ATME College of Engineering

13th K M Stone, Bannur Road, Mysore – 570028

A T M E

College of Engineering

DEPARTMENT OF CIVIL ENGINEERING

(ACADEMIC YEAR 2023- 24)

SUBJECT NAME: Engineering Geology

SEMESTER: 3RD

INSTITUTIONAL MISSION AND VISION

Vision of the Institute

Development of academically excellent, culturally vibrant, socially responsible and globally competent human resources.

Mission of the Institute

- To keep pace with advancements in knowledge and make the students competitive and capable at the global level.
- To create an environment for the students to acquire the right physical, intellectual, emotional and moral foundations and shine as tourch bearers of tomorrow's society.
- To strive to attain ever-higher benchmarks of educational excellence

DEPARTMENT VISION AND MISSION

Vision of the Department

To develop globally competent Civil Engineers who excel in academics, research and are ethically responsible for the development of the society.

Mission of the Department

- To provide quality education through faculty and state of art infrastructure
- To identify the current problems in society pertaining to Civil Engineering disciplines and to address them effectively and efficiently
- To inculcate the habit of research and entrepreneurship in our graduates to address current infrastructure needs of society

Program outcomes (POs)

Engineering Graduates will be able to:

PO1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write

effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

Program Specific Outcomes (PSOs)

PSO 1 – To apply science, mathematics and mechanics to solve problems in engineering realm

PSO 2 – To analyze the techniques, skills and modern engineering tools necessary for engineering practices

PSO 3 – To develop ability to function as a leader and a team player in multidisciplinary teams

PSO 4 – To recognize of the need for and an ability to engage in research and life-long learning for developing sustainable construction practices

PSO 5 – To design and conduct experiments as well as to analyze and interpret data

Program Educational Objectives (PEOs)

PEO 1- Engaged in professional practices, such as construction, environmental, geotechnical, structural, transportation, water resource engineering by using technical, communication and management skills.

PEO 2- Engaged in higher studies and research activities in various civil engineering fields and life time commitment to learn ever changing technologies to satisfy increasing demand of sustainable infrastructural facilities.

PEO 3- Serve in a leadership position in any professional or community organization or local or state engineering board

PEO 4- Registered as professional engineer or developed a strong ability leading to professional licensure being an entrepreneur.

COURSE MODULE FOR THE AY- 2023-24(ODD SEM)

Course Syllabus with CO's

Department: **Civil Engineering**							
Course Code	Course Title	Core/Elective	Prerequisite	Contact Hours			Total Hrs/ Sessions
				L	T	P	
BCV303	**Engineering Geology**	**Core**	**Evaluation and abatement ofgeologic hazards affecting construction projects andland use.**	**3**	**-**	**2**	**40T/8P**

Objectives

1. To inculcate the importance of earth's interior and application of Geology in civil engineering in Geo Hazard mitigation and management
2. To create awareness among Civil engineers regarding the resources of earth
3. To provide knowledge on dynamic Geology and its importance in modifying the physical character of rocks which cause rocks suitable or unsuitable in different civil engineering projects such as Dams,bridges, tunnels and highways.
4. To educate the ground water management regarding diversified geological formations, . To highlight the concept of rain water harvesting.
5. To understand the application of Remote Sensing and GIS, Natural disaster and management and environmental awareness. To understand the subsurface using geospatial data
6. To provide decision support on the nature of the basic raw materials used in construction. To provide decision support on lithological characters and subsurface conditions
7. To describe various geological maps and interpretation of geological data for mining and subsurface investigations

Topics to be Covered as per the VTU Syllabus

MODULE 1: Introduction, scope of earth science in Engineering, Geohazards and disasters, Mitigation and management

1. Earths internal dynamics ,Plate tectonics,
2. Earth quakes types, causes iso-seismal line, seismic zonation map, seismic proof structures, Numerical problems on location of epicenter
3. volcanic eruption, types, causes
4. landslides, causes types, preventive measures; tsunamis causes consequences, mitigation
5. cyclones, causes management

MODULE 2: Earth Resources

1. Minerals -Industrial, rock forming and ore minerals.
2. Physical properties, composition and uses Rocks as a construction materials- physical properties, texture, composition, applications for aggregate, decorative (facing/polishing), railway ballast, rocks for masonry work, monumental/architecture, rocks as aquifers, water bearing properties igneous, sedimentary

MODULE 3: Surface investigation for Civil Engineering projects

1. Weathering, type, causes, soil insitu, drifted soil
2. Soil profile, soil mineralogy , structure, types of soil, Black cotton soil v/s Lateritic soil
3. Effects of weathering on monumental rocks
4. River morphology and basin investigation for engineering Projects like earthen dam, gravity dam, arch dam.
5. Features of river erosion, deposition and their influences on river valley projects.

6. morphometric analysis of river basin, selection of site for artificial recharge, interlinking of river basins, coastal process and landforms, sedimentation /siltation, erosion.

MODULE 4: Subsurface investigation for deep foundation

1. Borehole data(and problems)
2. Dip and strike, and outcrop problems(numerical problem geometrical/ simple trigonometry based)
3. Electrical Resistivity meter, depth of water table, (numerical problems).
4. seismic studies, faults, folds, unconformity, joints types, recognition and their significance in Civil engineering projects like tunnel project, dam project,
5. Ground improvements like rock bolting, rock jointing, grouting.

MODULE 5: Geo-tools and techniques for civil Engineering Applications

1. Toposheets ,
2. Remote sensing and GIS.
3. Photogrammetry (scale, flight planning, overlap, elevation effects, interpretation keys, numericals on flight, planning scale , elevation, flying height, ….)
4. GPS
5. Ground Penetrating Radar (GPR), Drone, and their applications

List of Text Books

1. P.K. Mukerjee, “A Text Book of Geology”, World Press Pvt., Ltd. Kolkatta.
2. Parbin Singh, “Text Book of Engineering and General Geology”, Published by S.K. Kataria and Sons, New Dehli

List of Reference Books

1. Earthquake Tips - Learning Earthquake Design and Construction - C V R Murthy Published by National Information Centre of Earthquake Engineering, Indian Institute of Technology, Kanpur.
2. Dimitri P Krynine and William R Judd, “Principles of Engineering Geology and Geotechnics”, CBS Publishers and Distributors, New Delhi. 3. K V G K Gokhale, “Principles of Engineering Geology”, BSPublications, Hyderabad.
3. M Anji Reddy, “Text book of Remote Sensing and Geographical Information System”, BS Publications, Hyderabad.
4. Ground water Assessment, development and Management by K.R. Karanth, Tata Mc Graw Hills
5. K. Todd, “Groundwater Hydrology”, Tata Mac Grow Hill, New Delhi.
6. D. Venkata Reddy, “Engineering Geology”, New Age International Publications, New Delhi.
7. S.K Duggal, H.K Pandey and N Rawal, “Engineering Geology”, McGraw Hill Education (India) Pvt, Ltd.New Delhi.
8. Introduction to Environmental Geology by Edward A Keller, Pearson publications.
9. Engineering Geology and Rock Mechanics B. P. Verma, Khanna publishers
10. Principles of Engineering Geology and Geotechnics, Krynine and Judd, CBS Publications

List of URLs, Text Books, Notes, Multimedia Content, etc.

https://www.youtube.com/watch?v=aTVDiRtRook&list=PLDF5162B475DD915F
https://www.youtube.com/watch?v=EBiLLJAxBuU&index=2&list=PLDF5162B475DD915F
https://nptel.ac.in/courses
https://youtu.be/fvoYHzAhvVM
https://youtu.be/aTVDiRtRook

Course Outcomes	Student will be able to • Apply geological knowledge in different civil engineering practice. • Acquire knowledge on durability and competence of foundation rocks, and will be able to usethe best building materials. • Students will become competent enough for the safety, stability, economy and life of thestructures that they construct • Able to solve various issues related to ground water exploration, build up dams, bridges,tunnels which are often confronted with ground water

	problems • Students will become Intelligent enough to apply GIS, GPS and remote sensing as a latest tool in different civil engineering for safe and solid construction.

Internal Assessment Marks:

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%.The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

The Correlation of Course Outcomes (CO's), Program Outcomes (PO's)& Program Specific Outcomes (PSO's)

Subject Code:	BCV303	TITLE: Engineering Geology												
List of Course Outcomes	Program Outcomes (PO's)												PSO's	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO-1	1	-	-	-	-	-	-	-	-	-	-	1	-	-
CO-2	2	-	-	-	-	-	-	-	-	-	-	2	2	-
CO-3	2	-	-	-	-	2	-	-	-	-	-	2	2	-
CO-4	2	-	-	-	-	-	-	-	-	-	-	2	-	2
CO-5	2	-	-	-	-	-	-	-	-	-	-	2	2	-

Note: 3 = Strong Contribution 2= Average Contribution 1 = Weak Contribution -= No Contribution

MODULE-1

Definition of Geology: It is a Greek word "Geo" meaning Earth and "logos" meaning study. It is the science dealing with the study of physical features of Earth and atmosphere.

