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DEPARTMENT OF CIVIL ENGINEERING

A Field Visit to Malekhu (Geology-II)

SUBMITTED BY

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ACKNOWLEDGEMENT

At every step, an engineer has to encounter earth, and as a material or as construction site. So, it proves the importance of geology to Civil Engineering professionals: I would like to extend my heartfelt gratitude to Dr. Basanta Raj Adhikari, Mr. Deepak Gautam and Mr. Binod Adhikari, our esteemed subject teachers, for their invaluable guidance and support throughout our two day field visit to Malekhu. Their expertise and commitment to our learning experience greatly enhanced our understanding of Engineering Geology II (CE 553).

Furthermore, I would like to express my sincere appreciation to the Civil department for providing us with necessary transportation arrangements, and hotel staffs for providing us accomodations and fooding during the field visit. Their unwavering support played a vital role in the success of our learning endeavour.

ENGINEERING GEOLOGICAL FIELD WORK AT DHADING DISTRICT MALEKHU AREA AND GORKHA DISTRICT (SIURENI-TAR AREA)

OBJECTIVES: OF FIELD VISIT

(1) To study the Rock Mass classification system and Rock Mass classified by RMR (Rock Mass Rating) system.
(2) To study the slope stability analysis
(3) To study the underground excavation and support system.
(4) To study the site investigation.
(5) To prepare engineering Geological map of road section (route-mapping)
(6) To study the mass-movement.

METHODOLOGY

During the field trip following methods were practiced for investigation and study of various geological features

(a) Sighting on the field
(b) Sketching and Photography of field in its natural state.
(c) Data collection
(d) Interpretation and Analysis of Data

INTRODUCTION

Engineering, a discipline deeply rooted in practical application and field exploration, encompasses various specialized fields of study. Among these, Civil Engineering stands out as a domain where field visits prove exceptionally beneficial for both students and educators. The traditionally based classroom learning approach alone falls short in equipping aspiring civil engineers with the necessary knowledge and skills. Civil Engineering offers a captivating journey with its wide-ranging and interdisciplinary subjects woven into the curriculum.

In line with these principles, as part of the BE Civil Syllabus prescribed by the Tribhuwan University, we the, 2nd-year students, embarked on a field visit for our Engineering Geology (CE-503) course. Our destination was the Malekhu area in the Dhading district of central Nepal. This subject provides students with fundamental knowledge of geology, aiding in the identification of rocks, minerals, geological structures, processes and their impact on engineering structures. Along with these, we learned about mass movements and their types including Landslides, Debris flow, slope failure, Rock mass classification and slope stability analysis.

These reports provides us both theoretical and practical knowlege about rock mass classification and mass movements.

LOCATION - 1

About 2km from the bridge above Trishuli River connecting Benighat and Seurenitar on the way to Aarughat (Gorkha).

Objectives → To study the Rock Mass Classification System and Rock mass classified by RMR (Rock Mass Rating) System
↳ To study slope stability Analysis.

- Rock Mass: Mass containing both intact rock and discontinuities
- Discontinuity: Fracture, crack, or joint seen in rock.
- Intact Rock: Rock not having any discontinuity is called intact rock
  ↳ Larger is the size of intact rock, better is its quality.
- Weathering of rock: The Mechanical and chemical disintegration of rock is called weathering of rock

☐ Rock Mass Classification System

(1) Terzaghi Rock mass classification system
↳ Earliest reference used for design of tunnel support developed by Terzaghi.
↳ Less used.
↳ Descriptive Classification of Rock Mass

(2) Rock Quality Designation Index (RQD) System:
↳ Introduced by D.U. Deere
↳ Based on the qualitative estimate of rock mass quality from drill core logs.
↳ RQD is defined as the percentage of intact rock core pieces longer than 100mm (4 inches) to the total length of core.

$$RQD = \frac{\Sigma \text{Length of rocks} > 100mm}{\text{Total length of the core}} \times 100\%$$

