Lecture: 12 Wind Erosion Control Measures

Wind erosion is the process of detachment, transportation and deposition of soil particles by the action of wind. It occurs in all parts of the world and is a cause of serious soil deterioration. In India, Rajasthan has severe wind erosion problem. A large part of area the state is affected by sand dune formation. Some parts of coastal areas also have such problems. It most commonly occurs in the regions where soil is loose, finely divided and dry, soil surface is smooth and bare, and where wind is strong to detach the soil particles from the surface.

Wind Erosion Control

A suitable surface soil texture is the best key to wind erosion protection. Properly managed crop residues, carefully timed soil tillage, and accurately placed crop strips and crop barriers can all effectively reduce wind erosion. Proper land use and adaptation of adequate moisture conservation practices are the main tools which help in wind erosion control. In arid and semiarid regions where serious problem of wind erosion is common, several cultural methods can help to reduce the wind erosion. In the absence of crop residue, soil roughness or soil moisture can reduce the wind erosion effectively.

Three basic methods can be used to control wind erosion:

- Maintain Vegetative Cover (Vegetative Measures)
- Roughen the Soil Surface by Tillage Practices (Tillage Practices or may be called Tillage Measures)
- Mechanical or Structural Measures (Mechanical Measures)

There is no single recipe for erosion control as many factors affect the outcome. However, with an understanding of how soil is eroded, strategies can be devised to minimize erosion.

Vegetative Measures

Vegetative measures can be used to roughen the whole surface and prevent any soil movement. The aim is to keep the soil rough and ridged to either prevent any movement initially or to quickly trap bouncing soil particles in the depressions of the rough surface. A cover crop with sufficient growth will provide soil erosion protection during the cropping season. It is one of the most effective and economical means to reduce the effect of wind on the soil. It not only retards the velocity near the ground surface but also holds the soil against tractive force of wind thereby helping in reduction of soil erosion.

From the basic concept, the velocity of wind decreases near the ground surface because of the resistance offered by the vegetation. The variation in wind velocity with respect to height above the land surface increases exponentially (chapter 14).

Vegetative measures can be of two types:

1. Temporary Measures

2. Permanent Measures

The use of these measures depends upon the severity of erosion.

Tillage Practices

The tillage practices, such as ploughing are importantly adopted for controlling wind erosion. These practices should be carried out before the start of wind erosion. Ploughing before the rainfall helps in moisture conservation. Ploughing, especially with a disc plough is also helpful in development of rough soil surface which in turn reduces the impact of erosive wind velocity. Both the above effects are helpful in controlling the wind erosion.

Surface roughening should only be considered when there is insufficient (less than 50%) vegetation cover to protect the soil surface or when the soil type will produce sufficient clods to protect the surface. Roughening can be used in both crop and pasture areas. Surface roughening alone is inadequate for sandy soils because they produce few clods. Tillage ridges, about 100 mm high, should be used to cover the entire area prone to erosion. Ridges that are lower than 100 mm get quickly filled with sand, whilst the crest of the ridge that is higher than 100 mm tends to erode very quickly.

The common tillage practices used for wind erosion control are as under:

- Primary and Secondary Tillage
- Use of Crop Residues
- Strip Cropping

Mechanical Measures

This method consists of some mechanical obstacles, constructed across the prevailing wind, to reduce the impact of blowing wind on the soil surface. These obstacles may be fences, walls, stone packing etc., either in the nature of semi-permeable or permeable barriers. The semi-permeable barriers are most effective, because they create diffusion and eddying effects on their downstream face. Terraces and bunds also obstruct the wind velocity and control the wind erosion to some extent. Generally, in practice two types of mechanical measures are adopted to control the wind erosion; i) wind breaks and ii) shelter belts.

Wind Breaks

This is a permanent vegetative measure which helps in the reduction of wind erosion. It is most effective vegetative measure used for controlling severe wind erosion. The term wind break is defined as any type of barrier either mechanical or vegetative used for protecting the areas like building apartments, orchards or farmsteads etc. from blowing winds. The wind break acts as fencing wall around the affected areas, normally constructed by one row or maximum up to two rows across the prevailing wind direction.

A further use for "windbreaks" or "wind fences" is for reducing wind speeds over erodible areas such as open fields, industrial stockpiles, and dusty industrial operations. As erosion is proportional to the cube of wind speed, a reduction in wind speed by 1/2 (for example) will reduce erosion by over 80%. The largest one of these windbreaks is located in *Oman* (28 m high by 3.5 km long) and was created by Mike Robinson from Weather Solve Structures.

Shelter Belts

A shelterbelt is a longer barrier than the wind break, is installed by using more than two rows, usually at right angle to the direction of prevailing winds. The rows of belt can be developed by using shrubs and trees. It is mainly used for the conservation of soil moisture and for the protection of field crops, against severe wind erosion.

Shelterbelt is more effective for reducing the impact of wind movement than the wind break. Apart from controlling wind erosion, it provides fuel, reduces evaporation and protects the orchard from hot and cold winds.

Woodruff and Zingg (1952) developed the following relationship between the distance of full protection (d) and the height (h) of wind break or shelter belt.

$$d = 17h\left(\frac{v_m}{v}\right)\cos\theta$$

Where, d is the distance of full protection (m), h is the height of the wind barrier (wind break or shelter belt) (m), v_m is the minimum wind velocity at 15 m height required to move the most erodible soil fraction (m/s), v is the actual velocity at 15 m height, and θ is the angle of deviation of prevailing wind direction from the perpendicular to the wind barrier.