Engineering Geology: Is the scientific study of rocks, minerals, metals, ores used for industries, civil engineering structures such as dams, airports, stadiums, National Highways, State Highways, multistoried buildings, tunnels, bridges etc.

Branches of Geology

1. **Physical geology:** The branch of geology deals with earth's composition, structural change and geological activities.
Eg:- Earthquakes, volcanoes, tsunamis, climate change etc.

2. **Structural geology:** Branch of geology deals with structure of rocks which have deformed continuously due to the tectonic forces which help in site suitability mountain ranges, oil & gas reservoir.
Eg:- Folds, faults & joints.

3. **Historical geology:** The principles of geology to reconstruct the geological time-scale and to understanding the geological history of earth. It includes the evolution of single cell organisms, plants, animals and humans during geological time-scale.
Eg:- Evolution of earth.

4. **Mineralogy:** The scientific study of minerals their chemistry, crystal structure and physical properties to discriminate their specific use in particular industries.
Eg:- Quartz, pyrite (gold), galena.

5. **Petrology:** (Greek word "Petro"- rocks; "logos"- study). The branch of geology deals with the study of rocks, its structure, formation, texture, composition and origin.
Eg:- Banded gneiss, granite, marble.

6. **Mining Geology:** The Science and Technology deals with the extraction of minerals & ores from the earth.
Eg:- Iron, manganese, limestone, pyrite (gold) and copper.

7. **Geomorphology:** Branch of geology deals with the study of physical features of the earth's surface with their relation to geological structures.
Eg:- Mountains, valleys, desert, oceans etc.

8. **Paleontology:** Branch of geology deals with ancient life of animals and plants.
Eg:- Fossil wood, dinosaur, Hully Mammoth etc.

9. Environmental geology: Deals with the relation between humans and their environment which helps to solve land use problems in civil engineering projects.
Eg:- Land use, mitigation of natural hazards.

10. Civil Engineering Geology: Branch of geology deals with the planning, design, site suitability and maintaining the quality of civil structures.
Eg:- Roads, bridges, dams and similar structures.

APPLICATION OF GEOLOGY IN CIVIL ENGINEERING PRACTICES

1. Geology provides systematic knowledge of construction materials, occurrences, composition & durability for safe, stable and economic designs of major infrastructures.
2. Natural geological agent such as erosion, transportation and deposition will solve expensive problems of river control, coastal, harbor work and soil conservation.
3. Surface & sub-surface water mapping determines the volume of total runoff, drainage basin, silting depth and erosion potential before planning any hydraulic structures.
4. Geology mitigates natural disasters and provides preparedness for future sustainability such as Earthquakes, Tsunamis, Floods, and Landslides.
5. Planning of Dams, Airports, Stadiums, Highways, Multi-storied buildings are directly concerned with the underlying geology of the area.
6. Geological nature and structure of rocks are very necessary for tunneling and bridge constructions.
7. Geological structures of folds, faults, joints can be determined through drilled borehole data, trenches and pits to interpret earthquake conditions for site suitability.
8. Mapping of larger area through Aerial Photographs, Remote Sensing, GIS and GPS data will reduce the time and cost.
9. Extraction of hard rocks, economic minerals, ores and metals can be planned based on geological exploration techniques.
10. Slope stability analyses the landslide hazards in hilly terrains through amount of rainfall, rock characteristics and slope categories concerned with their physical environment.
11. Determining the stability of road cuts, slopes and rock structures is very much necessary in tunneling, canals and constructing roads in hilly terrains.
12. Determines public works such as drainage system, power plants, water treatment plants, canal, reservoir, railroads and parks, mine reclamation and dumping areas through RS and GIS techniques.

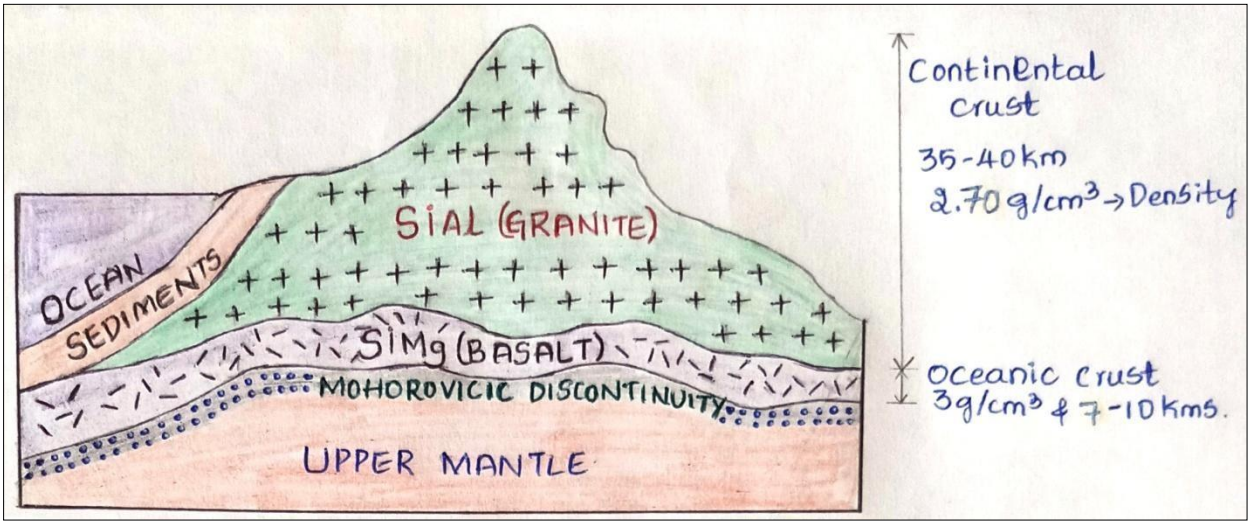
UNDERSTANDING THE INTERIOR OF THE EARTH:

Our Planet occupies third position from the sun with an approximate distance of 14,96,68,992 kms (93,000,000 miles). The light rays take 8 min & 21 sec to reach the earth surface. Rotation of earth in its own axis causes plates movements and its collision causing earthquakes. 72% of the earth is covered by water (ocean and sea) while only 28% is covered by land mass. The Polar diameter of the earth is about 12,755 kms; whereas the equator diameter covers about 12,713km.

The planet Earth is made up of layered of spherical shells and its structure & composition were made based on the

i. Observation of surface rocks and minerals followed by laboratory experiments.
ii. Earthquakes flow of heat, magnetic field and gravity.
iii. Comparison of the earth with other planets such as the sun, stars and meteorites.

The average density of earth is 5.5 g/cm^3; while the surface rock measures about 2.85 g/cm^3.



A section of Earth's Crust

INTERNAL STRUCTURE AND COMPOSITION

The major structural components separated by sharp discontinuities are the CRUST, MANTLE and CORE.

1. Crust: It forms a very thin surface layers which is divided into continental (land) and oceanic (water) crust. The average temperature of crust ranges from 500^{0}C - 900^{0}C.

a. Continental crust: It measures about 35-40 km in thickness with an average density of 2.7 g/cm^3 mainly composed of SiAl (Felsic composition). e.g., Granite.

b. Oceanic crust: This measures about 7-10 km in thickness with an average density of 3.0 g/cm^3 mainly composed on SiMg (Mafic composition). e.g., Basalt.

Mohorovicic discontinuity is the boundary between crust and mantle observed based on the increase in velocity of earthquake due to chemical differentiation.

2. Mantle: It is the thick shell that extends half the radius down into the earth. Mantle measures about 2,900 km in thickness with an average density of 4.5 g/cm^3. This mainly composed of ultramafic rocks such as Mg, K, Na, Ca and Ni. Temperature ranges from 1000^{0}C-4000^{0}C. e.g., Eclogites, peridotites.

Wichert Gutenberg's discontinuity: The boundary between mantle and core observed due to difference in velocities of solid mantle and molten outer core.

3. Core: It is the central part of the earth mainly composed of Iron and Nickel. It is divided into outer liquid core and inner solid core. The outer core measures about 2221 km in thickness with an average

density of 10-12 g/cm^3 and the temperature ranges about 4400^{0}C-5500^{0}C. The solid inner core measures about 1220 km in thickness with an average density of 13 g/cm^3 and temperature ranges from 6000^{0}C.