Sometimes the drilling of core is not available. In such case, RQD can be determined by the Palmstorm's emperical relation,

$$RQD = 115 - 3.3J_v$$

where,

J_v = sum of number of joints per unit length for all joint (discontinuity set

(Also, called joint volume or volumetric joint)

RQD(%)	Rock Quality Classification
<25	very poor
25-50	poor
50-75	Fair
75-90	Good
90-100	very Good

(3) Rock Mass Rating (RMR) Classification System

('or' Geomechanical Rock Classification)

('or' Bieniawski's Geomechanics Classification)

→ It uses six parameters to classify the rock using RMR system. They are:

(i) Uniaxial Compressive Strength of rock Material

(ii) Rock quality designation index (RQD)

(iii) Spacing of discontinuities

(iv) condition of discontinuities

It further includes

(a) Discontinuity length

(b) Separation (Aperture)

(c) Infilling Material (Gouge)

(d) Roughness

(e) Weathering grades

(v) Ground water conditions

(vi) Orientation of discontinuities

Rock classification based on RMR system

Class	Rating Value	Rock Quality
I	100 – 81	very Good
II	80 – 61	Good
III	60 – 41	Fair
IV	40 – 21	poor
V	<21	very Poor

~~(4) Rock~~

In field the parameters were identied as

(1) Strength

↳ By the use of Geological hammer

↳ Observing sound and rebound of hammer

↳ RMR rating was given according to percentage of metallic sound & rebound with maximum value of 15

(2) RQD

$$RQD = 115 - 3.3 * J_v$$

J_v = Volumetric Joint

(3) Spacing of discontinuity

↳ By measurement with tape

(4) Condition of discontinuity

(a) Length of discontinuity: by measurement with tape

(b) Separation → Joint spacing measurement

(c) Infilling material → hard filling ; soft filling; no filling

(d) Roughness → By touching surface

(e) Weathering grade → according to strength

↳ weathering $\propto \frac{1}{\text{strength}}$

(5) Groundwater condition

↳ moist 'or' dry rock mass

Field observation for classification of rock by RMR

Parameter	Range of value	Rating
i. Strength of intact rock material	1-2 MPa	4
ii. Drill core quality (RQD)	62.2% (50-75%)	13
iii. Spacing of discontinuities	23.77 cm (20-60 cm)	10
iv. Condition of discontinuities	According to chart below	13
v. Groundwater conditions	Dry	15

Guidelines for Classification of Discontinuities

Parameters	Range of values	Rating
(i) Discontinuity length	2.25m (1-3 m)	4
ii. Separation	1.55mm (1-5mm)	1
iii. Roughness	Slightly rough	3
iv. Infilling	Soft filling <5mm	2
v. Weathering	Moderately weathered	3

Thus,

RMR = 4+13+10+13+15 = 55

Thus, Rock class = III (Fair rock)

For given rock,

Excavation: → Top heading and bench
→ 1.5-3m advance in top heading
→ commence support after each blast
→ complete support ~~of~~ 10m from face

Rock bolts: Systematic bolts 4m long, spaced 1.5-2m in crown and walls with wire mesh in crown.

Short crete : 50-100mm in crown and 30mm in sides

Average standup time: 1 week for 5m span

Slope Stability Analysis

Slope stability refers to the condition of inclined soil on rock slopes to withstand or underogo movement. slope stability analysis is the static and dynamic, analytical or empeorical method to evaluate the stability of earth and rock fill dams, embankments, excavated slopes and natural slopes in soil and rock.

Types of slope Failure

(a) Plane failure

Conditions:

(i) The joint plane and hill slope should dip in same direction.

(ii) The dipping of the joint should be less than the dip of the hill slope.

(iii) The strike difference should be between 20°.

(iv) The dip of the joint should be more than the internal frictional angle.

(b) Wedge Failure

Conditions:

(i) The wedge and the hill slope should dip in the same direction.

