Resilient Design for Functional Recovery: Motivations and Drivers (and lots of examples!)

Presented by: Curt B. Haselton, PhD, PE
John F. O’Connell Endowed Faculty Chair and Professor @ CSU, Chico
Co-Founder and CEO @ Haselton Baker Risk Group (SP3)

Work by: Many Others
Structural Design Engineers, Policy Makers, and the SP3 research team
(D. Jared DeBock, Edward Almeter, Katherine Wade, Jack Baker, Shaunt Kojabashian, Mike McGlone, Tracy Rice, and Dustin Cook)

SP3 | where research meets practice
www.hbrisk.com

National Conference and EERI | March 6, 2020
Our profession now has the tools to quantitatively design buildings to recover function more quickly (and reduce repair costs), using FEMA P-58.

However, none of this is currently mandated, so all current uses are elective.

**The Question:** What are the motivations and drivers for more resilient design being done now (so we can build on this to expand the practice)?
What are we getting now with just current code?

**Safety:** Experience shows good safety, so job well done to SEs.

**Recovery Goal:** Not constrained in code design.

**Recovery Estimate:** From SP3 and FEMA P-58 Vol. 5 studies:

- RC II: Repair time of \(~6 \text{ wks}.\), high chance of impeding (7-8mo total)
- RC IV: Repair time of \(~4 \text{ wks}.\), high chance of impeding (6-7mo total)
Now, let’s look at some examples of projects where they wanted quicker recovery times than what code provides.

This is a fairly new frontier in design, so goals vary by project. For all examples, the performance is evaluated with FEMA P-58 and/or SP3 (damage, repair time, repair costs).

Current approaches to resilient design vary:

1) Some organizations have had resilient design goals for some time and are now using P-58/SP3 to quantify the benefits of their better design (e.g. USCF, Stanford).

2) Some have jumped in now and put resilient design goals in their RFP (e.g. reoccup. in 1 week, function in 1 month).

3) Others decided to progress to resilient design during the project (where other project constraints pushed them close).
Ex #1: UCSF Center for Vision Neurosciences

- **Project:** 12-story office/out-patient
- **Engineers:** Forell Elsesser
- **System:** RC Shear Walls
- **Performance:** UCSF Tier 2 (function in days to weeks)
- **Cost:** 0.6% construction cost
Example #2: Stanford Biomedical Building

- **Project:** Stanford Biomedical Innovations Building
- **System:** 4-story BRBF with frame
- **Engineers:** Rutherford & Chekene

- **Performance:** Stanford Class II
- **Motivation:** Reduced downtime for research (retain faculty)
- **Notes:** Cladding scrutiny, quality control

Credit: ZGF Architects
- **Project:** Portfolio of tilt-up warehouse buildings
- **Engineer:** HSA Associates
- **Owner:** Watson Land Company
- **Performance:** ASCE 41 IO, evaluated with P58/SP3 and shown to perform well
- **Motivation:** Reduce losses and downtime (tenant continuity)
- **Cost:** $1.27 per sq ft (~2-3%)
Example #4: Electric Utility Operation Center

- **Project:** EOC, data center, and office
- **Engineers:** KPFF (Portland)
- **Owner:** Electric utility

- **Performance:** Operational at MCE_R
- **Motivation:** EOC for running utility post-disaster
Example #4: Electric Utility Operation Center

- **System**: Looked at BRBF, then chose base-isolated to reduce floor accelerations
- **Cost**: Only 1% construction cost, owner decided to also isolate offices.