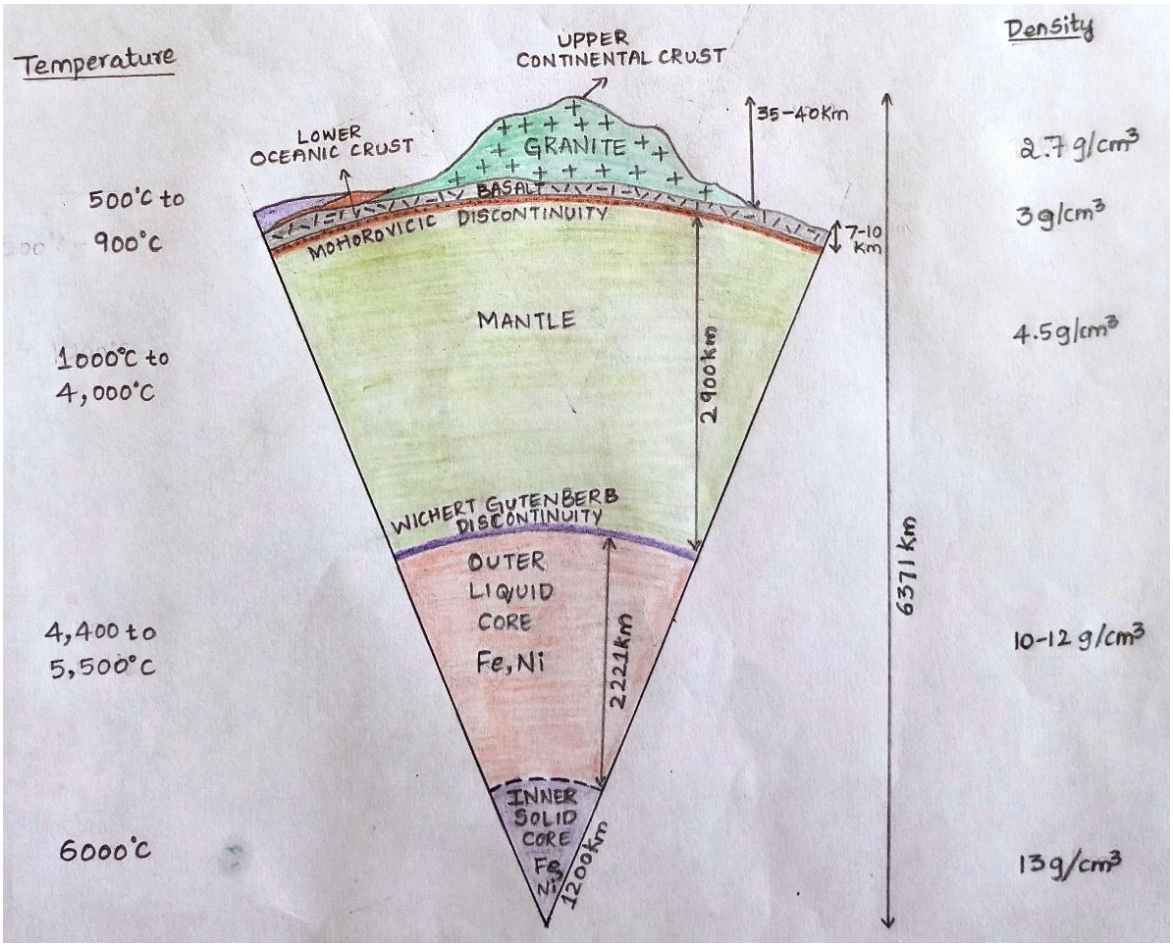
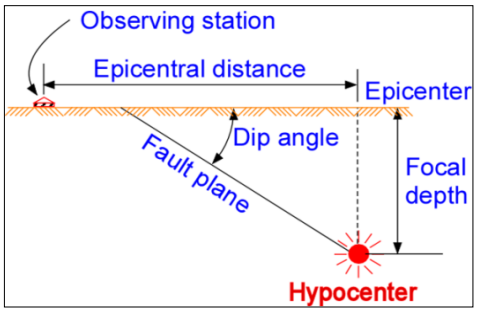


Fig.2. Interior of the Earth

SEISMOLOGY

EARTHQUAKE

It is a sudden and rapid shaking of the ground occurs due to rapid release of energy. Earthquake occurs occasionally but the destruction causes loss of life and property. **FOCUS** is the exact spot underneath the earth surface at which an earthquake originates **(Hypocenter),** while the point on the earth surface lying above the focus is defined as **EPICENTER.**



Earthquake focus is described based on the depth as follows,

i. Shallow:- It is less than 70 km below ground surface.

ii. Intermediate: Between 70 to 300 km.

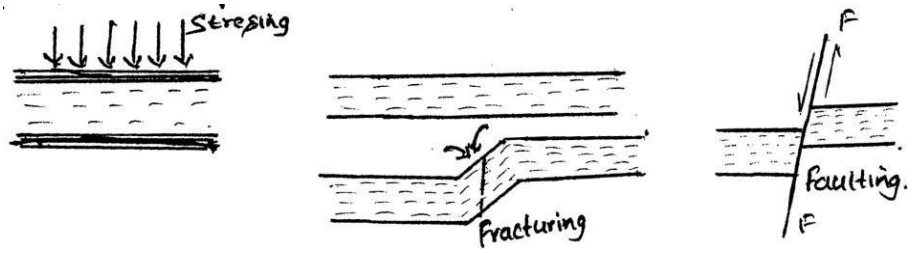
iii. Deep: Below 300 to 700 km.

***CAUSES* of Earthquakes:- broadly classified based on the following categories**

1. Surface (or) dynamic causes:- This occurs due to the collision of waves along sea shore, working of heavy machinery and heavy blasting in mines. Flowing of huge river water in steep slopes, railway tracks along hill slopes. These activities trigger the earthquake of low intensity and few of them are strong enough to be perceptible and some of them can destructive effects

2. Volcanic eruptions:- During volcanic outburst the earth trembles. It is still uncertain geological problems that volcanoes leads to vibration to the earth or earthquakes lead eruption of lava.

3. Folding and faulting activity:- Folding and faulting occurs when the earth crust undergo stress conditions. When stress accumulating in one direction, the rocks is subjected to fracturing and fractured blocks may even suffer relative displacement giving rise to fault. Continent-continent collision implies the folding and faulting of huge rock masses into Himalayas and other mountains.



EFFECTS

It's a complex manner which moves up and down as well as from side by side and depends upon the following

- Intensity and duration of earthquake
- Distance of place from the Epicenter
- Nature of groundmass.

Sl No.	Intensity	Acceleration produced cm/ sec	Effects
1.	Instrumental	<1 cm	Record by sensitive instrument
2.	Very feeble	>1 cm	Noted by few people
3.	Feeble	2.5 cm	Felt by people at rest
4.	Moderate	5 cm	Felt by people in motion
5.	Fairly strong	10 cm	Disturbance of furnishers
6.	Strong	25 cm	Slight damage of building
7.	Very strong	50 cm	Cracks in walls
8.	Destructive	100 cm	Chimneys falls
9.	Ruinous	250 cm	Damage of wall, pipeline
10.	Disastrous	500 cm	Many building destroyed
11.	Very disastrous	750 cm	Few structure left standing
12.	Catastropic	980 cm	Total destruction

Safety measures in seismic areas:- It is impossible to stop the earthquake and the effects depends from place to place. All earthquakes can create great damage to life, buildings, natural ecosystem etc. However it is possible to minimize the impact by predicting through Seismograph instrument.

SIESMIC WAVES:- The focus releases strain energy in several types of wave motions called as seismic or earthquake waves. These waves travel in all directions in different paths, modes and speeds proportional to the densities of the materials through which they travel. The speed increases with density

when they reach the ground surface and spread out in ever widening circles around the epicenter like water waves from a point of impact in a pond and cause that span of the ground to shake.

SEISMOLOGY:- Study of Earthquake.

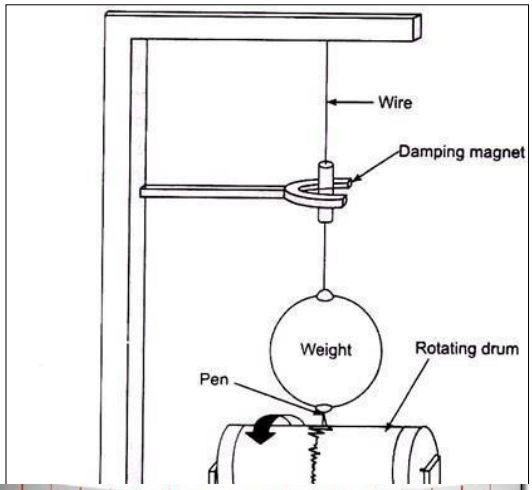
Different types of scales that measures the Intensity of earthquake in different countries as follows

- **Old gram scale of India**
- **Omari scale of Japan**
- **Rossiforel scale of Italy**
- **Richters scale of France**

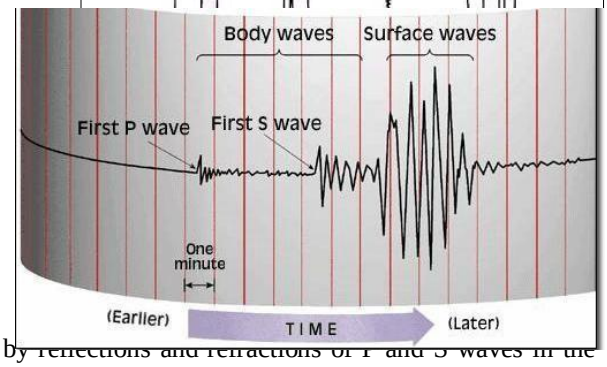
Richters is the standard scale among the above mentioned scales. In the year 1935, C.F. Richters developed different types of logarithmic scales for comparing the magnitude of California earthquake.