(ii) The dipping of the wedge should be less than the dip of the hill slope.

(iii) The strike difference should be between 20°.

(iv) The dip of the wedge should be more than the internal friction angle.

(c) Toppling Failure

Conditions:

(i) The joint plane and the hill slope should dip in Opposite direction.

(ii) The strike difference should be between 20°.

(iii) The dip of joint should be more than internal frictional angle.

Field Observation of Stability Analysis

Joint set no.	Strike	Dip direction	Dip amount
J_1	352°	259°	59°30"
J_2	6°	278°	42°10"
J_3	64°	329°	46°40"

Hill slope = 62°

SITE INVESTIGATION

It is the overall evaluation of specific site condition of project area where any civil Engineering infrastructures need to be constructed. Lithology, geological structures, topography, hydrogeology, seismicity and geomorphology are major parameters for evaluation of site condition.

Purpose of site investigation
- ↳ To know existing site condition of area
- ↳ To anticipate what can be expected during construction.
- ↳ To determine and develop design criteria based on determined physical condition.
- ↳ For overall evaluation of the feasibility of engineering project and data collection to find out the stability, safety, cost and time of completion of project.
- ↳ To estimate the mechanical and physical properties of the rock mass and mechanical behaviour of the ground mass.

Methods of Site Investigation
- (a) surface investigation
- (b) Sub-surface investigation

(a) Surface investigation:
Study and investigations of superficial details are done in surface investigation. It includes preparation of topographic maps and the data are collected by two methods:

(i) Direct method:
- ↳ site visit and observation
- ↳ Measurement, data collection and documentation
- ↳ Insitu test
- ↳ sketching and photography

(ii) Indirect Method

↳ study and interpretation of maps (topographical, geological, engineering geological, aerial maps)

↳ Literature review

(b) Sub-surface Investigation:

Study of details beneath the earth's surface is done in this investigation. It is done after surface investigation in two ways:

(i) Direct method:

↳ Pit excavation
↳ Auger boring
↳ Percussion drilling
↳ core drilling
↳ Adit excavation

(ii) Indirect method:

↳ Geophysical exploration
↳ Gravity method
↳ Magnetic method
↳ Radio-active method
↳ Electrical method
↳ seismic method
↳ Ground Penetration Radar (GPR)

Adit:

↳ Adit is an entrance to underground mine which is horizontal or nearly horizontal

↳ Unlike tunnel, it has opening only in one side without exit.

Study of support system of underground excavation

↳ The failure of rock mass around an underground opening depends upon in-situ stress levels and upon characteristics at rock mass depends on how heavily jointed rock mass fails.

supports need to be installed based on the type ...

- ↳ wedge failure → Rock bolting
  - ↳ short cretting
- ↳ stress induced failure → pattern support with grouted dowels
- ↳ very poor rock associated with shear zones
  - ↳ Fiber reinforced shortcrete steel ribs.

other support systems includes straps, mesh, steel sets, etc during underground excavation.

support types

① Rock bolt

- ↳ Hanging rock is stabled at its place by bolting, fixing at its position.
- ↳ Length of rock bolt depends upon the length of discontinuity
- ↳ may be oblique or perpendicular to surface.
- ↳ plate in the bolt takes load such that bolt is not affected.

② shortcrete

- ↳ Hard filling (concrete + chips) to make the jointed rock intact to its position.
- ↳ cement + chips ; seals the joint

(3) wire netting

- ↳ set mesh of metallic wire and put concrete in it
- ↳ The net structure bears load.

(4) steel ribs

- ↳ For poor quality rock usually for short sections.

