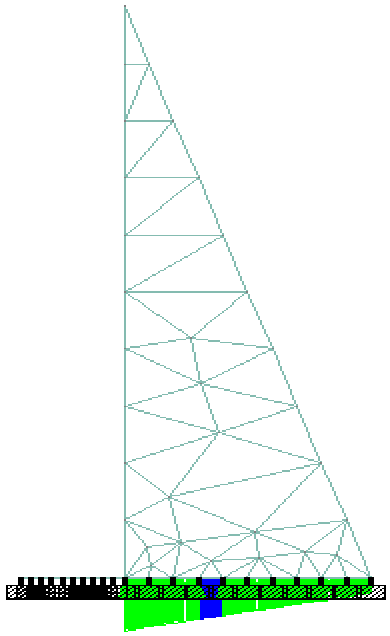


Figure 3.27 Load Case: Earth pressure at Toe slab = 195.51 KN/m^2 and 245.91 KN/m^2

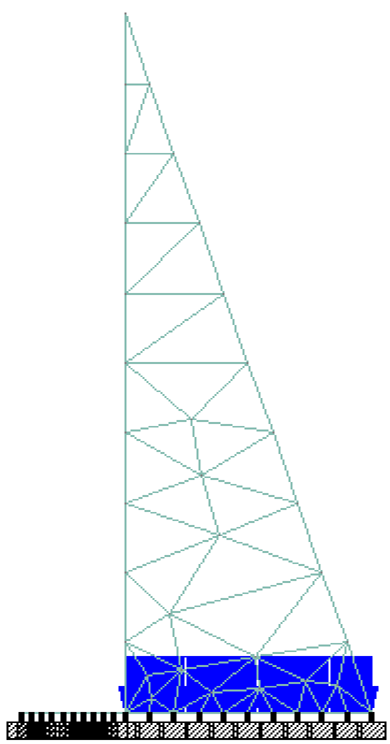


Figure 3.28 Load Case: Weight of Soil over Heel = 187.4 KN/m^2

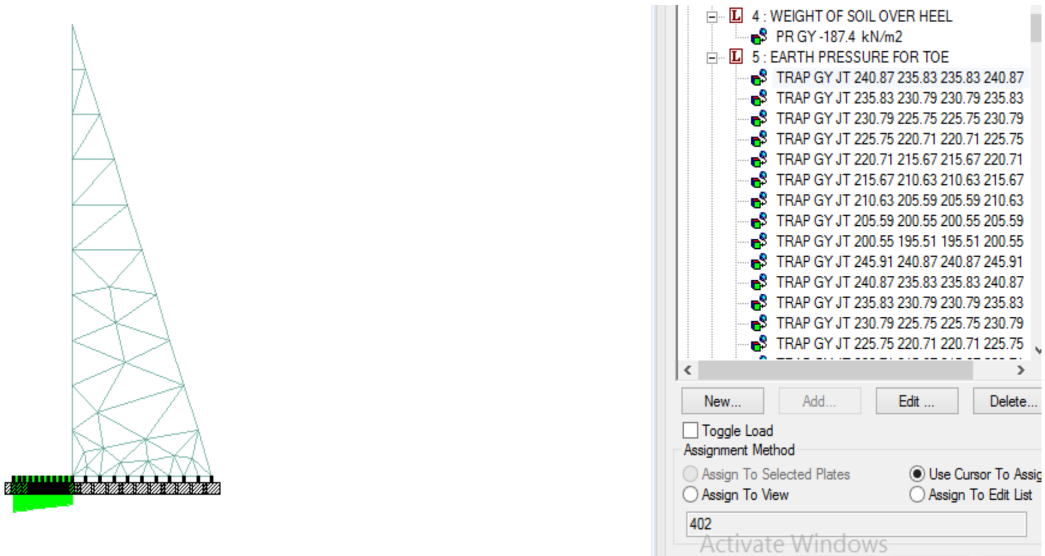


Figure 3.29 Load Case: Earth pressure at Toe slab = 195.51 KN/m^2 and 245.91 KN/m^2

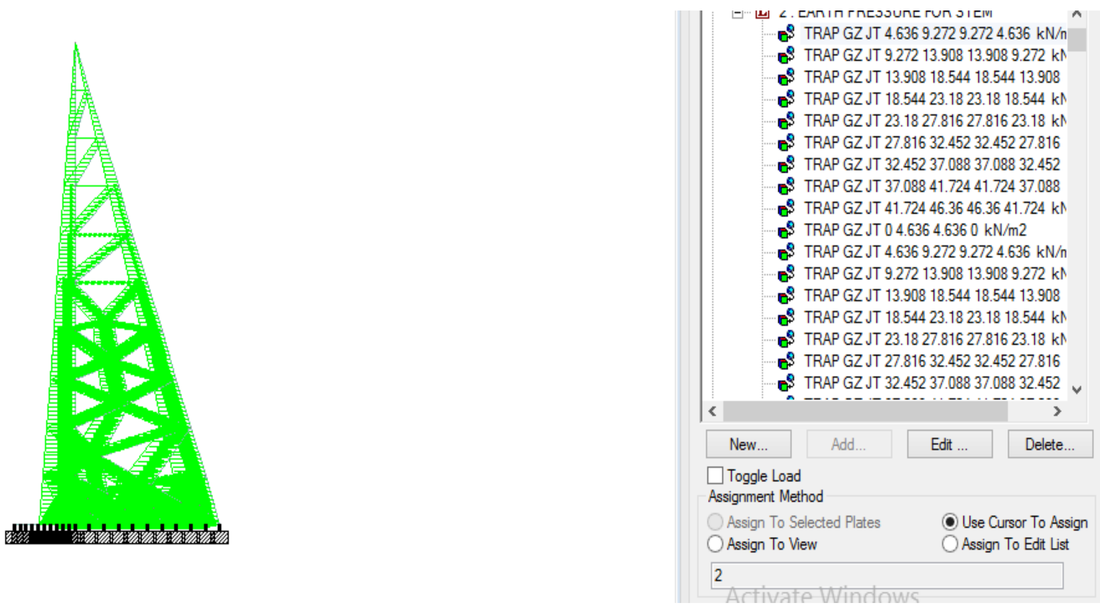


Figure 3.30 Load Case: Earth pressure at stem = 46.36KN/m

Plate thicknesses were taken accordingly for different portions of the retaining wall and the result of their specifications are as follows:

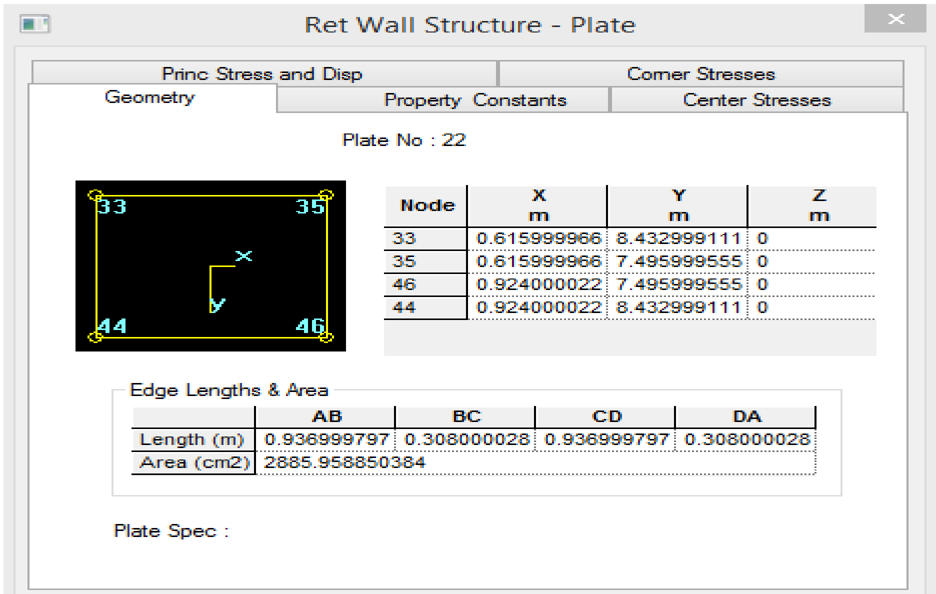


Figure 3.31 Geometry of the plates applied

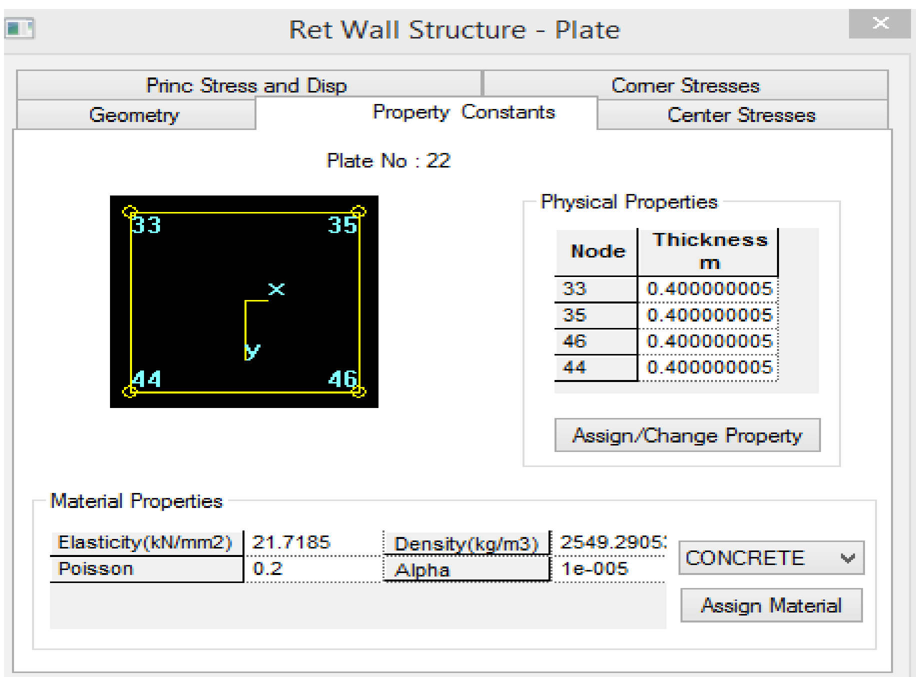


Figure 3.32 Properties applied on the plates

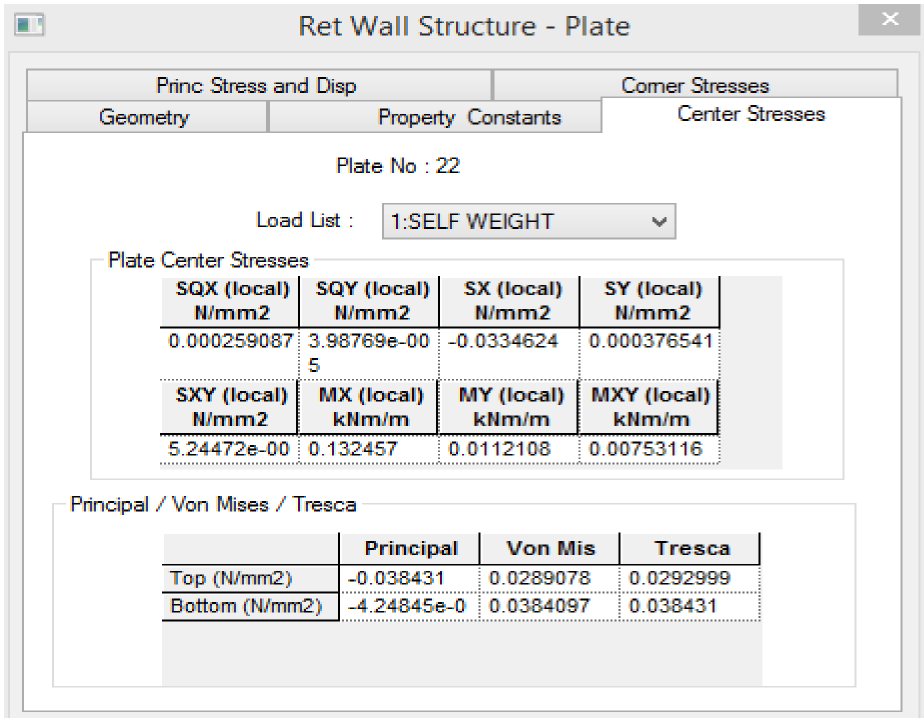


Figure 3.33 Stresses occurring on the plates

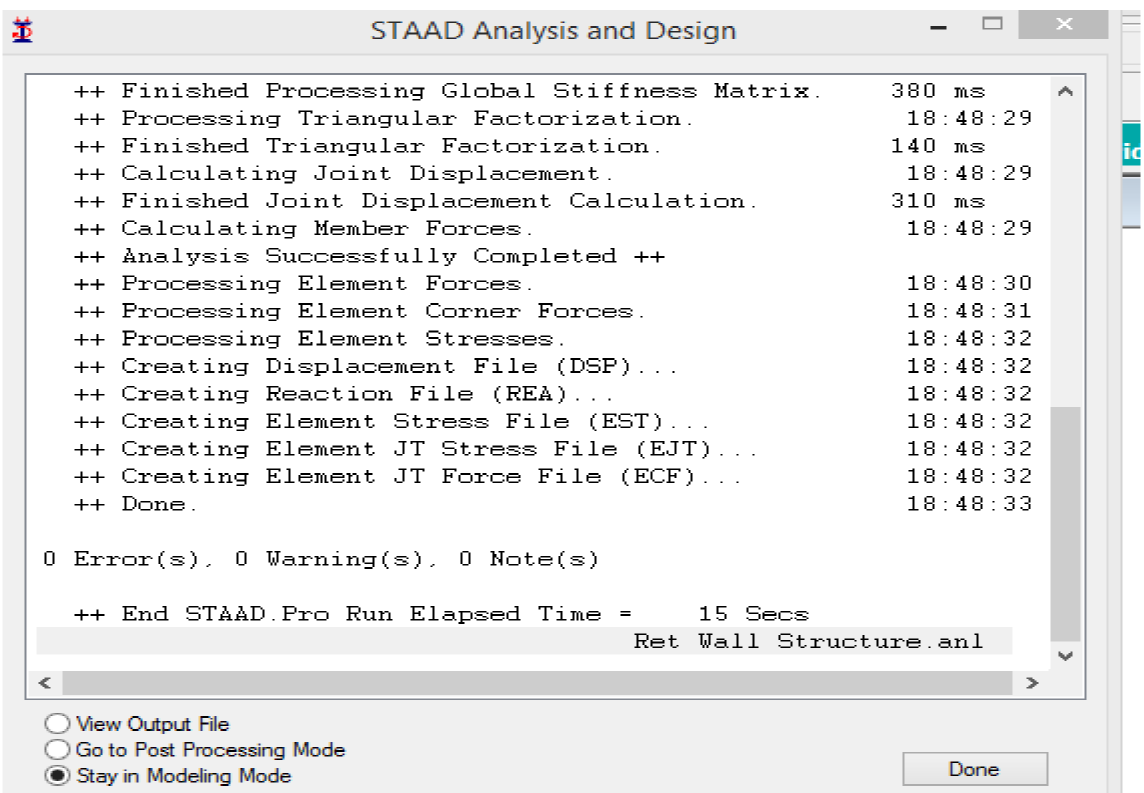


Figure 3.34 Run analysis of the structure with zero errors and warnings

Finally, a print analysis of the structure was attempted to check the errors and warnings of the structure and it was found that the structure had zero errors and warnings after designing the structure.

3.6.4 DESIGN OF COUNTERFORT RETAINING WALL USING CONCRETE BLOCKS

The design of counterfort retaining wall was done using concrete blocks with local demolition stones on Staadpro. A study was conducted by CBRI with the aim of reducing the thickness and degree of ability needed to create random rubble walls. Precast stone masonry blocks using stone spalls and a lean concrete mix with a natural stone texture on one side of the block were developed as a result of this research.

Stone-crete Blocks are usually 300x200x150 mm in size, resulting in 200mm thick walls. To ensure that the structure is hazard-resistant, these blocks are used in the same way that solid concrete blocks are used in the construction of masonry walls. Stone-crete blocks are less costly than brick walls if stones are available on site.

For ease of handling and other features, the block's nominal length and height were held at 300 mm & 150 mm, respectively, with 3 widths of 200, 150, and 100 mm. The block dimensions are kept 10 mm shorter to match the mortar joint. These blocks have a weight range of 90 to 180 N. The blocks are cast in such a way that the bottom face is revealed when they are laid in the wall, i.e. the block width is kept the same as the height of the moulds, and the height of the block is kept the same as the width of the mould.

The concrete blocks used for the experiment was of size 300x200x150mm. The size of stone used for the block is:

According to the table 3.6 compaction factor for the M20 grade concrete block 28 after days of curing was 0.85. This shows the concrete blocks with stones in it has medium workability.

Weight of 1 single stone is taken to 6.35kg

Considering the shape of the stone to be polygonal having 3 sides:

Depth of stone d = 50 mm

Length of stone L = 150mm

Weight of small stone = 4.5kg

Volume = $(1/4.\ n\ L^2 \cot(\pi/n)).d = 0.0009871\ m^3$

Density = 63.043 KN/m^3

Area = 0.00974 m^2

Perimeter = 0.45m

Interior angle = x = 60^0

Exterior angle = y = 120^0

Inradius = 0.0433 m

Circumradius = 0.0866 m

Figure 3.35 Placing two stones in a mould

Using the M20 grade of concrete to make the blocks which are used to construct the counterfort retaining wall. The data formed by experimental testing of the concrete blocks is utilized here to form the retaining wall and to compare it with rcc retaining wall for its properties. A M20 grade of precast stone masonry concrete block was used whose compressive strength is specified from the table of experimental data.

Firstly, block was made using the solid plains and then the size of 300x200x150mm was given. Then the blocks were placed on the retaining wall's stem, heel slab and toe slab accordingly as the thickness of the wall. At some places concrete blocks were cut accordingly to meet the measurement requirements.