Seismograph:- Sensitive instrument that records the vibration of earthquakes using Pen, Rotating drum, Spring/ wire, Weight rod, Damping magnet and Metallic frame. A simple seismograph consists of rigid metallic frame fixed firmly to the ground by a metallic frame.

A heavy weighted rod with attached pen is made oscillate freely through a wire on the rotating drum mounted with photosensitive graph paper. Minute oscillations occur inside the earth waves are recorded in zig zag pattern called seismograph.



Seismogram:- Vibrations detected by seismograph are commonly recorded on a photographic paper as a series of zig zag line called seismogram. Seismogram records the different kinds of earthquake waves namely P-waves, S-waves and L- waves.



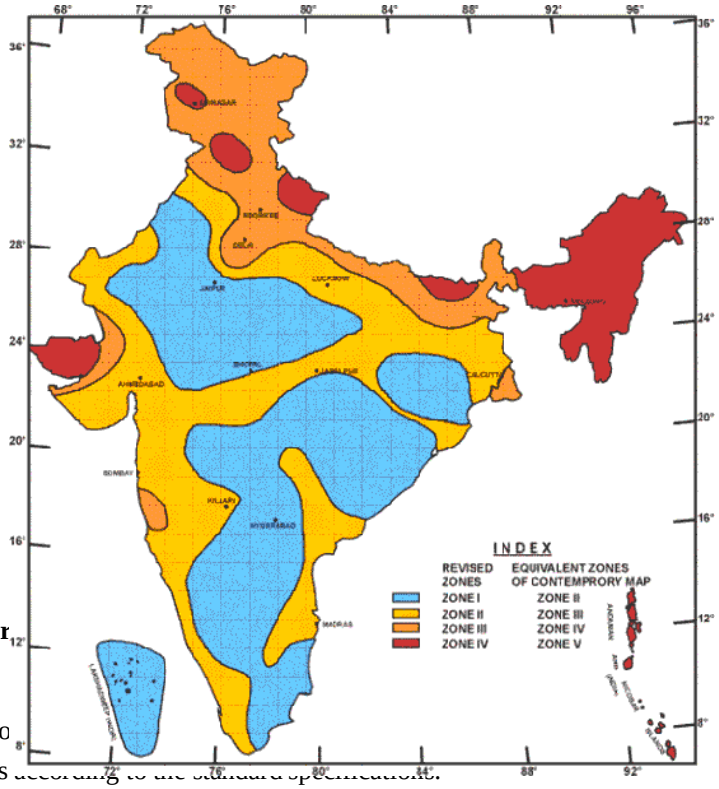
P-waves (Primary or push and pull waves):- These are the 1st recorded in recoding station as compressive type of push and pull waves, like sound waves. These waves can penetrate through solid, liquid and gaseous media and travel at a speed of about 5.4 km/sec.

S-waves (Secondary or shake waves):- These are vibrations caused by the shake of the earthquake such as light waves which travels at a speed of about 3.5 km/sec. This can penetrate only through solid media.

L-waves (Long or surface waves):- These are the waves produced by reflections and refractions of P and S waves in the immediate neighborhood of the epicenter. These travel with a rotary movement in the vertical plane, like sea waves. They travel at a speed of 1km/sec only along the ocean floor.

DISTRIBUTION OF EARTHQUAKE:-

Indian continent is divided into different zones based on the intensity of earthquake such as



***Zone Of Maximum Intensity*:-** It covers the North-Eastern regions especially the folded chains of Himalayas. Geographically, it covers the important states of Jammu & Kashmir, Assam, Himachal Pradesh, Nagaland, Uttar Pradesh etc.

***Zone Of Intermediate Intensity*:-** It covers the important regions of Indo-gangetic basin covering an area of Punjab, West Bengal, Bihar etc.

***Zone Of Minimum Intensity*:-** This covers the important states in South India such as Karnataka, Tamil Nadu, Kerala.

Important criteria to build Earthquake resisting structur

- Light and elastic constructions.
- Heavy and rigid constructions with uniform depth o
- One should strictly utilize the best quality materials according to the standard specifications.
- The size of the doors and windows should be minimized.
- Height of the building should be kept to single floor only.
- Seismic waves should be recorded using Seismograph before selecting a site for construction.
- Making reinforce structural columns should be maintained to distribute the load on each column.
- Use of polymer and light weight materials.
- Avoid stone cladding and stone pillars.
- Bridges with screw pile foundation stand better to the shocks.
- The wall should be continuous in nature, the long walls and cross walls be created simultaneously without any joints.
- Strongly designed steel framed or reinforced ferro-concrete structures posses' high degree of resistance should be well utilized.

TSUNAMI:- It is derived from Japanese word meaning very tall tidal waves (or) Harbor waves. The Intensity of Tsunami is measured by the speed and height of water waves on land. The run-off of water on land is related to the magnitude of the earthquake and may exceed 30mts (1000 ft) for the largest Tsunami. Tsunami occurred many times in history. Huge mass of rising water rushed at a tremendous speed destroying and devastating whatever came in its way. Tsunami caused a wide spread damage and destruction to life and property in coastal areas of Indonesia, Malaysia, Thailand etc.

- The first Tsunami in India struck in 1874 near Bhola, a small town in Bengal killing 12 lakh people.
- The second Tsunami hit Andaman and Nicobar Islands in India on 26th June 1941 and recorded a magnitude of 8.5 in Ritcher's scale.
- The latest Tsunami is occurred on 26th Dec 2004 in Indian Ocean with magnitude of 8.9 in Richter scale killing thousands of people in Chennai.

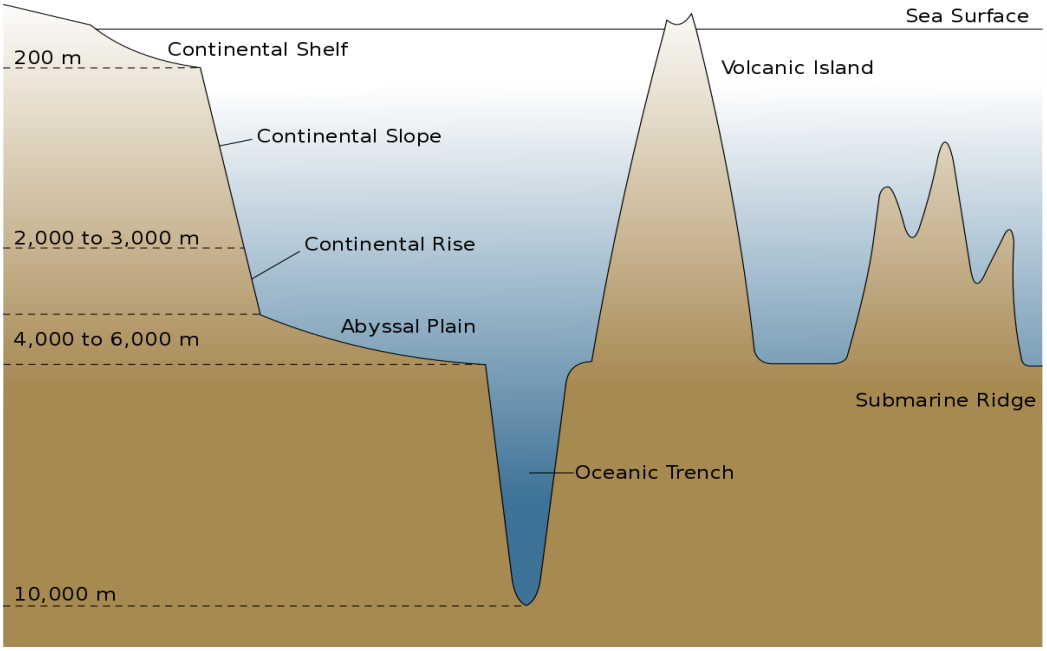


Fig. Section of Sea basin

SECTION OF SEA BASIN: Depth of earth crust about 35 km exist below the continents, a thickness of hardly 6 km if earth crust exist below an ocean and bottom of the ocean basin is about 5 km below the sea water level. The depth of ocean basin is not achieved abruptly and steeply from shoreline, but it is achieved gradually from the shore to the deep interior as shown in figure. Starting from the shore towards the deep sea, the following four may be recognized in an ocean basin.

i. **Littoral zone:-** The **littoral zone** is the near shore area of 5 to 10 mts depth where sunlight penetrates all the way to the sediment and allows aquatic plants (macrophytes) to grow. In coastal environments the littoral zone extends from the high water marks that is permanently submerged. This zone indicates the area between the high tide and low tide levels. The sediments found are the coarse fragments of the rock waste and bare sands zone make beautiful beaches.

ii. **Continental shelf:-** The maximum depth in this zone is about 180 to 200 mts and showing gentle slopes. The continental shelf starts below the low tide level and may extend upto 300 km in distance. The sediments deposited are well sorted with coarse particles in initial shallower zone, and finer particle towards the deeper portions. The upper portion is liable to be affected by the sunlight, seasonal temperature changes, and current wave action. A major part of sea plant life and animals like molasses grow. Lower part shows little penetration of sunlight and it is characterized by the deposition of only fine sediments like mud & sea animals like corals.

iii. **Continental slope:-** This zone is represented by a suddenly increased slope as shown in figure. The depth variation in this zone from sea level may be from 200 m to as much as 3000 m and so on. It is characterized low temperature and deposition of fine colored muds & micro organisms in this zone.

iv. **Abyssal zone/ deep sea:-** This is the deepest zone of the sea basin situated at the depth of 4000 to 6000 mts marking the deep sea/ ocean floor and it is characterized by deposition of finest muds of oozes and red clays. The red color of the fine clays of this zone is primarily due to iron oxidation.

