Quantifying the Post-Earthquake Downtime Induced by Cordons Around Damaged Tall Buildings

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Introduction

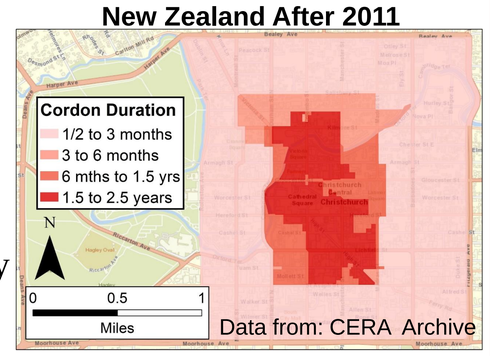
RECOVERY TARGETS FOR SAN FRANCISCO

	Months after earthquake occurs		
	4	36	36+
COMMUNITY RECOVERY			
95% neighborhood retail businesses open		X	
50% offices and workplaces open			X
Non-emergency city service facilities		X	
All businesses open			X

adapted from: SPUR 2009[1]

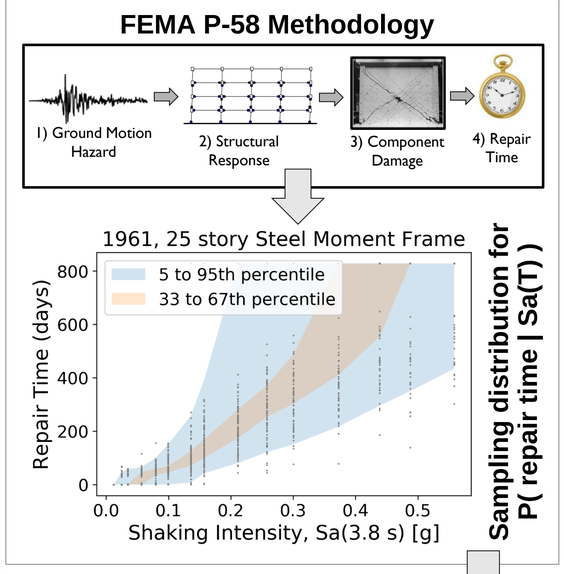
Resilience planning focuses on the time it would take for various community functions to recover after a hazard event, such as San Francisco's target timelines for post-earthquake recovery. However, the gap between the targets and the status quo is difficult to quantify, as highlighted by the multi-year access restrictions in Christchurch, New Zealand's Central Business District after the 2011 earthquake. Current downtime models consider communities as the sum of isolated buildings, ignoring the effect that safety cordons around damaged buildings may have on the accessibility of nearby, undamaged buildings. This framework incorporates high resolution, building-level assessments into a spatially distributed community recovery model that includes access restrictions due to damaged tall buildings. This type of analysis can support policy-makers in identifying, and developing strategies to reduce, the gap to the recovery targets.

Access Restrictions in Christchurch, New Zealand After 2011

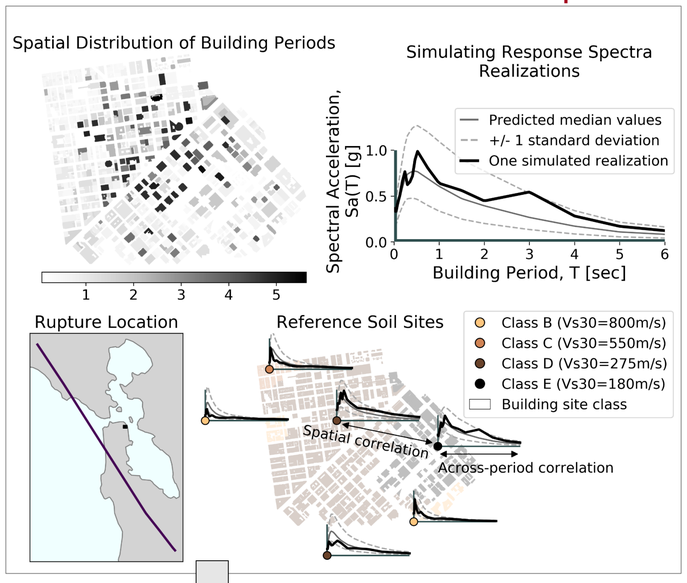


Assessment Framework

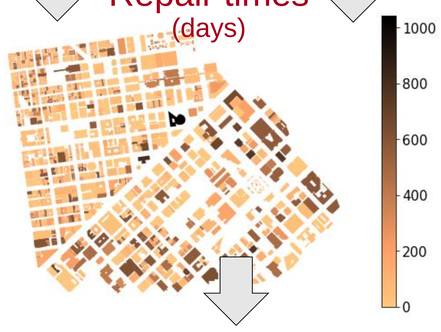
Building performance profiles for each building in the community



