Overview and Key Findings Report

CALIFORNIA SUPERIOR COURT BUILDINGS

SEISMIC RENOVATION FEASIBILITY STUDIES PROJECT

PREPARED BY ARUP

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JUDICIAL COUNCIL OF CALIFORNIA
ADMINISTRATIVE DIVISION
FACILITIES SERVICES

Contents

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I. INTRODUCTION

In January 2018, the Judicial Council of California Facilities Services engaged Arup, CO Architects, and MGAC (herein referred to as the consultant team) to perform a seismic renovation feasibility study for 26 court buildings in California. The study involved developing a conceptual seismic retrofit scheme for each building, determining the collateral impacts and associated construction costs of the retrofit schemes, and performing cost-benefit analyses to determine the most appropriate renovation strategy for each building.

This report summarizes the project approach and scope, key findings (see Section II), and important risks and assumptions (see Section III) from the feasibility study. Bolded terms throughout this report are explained in more detail in the glossary in Appendix A.

A. Background and Context

The Trial Court Facilities Act of 2002 (Sen. Bill 1732; Stats. 2002, ch. 1082) initiated the transfer of responsibility for funding, operation, and ownership of court buildings from the counties to the Judicial Council and State of California. The act required most existing facilities to be seismically evaluated and assigned a risk level, with VII being the worst and I being the best. Facilities evaluated as Risk Level V or worse were ineligible for transfer to the state because they were deemed to have unacceptable seismic safety ratings. In total, 225 court buildings (comprising 300 **building segments**) were evaluated; 72 segments were rated Risk Level IV, while 228 were rated Risk Level V.

In 2015, the Judicial Council engaged Rutherford + Chekene (R+C) to develop a more refined **seismic risk rating** (SRR) for the 139 Risk Level V building segments that remained in the council's portfolio since the initial 2002 study. Using the Federal Emergency Management Agency's (FEMA) Hazus Advanced Engineering Building Module, R+C assigned an SRR to each building segment based on the relative **collapse probability** obtained from the initial 2002 seismic assessment of the structure (R+C 2017).

Informed by the SRRs, the Judicial Council Trial Court Facility Modification Advisory Committee authorized the California Superior Court Buildings Seismic Renovation Feasibility Studies project on August 28, 2017. The committee directed Facility Services staff to study 27 buildings that meet specific criteria. For a court building to be a candidate for the renovation feasibility study, it needed to meet all the following criteria:

- It has a Very High or High SRR.
- It is not being replaced by an active new courthouse construction project.
- It is not subject to a memorandum of understanding restricting transfer because of historic building designation.
- It is owned by the Judicial Council or has a transfer of title pending, or the court occupies more than 80 percent of a county owned building.

- The investment would extend its useful life for long-term service to the public.

Facilities Services engaged the consultant team in January 2018 to perform the study, which was completed in December 2018. One court building was removed during the study due to a lack of structural and architectural drawings. The 26 court buildings studied have a total area of approximately five million gross square feet and comprise 43 building segments. Figure 1 shows the location and area of each court building included in the study.

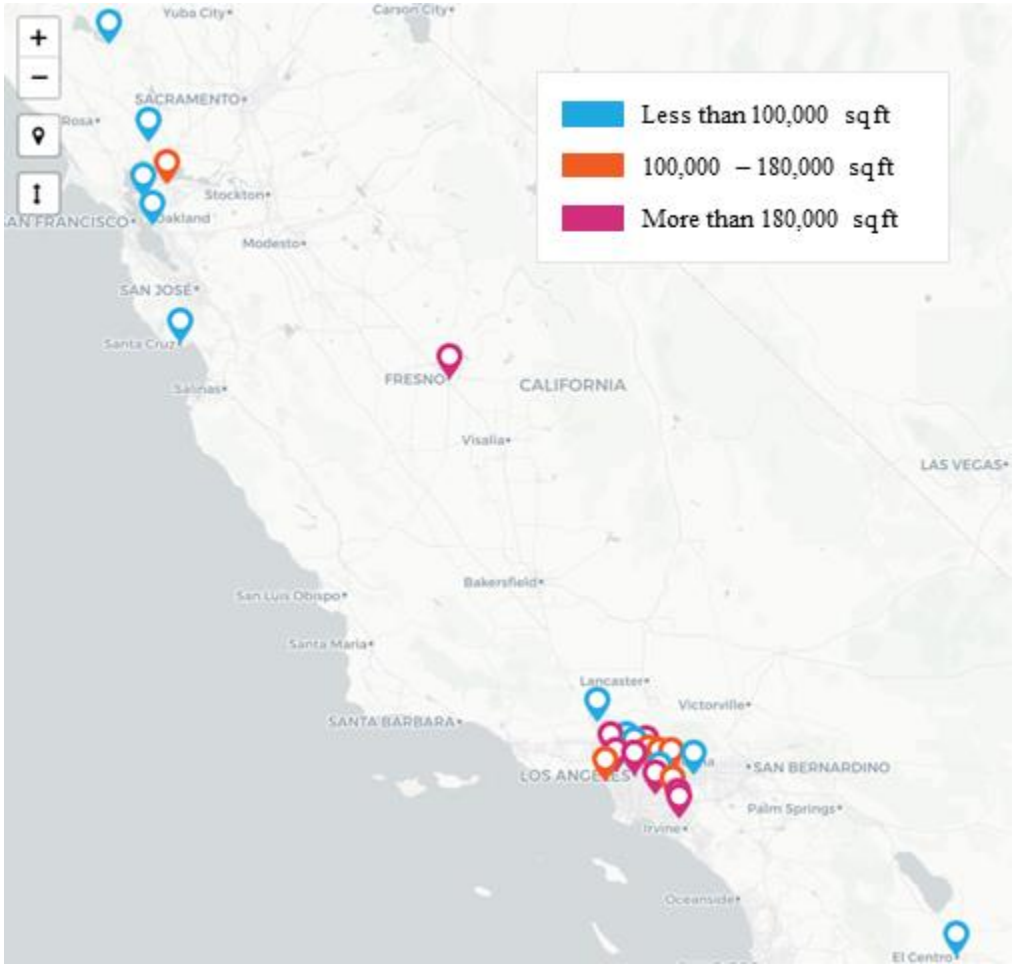

Figure 1. Location and Size of the 26 Court Buildings Assessed in This Study

B. Summary of Project Approach

As part of the seismic renovation feasibility study, the consultant team reviewed structural and architectural drawings and previous seismic assessment reports to understand the critical seismic deficiencies and general layout of the court building. The team then conducted a site inspection and interviewed court staff to verify critical seismic deficiencies and document overall facility conditions before performing a supplemental seismic assessment to confirm previously identified deficiencies and identify new ones.

