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Department of Civil Engineering
List of PBL Project
Class: SE Civil

SEM I | Division: A | Academic Year: 2023-24

Academic Year	Group No.	Roll No.	Name of Student	Name of Guide/Mentor	Project Title
2023-24	1	CE23D3A07	AHER SAURABH NANAJI	Prof.S.U.Pagar	Advance Earthquake Resistant Techniques
		CE23D3A09	AHIRE VAIBHAV NANDULAL	Prof.S.U.Pagar	Advance Earthquake Resistant Techniques
		CE23D3A32	AISHWARYA NARENDRA MORE	Prof.S.U.Pagar	Advance Earthquake Resistant Techniques
		CE23D3A29	KEDAR DHANASHREE DHARMENDRA	Prof.S.U.Pagar	Advance Earthquake Resistant Techniques
2023-24	2	CE23D3A01	CHAUDHARI RUSHIKESH DILIP	Prof.K.M.Deore	Precast Enginerring Building
		CE23D3A14	CHAVAN ASHWIN GULAB	Prof.K.M.Deore	Precast Enginerring Building
		CE23D3A15	DAWARE SHIVAM KIRAN	Prof.K.M.Deore	Precast Enginerring Building
		CE23D3A16	DEORE AMOL KEASHAV	Prof.K.M.Deore	Precast Enginerring Building
2023-24	3	CE23D3A02	DOKHE LAKHAN BALU	Prof.A.U.Mankar	Study on Flyash Bricks
		CE23D3A19	GIRASE ROHIT MAHENDRASING	Prof.A.U.Mankar	Study on Flyash Bricks
		CE23D3A20	JADHAV JATIN SAMBHAJI	Prof.A.U.Mankar	Study on Flyash Bricks
		CE23D3A03	KHAIRNAR ABHAY EKNATH	Prof.A.U.Mankar	Study on Flyash Bricks
2023-24	4	CE23D3A30	KHAIRNAR AKSHAY MADHAVRAO	Prof.D.D.Shelke	Detail case study on Nalanda University
		CE23D3A22	JAMBHALE SIDDHANT BHARAT	Prof.D.D.Shelke	Detail case study on Nalanda University
		CE23D3A24	KAMBLE RITESH RAVINDRA	Prof.D.D.Shelke	Detail case study on Nalanda University
		CE23D3A25	KANDALKAR DIPAK SHIVAJI	Prof.D.D.Shelke	Detail case study on Nalanda University
2023-24	5	CE23D3A31	KHAIRNAR SANJOG SANTOSH	Prof.D.D.Shelke	Study of Retaining wall construction using interlocking concrete block
		CE23D3A54	VASAVE JATIN VIJESINGH	Prof.D.D.Shelke	Study of Retaining wall construction using interlocking concrete block
		CE23D3A10	BAGUL GAURAV VILAS	Prof.D.D.Shelke	Study of Retaining wall construction using interlocking concrete block
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		CE23D3A39	PATIL ROHIT PURUSHOTTAM	Prof.T.R.Shinde	Lime Stabilized Soil Blocks
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		CE23D3A41	PAWAR SAKSHI VIJAY	Prof.R.R.Kuwar	Bamboo As A Building Material
		CE23D3A42	RAUT LALIT AMRUTA	Prof.R.R.Kuwar	Bamboo As A Building Material
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		CE23D3A46	SHIRSATH SHYAM SHIVAJI	Prof.N.R.Nimse	Type of Retaining Wall
2023-24	10	CE23D3A45	SHEWALE SIDDHI JAGDISH	Prof.S.U.Pagar	Study of Design of Reatining Wall
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A Project based learning report

ON

"TITLE OF YOUR SEMINAR"

STUDY OF RETANING WALL CONSTRUCTION USING INTERLOCKING CONCRETE BLOCKS

IN THE FULFILLMENT OF THE REQUIREMENT FOR

BACHELOR DEGREE OF CIVIL ENGINEERING

SUBMITTED BY:-

Gaurav Bagul

Guided By

PROF.D.D.Shelke

DEPARTMENT OF CIVIL ENGINEERING, LATE G.N. SAPKAL COLLEGE OF ENGINEERING,

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SAVITRIBAI PHULE PUNE UNIVERSITY, PUNE

(2023-24)

CERTIFICATE

This is certify that **Gaurav Bagul** have satisfactory carried out the SE. Project based learning entitled **"STUDY OF RETAINING WALL CONSTRUCTION USING INTERLOCKING BLOCKS ".** This work is being submitted for the award of degree of Bachelor of Engineering in Civil. It is submitted in Partial fulfilment of prescribed syllabus of Savitribai Phule Pune University for the academic year 2023-2024.

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Abstract

Concrete blocks retaining walls are commonly used for landscaping projects in which the retaining force strength of the structure is of paramount importance in preserving the integrity of the project and safety of humans and property. The effect of augmenting the retaining force strength of concrete block retaining walls was investigated using interlocking and interlocking with a horizontal steel re-bar and compared with regular concrete block walls.

Retaining walls provide lateral support to vertical slopes of soil. They are used to bound soils between two different elevations often in areas of terrain possessing undesirable slopes or in area where the landscape needs to be shaped severely and engineered for more specific purposes like hillside farming or roadway overpasses. This paper has been written to discuss various types of retaining wall for different heights, their behavior and various types of failures

CONTENT

FIGURE INDEX

CHAPTER 1

INTRODUCTION

In areas of landscaping where the ground elevation exceeds the angle of repose of the soil retaining walls are constructed to resist the lateral pressure of soil and keep it in place

[1] There are different designs of retaining walls suited for respective applications·

[2] Concrete block retaining walls are ideal for controlling small scale erosion, to level a hard-to-mow slope, build an embankment to add a planting bed, or to level an ideal patio area.

[3] Concrete blocks are one of the fastest and simplest material available for small scale retaining wall construction and offer a different option than poured concrete

This document has been prepared to provide guidance when designing retaining walls using Elite Precast Concrete Limited's interlocking concrete blocks. It is intended to assist civil/structural engineers and architects in the best practice of designing these types of gravity retaining structure.

Elite Precast Concrete Ltd (EPCL) supply three interlocking concrete block systems; Vee™, Duo™ and Legato™. Each system comprises precast blocks manufactured from high strength unreinforced concrete. The blocks are dry laid and incorporate interlocking elements to distribute loads between adjacent blocks. For each block type, the 'standard' block size is supplemented by blocks of different dimensions to facilitate various wall layouts. The standard block dimensions for the three systems are shown in Figure 1.1.

