6th Semester Civil Engineering

Disaster Management Notes

Chapter-4 LANDSLIDE

What is a landslide?

- The term' landslide' includes all varieties of mass movements of hill slopes and can be defined as the downward and outward movement of slope forming materials composed of rocks, soils, artificial fills or combination of all these materials along surfaces of separation by falling, sliding and flowing, either slowly or quickly from one place to another.
- Although the landslides are primarily associated with mountainous terrains, these can also occur in areas where an activity such as surface excavations for highways, buildings and open pit mines takes place. They often take place in conjunction with earthquakes, floods and volcanoes.
- At times, prolonged rainfall causing landslide may block the flow of river for quite some time. The formation of river blocks can cause havoc to the settlements downstream on its bursting.

Some of the common definitions are below:

1. **Landslide Hazard :**
   - **It** refers to the potential of occurrence of a damaging landslide within a given area; such damage could include loss of life or injury, property damage, social and economic disruption, or environmental degradation.

2. **Landslide Vulnerability:**
   - **It** reflects the extent of potential loss to given elements (or set of elements) within the area affected by the hazard, expressed on a scale of 0 (no loss) to 1 (total loss); vulnerability is shaped by physical, social, economic and environmental conditions.

1. **Landslide Risk:**
   - **It** refers to the probability of harmful consequences-the expected number of lives lost, persons injured, extent of damage to property or ecological systems, or disruption of economic activity –within a landslide prone area. The risk may be individual or societal in scope, resulting from an interaction between the hazard and individual or societal vulnerability.

4. **Landslide Risk Evaluation:**
   - **It** is the application of analyses and judgments (encompassing physical, social, and economic dimensions of landslide vulnerability) to determine risk management alternatives, which may include determination that the landslide risk is acceptable or tolerable.

Causes of Landslide

There are several causes of landslide. Some of the major causes are as follows:

1. Geological Weak material: Weakness in the composition and structure of rock or soil may also cause landslides.
2. Erosion: Erosion of slope toe due to cutting down of vegetation, construction of roads might increase the vulnerability of the terrain to slide down.
3. Intense rainfall: Storms that produce intense rainfall for periods as short as several hours or have a more moderate intensity lasting several days have triggered abundant landslides. Heavy melting of snow in the hilly terrains also results in landslide.
4. Human Excavation of slope and its toe, of slope/toe, draw down in reservoir, mining, deforestation, irrigation, vibration/blast, Water leakage from services.
5. Earthquake shaking has triggered landslides in many different topographic and geologic settings. Rock falls, soil slides and rockslides from steep slopes involving relatively thin or shallow dis-aggregated soils or rock, or both have been the most abundant types of landslides triggered by historical earthquakes.
6. Volcanic eruption Deposition of loose volcanic ash on hillsides commonly is followed by accelerated erosion and frequent mud or debris flows triggered by intense rainfall.

Type of Landslides:

The common types of landslides are described below. These definitions are based mainly on the work of Varnes (Varnes, D.J., 1978).

1) **Falls:** Abrupt movements of materials that become detached from steep slopes or cliffs, moving by free-fall, bouncing, and rolling.
2) **Flows:** General term including many types of mass movement, such as debris flow, debris avalanche, lahar, and mudflow.
3) **Creep:** Slow, steady downslope movement of soil or rock, often indicated by curved tree trunks, bent fences or retaining walls, tilted poles or fences.
4) **Debris flow** Rapid mass movement in which loose soils, rocks, and organic matter combine with entrained air and water to form slurry that then flows down slope, usually associated with steep gullies.
5) **Debris avalanche** A variety of very rapid to extremely rapid debris flow.
6) **Lahar** Mudflow or debris flow that originates on the slope of a volcano, usually triggered by heavy rainfall eroding volcanic deposits, sudden melting of snow and ice due to heat from volcanic vents, or the breakout of water from glaciers, crater lakes or lakes dammed by volcanic eruptions
7) **Mudflow** Rapidly flowing mass of wet material that contains at least 50 percent sand, silt, and clay-sized particles.

8) **Lateral spreads** Often occur on very gentle slopes and result in nearly horizontal movement of earth materials. Lateral spreads usually are caused by liquefaction, where saturated sediments (usually sands and silts) are transformed from a solid into a liquefied state, usually triggered by an earthquake.
9) **Slides** Many types of mass movement are included in the general term "landslide." The two major types of landslides are rotational slides and translational landslides.
10) **Topple** A block of rock that tilts or rotates forward and falls, bounces, or rolls down the slope.

