Improving Structural Engineering and Resilience for Natural Hazards

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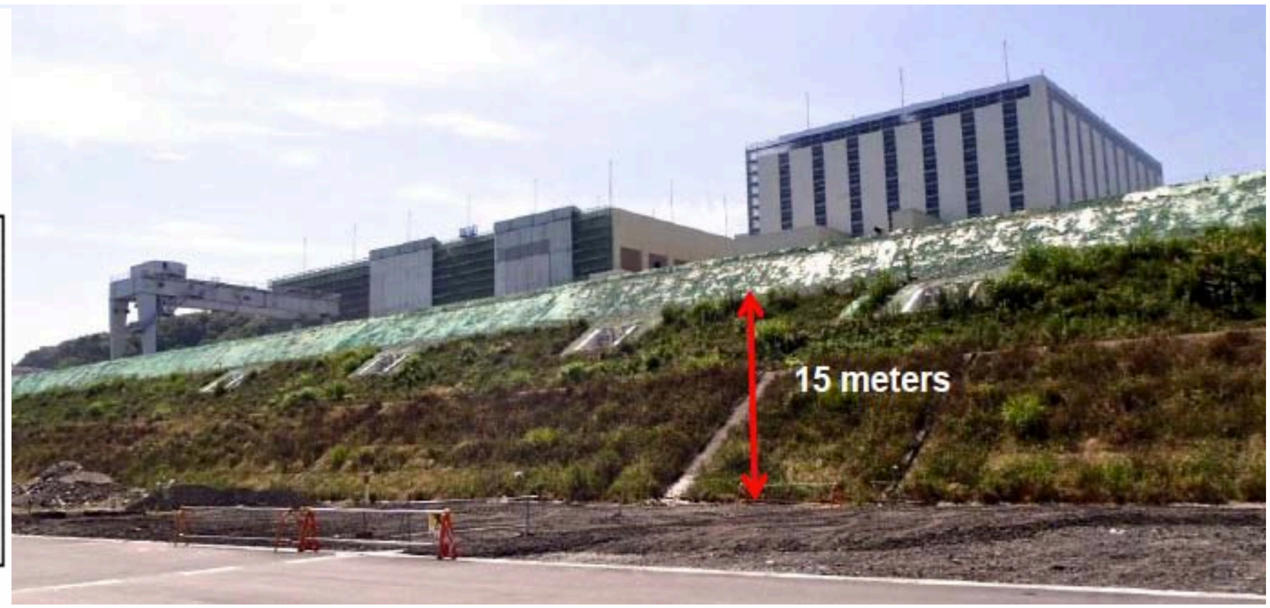
For Natural Hazards, risk management and resilience are the same thing

PHOTO: REUTERS

For Natural Hazards, risk management and resilience are the same thing

Success vs. Failure - Onagawa vs. Fukushima
Same Earthquake - Different Criteria, Resilience, and Results

図2-16　三陸大津波の教訓を伝える石碑(1).



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Chile 2010

Chile 1985

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Chile 2010

Chile 2010

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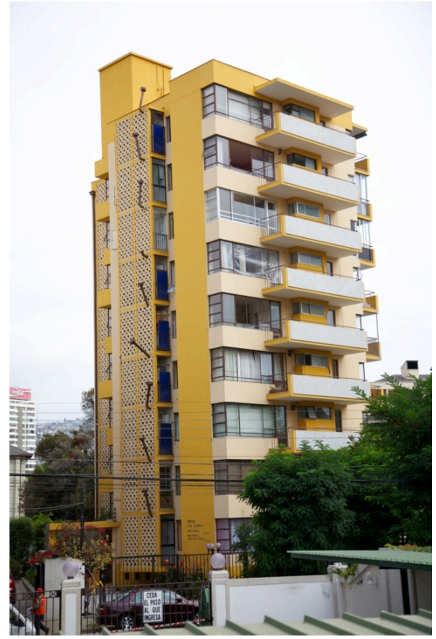


Chile 2010

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Santiago, Chile, 2010

The real costs:

- Original construction
- Demolition
- Business interruption
- Replacement

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For Natural Hazards, risk management and resilience are the same thing

A stronger structure (for earthquakes, etc.) is a more resilient structure. It will:

- Suffer less damage
- Cause less business interruption
- Less likely to be upgraded in the future
- Need less insurance

Resilience is not a structural issue. It is an investment issue.

It is our fault that the public does not understand that.

