

The Experience Of Dam Safety Evaluation In Taiwan

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I. The Importance Of Dam Safety Evaluation

- ◆ Dam is safe ?
 - ✓ Wrong ! If dam break, It would be a disaster.
- ◆ Deal with the problem until it happen !
 - ✓ Too late ! Dam break process could be short than few hours.
- ◆ Each Dam was designed in state of art at that time, why it would still break ?
 - ✓ Natural disaster ?
 - ✓ Improper construction ?
 - ✓ the knowledge is not perfect ?
 - ✓ Human error ?

I. The Importance Of Dam Safety Evaluation

- ◆ International Dam break example
 - ✓ 1952, landslide above the powerhouse of Whatshan dam(BC Hydro/ Canada), Destroy the switch yard and powerhous
 - ✓ 1963, Flood overflow Vaiont Dam(Italy), more than 2000 people death.
 - ✓ 1975, Banqiao dam break(china), more than 240 thousand people death. (note. named as top of 10 top technological catastrophe in the world(Discovery channel)
 - ✓ 1976, Teton Dam break(US), 11 people death, lost 4 Billion US dollars. US. Reclamation Bureau Reorganized.
 - ✓ 1999, Shigan Dam break, two million people in the Greater Taichung area were facing a shortage of water
 - ✓ ...Dam break Continuing...

I. The Importance Of Dam Safety Evaluation



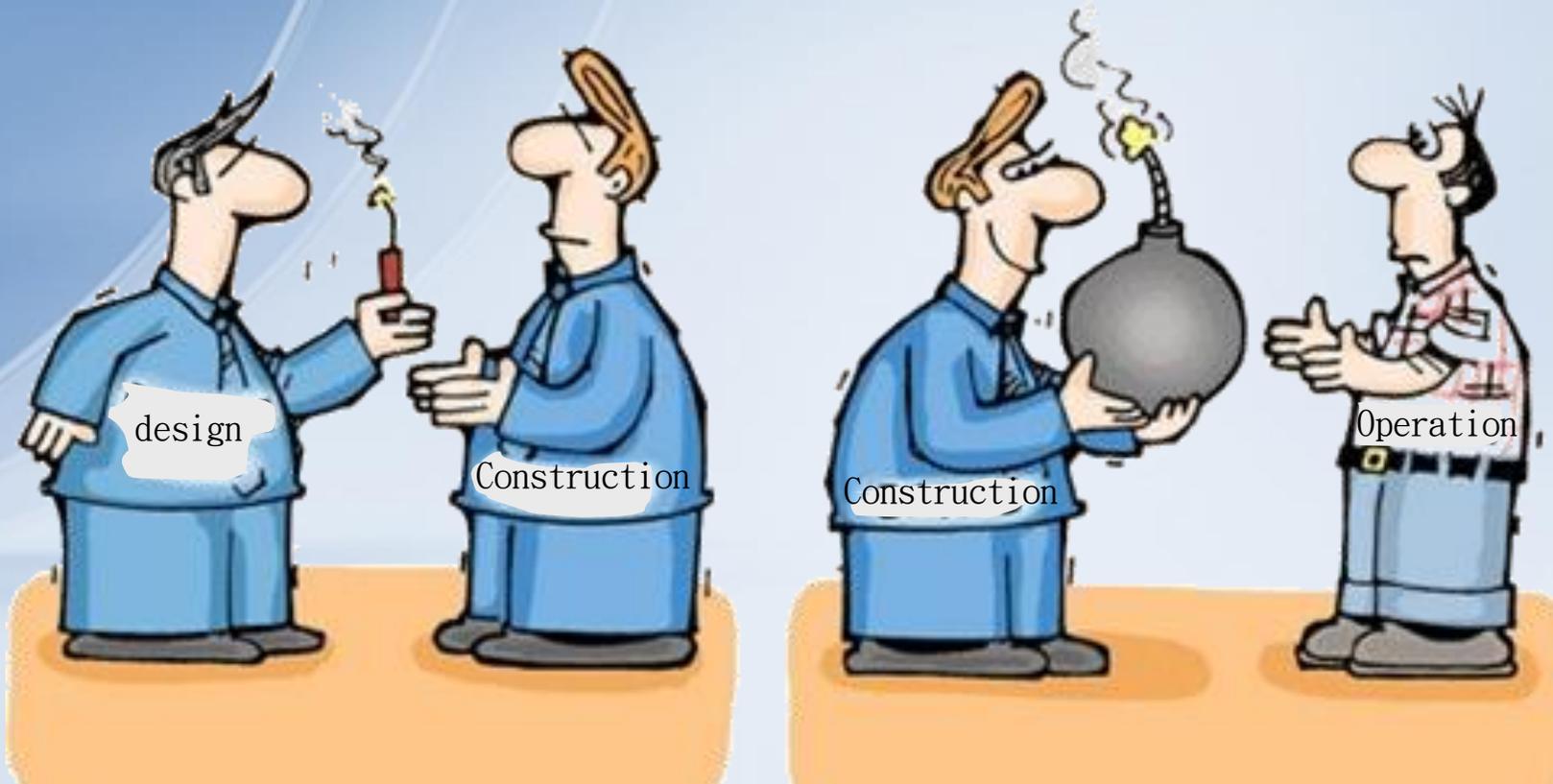
■ Banqiao dam after break (1975 Aug)



■ Shigan Dam after break(1999/9/21)

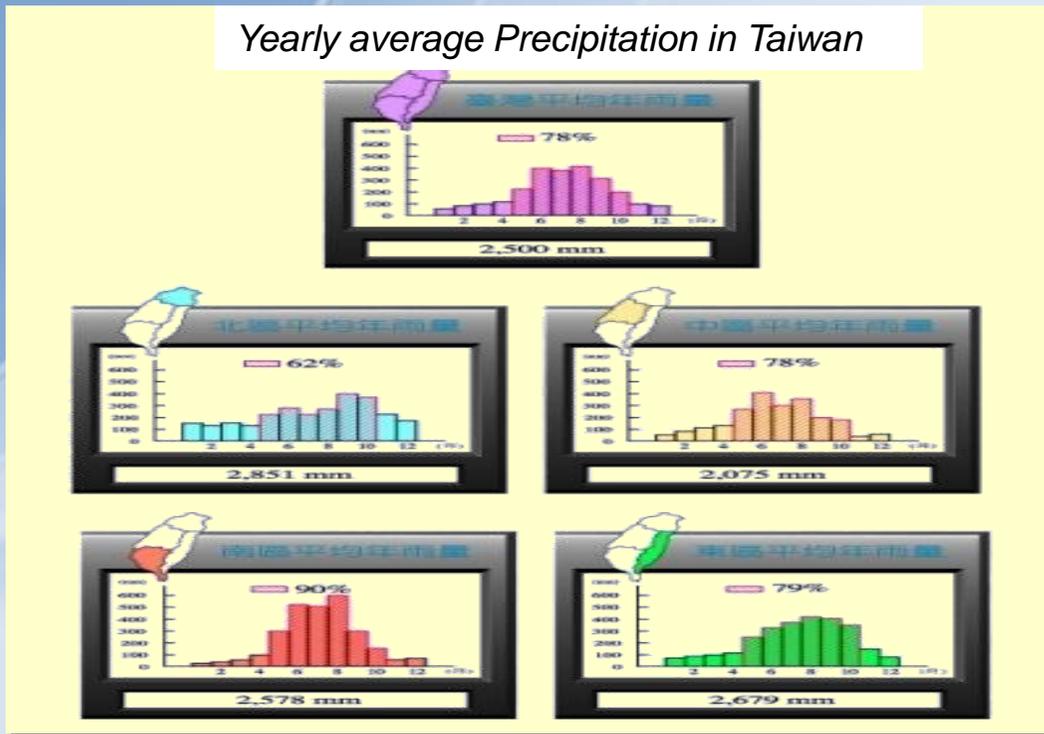
I. The Importance Of Dam Safety Evaluation

- ◆ How to ensure the dam safety during the reservoir operation period ?
 - ✓ Do the work of Inspection and Dam Safety Evaluation(D.S.E.).

