Los Angeles Soft, Weak, or Open-Front Wall Line Ordinance Retrofit Example

SEAOSC EBC Task Group

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Review Panel

LADBS • SEAOSC Board • SEAOSC Seismology Committee

Intent of the Ordinance

- The intent of the ordinance is to eliminate a specific deficiency, ***not*** to bring a building “up to code”.
- The building ***may*** still have other seismic deficiencies. The design professional must make the owner aware that other such deficiencies may still exist in the structure.

§91.9302 Scope

Wood-frame buildings:

1. Built under building code standards enacted before January 1, 1978.
2. The **ground floor** portion of the structure contains parking or other similar open floor space that causes **soft, weak, or open-front wall lines**, and there exists one or more stories above.

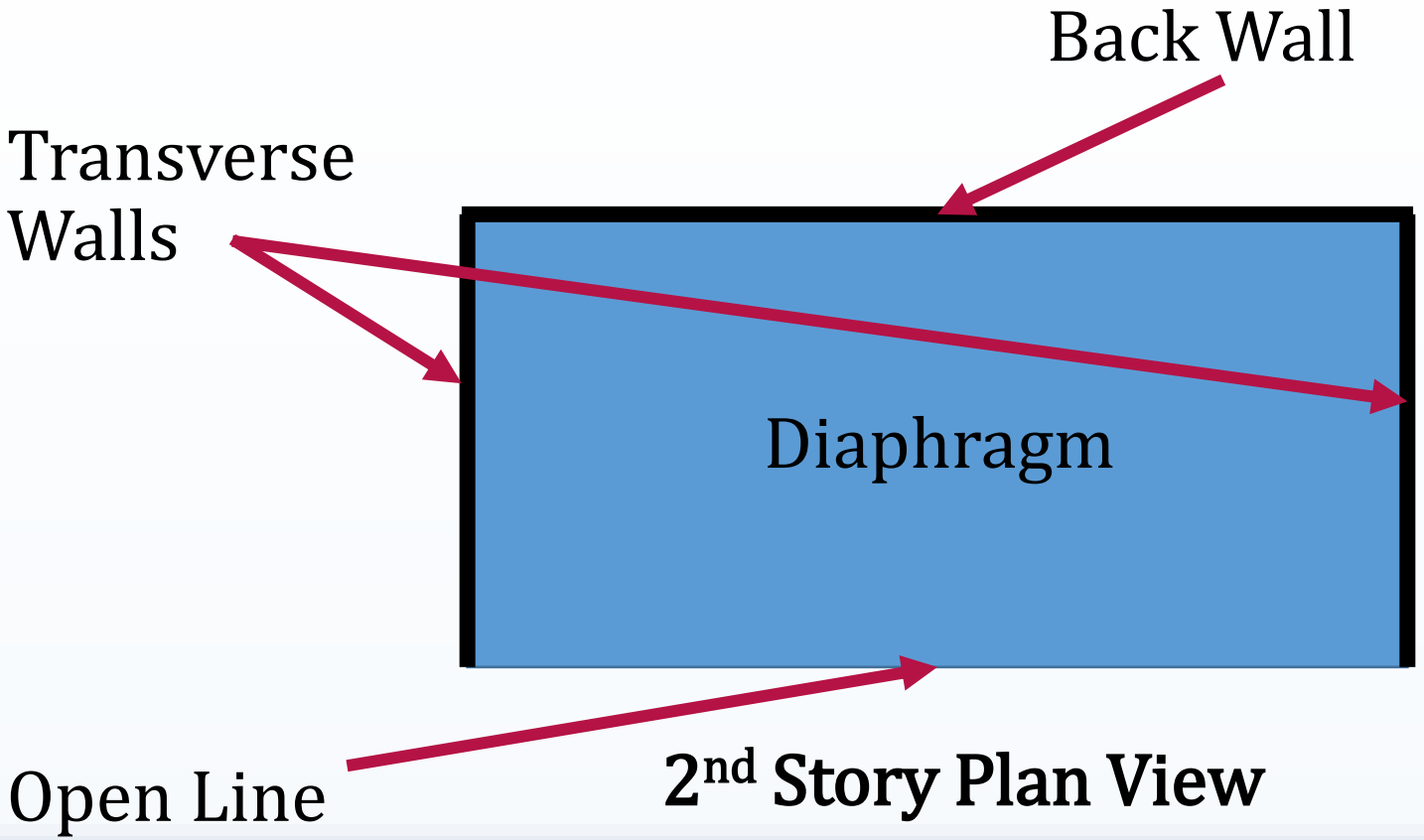
§91.9303 Definitions

<u>Open-Front Wall Line</u>:

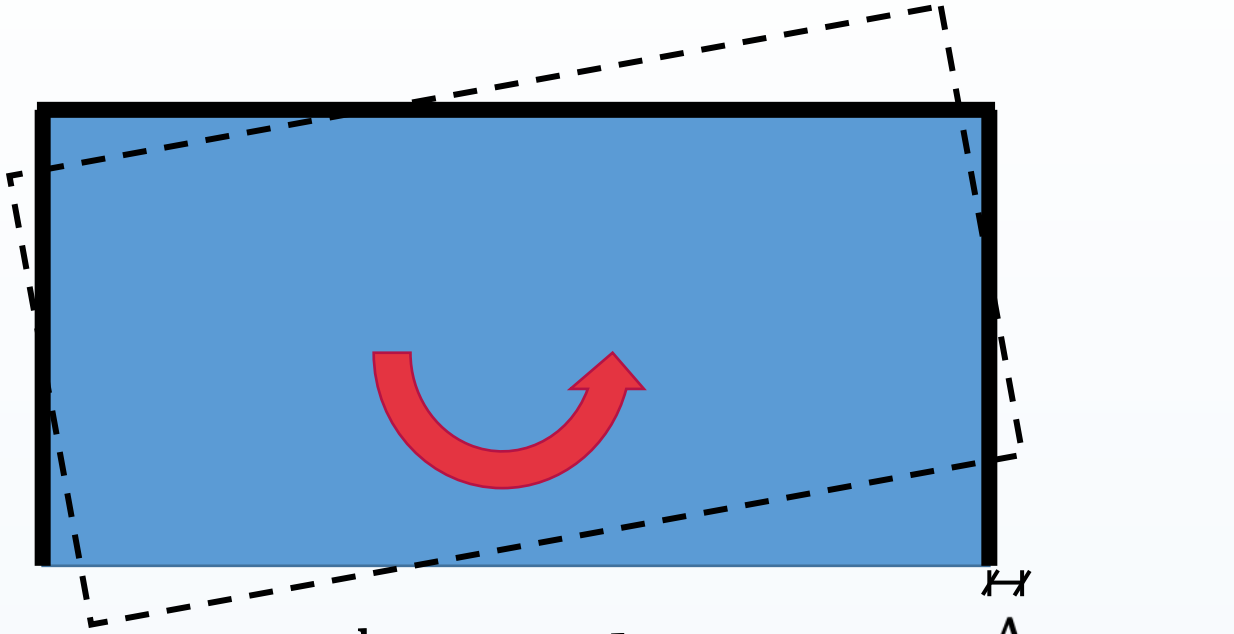
"Exterior wall line, without vertical elements of the lateral force-resisting system, which requires tributary seismic forces to be resisted by diaphragm rotation or excessive cantilever beyond parallel lines of shear walls…"