CAUSES

1. Tsunamis are caused by sudden movements of the earth that happens under the sea. Often the most destructive Tsunamis are caused by **earthquakes** but causes can also include volcanic eruptions, landslides or even a comet hitting the sea.
2. **Landslides** cause tsunamis when the debris falls into the water. This has the same effect of dropping a large stone into a pool - big ripples are created. But when this happens in the sea and it is thousands of tonnes of rock and earth falling into the sea a very large ripple, more like a tidal wave is created. This travels across the sea until it comes into contact with land and a tsunami is formed.
3. **Volcanoes** cause tsunamis when there is an eruption. The volcano can either be on land or under the sea, in which case it is known as a submarine volcano. If the volcanic eruption happens on land, the tsunami is caused by debris and lava from the volcano flowing into the sea, which once again causes a bug ripple.

If the eruption happens under water, the enormous power of the eruption sends shudders through the earth and disrupts the water. The water in the sea then breaks into waves which travel across the ocean until they come into contact with a coast. Here, a tsunami is formed.

EFFECTS

1. **Loss of Life:** People living in coastal regions, towns and villages have no time to escape. Since 1850 alone, tsunamis have been responsible for the loss of more than 430,000 lives. As Tsunami hits the land it leaves very little to time to escape. This results in instant death by drowning, building collapsing, electrocution and others.

2. **Disease:** Flooding and contamination of drinking water can cause disease to spread in the tsunami hit areas. Illnesses such as malaria arise when water is stagnant and contaminated. Under these conditions it is difficult for people to stay healthy and for diseases to be treated, so infections and illnesses can spread very quickly, causing more death.

3. **Environmental impacts:** It uproots trees and plants and destroys animal habitats such as nesting sites for birds. Land animals are killed by drowning and sea animals are killed by pollution if dangerous chemicals are washed away into the sea, thus poisoning the marine life. Solid waste and disaster debris are the most critical environmental problem faced by a tsunami-hit country.

4. **Cost:** Massive costs hit communities and nations when a tsunami happens. The total financial cost of the tsunami could be millions or even billions of dollars of damage to coastal structures and habitats. Reconstruction and clean up after a tsunami is a huge cost problem. Infrastructure must be replaced, unsafe buildings demolished and rubbish cleared.

5. **Psychological effects:** Victims of tsunami events often suffer psychological problems which can last for days, years or an entire lifetime. Survivors of the Sri Lankan tsunami of December 2004 were found to have PTSD (post traumatic stress disorder) when examined by the World Health Organization (WHO): 14% to 39% of these were children, 40% of adolescents and 20% of mothers of these adolescents were found to have PTSD 4 months after the tsunami.

VOLCANIC ERUPTION

It is an outpour of thick lava and ash into the earth when magma rises through cracks or weak-spots. Magma forms when a part of earth's upper mantle or lower crust melts. Mixture of melted rock and dissolved gases which accumulated below the earth crust is called as ***magma***; whereas the magma material which pours out of the surface through volcanic eruptions is called as ***lava***.

As an average, one volcano erupts in every **12 hours** and **1,500** volcanoes have been active has produced ash fall, ash flow and volcanic mudflows is likely to do the same in the future.

CAUSES:

i. Plate Tectonics: Movement of tectonic plates pushes under the other plate causing the magma chamber to burst out. This kind of eruption produces sticky, thick lava at temperatures from 800^0 to $1{,}000^0$C.

ii. The buoyancy of the magma: The volume of overlying magma will increase due to increase in temperature causing buoyancy. This lighter overlying magma then rises toward the surface by virtue of its buoyancy and erupts.

iii. The pressure from the gases in the magma: Water, sulfur dioxide and carbon dioxide are the volatiles occur in magma with zero atmospheric pressure. These increase their volume due to rise in pressure conditions.

iv. Forceful injection of new magma into the magma chamber will move up and erupt to the surface.

EFFECTS:

i. Tephra: During powerful explosion the old lava at the top will blasts into tiny pieces and will hurled into the air.

ii.Lahars: These are mixtures of water, rock, ash, sand and mud that originates from the slopes of a volcano occurs due to heavy rainfall.

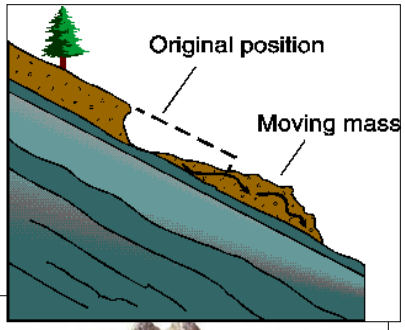
iii. Landslides: Heat from cooling magma can cause hydrothermal alteration of the rocks turning them into clay. This weakens the rocks and increases the risk of slope failures.

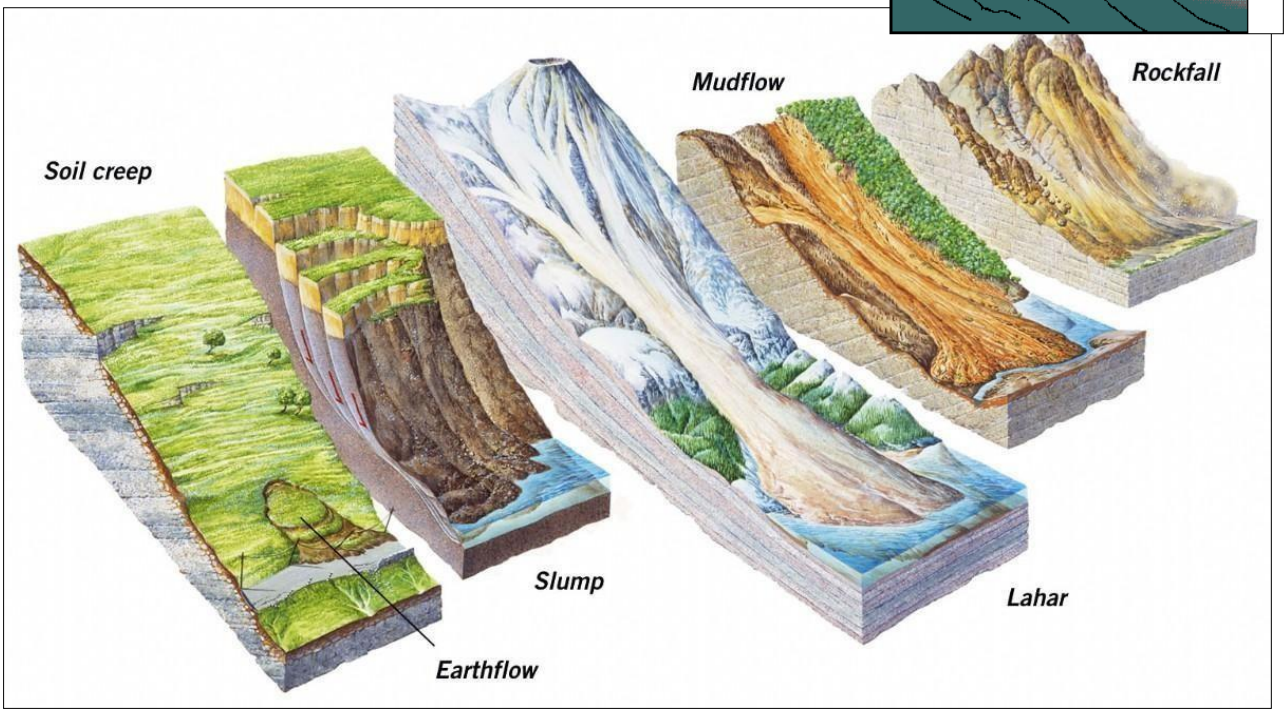
iv. Flooding: Explosive eruptions can change the surface areas around a volcano and disrupt drainage patterns leading to long-term flooding.

v. Volcanic eruption will also impacts on Food, Water Supply interruption, Homelessness, Businesses forced to close, Cost of insurance claims, Unemployment, Long-term issues with the tourism industry.

LANDSLIDES

The surface movements of the materials from its original position either by suddenly or extremely slow motion on the hill slope, valley, reservoir etc. Such movements of the surfacial rock mass which may be minor or major; may involve consolidated rocks or loose material which may take in any direction are popularly known as landslides.

