Salahaddin university
Engineering college
Civil department
1st class
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Engineering Geology

Geology of engineering projects

6th lecture
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Introduction

- Earth's surface has been considerably altered to meet the perceived needs of technological societies. The deliberate alterations which humans have made to Earth's surface have generally involved extraction of materials or construction of facilities for human use.

Examples of facilities that require considerable alteration of Earth's surface are highways, railways, bridges, dams and pipelines.

- The branch of engineering that deals with the planning, construction and maintenance of these major structures is known as **CIVIL ENGINEERING**.

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GEOLOGICAL CONSTRAINTS

The geology of an area dictates the location and nature of any civil engineering structures.

- **Roads and Railways:**

Problems for a road or railway project may be caused by any of the following geological features:

a) Faults.
b) junctions between hard and soft formations.
c) boundaries between porous and impermeable formations.
d) spring-lines.
e) fractured granites.
f) weathered schists.
g) landslip areas.
h) Areas where beds dip towards the road or railway, as shown in Fig. 1.

Figure 1

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GEOLOGICAL CONSTRAINTS

- If the terrain and proposed route are such that these features cannot be avoided, construction of suitable safety features is required. Earthwork construction must include an embankment to stabilize areas of landslip.
- Drainage holes can be drilled into rock to ensure that water is drained from potential slip surfaces, such as bedding planes. Unless water is properly drained from a rock embankment, pressures will build-up within and behind the rock, eventually causing it to fracture and collapse.

Figure 2

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GEOLOGICAL CONSTRAINTS

- **Dams:**

Geological investigations of a site proposed for construction of a dam must be complete and detailed. Features such as rock-types, geological structures, weathering, fractures and fissures must all be considered. The main considerations are that the material on which the dam rests must be able to carry the weight of the structure without failing. The geology upon which the dam is built must also be impervious to water. The abutments, (the rock faces to which the dam wall is attached) must also be impervious and strong enough to support the dam wall, especially in the case of an arch dam (where more force is transmitted to the abutments).

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GEOLOGICAL CONSTRAINTS

Failure of a dam can be due to many factors including:

1. Earthquakes.
2. A sudden drop in water level.
3. Inadequate protection of the reservoir side of the dam from wave action.
4. Insufficient spillway capacity, so that water flows over the whole of the dam surface, with consequent erosion.

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GEOLOGICAL CONSTRAINTS

- The type of dam selected depends largely on the nature of the surrounding rocks. If they are strong and stable, an arch dam is suitable. This type of dam requires a minimum of construction materials, but the concrete must be of high quality. The Roosevelt Dam in the United States is an example of an arch dam.

Figure 3

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GEOLOGICAL CONSTRAINTS

- An embankment dam must be constructed where the surrounding rocks are not strong enough to support an arch dam. This type of dam is more expensive to build, requiring much more materials. The main weight and strength of the dam is provided by compacted quarried rock. The core is made of impermeable material, such as clay, bitumen or concrete.

Figure 4

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GEOLOGICAL CONSTRAINTS

- **Building Foundations:**

Since the type of rock and soil inevitably affects stability of buildings, the quality of the foundation rock must be investigated before construction commences. This rock must not be weak, crushed, water saturated or have been subjected to chemical weathering.

The presence of fractures, faults, joints, cleavages, etc. may indicate that the site is unsuitable for building. The possibility of soil-creep, slope movement, landslides, etc. must be borne in mind and factored into the design of any building foundation. Obviously, buildings should not be situated too close to the coast, especially where the sea level is rising relative to the land.

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GEOLOGICAL CONSTRAINTS

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The Leaning Tower of Pisa, Italy. This is possibly the most famous example of “failed foundations”.

Figure 5

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GEOLOGICAL CONSTRAINTS

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- Rock and soil tests are taken before homes are built.
- For larger buildings, deep holes may be drilled to test the strength and stability of the rocks under the proposed building.
- The type and strength of foundations required are determined from the results of these tests.

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- People who build houses in areas of clay soil are likely to find that cracks appear in brick walls. Piers under the house move and concrete slabs may crack. This is because clays swell when wet and shrink after drying. Soils contain a type of clay called montmorillonite which swells to almost twice its dry volume when wet. This is responsible for many cracks in older buildings. These soils are said to be expansive.
- Two other types of problem soils are collapsing soils, which settle rapidly on wetting, and compressible soils that consolidate and settle slowly over several years.