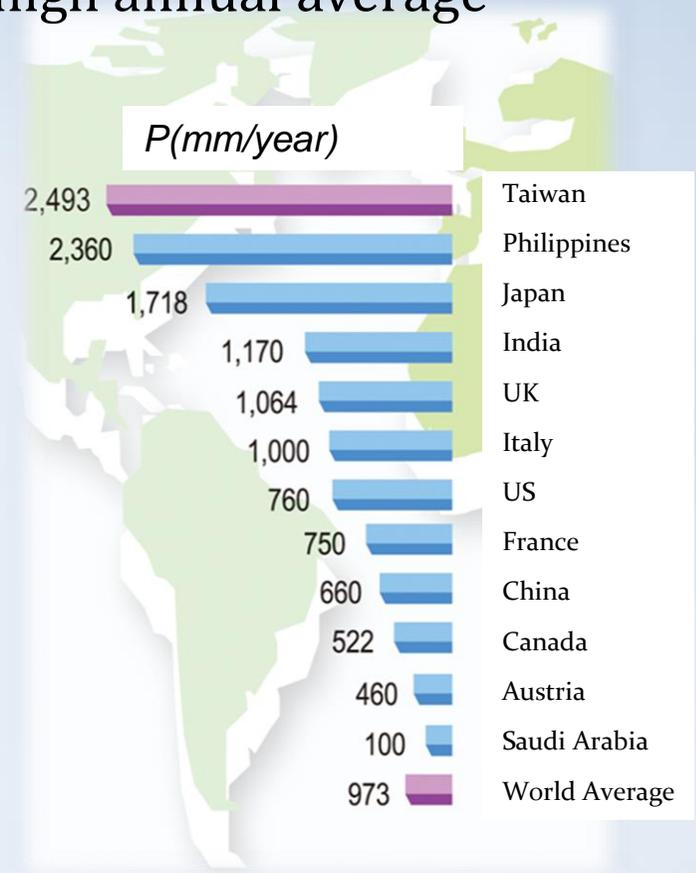


II. Overview Of The Execution Of Dam Safety Evaluation In Taiwan

- ◆ Harsh hydrological environment
 - ✓ Precipitation uneven in time and space, high annual average precipitation

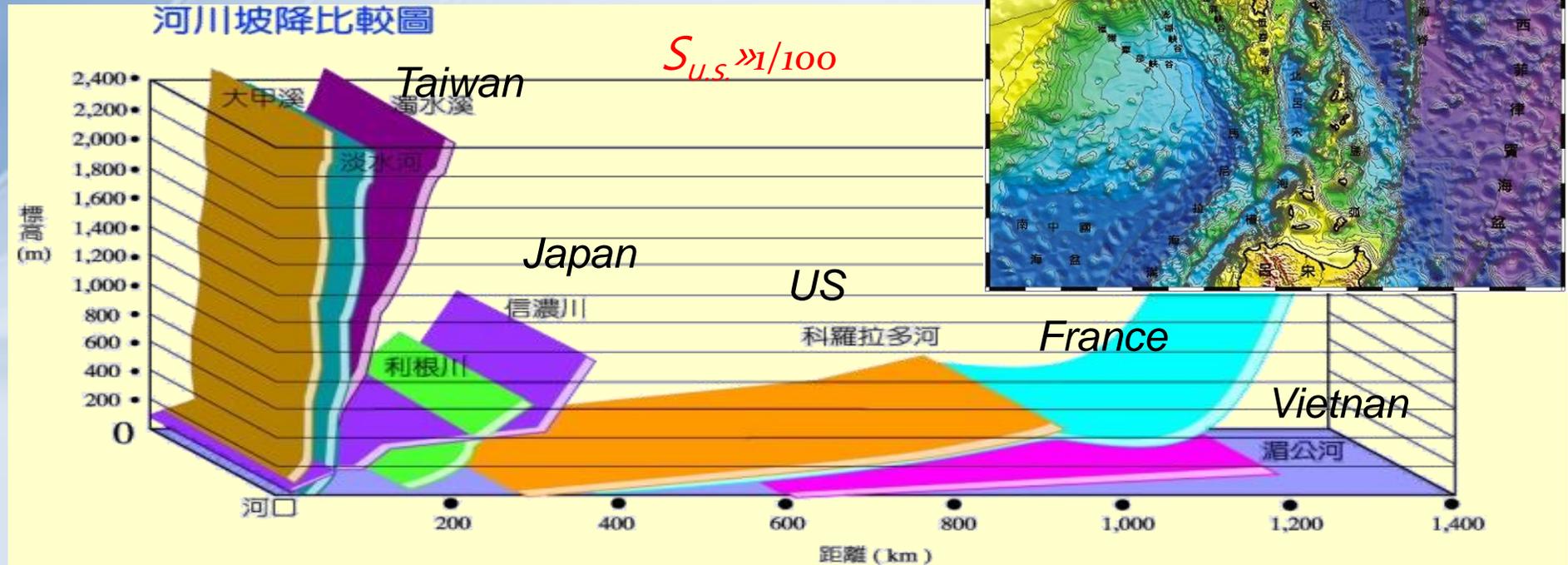
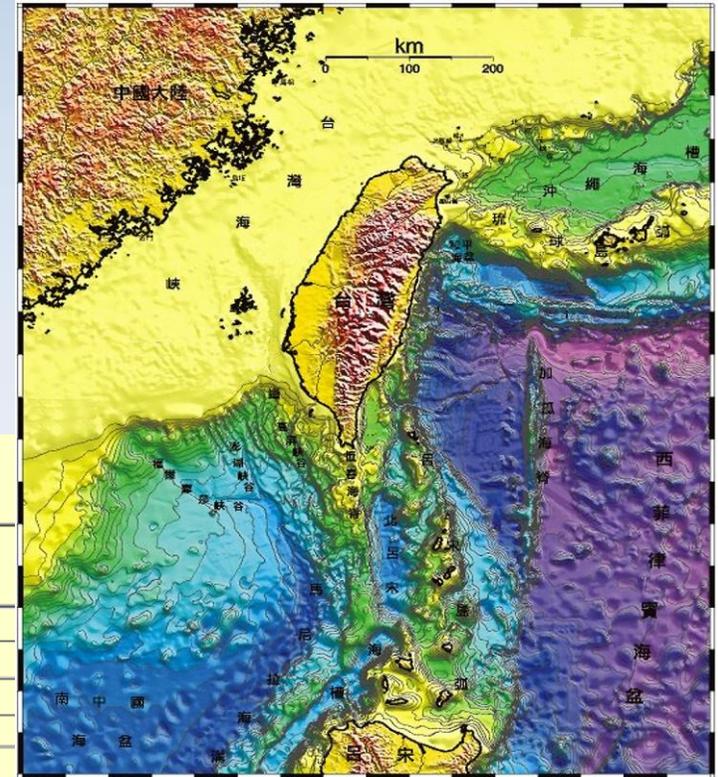


note : wet : dry > 9:1 (south area)