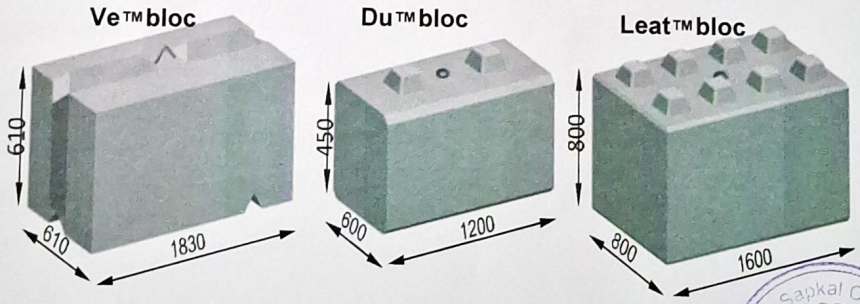


Fig 1.1 Elite Precast concrete (EPCL)

1.1 Importance of Transportation:-

A country cannot develop without a developed transportation system. Development of roads facilitates utilisation of natural resources lying unutilized in different hills, mountains, forests

and mines. Transportation system helps to send raw materials, fuel and machineries to different industries at right time and runs the industry.

Transportation system helps to raise the production of raw materials, fuels and machineries etc. by providing market to it. Transportation system widens the size of the market. Due to selling of commodities in an extensive manner in large areas, it leads to large-scale production.

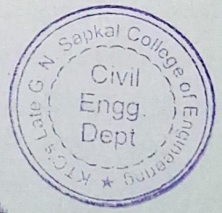
A developed transportation system reduces regional industrial disparity by facilitating establishment of industries in backward areas, because the backward area is brought nearer to developed area with the help of a developed transportation system by sending raw-materials to the backward industrial centre and by selling the products of industries in different areas.

Transportation system helps to solve the problem of unemployment in rural areas by sending surplus labourers to the industries and it also solves the needs of industries. Development of transportation system also leads to development of industries because transportation system utilizes the product of industries.

Different machineries and raw materials are supplied through roads, ships, motors, buses, trains, aeroplanes to industries. It shows that transportation system of a country affects economic development of a country in different manner.

Transportation system is regarded as a strong pillar to protect the people from the difficulties of war, natural calamities and other problems. Transfer of military equipment, soldiers and war heads during war is possible only through a developed transportation system. A developed transportation system is necessary to send necessary helps to the affected people during the period of natural calamities

Along this, transportation system helps to establish relationship among people from different parts of the country and strengthens the feeling of unity and brotherhood among the people. Lastly it makes Nation one and undivided.



1.2 Highway Significance:-

The transportation by highways has the maximum flexibility for travel with reference of route, direction, time and speed of travel. Highway transportation is having wider network in reference to the variance of topography of the countiy. Highway construction is easy, economical and less time consuming activity in comparison to the railway, metro rail and airway construction. The development of road network is very much essential for overall growth of that area. In world around 70% people uses road network for transportation and in India 75% people & 85% goods depends on highway transportation system.

1.3. Why the Retaining Wall:-

All highways which were constructed in and around of any cities/towns are almost reached their design capacity due to messy growth of Indian cities/towns and traffic their in especially at intersections. In this scenario traveling on highways with design speed is practically not possible and time taken by travelers from one place to another is more than desired. To get rid of this problem highway design engineer started thinking to reduce the time of travel. For this time consumed at intersections need to be reduced. This gives them an idea to elevate the highway from one another i.e. introduction of grade separated intersections. In earlier days land was not in that scarcity & the cost of land was also less, therefore natural slopes on approaches of structures were preferred. But this idea fails in cities and towns due to non availability of land for natural slopes on embankments and approaches of structures fewer lands available for grade separation from at grade. To fulfill these requirements we develop an idea to construct a masoni^ wall. Then in further development stages came in mind to restrain the approach with Reinforced Cement Concrete (RCC) Retaining Wall. Construction of RCC Retaining Wall requires huge Steel, Concrete, Form Work and Manpower. In order to economize highway construction Page 2 concept of Reinforced Earth Wall (RE Wall) were developed. Construction of RE Wall is time wise economical also as compared to RCC Wall. Other application of retaining structure include safety from washed out^due to storm water in heavy rainfall area, in water logged area, in flood prone zone, in cut or fill section to avoid rock falling or to avoid movement of rock, development of park, gardens in hilly area, to construct the walkway along the river or seashore, to facilitate the parking capacity with aesthetic view in hilly area. For the construction of Dam for power production and irrigation purpose

1.4 Importance of Research Topic:-

A research work was carried out to study about the material required for the construction of reinforced earth wall and its specifications and also the construction methodology adopted. A cost and time comparison study was also carried out between reinforced earthen wall and conventional retaining wall, and it was found that the cost for the construction of reinforced earthen walls was approximately 20% less than the cost of conventional RCC Retaining Wall. From the time comparison study it was observed that Page 3 the time required for construction of reinforced earthen walls was more when compared to the construction of retaining walls however time can be reduced if both the activities casting and erection runs parallel. If the wall height is more than 5.0 mtr. then Reinforced Earth Walls are preferred in the context of their stability, and also in its capacity to reduce the future settlement of pavement by controlling the erosion of soil fill with the help of geotextile placed between the soil fill and drainage aggregate.

1.5 Scope of the Study:-

In this study different components of RCC and RE Wall is considered like Steel, Concrete, Form work, Geogrids, Filter Media, Backfill material and ground Safe Bearing Capacity. A sample design (jf both RCC and RE Wall of 6.5 m. and 9.0 m. height was carried out. A cost comparison of the two i.e. RCC and RE Wall is also carried out for different heights ranging from 5.0 m to 9.0 m.

CHAPTER 2
LITERATURE RIEW

2.1 History of Retaining Structure

Being always at the mercy of a new discovery, we shall never know for sure when the first retaining wall was constructed. As soon as man became sedentary, in fact, which was towards the end of the tenth millennium B.C., he set about building defences by raising obstacles that were difficult to climb. These defensive constructions were followed by monuments with a religious purpose inspired by the myth of the ascension towards the heavens.

It would appear that the first examples of the idea of providing a vertical support for a mass of materials are to be found among the megalithic monuments on the Atlantic coast of Europe: a typical example is the New- grange Cairn in Ireland, erected in the fourth millennium B.C.

In 27 BC, the Roman emperor Augustus supposedly took the unfathomable decision to build in the middle of nowhere the grandest and mightiest temple of antiquity, the Temple of Jupiter, whose platform, and big courtyard are retained by three walls containing twenty-seven limestone blocks, unequal in size anywhere in the world, as they all weigh in excess of 300 metric tons.

