Shake Table Tests for Validation of Numerical FSI Models of Advanced Reactors

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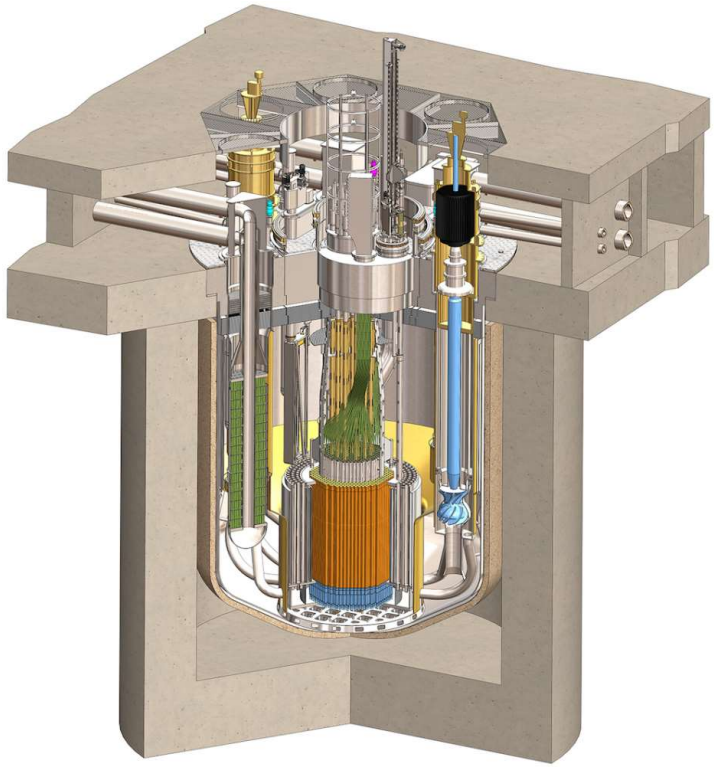
Outline

- Motivation
- Test plan
- Instrumentation
- Seismic inputs, fixed based and isolated
- Test results:
  - Frequency of convective mode
  - Damping in convective modes
  - Hydrodynamic responses
  - Base isolation
- Numerical modeling: linear and non-linear solvers in LS-DYNA
- Work in progress



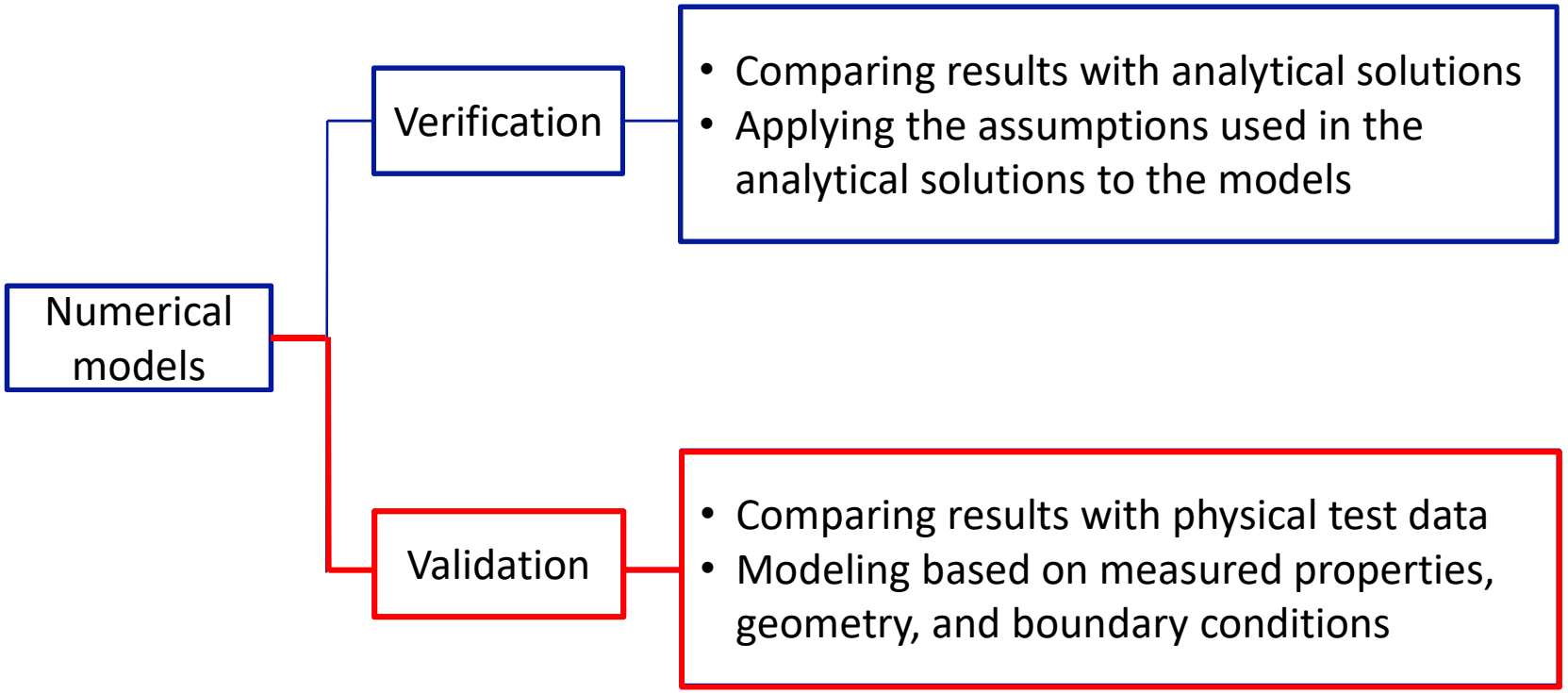
(Image: TerraPower)

Motivation

- Advanced reactors
  - Liquid metals for heat evacuation
  - Vessels may be thinner than in PWRs and BWRs
    - Reduced seismic capacity
- Fluid-structure interaction (FSI)
  - Building structure, reactor vessels, vessel internals
- Legacy FSI procedures - added mass and damping
  - Idealized geometries only (e.g. Chen et al. 1976, Dong 1978)
- FSI calculations for seismic design, qualification and risk assessment
  - Physical testing of equipment not feasible in most cases
  - Verified and validated FSI models needed
    - Conventionally supported
    - Isolated

TerraPower

Verification and validation



Building a dataset

- Base-supported vessel
- Phase-I:
  - No vessel head, RVIs, or HMOs
  - Results used for validation of numerical models in LS-DYNA: ALE and ICFD
- Phase-II:
  - Simplified representations of central and off-center RVIs
  - Testing completed; numerical modeling continues

Conclusions

- Experimental and analytical predictions of sloshing frequency
- Smaller damping in convective mode than ASCE 4
- Analytical solutions for lateral, rocking, and vertical excitations: results may be superimposed
- Base isolation leads to reduction in responses, except wave height
- Lagrangian approaches in LS-DYNA do not predict convective responses well
- ALE model in LS-DYNA validated; tracer card needs improvement
- If no convective response: Lagrangian model is faster than ALE
- Data to be made available on DesignSafe

23

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25

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26