II. Overview Of The Execution Of Dam Safety Evaluation In Taiwan

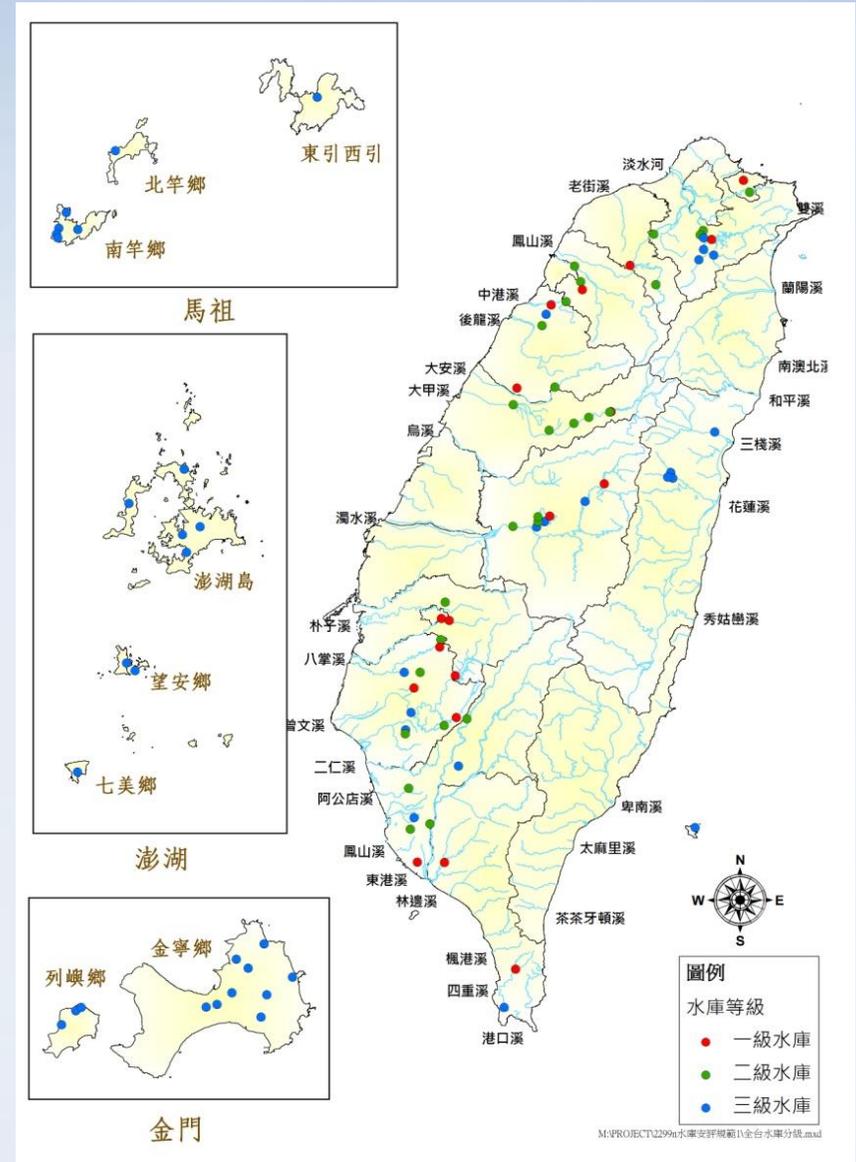
- ◆ Harsh geological environment
 - ✓ Located in Seismic zone, high Seismic freq. and scale
 - ✓ Steep river slope



II. Overview Of The Execution Of Dam Safety Evaluation In Taiwan

◆ 93 major reservoirs

Dam Level	No.
1	17
2	27
3	49
sum	93



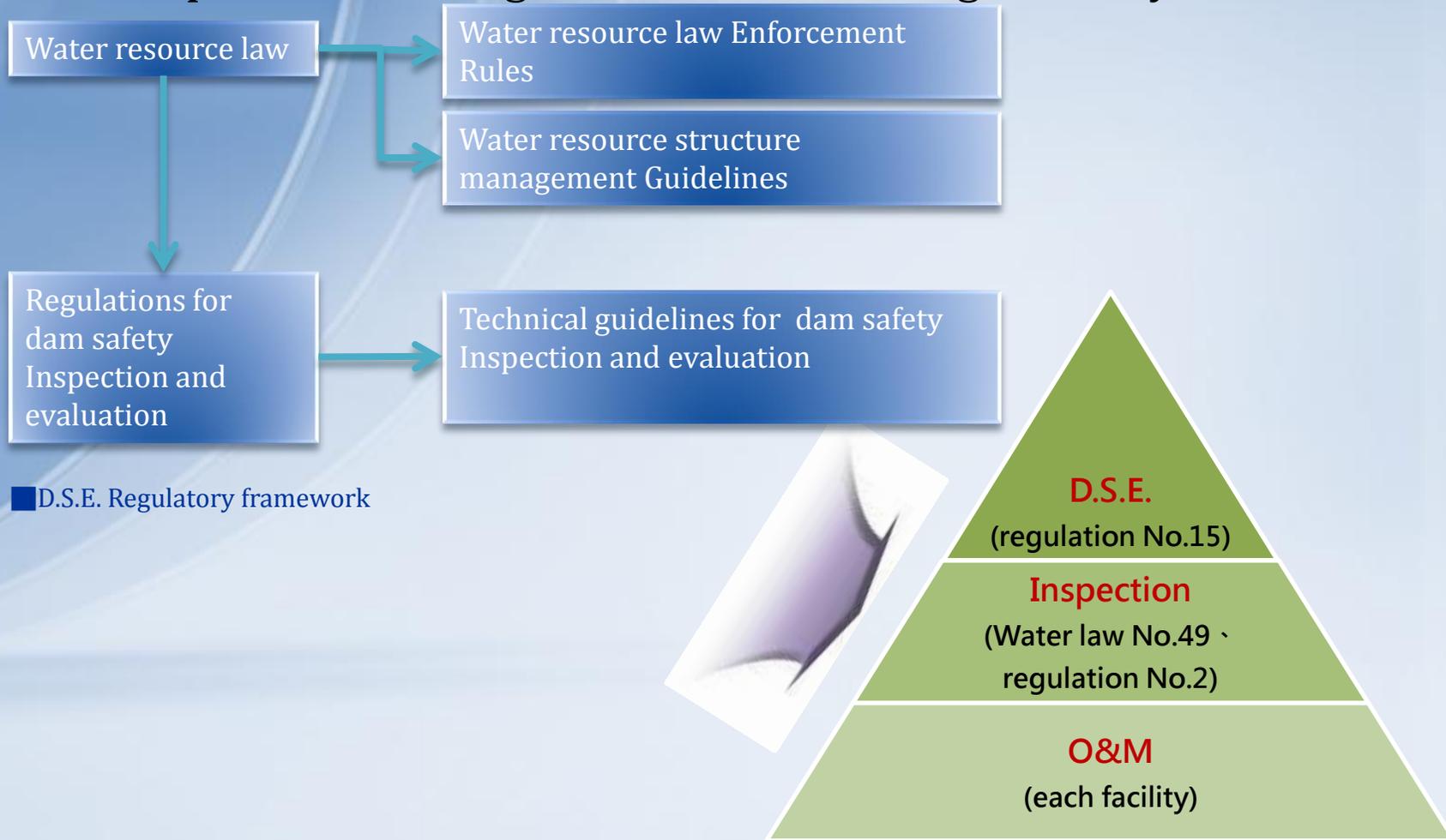
II. Overview Of The Execution Of Dam Safety Evaluation In Taiwan