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GEOLOGICAL CONSTRAINTS

- **SLOPE FAILURE:**

The term slope failure covers a wide range of ground movement, such as rock falls, deep failure of slopes, and shallow debris flows.

Figure 6

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GEOLOGICAL CONSTRAINTS

Causes of Slope Failure :

1. Gravity

Although gravity acting on an over-steepened slope is the primary cause of a landslide, other contributing factors include:

- Earthquakes that create stresses causing weak slopes to fail.
- Volcanic eruptions that produce loose ash deposits and debris flows.
- Vibrations from machinery, traffic, blasting, and even atmospheric thunder that may cause failure of very weak slopes.
- Excess weight from accumulation of rain, snow, the stockpiling of rock or ore, or from built structures that may stress weak slopes to failure.

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GEOLOGICAL CONSTRAINTS

2. Relief

Slope failure occurs in hilly or mountainous regions all over the world essentially wherever there is any significant topographic relief.

3. Water

- Rock and soil slopes are weakened through saturation by thaw snow or heavy rain. Water filling the pores of permeable materials allows the grains to slide on each other with little friction. Water acts as a lubricant increasing the ease of movement of rock and soil particles (and therefore slope failure).
- Slope material that becomes saturated with water may develop a debris flow or mudflow. The resulting slurry of rock and mud can pick up trees, houses, and cars, causing the blocking of bridges and tributaries and increasing the likelihood of flooding.

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GEOLOGICAL CONSTRAINTS

4. Undercutting

- Undercutting is erosion of material at the foot of a cliff or steep bank e.g. on the outside of a meander. Ultimately the overhang collapses and the process is repeated. Undercutting caused by rivers, glaciers, or ocean waves creates over-steepened slopes, which are prone to failure. Human activities, such as quarrying and road construction also result undercutting.

5. Rock Types

- In unconsolidated material, that is material not held together by cement or by a strong interlocking crystal structure, landslides start after a significant part of the whole rock mass is saturated with water and therefore lubricated. A single shock or vibration can cause the down-slope movement of an entire unstable hillside. Any area of very weak or fractured materials resting on a steep slope will be likely to experience landslides.

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GEOLOGICAL CONSTRAINTS

6. Slope Angle

- A pile of sand always assumes the same angle of slope, whether it is a few centimeters high, or a huge sand dune. The angle that the sand makes with the horizontal is called the angle of repose. It is about 37° for fine sand (1), and steeper for coarse sand (2) and angular pebbles (3).

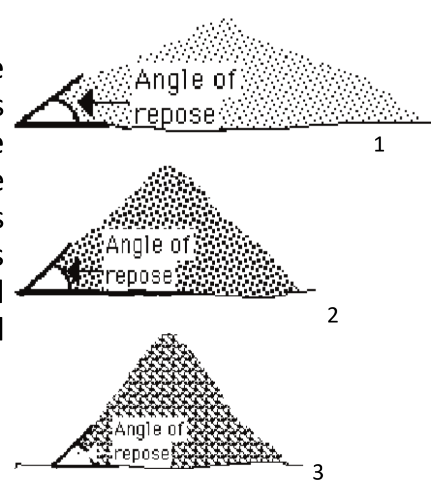

Figure 7

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GEOLOGICAL CONSTRAINTS

- If a slope is steepened beyond this natural angle, for example for a road cutting, it then becomes unstable and the slightest vibration may lead to slope failure. The angle of repose is reduced if the sand or unconsolidated rock material becomes water-saturated. Moreover, the angle of repose is significantly reduced underwater.

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Prevention of Slope Failure

Although the physical cause of many landslides cannot be removed; geologic investigations, good engineering practices, and effective enforcement of land-use management regulations can reduce landslide hazards. Strategies that can be used to control the mass movement of rock and soil include:

1. The construction of retaining walls.
2. Putting drains through retaining walls so that water is not trapped behind them.
3. Constructing terraces to reduce the angle of slope.
4. Using grasses or other plants whose roots anchor the slope.
5. Sinking piles through unstable debris down to firm bedrock.
6. Inserting bolts (rock bolts) to hold unstable rocks.
7. Of course, the best solution is not to build, or cut roads, through sites susceptible to slope failure, this may also have significant economic drawbacks.

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