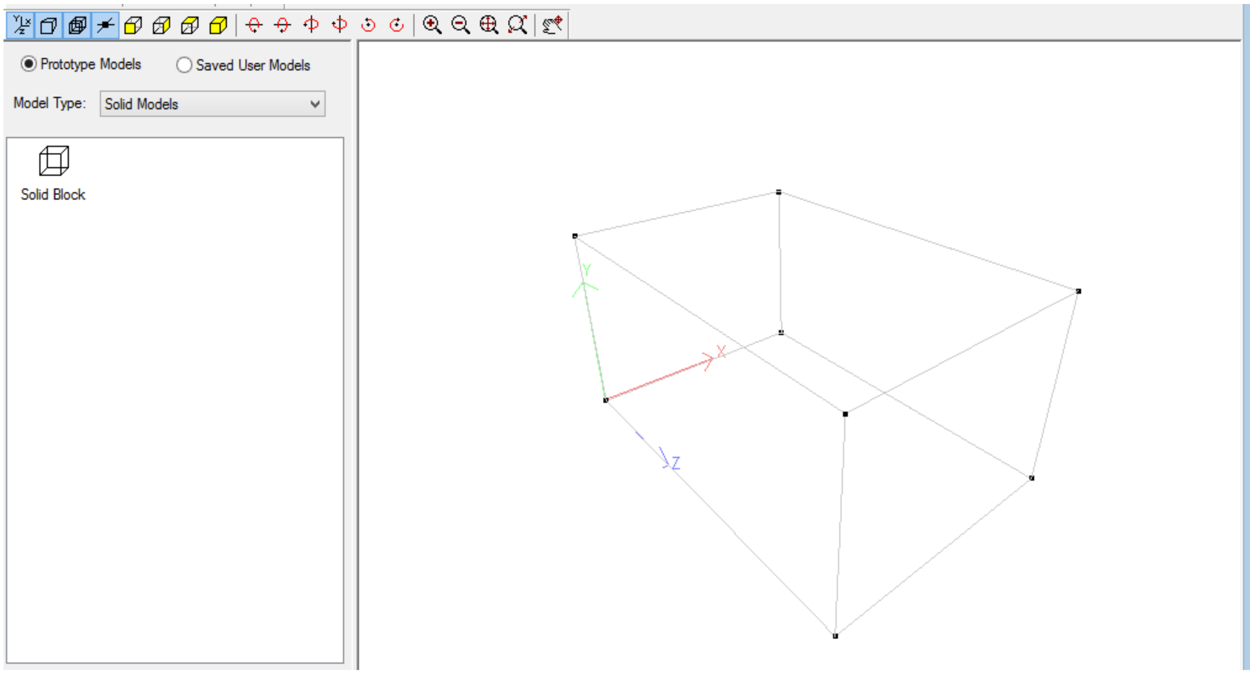


Figure 3.36 Concrete block of size 300x200x150mm

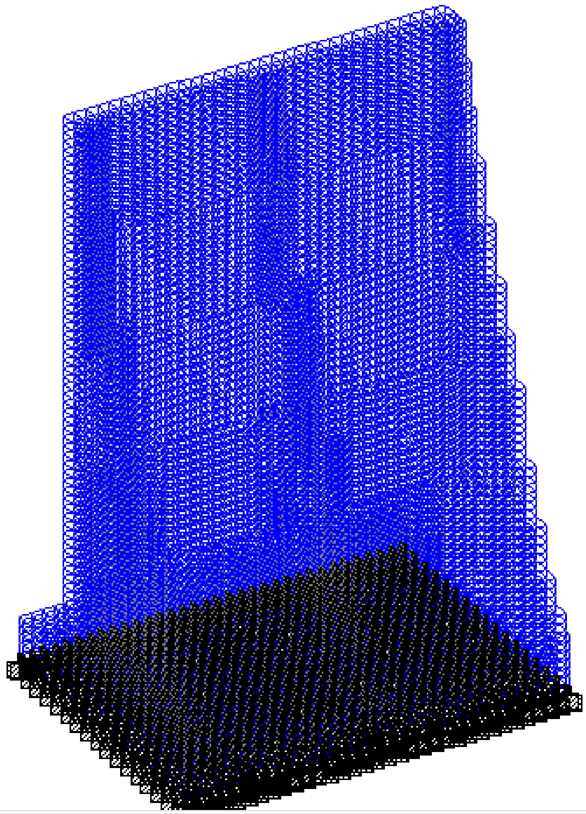


Figure 3.37 Retaining wall constructed with concrete blocks

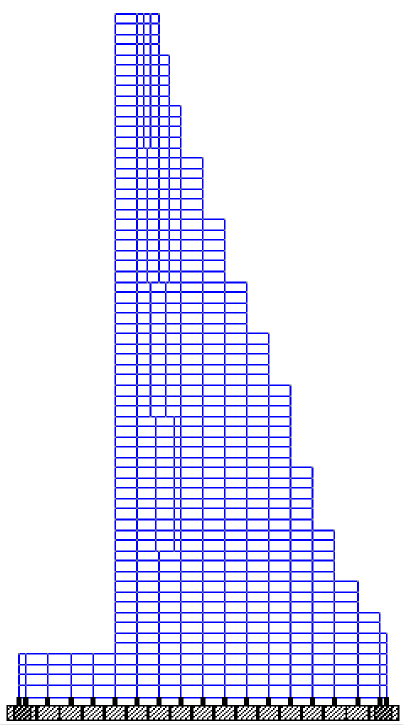


Figure 3.38 Side view of the Counterfort retaining wall

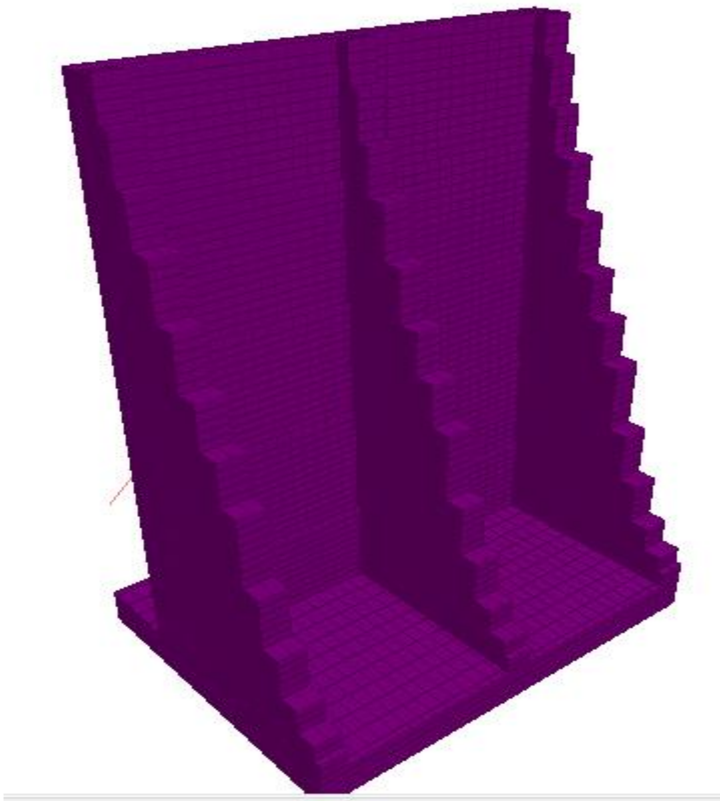


Figure 3.39 3D view of Counterfort Retaining Wall with concrete blocks

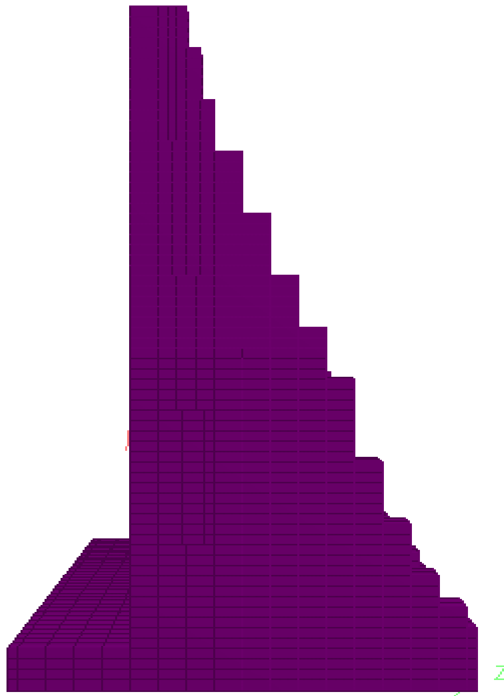


Figure 3.40 Side view of wall

Different load cases were assigned to the walls including:

1. Self weight
2. the earth pressure on the stem
3. earth pressure on the heel slab
4. weight of soil over heel slab
5. earth pressure on toe

The loads were calculated thoroughly according to the calculations and were compared with the calculations done for the rcc retaining wall structure that was constructed earlier on the staadpro. On this type of structure where solid blocks are taken the loads were calculated thoroughly and then were converted into the point loads for each blocks along their lengths. After applying the loads the following structures were formed which are shown in the figure below:

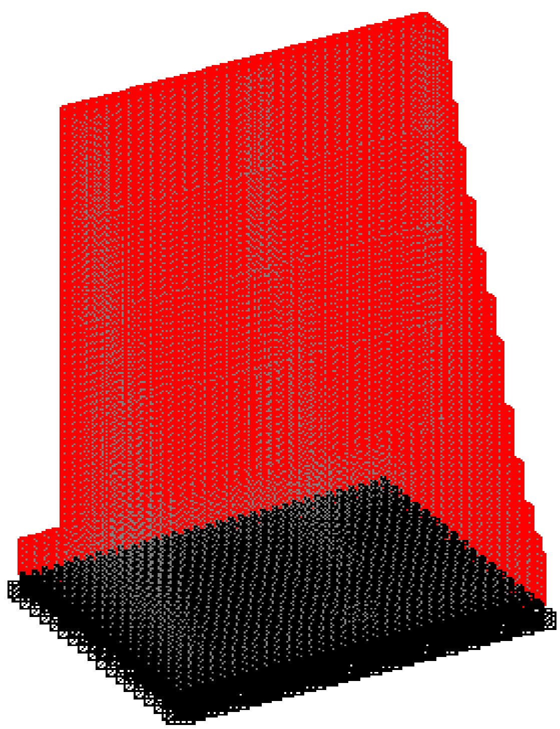


Figure 3.41 Load case self weight

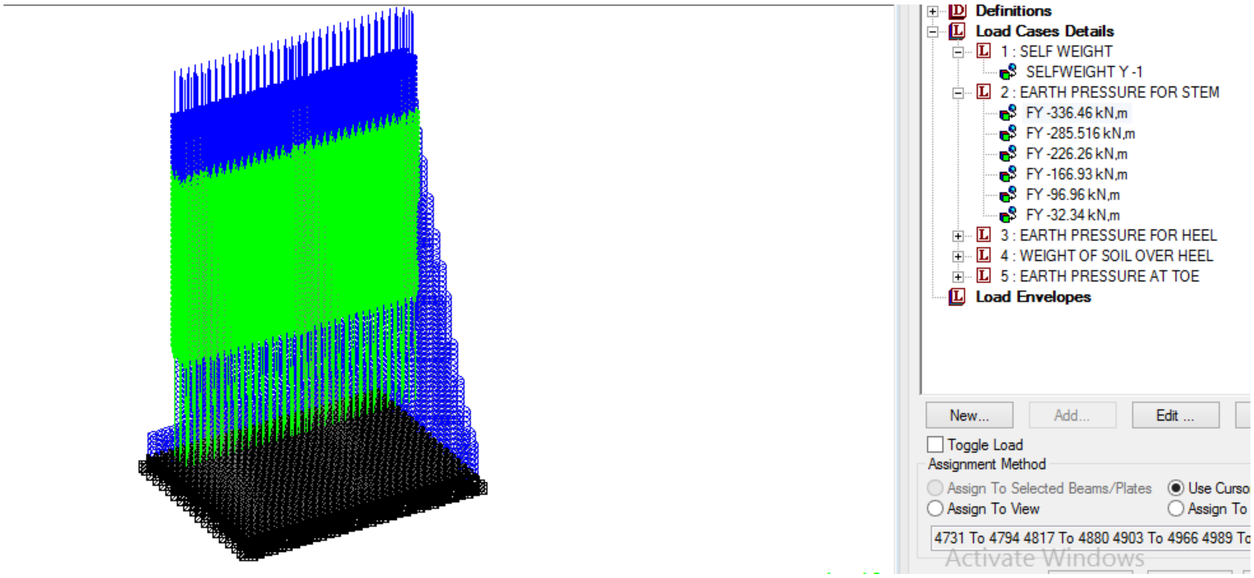


Figure 3.41 Load case showing Earth pressure on stem

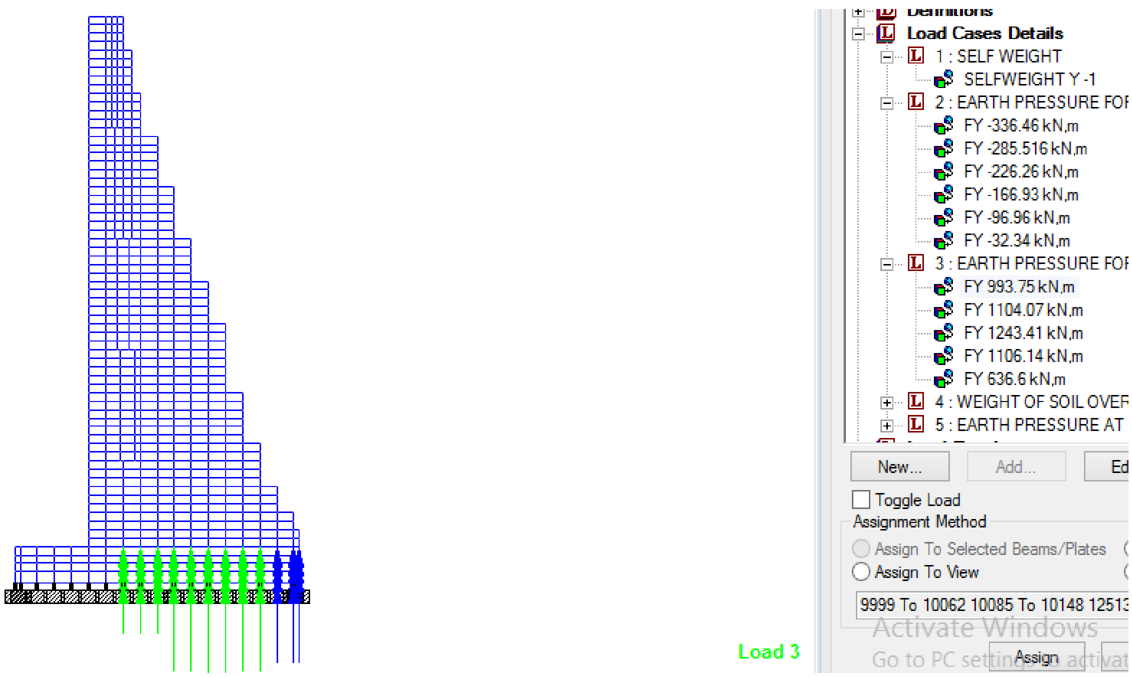


Figure 3.42 Load case showing Earth pressure on Heel slab

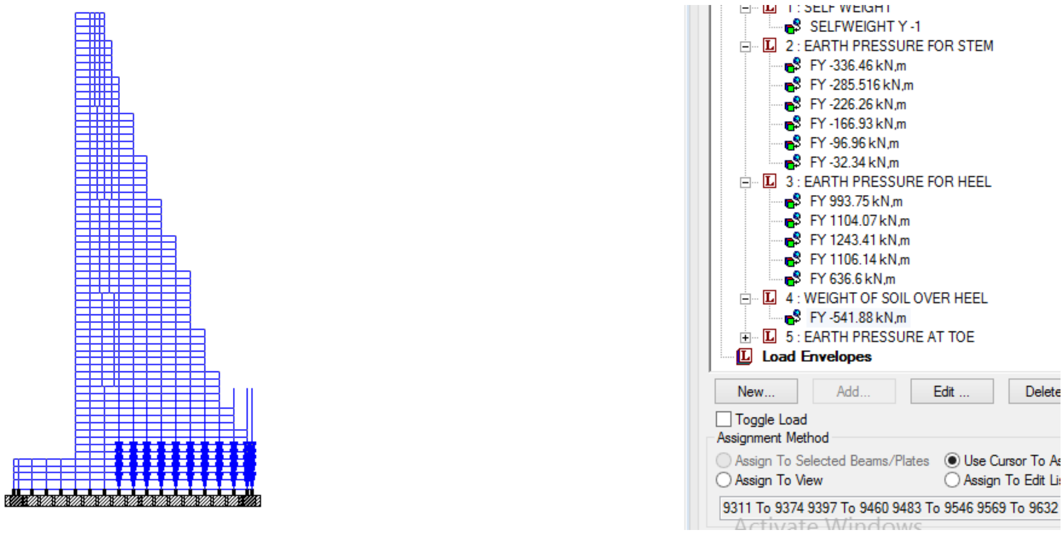


Figure 3.43 Load case showing weight of soil; over heel slab

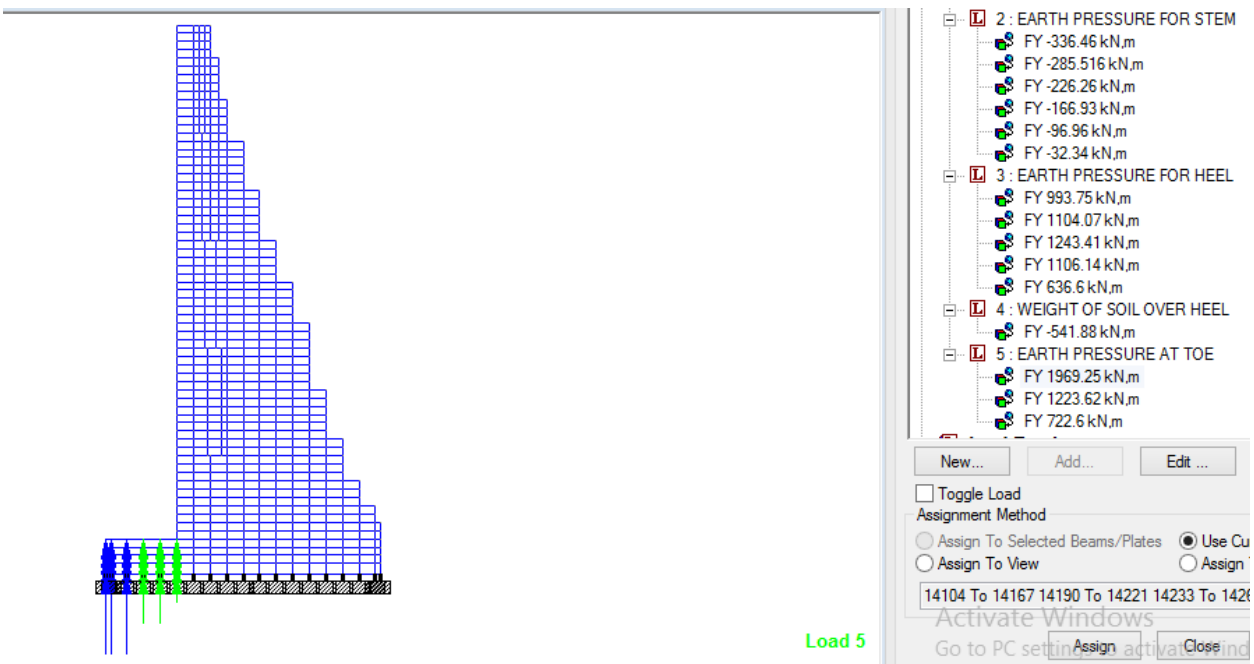


Figure 3.44 Load case showing earth pressure on toe slab

The load cases applied after calculations and all considerations have been shown in the figures above. After placing the load cases on the walls run analysis was done and it was observed to have zero errors. There were few warnings due to the joint in-coordination. This was due to the change in size of few blocks as few blocks were cut to different sizes that were needed according to the provided measurements. This model was then run to the post processing page where different aspects like shear, bending and torsional moments were compared with the properties of the live rcc retaining wall that was designed earlier. It was found that the retaining walls having concrete blocks are more stable to the loads and can bear the loads more effectively. Note that the concrete blocks used for the counterfort retaining wall here was of concrete grade of M20. Considering the data and the calculations done for applying the load cases on the two walls, the wall with concrete blocks was to be stable and showed better performance to the loads. The resultant diagrams representing or showing the reactions, displacement and moments are shown in the next chapter.

