OCEANIC MOVEMENTS: THE OCEAN WAVES.

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THE OCEAN WAVES

INTRODUCTION: -

Oceanography is an interesting subject. Coastal areas are very unique zones for human and marine life. Beaches are always considered as good tourist spots. Ocean water surface is never calm and smooth. They are uneven, irregular, rough and restless. Tides, Waves and currents are the three major features characterizing the oceanic water masses at the surface and around the coastal zones. Waves are disturbances of the water surface. Waves are never ending dynamic features created by the action of wind on the ocean water surfaces. Waves are undulations of the surface layers of sea water. The study of waves in an essential aspect in the subject of oceanography, marine biology, marine geology, fisheries, and marine engineering.

OCEAN WAVES: -

Sea waves are defined as undulations of seawater characterized by unique properties. The Waves are moving energy patterns. They travel along the interface between ocean and the atmosphere. In this lesson, the following aspects of ocean waves are highlighted:

1. Properties of sea-waves
2. Types of ocean waves
3. Processes that are responsible for wave formation
4. Breaking of waves and the
5. Seismic sea waves.

MOVEMENT OF SEA WATER: -

The movements of sea water are reflected in the form of

a) Waves, that are caused by the action of wind
b) Tides, that are caused by the attraction of moon and the Sun
c) Oceanic currents that are formed due to wind and radiation
d) Slow and circular movements of water from the high latitudes towards the equator and vice-versa and
e) Compensatory movements between two ocean basins differing from each other, in their density and salinity of water masses.

Among these, the waves are caused by the action of wind. Waves are never ending oscillations seen on the surface of all oceans. The pattern of waves generated by the oceanic masses will never be repeated in the same pattern. Hence, the study of waves is a very interesting aspect in oceanography.

PROPERTIES OF IDEAL WAVES: -

When we observe the ocean surface, we can see waves of varying sizes and dimensions will be moving in different directions, resulting in a complex wave pattern that is constantly changing. An idealized progressive

wave will have a series of crests and troughs. Crests are the upper parts of the undulations and the troughs are the lower parts of the undulations. These are the two major properties of waves.

WAVE HEIGHT AND PERIODS: -

The vertical height between a crest and its adjacent trough is known as its wave height(H). The horizontal distance between two adjacent crests or troughs is known as the wavelength(L). The ratio between the wave height and wavelength is known as wave steepness. The time that elapses during the passing of one wavelength, crossing a point, is known as the wave period(T). Wave speed is equal to wavelength divided by wave period. The number of wavelengths that pass a fixed point per unit of time is known as the frequency of waves. The circular orbits followed by the water particles at the surface have a diameter equal to the wave height. The diameters of particle orbits decrease with increased depth until particle motion associated with the wave ceases at a depth of one-half wavelength(L/2).

CLASSIFICATION OF WAVES: -

Waves are classified into longitudinal, transverse and orbital categories based on their properties. In the case of longitudinal waves, the particles will be moving back and forth in a direction parallel to the propagation of energy. These waves transmit energy through all states of matter.

In transverse waves, the propagation of energy is at right angles to the direction of particle vibration. These waves transmit energy only through solids. The average height of the wavelength is known as the still water level.

GENERATED BY WIND: -

Most of the waves present on the ocean's surface are wind-generated waves. Size and type of wind-generated waves are controlled by:

1. wind velocity
2. wind duration
3. Fetch and
4. original state of the sea surface.

As wind velocity increases wavelength, period and height increase, but only if wind duration and fetch are sufficient.

ORBITAL WAVES: -

The third type of waves are called as Orbital waves. Waves produced on the surface of the ocean, have particle movements that are neither longitudinal nor transverse.

Since, the particles move in circular orbits at the air-sea interface, such waves are called as orbital waves. The movement of particles along such an interface involves components of both since the particles move in circular orbits at the interface between the atmosphere and ocean. They are called as orbital waves or interface waves.

WAVE STEEPNESS: -

Wave steepness is a ratio of wave height divided by wavelength (H/L). In shallow water, wave height increases and wave length decreases. When H/L is larger than or equals 1/7 ($H/L \geq 1/7$), the wave becomes unstable and breaks. These are called as breakers. There are three types of wave breakers observed in the coastal zones. They are spilling breakers, plunging breakers, and surging breakers.

