

Full-Scale Structural and Nonstructural Building System Performance during Earthquakes & Post-Earthquake Fire

A Joint Venture between Academe, Industry and Government

Fire Testing Overview

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Research Team and Stakeholders

- ▶ **Current research team**
 - ▶ Brian Meacham, WPI (lead fire investigator)
 - ▶ Brian McLaughlin, Arup (MEP and fire design)
- ▶ **Current Industry Support**
 - ▶ Arup – Fire and MEP engineering
 - ▶ Hilti – Anchorage & firestop products
 - ▶ Mason Industries – Piping restraint / isolation
 - ▶ Schindler – Elevator
 - ▶ Ruskin – HVAC & fire dampers
 - ▶ NFSA – Sprinkler system
 - ▶ SimplexGrinnell – FAS
 - ▶ FMGlobal, others...



▶ 2

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Funding Situation

- ▶ **Post-Earthquake Fire Performance**
 - ▶ Not funded by NSF
 - ▶ Proposals previously submitted to NIST not awarded
 - ▶ Current proposal to DHS – International Cooperative Research Program (2 yr, \$675,000) – will not know before March 2011
 - ▶ WPI lead, with BRANZ and University of Canterbury, New Zealand, and Tokyo University of Science
 - ▶ Also watching for next DHS / USFA safety to fire fighters research grant solicitation
- ▶ **Industry Support**
 - ▶ In-kind equipment & services and cash
 - ▶ Good equipment and services support, limited cash

▶3

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Goals

- ▶ Study the performance of passive and active fire-safety measures, systems and products during strong ground shaking and post-earthquake fire conditions through tests of the 5-story building at the component level
- ▶ Begin moving towards development of an integrated performance-based design approach for earthquake and fire

▶4

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Planned Tasks

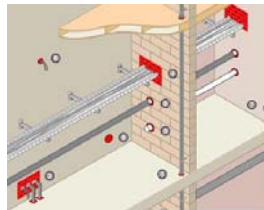
1. Full building testing (5-story structure)
 - ▶ System response to ground motion
 - ▶ In-situ post-ground motion fire performance
2. Component level testing
 - ▶ Response to motion tests
 - ▶ Post-ground motion fire tests
3. Pre- and post-event simulations
 - ▶ Design basis fire determination
 - ▶ Two-zone model and CFD model
4. Steps toward development of risk-informed performance-based analysis approach

▶5

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Architectural / Passive Fire Protection

- Cladding / glazing
- Floor types (e.g., raised)
- Stairs (safety, integrity)
- Partition walls / seals
- Suspended ceilings / fixtures
- Doors



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▶6

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Mechanical, Electrical & Fire Systems

- Elevator
- HVAC
 - Heating / chillers
 - Fans / ducts / dampers
- Piping systems
- Fire suppression system
- Pumps / tanks
- Electrical distribution
- Fire detection / alarm
- Voice communication
- Telecommunications

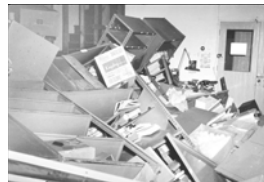
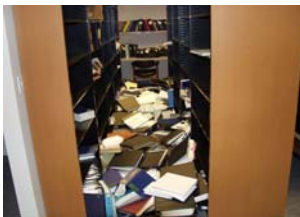


▶ 7

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Contents / Fire Load

- ▶ Fully functional pressurized hospital ICU
- ▶ Servers on raised access floors
- ▶ Rooftop equipment



▶ 8

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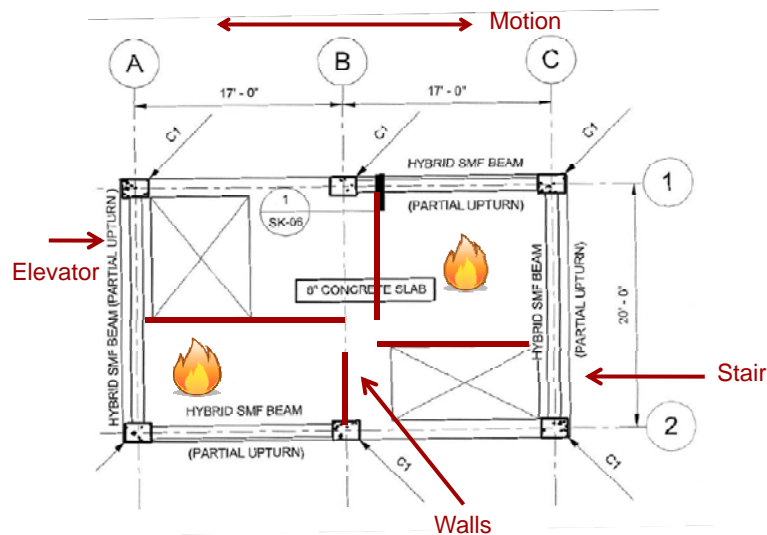
Task 1 – Full Building Testing

