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# Wave erosion on up stream slopes of earthen dams

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Slopes of earthen dams are mainly designed for stability. Slope deterioration will take place due to various reasons. Erosion is one cause. Therefore slope protections are designed to minimise erosion. Erosion is mainly due to rain water and other factors like seepage forces, wave erosion etc. While rain

water and seepage forces damage both upstream (U/S) and downstream (D/S) surfaces, wave erosion damages only the up stream surface.

Wave erosion has not been considered very much in designing rip rap protection in several dams. Due to this negligence, rip rap has been constructed only up to the reservoir full supply level. This paper discusses the damages caused by the non availability of rip rap protection up to the required elevation.

On D/S, slope protections are designed to overcome the erosion problems. Grass cover is common to protect the slope from rain water erosion. In high dams, horizontal berms of about 2 m. width are constructed at 10m elevations. On these berms, catch water drains are provided to collect rain water and then will be carried up to toe drain with suitable drainage methods to prevent the formation of gullies on the slope. Erosion due to seepage forces on D/S slope will be controlled by the means of filter drains, rock toe and toe drains etc.

On U/S, rip rap with bedding filter materials will protect the slope against all the causes i.e. rain water, seepage forces wave erosion etc.

During the monsoon period, most of the reservoirs are at full supply (FSL) level, or at high flood level (HFL). Therefore, mostly above FSL of the U/S slope is vulnerable for wave attack.

Once the wave hit the U/S slope, it will ride up along the slope up to a certain elevation. Due to wind blowing, the water surface tends to elevate a little at the upstream slope. This phenomenon is known as wind set up, and it is maximum if the dam is perpendicular to the wind direction and facing wind ward. If the water depth is high, wind set up is negligible and in shallow reservoirs wind set up is countable. Considering the above mentioned wave ride up, wind setup, wave height etc., free board for the dam is estimated.

Wave heights are calculated theoretically adopting several methods for the purpose of designing rip rap protection. Thumb rules and approximate methods give high wave heights and rigorous methods give lesser values. In some working reservoirs observed maximum values may be available during past cyclones.

Over estimation of wave height is favorable in designing free board and slope protections. Savings on reduction of free board and curtailing the rip rap cannot compensate the damages due to embankment failure.

Behavior of waves during winds or cyclones and the affected slope area can be predicted. When the water level is at maximum probable elevation such as FSL or HFS, the affected slope area can be marked on the **u/s** slope of the bund. The affected area has been found identical in this case study. To overcome this erosion problem, rip rap protection should be constructed up to the bund top level.

Such failure and remedial measures constructed are discussed in this paper.

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