MOTION OF WATER PARTICLES: -

Motion of water particles(WP) is the underlying principle behind these oceanic waves. Water Particles in a sea wave follow the circular orbits at the sea surface.

The diameter of such circular orbit is equal to the wavelength. At the crest, the water particles move in the direction of the energy propagation. The size of the circular orbits flowed by the particles get diminishing with increasing depth below the sea surface. The water particles in the trough of a wave will move in the opposite direction of the wave. Half of the orbit of the water particles in the trough, is at a lower velocity than the other half of the orbit in which the particles will follow the crest of the wave.

SHALLOW-WATER WAVES: -

Waves in which the water depth D is less than one-twentieth of the wavelength, i.e., $D < L/20$, are classified as shallow-water waves. These are also called as long waves.

As waves enter the shallow water zone, they become taller and slow down, and eventually be breaking on the sea-shore.

TIDAL WAVES: -

Tidal waves are generated by the gravitational attraction of sun and moon.

The shallower the water, the greater the interaction between the wave and the bottom alters the wave properties. tn these, the Wave speed decreases as the depth decreases. The Wavelength decreases as the depth decreases. The Wave height increases as the depth decreases. The wave troughs become flattened and the wave profile becomes extremely asymmetrical. The wave period remains unchanged.

FETCH AND SEA: -

Fetch is the area of contact between the wind and the water and is where wind-generated waves begin. The Sea is the term applied to the sea state of the fetch when there is a chaotic jumble of new waves. Waves continue to grow until the sea is fully developed or becomes limited by fetch restriction or wind duration. Wave interference is the momentary interaction between waves as they pass through each other. Wave interference can be constructive or destructive.

Wave refraction is the bending of a wave crest into an area where it travels more slowly

CAPILLARY WAVES: -

As the wind blows over the surface of the oceanic water, energy is transferred from wind to the water mass. The ocean surface gets deformed into small rounded waves with v-shaped troughs. The wave length of such initial waves is less than 1.74 cm. These are called as Capillary Waves. Such waves are easily destroyed by the surface tension.

GRAVITY WAVES: -

When the surface of oceanic water mass gets more and more energy from the wind blowing over it, waves increase in height and length. When the wavelength exceeds 1.74 cm, their shape resembles a sine curve. Such waves are called as Gravity Waves**.**

These waves are characterized by pointed crests and rounded troughs.

SWELL: -

A swell is the formation of long wavelength waves on the surface of the seas. These are composed of series of surface gravity waves. These are not generated by the local wind. Swell waves often have a long wavelength but this varies with the size of the water body. Their wavelengths may rarely exceed more than 150 m. Swell wavelength, also, varies from event to event. Occasionally, swells which are longer than 700 m occur as a result of the most severe storms.

There are three factors that influence the level of energy contained in swells. Wind velocity, wind area (fetch), and duration. That is, the speed of the wind, the amount of ocean surface area affected by wind blowing in the same direction (also known as fetch), and the amount of time those winds blow over the same part of the ocean.

SEAS: -

Seas are larger waves that are formed under irregular and un-sustained winds. These can last long after the winds have died out. As seas propagate away from their area of origin, they naturally separate according to their direction and wavelength. They are irregular waves running in different directions.

The factors responsible for this are:

a) Wind Speed

b) The time during which the wind blows in one direction and

c) The fetch, the distance over which the wind blows in one direction.

The amount of energy gained by a wave is reflected on its wave height. The usual height in a sea wave hardly exceeds 2 m, in the normal condition. Waves commonly break when one angle at the crest is less than 120^0 (or the ration of wave height to wavelength is 1/7.

RIPPLES: -

Ripples appear on smooth water surface when the wind is light, but if the wind dies, so do the ripples. Seas are created when the wind has blown for a while at a given velocity. They tend to last much longer, even after the wind has died. Ripples are also known as capillary waves. Ripples appear on smooth water when the wind blows, but will die quickly if the wind stops. The restoring force that allows them to propagate is surface tension.

