| GLOBAL FAILURE MODES | | ELEMENT AND/OR ELEMENT FUNCTION | MOST BASIC FUNCTIONAL FAILURE CHARACTERISTICS | External Hazards | | | Internal Hazards (Design, Construction, Maintenance, Operation) | | | |
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| | | | | Meteorological | Seismic | Reservoir Environment | Water Barrier | Hydraulic Structures | Mechancial / Electrical | Infrastructure & Plans |
| DAM COLLAPSE BY OVERTOPPING (erosion or overturning) | Water elevation too high | **Adequate installed discharge capacity** | Meteorological inflow > buffer + outflow capacity | Could a meteorological event cause the inflow to be greater than the buffer + outflow capacity and lead to a failure? | ~~Could a seismic event cause a meterological event and cause the dam to be overtopped/fail from a reduced discharge capacity (channels, chutes)?~~ | ~~Could the reservoir environment (landslide? debris?) cause a meterological event leading to the dam to be overtopped/fail because of insufficient installed discharge capacity~~ | ~~Could design or construction of the water barrier cause a meteorological event leading to dam overtopping / failure due to insufficient installed discharge capacity ?~~ | ~~Could design or construction of the hydraulic structure cause a meteorological inflow greater than the buffer + outflow capacity and cause the dam to be overtopped/fail?~~ | ~~Could the design or construction of the mech/elec systems cause a meteorological inflow greater than the buffer + outflow capacity and lead to the dam being overtopped/fail due to~~ | ~~Could inadequate infrastructure and plans cause a meteorological inflow greater than the buffer + outflow capacity and lead to the dam being overtopped/fail due to insufficient~~ |
| | | **Adequate available discharge capacity** | Inadequate reservoir operation (rules not followed) | Could a meteorological event cause the operating rules to not be followed and lead to a failure? | Could a seismic event cause the operating rules to not be followed and lead to a failure? | Could the reservoir environment cause the operating rules to not be followed and lead to a failure? | Could design or construction of the water barrier cause the operating rules to not be followed and lead to a failure? | Could the design or construction of the hydraulic structure cause the operating rules to not be followed and lead to a failure? | Could the design or construction of the mech/elec systems cause the operating rules to not be followed and lead to a failure? | Could inadequate infrastructure and plans cause the operating rules to not be followed and lead to a failure? |
| | | | Random functional failure on demand | Could a meteorological event cause a random functional failure on demand and lead to a failure? | Could a seismic event cause a random functional failure on demand of discharge capacity and lead to a failure? | Could the reservoir environment cause random functional failure on demand of discharge capacity and lead to a failure? | Could design or construction of the water barrier cause a random functional failure on demand of discharge capacity and lead to a failure? | Could the design or construction of the hydraulic structure cause random functional failure on demand of discharge capacity and lead to a failure? | Could the design or construction of the mech/elec systems cause a random functional failure on demand of discharge capacity and lead to a failure? | Could inadequate infrastructure and plans cause random functional failure on demand of discharge capacity and lead to a failure? |
| | | | Discharge capability not maintained or retained | Could a meteorological event cause the discharge capability to be not maintained or retained and lead to a failure? | Could a seismic event cause the discharge capacity to be not maintained or retained and lead to a failure? | Could the reservoir environment cause the discharge capability to be not maintained or retained and lead to a failure? | Could design or construction of the water barrier cause the discharge capability to be not maintained or retained and lead to a failure? | Could the design or construction of the hydraulic structure cause the discharge capability to be not maintained or retained and lead to a failure? | Could the design or construction of the mech/elec systems cause the discharge capability to be not maintained or retained and lead to a failure? | Could inadequate infrastructure and plans cause discharge capability to be not maintained or retained and lead to a failure? |