This way the concepts were develop to construct the walls for safety from enemies, land sliding and flood. These are the great walls constructed around the world for the same

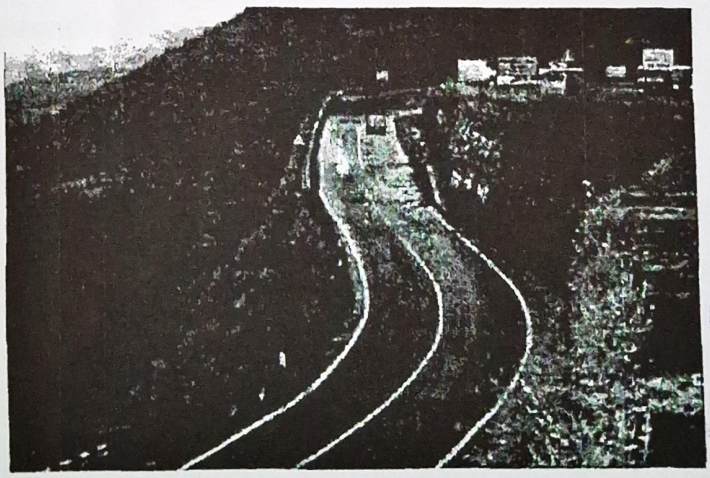


Fig 2.1.1 First Stage Development of Retaining Wall (Stone Masonry)

This construction methodology was time taken and costly, then we started thinking for alternative and we use plain concrete in construction of wall.

Retaining Wall (RCC) The first RE Wall in the USA was built in the year 1971 on State Route 39 near Los Angeles. The highest RE Wall built in the USA is of 30 mtr.

The first Reinforced Soil Wall in India was constructed using paraweb as reinforcement by Soil Structures International Ltd. in the year 1988, at ROB on GT Road (National Highway No. l) in Ludhiana, Punjab with maximum height of 10 mtr.

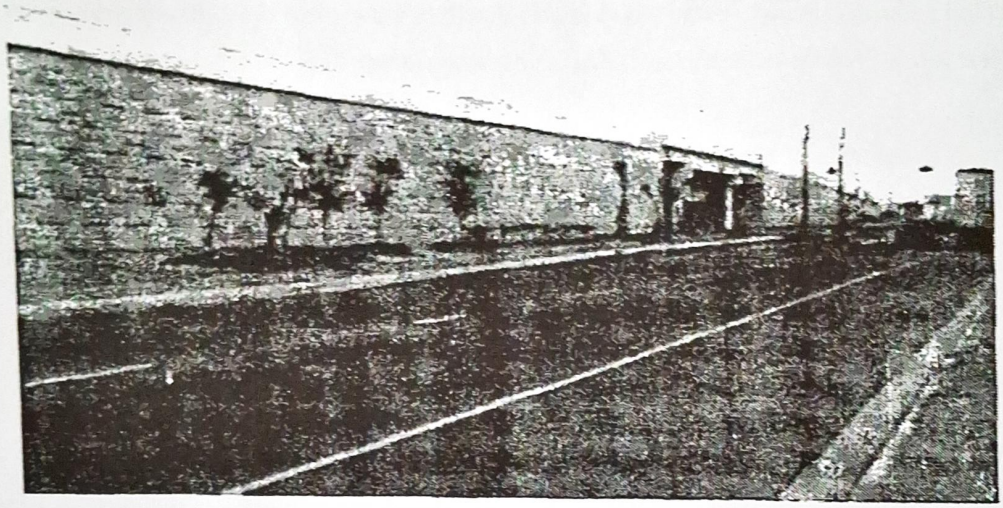


Fig. 2.1.2 A typical RE wall

2.2 Application of Retaining Wall

Earth embankments/slopes are commonly required on railways, roads, earth dams etc. The stability of these slopes must therefore be thoroughly analysed as their failure may lead to loss of human life as well as economic loss.

A retaining wall is a stabilizing structure used to hold sloping ground in place and to prevent the erosion and the movement of soil. A retaining wall must be substantial and sturdy in structure in order to accommodate and redistribute lateral pressure caused by slopes. It is normally designed with seepage holes, which allow collected ground water to escape. This releases the additional pressure created by accumulated water and helps keep the retaining wall stable.

Retaining walls are structures designed to restrain soil to unnatural slopes. They are used to bound soils between two different elevations often in areas of terrain possessing undesirable slopes or in areas where the landscape needs to be shaped severely and engineered for more specific purposes like hillside farming or roadway overpasses.

A retaining wall can be a series of "steps" or tiers, which allows for a more attractive design as well as more efficient erosion control. The design can include different types of plantings, flowers or materials in each tier to bring more texture, color and interest to the Page 9 area. Aside from the aesthetic value, a tiered design also provides better erosion control by breaking down the amount of soil, and therefore pressure, held by each division of the retaining wall.

In another way Retaining walls are a great way to add visual interest to a garden or to create separate levels on a sloping block in order to maximise the usable garden space.

2.3 Material's Used in Retaining Walls:-

The most commonly used materials in retaining walls include.

- Stone retaining wails: stone can be used for both decorative and structural walls and stone retaining walls are very durable and can last many years, in some cases. as long as the home. There are two types of stone retaining walls — wet and dry. Wet stone uses mortar or other fixatives and thus is suitable for the more structural walls that need to hold back a large volume of earth. DIY stone 'vvalls are where the stone is fitted together without actually using any form of fixative.
- Timber retaining walls: timber does not last as long as other materials used in retaining walls and it generally has a lifespan of around ten to twenty years. If using timber, ensure that it is suitable for soil contact and that it is of at least a H4 rating. If the timber is being cut at all, the ends will need to be painted with a treatment solution.
- Brick retaining walls: brick retaining walls are strong and last for a long time, but may turn out to be more costly than stone or concrete blocks.

2.4 TYPES OF RETAINING WALL

The different types of retaing wall are as follows :-

1. Gravity retaining wall.
2. Cantilever retaining wall.

3. Counterfort retaining wall.
4. Buttress wall
5. Bridge abutment.
6. Box culvert.

2.5 Various Forces Acting on These Structures:-

There are a number of forces that act on the retaining wall. Some are relatively constant while others intensity may vary due to factors such as weather.

These forces are:-

(i) Weiglit of the wall This force acts on the gravity centroid of the section.

(ii) Pressure of the retained soil

(iii) The pressures on the foundation They are usually considered as being linearly distributed in the form of a trapezoidal shape.

(iv) The pressure of the soil against the front of the wall The soil on the front of the wall exerts a passive force (resistance) against the active force of the retained soil. This force is usually neglected due to the uncertainty of its magnitude.

(v) The loads on the retained soil

(vi) Forces due to water If there's a body of water on the back of the wall, there'll be hydrostatic pressure acting on it.

(vii) Sub pressures When the drainage under the wall is not adequate or is damaged, it can lead to storage of water in that zone. If the foundation is impervious the water will flow until it will emerge on the frontal part of the soil. If the foundation is pervious, the water will generate pressure against the wall.

(viii) Vibration They are produced by traffic, power plants, and others. Frequently, vibrations effects on retaining walls are neglected because of their little contribution. In some cases, engineers simply use the magnitude instead of the normal component of the pressures of the retained soil on the wall.

