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## Causes of Embankment Failure

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**Abstract** An embankment is a wall or a bank of earth or stone built to carry a road or railway over an area of low ground or to prevent a river flooding an area. Partial or total destruction of an embankment can be technical (due to defects in design, construction or materials, aging of the structure), natural (following earthquakes, exceptional floods, a storm, a marine submersion, landslides) or human (by insufficiency of the preliminary studies and the control of execution, by error of use, control and maintenance, or maliciously). In this technical note the main causes of embankment failure are reviewed and discussed.

**Keywords** Embankment, cause, failure, overtopping, seepage, settlement

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### Introduction

An embankment is an artificial slope of earth, stones, bricks or combination of all of them. Its stability is an important element in the field of geotechnical engineering. Any error or misconception in the design may lead to fatal damages of constructions, as shown in Figures 1 and 2.



Figure 1: Collapse of a house caused by slope shear failure (Leverett Bradley/Tony Stone Images/New York, Inc., Budhu, 2015)





Figure 2: Road embankment failure (<https://adda.com.my/project-page/landslide-slope-and-road-embankment-failures-in-general/>)

There are three main causes of embankment failure, in this case: overtopping, piping and seepage, and foundation defects (Figure 3). Overtopping manifests when the level of water is higher than the embankment crest elevation, leading to settlement and erosion of the embankment crest, thus reducing freeboard. Piping failure of embankment is caused by the removal of soil particles through the inter-granular flow within the soil mass of the embankment. This happens when the discharge hydraulic gradient across the embankment exceeds the critical hydraulic gradient of the soil. Then, the soil particles nearest the point of discharge move out of the soil structure. The downstream point of discharge toward the reservoir side of the embankment, creating a pipe-shaped tunnel.

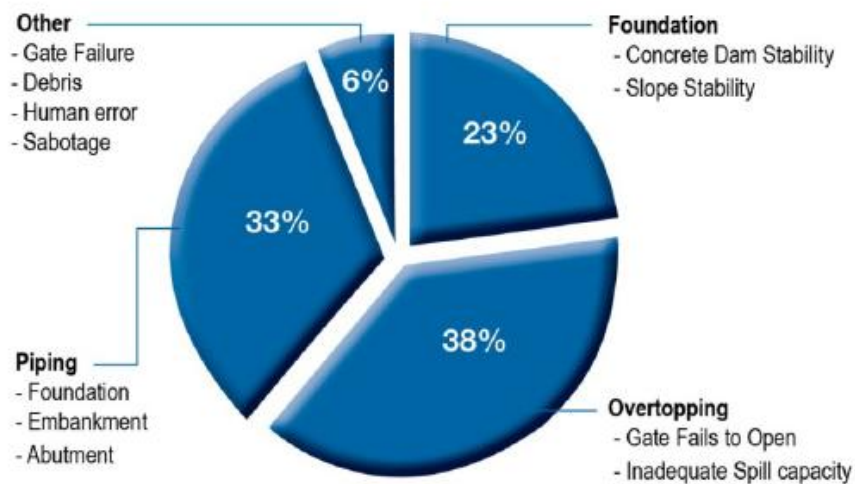


Figure 3: Main causes of embankment failure (ASCE/USCOLD, 1975)

Although, embankments are designed to be water tightness, but water may seeps through it. Seepage is defined as the flow of a fluid; usually water, through a soil under a hydraulic gradient. As water seeps through soils movement, migration and erosion of soil particles can occur. This phenomenon may be described by two



mechanisms piping or suffusion. Embankment failure by seepage results generally from the lack of appropriate internal drainage, inadequate core or cutoff, inappropriate embankment material, inadequate compaction, clogging of drains or filters, seepage into, out of, or along conduits and drains, and surface erosion gullies intersecting seepage zone.

Flow through embankment is an important design consideration. We need to ensure that the pore water pressure at the downstream end of the embankment will not lead to instability and the exit hydraulic gradient does not lead to piping or suffusion. The stability in this case is concerned by two important features and useful parameters, namely rate of flow in the embankment body, and gradient existing in the embankment. The determination of these two useful parameters goes through the determination of the flow net. The rate of flow should be very limited (very small). Furthermore, the gradient should be less than  $i_{cr}$  ( $i_{cr}$  = critical hydraulic gradient).

The third cause of embankment failure is foundation defects (i.e. settlement and sliding). Settlement failure is caused by bearing capacity failure, deflection of the foundation structure, change in density due to shock or vibration, consolidation of soil foundation or rock, and underground erosion. Whereas, the general reasons of sliding failure are slopes too steep, phreatic surface too high, rapid drawdown of reservoir or tailwater, decaying organic material in embankment, removal of material from the toe of the embankment, addition of a surcharge load on the embankment, material was not placed with enough compaction, and inadequate strength to resist the driving forces.

### Conclusion

Embankment failure is caused by overtopping, piping and seepage, and foundation defects. The embankment failure generally lead to collapse of the entire area and loss of lives, roads and bridges may be out, city or town may be flooded with water due to failure. Furthermore, floodwaters may have dangerous contents such as debris, flammable liquids, hazardous materials, and untreated sewage.

### Reference

- [1]. Budhu Muni (2015). Soil Mechanics and Foundations, 3<sup>rd</sup> Edition. John Wiley and Sons, Ltd.
- [2]. Committee on Failures and Accidents to Large Dams of the United States Committee on Large Dams (1975). Lessons from dam incidents (USA), ASCE American Society of Civil Engineers, New York, NY, and USCOLD.
- [3]. Jurutera Adda Engineering Consultant (2019).Landslide, slope and road embankment failures in general(<https://adda.com.my/project-page/landslide-slope-and-road-embankment-failures-in-general/>)