| | | **Adequate freeboard** | Excessive elevation due to landslide or U/S dam | Could a meteorological event cause excessive elevation due to a reservoir landslide or upstream dam failure and lead to a failiure of the dam system? | Could a seismic event cause excessive elevation due to landslide or upstream dam failure and lead to a failure? | Could the reservoir environment cause excessive elevation due to landslide or upstream dam failure and lead to a failure? | Could design or construction of the water barrier cause excessive elevation due to landslide or upstream dam failure and lead to a failure? | Could the design or construction of the hydraulic structure be inadequate for excessive elevation due to a landslide or upstream dam failure and lead to a failure? | Could the design or construction of the mech/elec systems be inadequate for excessive elevation due to landslide or upstream dam failure and lead to a failure? | Could inadequate infrastructure and/or plans cause excessive elevation due to landslide or upstream dam failure and lead to a failure? |
| | | | Wind-wave dissipation inadequate | Could a meteorological cause the wind-wave dissipation to be inadequate and lead to a failure? | Could a seismic event cause inadequate wind wave dissipation and lead to a failure? | Could the reservoir environment cause inadequate wind wave dissipation and lead to a failure? | Could design or construction of the water barrier result in inadequate wind wave dissipation and lead to a failure? | Could the design or construction of the hydraulic structure be inadequate for wind wave dissipation and lead to a failure? | Could the design or construction of the mech/elec systems be inadequate for wind wave dissipation and lead to a failure? | Could inadequate infrastructure and plans cause inadequate wind wave dissipation and lead to a failure? |
| | Management System Failure | **Safeguards provide timely detection and correction** | Operation, maintenance and surveillance fail to detect/prevent hydraulic inadequacy | Could a meteorological event prevent a hydraulic inadequacy from being detected / prevented and lead to a failure? | Could a seismic event prevent a hydraulic inadequacy from being detected / prevented and lead to a failure? | Could the reservoir environment prevent a hydraulic inadequacy from being detected / prevented and lead to a failure? | Could design or construction of the water barrier prevent a hydraulic inadequacy from being detected / prevented and lead to a failure? | Could design or construction of the hydraulic structure prevent a hydraulic inadequacy from being detected / prevented and lead to a failure? | Could design or construction of the mech/elec systems prevent a hydraulic inadequacy from being detected / prevented and lead to a failure? | Could inadequate infrastructure and plans prevent a hydraulic inadequacy from being detected / prevented and lead to a failure? |
| | | | Operation, maintenance and surveillance fail to detect poor dam performance | Could a meteorological event prevent poor dam performance from being detected / prevented and lead to a failure? | Could a seismic event prevent poor dam performance from being detected / prevented and lead to a failure? | Could the reservoir prevent poor dam performance from being detected / prevented and lead to a failure? | Could design or construction of the water barrier prevent poor dam performance from being detected / prevented and lead to a failure? | Could design or construction of the hydraulic structure prevent poor dam performance from being detected / prevented and lead to a failure? | Could design or construction of the mech/elec systems prevent poor dam performance from being detected / prevented and lead to a failure? | Could inadequate infrastructure and plans prevent poor dam performance from being detected / prevented and lead to a failure? |
| DAM COLLAPSE BY LOSS OF STRENGTH (External or internal structural failure and weakening) | Crest elevation too low | **Stability under applied loads** | Mass movement (external instability:- displacement, tilting, seismic resistance) | Could a meteorological event cause mass movement and lead to a failure? | Could a seismic event cause mass movement and lead to a failure? | Could the reservoir environment cause mass movement and lead to a failure? | Could design or construction of the water barrier cause mass movement and lead to a failure? | Could the design or construction of the hydraulic structure cause mass movement and lead to a failure? | Could the design or construction of the mech/elec systems cause mass movement and lead to a failure? | Could inadequate infrastructure and plans cause mass movement and lead to a failure? |
