

ATC-138 Functional Recovery Project

Building Reoccupancy and Recovery Times as Measured by the ATC-138 Functional Recovery Methodology

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Purpose of this Presentation

Purpose of Talk: Provide seed information for the Session #2 breakout discussions.

Session #2: Hazard Level(s) and Target Recovery Times

Small Group Break-out Discussions:

- Topic 2A (35 min): What **hazard level(s)** should be used for FR performance objective(s)? (What is appropriate amount of consideration for FR at various hazard levels?)
- Topic 2B (30 min): What should be the **Target FR times** or priorities for various occupancies (and for different hazard levels)?
- Topic 2C (30 min): How should **impeding factors** be addressed in recovery time calculations and in communicating results?

Focus of Talk: Show estimated functional recovery times (and reoccupancy times) for new buildings. Times based on FEMA P-58 with recent ATC-138 Functional Recovery Methodology extension.

Overview of Topics:

- Building/site text matrix (592 buildings shown here)
- Functional recovery time results for modern buildings
 - ✓ Individual building examples
 - ✓ Results for all buildings (average and variability)
 - ✓ “Common offenders” (which building systems/components are damaged)
- Sensitivity assessments:
 - ✓ Methodology components (e.g. if we include impeding times)
 - ✓ Design aspects (e.g. RC II vs. RC IV)
- Summary/discussion

Building Test Matrix: Building Types

Structural System	Age	Occupancy	Risk Category	Stories
Wood Light Frame	New	Residential	II	1, 2
Wood Light Frame	New	Residential	II, IV	5
Wood Light Frame	New	Office	II, IV	5
Precast Concrete Tilt-Up	New	Warehouse	II, IV	1
Precast Concrete Tilt-Up	Pre-NR	Warehouse	II, IV	1
Steel Perimeter Moment Frame	New	Office, Healthcare	II, IV	3, 5, 12, 20
Steel Perimeter Moment Frame	Pre-NR	Office	II, IV	5, 12
Steel BRBF, no back-up frame	New	Office	II, IV	5, 12
Steel BRBF, with back-up frame	New	Office	II, IV	5, 12
Steel Concentric Braced Frame	New	Office	II, IV	5, 12
Reinforced Concrete Moment Frame	New	Office, Residential	II, IV	5, 12
Reinforced Concrete Moment Frame	Pre-1971	Office	II	5, 12
RC Shear Wall (coupled in one direction)	New	Office, Healthcare	II, IV	3, 5, 12, 20
RC Shear Wall (coupled in one direction)	New	Residential	II, IV	5
RC Cantilever Shear Wall	Pre-1971	Office	--	5, 12

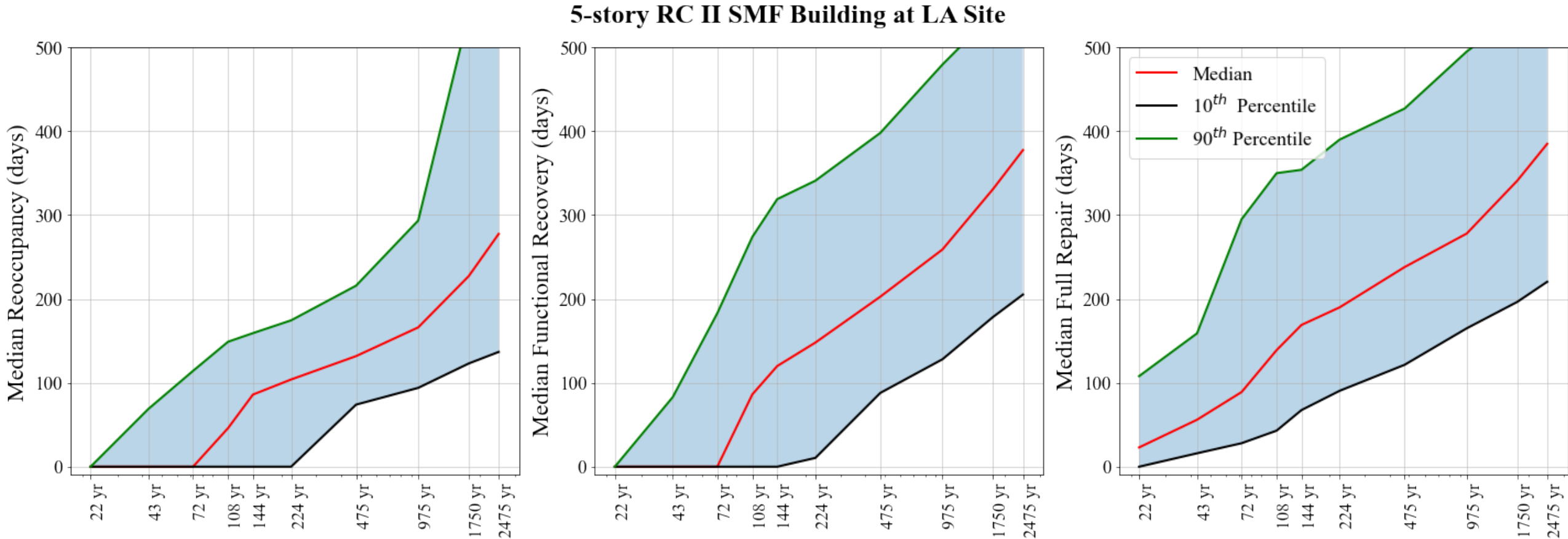
Building Test Matrix: Site Locations

City	State	Site Class	S_s [g]	S_1 [g]	SDC	Lat	Long	FEMA 570 Site ID	Return Period @ DE (years)	Return Period @MCE (years)
Los Angeles	California	D	2.40	0.84	E	34.05	-118.25	1	581	1356
Riverside	California	D	1.50	0.60	D	33.95	-117.40	6	330	839
San Francisco	California	C	1.50	0.64	D	37.75	-122.40	16	415	986
San Diego	California	D	1.25	0.48	D	32.70	-117.15	9	--	
Oakland	California	D	1.86	0.75	D	37.80	-122.25	12	--	
Sacramento	California	D	0.67	0.29	D	38.60	-121.50	15	--	
San Jose	California	D	1.50	0.60	D	37.35	-121.90	18	--	
Seattle	Washington	C	1.37	0.53	D	47.60	-122.30	22	--	
Portland	Oregon	D	0.98	0.42	D	45.50	-122.65	25	--	
Salt Lake City	Utah	D	1.54	0.56	D	40.75	-111.90	26	--	
St. Louis	Missouri	C	0.44	0.17	C	38.60	-90.20	30	--	
Memphis	Tennessee	D	1.01	0.35	D	35.15	-90.05	31	--	
New York	New York	C	0.28	0.07	B	40.75	-74.00	34	--	
Anchorage	Alaska	D	1.50	0.68	D	61.22	-149.90	--	--	
Hilo	Hawaii	C	1.50	0.60	D	19.71	-155.09	--	--	
Average									442	1060

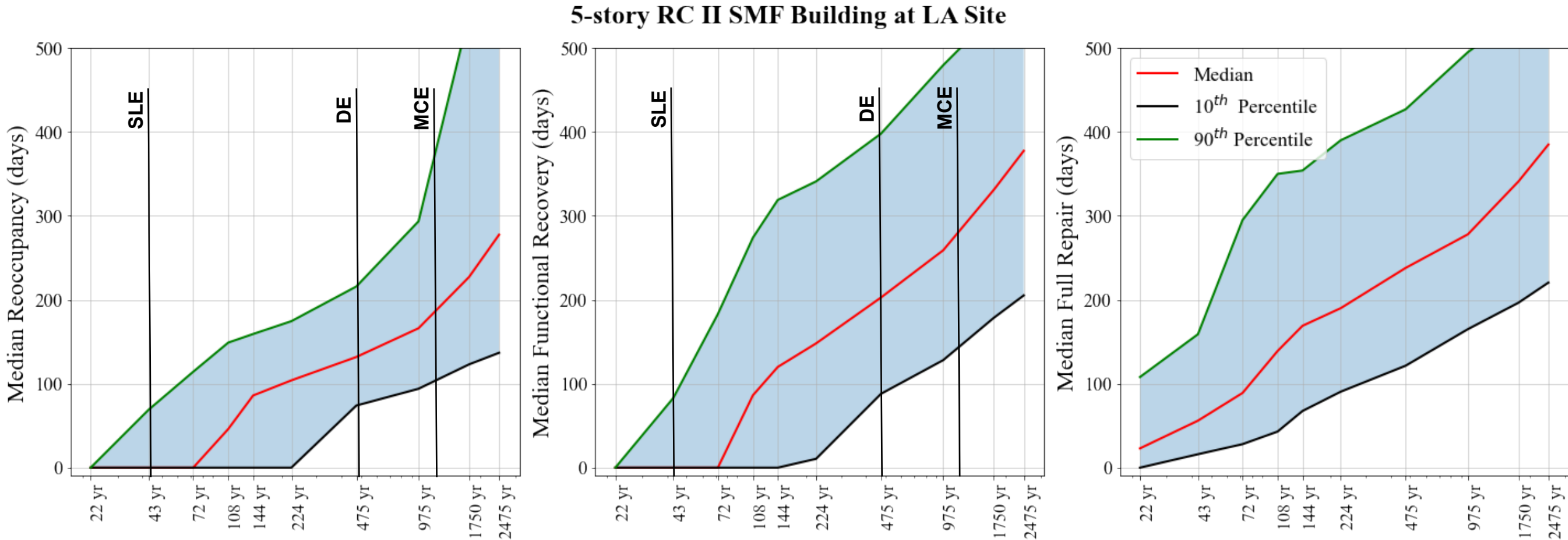
592 building cases run. Baseline plots are for new RC II buildings at three high seismic sites (LA, Riverside, SF), and variations are noted.

Results for Individual Buildings: New Steel Moment Frame

Take Away: Low times at SLE (just for median), several months at DE, a year at MCE.