- ▶ Data collected relative to forces on the fire protection systems during ground movement.
- ▶ This will then be followed by visual, pressure, and other non-destructive testing.
- ▶ The building will then be subjected to controlled fires, which will be used to assess thermal and non-thermal response.
 - ▶ Size and location of fires to be set by review of past events, likely fuel load distribution, and related factors associated with selected occupancies (developed under Task 3)

▶9

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Task 1 – Full Building Testing



▶10

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Task 1 – Full Building Testing

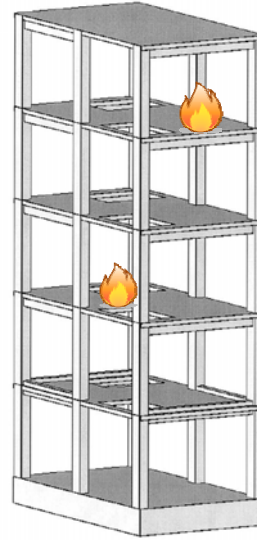
▶ Testing

▶ Seismic performance

- ▶ Drift and acceleration (movement, damage, operability)
- ▶ Equipment / connections / anchors
- ▶ Floor-to-floor / within a floor

▶ Fire performance

- ▶ Post-EQ damage / operability
 - Visual, pressure, and other non-destructive testing
- ▶ Limited fire / smoke tests
 - Controlled fires – test response, effectiveness of systems
 - Fire and smoke spread

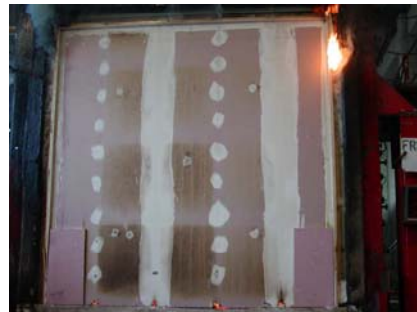


▶ 11

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Task 2 – Component Testing

- ▶ Small shake table and simulated damage from large building tests
- ▶ Post-damage fire testing of compartments and assemblies
- ▶ Custom built and standard furnace and other tests
- ▶ Planned to be conducted at BRANZ



▶ 12

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Task 3 – Simulations

- ▶ **Pre- and post-fire simulations using BRANZ Fire and FDS**
 - ▶ Identify scenarios from past events and analysis of fuel load characteristics and distribution
 - ▶ Simulate planned scenarios using available data, expectations regarding the post-EQ condition of the building and fire protection systems and predict the post-EQ fire conditions.
 - ▶ Two-zone model (BRANZ Fire)
 - ▶ CFD model (FDS)
 - ▶ Following the ground motion tests, the pertinent input parameters will be used and the simulations rerun to assess potential variability in predicted outcomes
 - ▶ Fire tests will then be conducted and compared to simulations
 - ▶ University of Canterbury and WPI

▶13

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Task 4 – Risk-Informed Approach

- ▶ **Assessment of PEER approach for fire and outline of risk-informed approach**
- ▶ Evaluation of seismic fragility curves of fire protection systems
- ▶ Method for describing the seismic induced functional failure of fire protection systems
- ▶ Evaluation of ignition probability of post-earthquake fires
- ▶ Total assessment method of seismic-induced fire risk
- ▶ Led by Tokyo University of Science

▶14

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Research Plan (Pending Funding)

Task	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Research Project 1: Full Building Tests								
1a – System design and installation*								
1b – Instrumentation and test plan								
1c – Ground motion tests								
1d – Fire tests								
Research Project 2: Component Testing								
2a – Test rig setup								
2b – Motion tests								
2c – Fire tests								
Research Project 3: Data Analysis & Simulation								
3a – Fuel load characterization								
3b – Pre-test simulations								
3c – Full building testing data analysis								
3d – Component testing data analysis								
3e – Post-test simulations								
Research Project 4: Integrated Approach								
4a – Investigate PEER and other approaches								
4b – Seismic fragility curves for FP systems								
4c – Seismic induced FP system failure								
4d – Ignition probability of post-EQ fire								
4e – Method for seismic-induced fire risk								

►15

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Questions?

►16

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