Ground motion realization maps



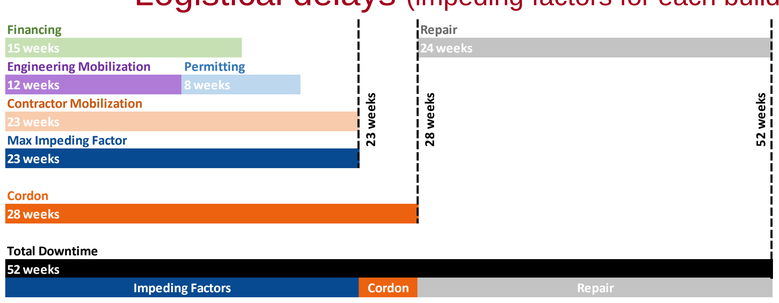
Repair times (days)

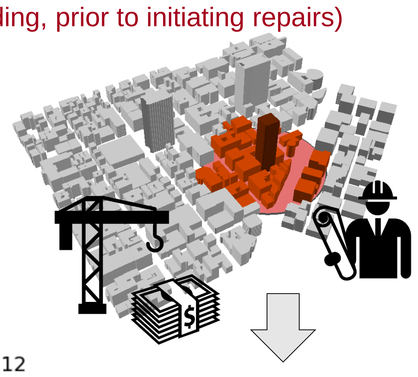


Sample each building's damage from the building performance profiles, based on Sa(T) values from one ground motion realization map.

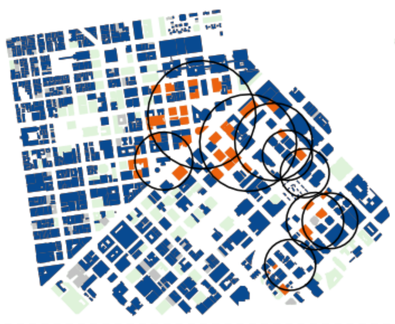
If the damage to a tall building (240ft+) triggers a cordon, all buildings within a 1.5H radius are inaccessible until the building is stabilized.

Logistical delays (impeding factors for each building, prior to initiating repairs)



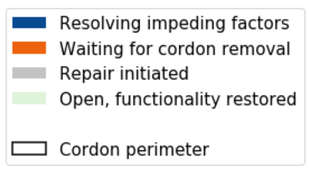


Months after the earthquake: 4



Months after the earthquake: 12

One realization of community recovery, mapped through time

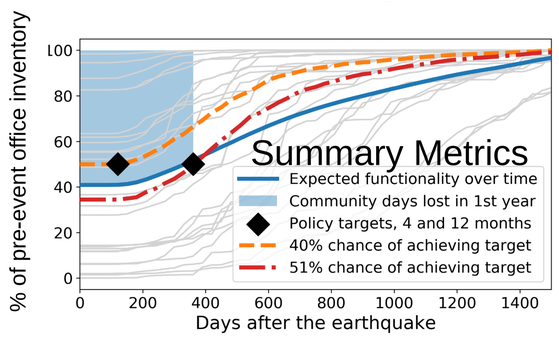


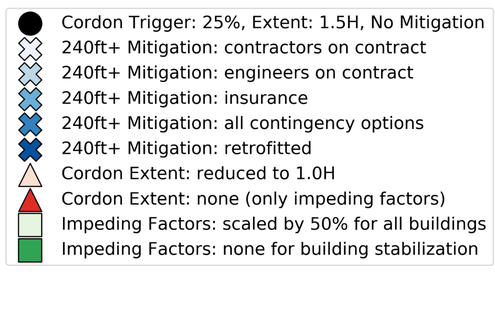
Case Study

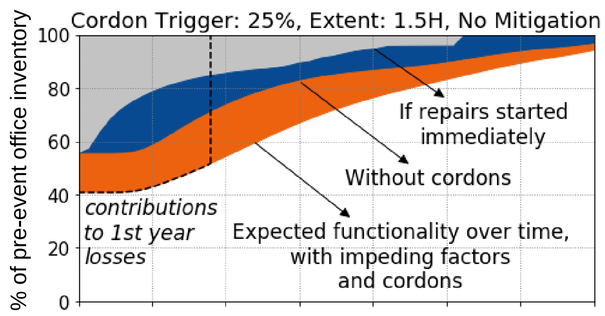
- Downtown San Francisco
- ~1000 buildings in analysis
- 92 buildings over 240ft tall
- 7.2 Mw on the San Andreas Fault
- Policy targets for office space:
  - 50% of pre-event inventory open
  - assess two targets: 4 and 12 months