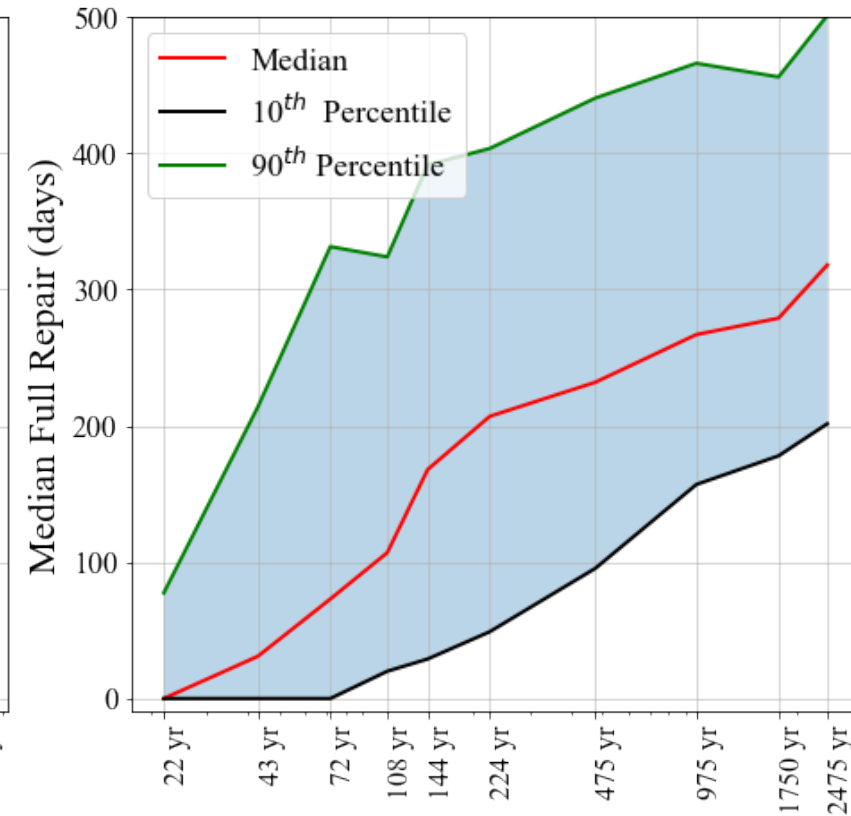
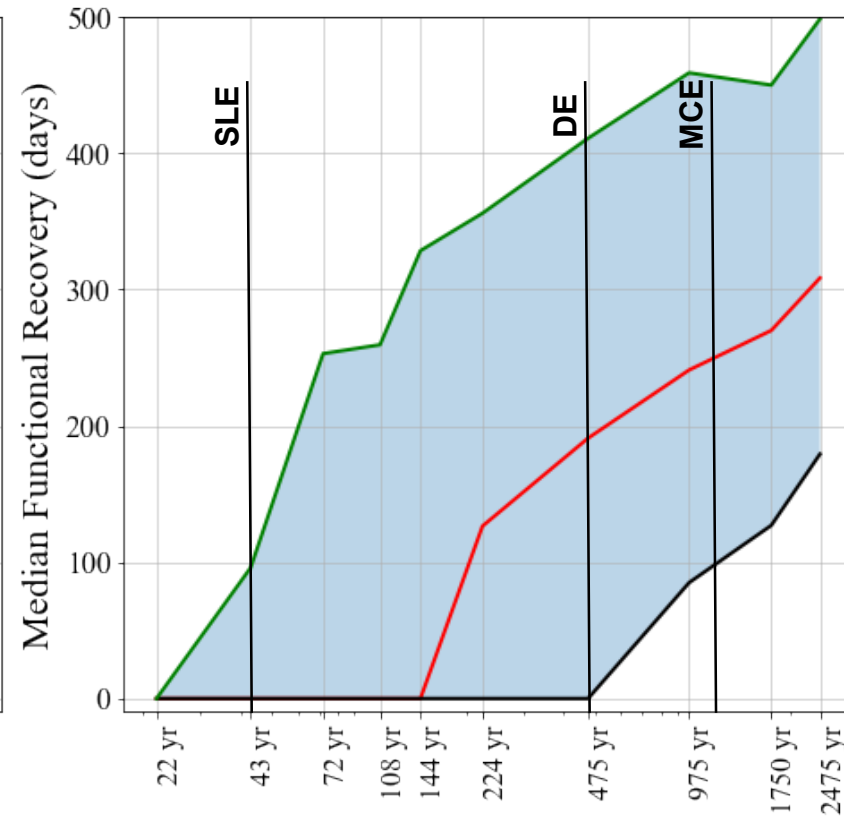
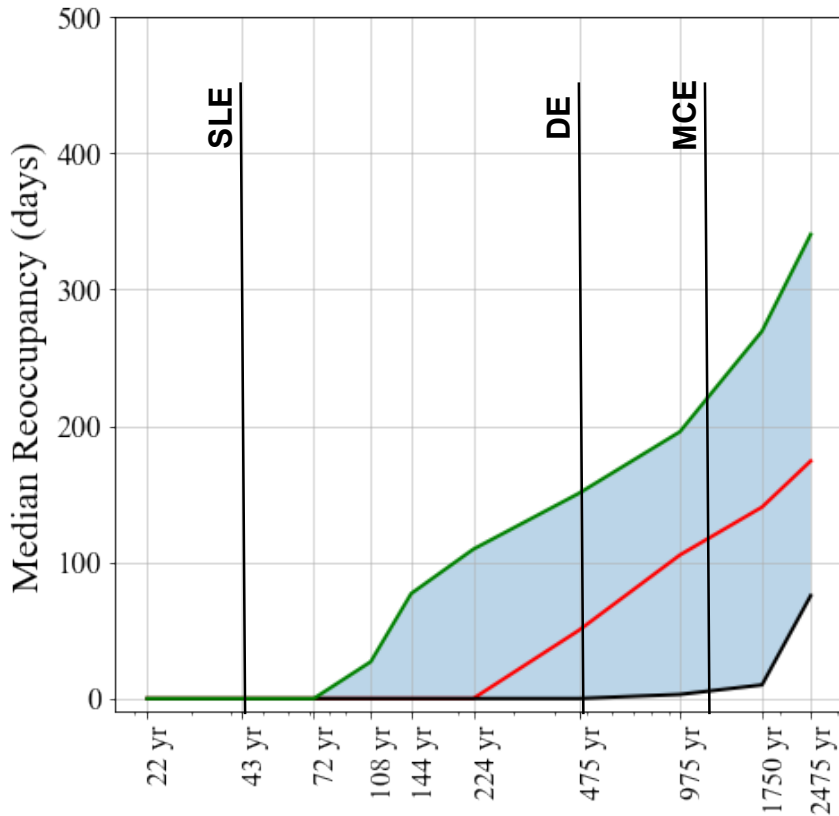


Take Away: Low times at SLE (just for median), several months at DE, a year at MCE.