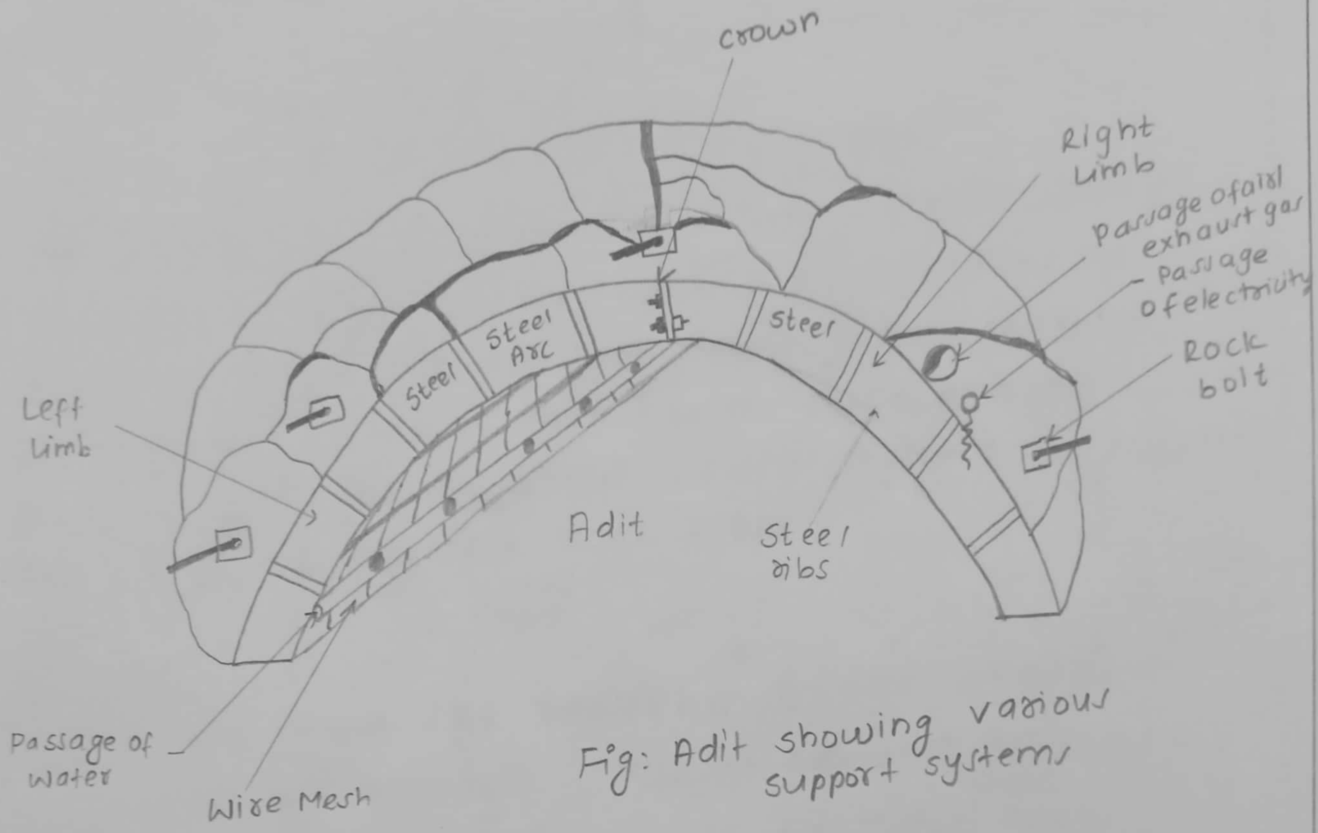


Fig: Adit showing various support systems

LOCATION 2:

Near the dam axis of the proposed Budigandaki Hydropower project, about 2.5km on the way to Arughat Bazaar (Gorkha) from the bridge connecting Benighat and Seurenitar above Trishuli River.

Objectives: → To study the underground excavation and support system

→ To study the site investigation.

→ At this location, we observed adit tunnel for the study of proposed Budigandaki Hydropower project. It is an example of direct sub-surface investigation method. Adit is a type of tunnel that has a single entrance.

→ Moreover, we learned about various system of supporting the jointed & unstable rock mass.

