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Technology of Multi-functional Infrastructural Systems for Earthquake Disaster Mitigation

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Outlines

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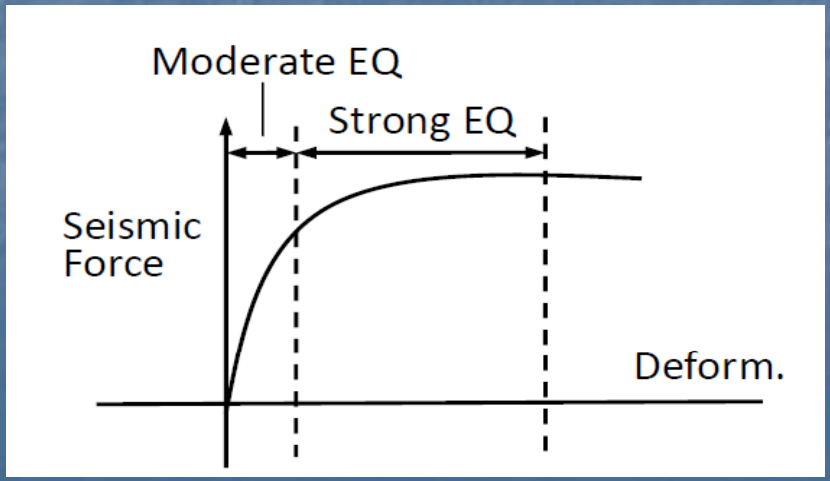
- Drawbacks of current seismic-resistant technology for infrastructural systems
- Concept of multi-functional infrastructural systems (MFIS)
- Examples of MFIS
- Research needed for MFIS

Preface

- The intensity and frequency contents of earthquakes are generally unpredictable.
- A conventional infrastructure system usually has constant design parameters determined based on design seismic load; therefore, it may not perform satisfactorily in an earthquake that is considerably different from the design earthquake.
- It is almost impossible to design a conventional infrastructure system that will perform well in a wide range of earthquakes.
- Advanced infrastructural systems should have multi-functional properties or multi-level performances to resist earthquakes with different intensities or characteristics.

Drawbacks of Current Technology (1/2)

- Structures with ductility design:
  - A structural system with ductility design may be considered as one kind of multi-functional infrastructural systems (MFIS).
  - A structure with ductility design uses its elastic property (stiffness) to resist a moderate earthquake, and uses its inelastic property (ductility) to resist a strong earthquake.
  - The structural ductility in these systems is provided by the structural members or joints.



Drawbacks of Current Technology (2/2)

- Drawbacks of structures with ductility design:
  - In a strong earthquake, the primary structural components will enter their ductility range, so the structure is severely damaged and becomes un-repairable. Therefore, the resiliency of these infrastructures will be costly and time-consuming.
  - Because the inelastic property (ductility) is provided by the structural elements and joints, due to the on-site construction conditions and structural complexity, it is usually very difficult to construct a structure whose overall inelastic behavior exactly follows the ductility design theory.
  - In a moderate earthquake, the structure may be in its elastic range and undamaged, but the interior equipment may suffer large acceleration due to structural dynamic amplification. This will jeopardize the societal resiliency after the earthquake.

Concept of Multi-Functional Infrastructure System (MFIS)

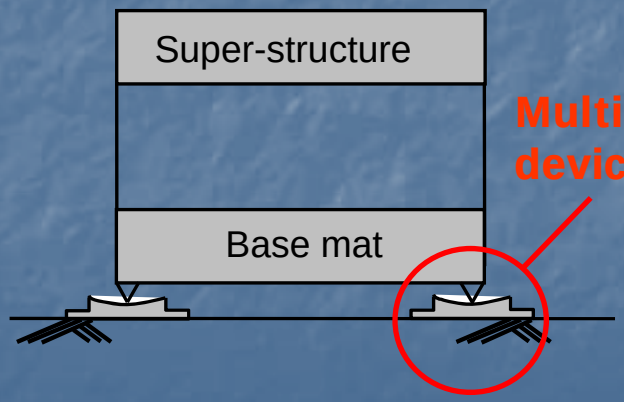
- A MFIS functions differently in different earthquakes.
- A MFIS can be designed to ensure:
  - comfortablity in a small earthquake
  - functionality in a moderate earthquake
  - live-safety in a strong earthquake
  - being repairable after a major earthquake.
- A MFIS can be realized by adding passive-type multi-functional devices in an infrastructural system, in stead of using its own structural member as the devices.