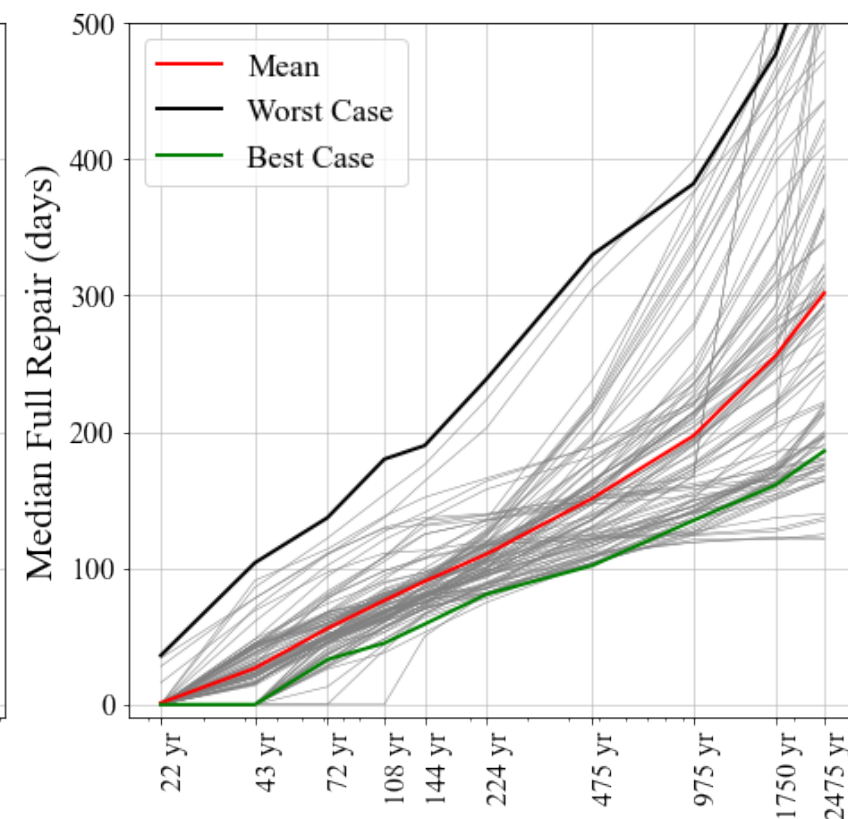
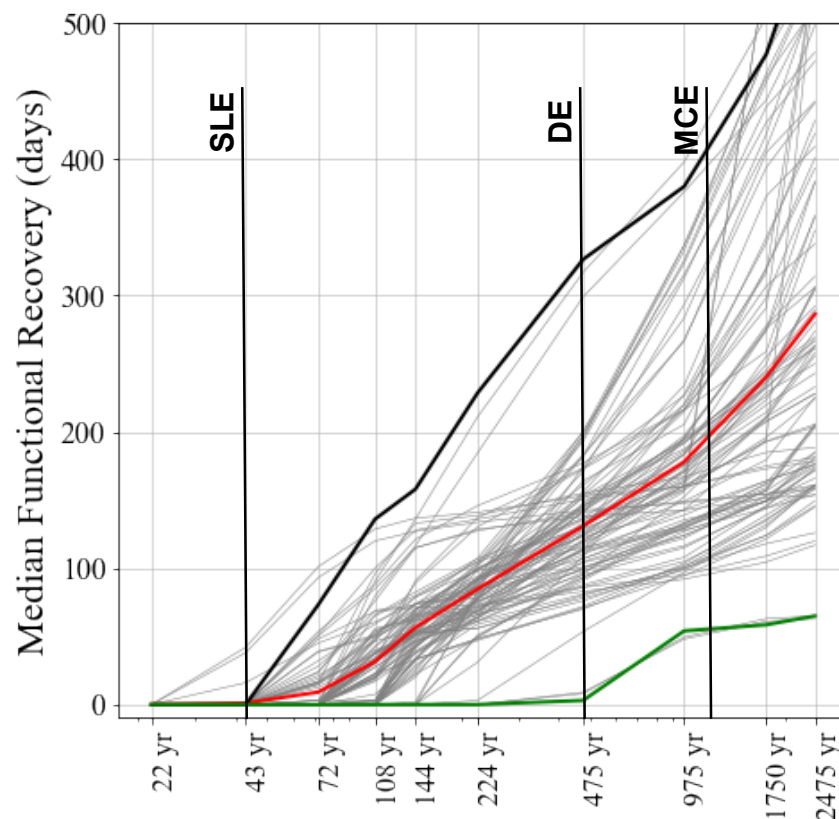
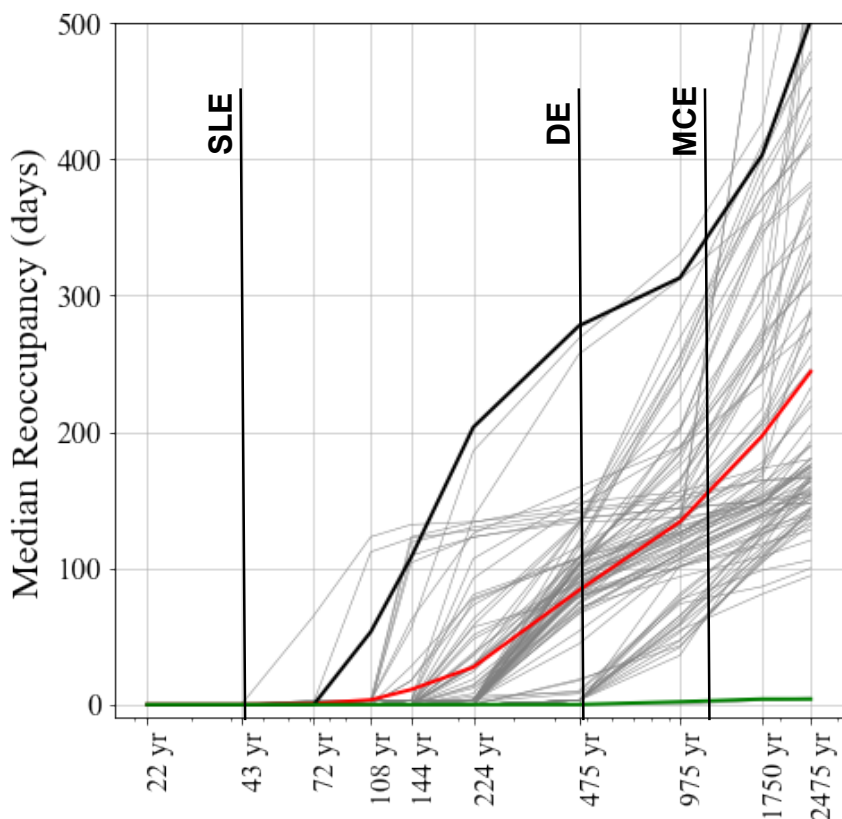
Take Away: Low times at SLE (just for median), several months at DE, a year at MCE.

5-story RC II RC Coupled SW Building at LA Site



Take Away: Lots of spread between buildings (since code doesn't design for function).

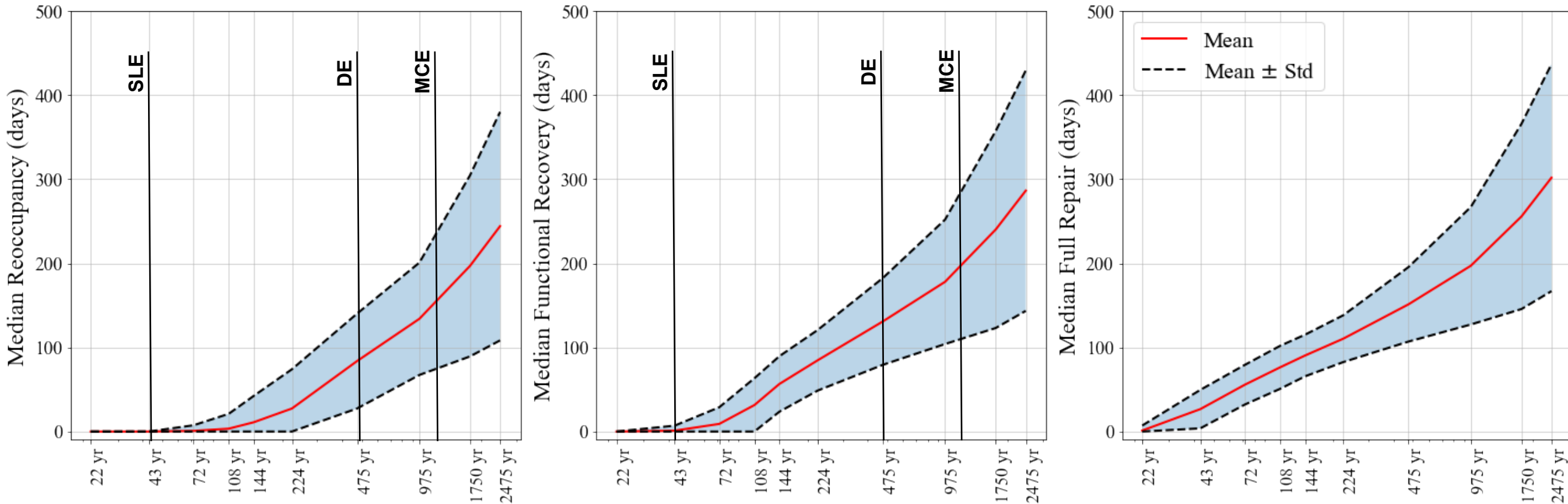
Risk Category II New Buildings at High Seismic Sites



Sanity Checks:

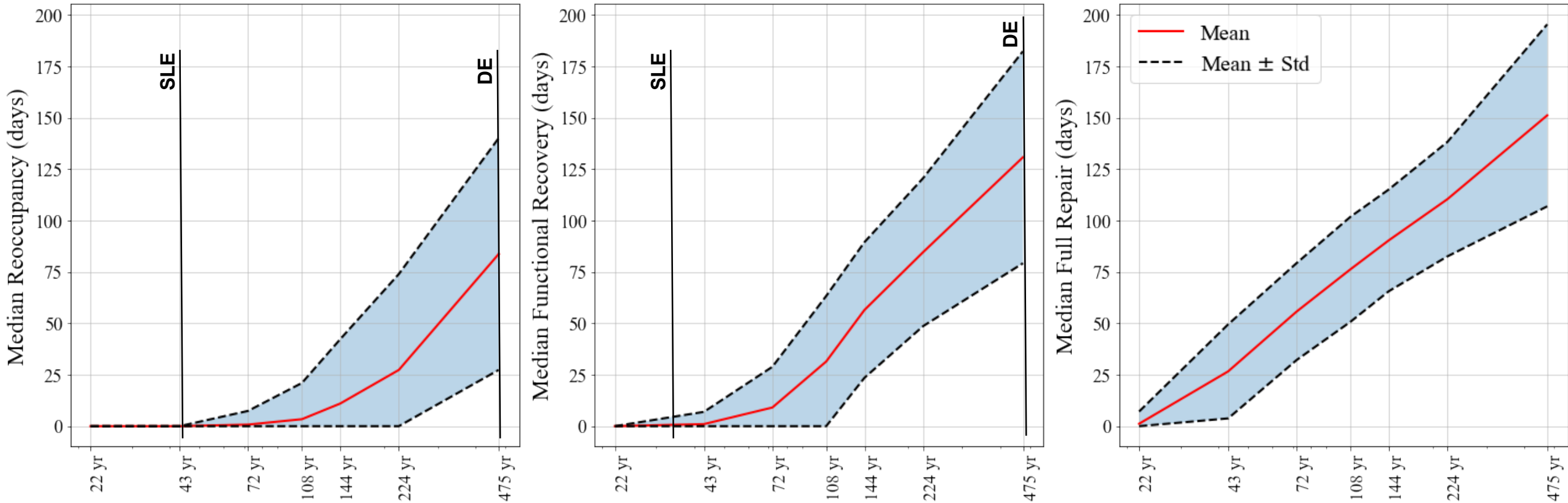
- Typical Best Case: 1-Story Residential WLF in LA
- Typical Worst Case: 12-story Office SCBF in Riverside