LOCATION 3:

About 2700m from the Malekhu Bridge which is in Prithvi Highway towards Huaxin cement Factory.

Objective: To prepare Engineering Geological map (Route Mapping)

Geological Map

↳ It depicts the distribution of rocks ; rock types and its sub-types; orientation of bedding plane of rock; geological cross-section and geological structures (fault, fold, etc.)

↳ It is concerned with rock.

Engineering Geological Map

- It is an special purpose maps depicting geological features like rock mass, lithology, geomorphology or topography, hydrogeological condition, surface instabilities, rock weathering grade; soil type and its thickness; erosion condition; flood/landslides vulnerable areas and Ground-water condition.
- It is used in planning of various civil Engineering Infrastructures.

Preparation of Engineering Geological Maps

(1) All geological features (fold, fault, etc.) must be shown.

(2) Rock units or geological strata are shown by appropriate symbols.

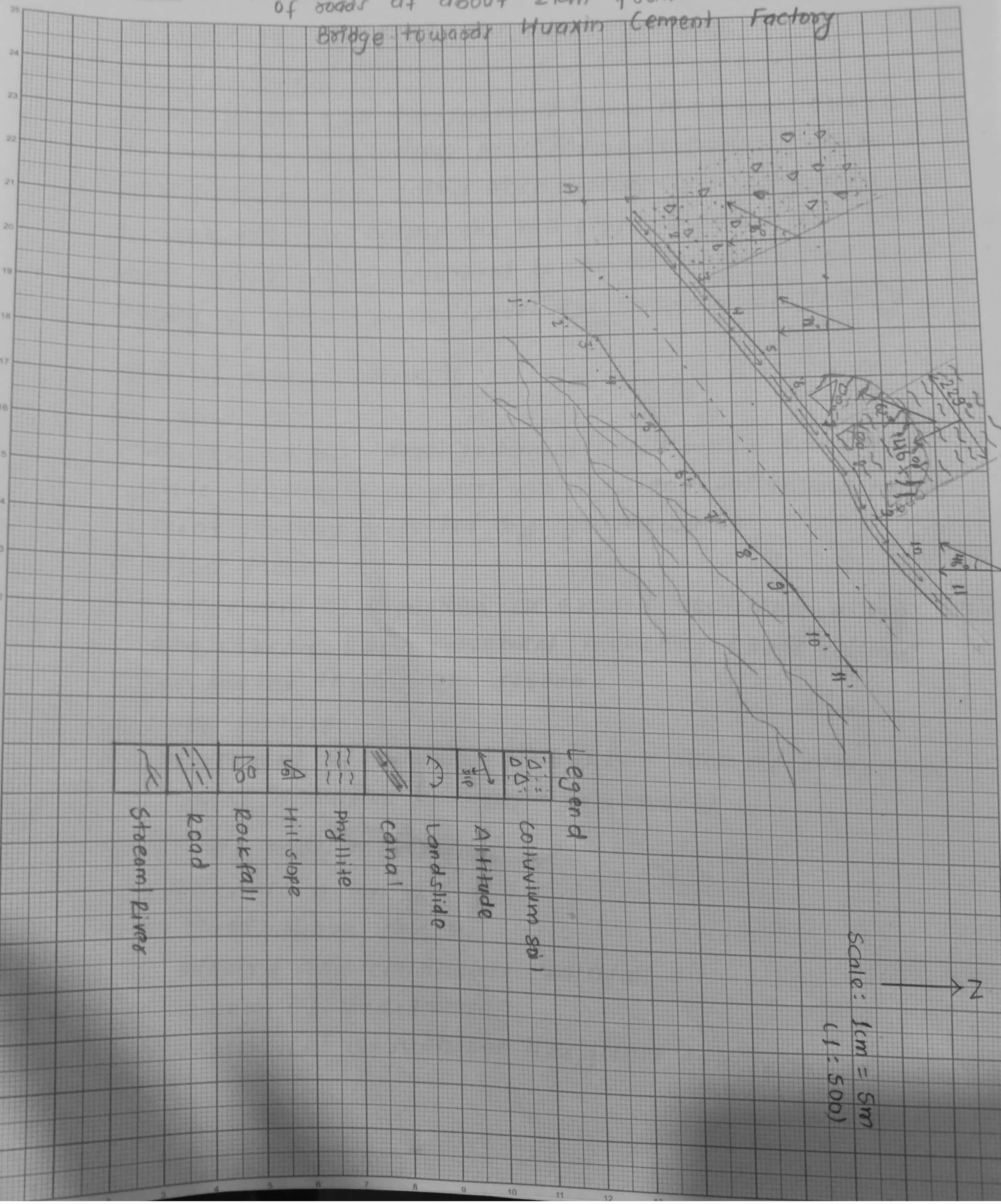
(3) Bedding planes and structural features like fault, are shown by dip and strike.