The consultant team then designed a conceptual retrofit scheme for each court building to address the critical seismic deficiencies identified from the supplemental seismic evaluation. The primary objective of the retrofit scheme is to reduce the seismic risk level of the court building from Risk Level V to IV, typically by strengthening existing **structural components,** adding new ones, or a combination of both.

The team then determined the **collateral impacts** of the retrofit scheme and identified code-required upgrades to accessibility and fire and life safety systems. Collateral impacts refer to repair work to **nonstructural components** (e.g., walls, ceilings, lighting, carpeting) made necessary by the retrofit. This scope of work is referred to as the **baseline retrofit option (Option 1)** because it represents the minimum required effort to achieve Risk Level IV seismic performance.

Because a seismic retrofit can be highly invasive, it provides an opportunity to make additional building repairs and upgrades for relatively little incremental cost. The Judicial Council Facilities Services staff asked the consultant team to include approved, unfunded facility modifications in addition to the minimum scope of work required in the baseline retrofit. Approved, unfunded facility modifications, referred to as **priority upgrades**, include building maintenance and systems upgrades that have been approved by the Judicial Council or Superior Court but do not have specific funding sources identified yet. Consequently, these facility modifications would be attractive candidates for inclusion in a seismic renovation. This option is referred to as the **priority upgrades retrofit option (Option 2)**.

Furthermore, because a seismic retrofit can be extremely costly, the consultant team also included a full renovation option and two replacement options for the purposes of benchmarking. While these three options did not involve any design work, they were included in the study as a reference point to identify situations where it may be more cost effective to either fully renovate or replace a court building. The **full renovation option (Option 3)** involves the same seismic retrofit as the baseline retrofit, plus full demolition and replacement of the building interior down to the structural skeleton and removal and replacement of the exterior wall and roof cladding. The first replacement option, referred to as the **replace to 2016 CBC option (Option 4)**, involves replacing the existing court building with a new facility that satisfies the requirements of the 2016 **California Building Code** (CBC; CBSC 2016a). The second replacement option, referred to as the **replace to beyond code option (Option 5)**, involves replacing the existing court building with a new facility that goes beyond the minimum requirements of the 2016 CBC to achieve more resilient seismic performance (e.g., reduced damage, repair costs, and downtime).

A total of five retrofit and replacement options were considered for each court building. The consultant team developed construction cost estimates and durations for each option and compared these costs to the benefits of retrofitting or replacing the court building. The primary benefit of retrofitting or replacing the court building is reduced seismic risk relative to the existing court building, including reduced collapse probability, fatalities, repair costs, and downtime. Additional benefits stemming from retrofitting or replacing the court building

(e.g., improved energy efficiency, accessibility, fire and life safety, security, employee productivity) were not quantified, though the costs of these upgrades were included in the cost-benefit analysis. The design team developed a risk model for each retrofit and replacement option to predict the reduction in seismic risk.

The consultant team then performed cost-benefit analyses to compare the financial effectiveness of the five retrofit and replacement options for each court building. The benefit-cost ratio measures the benefits of an option relative to its cost and was the primary consideration in the Judicial Council Facilities Services staff's decision of which retrofit or replacement option to select.

The conceptual retrofit schemes were reviewed by R+C, the structural peer reviewer retained by the Judicial Council for this study, to confirm the validity and appropriateness of the proposed interventions. R+C also reviewed results from the seismic risk assessments and cost-benefit analyses.

Table 1 summarizes the selected retrofit or replacement option for each court building. Table 2 summarizes the costs and benefits included and excluded from the cost-benefit analysis.

Table 1. Summary of Selected Option for Each Court Building

ID	Name	Address	Selected option
01-F1	George E. McDonald Hall of Justice	2233 Shoreline Dr., Alameda	Priority upgrades
07-A2	Wakefield Taylor Courthouse	725 Court St., Martinez	Priority upgrades
07-F1	George D. Carroll Courthouse	100 37th St., Richmond	Replace to 2016 CBC
10-A1	Fresno County Courthouse	1100 Van Ness Ave., Fresno	Baseline
13-A1	Imperial County Courthouse	939 W. Main St., El Centro	Replace to 2016 CBC
17-B1	Clearlake Branch Courthouse	7000A S. Center Dr., Clearlake	Replace to 2016 CBC
19-AD1	Santa Clarita Courthouse	23747 W. Valencia Blvd., Santa Clarita	Baseline
19-AK1	Norwalk Courthouse	12720 Norwalk Blvd., Norwalk	Baseline
19-AO1	Whittier Courthouse	7339 Painter Ave., Whittier	Priority upgrades
19-AP1	Santa Monica Courthouse	1725 Main St., Santa Monica	Baseline
19-AQ1	Beverly Hills Courthouse	9355 Burton Way, Beverly Hills	Replace to beyond code
19-AX2	Van Nuys Courthouse West	14400 Erwin St. Mall, Van Nuys	Priority upgrades
19-G1	Burbank Courthouse	300 E. Olive Ave., Burbank	Replace to 2016 CBC
19-H1	Glendale Courthouse	600 E. Broadway, Glendale	Priority upgrades