Risk Category II New Buildings at High Seismic Sites



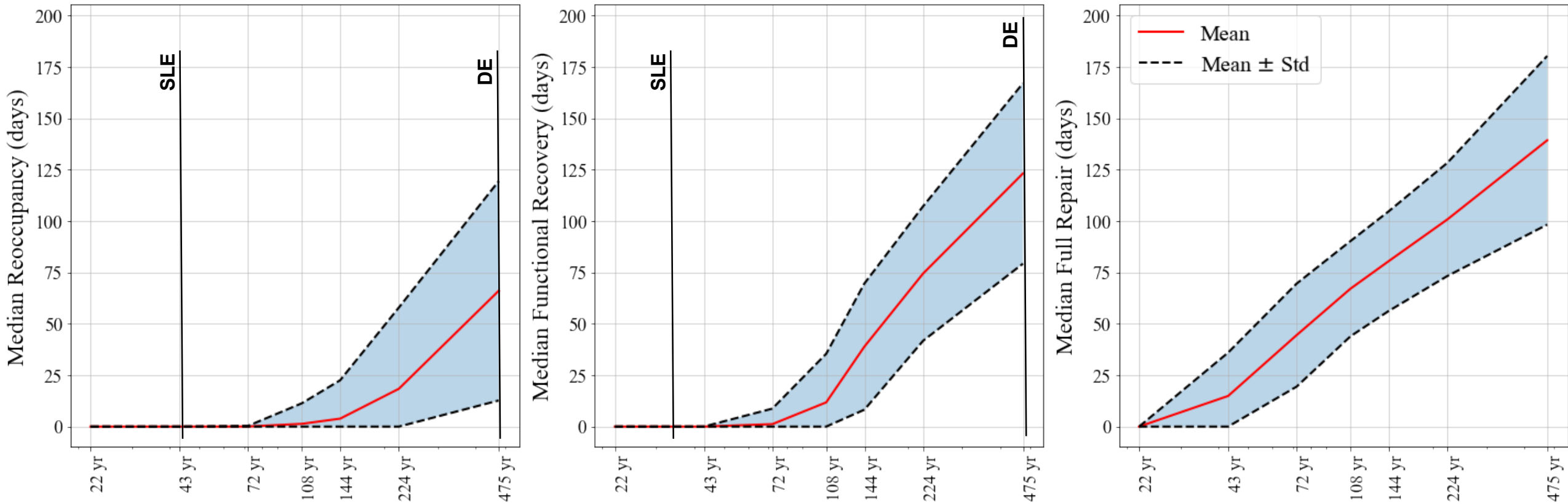
Results for Full Set of Buildings: RC II vs. RC IV

Risk Category II New Buildings at High Seismic Sites



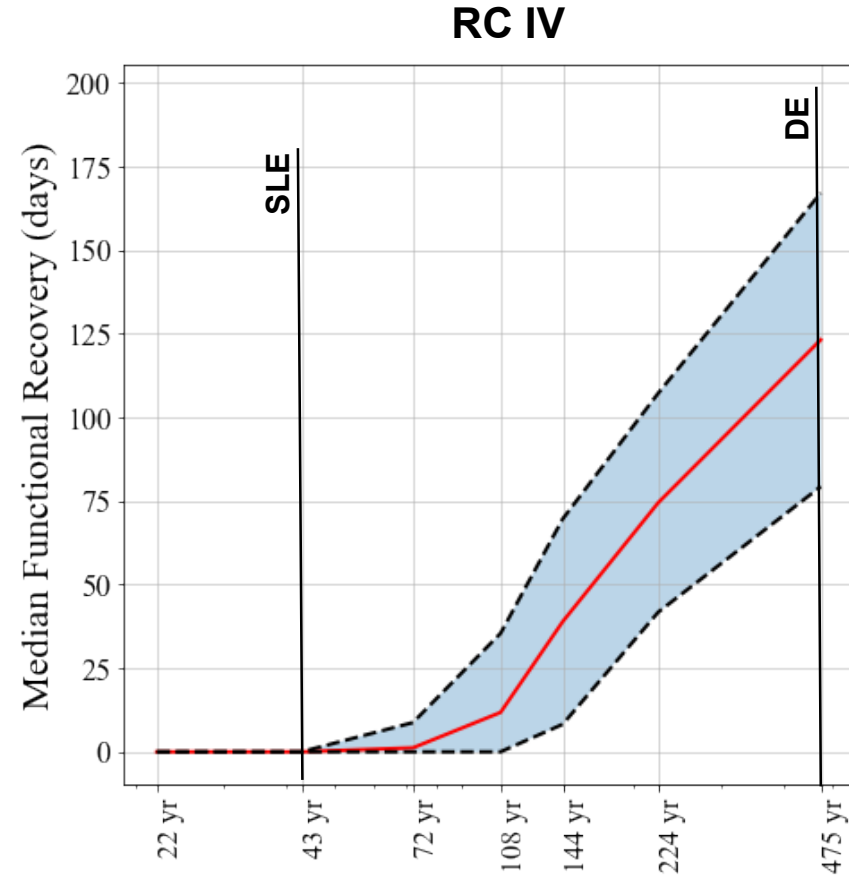
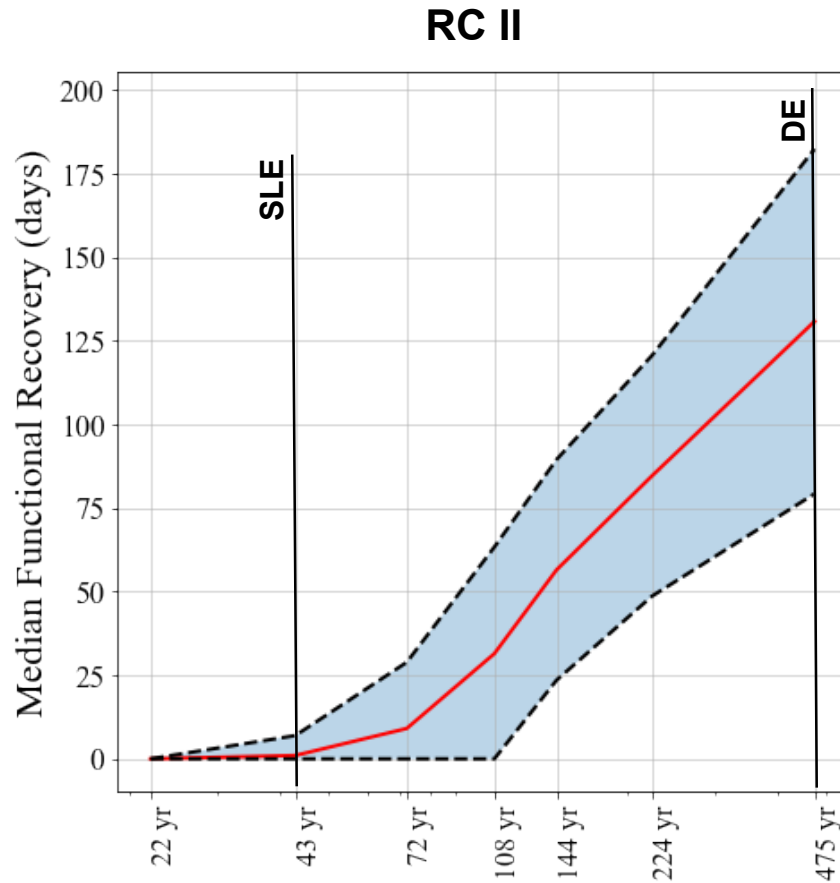
Results for Full Set of Buildings: RC II vs. RC IV

Risk Category IV New Buildings at High Seismic Sites



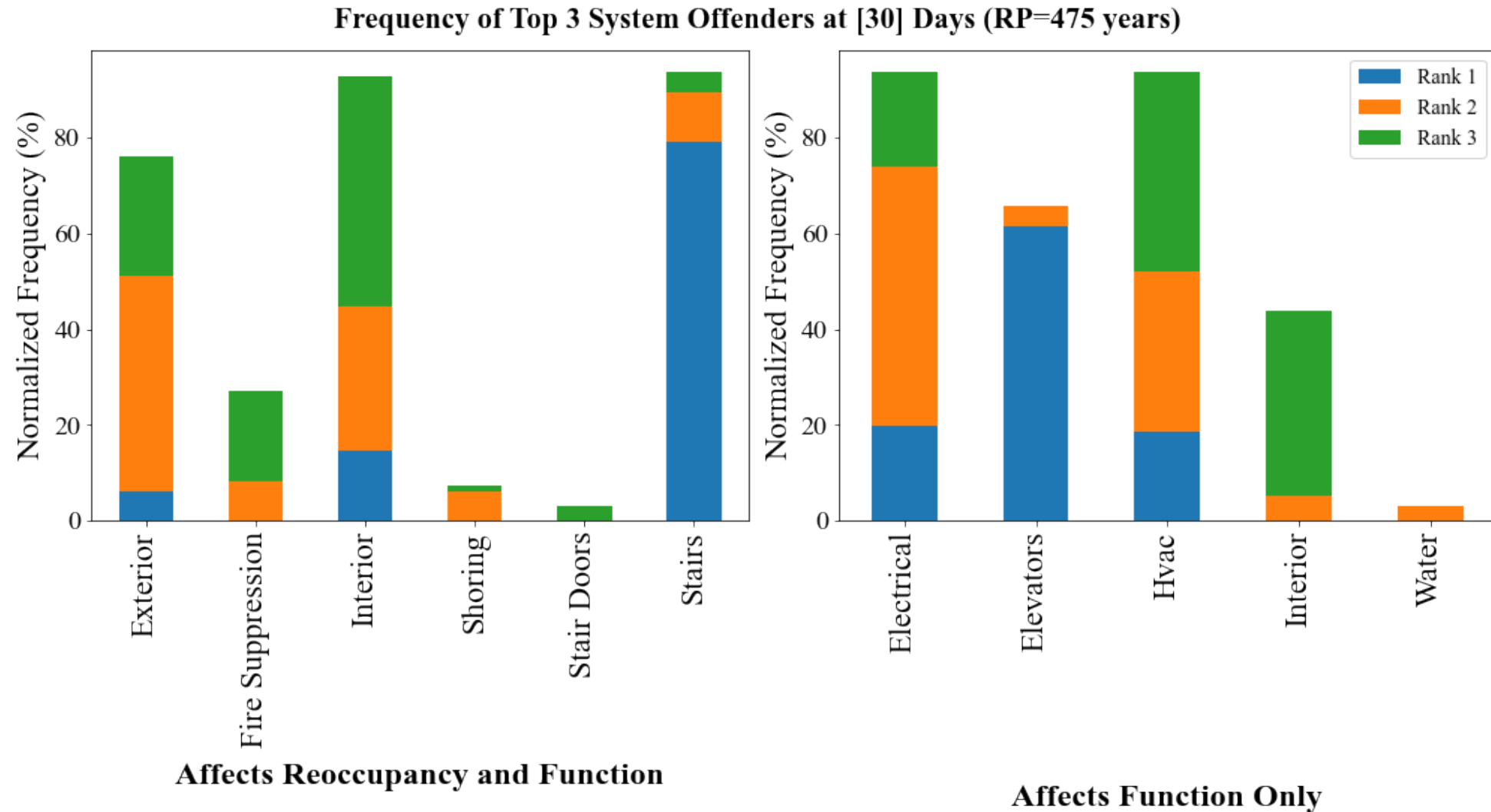
Results for Full Set of Buildings: RC II vs. RC IV

Take Away: Risk Category IV delays the onset of damage around SLE, but results similar at DE (and MCE) levels.



