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Technology of Multi-Functional Infrastructural Systems for Earthquake Disaster Mitigation

Motivation:

- Because the intensity and frequency contents of an earthquake are generally unpredictable, conventional infrastructure systems, which have constant design parameters, usually do perform satisfactorily in an earthquake that is considerably different from the design earthquake.

- It will be uneconomical to design a conventional structural system that is able to sustain a wide range of earthquakes.

- Therefore, future infrastructural systems should be more adaptive to seismic loadings, and be designed with multi-functional properties for different types of earthquakes.

Disadvantages of conventional infrastructural systems:

- A structural system with ductility design may be considered as one kind of multi-functional infrastructural systems. This type of structures uses its elastic property (stiffness) to resist a medium earthquake, and uses its inelastic property (ductility) to resist a strong earthquake. The structural ductility is provided by the structural members or joints.

- Disadvantages: (1) In a strong earthquake, the primary structural components will be severely damaged, so the structure becomes un-repairable. The resiliency of these infrastructures is costly and time-consuming. (2) Because the ductility is provided by the structural elements and joints, due to structural complexity and on-site construction conditions, it is usually very difficult to construct a structure whose inelastic behavior exactly follows the design theory.

Multi-functional infrastructural systems (MFIS):

- A MFIS is able to ensure: comfortablity in a minor earthquake; functionality in a strong earthquake; live-safety in a strong earthquake; being repairable after a major earthquake. A MFIS can be realized by adding multi-functional devices in an infrastructural system.

- The features of a multi-functional device: (1) it has different mechanical properties in different types of earthquakes. (2) It is usually nonlinear. Its nonlinear or inelastic mechanical properties designed by the engineers should be easily fabricated. (4) It can be sacrificed in a severe earthquake to protect the infrastructure system itself. If damaged, the device can be easily replaced to expedite the infrastructure resiliency.

- Example of multi-functional devices: seismic isolators with variable properties. The design goal of this kind of isolators is to reduce the transmitted ground acceleration to a minimum for earthquakes within the design range, but to suppress the isolator displacement to ensure the safety of the system in a severe earthquake that may produce an excessive isolator displacement.