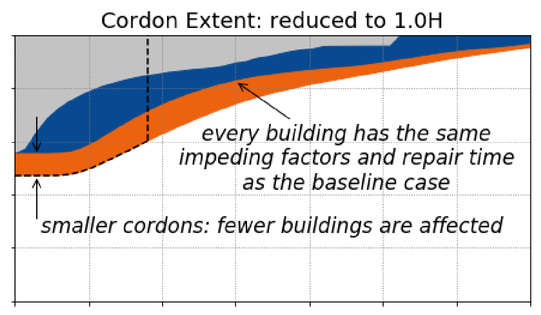
Results

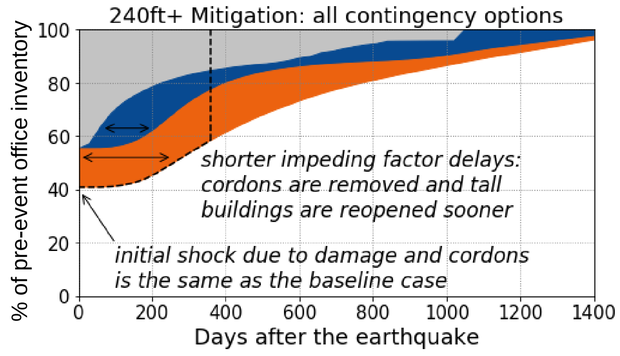
Community functionality is plotted over time for each recovery realization. Summary metrics for the distribution of realizations facilitate comparisons among policy options and sensitivity studies.

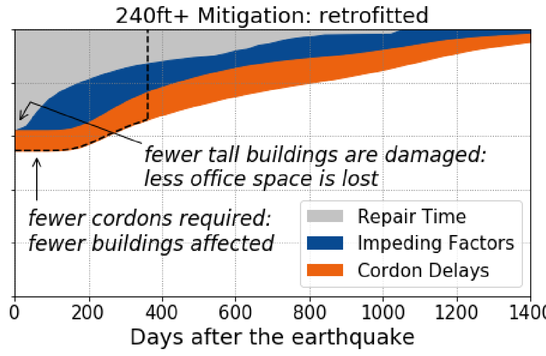


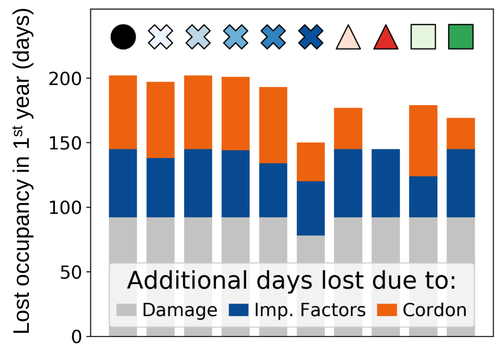


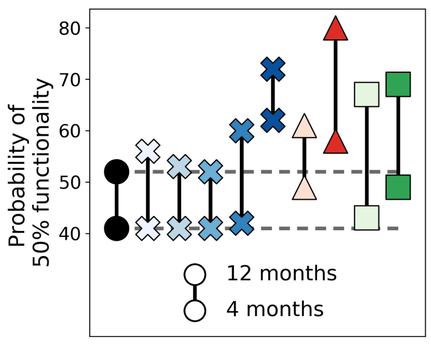












A policy that has little effect at an early time target may be more effective later.

Contributions

By incorporating access restrictions due to safety cordons around damaged tall buildings, this community recovery framework seeks to capture a dimension of recovery that is not considered in current regional models.

The framework can also evaluate the potential benefit of various policy options, such as resilience planning to facilitate post-earthquake logistics or mandatory retrofits for the buildings that may require a cordon. The direct applicability to community resilience targets supports policy-makers who are seeking to make their communities more seismically resilient.

Acknowledgements

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References

[1]San Francisco Planning and Urban Research Association (SPUR), "The resilient city: defining what San Francisco needs from its seismic mitigation policies," San Francisco, CA, 2009.

[2]FEMA, "FEMA P-58: Seismic Performance Assessment of Buildings," Washington, D.C., 2012.

[3]I. Almufti and M. Willford, "REDi Rating System: Resilience-based Earthquake Design Initiative for the Next Generation of Buildings," Arup, San Francisco, CA, 2013.

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