Most Frequent System/Component “Offenders”

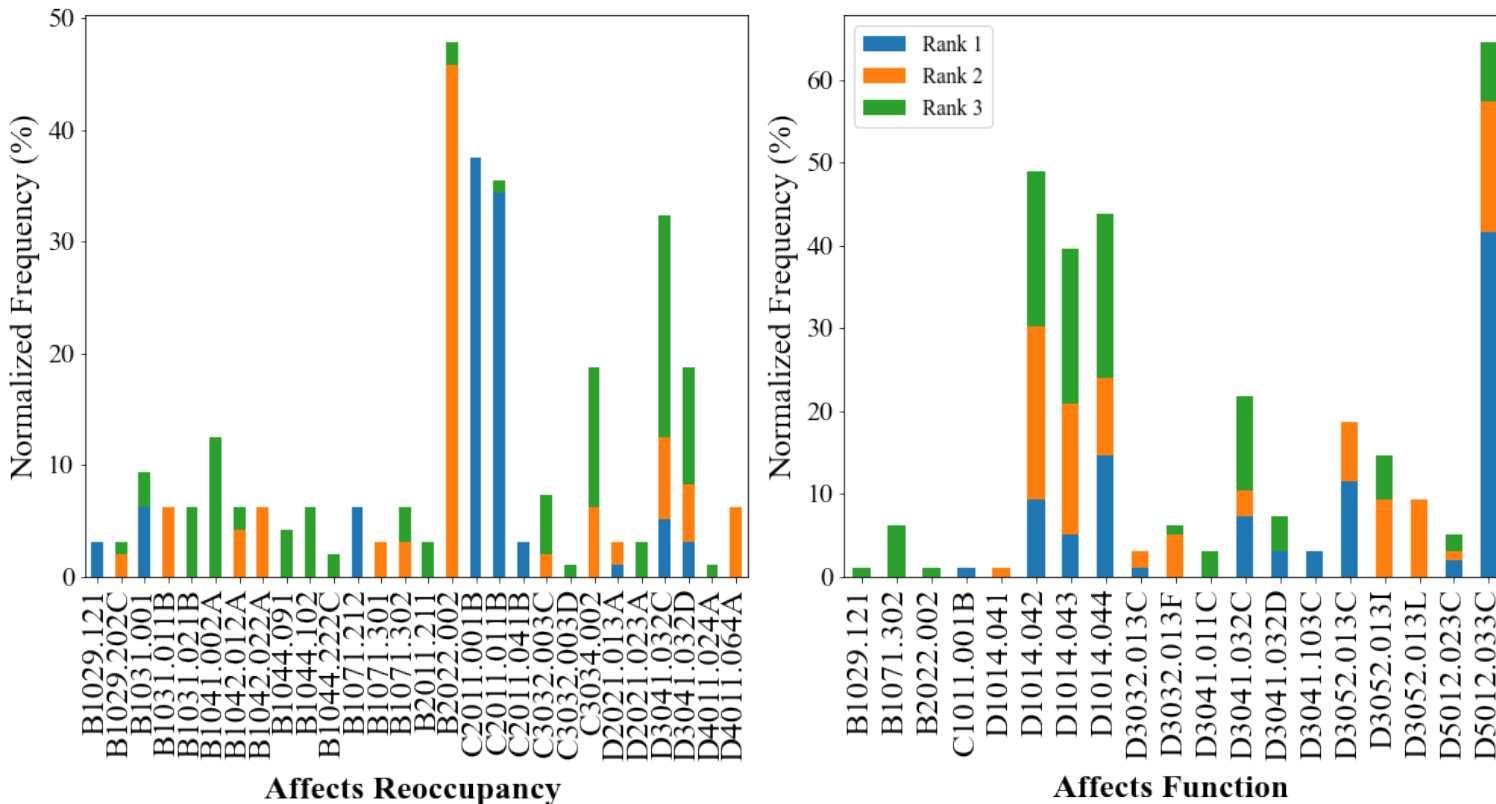
Take Away: FEMA P-58/ATC-138 identifies system causing issues, so they can be designed resiliently.



Most Frequent System/Component “Offenders”

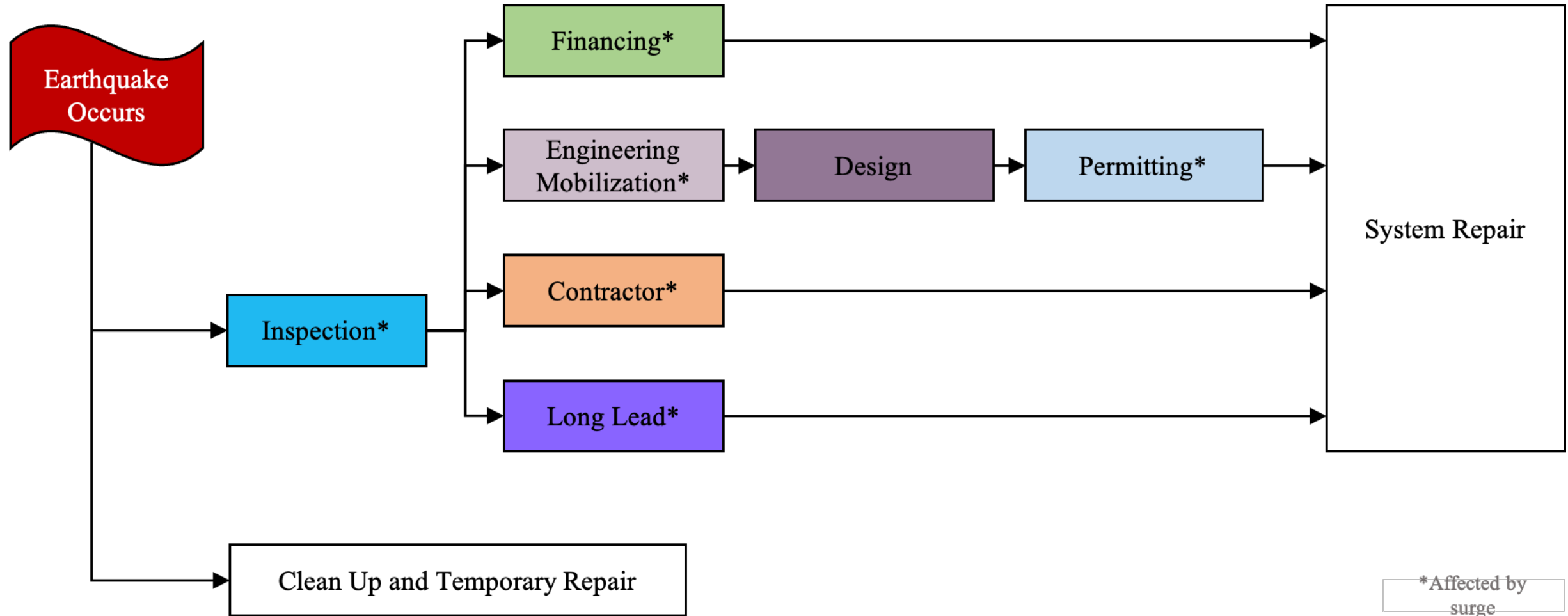
Take Away: FEMA P-58/ATC-138 also identifies the specific components causing issues, so they can be designed resiliently.