TRANSITIONAL WAVES: -

Transitional waves are another type of waves that are having wavelength greater than the depth of water, but less than 20 times the water depth are categorized as transitional waves. In these types, the velocity depends partly on the wavelength and partly on the depth of water. The wind speed versus water depth diagram can show these three wave distributions clearly. When water depth increases and wave speed increases proportionately, we get deep water waves. Even if the wave speed increases, in shallow waters, we will get shallow water waves. In between these two, we get the transition waves.

WIND AND WAVES: -

The interrelationship between the wind and the waves is so important to skippers. A classification system was designed as a guideline by incorporating both wind speed and the wave conditions for skippers. This system is called as the **Beaufort Scale. It** was developed in 1805, by Admiral Sir Francis Beaufort of the British Navy. It is a guideline for weather classification system, in oceans.

WAVES ON BEACHES: -

Waves normally dominate the beach processes. Currents and turbulence generated by waves stir up all the sediments and long-shore currents caused by the waves and tides, transport the sediments parallel to the coast. Large amounts of sands are transported in suspension. Due to these, the beach morphology and topographic configuration changes periodically. Waves Arely approach a beach at right angles.

PROCESSES CAUSING WAVE FORMATION: -

Ocean waves are undulations of the sea surface with unique properties. The surface appears to be composed of random waves of various lengths and periods. Ocean waves are mostly produced by the wind. The faster the wind, the longer the wind blows and the bigger the area over which the wind blows, the bigger the waves generated. Wave phenomena involve the transmission of energy and momentum by means of vibrating impulses through the states of matter. The particles which constitute the medium simply move in a forward, backward and circular pattern, transmitting the energy from one to another. These waves may range from tiny ripples, caused on the surface of the lake, to gigantic roller coasters. The most prominent factors involved in the formation of waves on a water body include wind speed, depth of the water, fetch (i.e. the distance covered by the wind), etc.

CAUSATIVE FACTORS: -

Generation of sea waves are caused by the following factors:

1. Atmospheric circulation and wind
2. Movement of fluids of two contrasting density (air and water) along the interface of two fluids of differing densities.
3. Movement of turbidity currents.
4. Earth induced tectonic forces.
5. Underwater volcanic eruptions
6. Gravitational forces of the sun and the moon
7. Atmospheric storms and
8. Nuclear tests, missile tests, etc.

WAVE FORMATION: -

Wave Formation is a unique and is also a complicated process. The three main factors that cause the origin of waves in the ocean are:

- The speed of the wind
- The distance of the water over which the wind has blown
- The duration of time the wind has blown over the surface of the water.

The greater each of the above factors is, the larger will be the waves. Waves come in various shapes and sizes. The size of the wave depends on the velocity of the wind.

The faster the wind is blowing, the bigger will be the waves.

FORCES: -

Wave formation involves two basic types of forces

1. Those that initially disturb the water and
2. Those that act to restore the equilibrium (or) promote still water condition.

Wind is the cause for most of the oceanic waves. Winds are highly variable. The third disturbing force is the attraction of the Sun and Moon, on ocean water. These cause the longest waves of all, called the tides.

BREAKING OF WAVES: -

Waves in shallow waters near the beaches are found to be diving and breaking. They are called as wave breakers. An impressive amount of energy is dissipated by breaking waves in the swift. A single wave 1.2 m high with a 10 second period, striking the coast is estimated to release 50 million horse power of energy. Most of this energy is released as heat which is not detectable. Waves are destroyed by opposing winds. Others interact and some cancel each other, but most of them end up as breakers. As waves encounter shallow water, the wave heights increase and wavelength decreases. Consequently, wave steepness (H/L) increases. The wave becomes unstable and forms the breakers. The belt of nearly continuous breaking waves along the shore over a submerged bank is known as surf.

SURF ZONE: -

Surf is a mix of breakers. It forms, when different types of waves approach a shore and interact with the shallow water bottom. There are four basic types of breaking water waves as:

a. Spilling breakers
b. Plunging breakers
c. Surging breakers and
d. Collapsing breakers.