CHAPTER 3
FAILURE TYPES

3.1 Introduction

This guidance document is primarily concerned with the design of retaining walls rather than free-standing walls. However, many of the design considerations are equally applicable to be both types of structure.

all types of retaining structure including loss of overall stability, failure of a structural element, excessive movement and unacceptable leakage. In addition, the standard lists the following limit states that shall be considered for gravity walls (see Figure)

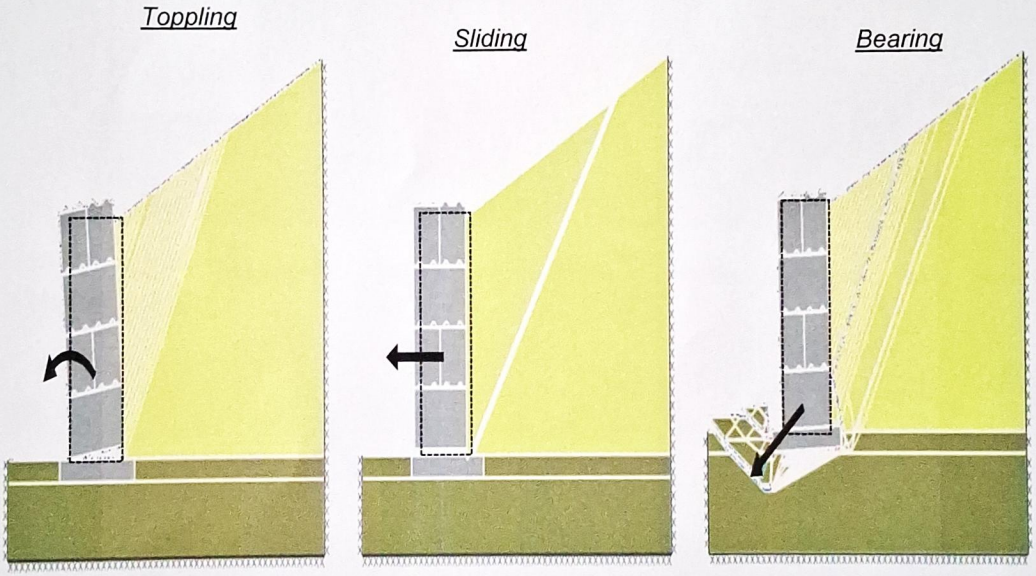


FIG. 3.1 Ultimate limit states for gravity retaining walls

The retained ground (or stored materials) and imposed surcharge loads exert pressures on the retained side of the wall (see Figure 1.). These are considered 'unfavourable' actions as they are acting to de-stabilise the structure. The self-weight of the retaining wall is usually a 'favourable' action, as the effects of it are to counter the effects of the unfavourable actions. For bearing failure, the self-weight of the wall may be 'favourable' or 'unfavourable'.

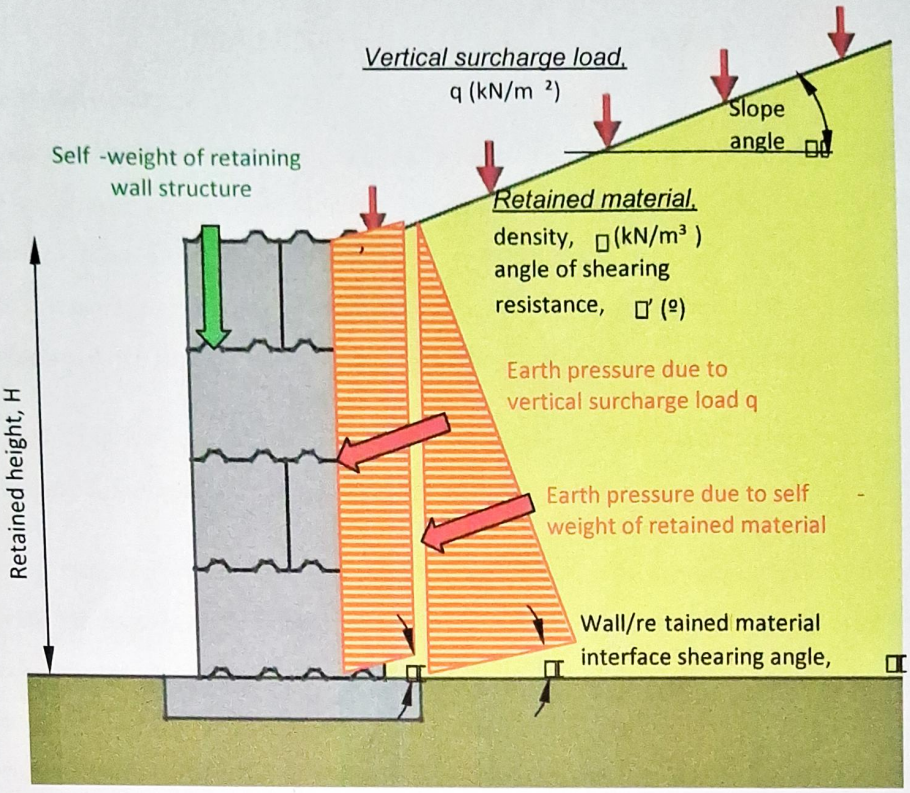


FIG 3.2. Favourable and unfavourable actions applied to gravity retaining wall

CHAPTER 4.

DESIGN OF RCC RETAINING WALL

4.1 Introduction:-

Retaining Walls are structures designed to restrain soil, rock or other materials to unequal level of ground or unnatural slopes. They are used to bound soils between two different elevations often in areas of terrain possessing undesirable slopes or in areas where the landscape needs to be shaped severely and engineered for more specific purposes like roadway overpasses, steep slopes around homes, parks, and walkways around river areas.

This retaining wall can be made from stone, sheet piles, wooden plank, plain cement concrete (PCC) and Reinforced Cement Concrete (RCC).

A RCC retaining wall is a stabilizing structure used to hold sloping ground in place and to prevent the erosion and the movement of soil. A RCC retaining wall must be substantial and sturdy structure in order to accommodate and redistribute lateral pressure caused by sloping. It is normally designed with seepage holes, which allow collected ground water to escape. This releases the additional pressure created by accumulated water and helps keep the retaining wall stable.

RCC retaining walls are commonly used to level or retain slopes and give them a more vertical character. Generally, the more restricted or congested the site, the greater the need for retaining walls to provide usable space for landscape purposes.