CHAPTER 4
RESULTS AND DISCUSSIONS

4.1 GENERAL

This part shows results of the experimental testing and software analysis of the counterfort retaining wall with concrete blocks and normal rcc are discussed. Firstly, the concrete blocks were casted then they were tested under a load at UTM machine. Using the data of those results workability, compressive strength, durability and a cost analysis was done comparing the precast stone masonry blocks with reinforced concrete for a counterfort retaining wall structure. The comparison of test results were done for the twon walls and the result are as follows:

4.2 RESULTS OF EXPERIMENTAL TESTING

`The precast stone masonry blocks casted were of the size 300x200x150mm. Many tests were done prior to the formation of the concrete blocks on cement, sand and aggregates and their results are as follows:

Normal consistency of cement = 35%

Initial stting time for cement = 90 mins

Final setting time for cement = 4 hours 30 mins

Specific gravity of cement = 2.91

Specific gravity of sand = 2.7

Water absorption test on coarse aggregate = 1.5%

The casting of the blocks was then further implied after the materials were tested on the lab. The casting of the blocks was done on a mould of size 300x200x150mm and the blocks were casted using the mould. The blocks were cured for 7 days and 28 days each and were tested for their strength under UTM machine provided in the lab. The data for the same is provided in the Table 3.4. As the block used for the counterfort retaining wall is of M20 grade concrete as the live rcc design of the counterfort retaining wall is of M20 grade concrete. Assuming that the M20 garde of normal concrete wall has a compressive strength of 20MPa for 28 days curing as per the IS code 456-2000. The data from the Table 3.4 shows that the compressive strength for M20 grade of concrete with 2 small stones is 26.18MPa. It shows that the precast stone masonry blocks with M20 grade of concrete has more compressive strength then that for the normal M20 grade of concrete. It can be further calculated for the retaining walls to find the difference between the compressive strength for the whole structures to compare them with each other. The higher compressive strength represents the high durability of the structure.

This also shows that the local demolition stones that are utilized in the concrete blocks add more strength to the concrete blocks in comparison to the normal concrete. The utilization of the demolition stones in concrete blocks can further help in solving the dumping problems of the excavated stones and bring a environment friendly surroundings. They add the strength to the blocks when the stone binds with concrete and is then properly cured for 28 days. The compaction of the concrete blocks was done using the rod. The compaction factor was found to be 0.85 which shows that the concrete Medium workability.

The cost analysis of the blocks was done with the hand calculations considering the market price of the materials. For M20 grade of concrete density of cement is 1440 kg/m^3 and for $1m^3$ of concrete 8.062 bags of cement is used. Considering the rate of each bag of cement to be 400INR, which is equal to Rs 3226. Then for sand for $1m^3$ of concrete the sand taken is $14.83m^3$ and considering the rate of per cft of sand to be Rs50 the total comes to be Rs 742. The coarse aggregate was found to be 29.6 cft and the rate considerd was Rs 50 per cft which is equal to Rs1776. The steel used for $1m^3$ is 80kg and rate considered to be Rs45/kg so the steel in total is Rs 3600. The gross total amount for Rcc design for $1m^3$ of M20 grade of concrete is Rs 9343.6 after adding all the amounts together. For the concrete blocks that are precasted with the stone spalls the rate of cost of construction reduces as the stone spalls are easily available on the sites and the blocks can be casted on the site itself. Here the amount of steel is deducted and the area that will be covered by the stone is also considered which reduces the quantity of concrete used. Assuming that the there will be 10% reduction in the quantity of concrete to be used. The rate for making this block after deducting the cost of steel is Rs 5743.6 and after 10% deduction the cost is Rs 5170. On comparing the costs of construction of the two we find that the precasted stones are 55% more efficient than the rcc costruction and saves the high amount o cost of construction and can be easily casted on the site and reduces the transportation costs also.

4.3 RESULT COMPARISON OF RETAINING WALLS

The load cases applied on the walls were done after calculations and the design was done on the staadpro software for better analysis of the two walls. After the proper analysis the results that were formed showed that counterfort retaining wall with the precast stone masonry blocks of M20 grade of concrete is more stable to the load cases that were applied and bears more load and shows more strength as compared to the rcc retaining wall. The moment diagrams representing theresults of the following are as follows:

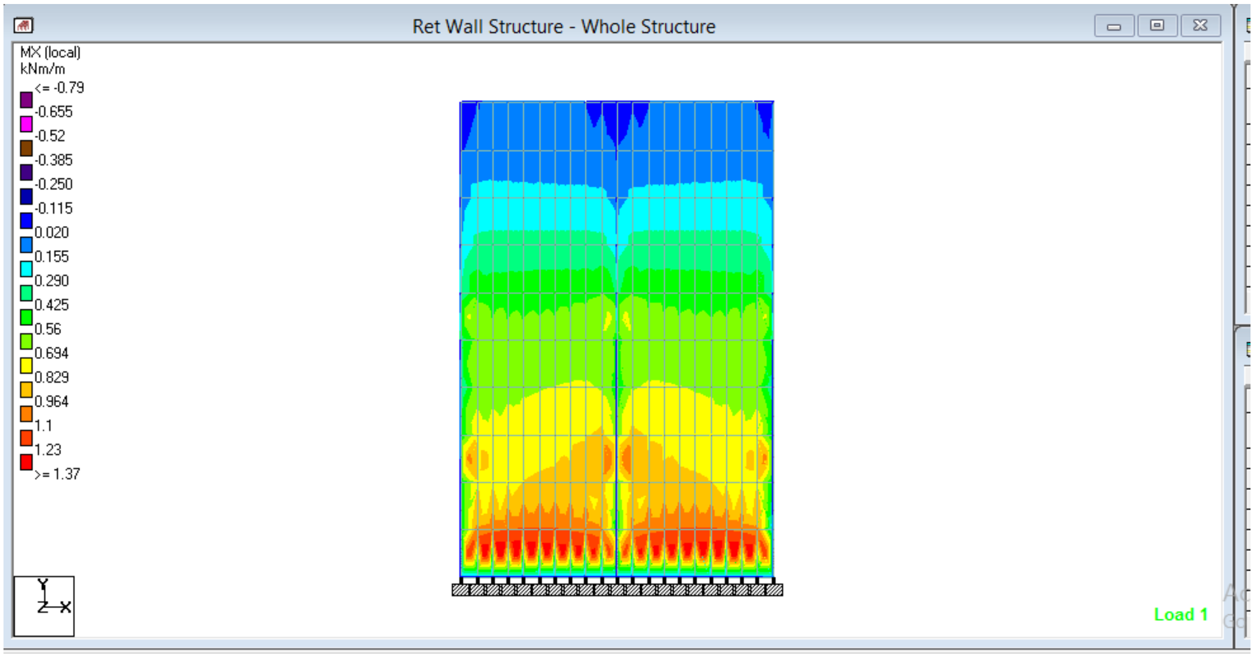
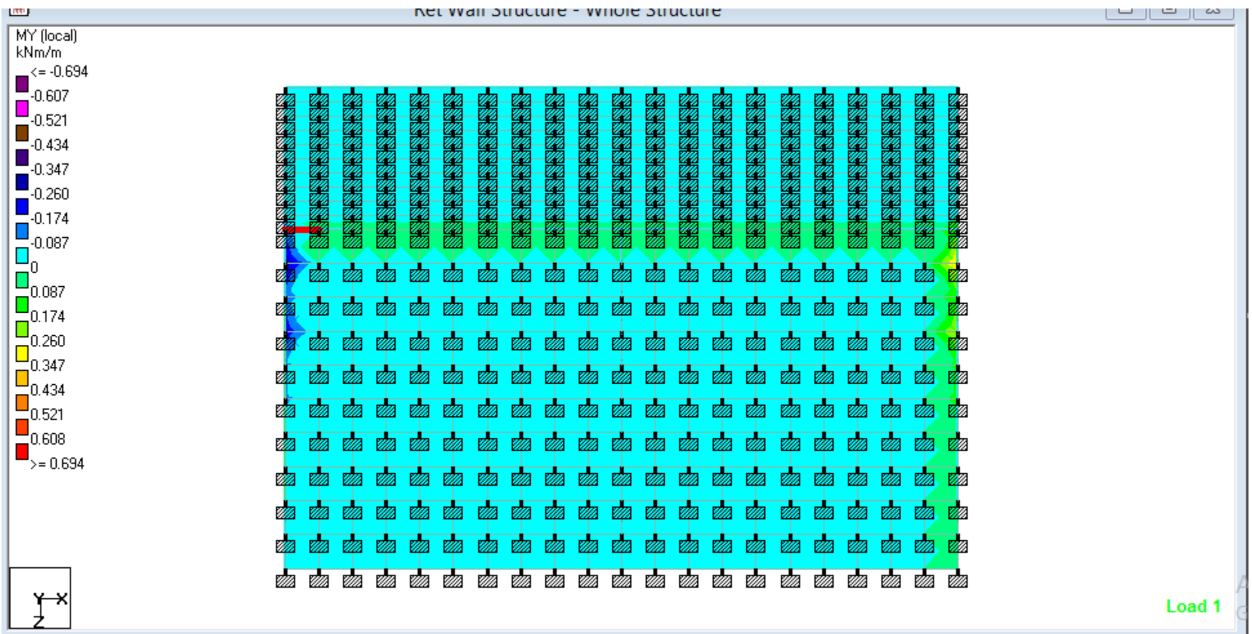