◆ Process of dam management

TIME	Action
1929	St. Francis Dam break
1972.08.08	US congress signed No. 92-367 Bill Corps of Engineers
1979	The Executive Yuan Issue and suggestion about reservoir safety in Taiwan
1981.1.23	Shuangxi Dam flood discharge disaster → → → → <i>open gate for flushing out debris in reservoir</i>
1981.02	M.O.E.A. arranged a study tour to US about dam safety issue <i>(15 death, 12 injured, students most)</i>
1986.03	Set dam safety evaluation team
1988.05.12	Pass the Regulations for dam safety Inspection and evaluation
2008.5	Pass the technical guidelines for dam safety Inspection and evaluation

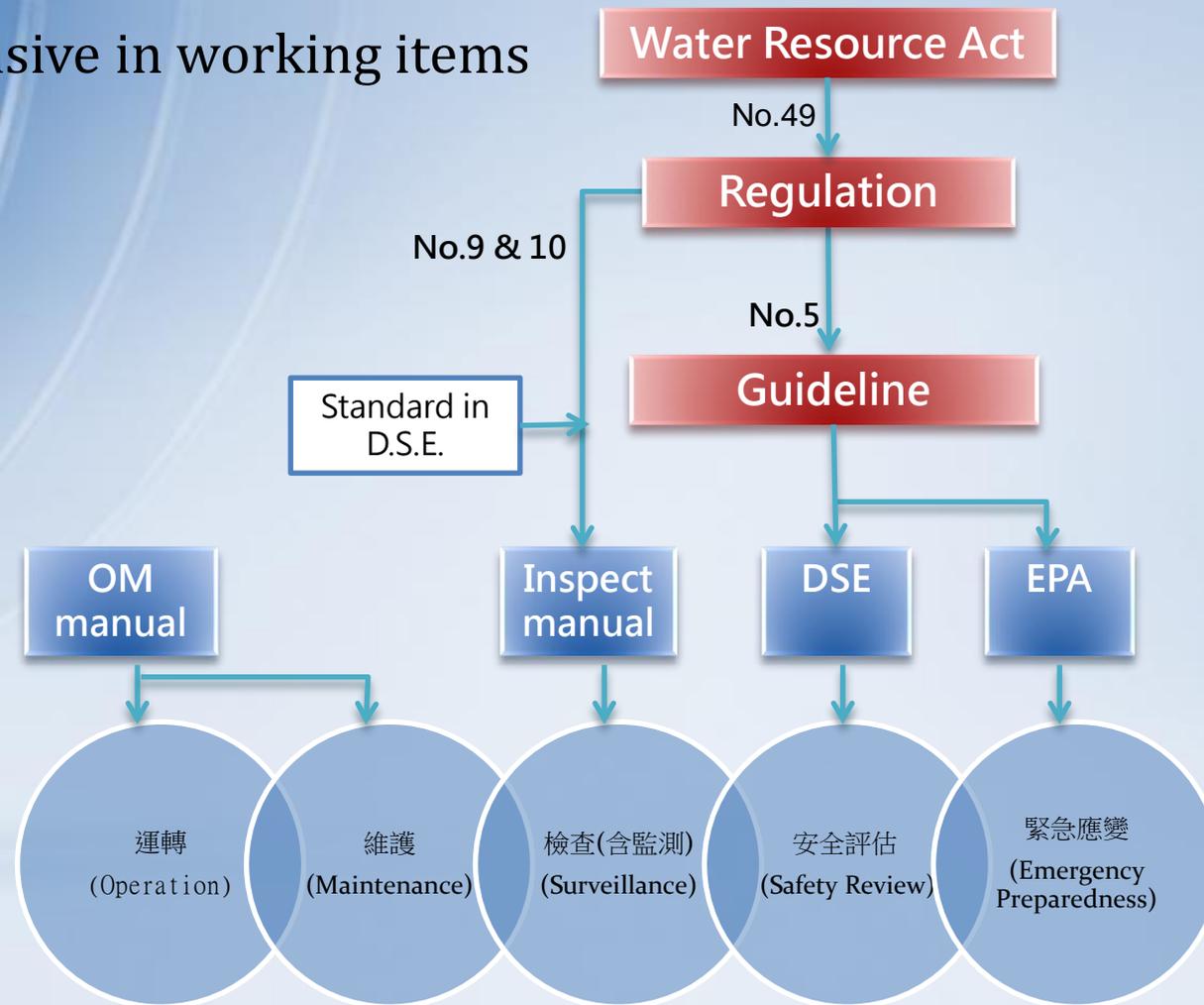
II. Overview Of The Execution Of Dam Safety Evaluation In Taiwan

- ◆ Completed in laws, guidelines and management system.