4.2 Types of Retaining Walls:-

Following types of retaining walls are generally used.

i. **Gravity Walls: -** Gravity walls are the earliest known retaining structures. They are built from solid concrete or rock rubble mortared together. The lateral force from backfill is resisted by weight of wall itself and due to their massive nature they develop little or no tension. Therefore, they are Page 13 usually not reinforced with steel. Gravity walls are economical for heights up to 3 m (10 ft).

ii. **Semi-gravity Walls:-** A specialized type of gravity walls is a semi-gravity retaining wall. These have some tension reinforcing steel included so as to minimize the

thickness of the wall without requiring extensive reinforcement. They are a blend of the gravity wall and the cantilever wall designs.

iii. **Cantilever Walls: -** Cantilever retaining walls are constructed of reinforced concrete. They consist of a relatively thin stem and a base slab. The base is also divided into two parts, the heel and toe. The heel is the part of the base under the backfill. The toe is the other part of the base. Use much less concrete than monolithic gravity walls, but require more design and careful construction. Generally economical up to about 25 ft. in height. The resistance to sliding of a cantilever type of retaining wall is sometimes increased by providing vertical projection known as key at the base. The key may be provided near the toe, near heel or at the middle of base.

iv. **Counterfort retaining Walls: -** Counterfort retaining walls are similar to cantilever walls except they have thin vertical concrete webs at regular intervals along the backside of the wall. These webs are known as counterforts.

v. **Buttressed Wails:-** A buttressed wall is similar to counterfort type of wall but in this case counterforts are placed on the front of the wall and are known as buttresses rather than counterforts. In this type of wall heel projection is small and hence backfill contributes less to the stability of wall. Also buttress reduce clearance in front of the wall. These types of walls are rarely used.

4.3 Components of RCC Retaining Walls

- Soil
- Stone
- Cast in situ panels frames
- Steel
- Concrete

4.4 Batter in RCC Retaining Wall:-

RCC Retaining Wall is given a batter of V". Back of the Retaining Wall is not kept vertically straight as the pressure of soil is more at the bottom therefore it is kept inclined to avoid overturning.

Fig. 4.6.1 RCC Retaining Wall Initial stage

Fig. 4.6.2 RCC Retaining Wall Final stage

4.6 Steps of Design

4.6.1 Design of Toe:

The toe is subjected to upward pressure from the soil and self load which acts downwards. The maximum Shear Force (S.F.) and Bending Moment (B.M.) will occur at the face of the stem. Adequate depth and reinforcement is provided to resist S.F. and B.M.

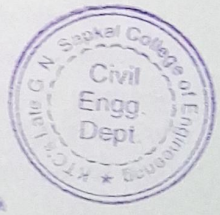
4.6.2 Design of Heel: -

The heel is subjected to upward pressure from the soil and downward load due to self-weight and earth above the heel. Normally B.M. and S.F. are maximum at the junction of heel with stem. The B.M. due to earth retained and self-load shall be more than that due to upward pressure from soil. Adequate depth and reinforcement are provided to resist S.F. and B.M.

4.6.3 Check against Sliding: -

The tendency of ealth pressure is to slide the base. This efTect is counterbalanced by the friction between base and the soil. If is co-efficient of friction, frictional resistance to sliding shall be ,uW, where W is the total vertical load. For safety PW should be at least 1.5 times the horizontal component of the earth pressure.

In case the frictional resistance is not sufficient, key is provided preferably below the stem.



CHAPTER 5

RETAINING AND REINFOCED EARTH WALL WORKS

5.1 General

Retaining walls are structures, which support and retain earth in order to prevent failure of sediments in the places where stability of slope can not be assured by ground condition itself or by other slope protection works.

Along the N-M highway, a lot of retaining walls, which consist mainly of gravity type concrete wall, block masonry wall and gabion wall, have been constructed. However, a large number of structural deformation and failure on the retaining walls were visibly and clearly observable.
The main problems regarding to the retaining walls are listed as follows:

a) No or no enough geotechnical investigations were conducted to obtain foundation information for the design of retaining walls. Some retaining walls rest on loose and soft ground that has no enough bearing capacity to support the retaining structures.
b) No or less foundation works were executed. Some retaining walls were placed on deposit layers without foundation treatment, which is the main cause of retaining structure damage.
c) In some cases, retaining walls are misused because of the failure masses or earth pressure that may be the several time larger than the wedge of earth retained by these retaining walls. To be effective, the wedge of earth supported by the wall should be similar or larger in size to that of the failed or potential failure mass. If the potential failure mass is much larger than the wedge of earth that the retaining wall can potentially retain, a tieback system or some other method of stabilization should be used in combination.
d) In some cases, anti-proof sand treatment (geotextile and filter material) behind the walls were not designed and executed. This may cause flow out of backfilling materials, leading to soil subsidence behind the wall and subsequent deformation and collapse of the retaining wall.

This chapter, focusing the above-mentioned problems, discusses consideration points in planning, designing and constructing a retaining wall.

In addition, as a new method, reinforced earth walls, which has the function of a retaining wall, has been widely used in unstable sites in mountainous areas in recent years. It is a technically attractive and cost-effective technique for increasing the stability of natural soil and constructed fill slopes and for reducing earth pressures against retaining walls. The method is ideal for very high or heavily loaded retaining walls because of its high load-carrying capacity. The method is thus introduced in this technical guide, in consideration of its applicability in Nepal in the future.

5.2 General Considerations

5.2.1 Classification of Retaining Walls

Retaining walls are generally classified into the following types in accordance with shapes, characteristics, design criteria and applications.

a) Stone (or block) masonry retaining wall
b) Gravity type retaining wall
c) Supported type retaining wall
d) Cantilever beam type retaining wall
e) Counterfort type retaining wall
f) Buttress type retaining wall
g) Gabion retaining wall

Table 5.2.1 summarizes retaining wall types and their characteristics.

5.2.2 Application of Retaining Walls

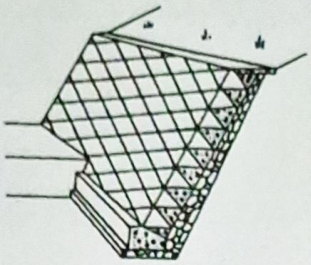
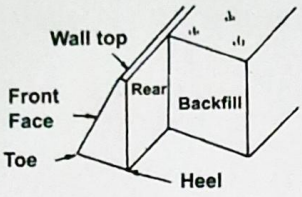
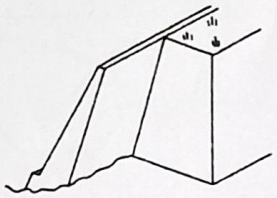
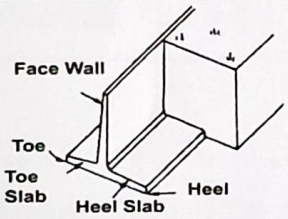
As summarized in Table 4.2.1 below, selection of the type of retaining wall is generally based on the topographical and geological conditions at the place of the wall construction, work conditions, purpose of retaining wall, and height of wall.