This relationship (equation) is valid only for wind velocities below 18 m/s. This equation may also be adapted for estimating the width of strips by using the crop height in the adjoining strip in the equation. The value of v_m for a bare smooth surface after erosion has been initiated and before wetting by rainfall and subsequent surface crusting is about 9.6 m/s.

Sand Dunes Stabilization

A 'Dune' is derived from English word 'Dun' means hilly topographical feature. Therefore a sand dune is a mount, hill or ridge of sand that lies behind the part of the beach affected by tides. They are formed over many years when windblown sand is trapped by beach grass or other stationary objects. Dune grasses anchor the dunes with their roots, holding them temporarily in place, while their leaves trap sand promoting dune expansion. Without vegetation, wind and waves regularly change the form and location of dunes. Dunes are not permanent structures.

Sand dunes provide sand storage and supply for adjacent beaches. They also protect inland areas from storm surges, hurricanes, flood-water, and wind and wave action that can damage property. Sand dunes support an array of organisms by providing nesting habitat for coastal bird species including migratory birds. Sand dunes are also habitat for coastal plants. For example: 'The Seabrook dunes' are home to 141 species of plants, including nine rare, threatened and endangered species.

There are three essential prerequisites for sand dune formation:

(1) An abundant supply of loose sand in a region generally devoid of vegetation (such as an ancient lake bed or river delta);

(2) A wind energy source sufficient to move the sand grains.

(3) A topography whereby the sand particles lose their momentum and settle down.

The best method by which the sand dunes can be stabilized is to reduce the erosive velocity. Therefore, various methods which are employed for sand dune stabilization are based on the principle to dissipate the erosive power of wind, so that the detachment and transportation of soil particles cannot take place. Some methods employed for sand dune stabilization are:

- Vegetation/Vegetative Measures
- Mechanical Measures
- Straw (Checkerboard and Bales)/Mats and Netting
- Chemical Spray

Vegetative Measures

This method is most common and preferred worldwide for sand dune stabilization. It is a most effective, least expensive, aesthetically pleasing method which mimics a natural system with self-repairing provision. However, it has some disadvantages as the plant establishment phase is critical, it needs irrigation and maintenance until self-sustaining system is developed. Most common practices adopted under this are:

Raising of Micro Wind Breaks

It is preferred in those areas where wind velocity is intensive and rainfall is less than 300 mm per year. The raising of wind break should be completed before the onset of monsoon. Twigs or brush woods are inserted into the soil parallel to one another at about 5 m spacing. The spacing depends on the intensity of erosive wind velocity, if the velocity is more spacing is less and vice versa. The fencing of dunes using brush woods reduces evaporation loss and also enriches the humus content in the soil.

Retreating the Dunes

In this, the micro wind breaks are treated again by planting tree saplings and grasses in the space left. The grasses grown in the intersection of plants of wind break reduce the soil loss from the dune surface significantly.

Mechanical Measures

Wind breaks, shelterbelts, stone pitching, fences etc., either manmade or natural barriers are helpful to reduce the wind velocity thereby favoring the stabilization of sand dunes.

Straw Checker Boards

This technique of sand dunes stabilization is extensively used in China since 1950's. Wheat or rice straw or reeds (50 – 60 cm in length) are placed vertically to form the sides of the checkerboard, which are typically 10 to 20 cm high. Optimum grid size of checker ranges from 1 x 1 m to 2 x 2 m, depending on local wind and sand transport conditions. Smaller grids are used in areas where winds are stronger.

Chemical Spray

Sometimes crude oils are used for the successful stabilization of sand dune. The oil is heated to 50 °C and sprayed on the dune at the rate of 4 m^3/ha. It is a temporary measure, lasting only for 3-4 years and during those years, it is expected that the vegetation growth will take place in that area. This method is costly and suitable only for small areas.

Solved Problems:

1. Determine the spacing between windbreaks that are 15 m high. 5 year return period wind velocity at 15 m height is 15.6 m/s and the wind direction deviates 10° from the perpendicular to the field strip. Assume a smooth, bare soil surface and a fully protected field.

Solution:

Given: h = 15 m

V = 15.6 m/s

ϑ = 10°

Vm = 9.6 m/s (for smooth, bare soil surface)

Spacing = distance of full protection by a windbreak,

Therefore,

$$d = 17h\left(\frac{V_m}{V}\right)\cos\theta \quad = 17x15\left(\frac{9.6}{15.6}\right)\cos 10^o$$
$$= 154.54\,m$$

Thus, the spacing between windbreaks = 154.54 m.

2. Determine the full protection strip width for field strip cropping if the crop in the adjacent strip is wheat, 0.9 m tall, and the wind velocity at 15 m height is 8.9 m/sec at 90° with the field strip.

Solution:

Given: h = 0.9 m

v = 8.9 m/s

ϑ = 0°

Assuming v_m = 8.9 m/sec (Because theoretical v_m = 9.6 m/sec which is greater than the prevailing wind velocity). Since the field conditions are not specified taking $v_m = v$.

Full protection width-

$$d = 17h\left(\frac{V_m}{V}\right)\cos\theta \quad = 17x0.9\left(\frac{8.9}{8.9}\right)\cos\theta$$
$$= 15.3\,m$$

Thus, strip width = 15.30 m.