SPILLING BREAKERS: -

When the ocean floor has a gradual slope, the wave will steepen until the crest becomes unstable, resulting in turbulent whitewater spilling down the face of the wave. This continues as the wave approaches the shore, and the wave's energy is slowly dissipated in the whitewater. Because of this, spilling waves break for a longer time than other waves, and create a relatively gentle wave. Onshore wind conditions make spillers more likely. They cause rows of breakers, rolling towards the beach. Such breakers gradually transport water towards the beach during groups of high waves. These are also called as rolling breakers. The Spilling or rolling breakers are the safest waves on which to surf. They can be found in most areas with relatively flat shorelines. They are the most common type of shore breaks.

PLUNGING BREAKERS: -

A plunging wave occurs when the ocean floor is steep or has sudden depth changes, such as from a reef or sandbar. The crest of the wave becomes much steeper than a spilling wave, becomes vertical, then curls over and drops onto the trough of the wave, releasing most of its energy at once in a relatively violent impact. A plunging wave breaks with more energy than a significantly larger spilling wave. If a plunging wave is not parallel to the beach (or the ocean floor), the section of the wave which reaches shallow water will break first. **Plunging**, or **dumping breakers** are the preferred waves for experienced surfers. A plunging breaker is dangerous for swimmers because its intensity is greatly augmented by backwash from its predecessor.

SURGING BREAKERS: -

Surging breakers occur where the beach slope exceeds wave steepness. The wave does not really curl and break but runs up against the shore while producing foam and large surges of water. Such places are dangerous for swimmers because the rapidly moving water can drag swimmers over the rocks. When waves break, their energy is absorbed and converted to heat. On steeper beaches, the energy of the wave can be reflected by the bottom back into the ocean, causing standing waves. This can result in a very narrow surf zone.

COLLAPSING BREAKERS: -

Collapsing waves are a cross between plunging and surging breakers. In these, the crest never fully breaks, yet the bottom face of the wave gets steeper and collapses, resulting in foam.

ROGUE WAVES: -

Rogue waves are another categories of waves. They are also known as freak waves, monster waves, killer waves, extreme waves, and abnormal waves. They are relatively large and spontaneous ocean surface waves that occur far out in sea. They are a threat even to large ships and ocean liners. Rogue waves seem to occur in deep water or where a number of physical factors such as strong winds and fast currents converge.

STORM SURGE: -

Storm surge is the rise in sea level resulting from low atmospheric pressure and the accumulation of water driven shoreward by storm winds. Water is deeper at the shore area, allowing waves to progress farther inland. Storm surge is especially severe when superimposed upon a spring high tide. A storm surge can cause flooding of low-lying coastal areas. Following a storm, the sea level continues to rise and fall. Storm surges can be predicted, based on wind speeds and direction, fetch, water depth and shape of the shoreline.

SEICHES: -

Standing waves or seiches (pronounced as saysh) consist of a water surface which will be like a “seesawing” back and forth. A seiche is a standing wave in an enclosed or partially enclosed body of water. Seiches are often imperceptible to the naked eye. Any observer, in boats on the sea surface, may not notice that a seiche is occurring. This happens due to its extremely long wavelengths. Seiches are normally observed in seas such as the Adriatic Sea and the Baltic Sea. Seiches may also be induced by a tsunami and a wave train (series of waves).

OTHER TYPES OF PROGRESSIVE WAVES: -

Internal waves form within the water column along the pycnocline. Because of the small density difference between the water masses above and below the pycnocline, wave properties are different when compared to the surface waves. Internal waves display all the properties of surface progressive waves including reflection, refraction, interference, breaking, etc. Any disturbance to the pycnocline can generate internal waves, including: flow of water related to the tides, flow of water masses past each other, storms, or submarine landslides.

WAVE TRAINS: -

In deep water, as waves move away from the fetch that generated them, they form a continuous chain of swells known as a wave train. Wave trains radiate outward in all direction from the fetch, with the largest waves moving in the same direction as the winds within in the fetch. Over distance and time, waves that are moving at nearly the same speed keep pace with one another and form a group. There can be anywhere from 3-15 or more waves in a group. An interesting thing occurs as the group travels. A group normally consists of smaller waves in the lead, larger waves in the middle, and smaller waves again at the rear of the pack.