Retaining walls are used to correct highway failures by increasing the forces tending to resist failures. Generally, retaining wall is placed at the toe of the distressed area or potential slope failure.

Retaining walls have some potential applications as follows:

a) To maintain the stability of the foot part of a slope after being distressed (Figure 4.2.1),
b) To prevent small-scale shallow collapse and toe collapse of large-scale slope failures,
c) To support slope fattening and berm fills,
d) To function as a foundation for other slope protection works such as crib works,
e) To catch rock fall mater in order to protect vehicles from rock fall (Figure 4.2.2), and
f) To provide road space especially where right of way is limited.

Table 5.2.1 Types and Characteristics of Retaining Walls

Type	Shape	Height and Gradient	Characteristics	Technical Note
Block (Stone) Masonry		Normally less than 7.0 m in height. Up to 15.0 m in height for large block masonry. Front slope is 1:0.3 to 1:0.6 (V:H)	Frequently used to prevent small scale collapse at the foot of the slope or to protect the slope.	Mainly Applicable for light earth pressure loads where the soil behind the wall is dense or good soil sediment. Structurally weak to resist the effects of an earthquake.
Gravity		Less than 5.0 m in height. The width of wall base is about 0.5 to 0.7 times the height of the wall.	Supports the earth pressure by its deadweight.	Applicable on good ground foundations because of great ground reaction. Inapplicable for pile foundations.
Leaning		Less than 10.0 m in most cases. Up to 15.0 m in some cases. Front slope is 1:0.3 to 1:0.6 (V:H)	Supports the earth pressure by its own deadweight while being supported by the earth at the rear or by the backfill.	Applicable for widening the existing road in mountainous terrain. Frequently used in places with land and topographical constraints.
Cantilever		3.0 to 10.0 m in height. The width of wall base is about 0.5 to 0.8 times the height of wall.	Vertical wall resist the lateral load or earth pressure. The weight of backfill over the heel slab can be used to support the earth pressure.	Applicable for pile foundations. Precast concrete is frequently used.

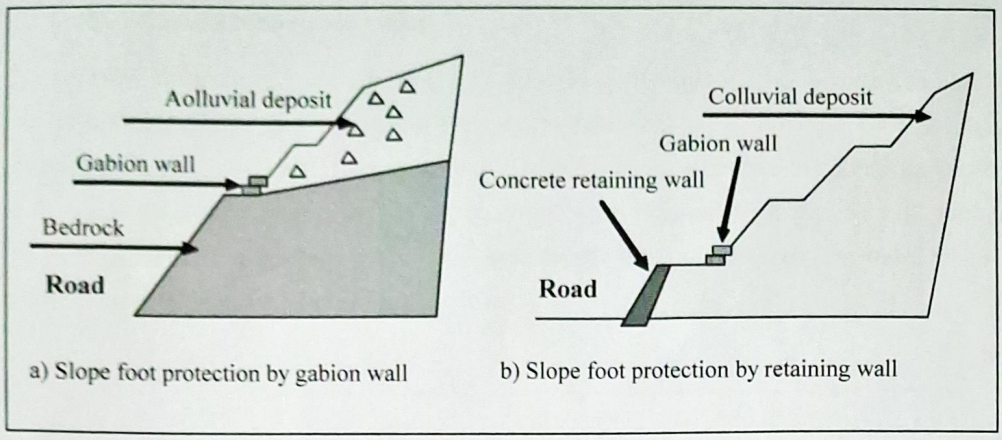


Figure 5.2.1 Schematic Diagram of Slope Foot Protection

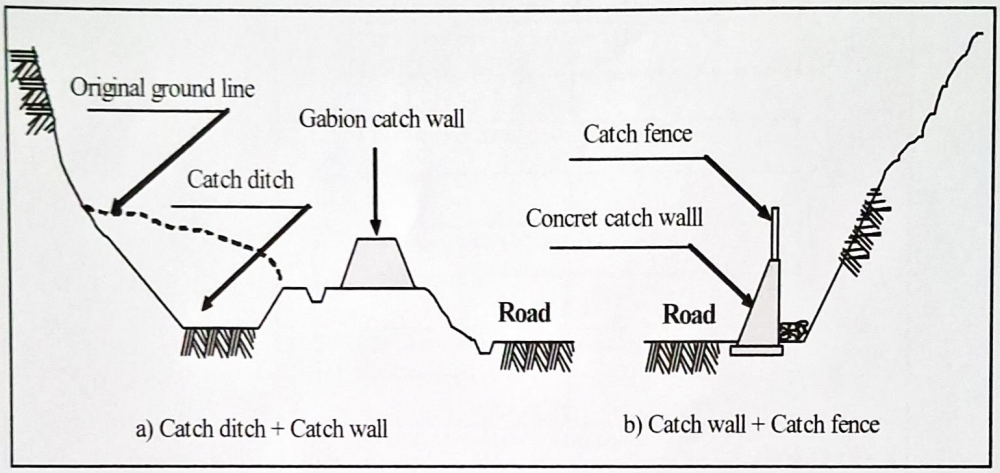


Figure 5.2.2 Schematic Diagram of Rock Fall Protection

5.2.3 Design Procedure of Retaining Wall

Figure 5.2.3 shows the design procedure of retaining wall works. The following sections will give brief descriptions of design procedures for retaining walls.

1) Selection of types of structures

As shown in Table 5.2.1 before, there are many types of structures for retaining walls and the selection of type of structures are dependent mainly on the topographical and geological conditions at the place of the wall construction, work conditions, purpose of retaining wall, and height of walls.

2) Selection of foundation types

The types of foundations for a retaining wall are principally classified into spread foundations and pile foundations. The preferable type of foundations for a retaining wall are spread foundation in view of their movement together with the bearing stratum and the filling material at the back. In some cases, if surface layer is soft, spread foundations can also be used with the replacement or improvement of the soft layer. Pile foundations are used when the application of spread foundations are difficult.