II. Overview Of The Execution Of Dam Safety Evaluation In Taiwan

- ◆ Comprehensive in working items



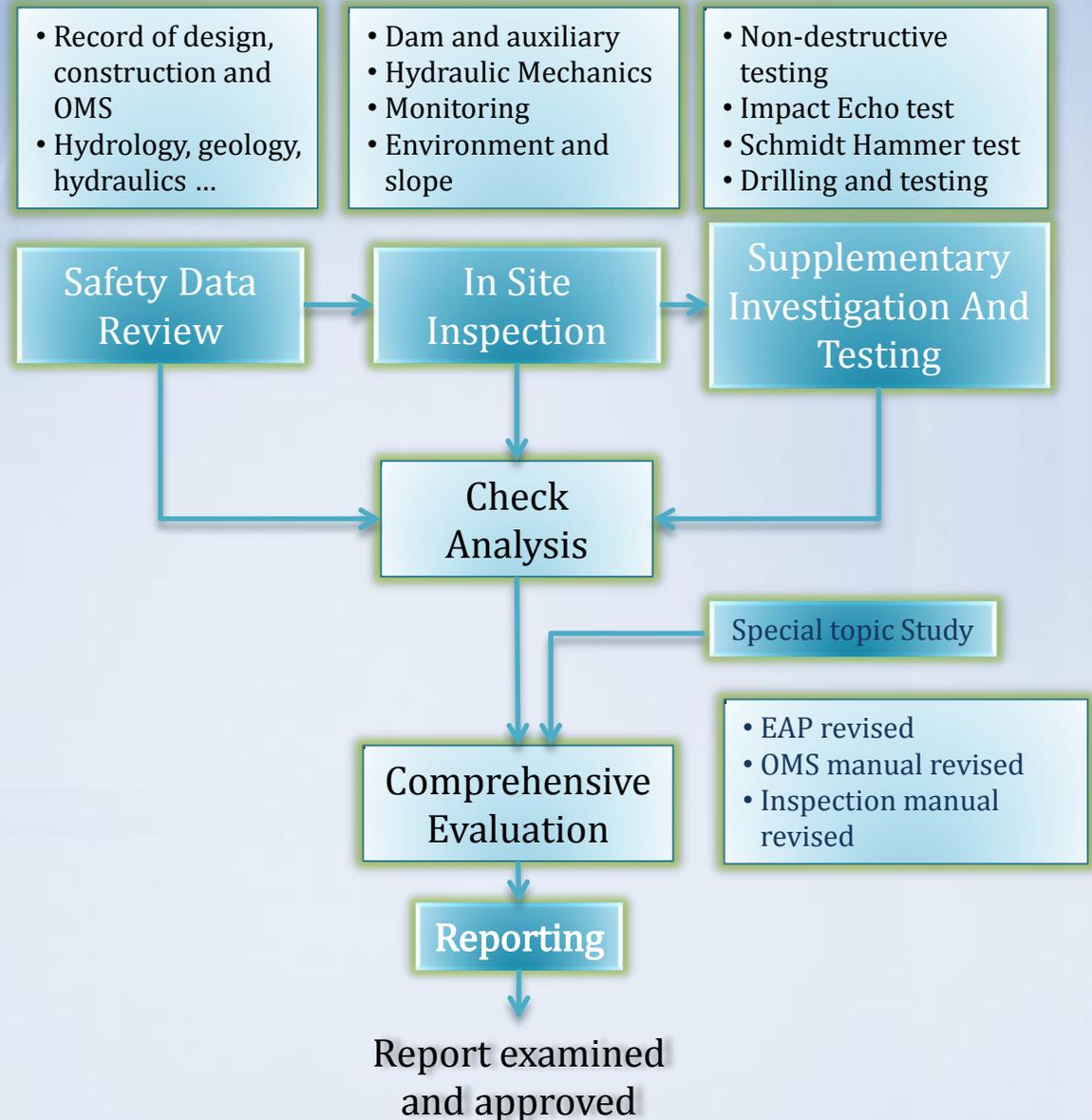
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◆ The type of D.S.E. (from regulation)

Type		Note
Inspection	Periodic inspection	day, month, or year
	Non-Periodic inspection	After severe flood, earthquake or special event
	Review	If needed by authority
D.S.E.	Before filling	Before filling
	1 st After filling	5 years after filling or operation
	Periodic	Every 5 years
	Non-Periodic	After severe flood, earthquake or special event

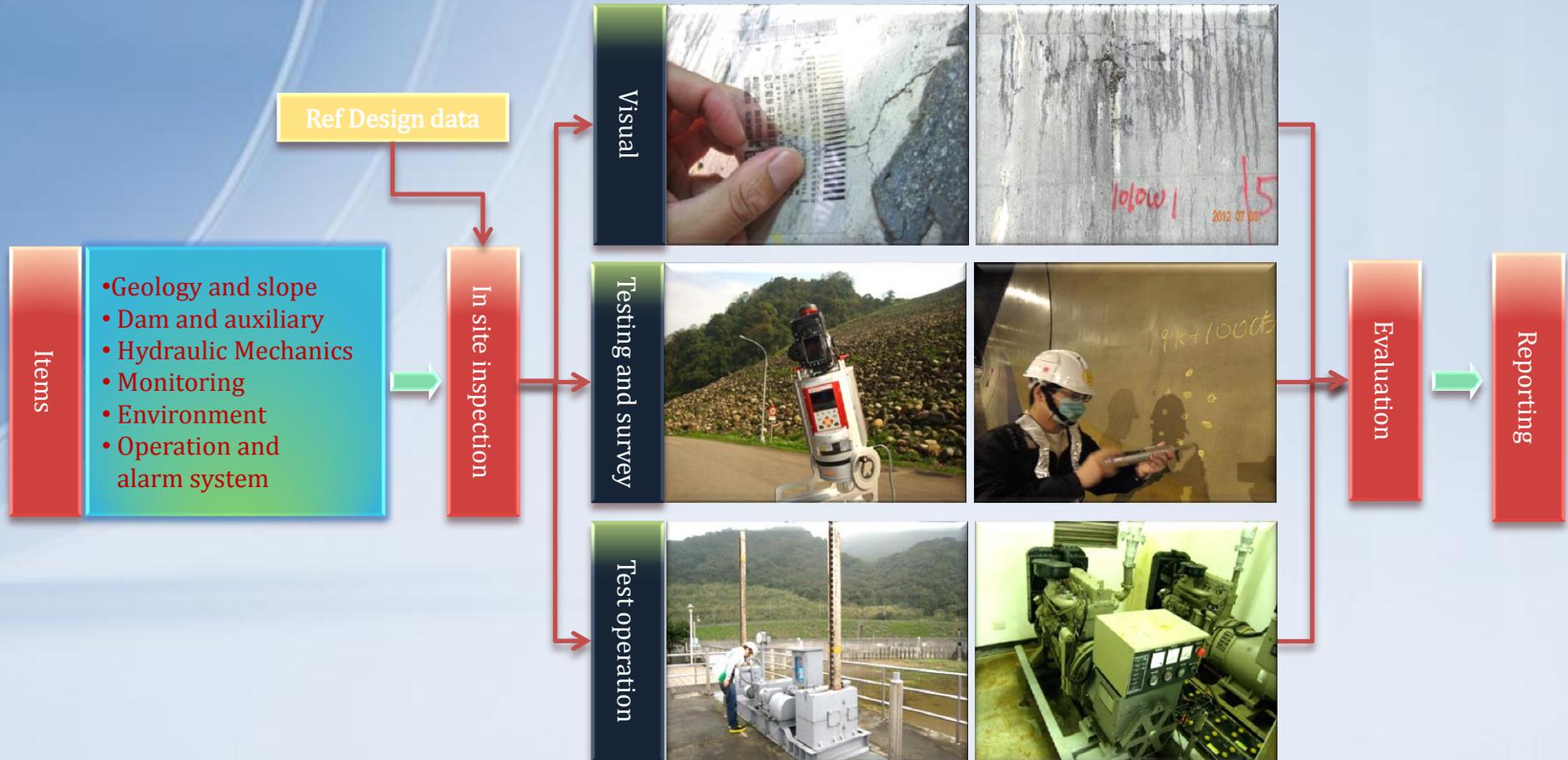
II. Overview Of The Execution Of Dam Safety Evaluation In Taiwan

◆ Executing process of D.S.E.