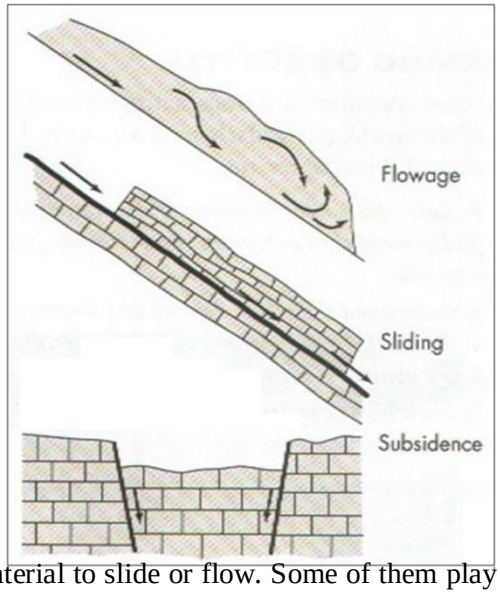




Classification of Landslides:- Mass failure is divided into four major groups on the basis of type of failure. Each, group is further subdivided into classes on the basis of rate of movement, nature of the mass and degree of saturation.

Sl No	Flowage		Sliding	Subsidence
	Slow flowage	Rapid flowage		
1.	Rock creep	Earth flow	Slump	Sinking of the mass
2.	Soil creep	Mud flow	Rock slides	
3.	Solifluction		Rock fall Debris slides Debris fall	

Flowage:- It is a downgrade movement of mass of invariably loose packed by natural process of decay. Flowage is further divided into slow and rapid flowage. Slow flowages will move down about few cms a year; while rapid flowages are visible and may travel a few meters a day or even more.

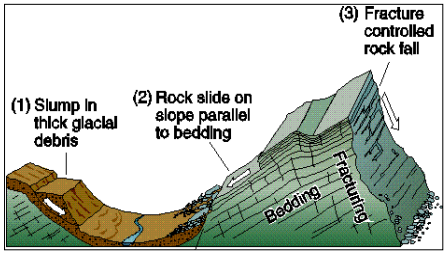


Sliding:- An unstable rock mass fails and move along the slopes due to underneath soft soil or rock of curved surface. In loose rock mass and weathered top surfaces failures mostly noticed along curved surfaces.

Subsidence:- It is the sinking of the ground in almost vertically downward direction, which may occur due to removal of the support from the underground and overlying mass.

CAUSES OF LANDSLIDES:- Many factors are causing a mass of material to slide or flow. Some of them play a direct role and are easily understand whereas others are indirectly responsible for the instability of the landmass. All such factors that facilities land sliding in one way or another is generally grouped under two headings.

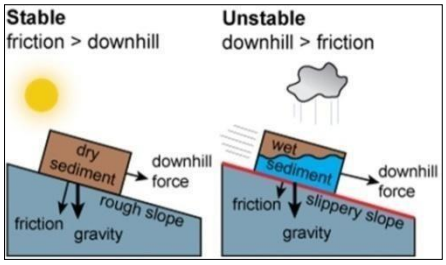
I. INTERNAL FACTORS:-



a. The nature of slope:- Great majority of mass failure indicates that the slopes are directly responsible. In some cases, steep to very steep slopes are stable, but in some other cases, even gentle slopes show unstable conditions.

b. Water content:- Water act in a number of ways to reduce the shearing strength of the rock or soil mass. Presence of water in the rocks pore spaces affects all the strength properties adversely, when water flow around the grains. This flow of water around grains and planes of weaknesses creates lubricating action which is of greater importance.

c. Composition and compaction of the mass:- Compaction plays as important part in stability of the masses. Sandstone exhibits a great variation in chemical composition. Siliceous sandstones would be highly stable even during intensive rains and at steep slopes; whereas clayey or calcareous may suffer repeated failure under same conditions. Texture of rocks also plays an important part indicating the degree & packing of grains. Porosity and



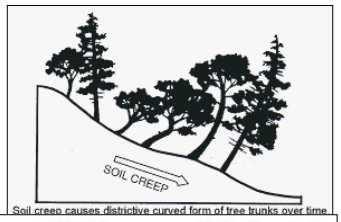
permeability are the two important factors influencing the percolation of water through the mass.

d. Geological structures: Of all the geological structure the inclination (dip), joints, fault zones of the rock beds, presence or deposition of shear and other planes of weakness are important in defining their stability.

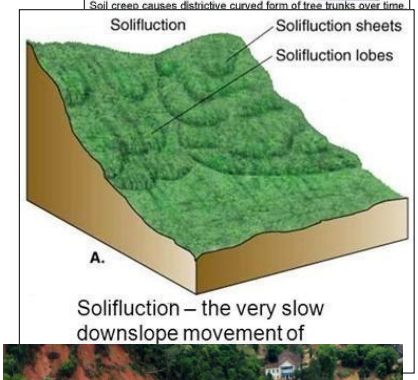
II. EXTERNAL FACTORS:- Rock mass failure occurs due to earthquakes and blasting around mines nearby.

a. Soil creep:- It is a type of slow flowage of soil take place under the vegetation cover commonly in cold humid slopes. Frost (ice) action favors soil creep in particular when water seeping in pores and expands due to freezing. This repeated expansion and contraction or drying and wetting may result in breaking the soil to loose grains that can be moved downward under

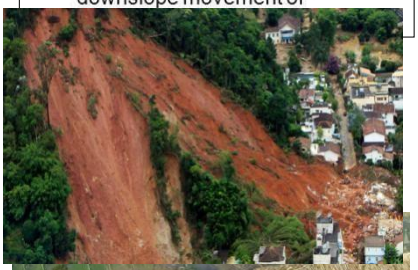
the pull of the gravity.



b. Solifluction:- It is also a slow flowage type of mass movement and is similar to soil creep in the rate of downward. It is the slow movement of blankets of soil or rock fragments occurs even in very gentle slopes after rainfall. It differs from soil creep in water content and that it is comparatively faster.



c. Earth and Mud flow:- These are rapid type of clays, silts type of mass movements takes place usually after heavy rains or heavy melting of snow and ice. Clay on becoming wet rendered plastic and start almost slipping under its own load in the presence of water. In mudflows the quantity of the water is very high so that the whole mass is reduced to slush or mud.



d. Rock slides:- It's a type of compact rock fails due to the pull of gravity which starts moving downward without rolling action. This failure surface may be curved or planar in nature. It's a very complex phenomenon occurs due to either natural or artificial frictional forces offered by the mass against gravity. Rocks containing layers of clay with dipping towards valley are likely to cause rockslides.

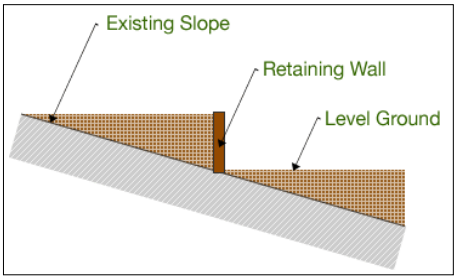
f. Rock falls:- This occurs when the slopes are extremely high or rock

surface is highly fractured or jointed so that the falling mass is made up of numerous small or large blocks. These blocks slide for some distances and then start rolling down when the slope is very steep.

REMEDIAL MEASURES OF LANDSLIDES

Many methods for controlling the slides are available and choice of many methods will dependof factors like nature of slide, the underlying cause for it, the nature and amount of material involved andthe economical consideration, of such method most important are.

1. Providing adequate drainage:- It involves the removal of moisture from the rocks as well as preventing any further moisture to approach the material to sliding. This may be achieved either by surface drainage or by subsurface drainage, construction of interpretation ditches, waterway, trenches and drainage tunnels may become necessary. Grouting the joints and other fractures may also prove helpful.



2. Construction of retaining walls:- All such devices like construction of retaining wall are aimed to stop the moving mass by force and their success is always doubtful. Construction ofretaining wall requires an accurate assessment of the forces, which the wall has to withstand. Retaining walls may prove exceptionally,successful where,

i) The ground is neither too fine nor too plastic
ii) The sliding mass is likely to remain dry
iii) The movement is of shallow nature

3. Slope treatment:- When the material is soil and situation is a slope the failure is attributed to a loss of stability. In such cases the treatment involves stability for the particular type of soil and slope and if such computation indicate that a given slope of soil will not be stable, then the solution lies in either.

i) Flattening the slope
ii) Decreasing the load
iii) Increasing the shearing resistant of the soil by decreasing its water content with help of drains and evaporation

iv) Afforestation that is growth of vegetation cover with intricate and interwoven root system has also been found useful in stabilizing the barren slopes.

MODULE-2

It is the scientific study of minerals, their chemistry, crystal structure and physical properties. The varieties of minerals were widely used in human's daily life, building and industrial activities.

Mineral: Homogenous, solid, naturally occurring inorganic substances with definite chemical composition and atomic structure. More than 5,300 minerals were observed on the earth's surface; while only 5230 number of minerals was approved by United State Geological Survey (USGS) in March-2017. These minerals may be divided into two groups such as rock forming minerals and ore forming minerals.

i. Rock forming minerals: Rock made up of aggregate of minerals which are abundance in the earth crust.

ii. Ore forming minerals: High concentration of elements sufficient for economic extraction and do not occurs abundantly in earth crust; but site specific.