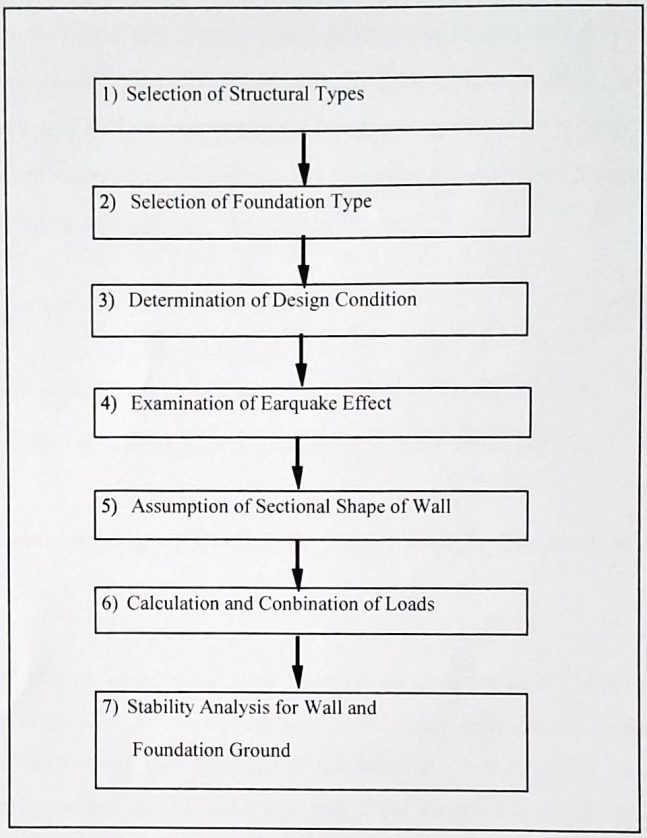


Figure 5.2.3 Flowchart of Retaining Wall Design

4.5 Construction Procedure of RCC Retaining Wall:-

Various steps involved in the construction of RCC retaining Wall include Excavation & Ground Preparation, Construction of Base & Raft Foundation with Panels, Concreting Foundation, Curing, Placing of Filter Media and Backfilling etc. (Figure 3.1 to 3.3). These procedures are briefly explained as under.

4.6. Drainage of Retaining Wall

When the backfill is submerged retaining wall is to be designed to resist hydrostatic pressure in addition to pressure exerted by the submerged soil. Surface or underground water may seep into backfill and this shall cause hydrostatic pressure. In such cases retaining wall should be designed for earth pressure and hydrostatic pressure. In case retaining wall is designed only for earth pressure, effective drainage should be provided to prevent the water from accumulating at the back and thus coming in contact with the face of the wall.

The drainage system of walls consists of three steps:

- Firstly effective drainage should be provided at surface to drain off surface water.
- Secondly, a relatively impervious blanket should be provided at the top of the backfill to reduce the seepage of water.
- Finally weep holes or weepers are provided inside the wall to drain off the water that accumulates at the back of the wall.

Weep holes are generally formed by embedding 10 cm diameter pipes in the wall. The vertical distance between horizontal rows of weep holes should not exceed about 1.5 m. The horizontal spacing between weep holes depends upon the arrangement provided at the back of the wall for seepage. Cheapest method is to provide gravel or crushed stone at the intake end of the weep holes. The horizontal spacing of weep holes in this case is also about 1.5 m.

5.3 Design of Main Retaining and Reinforced Earth Walls

5.3.1 Reinforced Earth Walls

The method consists of three parts, namely, 1) wall facing materials, 2) reinforcement materials and 3) backfill materials. Wall facing materials include precast concrete blocks and concrete panels, cast-in-place concrete and steel wire boxes. Reinforcement materials include steel belts (strips), anchor plates or bars, welded wire sheets, geotextiles, geogrids, and fibers. Backfill materials are non-cohesive granular soils.

Reinforced earth walls are used to prevent small-scale soil collapse and road slips on steep and large slopes in lieu of retaining walls. The method is the best solution to situations such as restricted right-of-way and steep road slips.

The method requires the inclusion of tensile resistant elements in a soil mass to improve its overall shearing strength and thereby increase the capacity of the retaining wall. Figure 6.3.5 gives the conceptual mechanism of reinforced earth walls

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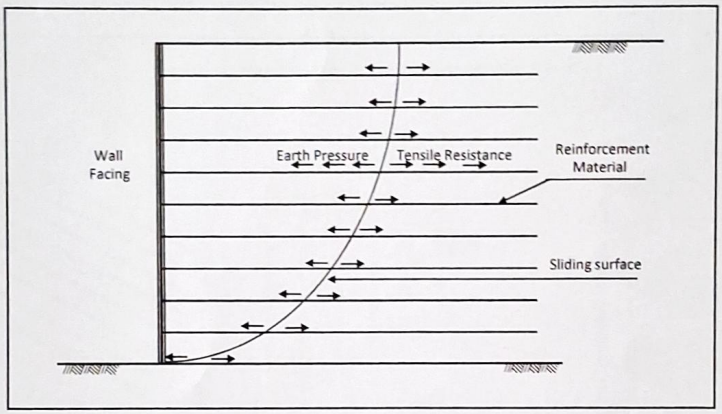


Figure 5.3.1.Conceptual Mechanism of Reinforced Earth Walls

Since the first reinforced earth wall (Terre Armee) was developed in the 1960s, many other types of reinforced earth walls have been developed. Table 6.3.4 summarizes the methods and the characteristics of the most typical reinforced earth walls. Figure 6.3.6 gives the images of reinforced earth walls

Table 5.3.1Typical Reinforced Earth Walls

Method	Reinforcement Materials	Wall Facing Materials	Characteristics	Remarks
Terre Armee Wall	Steel belts (Strips)	Concrete panels	Improve the retaining function of the wall by tensile resistance due to the increased frictional force between strips and backfill.	• Granular soil with low friction • Galvanized (corrosion treatment) steel strips should be used
Anchor Reinforced Earth Walls	Anchor plates & bars	Concrete panels	Improve the strength of the retaining wall by applying tensile force from the anchor plate.	• Sandy or gravely soils having high friction • Corrosion treatment for steel bars
Geotextile Reinforced Earth Wall	Geotextiles	Concrete panel and block, cast-in-place concrete, Steel wire box	Reduce the load on the retaining wall by increasing the frictional force between the geotextiles and the backfill.	• Angular gravels will damage the geogrids. • Tensile strength of geogrids is subject to deterioration by high temperature.

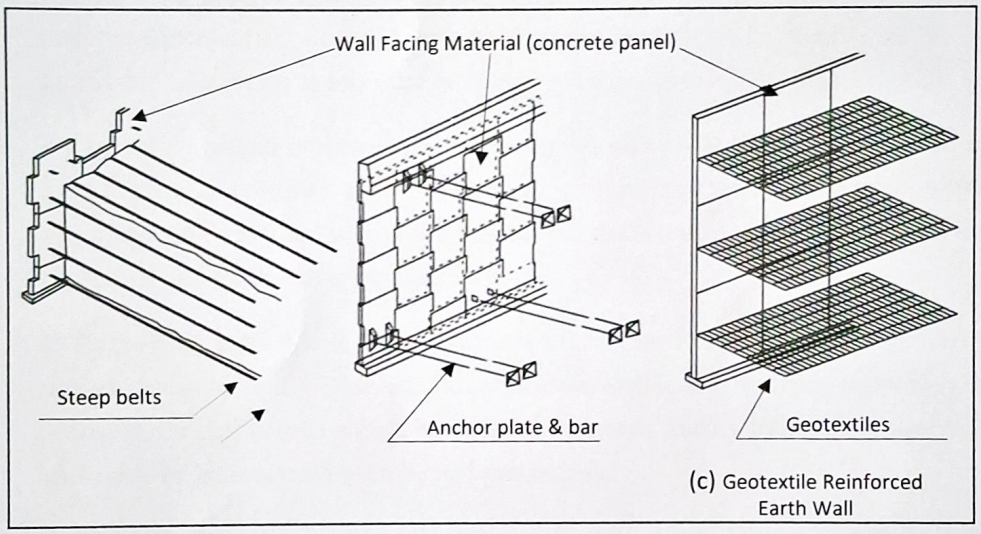


Figure 5.3.2 Schematic Drawing of Reinforced Earth Walls

In principle, the design of reinforced earth walls includes (a) Internal stability analysis, (b) External stability analysis, and (c) Overall stability analysis, as graphically shown in Figure 6For (b), the stability analyses are similar to that for retaining walls, including sliding, overturning and bearing capacity of the foundation.