Frequency of Top 3 Component Offenders at [30] Days (RP=475 years)



- Reoccupancy offenders (ordered, mostly falling hazards):
 - Stairs when no seismic joint (C2011.xx)
 - Curtain/exterior walls (B2022/B1071)
 - HVAC components (C3041)
 - Pendant lighting (C3034.002)
 - Suspended ceilings (C3032.003c)
- Functional Recovery (ordered):
 - Electrical distribution panel (D5012)
 - Elevators (D1014)
 - HVAC components – ducting, drops, VAV boxes (D3041)
 - Air handling units (D3052)
 - Cooling tower (D3031)
 - Exterior walls (B1071)

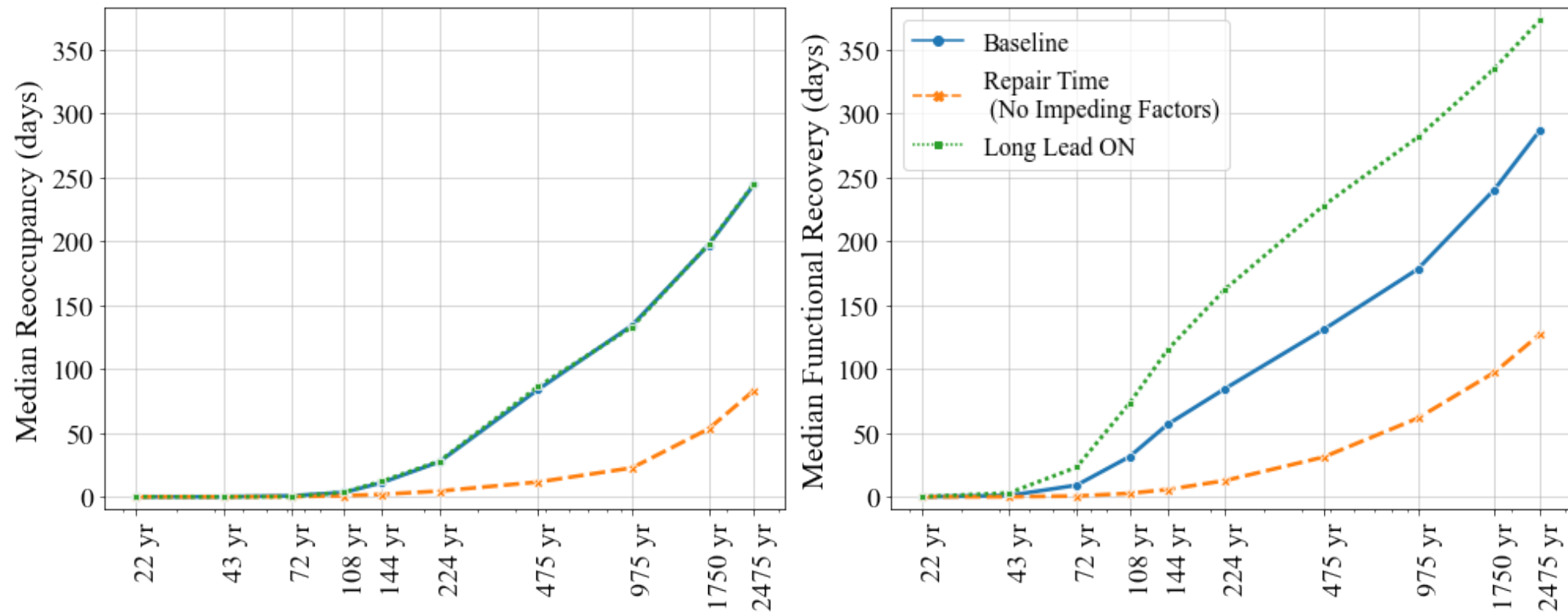
Sensitivity to Methodology Components



*Affected by
surge

Take Away: Impeding factors and long-lead items increase recovery times substantially.

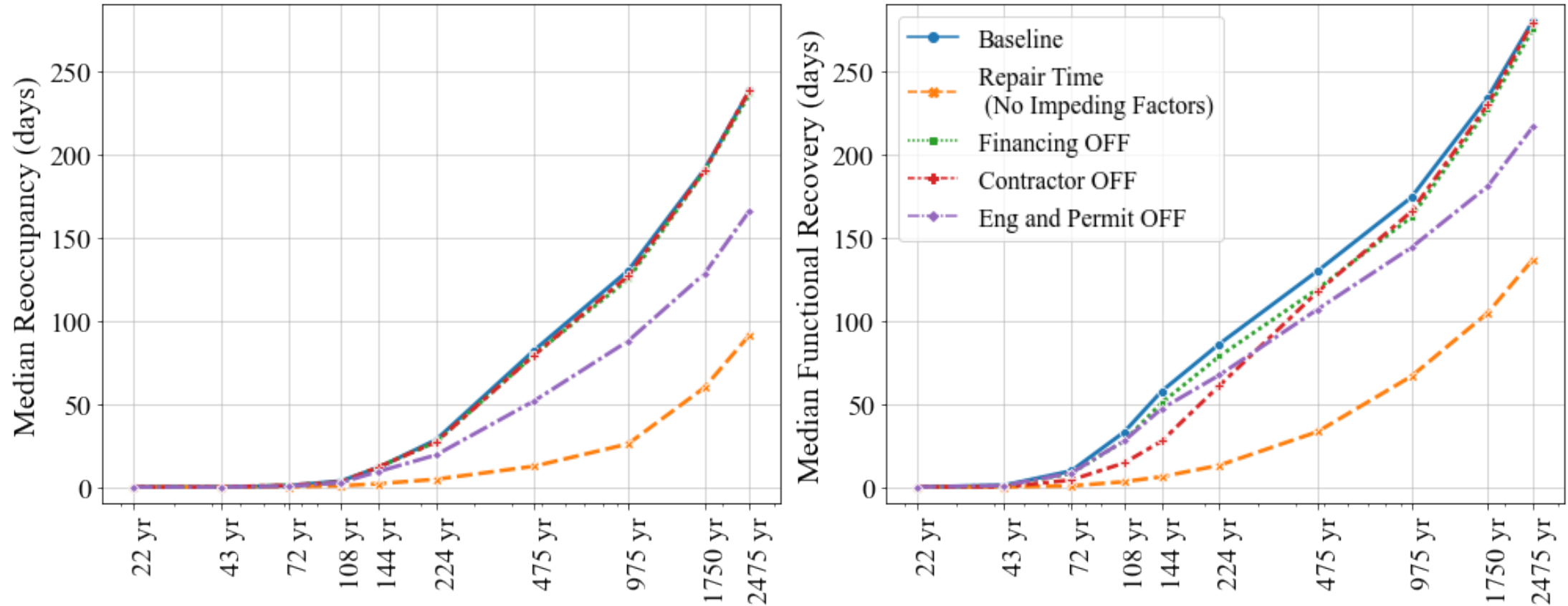
Risk Category II New Buildings in High Seismic Sites



Sensitivity to Method Components: Specific Impeding Times

Take Away: Impeding factors are mostly in parallel, so you get most of the effect even if you turn some off.

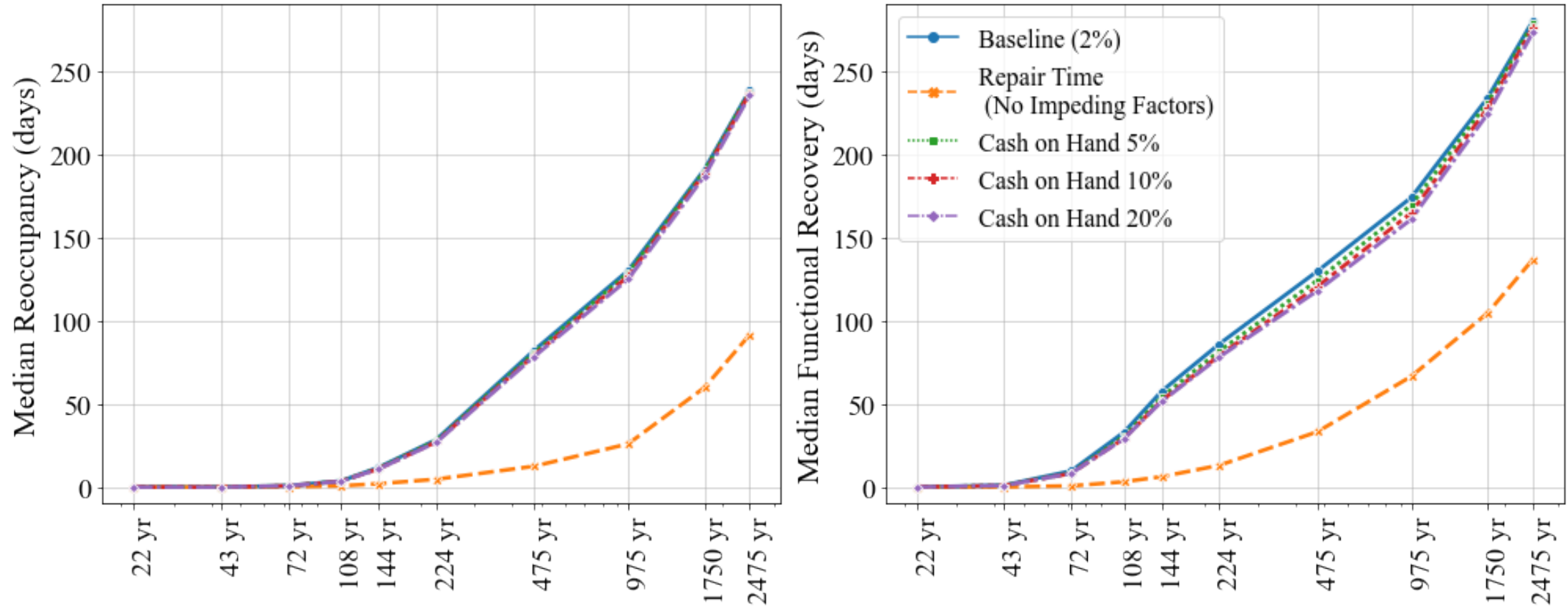
Risk Category II New Buildings in High Seismic Sites