TSUNAMIS- THE SEISMIC SEA WAVES: -

A tsunami is a seismic sea wave. Tsunamis are series of huge waves that can cause major devastation and loss of life when they hit the coast. The word tsunami is a Japanese word which means 'harbor waves' (tsu - harbor, nami - waves). The possible causes of a tsunami are an underwater earthquake with the Richter scale magnitude of over 6.75, sub marine rock slides, volcanic eruptions or if an asteroid or a meteoroid crashes into the water from the space.

A tsunami starts when a huge volume of water is shifted by any of these underwater mechanism happens. When such a large volume of water is moved, the resulting wave is very large and can be spread over an area of a thousands of sq.km. Tsunamis can travel from the point of origin to the coast at great speed.

The speed may be as high as 1000kmph in the open ocean. This is the speed with which a jet aircraft travels. A tsunami can move from one end of the ocean to the other end in a few hours. With the advance in technologies over the years, tsunamis can now be detected before they hit the coast thereby reducing loss of life.

ENERGY FROM WAVES: -

Waves are potential energy sources. Energy can be extracted from waves by devices floating in the water and by fixed structures. Wave power varies considerably in different parts of the world. Areas of the world with abundant wave power resource include the western coasts of Scotland, northern Canada, southern Africa, Australia, and the northwestern coast of the United States, particularly Alaska.

CONCLUSION: -

Waves are caused by the wind blowing over the surface of the ocean. In many areas of the world, the wind blows with enough consistency and force. The generate continuous waves along the shorelines. Waves are powerful geological agents. They can erode, transport and deposit sediments along the coastlines. Waves carry out both constructive and destructive actions. The geomorphology of a coastal region is controlled by the action of waves in that region. Study of ocean waves is a basic necessity to understand their processes.

Fig.1: Motion of Waves and Water Molecular.

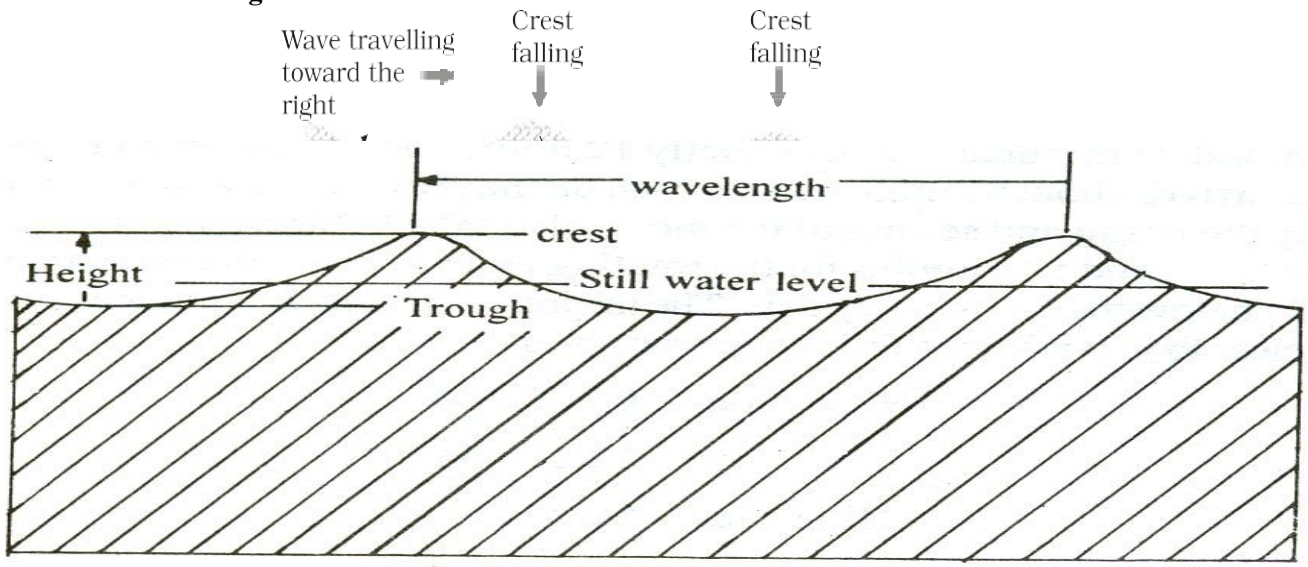

Fig. 2: Part of a Wave