Eg:- Gold, Silver, Copper, Lead, Uranium, Iron, Manganese etc.

MINERAL PROPERTIES

Every mineral have as set of physical, chemical and optical properties that differs from one to other minerals. It is an utmost important to study and identify these minerals in order to make an optimum utilization in specified industrial and as building material uses.

1. Color: The passionate attraction of any object which can be seen with the naked eye only when the light appears on it. It is the most important physical properties which occur due to impurities and isomorphous variation.

e.g., Galena and pyrite are cubic in structure but galena shows lead grey; while pyrite shows brass yellow color.

2. Streak: The color of fine powder scratched against a hard porcelain plate (Streak plate).

e.g.,	***Minerals***	***Color***	***Streak color***
	i. Pyrite	brass yellow	dark green
	ii. Magnetite	black	cherry red

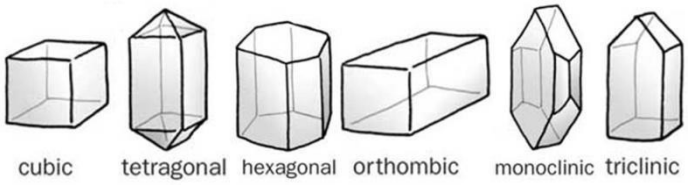
3. Luster: The surface appearance of the mineral in the reflected light. The luster depends upon the amount of reflection of the light strikes the surface.

e.g., **i. Vitreous luster:** broken glass like shine (quartz).
ii. Silky luster: silk like shine (Asbestos).
iii. Resinous luster: Greasy shine (Talc).
iv. Metallic luster: metal like shine (Hematite; galena)
v. Pearly luster: pearl like shine (Muscovite)
vi. Dull luster: No luster.

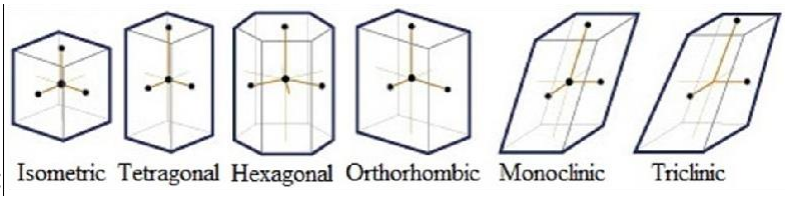
4. Crystal System: The regular polyhedral form bounded by smooth surfaces due to intermolecular forces. There are six groups of crystal systems for common practices.

a. Isometric/ Cubic b. Tetragonal c. Hexagonal
d. Orthorhombic e. Monoclinic f. Triclinic

Crystal structure:

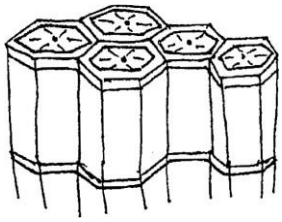


Crystal models:



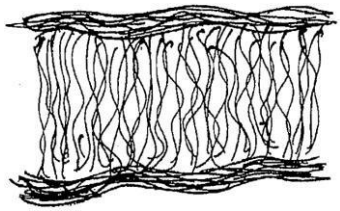
5. Structure/ Habit: The arrangement of atoms within the mineral to form a specific structure.

a. Columnar structure: Arrangement of minerals in the form of thin and thick columns.



e.g., Hornblende

b. Fibrous structure: Arrangement of minerals in thread/ hair like structures.

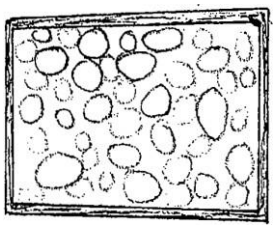


e.g., Asbestos.

c. Bladed structure: Arrangement of minerals in thin blade like parts.

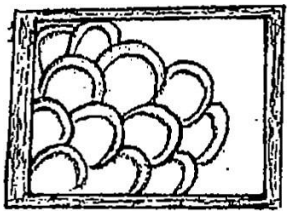
e.g., Kyanite.

d. Granular structure: Arrangement of minerals in numerous coarse and fine grains.



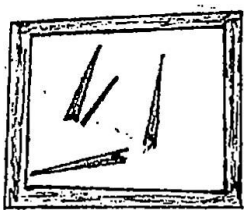
e.g., Chromite.

e. Botryoidal structure: Minerals shows aggregates of spheroidal mass resembling of grapes.



e.g., Hematite.

f. Accicular structure: Arrangement of minerals in thin sharp needle like structures.

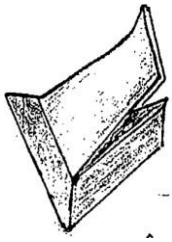


e.g., Muscocite mica.

g. Radiating: This forms when needles are arranged around a central point.

e.g., Iron pyrite.

h. Foliated: Minerals consists of thin separable sheets.



e.g., Mica.

6. Specific gravity: The ratio of the mineral weight to an equal volume of water. The heavier and closely spaced atoms will have high specific gravity; whereas lighter and widely spaced atoms will have low specific gravity such as high, medium and low.

7. Hardness: The ability to scratch one mineral by another higher order of mineral. Friedrich Mohs (1812), a German Mineralogist has selected ten minerals of distinctly different hardness that ranged from a very soft mineral (talc) to a very hard mineral (diamond).

Moh's Scale of Hardness

Resistance Number	Name of the Minerals	Composition	Remarks
1	Talc	$Mg_3 (SiO_{10})(OH)_2$ (Hydrated silicate)	Can be easily scratched by Finger nail
2	Gypsum	$CaSO_4$ (Hydrated Calcium Sulphate)	
3	Calcite	$CaCO_3$ (Calcium Carbonate)	Can be hardly scratched by finger nail and easily by penknife
4	Fluorite	CaF_2 (Calcium Fluorite)	
5	Apatite	Ca_3 (F, Cl, OH) $(PO)_4$	
6	Orthoclase	$KAlSi_3O_8$	Can be hardly scratched with penknife
7	Quartz	SiO_2 (Silicon di oxide)	
8	Topaz	$Al_2 (SiO_4)(SOH)_2$	
9	Corundum	Al_2O_3 (Oxides of Al)	Cannot be scratched
10	Diamond	C (Pure Carbon)	

8. Cleavage: The tendency of a mineral to split up in a specified direction. The different terms of cleavage are ***perfect*** *(mica) and* ***imperfect*** *(fluorite)*. Perfect cleavages are those minerals which splits up to form smooth surface easily; whereas imperfect minerals do not split up evenly with an average force.

9. **Fractures:** The appearance of the mineral broken surface. The different terms of fractures are ***even, uneven, conchoidal and hackly.***

Even: Minerals break up with smooth and flat surface.

Uneven: Mineral breaks up with rough surface.

Conchoidal: Mineral breaks up with curved surface.

Hackly: Mineral breaks with irregular surface and having sharp edges.

These minerals were classified into 5 groups such as oxides, silicates, carbonates, sulfides and sulfates.

Sl No	Groups	Minerals	Chemical Composition
1.	Oxides	i. Hematite ii. Magnetite	Fe_2O_3 Fe_3O_4
2.	Silicates	i. Quartz ii. Feldspars: a. Orthoclase b. Plagioclase iii. Mica: a. Biotite b. Muscovite	SiO_2 $K\ Al\ Si_3O_8$ $Na\ Al\ Si_3O^8$ (Albite) $K\ (Mg\ Fe)\ Al\ Si_3O_{10}\ (OH)_2$ $K\ Al_2\ (Si_2\ Al_{10})\ (OH)_2$
3.	Carbonates	i. Limestone ii. Dolomite iii. Siderite	$CaCO_3$ $Ca\ Mg\ CO_3$ $FeCO_3$
4.	Sulfides	i. Pyrite ii. Galena iii. Spharelite	FeS_2 PbS ZnS
5.	Sulfates	i. Gypsum ii. Barite iii. Monazite	$CaSO_4\ 2H_2O$ $BaSO_4$

COMPOSITION AND THEIR USE IN THE MANUFACTURE OF CONSTRUCTION MATERIALS

I. OXIDE GROUP OF MINERALS

1. HEMATITE and 2. MAGNETITE

Sl No	Identification criteria	Physical properties of minerals	Physical properties of minerals
1.	Name of the mineral	***Hematite***	***Magnetite***
2.	Chemical composition	Fe_2O_3	Fe_3O_4
3.	Color	Metallic grey, dull to bright red	Black
4.	Streak	Bright red to dark red	Cherry red
5.	Luster	Metallic	Metallic
6.	Crystal Structure	Trigonal	Isometric
7.	Structure/ Habit	Radiating, fibrous, botryoidal	Octahedral
8.	Specific gravity	5	5
9.	Hardness	6	6
10.	Cleavage	None	Imperfect
11.	Fracture	Uneven	Uneven
12.	Uses	Used as main ore of iron, pigments, radiation shielding, ballast and steel.	Used as iron ore and conversion of steel, audio recording and magnetite powder as recording medium.