(4) Contours are drawn to find topography of land.

OBSERVATION TABLE

S.N.	Bearings	Length (m)	Width (m)	Rock Type	Attitudes	Weathering Grade	Geological Structure	Soil Type	Soil thickness	Slope direction Left (UP)	Slope direction Right (Down)	Slope Instability condition	Ground water condition	Surface Drainage	Remarks
1.	5.36m from A	14°	14.2	-	-	-	-	Colluvium	1m	76°	-	-	Dry	-	Canal (1.428m)
2	5m	48°	12.1	-	-	-	-	Colluvium	1m	78°	-	-	Dry	-	-
3	5m	52°	11.7	-	-	-	-	Colluvium	1m	78°	-	-	Dry	-	-
4	5m		12.8	-	-	-	-	-	-	78°	-	-	Dry	-	-
5	5m		12.6	-	-	-	-	-	-	78°	-	-	Dry	-	-
6	5m		11.9	-	-	-	-	-	-	62°	-	Rock Fall	Dry	-	-
7	5m		12	Phyllite	Strike: 229°	Moderate	-	-	-	62°	-	Rock Fall	Dry	-	-
8	5m		11.32	Phyllite	Dip dir^n: 131	Moderate	-	-	-	62°	-	Land slide	Dry	-	-
9	5m		12.06	Phyllite	Dip amount: 46°	Moderate	-	-	-	64°	-	Land slide	Dry	-	-
10	5m		12.45	-	-	-	-	-	-	46°	-	-	Dry	-	-
11	5m		12.78	-	-	-	-	-	-	46°	-	-	Dry	-	-

Engineering Geological Route Map of a road Section of roads at about 2 km from Malekhu River Bridge towards Huaxin Cement Factory



LOCATION 4:

About 250 m from the Malekhu Bridge which is in Prithivi Highway towards Huaxin Cement Factory.

OBJECTIVE: To study the Mass-Movement

Mass Movement:

Disintegrated and fragmented rock materials due to mechanism of weathering processes (mechanical, chemical, biological, etc.) are called rock wastes. Generally, movement of rock wastes along the hill slope is called mass-movement. Hence, mass movement is the detachment and down flowing of rock wastes under the influence of gravity.

Types of mass movements

(a) Landslide:

Movement of large sediment block which has clear slide surface, large dimension, slow and continuous movement mainly affected by groundwater.

(b) Debris flow:

Movement of deposited or eroded sediments along the stream. Rapid movement including large volume of water through the stream.

(c) Slope failure:

Movement of weathered surface rock of steep slope (small dimension and rapid movement)

Causes of Mass movements

i. Volcanic activity
ii. Earthquake shocks
iii. Heavy and continuous rainfall
iv. Lack of vegetation.
v. Geological structures like joints, faults, etc.

Mitigating measures

(i) Slope stability analysis for failure prediction and preparation.
(ii) RMR testing to determine the type of support system.
(iii) construction of retaining structures, gabion walls, etc
(iv) water drainage canal management.
(v) Plantation of vegetation.
(vi) Rock bolting, wire mesh and toe protection for landslide.