ID	Name	Address	Selected option
19-I1	Alhambra Courthouse	150 W. Commonwealth Ave., Alhambra	Baseline
19-J1 J2	Pasadena Courthouse	300 E. Walnut St., Pasadena	Replace to beyond code
19-K1	Stanley Mosk Courthouse	110 N. Grand Ave., Los Angeles	Baseline
19-L1	Clara Shortridge Foltz Criminal Justice Center	210 W. Temple St., Los Angeles	Priority upgrades
19-O1	El Monte Courthouse	11234 E. Valley Blvd., El Monte	Replace to 2016 CBC
19-W2	Pomona Courthouse North	350 W. Mission Blvd., Pomona	Replace to 2016 CBC
19-X1	West Covina Courthouse	1427 W. Covina Pkwy., West Covina	Baseline
28-B1	Napa Courthouse	825 Brown St., Napa	Replace to 2016 CBC
30-A1	Central Justice Center	700 Civic Center Dr. West, Santa Ana	Priority upgrades
30-B1	Lamoreaux Justice Center	341 The City Dr. S, Orange	Priority upgrades
30-C1 C2	North Justice Center	1275 N. Berkeley Ave., Fullerton	Baseline
44-A1	Santa Cruz Courthouse	701 Ocean St., Santa Cruz	Replace to 2016 CBC

Table 2. Summary of Costs and Benefits Included in cost-benefit analysis

Item	Included in cost-benefit analysis					Notes
	Retrofit or replacement option					
	1	2	3	4	5	
Costs						
Hard construction costs	Yes	Yes	Yes	Yes	Yes	Includes costs of site preparation, design contingencies, and labor and material required for repair or construction of substructure, shell, interiors, and building services (as applicable). For Options 1 and 2, the costs of upgrades to accessibility and fire and life safety systems were explicitly calculated. For Options 3-5, compliance with current accessibility and fire and life safety requirements is assumed as part of the construction work.

Item	Included in cost-benefit analysis					Notes
	Retrofit or replacement option					
	1	2	3	4	5	
Temporary relocation costs	Yes	Yes	Yes	N/A	N/A	For Options 1-3 (unphased), includes fit out and rental costs required to relocate court staff and functions to temporary space for the duration of the retrofit. For Options 4-5, temporary relocation costs are not applicable because it is assumed court staff and functions can remain in the existing court building while the new one is constructed in a nearby location.
Construction phasing costs	Yes	Yes	No	N/A	N/A	For Options 1 and 2 (phased), includes costs for phasing the construction work by zones or floors to keep the court building open during the retrofit. For Option 3, construction phasing costs were not included because phasing was assumed to be impractical due to disruptiveness of the construction work.
Demolition costs	N/A	N/A	N/A	No	No	For Options 4 and 5, does not include costs of demolishing current existing building. For Options 1-3, demolition costs are not applicable.
Land costs	N/A	N/A	N/A	No	No	For Options 4 and 5, does not include costs of acquiring land for new court building. For Options 1-3, demolition costs are not applicable.
Escalation costs	No	No	No	No	No	Does not include escalation in construction costs from the time of this study to the actual start of a retrofit or replacement project.
Design and engineering consultant fees	No	No	No	No	No	Does not include consultant fees for further engineering analyses or detailed design services prior to retrofit or replacement of a court building.
Construction and owner contingencies	No	No	No	No	No	
Loose furniture, fixtures, and equipment	No	No	No	No	No	
Benefits						
Avoided injuries in future earthquakes	No	No	No	No	No	Does not include the benefit of avoided injuries due to incomplete data on the financial cost of injuries.

Item	Included in cost-benefit analysis					Notes
	Retrofit or replacement option					
	1	2	3	4	5	
Avoided fatalities in future earthquakes	Yes	Yes	Yes	Yes	Yes	Includes the benefit of avoided fatalities. Fatalities were calculated using peak instantaneous building populations, which were derived from magnetometer counts for each court building. The value of a statistical life (i.e., cost of a fatality) was selected to be $9 million for this study. Refer to detailed methodology report (Arup 2019) for further discussion.
Avoided repair costs in future earthquakes	Yes	Yes	Yes	Yes	Yes	Includes costs to repair damage to major structural and nonstructural components. Does not include losses from damage to building contents (e.g., furniture, computers).
Avoided downtime in future earthquakes	Yes	Yes	Yes	Yes	Yes	Includes cost to fit out and rent temporary space for the duration of repair work after an earthquake. Does not include indirect costs from protracted downtime (e.g., increased backlog of court cases, employee attrition)
Improved energy efficiency	No	No	No	No	No	Does not include the benefit of improved energy efficiency from replacing existing mechanical and electrical equipment.
Improved accessibility	No	No	No	No	No	
Improved fire and life safety	No	No	No	No	No	
Improved functionality	No	No	No	No	No	Does not include the benefit of improved functionality from construction work, including possible improvements to daylighting, security, and building layout.
Asset-life extension						
Minimum asset-life extension (years)	15	25	40	50	50	Asset-life extension refers to the assumed life time of a building before further necessary building-wide renovation or replacement is required. It is the length of time over which the benefits (above) are assumed to accrue. It is not a prediction of the length of actual court occupancy in a particular building. Refer to detailed methodology report (Arup 2019) for further discussion.

II. SUMMARY OF KEY FINDINGS

The following sections summarize key findings from the seismic renovation feasibility study performed by the consultant team.

A. Common Seismic Deficiencies

The 26 court buildings included in this study were evaluated previously as some of the most seismically vulnerable buildings in the Judicial Council's portfolio. Most were built before modern seismic design codes were in place and have one or more significant seismic deficiencies that could jeopardize their structural integrity and occupant safety in an earthquake. Figure 2 lists common seismic deficiencies for the 26 buildings, including the percentage of buildings having each deficiency. Table 3 describes each seismic deficiency and the risk it poses to the safety of building occupants.