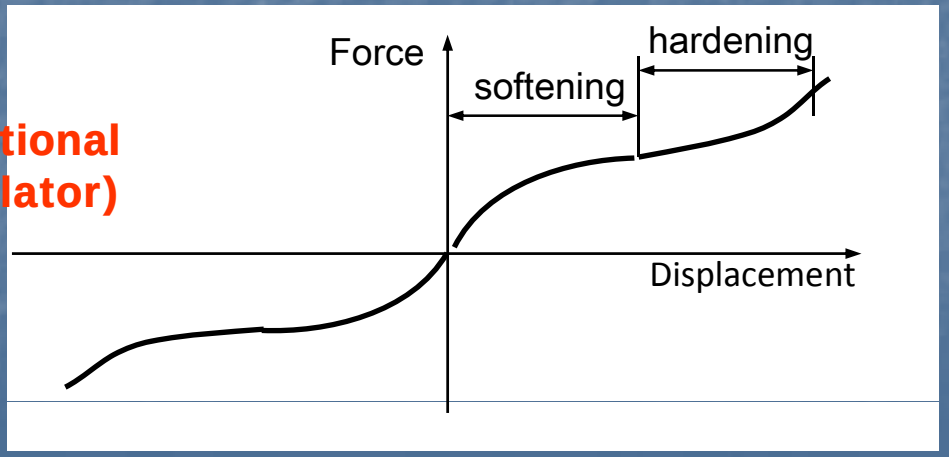
Features of Multi-Functional Devices

- It is an added part to the infrastructure system.
- It possesses different mechanical properties in earthquakes with different intensities or features.
- It is usually nonlinear. Its nonlinear or inelastic mechanical properties designed by the engineers should be easily and precisely fabricated.
- It can be sacrificed in a severe earthquake to protect the infrastructure system itself.
- If damaged, it can be replaced or repaired to increase infrastructure resiliency.

Examples of Multi-Functional Devices

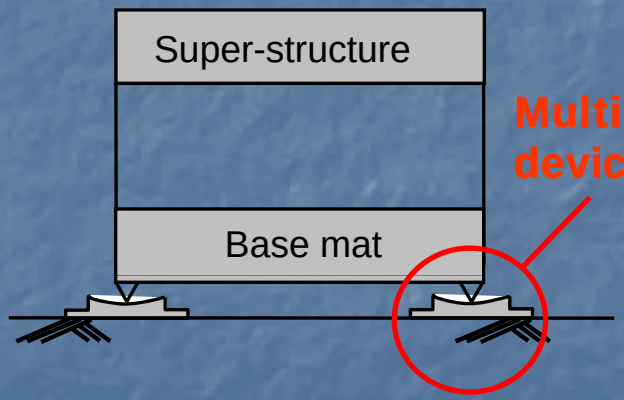
- Seismic isolator with variable stiffness
  - In a moderate earthquake, the softening section intends to reduce the transmitted ground acceleration.
  - In a severe earthquake, the hardening section intends to suppress the isolator displacement to ensure the safety of the whole system.
  - If damaged, the isolators can be replaceable.

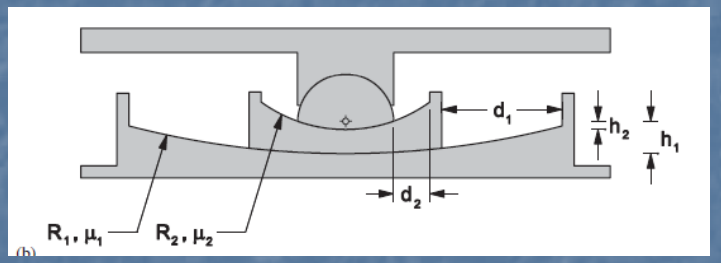


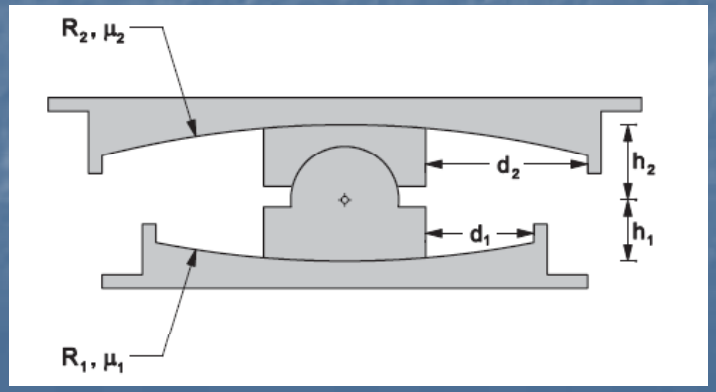


Examples of Multi-Functional Devices

- Double concave friction pendulum isolator
  - Proposed by Fenz and Constantinou (2008)
  - Tow sliding surfaces may have different curvature and frictional coefficients to resist different seismic loads.







By Fenz and Constantinou (2008)

Research Needed for MFIS

- For various types of earthquakes, identify what is the most favorable mechanical property of the multi-functional devices, which will protect the personnel, the equipment and the structure as a whole.
- The favorable mechanical property can be nonlinear or inelastic.
- Develop responsive multi-functional devices that fulfill the favorable mechanical.
- Develop durable and replaceable (or repairable) devices to increase infrastructure resiliency.

Thank you for your comments!

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