Figure 4.1 & 4.2 Moment of self weight of simple concrete retaining wall



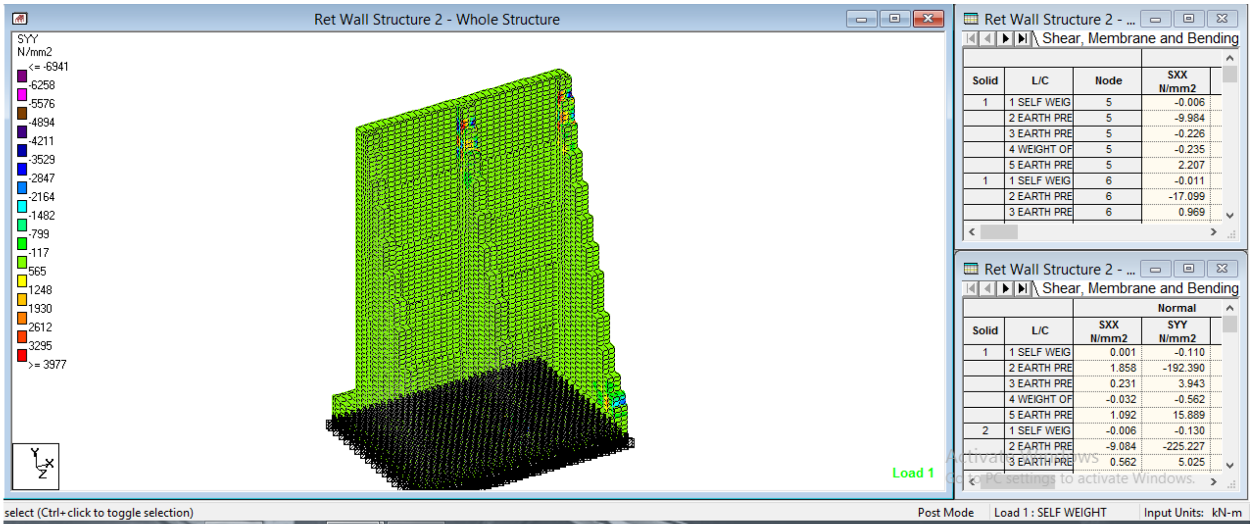
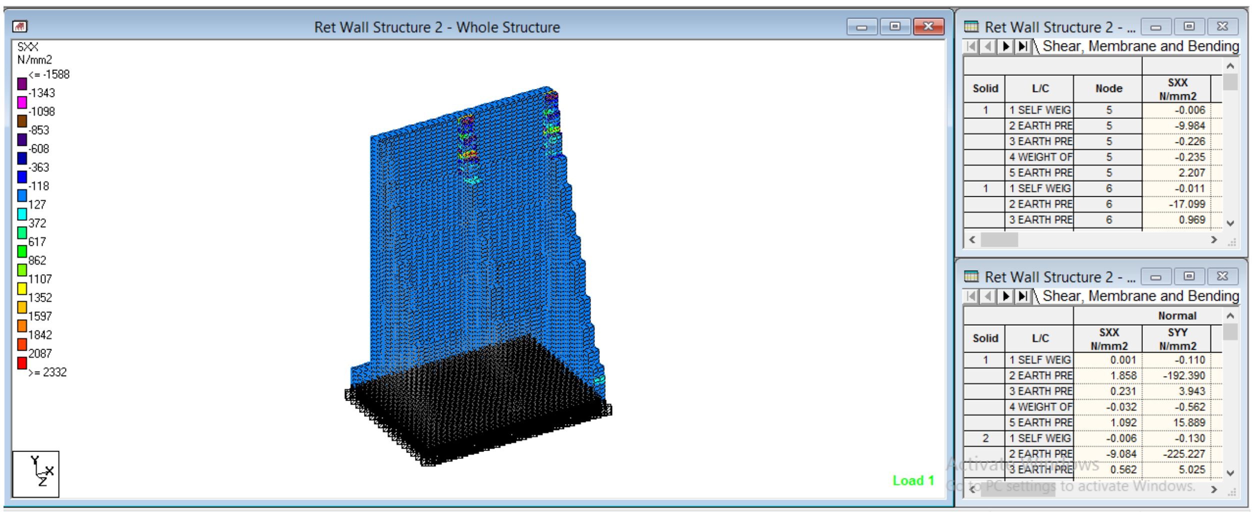