Adverse Effects:

1. The most common elements at risk are the settlements built on the steep slopes, built at the toe and those built at the mouth of the streams emerging from the mountain valley.
2. All those buildings constructed without appropriate foundation for a given soil and in sloppy areas are also at risk.
3. Roads, communication lines are vulnerable.

Distributional Pattern:

- Landslides constitute a major natural hazard in our country, which accounts for considerable loss of life and damage to communication routes, human settlements, agricultural fields and forest lands.
- The Indian subcontinent, with diverse physiographic, seismic, tectonic and climatological conditions is subjected to varying degree of landslide hazards; the Himalayas including Northeastern mountains ranges being the worst affected, followed by a section of Western Ghats and the Vindhyas.
- Removal of vegetation and toe erosion have also triggered slides.Torrential rainfall on the deforested slopes is the main factor in the Peninsular India namely in Western Ghat and Nilgiris. Human intervention by way of slope modification has added to this effect.
- One of the worst tragedies took place at Malpa Uttarkhand (UP) on 11th and 17th August 1998 when nearly 380 people were killed when massive landslides washed away the entire village. This included 60 pilgrims going to Lake Mansarovar in Tibet. Consequently various land management measures have been initiated as mitigation measures. .

Possible risk reduction measures:

1) **Hazard mapping**
   a) **It** locates areas prone to slope failures. This will help to avoid building settlements in such areas. These maps will also serve as a tool for mitigation planning.

2) Land use **practices such as:**
   - **a)** Areas covered by degraded natural vegetation in upper slopes are to be afforested with suitable species.
   - **b)** Existing patches of natural vegetation (forest and natural grass land) in good condition, should be preserved
   - **c)** Any developmental activity initiated in the area should be taken up only after a detailed study of the region has been carried out.
   - d) In construction of roads, irrigation canals etc. proper care is to be taken to avoid blockage of natural drainage
   - e) Total avoidance of settlement in the risk zone should be made mandatory.
   - f) Relocate settlements and infrastructure that fall in the possible path of the landslide
   - g) No construction of buildings in areas beyond a certain degree of slope.

3) **Retaining Walls :**
   - a) **These** can be built to stop land from slipping (these walls are commonly seen along roads in hill stations). These are constructed to prevent smaller sized and secondary landslides that often occur along the toe portion of the larger landslides.

4) **Surface Drainage Control Works:**
   - a) The surface drainage control works are implemented to control the movement of landslides accompanied by infiltration of rain water and spring flows.

5) **Engineered structures**
   - a) **Engineered structures** with strong foundations can withstand or take the ground movement forces. Underground installations (pipes, cables, etc.) should be made flexible to move in order to withstand forces caused by the landslide

6) **Increasing vegetation cover:**
   - a) **It** is the cheapest and most effective way of arresting landslides. This helps to bind the top layer of the soil with layers below, while preventing excessive run-off and soil erosion.

7) **Insurance:**
   - a) **It** will assist individuals whose homes are likely to be damaged by landslides or by any other natural hazards.

Chapter-5 CYCLONE

Possible Risk Reduction Measures:

1) **Coastal belt plantation –**
   a) Green belt plantation along the coastal line in a scientific interweaving pattern can reduce the effect of the hazard.
   b) Providing a cover through green belt sustains less damage.
   c) Forests act as a wide buffer zone against strong winds and flash floods.
   d) Without the forest the cyclone travel freely inland.
   e) The lack of protective forest cover allows water to inundate large areas and cause destruction.
   f) With the loss of the forest cover each consecutive cyclone can penetrate further inland.
2) **Hazard mapping** –
   a) Meteorological records of the wind speed and the directions give the probability of the winds in the region.
   b) Cyclones can be predicted several days in advance. The onset is extensive and often very destructive.
   c) Past records and paths can give the pattern of occurrence for particular wind speeds.
   d) A hazard map will illustrate the areas vulnerable to cyclone in any given year. It will be useful to estimate the severity of the cyclone and various damage intensities in the region. The map is prepared with data inputs of past climatological records, history of wind speed, frequency of flooding etc.
3) **Land use control**
   a) designed so that least critical activities are placed in vulnerable areas.
   b) Location of settlements in the flood plains is at utmost risk.
   c) Siting of key facilities must be marked in the land use.
   d) Policies should be in place to regulate land use and building codes should be enforced.