II. Overview Of The Execution Of Dam Safety Evaluation In Taiwan

◆ In Site Inspection

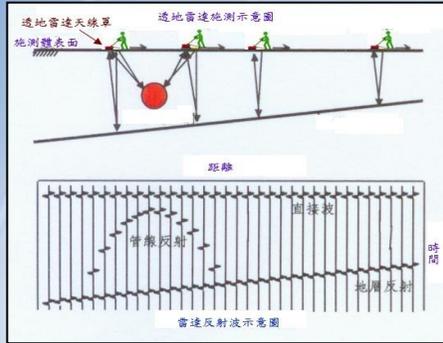


II. Overview Of The Execution Of Dam Safety Evaluation In Taiwan

◆ Supplementary Investigation And Testing



• Schmidt Hammer test



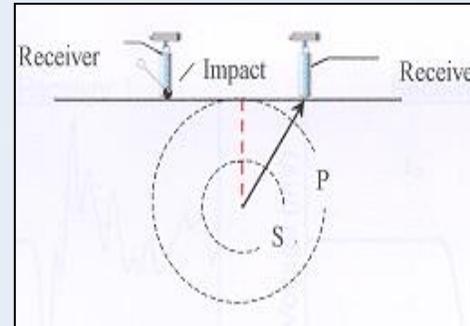
• GPR test



• ROV(underwater)



• UAV inspection

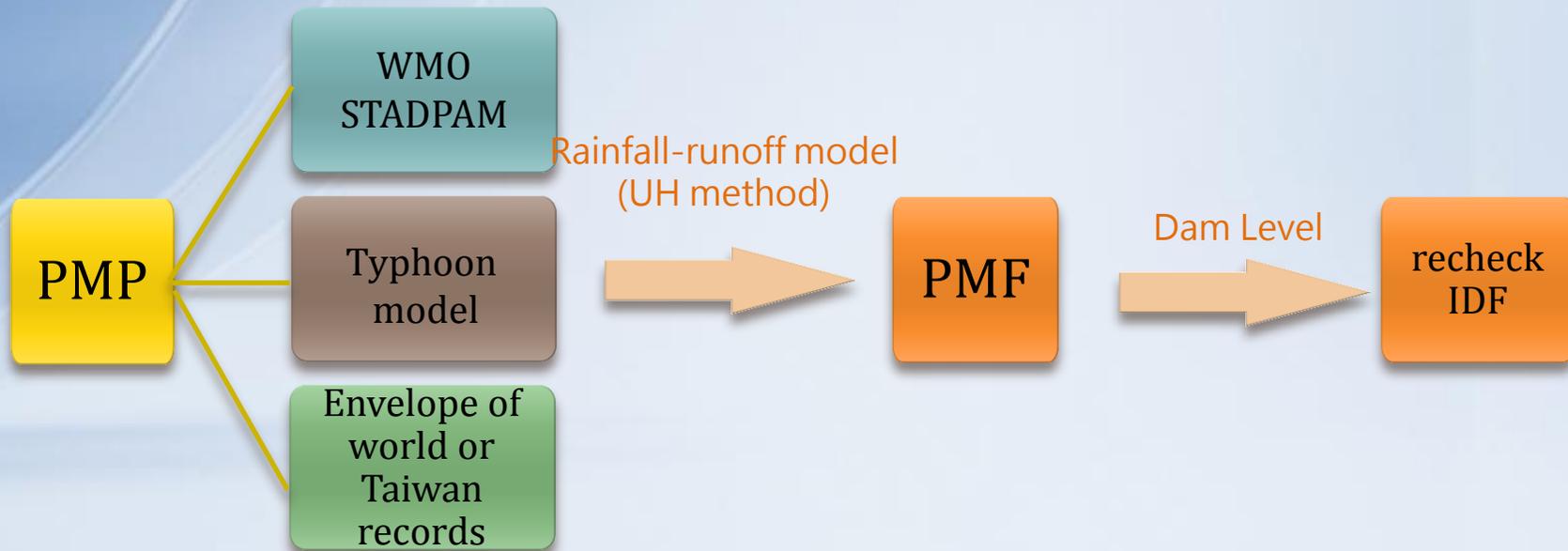


• Impact Echo test



II. Overview Of The Execution Of Dam Safety Evaluation In Taiwan

- ◆ Inflow design flood(IDF) review
 - ✓ PMP、PMF
 - ✓ Following standard in regulation, recheck IDF



STADPAM: Storm transposition and dew point adjustment method

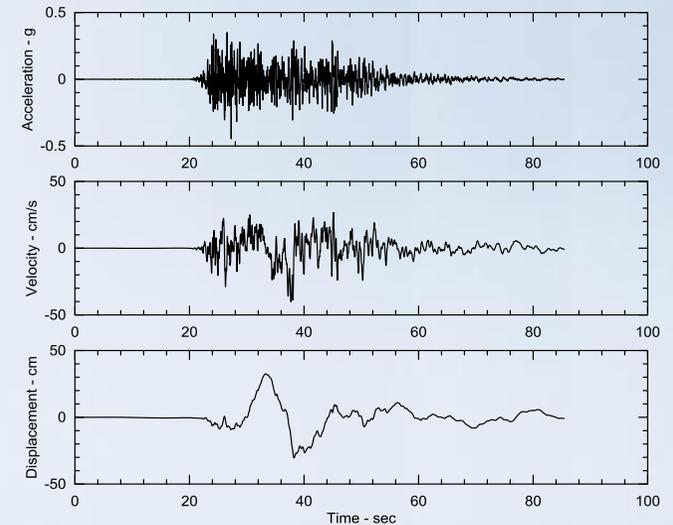
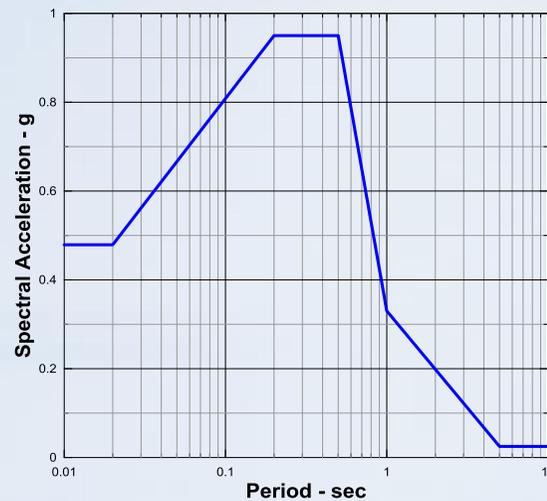
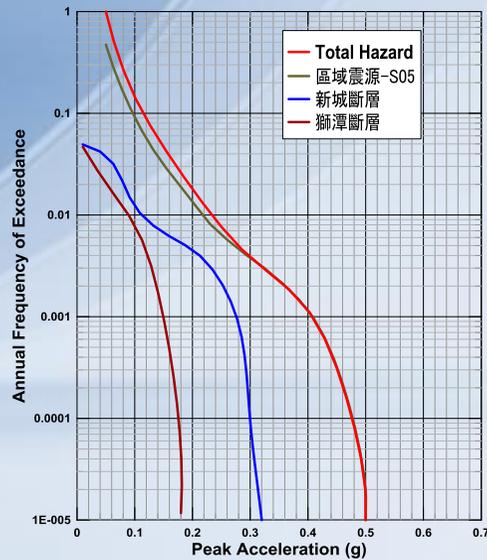
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◆ Seismic Review