Figure 6.3.8 gives the general design procedure for reinforced earth walls. Geotechnical parameters relevant to reinforced earth wall design include unit weight, stress strength of the backfill and ground, and bearing capacity of the ground. Detailed guidance on the selection of such parameters is in the other chapters of this Guide.

Construction of Retaining Walls

Retaining walls should be carefully constructed because these structures are designed to retain the extensive earth pressure and therefore the failure of these structures will result in the severe damage not only to the road facilities but also to the road users.

Foundation Work

The foundation works for retaining walls should be considered as follows:

a) The bearing ground should be excavated to a depth required for placing a footing if it is bedrock, the excavated foundation surface of bedrock should be cleaned, and then the spread footing should be placed.

b) If the bearing ground is earth or gravel, rubble stones should be laid over the excavated surface and rolled fully and uniformly, leveling concrete should be poured over the rubble stones, and then the spread foundation should be placed over it.

c) If the bearing ground is slanted, the portion at the valley side should be excavated in the form of steps and the rock should be replaced with concrete to the bedrock line to form a horizontal, uniform foundation. After this, the body of retaining walls or sabo dams should be directly constructed over the foundation.

d) If the bearing ground is soft and compressible, a pile foundation should generally be applied. In addition, if the soft ground (or stratum) is thin or if replacing material is easily available, the soft ground should be replaced with good quality soils so that the retaining walls may be built directly over the replaced material.

e) Timber piles, for example, 80 to 100 mm in diameter, 2.0 m to 3.0 m long, may be installed on gabion walls at longitudinal spacing of 3.0 to 4.0 meters to prevent the deformation of the gabion from the earth pressure of the back slope.

Backfill Work

Backfilling should be not allowed until the retaining structure become stable and strong enough to resist the earth pressure.

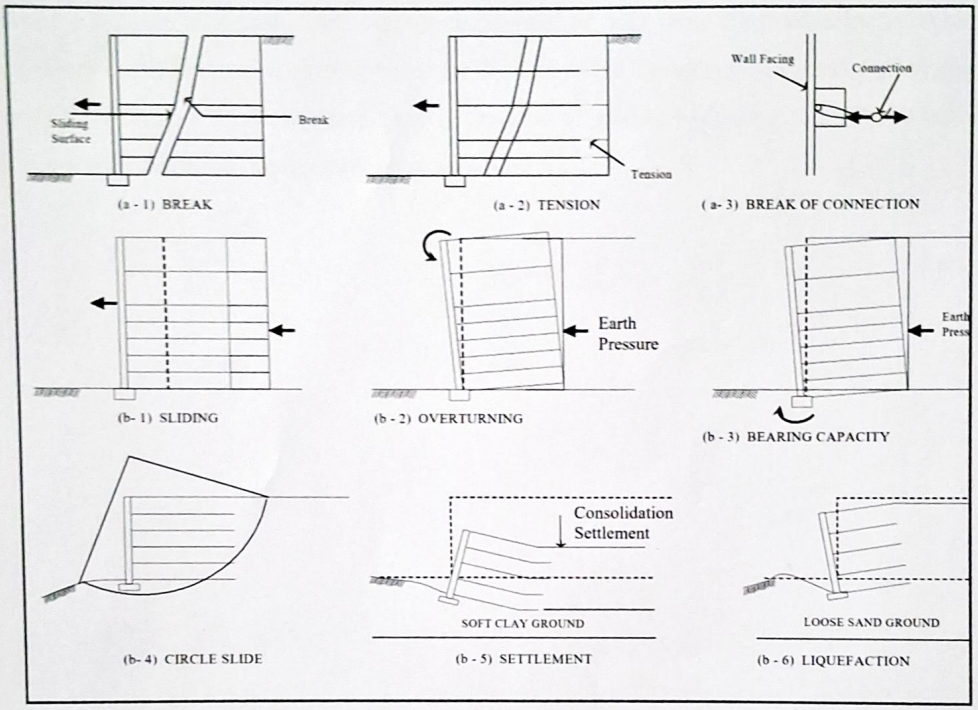
a) Only selected quality materials should be used to backfill the retaining wall.

b) Compaction is completely required.

c) Rain water should be completely prevented from flowing into the portion of backfilling.

d) Drainage facilities must be provided in order to drain the seepage water. Especially weep holes must always be provided with a rate of one weep hole per 2-4 m^2 of retaining wall.

In addition, in principle, anti-proof sand treatment behind the walls should be placed between the walls and the back slope or backfilling to prevent the flow out of fine soil from the back slope, and hence preventing from disturbing the stability of soil mass behind the walls.



For each design situation, concentrated or distributed loads, which may result in forces acting on the reinforced earth wall, are evaluated. The general types of direct loads are a) Deadweight, b) Surcharge, c) Earth pressure, d) Water pressure and e) Seismic load. No common method for stability analysis is applicable to all reinforced earth walls. Table 6.3.5 gives a comparison of stability analysis among the typical reinforced earth wall

CHAPTER 6

CONCLUSION

The worker/labour required more Tor construction of RCC Retaining Wall since it involves too many activities but RE Wall needs less number of manpower since half of the activities is pre-casted like panel casting.

RE Wall needs less working place, no form work but RCC Retaining Wall requires more working place and form work.

The work of RE Wall needs more skilled labour in comparison to RCC Retaining Wall.

For construction of approaches to flyovers and Road Over Bridge's, Reinforced earth technology has almost completely replaced conventional retaining structures. Geogrid Reinforced earth wall retaining structures have gained wide acceptance in India as a technically proven and cost effective alternative to conventional RCC Retaining Wall. The ongoing and planned initiatives of Central and State Governments for improving the road infrastructures in the country are likely to give a major boost for the demand of Geogrid Reinforced wall systems.

The RCC Retaining Wall can't be reused in the case of further widening of Highway but old RE Panel may be reused once again after widening

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