Figure 4.3 & 4.4 Moments of self weight for stone crete blocks



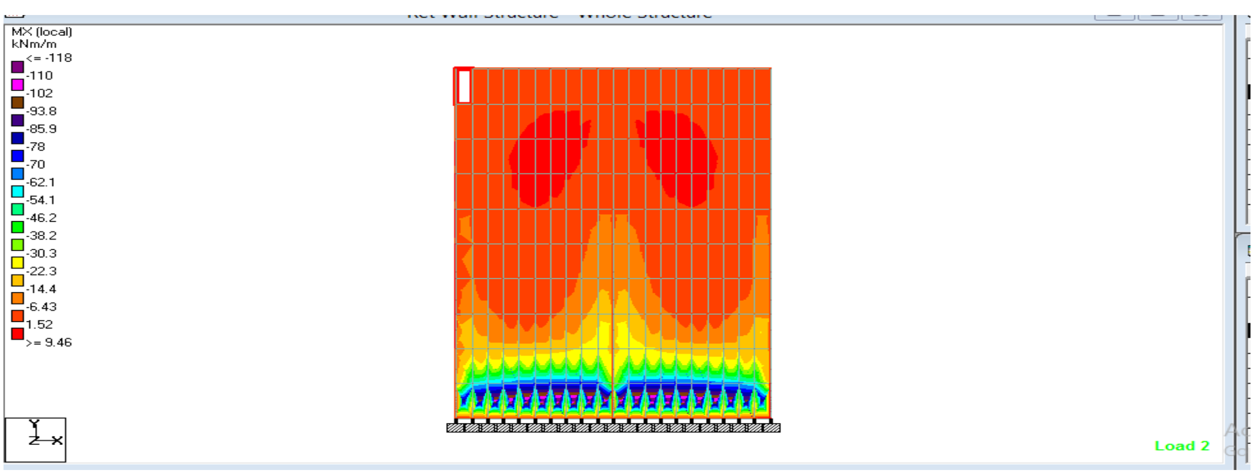


Figure 4.5 & 4.6 Moments diagram for stem walls

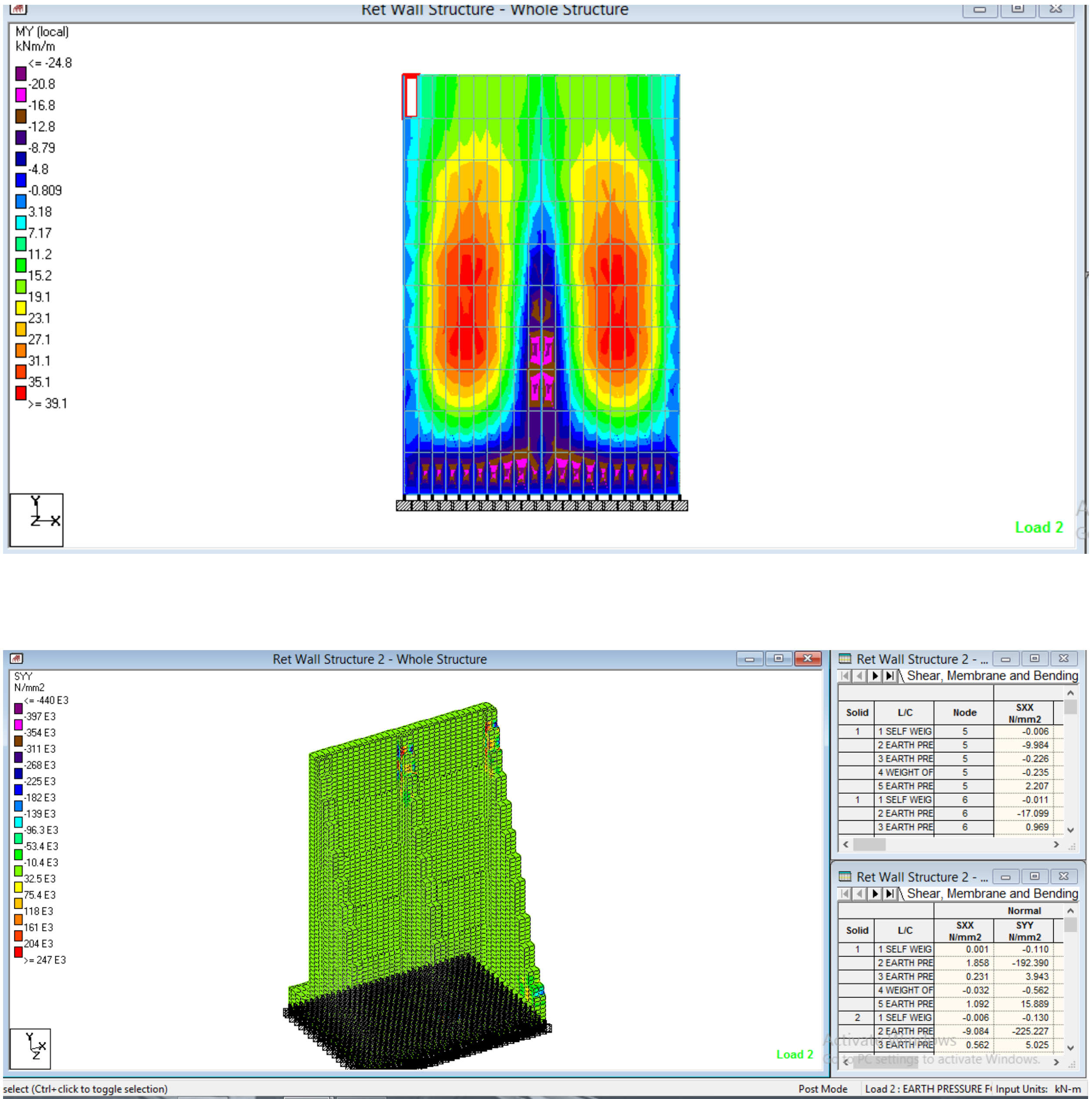


Figure 4.7 Moments diagram for stem wall with blocks

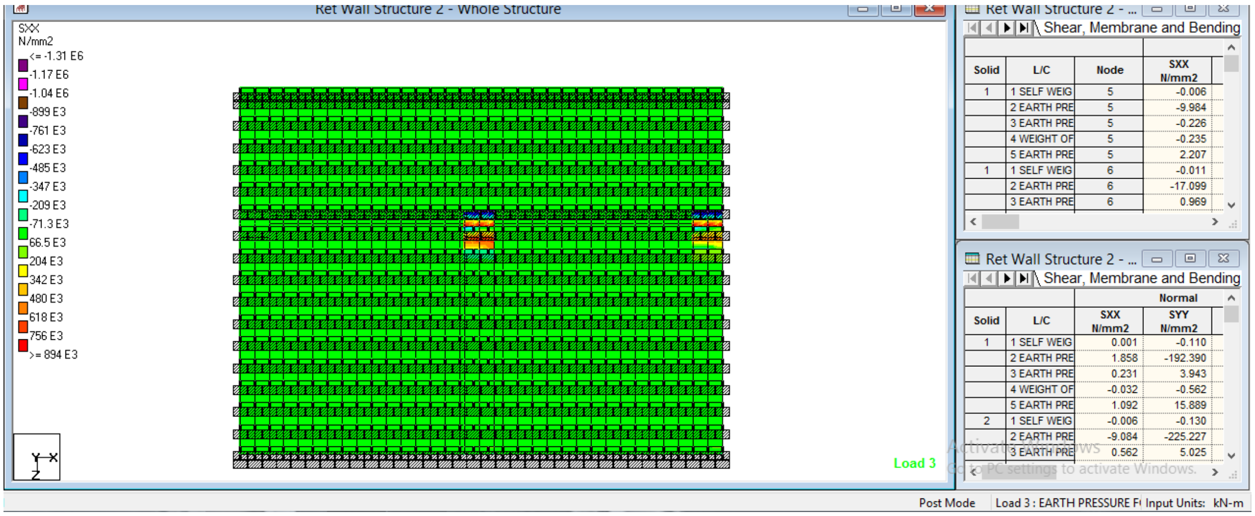
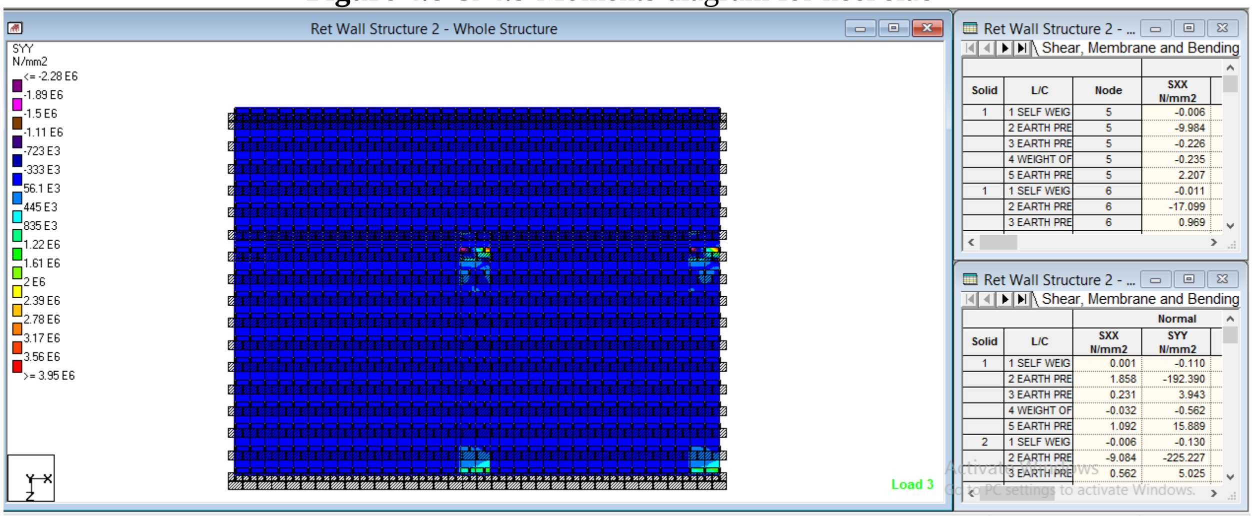


Figure 4.8 & 4.9 Moments diagram for heel slab



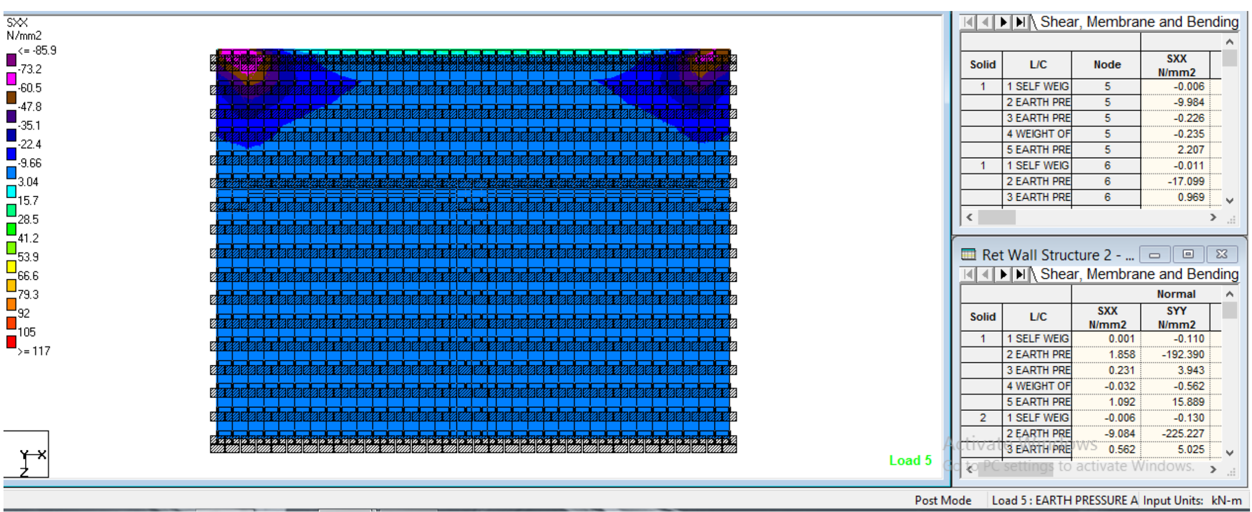
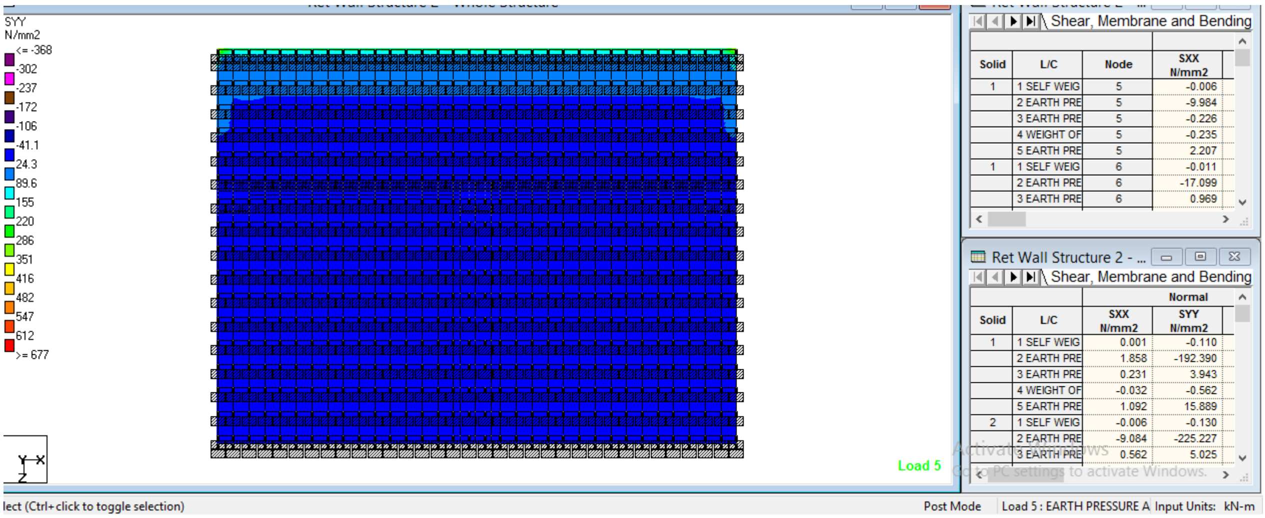