Deterministic seismic hazard analysis
Probabilistic seismic hazard analysis

Design response spectrum

Artificial acceleration time history



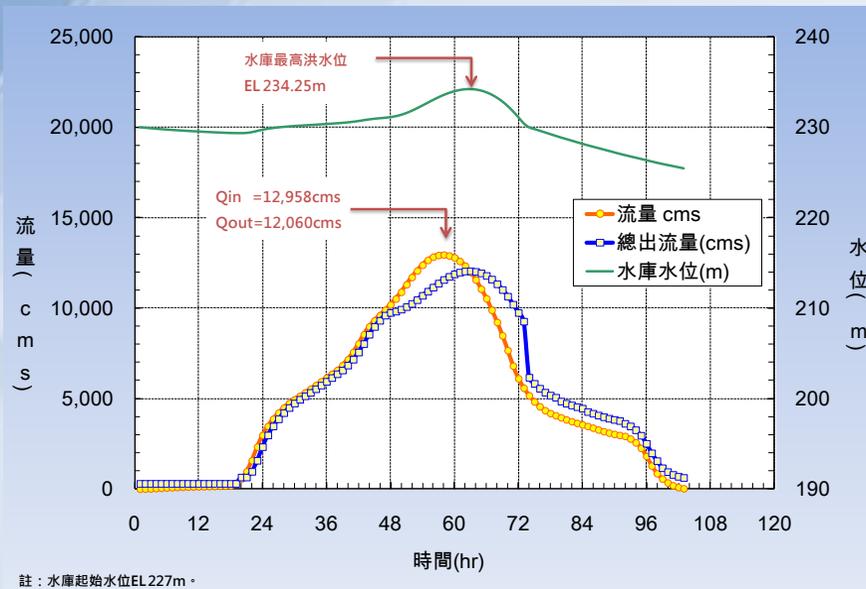
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◆ Flood Discharging capacity review

- H-A-V
- H-Q curve
- Reservoir routing

- Freeboard
= max[normal condition(earthquake),
flood condition(flood)]

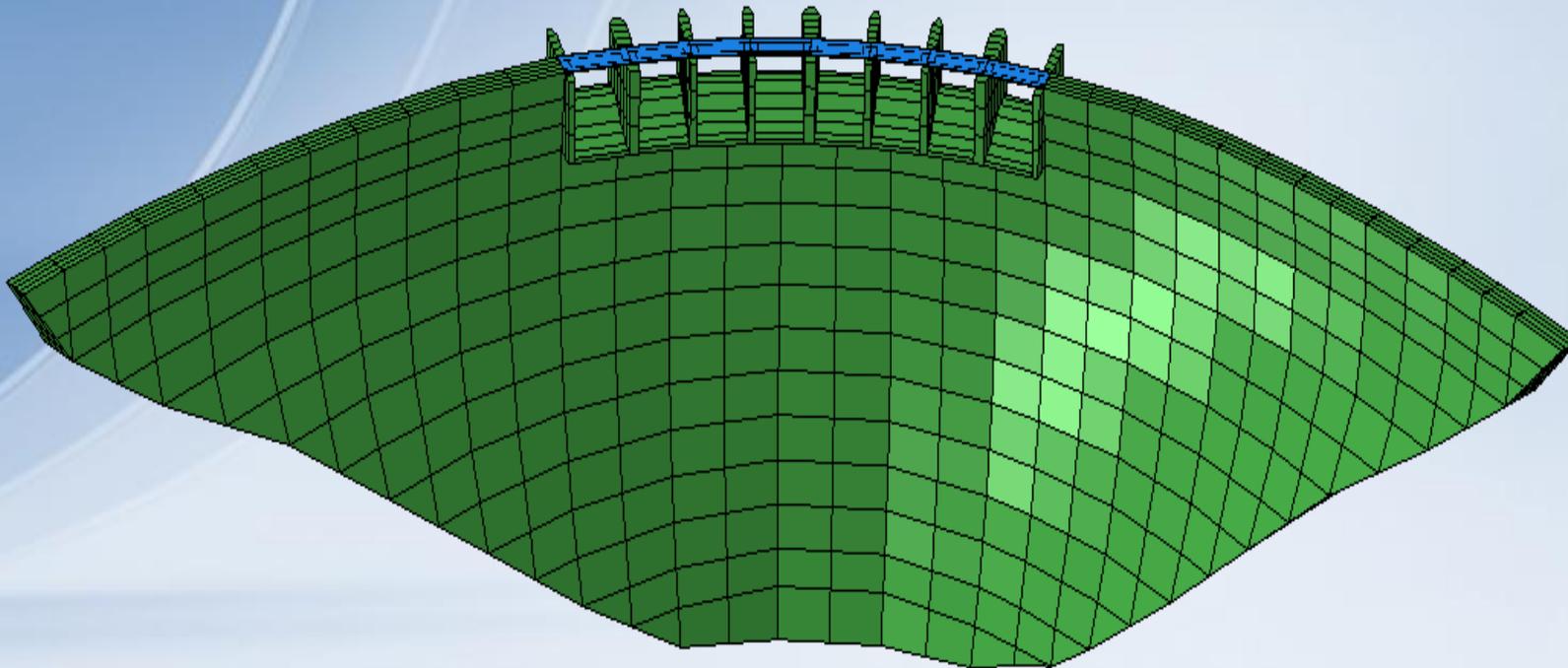
$$\frac{I_1 + I_2}{2} - \frac{O_1 + O_2}{2} = \frac{S_2 - S_1}{\Delta t}$$



II. Overview Of The Execution Of Dam Safety Evaluation In Taiwan

◆ Structure Safety Review

- Stability analysis
- Stress analysis (ABAQUS/3D)