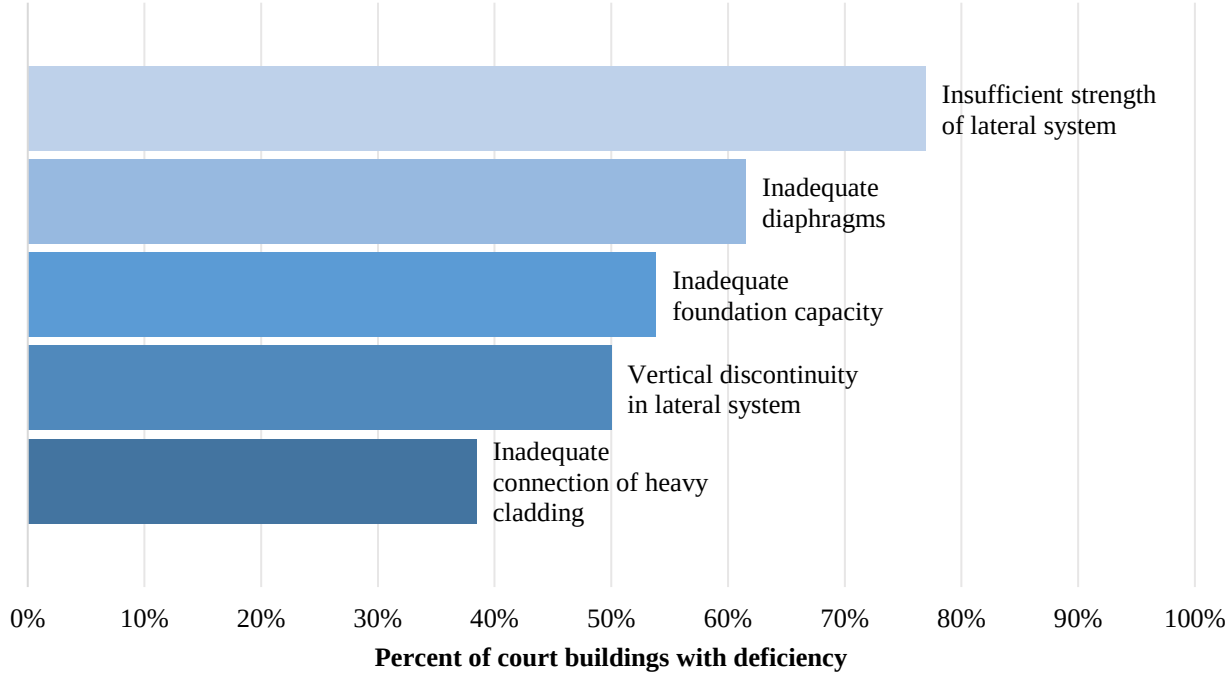

Figure 2. Common Seismic Deficiencies For the 26 Court Buildings in This Study

Table 3. Description of Common Seismic Deficiencies

Deficiency	Description	Risk
Insufficient strength of lateral system	The lateral system refers to the structural elements that provide resistance against earthquakes. This is as opposed to the gravity system, which supports vertical loads only. Some structural elements serve both purposes. Insufficient strength implies that the system is too weak to withstand earthquake forces.	The structure could suffer excessive damage, potentially very suddenly. This could pose a significant risk to the safety of building occupants.
Inadequate diaphragms	Diaphragm refers to a floor slab or roof. The material may be timber planks or sheathing, reinforced concrete, or some form of metal sheathing. Inadequate diaphragms have insufficient strength or stiffness to transfer loads to other parts of the structure.	Damage to the diaphragm itself could occur. Excessive local damage could also cause damage to connecting walls.
Inadequate foundation capacity	The foundation has insufficient strength or stiffness to prevent either structural failure or excessive deformation of the soil underneath.	Collapse from excessive movement in a foundation is rare. It is more common that foundation failure leads to excessive settlement and damage to a building.
Vertical discontinuity in lateral system	The lateral system, such as a wall or braced frame, does not continue uninterrupted from the roof to the foundation.	Excessive damage could occur below the interrupted element, where load cannot be transferred to the foundation. This could pose a significant risk to the safety of building occupants.
Inadequate connection of heavy cladding	Heavy cladding typically refers to stone or concrete facade panels. They are connected to the main structure with clips or similar connections. Older styles of construction did not consider the requirement to restrain the panels from lateral acceleration.	While unlikely to lead to building collapse, falling cladding could pose a significant risk to the safety of building occupants.

B. Common Retrofit Measures

A custom conceptual seismic retrofit scheme was developed for each court building. However, similar **building types** typically had similar retrofit measures. Figure 3 lists common retrofit measures across the 26 buildings studied, including the percentage with each retrofit measure. Table 4 describes the typical scope of structural work for each retrofit measure but does not include the architectural impacts of such work (e.g., removal of wall finishes, ceilings, floor coverings), which can be significant.