But we can change that.

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The system is stacked against resilience and risk management

Overreliance on the existing design philosophy (life safety):

Always playing catch up to new developments. Always updated and improved after catastrophes.

Codes are driven by structural engineers and their clients with a narrow view to the structure. Where is the public?

Lack of understanding of natural hazards by the design professions.

Manipulation of the codes, especially with “independent” review panels, engineering software, optimization……

Do we really understand the legal ramifications?

The system is stacked against resilience and risk management

Cost management trumps risk management:

Completely for developers

Much less so for companies if management understands the issues.

Structural engineers have minimal to no influence

As in Chile, perhaps developers should be liable and responsible for their buildings for at least 10 years after they are completed and sold?

Structural engineers rarely understand the system (the business). They rarely have a strong impact on the system. We can change that.

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"Structural engineering" for hospitals in California

Performance Based Engineering

Structural engineers and risk management

Are More Analysis, Testing, and Structural Engineering Really Needed Here?

Lessons in risk management from the latest earthquake – Napa

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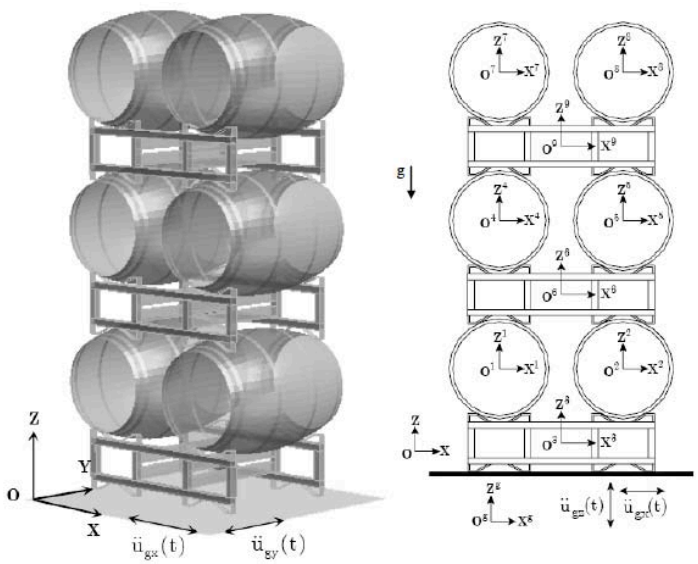

$$\mathbf{F}^{ij} = \sum_{Q}\left(\frac{\partial \mathbf{r}^{i}_{Q*}}{\partial \mathbf{q}^{i}}\right)^{T}\mathbf{F}_{QQ*} = \sum_{Q}\left[\mathbf{I} \quad \mathbf{H}^{i}\bar{\mathbf{u}}^{i}_{Q*}\right]^{T}\mathbf{F}_{QQ*}$$

$$\mathbf{F}^{ji} = -\sum_{Q}\left(\frac{\partial \mathbf{r}^{j}_{Q*}}{\partial \mathbf{q}^{j}}\right)^{T}\mathbf{F}_{QQ*} = -\sum_{Q}\left[\mathbf{I} \quad \mathbf{H}^{j}\bar{\mathbf{u}}^{j}_{Q*}\right]^{T}\mathbf{F}_{QQ*} \qquad (2.7)$$

In general, the accuracy in the computation of the contact forces using this procedure depends on the spatial discretization used for the contact surface and the smoothness characteristics of the target surfaces. In order to state the equilibrium of the *i-th* body, the work done by internal forces is equal to the work done by external forces, hence $W_I^i + W_C^i = W_C^i$. Substituting these results, the dynamic equation of motion for the *i-th* body is

$$\mathbf{M}^{i}\ddot{\mathbf{q}}^{i} - \mathbf{C}^{i}_{v} + \mathbf{F}^{ij} = \mathbf{P}^{i} \qquad (2.8)$$

where $\mathbf{M}^i$ and $\mathbf{C}^i_v$ represent the mass and viscous damping matrices of the *i-th* body, respectively, and $\mathbf{P}^i$, the external forces on this body. Assembling similar equations for each of the bodies of the system, the global equations of motion for *N* interacting bodies are

$$\mathbf{M}^{i}\ddot{\mathbf{q}}^{i} - \mathbf{C}^{i}_{v} + \mathbf{F}^{i} = \mathbf{P}^{i} \qquad \text{where} \qquad \mathbf{F}^{i} = \sum_{h \neq i}\mathbf{F}^{ih} \qquad (2.9)$$