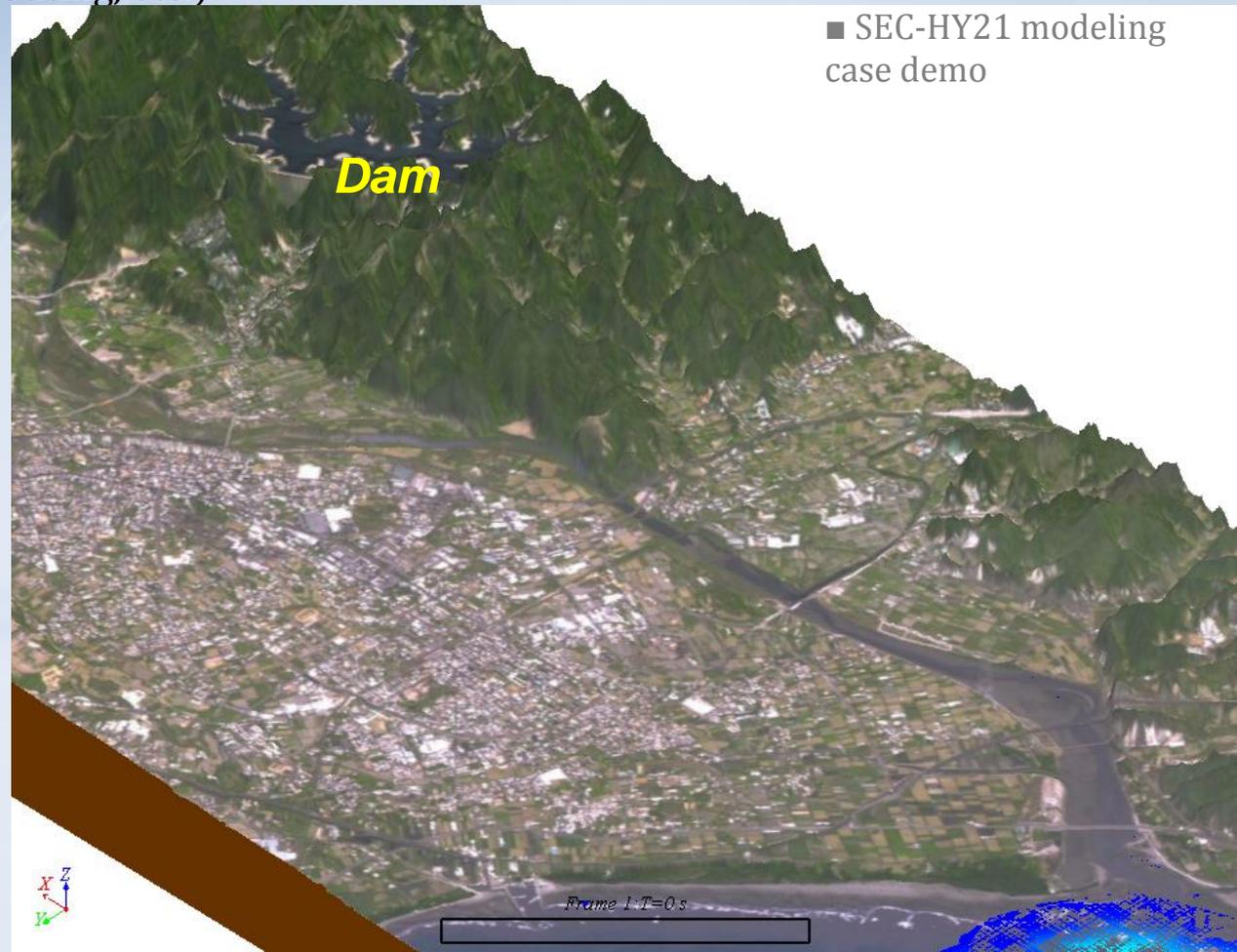


■ ABAQUS modeling case - Feitsui arch dam



II. Overview Of The Execution Of Dam Safety Evaluation In Taiwan

- ◆ Emergency Action Plan(EAP)
 - ✓ SEC-HY21 model demo(Steady/unsteady flow, sedimentation, dam break routing, inundation routing, etc.)

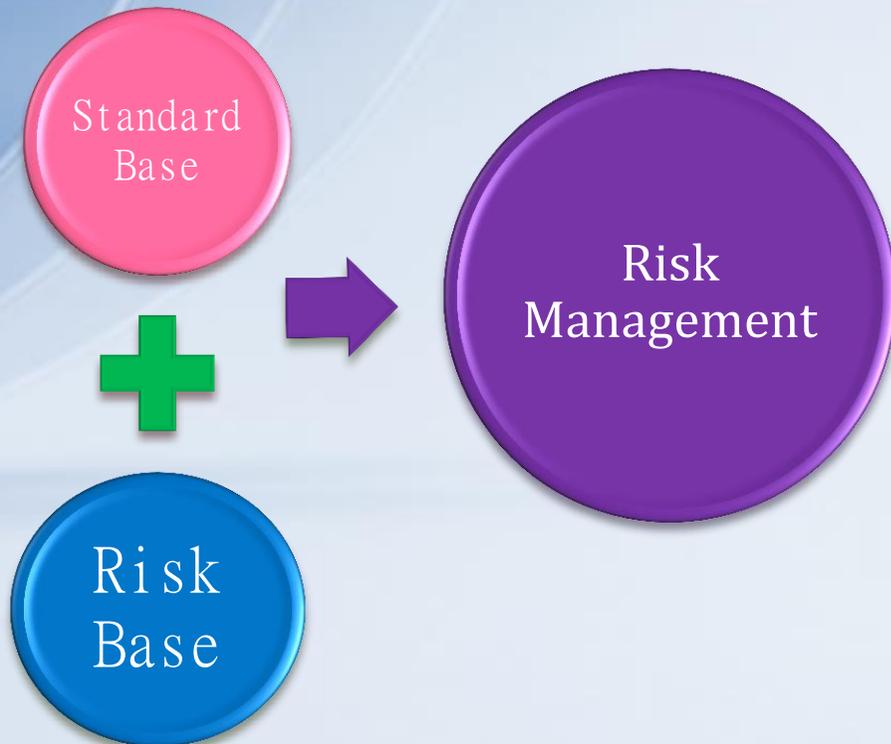


II. Overview Of The Execution Of Dam Safety Evaluation In Taiwan

- ◆ Rich staff training experience -
 - ✓ According to their aptitude for the job
 - ✓ Trainees indicated that they could finally understand the safety assessment report and suggested that they should conduct outsourced dam safety inspection (consciously and spontaneously) to understand the importance of dam safety.

II. Overview Of The Execution Of Dam Safety Evaluation In Taiwan

- ◆ Risk management included
 - ✓ Potential Failure Mode Analysis(PFMA)
 - ✓ Adequacy assessment of Monitoring system



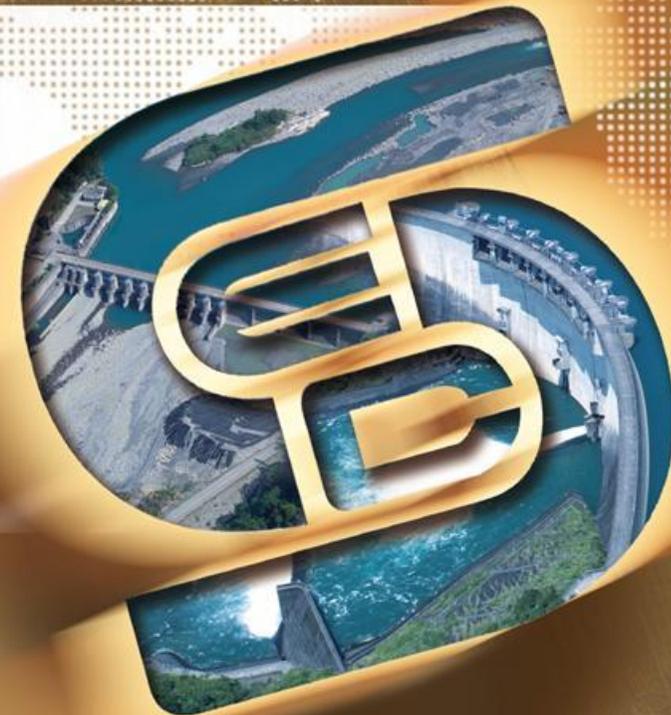
■ PFMA keynote

III. Characteristic of Taiwan's Experience

- ◆ Completed in laws and regulations
- ◆ Powerful self-developed 2D hydraulic model SEC-HY21
- ◆ Diversification of reservoir cases, D.S.E. experience is complete and rich
 - ✓ Small to large scales, arch dams, embankment dams, concrete gravity dams
 - ✓ Diversification in management



Thank you



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