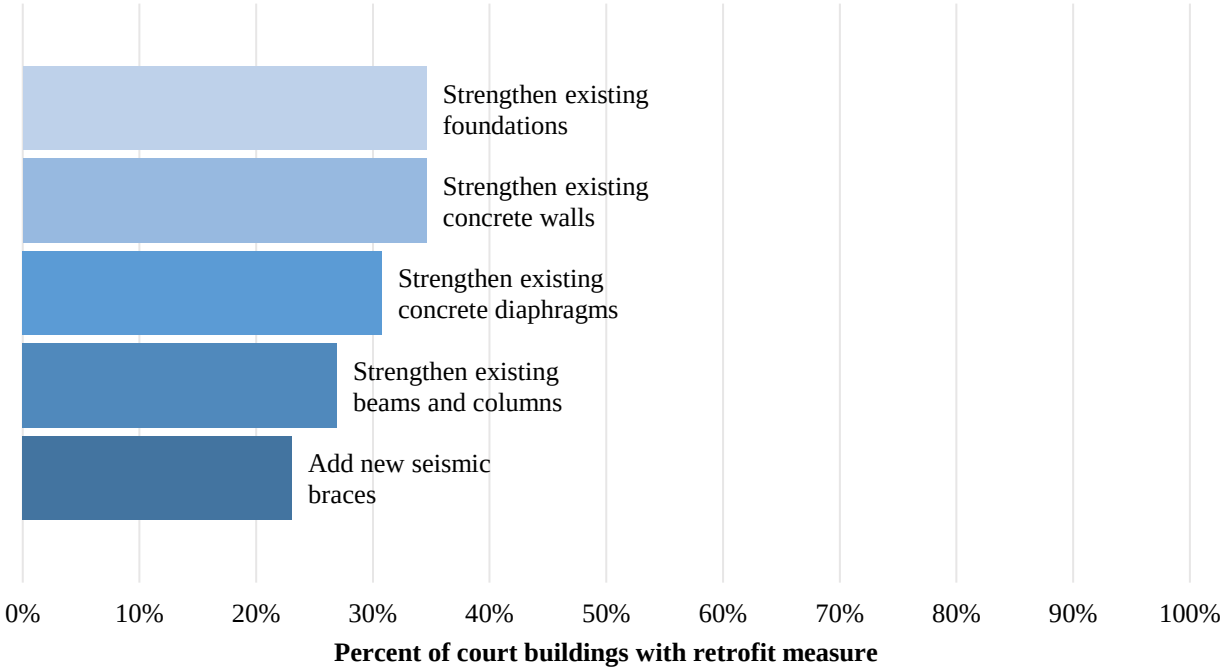

Figure 3. Common Retrofit Measures For the 26 Court Buildings in This Study

Table 4. Description of Typical Retrofit Measures

Retrofit Measure	Description
Strengthen existing foundations	Increase the size of existing concrete footings beneath structural walls, braces, or columns (in select locations) through the addition of concrete and steel reinforcement.
Strengthen existing concrete walls	Increase the thickness or length of existing concrete walls (in select locations) through the addition of concrete and steel reinforcement, or wrap existing concrete walls (in select locations) with a fiber-reinforced polymer.
Strengthen existing concrete diaphragms	Install a layer of fiber-reinforced polymer on top of concrete diaphragms, or add concrete edge beams to strengthen the connection between diaphragms and structural walls.
Strengthen existing beams and columns	Reinforce existing beams and columns below discontinuous structural walls through the addition of steel reinforcement and concrete (for concrete wall buildings) or steel plates (for steel moment frame buildings).
Add new seismic braces	Install new seismic braces within existing steel frames (in select locations), and strengthen existing beams, columns, and connections around the frames.

C. Cost of Phased Construction versus Temporary Relocation

Because of the disruptive nature of seismic retrofits, the consultant team considered two construction scenarios. The first assumes the court building remains occupied during the

seismic retrofit. Consequently, the retrofit work is performed in multiple phases, either by floors or zones of the building, to minimize disruption to court operations. This scenario is referred to as **phased construction**. It results in longer construction times but does not require court staff and functions to relocate to temporary facilities. The consultant team estimated the cost premium for phased construction for each court building based on the scope and extent of the proposed retrofit scheme. The premium includes scheduling costs to cover the extended construction duration due to phasing and escalation costs to cover increases in the price of labor and materials due to the extended construction duration. However, it does not include the impact of phased construction on the capacity or efficiency of court operations, employee productivity, and other similar factors. On average, the cost premium across the 26 court buildings is $90 per square foot for phased construction, which is in addition to hard construction costs for the retrofit. Note that in the cost-benefit analysis of each court building, the actual cost premium (as determined by the consultant team) was used, not the average.

The second construction scenario assumes the court building is completely vacated during the seismic retrofit. This scenario is referred to as **unphased construction** because the entire facility is shut during the retrofit. This results in shorter construction times but requires court staff and functions to relocate to temporary facilities for the duration of the retrofit. Based on typical commercial office space rental rates and fit out costs for court occupancies, the consultant team estimated the cost premium for unphased construction for each court building (see Equation 1 for more detail). The premium for unphased construction includes only rental and fit out costs, and excludes additional relocation costs that may be incurred (e.g., moving costs, parking costs, shortages of available rental space). On average, the cost premium across the 26 court buildings is $220 per square foot for temporary relocation, which is in addition to hard construction costs for the retrofit.

$$C_{relocate} = 0.75 \times GFA_{JCC} \times \left(C_{fitout} + C_{rental} \times T_{retrofit}\right) \quad \text{Equation 1}$$

Where:

$C_{relocate}$ = cost of temporary relocation

GFA_{JCC} = gross floor area occupied by the Judicial Council in current existing facility

$0.75 \times GFA_{JCC}$ = gross floor area rented by the Judicial Council in a temporary facility (75% reduction factor developed in consultation with Facilities Services staff)

C_{fitout} = cost to fit out temporary space

= $250 per square foot

C_{rental} = cost to rent temporary space

= $50 per square foot per year for San Francisco Bay Area and Los Angeles and Orange counties ($30 per square foot per year for other locations)

$T_{retrofit}$ = construction duration of retrofit (determined by consultant team)

The significant difference in average cost premium for the two scenarios ($90 per square foot for phased construction versus $220 for unphased construction) results in phased construction typically being the more financially attractive scenario across the portfolio of 26 court buildings in this study. However, when a retrofit of a court building is undertaken in the future, the costs of both scenarios should be re-evaluated as market conditions are likely to have changed. In addition, individual court buildings may be subject to constraints that were not considered in this study that could bias one scenario over another (e.g., a lack of suitable rental space nearby). Furthermore, it may be possible to relocate court staff and operations temporarily to a nearby court building, thus avoiding some or all temporary space costs.

D. Reduction in Anticipated Seismic Losses

The primary consequence of retrofitting or replacing a court building is an overall reduction in the collapse risk relative to the current existing facility. In addition, the retrofitted or replaced building is also expected to experience reduced repair costs and downtime in future earthquakes. The consultant team developed probabilistic risk models for each of the 26 existing court buildings and its five retrofit and replacement options. The risk models predict damage and related consequences (in terms of fatalities, repair costs, and downtime) for each retrofit/replacement option and court building under various earthquake intensity levels, ranging from small, frequent earthquakes to large, rare ones.

The predicted losses at each earthquake intensity can be converted into annualized losses for each court building and retrofit/replacement option. Annualized losses represent the anticipated seismic losses in any given year, and typically would not be incurred every year (i.e., in most years, there are no earthquakes and therefore no losses; however, if a significant earthquake occurs, the losses that year will greatly exceed the annualized losses). Over a long period of time, the actual losses incurred would approach the anticipated annualized losses. Though abstract in nature, annualized losses are useful because they capture in a single metric the magnitude of losses across a range of seismic intensities, thus enabling the risk reduction potential of each retrofit and replacement option to be compared more readily.

Table 5 presents annualized losses, in terms of fatalities, repair costs, and downtime, for each of the 26 court buildings and the selected retrofit or replacement option.