Figure 4.10& 4.11 Moments diagram for Toe slab



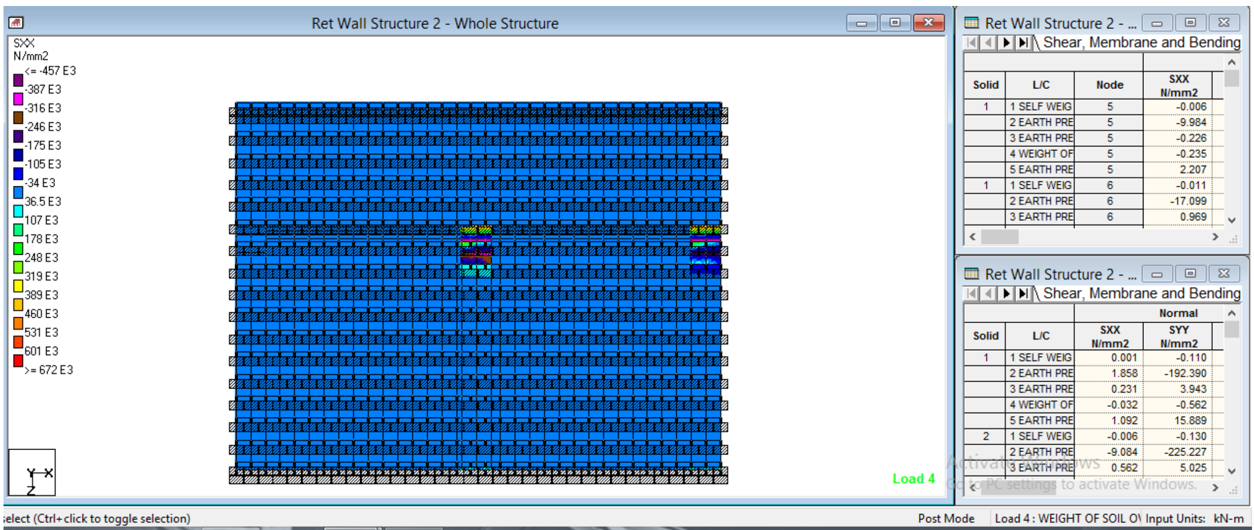
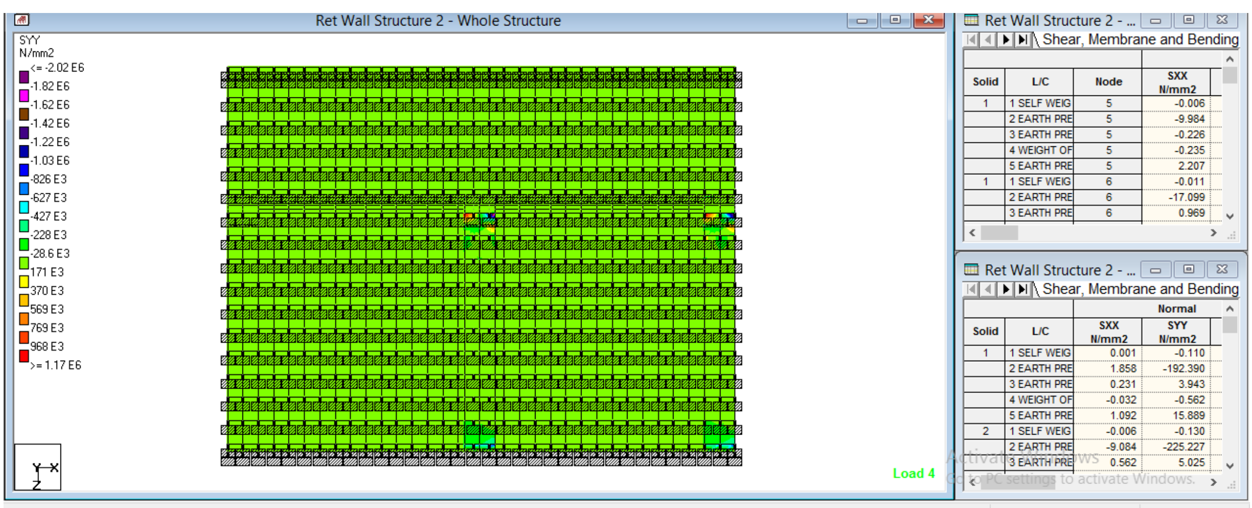


Figure 4.12& 4.13 Moments diagram for weight of soil over heel slab



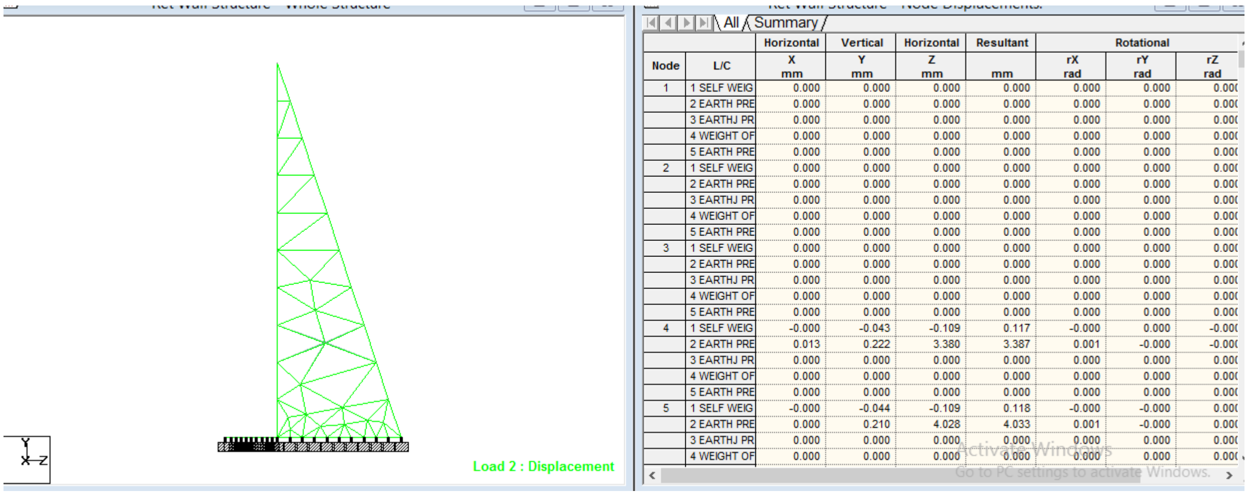


Figure 4.14 Displacements of the wall

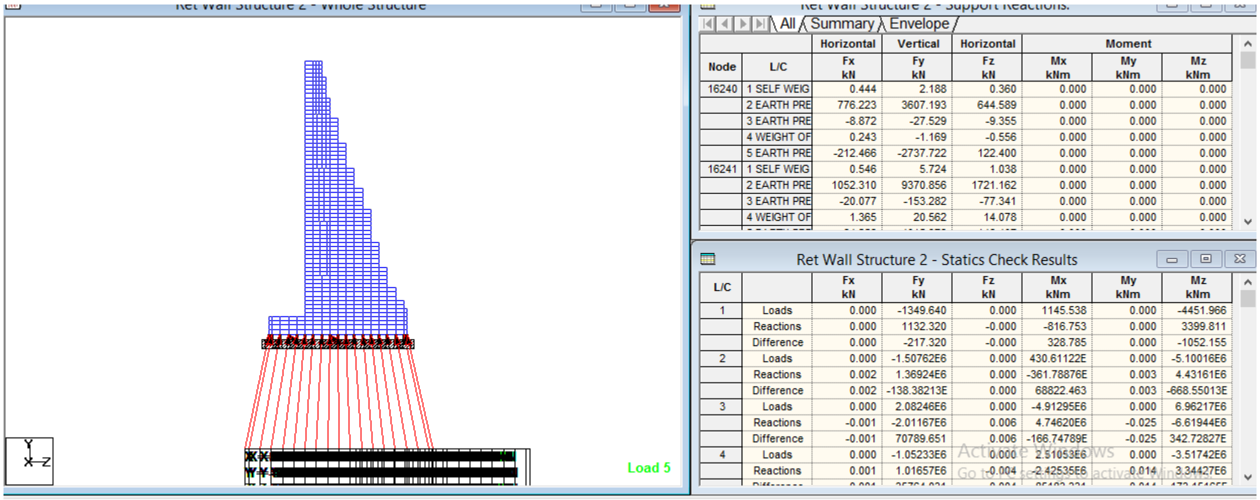


Figure 4.15 Reactions of the wall

CHAPTER 5

CONCLUSION

The precast stone masonry blocks used were 300x200x150mm in scale. Many experiments on cement, sand, and aggregates were conducted prior to the construction of concrete blocks, and the following are the results: Initial setting time for cement = 90 minutes, final setting time for cement = 4 hours 30 minutes, normal quality of cement = 35%, initial setting time for cement = 90 minutes, water absorption test on coarse aggregate = 1.5 percent, Specific gravity of cement = 2.91, Specific gravity of sand = 2.7, and Specific gravity of cement = 2.91. After the materials were examined in the lab, the casting of the blocks was further inferred. The blocks were cast using a mould with dimensions of 300x200x150mm. The blocks were cured for 7 and 28 days, respectively, before being checked for strength on a UTM unit in the lab. Table 3.4 contains the relevant information. Since the counterfort retaining wall's block is made of M20 grade concrete, the counterfort retaining wall's live rcc design is also made of M20 grade concrete. Assume that the M20 guard of a standard concrete wall has a compressive strength of 20MPa after 28 days of curing. The strength of the concrete blocks with stone spalls was found to be 26.18MPA which shows that it adds more strength to the structure. The stone spalls can be utilized in the concrete blocks and can be made easily on the site and lowers the cost of the construction to 55% as compared to the normal rcc construction. This represents that the use of the demolition stones on the concrete blocks are more efficient costly, provides more strength, durability, workability and can be easily casted at the sites of construction. Finally, the analysis of both the walls was done and was found that the counter fort retaining wall with the precast stone masonry blocks showed more strength towards the loading. Thus, the stone crete blocks can be used to form the retaining walls and will provide more strength and durability and also helps the environment by solving the problems of the demolition stones.

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