4) **Engineered structures** –

   structures need to be built to withstand wind forces. Good site selection is also important. Majority of the buildings in coastal areas are built with locally available materials and have no engineering inputs. Good construction practice should be adopted such as:
   a) Cyclonic wind storms inundate the coastal areas. It is advised to construct on stilts or on earth mound.
   b) Houses can be strengthened to resist wind and flood damage. All elements holding the structures need to be properly anchored to resist the uplift or flying off of the objects. For example, avoid large overhangs of roofs, and the projections should be tied down.
   c) A row of planted trees will act as a shield. It reduces the energy.
   d) Buildings should be wind and water resistant.
   e) Buildings storing food supplies must be protected against the winds and water.

f) Protect river embankments. Communication lines should be installed underground.
g) Provide strong halls for community shelter in vulnerable locations

5) **Flood management** –
   a) Torrential rains, strong wind and storm range leads to flooding in the cyclone affected areas.
   b) There are possibilities of landslides too.
   c) Flood mitigation measures could be incorporated

6) **Improving vegetation cover** –
   a) The roots of the plants and trees keep the soil intact and prevent erosion and slow runoff to prevent or lessen flooding.
   b) The use of tree planted in rows will act as a windbreak.
   c) Coastal shelterbelt plantations can be developed to break severe wind speeds.
   d) It minimizes devastating effects.
   e) The Orissa calamity has also highlighted the need for urgent measures like shelterbelt plantation along cyclone-prone coastal areas. Species chosen for this purpose should not only be able to withstand the impact of strong cyclonic winds, but also check soil erosion.

Chapter- 6 FLOOD

- Flood is a state of high water level along a river channel or on the coast that leads to inundation of land, which is not usually submerged. Floods may happen gradually and also may take hours or even happen suddenly without any warning due to breach in the embankment, spill over, heavy rains etc. There are different types of floods namely: flash flood, riverine flood, urban flood, etc.
- **Flash floods** can be defined as floods which occur within six hours of the beginning of heavy rainfall, and are usually associated with cloud bursts, storms and cyclones requiring rapid localized warnings and immediate response to reduce damage. Wireless network and telephone connections are used to monitor flood conditions. In case of flash floods, warnings for timely evacuation may not always be possible.

Causes:

There are several causes of floods and differ from region to region. The causes may vary from a rural area to an urban area. Some of the major causes are:

a. Heavy rainfall

b. Heavy siltation of the river bed reduces the water carrying capacity of the rivers/stream.

c. Blockage in the drains lead to flooding of the area.

d. Landslides blocking the flow of the stream.

e. Construction of dams and reservoirs

f. In areas prone to cyclone, strong winds accompanied by heavy down pour along with storm surge leads to flooding.

Typical Adverse Effects:

a) The most important consequence of floods is the loss of life and property.

b) Structures like houses, bridges; roads etc. get damaged by the gushing water, landslides triggered on account of water getting saturated, boats and fishing nets get damaged.

c) There is huge loss to life and livestock caused by drowning.

d) Lack of proper drinking water facilities, contamination of water (well, ground water, piped water supply) leads to outbreak of epidemics, diarrhoea, viral infection, malaria and many other infectious diseases.

e) Flooding also leads to a large area of agricultural land getting inundated as a result there is a huge crop loss. This results in shortage of food, and animal fodder. Floods may also affect the soil characteristics. The land may be rendered infertile due to erosion of top layer or may turn saline if sea water floods the area.

Distributional Pattern of floods in India

- Floods occur in almost all the river basins of the country.
- The Vulnerability Atlas of India shows pictorially the areas liable to floods. Around 12 per cent (40 million hectare) of land in India is prone to floods.

- Most of the flood affected areas lie in the Ganga basin, Brahmaputra basin (comprising of Barak, Tista, Torsa, Subansiri, Sankosh, Dihang and Luhit), the northwestern river basin (comprising Jhelum, Chenab, Ravi, Sutlej, Beas and the Ghagra), peninsular river basin (Tapti, Narmada, Mahanadi, Baitarani, Godavari, krishna, Pennar and the Kaveri) and the coastal regions of Andhra Pradesh, Tamilnadu, orissa and Kerela. Assam, Uttar Pradesh, Bihar and Orissa are some of the states who have been severely prone to floods.
- Our country receives an annual rainfall of 1200 mm, 85% of which is concentrated in 3-4 months i.e June to September. Due to the intense and periodic rain, most of the rivers of the country are fed with huge quantity of water, much beyond their carrying capacity.

