Findings & Recommendations

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17th U.S.-Japan-New Zealand Workshop on the Improvement of Structural Engineering and Resilience

Sessions

- Session 1: Innovative Structural Design for Large or Multiple earthquakes
- Session 2: Risk Identification and Reduction
- Session 3: Resilience- and Performance-Based Engineering: Progress and Developments
- Session 4: Earthquake Response, Recovery, Repair, and Reconstruction
- Session 5: Lessons Learned from Recent and Past Events

Categories of Findings & Recommendations

- Research
- Engineering Practice
- Resilience Incentives
- Regulatory Environment/Policy

Findings & Recommendations: Research

- Continue to work on understanding residual capacity and repairability of buildings (topic touched upon at prior workshop).
  - Consider that structural tests might not reflect other system level interactions that might affect repairability. Explore opportunities with Japan to test the WHOLE building (e.g., investigate repairability after shake table tests).
  - Consider that not all "repairable" buildings will be repaired. There are other factors that are not technical (e.g., financial/insurance payout, fear of inhabiting building, culture, politics). Consider creating a benchmark to identify buildings that might be repaired.
- Further study the impact and revision of damping values.
- Further investigate impact of duration and how to include it in the design process.

Findings & Recommendations: Research

- Most reports on past events focus only on damage. We also need to report on good structural and nonstructural performance.
- Develop inspection methods to provide better confidence in identifying damage (e.g., steel moment frame damage following the Northridge earthquake). Requiring instrumentation for new buildings can help with this.
- Sites and their impact on performance needs to be better assessed and documented. Identify what is causing damage. It might not just be ground shaking (also look at liquefaction issues, etc.).
- We need better post-earthquake data on nonstructural performance (e.g., % of pipes broken and resulting impact).

Findings & Recommendations: Research

- Investigate strategies for achieving resilience at wider scales (e.g., community-wide resilience).
  - Look at other fields as examples of how they've managed complex, evolving issues when thinking through how to achieve resilience and how to communicate uncertainties to the public (e.g., parallels in environmental and medical field).
- Frequency content of input motion to structures makes a big difference in impact. For example, performance of buildings in the Nepal earthquake was highly driven by frequency content. Design philosophy in Mexico is to avoid resonance.

Findings & Recommendations: Engineering Practice

- Explore new performance objectives, such as low damage design and functional recovery. We need to define these and consider their implications.
- Improve engineering designs/strategies to provide better performance at minimal or no extra cost. Encourage engineers to consider performance in their design decisions (e.g., selection of structural system).
- There are very few buildings with seismic isolation in the U.S. In Japan, ductile design is very complicated and complex without a clear performance objective, but seismic isolation is simple and understandable in its performance. Consider reducing the R factor in the U.S. to simplify design and improve resilience.

Findings & Recommendations: Engineering Practice

- Consider how drift limits in the code impact resilience. There is inherent resilience in stricter drift limits.
  - Drift limits are stricter in Japanese code (1%) vs US/NZ code.
  - There are other aspects of the Japanese code that implicitly limit drift (ds – inverse of ductility).
- We need to improve resilience of nonstructural systems.
  - Consider the different pathways to compliance – design vs testing vs inspection.
  - Consider developing trade certificate for bracing of nonstructural elements to be done by construction workers (could address 90% of work, while engineers only focus on difficult 10%).
  - We need to broaden our communication network and be talking those that develop nonstructural components (pipes, etc.).

Findings & Recommendations: Resilience Incentives

- We need to improve our communication to encourage resilience.
  - Develop a framework for client communication that the industry can adopt, but don't just involve engineers in the development.
  - Further explore how to communicate probability to stakeholders. We need to be clear about uncertainties as there are many things we don't know. The graphic from FEMA P-58 is good example. It is an honest way to indicate what we don't know.
  - We need to consider potential communication issues with rating buildings pre-event.
  - Perhaps we should turn the conversation of seismic design performance into one about investment.
  - If we want to get to low damage buildings, communication with the client needs to involve the whole design team, not just structural engineers.
  - Consider engaging occupants of buildings to incentivize resilience.
  - Improve our communication of structural versus nonstructural damage.

Findings & Recommendations: Resilience Incentives

- Improve our understanding of cost of increased resilience so that we can communicate cost-benefit to stakeholders.
  - This can help get buy-in from clients.
  - Include longterm costs, as well as direct and indirect costs, not just initial costs.
  - Compare to cost-benefit to NOT doing anything.
  - Need to consider who is paying these costs (e.g., developers vs owners).
- Explore how we can use market forces to drive resilience.
- Nonstructural performance can have big impacts on resilience. For example, a building may have good structural performance, but may be perceived as having inadequate performance by the public due to nonstructural damage.

Findings & Recommendations: Regulatory Environment/Policy

- Our mission is for society. We should focus on the outcome for society.
  - In code development/update, we need feedback from those we are serving. We need better communication and understanding of what they want. To a certain extent, practicing engineers hear that clients want buildings with better performance.
  - We already tackled life safety, better performance is our next challenge.
  - Explore what post-event success would look like for a community. This can help guide and drive decisions.
- We need to further understand acceptable risk. It can depends on many things, like insurance levels (e.g., acceptable risk in Christchurch might not apply in other areas).
- Having legislation that supports our processes is important. Consider using videos of nonstructural damage to get support for better legislation and processes to improve resilience.

Findings & Recommendations: Regulatory Environment/Policy

- Even relatively new buildings become non-compliant because codes are continuously updated for regulatory and/or structural safety/performance reasons – how do we deal with this issue that is more than just technical?
  - Concerning structural safety and performance improvement, is focusing on existing buildings the most effective approach? Perhaps we need to be more strategic as it is very expensive to bring existing buildings to current code and it is more cost effective to ensure that new construction has good performance, although non-compliance will eventually occur due to codes changes.
  - However, addressing risk in our existing building stock, especially in old buildings, is of high importance ("We must address the risks in our existing building stock," was a recommendation from the last workshop).
- Focus on the bigger picture – look at systems at the regional level, focus on improving new construction as there will always be growth, be realistic about improving the existing building stock while being conscious of the importance of keeping the existing building stock safe, and incorporate land use planning considering hazards.
- We are not policymakers, but should serve as advisors to policymakers. We need to tell our story well.

Findings & Recommendations: Regulatory Environment/Policy

- We continue to have the challenge of engaging decision makers (e.g., politicians) in the conversation around resilience. We need more compelling arguments (e.g., economic impacts).
- Lobby group of countries to highlight nonstructural performance issues and how they are enforced in different countries.
- Consider targeting damage limits in the code instead of just focusing on collapse. If so, should consider liability for practicing engineers as overpromising can lead to a lot of issues.
- Reconsider serviceability limit state / Level 1 in Japan.