Classification of Landslide

(i) on the basis of movement

a. Fall

b. Topple

c. Slide
- Rotational
- Translational

d. Lateral spread

e. Flow

f. complex

(ii) on the basis of type of material

a. Rock
b. Earth
c. Debris

Parts of Landslide

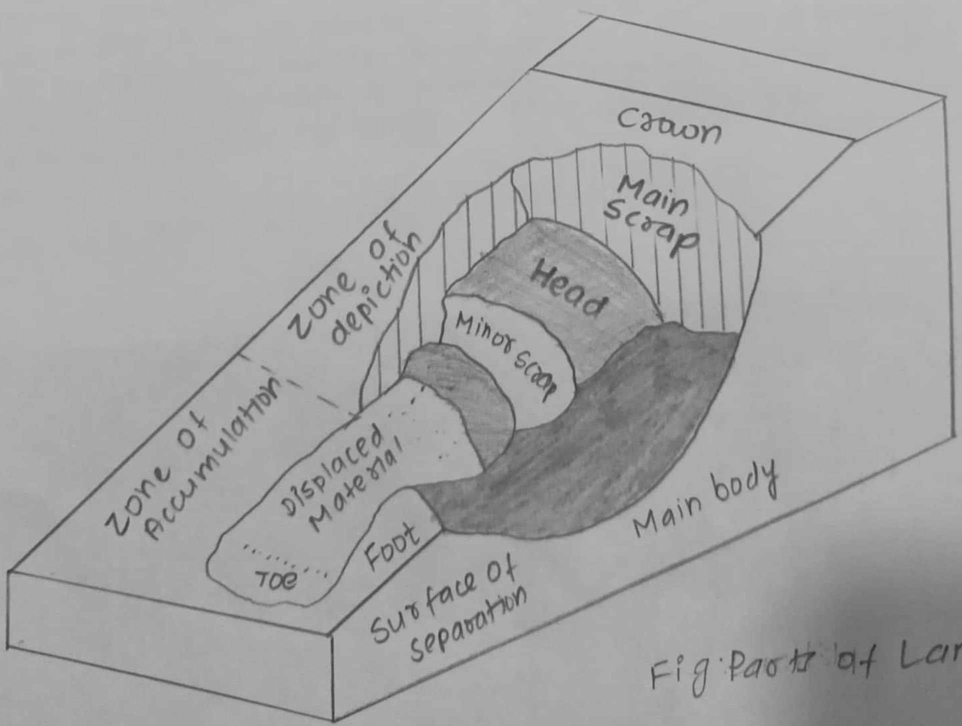


Fig: Parts of Landslide

OBSERVATION:-

At Location 4, the mass movement we observed was Landslide, near the bank of river. The Rough sketch of observed landslide is shown below:

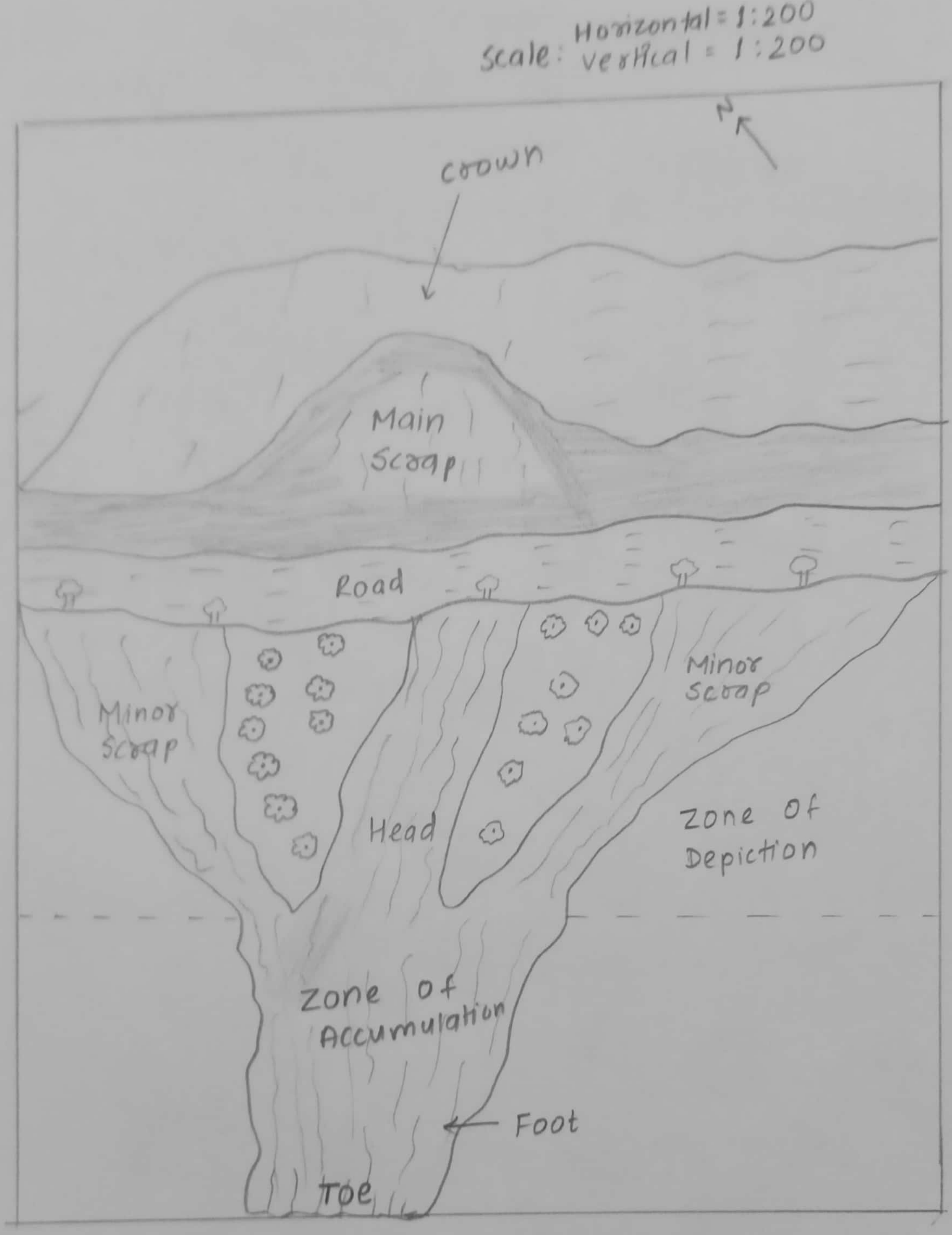


Fig: Landslide at location 6

Causes of Landslide observed:

1. Road excavation
2. High slope
3. Erosion in River Bed
4. Lack of sufficient vegetations
5. Disturbance in Natural slope
6. Earthquake (Seismic activity)
7. Excessive rainfall leading to saturation of soil and thus landslide.

Mitigation measures:

1. Establishment of Retaining walls
2. Bio-engineering in possible areas.
3. Constructing Toe wall at river bed.
4. Nail Filling
5. Wire Meshing
6. Tarping to prevent soil saturation.

CONCLUSION

Finally, our exploration of Malekhu and its surrounding areas has proven to be a treasure trove of geological curiosity. Despite its relatively small size, Malekhu beasts on abundance of geological phenomena and features, providing invaluable knowledge for learners like us.

During the observation, we learnt how rock slope failure can occur and impact civil engineering construction and how can we mitigate them, and provide support system for underground excavation and how rock mass classification is done. Moreover, we learnt about preparation of Engineering geological map (route-mapping) and site-investigation.

The knowledge and skills we have acquired during this excursion will undoubtebly prove invaluable as we pursue our journey in the field of geological and civil engineering.

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