Warning:

- Flood forecasting and warning has been highly developed in the past two decades. With the advancement of technology such as satellite and remote-sensing equipments flood waves can be tracked as the water level rises.
- Except for flash floods there is usually a reasonable warning period. Heavy precipitation will give sufficient warning ofthe coming river flood. High tides with high winds may indicate flooding in the coastal areas. Evacuation is possible with suitable monitoring and warning.
- Warning is issued by the Central Water Commission (CWC),Irrigation & Flood Control Department, and Water Resources Department. CWC maintains close liaison with the administrative and state engineering agencies, local civil authorities to communicate advance warning for appropriate mitigation and preparedness measures.

Possible Risk Reduction Measures:

1. **Mapping of the flood prone areas**
    a. It is a primary step involved in reducing the risk of the region. Historical records give the indication of the flood inundation areas and the period of occurrence and the extent of the coverage.
    b. Warning can be issued looking into the earlier marked heights of the water levels in case of potential threat. In the coastal areas the tide levels and the land characteristics will determine the submergence areas.
    c. Flood hazard mapping will give the proper indication of water flow during floods.

2. **Land use control**
    a. It will reduce danger of life and property when waters inundate the floodplains and the coastal areas.
    b. The number of casualties is related to the population in the area at risk. In areas where people already have built their settlements, measures should be taken to

relocate to better sites so as to reduce vulnerability. No major development should be permitted in the areas which are subjected to high flooding. Important facilities like hospitals, schools should be built in safe areas. In urban areas, water holding areas can be created like ponds, lakes or low-lying areas.

3. **Construction of engineered structures**
    a. Construction of engineered structures in the flood plains and strengthening of structures to withstand flood forces and seepage. The buildings should be constructed on an elevated area. If necessary build on stilts or platform.

4. **Flood Control**
    a. **It** aims to reduce flood damage.
    b. This can be done by decreasing the amount of runoff with the help of reforestation (to increase absorption could be a mitigation strategy in certain areas), protection of vegetation, clearing of debris from streams and other water holding areas, conservation of ponds and lakes etc.
    c. Flood Diversion include levees, embankments, dams and channel improvement. Dams can store water and can release water at a manageable rate. But failure of dams in earthquakes and operation of releasing the water can cause floods in the lower areas.
    d. Flood Proofing reduces the risk of damage.
    e. Measures include use of sand bags to keep flood water away, blocking or sealing of doors and windows of houses etc. Houses may be elevated by building on raised land. Buildings should be constructed away from water bodies.

- **Flood Management**
    a. In India, systematic planning for flood management commenced with the Five Year Plans, particularly with the launching of National Programme of Flood Management in 1954.
    b. During the last 48 years, different methods of flood protection structural as well as nonstructural have been adopted in different states depending upon the nature of the problem and local conditions.
    c. Structural measures include storage reservoirs, flood embankments, drainage channels, antierosion works, channel improvement works, detention basins etc. and non-structural measures include flood forecasting, flood plain zoning, flood proofing, disaster preparedness etc.
    d. The flood management measures undertaken so far have provided reasonable degree of protection to an area of 15.81 million hectares through out the country.

Chapter- 7 DROUGHT

What is Drought?

1. Drought is either absence or deficiency of rainfall from its normal pattern in a region for an extended period of time leading to general suffering in the society.
2. It is interplay between demand that people place on natural supply of water and natural event that provides the water in a given geographical region. **The state of Kerala which receives more than 3000 mm of rainfall every year is declared drought affected as it is insufficient to have two good crops.**
3. The more the imbalance in supply the higher is the drought. The following will help explaining this general definition of the drought further.
    (a) It is a slow on-set disaster and it is difficult to demarcate the time of its onset and the end.
    (b) Any unusual dry period which results in a shortage of useful water.
    (c) Drought is a normal, recurrent feature of climate. Climate is expected to show some aberrations and drought is just a part of it.
    (d) Drought can occur by improper distribution of rain in time and space, and not just by its amount.
    (e) Drought is negative balance between precipitation and water use (through evaporation, transpiration by plants, domestic and industrial uses etc) in a geographical region.

The effects of drought accumulate slowly over a considerable period of time.

Causes of Drought

2. Though drought is basically caused by deficit rainfall, which is a meteorological phenomenon, it manifests into different spheres because of various vulnerability factors associated with them. Some of these factors are human induced.
3. Though drought is a natural disaster, its effects are made worst in developing countries by over population, over grazing, deforestation, soil erosion, excessive use of ground and surface water for growing crops, loss of biodiversity.

General Characteristics:

Types of droughts

Drought proceeds in sequential manner. Its impacts are spread across different domains as listed below.

– Meteorological drought

Meteorological drought is simple absence/deficit of rainfall from the normal. It is the least severe form of drought and is often identified by sunny days and hot weather.