- **KPFF**: The base-isolation approach and advanced risk analysis gave them confidence in talking with client (not giving 100 caveats on performance).
Example #5: CA State Office in Sacramento

- **Project:** 11-story office
- **Engineer:** KPFF
- **System:** RC core wall
- **Motivation:** State of CA wanted this functional after EQ to support recovery
- **Performance:** USRC Platinum (<5%, 5 days)
Example #6: Long Beach Civic Center

- **Project:** Long Beach Civic Center (two 11-story, city council)
- **Engineers:** Nabih Youssef and SOM (SP3 consultant, Arup as peer review)
- **Owner:** Long Beach city and port

- **Performance:** REDi/USRC Gold/Platinum (2% loss, ~1 week)
- **Motivation:** They wanted to run their city and port after the earthquake!
Example #7: SF Affordable Housing

- **Project:** Casa Adelante (9-story affordable housing)
- **Engineers:** Mar Structural Design
- **System:** Rocking RC wall with dampers
- **Goal:** Be intentional to design for faster recovery, with ~ same $
- **Performance:** USRC Gold (<10%, days of recovery)
- **Outcome:** Vulnerable populations will go home sooner after EQ
- **Cost:** 0.24% (only $100k)
Example #8: 181 Fremont

- **Project:** 57-story mixed use
- **Engineer:** Arup
- **Developer:** Jay Paul
- **Performance:** REDi Gold
  (<10%, 1 month)
- **System:** Novel steel mega-brace system with dampers
- **Motivation:** Show innovation in the market place
Example #9: Roseville City Hall

- **Project:** 4-story City Hall
- **Engineer:** Buehler
- **System:** Precast post-tensioned hybrid moment frame

- **Performance:** USRC Platinum (<5%, 5 days)
- **Cost:** ~0%, oversized architectural frames, PT self-centering system, low seismic
Example #10: Bluxome SF Offices

- **Project:** 5-Story SF Office
- **Engineers:** ZFA
- **Owner:** Bluxome Partners

- **Initial Motivation:** Stiffen building to reduce seismic gap and have more leasing space.
- **Expanded Motivation:** Gave opportunity to make a more resilient building.
Example #10: Bluxome SF Offices

- **Structure System**: Stiff 3-Bay Steel Frame with SidePlate®

- **Performance**: USRC Gold (<10% loss, 1 month recovery time)

- **Outcome**: Tenant leased space because they wanted office to be functional soon after an earthquake (through better design and emergency generator on roof).
What about the Community Recovery Time?

What about recovery of the community and not just each individual building? (though I am excited about individual building progress!)

There is also motivation and drivers for the city to recover quickly, and this will require more than elective design for function (e.g. leaning neighbor mentioned by David Bonowitz in plenary).
What about the Community Recovery Time?

- All levels of government are now looking at “design for Functional Recovery”:
  - **Federal**: NIST/FEMA mandate and a report to Congress is due in June (Thursday 4pm session).
  - **State**: California AB-1997 on a Functional Recovery Standard (Nazarian)
  - **Local**: San Francisco tall building study and ongoing discussions of design for function and not just safety

- These efforts at all levels of government recognize many buildings will need to be resilient for the community to regain function quickly.
Community-Level P-58 Design Studies Possible

Current buildings (for fun, even though not the focus here!)

New – ASCE7 (Risk Cat. II)

Closure unlikely
Closure likely
Closure sure, moderate damage
Closure sure, extensive damage

New – ASCE7 (Risk Cat. IV)

New – Direct Resilient Design
- Code design achieves the safety goals well (per past EQ history), but has not aimed to provide post-earthquake function (so results in ~ 6-9 months downtime).
- Even though not mandated, engineers are electively designing for resilience (less damage, quicker recovery, less repair cost).
- Engineers are creative people, so we are finding that they can provide quicker recovery times with minimal (or no) added costs. They just need to add quick recovery to their design goals and be intentional to design for it!
- There are motivators for individual-building resilient design, and motivation varies some by project.
- There are also motivators at the community-level for resilient design (prevent mass out-migration, etc.); this would likely require some type of mandate for design for functional recovery (e.g. code change at any level of code adoption).
Questions and Discussion!

- Thank you for your time.
- Our goal is to support adoption of resilience-based design for Functional Recovery, and overall seismic risk assessment, and we welcome feedback and suggestions.

- Time for questions and discussion!

Curt Haselton: curt@hbrisk.com, Direct: (530) 514-8980
Tracy Rice (HB-Risk admin): tracy@hbrisk.com

www.hbrisk.com