$$\mathbf{r}^{i} = \mathbf{R}^{i} + \mathbf{A}^{i}\bar{\mathbf{u}}^{i} = \left[\mathbf{I} \quad \mathbf{0}\right]\mathbf{q}^{i} + \mathbf{A}^{i}\bar{\mathbf{u}}^{i}$$

$$\dot{\mathbf{r}}^{i} = \dot{\mathbf{R}}^{i} + \dot{\mathbf{A}}^{i}\bar{\mathbf{u}}^{i} = \left[\mathbf{I} \quad \mathbf{H}^{i}\bar{\mathbf{u}}^{i}\right]\dot{\mathbf{q}}^{i}$$

$$\ddot{\mathbf{r}}^{i} = \ddot{\mathbf{R}}^{i} + \ddot{\mathbf{A}}^{i}\bar{\mathbf{u}}^{i} = \left[\mathbf{I} \quad \mathbf{H}^{i}\bar{\mathbf{u}}^{i}\right]\ddot{\mathbf{q}}^{i} - \mathbf{A}^{i}\bar{\mathbf{u}}^{i}\left(\omega^{i}\right)^{2}$$

where $\omega^i = \dot{\theta}^i$ is the angular velocity of the *i-th* body and the matrices $\mathbf{A}^i$ and $\mathbf{H}^i$ are given by

$$\mathbf{A}^{i} = \begin{bmatrix}\cos\theta^{i} & -\sin\theta^{i} \\ \sin\theta^{i} & \cos\theta^{i}\end{bmatrix} \quad \text{and} \quad \mathbf{H}^{i} = \frac{d}{d\theta^{i}}\mathbf{A}^{i}$$

and satisfy $\mathbf{A}^{i^T}\mathbf{A}^{i} = \mathbf{I}_{2\times 2}$, i.e., $\mathbf{A}^i$ is an orthonormal matrix.

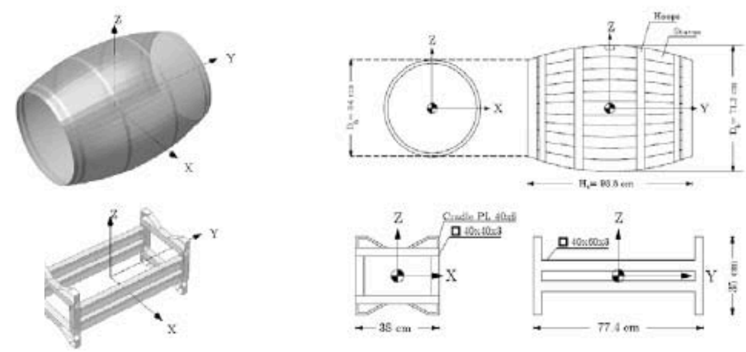

Figure 2 Typical dimensions of barrel and cradle considered in the study

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Building Rating Systems

- Inherently subjective and therefore difficult to control
- Require total independence
- This is not a structural engineering issue
  - LEED / UL / engineering / insurance / common sense / legal /government / public / etc.

Modeling (for natural hazards)

- Individual risks
- Simple vs. complex risks
- Portfolio risk

Thank you.

Improving Structural Engineering and Resilience for Natural Hazards

Peter Yanev and Alexander Yanev, Yanev Associates, LLC

This presentation will address the primary issues that impede improvements in the resilience of structures for natural hazards, including earthquakes and hurricanes. These issues are not adequately understood and addressed by the design professions or their clients. The solutions are fundamentally non-technical but require a deep understanding of the capabilities of existing technologies for the identification and control of natural hazards risks.

Resilience, like risk management, involves much more than engineering – engineering is just one of the necessary tools. The concept of structural "resilience" is simply an increase in the capacity of structures to resist extreme and/or infrequent loads, leading to an increase in the up-front costs and a reduction of both risk and associated costs over the lifecycle of the structure.

The current system for the design of structures and systems for natural hazards is stacked against improvements in resilience, durability, and risk management. This is primarily due to the extreme pressures to reduce up-front costs and a general lack of understanding and appreciation of the long-term cost of risk.

Much-needed changes in the engineering fields will lead to reduction of risk and increase in resiliency.

Abstract for the 15th U.S.-Japan Workshop on the Improvement of Structural Engineering and Resiliency, December 3-5, 2014, Island of Hawaii