Sensitivity to Method Components: Cash-on-Hand Before Loan

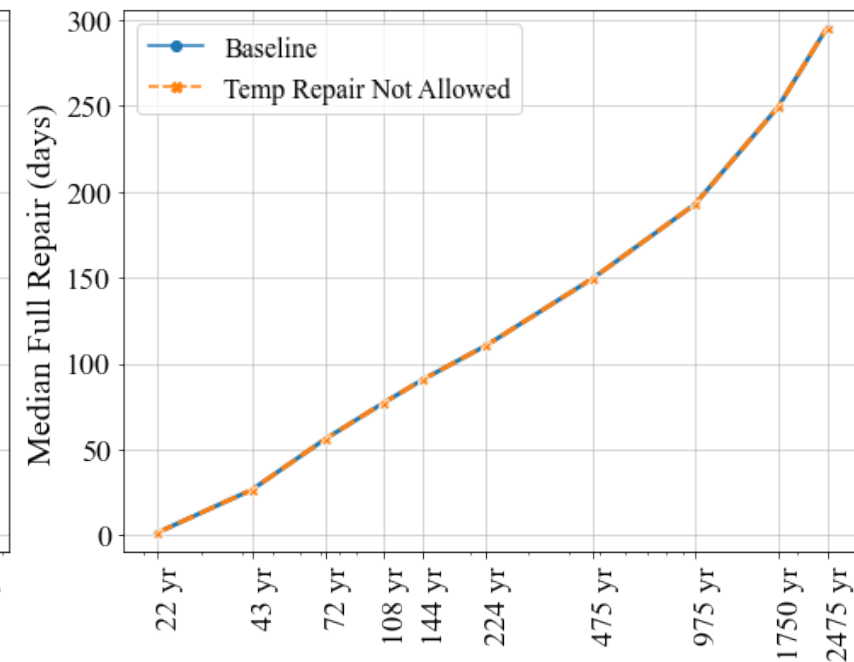
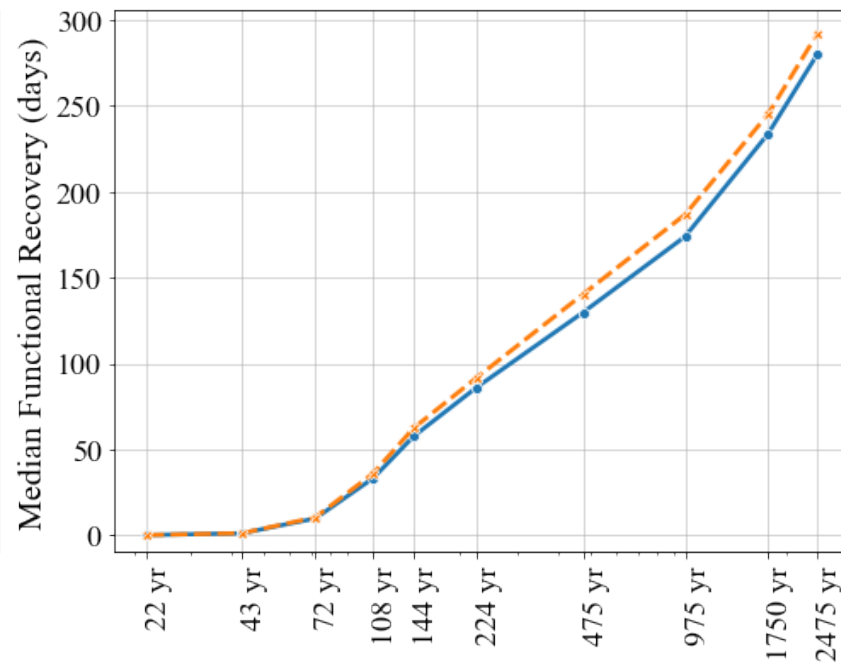
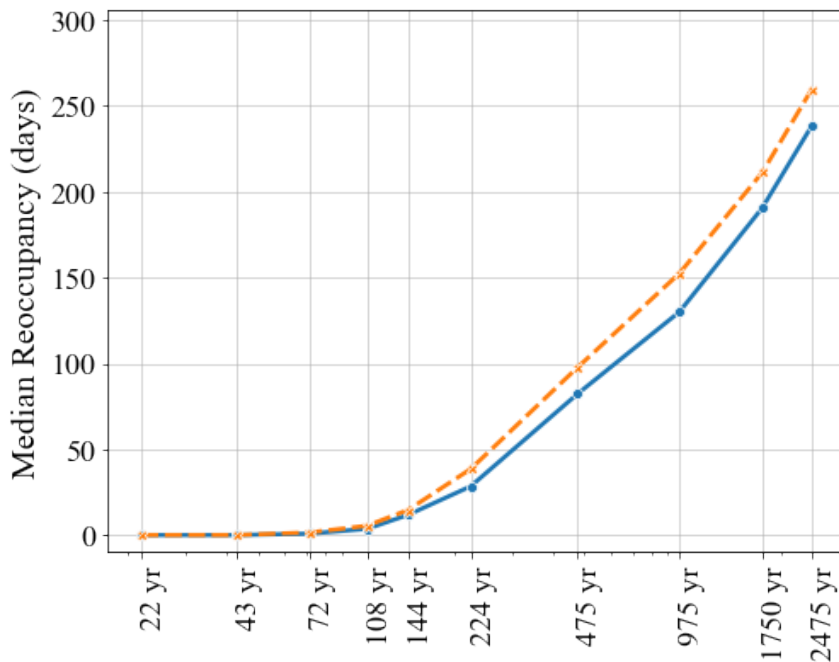
Take Away: Financing details generally don't control (permitting/design/contracting does).

Risk Category II New Buildings in High Seismic Sites



Take Away: Allowing temporary repairs reduce recovery times some. Important caveat is that the impact depends heavily on what is allowed to be temporarily repaired to regain basic function; if we are more permissive with what can be resolved with temp repair, then recovery times would be much lower between at SLE and even some DE levels.

Risk Category II New Buildings in High Seismic Sites

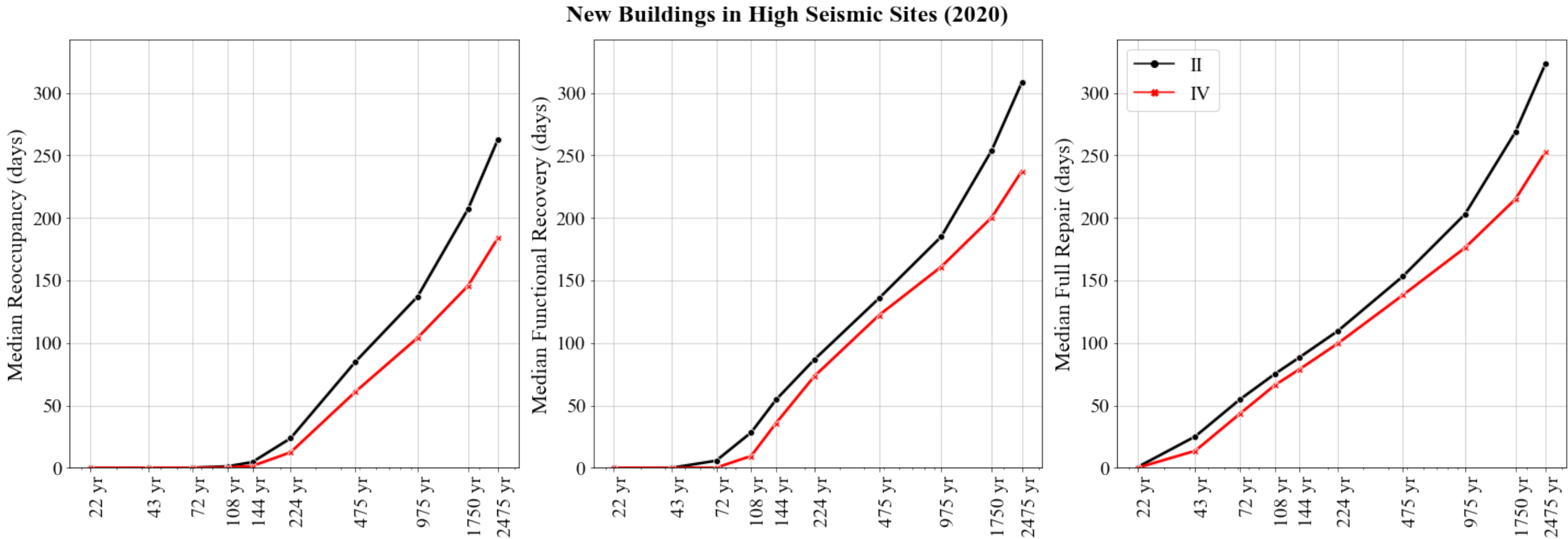


What do some occupancy and design items affect results?

- RC II vs. IV
- New vs. Old buildings
- Occupancy (residential vs. commercial office)

Trends for Building Design: Risk Category II versus IV

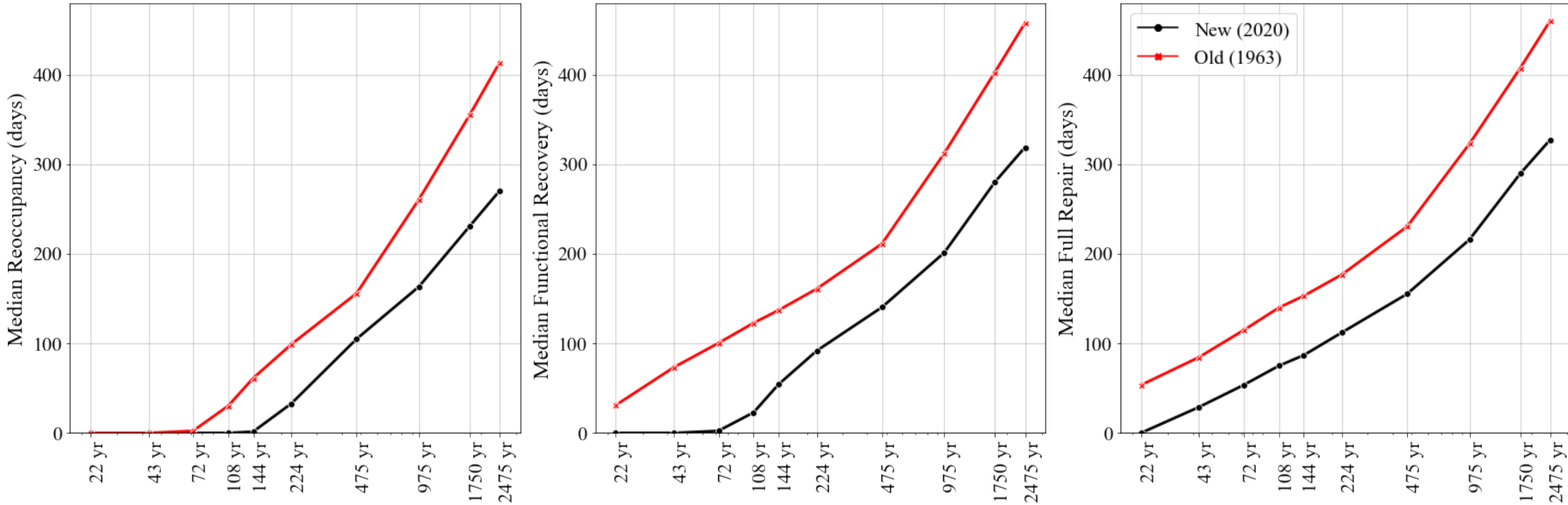
Take Away: RC IV delays onset of FR issues (near 72yr to 108yr), but then results are similar for DE and MCE.