Table 5. Annualized Losses for the Portfolio of 26 Court Buildings

County	ID	Name	Selected option*	Annualized loss ($thousands)					
				Existing court building			Selected option		
				F†	RC‡	DT**	F†	RC‡	DT**
Alameda	01-F1	George E. McDonald Hall of Justice	2	2,276	141	112	115	29	73
Contra Costa	07-A2	Wakefield Taylor Courthouse	2	3,353	624	430	1,422	184	409
	07-F1	George D. Carroll Courthouse	4	9,910	406	383	NS††	86	304
Fresno	10-A1	Fresno County Courthouse	1	11,405	204	325	4,697	100	281
Imperial	13-A1	Imperial County Courthouse	4	19,637	1,193	513	NS††	71	238
Lake	17-B1	Clearlake Branch Courthouse	4	1,221	29	42	NS††	4	15
Los Angeles	19-AD1	Santa Clarita Courthouse	1	2,629	73	161	313	34	137
	19-AK1	Norwalk Courthouse	1	8,261	377	767	3,402	194	750
	19-AO1	Whittier Courthouse	2	2,495	180	329	280	49	257
	19-AP1	Santa Monica Courthouse	1	2,879	134	231	833	37	142
	19-AQ1	Beverly Hills Courthouse	5	1,113	162	545	NS††	23	140
	19-AX2	Van Nuys Courthouse West	2	9,338	442	880	3,845	202	838
	19-G1	Burbank Courthouse	4	2,235	168	217	NS††	30	167
	19-H1	Glendale Courthouse	2	3,920	106	224	374	49	159
	19-I1	Alhambra Courthouse	1	1,021	136	361	295	77	337
	19-J1 J2	Pasadena Courthouse	5	4,755	380	534	NS††	115	454
	19-K1	Stanley Mosk Courthouse	1	25,376	676	1,396	NS††	8	32
	19-L1	Clara Shortridge Foltz Criminal Justice Center	2	8,104	797	1,853	2,338	342	1,374
	19-O1	El Monte Courthouse	4	5,571	289	440	NS††	76	281
	19-W2	Pomona Courthouse North	4	5,029	157	203	NS††	35	116
	19-X1	West Covina Courthouse	1	5,219	144	374	NS††	31	223
Napa	28-B1	Napa Courthouse	4	3,179	194	152	NS††	64	91
Orange	30-A1	Central Justice Center	2	17,915	694	1,935	6,780	368	1,505
	30-B1	Lamoreaux Justice Center	2	8,483	409	658	3,493	213	571
	30-C1 C2	North Justice Center	1	6,508	329	619	775	122	607
Santa Cruz	44-A1	Santa Cruz Courthouse	4	5,866	120	188	NS††	31	106

* Option 1: Baseline Retrofit
Option 2: Priority Upgrades Retrofit
Option 3: Full Renovation
Option 4: Replace to 2016 CBC
Option 5: Replace to Beyond Code

† F: annualized loss from fatalities ($thousands), which are based on peak building populations and 90th percentile estimates of fatalities from the seismic risk assessment and, thus, likely represent an upper bound on annual losses from fatalities. Refer to the detailed methodology report (Arup 2019) for findings from a sensitivity study of populations.

‡ RC: annualized loss from repair costs ($thousands)

** DT: annualized loss from downtime ($thousands). For buildings where the selected option is 1, 2, or 3, the primary intent of the retrofit is to reduce the risk of collapse and fatalities. While some reduction in downtime may be expected, the conceptual retrofit scheme does not include specific measures to reduce downtime. Therefore, downtime losses typically do not decrease significantly because of the retrofit.

†† NS: not significant. New replacement buildings (or, in the case of Stanley Mosk, base-isolated retrofits) are expected to have significantly improved seismic safety relative to current existing court buildings; therefore, in this study, fatalities were not modelled.

E. Comparison of Selected Options

Table 6 compares benefit-cost ratios (BCRs) of the selected retrofit or replacement options across the portfolio of 26 court buildings included in this study. The BCR measures the benefits of an option relative to its cost and was the primary consideration in the Judicial Council Facilities Services staff's decision of which retrofit or replacement option to select. If the BCR exceeds one, then the benefits of the option exceed its costs, indicating it is effective from a purely financial perspective.

Court buildings in Table 6 are sorted from highest BCR to lowest. Court buildings with the largest BCRs represent the best retrofit or replacement investments, but additional factors (e.g., total construction cost, **asset-life extension**, importance of the existing court building to continuing Superior Court operations) need to be considered in developing judicial branch-wide renovation strategies or priorities. The total estimated construction cost associated with retrofitting or replacing all 26 court buildings is $2.3 billion.

Table 6. Comparison of Construction Costs and Benefit-Cost Ratios for 26 Court Buildings

County	ID	Name	Court departments	Selected option*	Total construction cost (millions)	Benefit-cost ratio	Asset-life extension (years)
Imperial	13-A1	Imperial County Courthouse	7	4	$48.9	6.78	50
Lake	17-B1	Clearlake Branch Courthouse	1	4	$8.0	2.50	50
Los Angeles	19-O1	El Monte Courthouse	6	4	$41.0	2.28	50
Los Angeles	19-X1	West Covina Courthouse	11	1	$23.6	2.26	15
Contra Costa	07-F1	George D. Carroll Courthouse	8	4	$82.2	1.98	50
Santa Cruz	44-A1	Santa Cruz Courthouse	7	4	$49.8	1.91	50
Los Angeles	19-AD1	Santa Clarita Courthouse	3	1	$12.9	1.79	15
Los Angeles	19-W2	Pomona Courthouse North	7	4	$47.9	1.73	50
Napa	28-B1	Historical Courthouse (Napa)	4	4	$32.6	1.63	50
Alameda	01-F1	George E. McDonald Hall of Justice	3	2	$18.4	1.61	25

County	ID	Name	Court departments	Selected option*	Total construction cost (millions)	Benefit-cost ratio	Asset-life extension (years)
Los Angeles	19-AK1	Norwalk Courthouse	20	1	$45.9	1.07	15
Los Angeles	19-H1	Glendale Courthouse	8	2	$44.0	1.07	25
Orange	30-A1	Central Justice Center	65	2	$196.5	0.77	25
Orange	30-C1 C2	North Justice Center	18	1	$75.4	0.77	15
Los Angeles	19-G1	Burbank Courthouse	7	4	$50.4	0.76	50
Fresno	10-A1	Fresno County Courthouse	28	1	$103.0	0.65	15
Orange	30-B1	Lamoreaux Justice Center	29	2	$106.7	0.63	25
Los Angeles	19-K1	Stanley Mosk Courthouse	100	1	$461.3	0.58	15
Los Angeles	19-AO1	Whittier Courthouse	7	2	$54.3	0.57	25
Los Angeles	19-J1 J2	Pasadena Courthouse	19	5	$157.4	0.52	50
Contra Costa	07-A2	Wakefield Taylor Courthouse	12	2	$64.6	0.47	25
Los Angeles	19-AQ1	Beverly Hills Courthouse	6	4	$45.1	0.47	50
Los Angeles	19-AX2	Van Nuys Courthouse West	23	2	$160.4	0.46	25
Los Angeles	19-AP1	Santa Monica Courthouse	17	1	$50.5	0.43	15
Los Angeles	19-L1	Clara Shortridge Foltz Criminal Justice Center	60	2	$300.2	0.27	25
Los Angeles	19-I1	Alhambra Courthouse	9	1	$42.3	0.19	15