3.CHROMITE and 4. BAUXITE

Sl No	Identification criteria	Physical properties of minerals	Physical properties of minerals
1.	Name of the mineral	***Chromite***	***Bauxite***
2.	Chemical composition	$FeCr_2O_4$	$Al_2O_32H_2O$
3.	Color	Black	Reddish brown, yellowish by iron oxides
4.	Streak	Brownish black	White stained red
5.	Luster	Sub metallic	Dull
6.	Crystal Structure	Hexa-Octahedral	Monoclinic
7.	Structure/ Habit	Crystalline, Massive	Pisolitic earthy, massive
8.	Specific gravity	4.8	2.5
9.	Hardness	5.5	3
10.	Cleavage	Nil	Nil
11.	Fracture	Uneven	Earthy, Uneven
12.	Uses	Refractory materials, ore of Chromium	Ore of aluminum, refractory bricks, porcelain cement

II. SILICATE GROUP OF MINERALS

5. QUARTZ

Sl No	Identification criteria	Physical properties of minerals
1.	Name of the mineral	***Quartz***
2.	Chemical composition	SiO_2
3.	Color	White, Pink, Grey and colorless
4.	Streak	White/ colorless
5.	Luster	Vitreous
6.	Crystal Structure	Hexagonal
7.	Structure/ Habit	Granular/ massive
8.	Specific gravity	2.7 (medium)
9.	Hardness	7 to 7.5
10.	Cleavage	Absent
11.	Fracture	Conchoidal
12.	Uses	Most important rock forming mineral in granite, gneisses, sandstone and quartzite. Used as gemstones, ornamental stones, manufacturing of oscillator plates, optical lenses and building stones etc.

6. KAOLIN and 7. ASBESTOS

Sl No	Identification criteria	Physical properties of minerals	Physical properties of minerals
1.	Name of the mineral	***Kaolin***	***Asbestos***
2.	Chemical composition	China clay- $H_4Al_2SiO_9$	$2H_2O$, CaMg Silicate
3.	Color	Dull white	Grayish, yellowish
4.	Streak	White	Pale grayish white
5.	Luster	Greasy, pearly	Silky
6.	Crystal Structure	Triclinic	Orthorhombic
7.	Structure/ Habit	Powdery	Fibrous
8.	Specific gravity	2.65	3.2
9.	Hardness	1	2.5
10.	Cleavage	Nil	Perfect
11.	Fracture	Earthy	Hackly
12.	Uses	Cement stiffener, bricks, glazed tiles filler, ceramic and refractory	Fire proof, Electrical & thermal insulator, Ayurvedic medicine

VARIEITES OF QUARTZ

1. Quartz crystal: It is a transparent and colorless mineral of quartz having composition of pure Silicon-di-oxide (SiO_2).

2. Rose quartz: It's a pink color and translucent variety of quartz mineral. The color of the mineral is due to the mineral content of Dumortierite (aluminium boro-silicate).

3. Milky quartz: It's a white color and commonest variety of quartz.

4. Amethyst: It's a purple/ violet variety of transparent mineral.

5. Flint: It's a compact cryptocrystalline silica of black or various shades of grey color. This breaks up with well marked conchoidal fracture and shows sharp cutting edges. This has main uses in fabrication of weapons, jewellery industries and building materials.

6. Opal: It's hydrated silica in chemical composition, compact form and occurs in various colors such as white, grey, yellow, red and brown. This shows subvitreous to vitreous luster, conchoidal fracture, hardness of 5 to 7 with medium specific gravity. This exhibits brilliant play of colors and used in gemstone jewellery.

8. FELDSPAR: (a). ORTHOCLASE FELDSPAR and (b). PLAGIOCLASE FELDSPAR

Sl No	Identification criteria	Physical properties of minerals	Physical properties of minerals
1.	Name of the mineral	***Orthoclase feldspar***	***Plagioclase feldspar***
2.	Chemical composition	$KAlSi_3O_8$	$NaAlSi_3O_8$
3.	Color	Pink, orange	White
4.	Streak	White	White
5.	Luster	Vitreous to pearly	Vitreous, pearly
6.	Crystal Structure	Monoclinic	Triclinic
7.	Structure/ Habit	Prismatic/ tabular	Massive to granular
8.	Specific gravity	2.6	2.7
9.	Hardness	6	6
10.	Cleavage	Basal/ prismatic	Perfect in two directions
11.	Fracture	Conchoidal to uneven	---
12.	Uses	Used in the manufacture of glass and ceramics; Moonstone orthoclase mineral used as gemstone.	Important component of many building stones. Labrodorite, spectrolite, sunstone and moonstone are gem-quality plagioclase feldspars.

9. MICA: (a). BIOTITE (b). MUSCOVITE

Sl No	Identification criteria	Physical properties of minerals	Physical properties of minerals
1.	Name of the mineral	***Biotite mica***	***Muscovite mica***
2.	Chemical composition	$K\ (Mg,Fe)_3\ AlSi_3O_{10}\ (F,\ OH)_2$	$KAl_2(AlSi_3O_{10})(F,OH)_2$
3.	Color	Dark brown	White, silvery
4.	Streak	White	White
5.	Luster	Vitreous to pearly	Vitreous, silky, pearly
6.	Crystal Structure	Monoclinic	Monoclinic
7.	Structure/ Habit	Massive to platy	Massive to platy
8.	Specific gravity	3	2.7
9.	Hardness	2.5	2
10.	Cleavage	Perfect	Perfect
11.	Fracture	Micaceous	Micaceous
12.	Uses	It is used extensively to constrain ages of rocks by either K-Ar dating. Used to assess the temperature of	Used in fireproofing and insulating materials and to some extent as a lubricant.

		metamorphic rocks due to partitioning of iron and magnesium occurs between biotite and garnet.	

III. CARBONATE GROUP OF MINERALS

10. CALCITE AND 11. DOLOMITE

Sl No	Identification criteria	Physical properties of minerals	Physical properties of minerals
1.	Name of the mineral	***Calcite***	***Dolomite***
2.	Chemical composition	$CaCO_3$	$CaMgCO_3$
3.	Color	White	Brown
4.	Streak	Granular	White
5.	Luster	Vitreous	Vitreous, pearly
6.	Crystal Structure	Rhombohedral	Hexagonal
7.	Structure/ Habit	Crystalline	Granular
8.	Specific gravity	2.7	2.9
9.	Hardness	3	4
10.	Cleavage	Perfect	Perfect
11.	Fracture	Conchoidal	Uneven
12.	Uses	Used in optical microscopes, chemical industries, manufacture of bleaching powder, calcium carbide, glass, papers and paints.	Used in construction industry, crushed and sized for road base material, production of cement, acid neutralization in the chemical industry.

IV. SULPHIDE GROUP OF MINERALS

12. PYRITE and 13. GALENA

Sl No	Identification criteria	Physical properties of minerals	Physical properties of minerals
1.	Name of the mineral	***Pyrite***	***Galena***
2.	Chemical composition	FeS_2	PbS
3.	Color	Brass yellow	Bright metallic lustre
4.	Streak	Dark green to dark brown	Lead grey to black
5.	Luster	Metallic	Metallic
6.	Crystal Structure	Isometric	Isometric
7.	Structure/ Habit	Cubic	Cubic
8.	Specific gravity	5	7.5
9.	Hardness	6.5	2.5
10.	Cleavage	Conchoidal	Perfect
11.	Fracture	Uneven	uneven
12.	Uses	Pyrite contains 0.25% of gold by weight or more, also used for the production of sulfur and sulfuric acid and crude oil processing.	Ore of lead used in residential paints, motor vehicle fuels, ammunition, fishing weights, ceramic glazes and pesticides.

14. CHALCOPYRITE

Sl No	Identification criteria	Physical properties of minerals
1.	Name of the mineral	***Chalcopyrite***
2.	Chemical composition	$CuFeS_2$
3.	Color	Golden yellow
4.	Streak	Black to greenish black
5.	Luster	Metallic
6.	Crystal Structure	Tetragonal
7.	Structure/ Habit	Crystalline
8.	Specific gravity	4.3
9.	Hardness	4
10.	Cleavage	Absent
11.	Fracture	Uneven
12.	Uses	Ore of copper & silver

V. SULFATE GROUP OF MINERALS

15. BARITE and 16. GYPSUM

Sl No	Identification criteria	Physical properties of minerals	Physical properties of minerals
1.	Name of the mineral	***Barite***	***Gypsum***
2.	Chemical composition	BaSO4	$CaSO_4$, $2H_2O$
3.	Color	White	White
4.	Streak	Colorless	Colorless
5.	Luster	Vitreous	Vitreous
6.	Crystal Structure	Orthorhombic	Monoclinic
7.	Structure/ Habit	Flaky	Flaky
8.	Specific gravity	4.5	2.3
9.	Hardness	3.5	1.5
10.	Cleavage	Perfect	Perfect
11.	Fracture	Uneven	Fibrous
12.	Uses	Used in chemical & sugar industries, paper, paint, ceramic industries, glass and paint.	Used in the manufacture of plaster of Paris, cement and other constructive materials, fertilizers and as ornamental stones.