Trends for Building Design: Old vs. New Buildings

Take Away: New buildings are better (but we didn't need to tell you that).

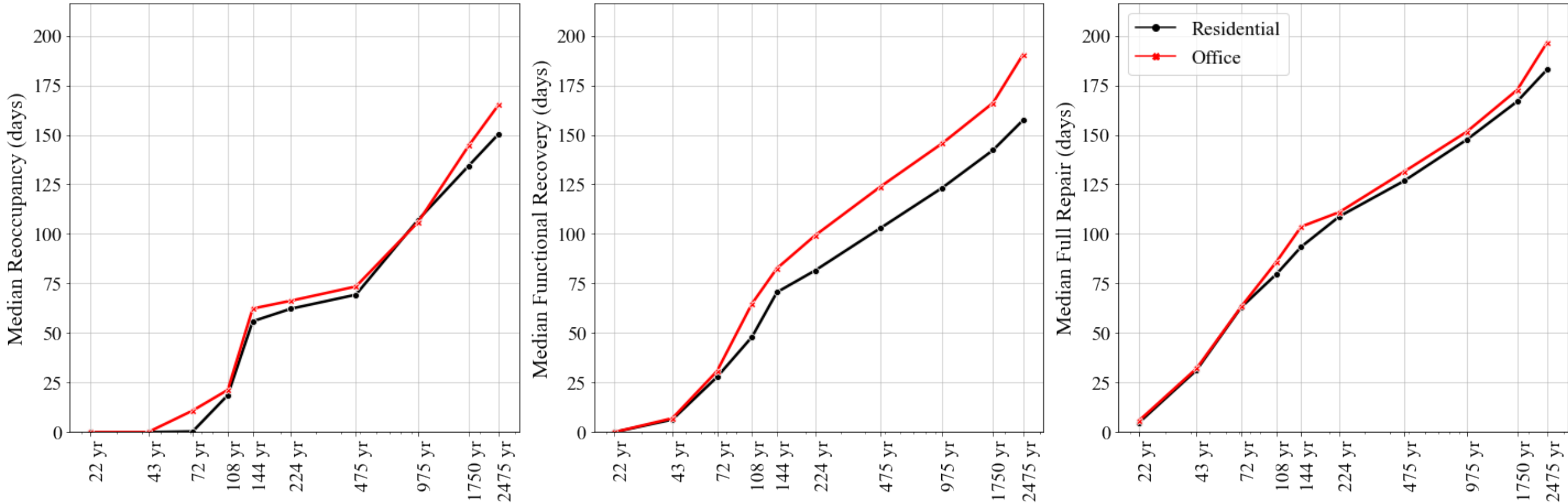
Risk Category II Buildings in High Seismic Sites (None)



Trends for Building Design: Occupancy

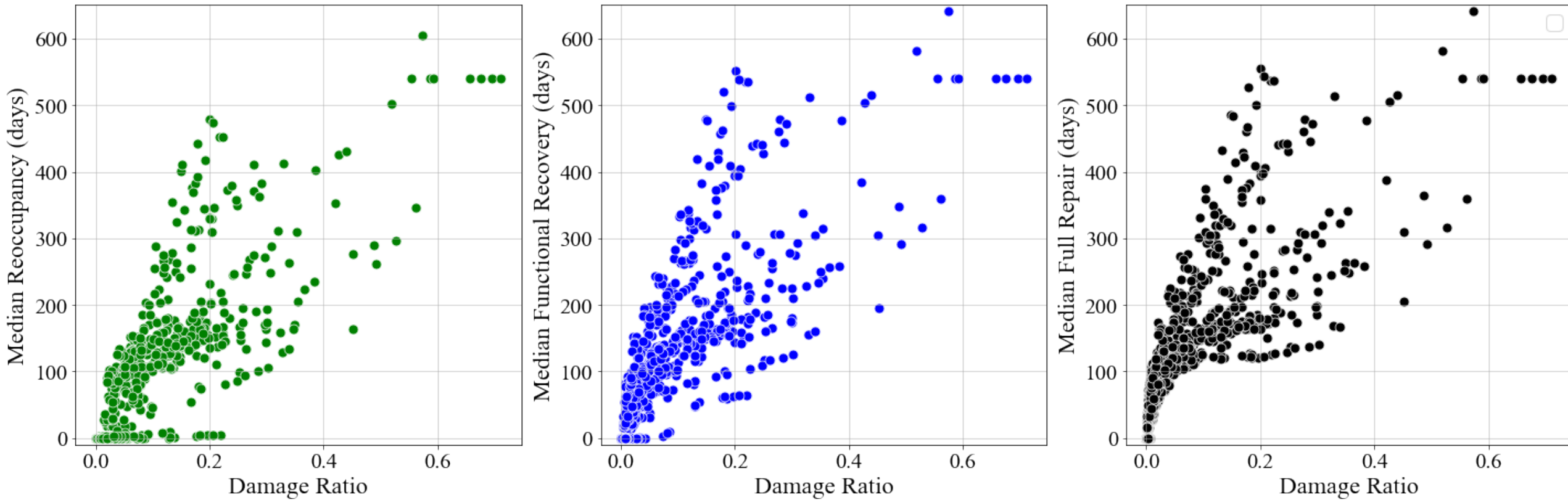
Take Away: Similar results, with residential slightly better because more damage is allowed.

Risk Category II Buildings in High Seismic Sites (2020)



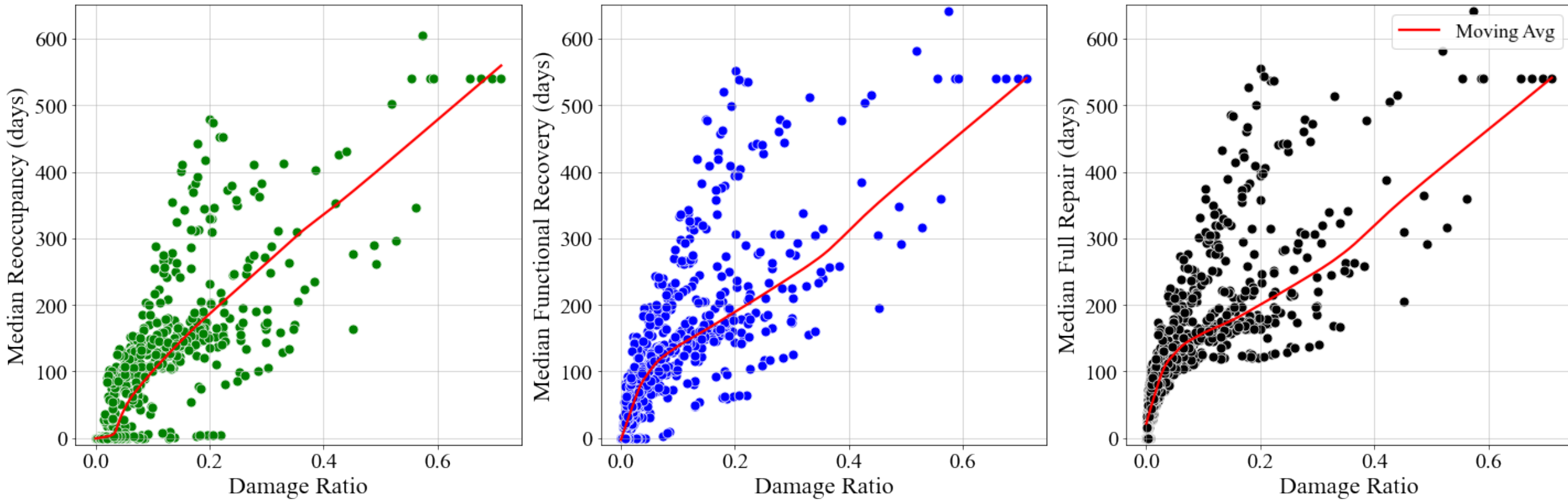
Recovery Times vs. Damage Ratio

Risk Category II New Buildings at High Seismic Sites



Recovery Times vs. Damage Ratio

Risk Category II New Buildings at High Seismic Sites



Results for a Real Project (Mar Structural Design)

Take Away: New practitioner design (RC wall lab building) was also taken through this process (full RHA). Results are comparable to what we have shown for main 592 building study. FEMA P-58/ATC-138 is enabling resilient design for this project by identifying which specific components need more resilient design.



- ATC-138 has extended the FEMA P-58 analysis method to now model/estimate functional recovery time (and reoccupancy times).
- Results for code-compliant buildings vary widely building-to-building and site-to-site (because the code doesn't try to design for function). Typical average values for high-seismic CA sites are:
 - ✓ SLE: Current code design delivers near-immediate occupancy/function for most systems
 - ✓ DE: Several months of recovery time (so need more resilient design to have quick recovery at DE)
 - ✓ MCE: Long recovery (but probably not the focus of FR design)
- Impeding factors have important influence in the estimated recovery times (so please discuss how to handle them in Breakout #2c!).
- Risk Category IV delays onset of damage and function issues (near SLE), but doesn't help much once we get to DE and MCE levels.
- Results are similar for a current practitioner design (and this methodology is already being used to inform resilient design as we speak).
- Looking toward the future, FEMA P-58/ATC-138 studies like this can be use to both inform FR acceptance criteria, and also to calibrate what prescriptive design requirements would meet FR goals.