* Option 1: Baseline Retrofit
Option 2: Priority Upgrades Retrofit
Option 3: Full Renovation
Option 4: Replace to 2016 CBC
Option 5: Replace to Beyond Code

As described in the footnotes to Table 6, annual losses from fatalities are based on peak building populations and 90th percentile estimates of fatalities from the seismic risk assessment, likely resulting in an upper bound on annual losses from fatalities. In contrast, annual losses from repair costs and downtime are based on mean estimates of repair costs and downtime, respectively, which effectively translates into a higher weighting for losses stemming from fatalities. This higher weighting is consistent with the primary focus of the study: improving the seismic safety of the current existing court building. However, it inflates the BCRs relative to if an equivalent continuous occupancy (ECO) population were assumed for each court building. An ECO population accounts for the fact that the peak population persists for only a short period of time in a building over a typical year, so there is only a small probability that an earthquake would occur when the building is fully occupied. As a result, because the BCRs emphasize fatalities, they should not be considered absolute.

The detailed methodology report (Arup 2019) presents findings from a sensitivity study of the BCRs to the assumed building population to investigate whether the higher weighting given to fatalities might also change the relative rankings of the BCRs for each of the five retrofit or replacement options considered for each court building. In summary, changing the building population from peak to ECO, which typically reduces the number of fatalities reported by a factor of 4, does not change the relative order of the retrofit and replacement options. While the BCRs were not the only factor in the decision-making process, the sensitivity study demonstrates that changes to the assumed building population does not impact the selected option for each court building.

Figure 4 shows the number of court buildings per selected option. Approximately 60 percent of court buildings were selected for retrofit (Options 1, 2, or 3), while 40 percent were selected for replacement (Options 4 or 5). Figure 5 show the total gross floor area per selected option. Approximately 80 percent of gross floor area was selected for retrofit, while 20 percent was selected for replacement. Together, these figures illustrate the overall trend of replacing smaller court buildings while retrofitting larger ones.

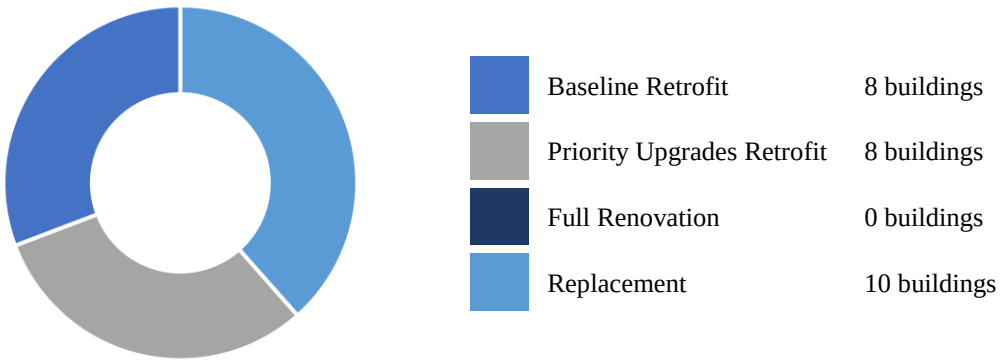

Figure 4. Number of Court Buildings Per Selected Option

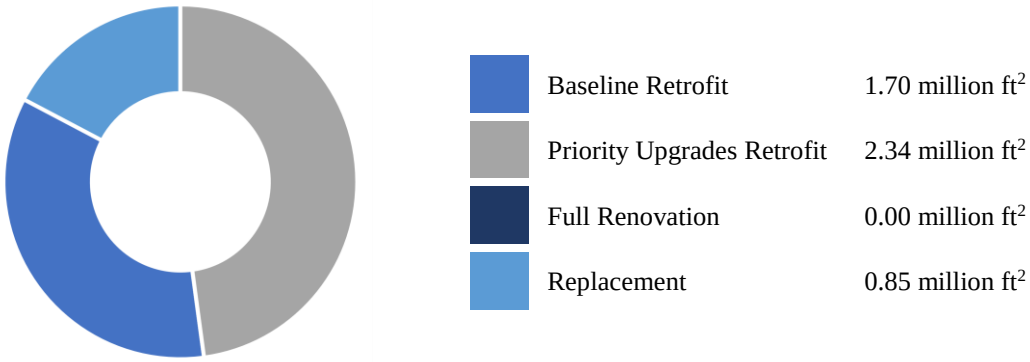

Figure 5. Total Area Per Selected Option

III. SUMMARY OF PROJECT RISKS AND ASSUMPTIONS

Table 7 summarizes important project risks and assumptions for the feasibility study, and describes the potential impact each item could have on the conceptual retrofit schemes, its collateral impacts, and its construction costs and duration. These items need to be considered in later phases of the project when more detailed designs of the seismic retrofit schemes or replacement facilities are completed.