| | | | Loss of support (foundation or abutment failure) | Could a meteorological event cause a loss of support in foundation or abutments and lead to a failure ? | Could a seismic event cause a loss of support in foundation or abutments and lead to a failure? | Could the reservoir environment cause a loss of support in foundation or abutments and lead to a failure? | Could design or construction of the water barrier cause a loss of support in foundation or abutments and lead to a failure? | Could the design or construction of the hydraulic structure cause a loss of support in foundation or abutments and lead to a failure? | Could the design or construction of the mech/elec systems cause a loss of support in foundation or abutments and lead to a failure? | Could inadequate infrastructure and plans cause a loss of support in foundation or abutments and lead to a failure? |
| | | **Watertightness** | Seepage around interfaces (abutments, foundation, water stops) | Could a meteorological event cause seepage around interfaces/abutments/foundation and lead to a failure? | Could a seismic event cause seepage around interfaces / abutments / foundation and lead to a failure? | Could the reservoir environment cause seepage around interfaces / abutments / foundation and lead to a failure? | Could design or construction of the water barrier cause seepage around interfaces / abutments / foundation and lead to a failure? | Could the design or construction of the hydraulic structure cause seepage around interfaces / abutments / foundation and lead to a failure? | Could the design or construction of the mech/elec systems cause seepage around interfaces / abutments / foundation and lead to a failure? | Could inadequate infrastructure and plans cause seepage around interfaces / abutments / foundation and lead to a failure? |
| | | | Through dam seepage control failure (filters, drains, pumps) | Could a meteorological event cause through-dam seepage control failure (filters/drains/pumps) and lead to a failure? | Could a seismic event cause through-dam seepage control failure (filters/drains/pumps) and lead to a failure? | Could the reservoir environment cause through-dam seepage control failure (filters/drains/pumps) and lead to a failure? | Could design or construction of the water barrier cause through-dam seepage control failure (filters / drains / pumps) and lead to a failure? | Could the design or construction of the hydraulic structure cause through-dam seepage control failure (filters / drains / pumps) and lead to a failure? | Could the design or construction of the mech/elec systems cause through-dam seepage control failure (filters / drains / pumps) and lead to a failure? | Could inadequate infrastructure and plans cause through-dam seepage control failure (filters / drains / pumps) and lead to a failure? |
| | | **Durability / cracking** | Structural weakening (internal erosion, AAR, crushing, gradual strength loss) | Could a meteorological event cause structural weakening (internal erosion, AAR, crushing, cracking, strength loss) and lead to a failure? | Could a seismic event cause structural weakening (internal erosion, AAR, crushing, cracking, strength loss) and lead to a failure? | Could the reservoir environment cause structural weakening (internal erosion, AAR, crushing, cracking, strength loss) and lead to a failure? | Could design or construction of the water barrier cause structural weakening (internal erosion, AAR, crushing, cracking, strength loss) and lead to a failure? | Could design or construction of the hydraulic structure cause structural weakening (internal erosion, AAR, crushing, cracking, strength loss) and lead to a failure? | Could the design or construction of the mech/elec systems cause structural weakening (internal erosion, AAR, crushing, cracking, strength loss) and lead to a failure? | Could inadequate infrastructure and plans cause structural weakening (internal erosion, AAR, crushing, cracking, strength loss) and lead to a failure? |
| | | | Instantaneous change of state (static liquefaction, hydraulic fracture, seismic cracking) | Could a meteorological event cause instantaneous change of state occur (liquefaction, hydraulic fracture) and lead to a failure? | Could a seismic event cause instantaneous change of state to occur (liquefaction, hydraulic fracture) and lead to a failure? | Could the reservoir environment cause instantaneous change of state to occur (liquefaction, hydraulic fracture) and lead to a failure? | Could design or construction of the water barrier cause instantaneous change of state to occur (liquefaction, hydraulic fracture) and lead to a failure? | Could the design or construction of the hydraulic structure cause instantaneous change of state to occur (liquefaction, hydraulic fracture) and lead to a failure? | Could the design or construction of the mech/elec systems cause instantaneous change of state to occur (liquefaction, hydraulic fracture) and lead to a failure? | Could inadequate infrastructure and plans cause instantaneous change of state to occur (liquefaction, hydraulic fracture) and lead to a failure? |