– Hydrological drought

Hydrological drought often leads to reduction of natural stream flows or ground water levels, plus stored water supplies. The main impact is on water resource systems.

– Agricultural drought

i. This form of drought occurs when moisture level in soil is insufficient to maintain average crop yields. Initial consequences are in the reduced seasonal output of crops and other related production.

ii. An extreme agricultural drought can lead to a famine, which is a prolonged shortage of food in a restricted region causing widespread disease and death from starvation.

Socio-economic drought

- Socio-economic drought correlates the supply and demand of goods and services with the three above-mentioned types of drought.
- When the supply of some goods or services such as water and electricity are weather dependant then drought may cause shortages in supply of these economic goods.

Measuring Drought :

❖ Elements at Risk

- In general, all those elements that are primarily dependent on water are most affected.
- It affects the rainfed crops and then slowly creeps into the irrigated crops. People who are dependent on agriculture and areas where the other livelihood opportunities are least developed are greatly affected.
- The herdsman, landless labourer, subsistence farmers, women, children and farm animals are the most vulnerable groups.

Vulnerability Factors of Drought:

– Low soil moisture holding capacity
– Absence of irrigation facilities
– Livestock without adequate fodder storage facilities
– Poor water management
– Deforestation
– Over grazing
– Water consuming cropping patterns
– Excessive ground water draft
– Soil erosion
– Population growth and urbanization
– Industrialization
– Global warming

Drought Mathematics

The following criteria have been set by the Indian Meteorological Division (IMD) for identifying the drought.

(a) Onset of drought: Deficiency of a particular year's rainfall exceeding 25 percent of normal.
(b) Moderate drought: Deficit of rainfall between 26-50 per cent of normal.
(c) Severe drought: Deficit of rainfall more than 50 per cent of normal.

Typical adverse effects

1. Drought, different from any other natural disaster, does not cause any structural damages.
2. As the meteorological drought turns into hydrological drought, the impacts start appearing first in agriculture which is most dependent on the soil moisture.
3. Irrigated areas are affected much later than the rain fed areas. However, regions surrounding perennial rivers tend to continue normal life even when drought conditions are prevailing around.
4. The impacts slowly spread into social fabric as the availability of drinking water diminishes, reduction in energy production, ground water depletion, food shortage, health reduction and loss of life, increased poverty, reduced quality of life and social unrest leading to migration.

Distribution Pattern

1) Around 68 per cent of India's total area is drought prone to drought.
2) 315 out of a total of 725 Talukas in 99 districts are drought prone.
3) 50 million people are annually affected by drought.
4) In 2001 more than eight states suffered the impact of severe drought.
5) In 2003 most parts of Rajasthan experienced the fourth consecutive year of drought.

Possible Risk Reduction Measures:

There are various mitigation strategies to cope up with drought.

1. Public Awareness and education:

- If the community is aware of the do's and don'ts, then half of the problem is solved.
- This includes awareness on the availability of safe drinking water, water conservation techniques, agricultural drought management strategies like crop contingency plans, construction of rain water harvesting structure.
- Awareness can be generated by the print, electronic and folk media.
-

2. **Drought Monitoring:**
   - It is continuous observation of the rainfall situation, availability of water in the reservoirs, lakes, rivers etc and comparing with the existing water needs in various sectors of the society.
3. **Water supply augmentation and conservation**
   - Through rainwater harvesting in houses and farmers' fields increases the content of water available.
   - Water harvesting by either allowing the runoff water from all the fields to a common point (e.g. Farm ponds) or allowing it to infiltrate into the soil where it has fallen (in situ) (e.g. contour bunds, contour cultivation, raised bed planting etc) helps increase water availability for sustainedagricultural production.

4. **Expansion of irrigation**
   - These facilities reduces the drought vulnerability. **Land use** based on its capability helps in optimum use of land and water and can avoid the undue demand created due to their misuse.

5. **Livelihood planning**
   - **It** identifies those livelihoods which are least affected by the drought. Some of such livelihoods include increased off-farm employment opportunities, collection of non-timber forest produce from the community forests, raising goats, carpentry etc.
6. **Drought planning:**
   - The basic goal of drought planning is to improve the effectiveness of preparedness and response efforts by enhancing monitoring, mitigation and response measures.
   - Planning would help in effective coordination among state and national agencies indealing with the drought.
   - Components of drought plan include establishing drought taskforce which is a team of specialists who can advise the government in taking decision to deal with drought situation, establishing coordination mechanism among various agencies which deal with the droughts, providing crop insurance schemes to the farmers to cope with the drought related crop losses, and public awareness generation.