Table 7. Summary of Important Project Risks and Assumptions

Category	Description	Impact
Analysis scope	The conceptual retrofit schemes developed for this study are based on limited information and seismic analysis. For example, no materials testing, geotechnical studies, or intrusive testing have been performed. Analytical models of the court buildings were not developed. Furthermore, design optimization has not been carried out (i.e., minimizing collateral impacts and construction costs). While this is appropriate for budgetary checking, more thorough engineering studies would need to be performed prior to construction.	More thorough studies could impact construction costs and collateral impacts.
Asbestos abatement	For many court buildings, the Judicial Council database indicates the presence of asbestos. While the cost estimates for retrofit developed for this study include abatement, further study is required to understand the full extent and impact of asbestos contamination.	Depending on the extent of asbestos, its presence could impact construction costs.
Cost estimates for replacement court buildings	Replacement court buildings are assumed to be constructed on land near existing facilities. As a result, cost estimates for replacement buildings do not include rental costs for temporary space because the court can occupy the existing facility until the new one is finished. Land costs are also not included.	If suitable land is not available, an existing facility may need to be demolished before a new one can be built, which would impact construction costs and duration.
Facade connections	For some court buildings, the conceptual retrofit scheme assumes existing facade connections are deficient. Consequently, the facade is removed and replaced with a lightweight design. However, further investigation of the connections is required as part of detailed retrofit design.	If the facade connections are adequate, it could reduce construction costs and collateral impacts.
Liquefaction	Some court buildings have high liquefaction risk. The conceptual retrofit scheme does not mitigate this risk. To determine the extent of foundation retrofit required, a site-specific geotechnical investigation is required.	If foundation strengthening is required, it could impact construction costs and collateral impacts.
Historical elements	While none of the 26 court buildings is on the state or federal historical register, some are local points of historic interest, which could limit the range of possible interventions. Therefore, to the extent practical, the conceptual retrofit scheme avoids modifying of the following items: exterior appearance of the building, interior public spaces (e.g., lobbies), and courtrooms.	If a court building is placed on the state or federal historical register, it could impact construction costs and collateral impacts.

IV. REFERENCES

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APPENDIX A. ABBREVIATIONS AND GLOSSARY

A. Abbreviations

ASCE	American Society of Civil Engineers
BCR	benefit-cost ratio
CBC	California Building Code
CBSC	California Building Standards Commission
FEMA	Federal Emergency Management Agency
R+C	Rutherford + Chekene
SRR	seismic risk rating

B. Glossary

Asset-life extension – For a given retrofit or replacement option, the assumed life time of a building before further necessary building-wide renovation or replacement renovation is required. This is used to calculate total benefit. Asset-life extension is not a prediction of the length of actual court occupancy in a particular building.

Baseline retrofit option (Option 1) – A retrofit option that represents the minimum level of effort and expenditure to mitigate the seismic risk at a court building, including seismic upgrades to structural and nonstructural components (e.g., stairs, elevators, ceilings, lights, partitions) to achieve Risk Level IV performance, nonstructural repairs made necessary by the retrofit, and triggered upgrades to accessibility and fire and life safety systems.

Building segment – A portion of a building that may respond independently of other sections in an earthquake. Building segments can have very different properties (e.g., construction material and number of floors) and be built at different times, but from an operational perspective, they typically function together as a single facility.

Building type – A classification that groups buildings with common seismic-force-resisting systems and performance characteristics in past earthquakes. The building types relevant to the 26 court buildings in this study include those listed in the table below (ASCE 2003):

Type	Description
C1	Concrete moment frames
C2	Concrete shear walls with stiff diaphragms
C2A	Concrete shear walls with flexible diaphragms
PC1A	Precast/tilt-up concrete shear walls with stiff diaphragms
RM1	Reinforced masonry bearing walls with flexible diaphragms
RM2	Reinforced masonry bearing walls with stiff diaphragms
S1	Steel moment frames with stiff diaphragms
S2	Steel braced frames with stiff diaphragms

Type	Description
S4	Steel frames with concrete shear walls
URM	Unreinforced masonry bearing walls with flexible diaphragms

California Building Code (CBC) – The set of regulations in California that governs how new buildings are designed and constructed.

Collapse probability – The likelihood that a building will either partially or totally collapse in an earthquake. FEMA P-154 (2015) defines *collapse* as when the gravity load carrying system in part or all of the building loses the ability to carry the weight.

Collateral impacts – Repair work to nonstructural components (e.g., walls, ceilings, lighting, carpeting) made necessary by the seismic retrofit.

Full renovation option (Option 3) – A retrofit option that includes the same seismic upgrades to structural components as the baseline retrofit option, plus full demolition and replacement of the interior down to the structural skeleton and removal of the exterior wall and roof cladding. Note that the budget for the nonstructural components is based unit costs per square foot, and no design was performed as part of this study.

Nonstructural components – Architectural, mechanical, and electrical components of a building permanently installed in or integral to a building system.

Phased construction – A scenario in which the court building would be kept open and operational during the retrofit, requiring the work would need to be done in multiple phases either by floors or zones of the buildings.

Priority upgrades – A list of approved, unfunded facility modifications at a court building. Priority upgrades do not include all possible maintenance needs at a court building.

Priority upgrades retrofit option (Option 2) – A retrofit option that includes the same upgrades as the baseline retrofit option, plus any priority upgrades. This retrofit option was included in the study because seismic retrofits often provide an opportunity to upgrade outdated or deficient building systems (which would normally be highly disruptive) at relatively little additional cost

Replace to 2016 CBC option (Option 4) – A replacement option that involves replacing an existing court building with a new facility that satisfies Risk Category III requirements of the 2016 California Building Code (CBC). Risk Category III refers to "buildings and structures that could pose a substantial risk to human life in case of damage or failure," including those with a potential to cause "a substantial economic impact and/or mass disruption of day-to-day civilian life" (ASCE 2013). California Superior Court buildings are classified as Risk Category III because of the consistent large density of occupants in these public buildings.

Replace to beyond code option (Option 5) – A replacement option that involves replacing an existing court building with a new facility that goes beyond the minimum requirements of the 2016 CBC to achieve more resilient seismic performance (e.g., reduced damage, repair costs, and downtime).

Seismic risk rating (SRR) – A ranking based on the relative probability of collapse in a seismic event as estimated by a Hazus model of the building, which considers the structural capacity of the building, site-specific seismic hazard, and structural characteristics that influence the capacity or response to earthquakes. Court buildings with SRRs exceeding 10 are classified as Very High Risk, while those with SRRs between 2 and 10 are classified as High Risk.

Structural components – Components of a building that provide gravity- or lateral-load resistance as part of a continuous load path to the foundation, including beams, columns, slabs, braces, walls, wall piers, coupling beams, and connections.

Unphased construction – A scenario in which the court building is closed and vacated during construction, requiring court staff and functions to be relocated to a temporary facility.