Tuck under parking only in part of the line

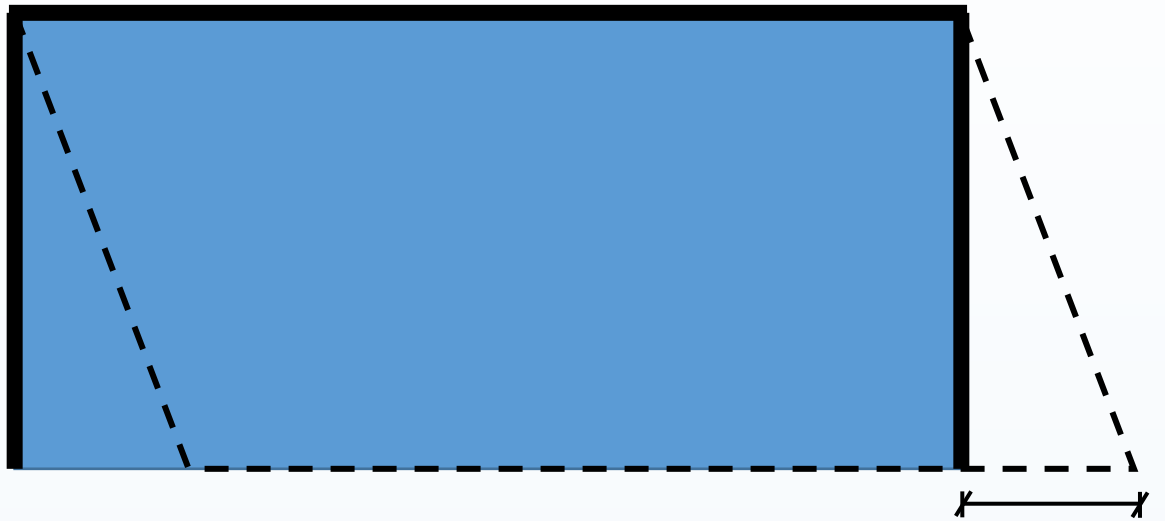
Primary Target of the Ordinance: Open Line Condition



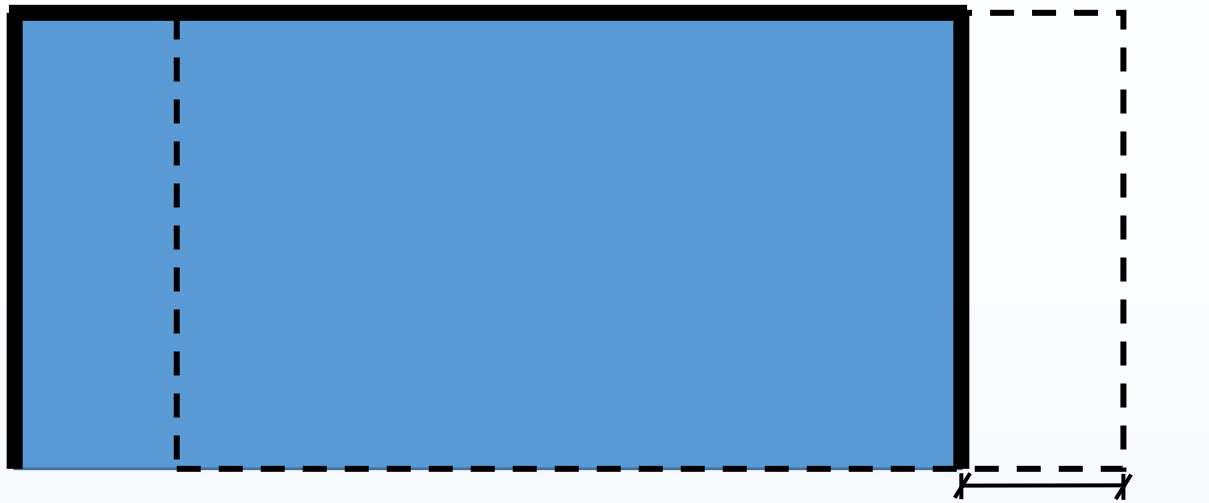
Deflection on Open Line due to Diaphragm Rotation



Deflection on Open Line due to Diaphragm Shear Deformation



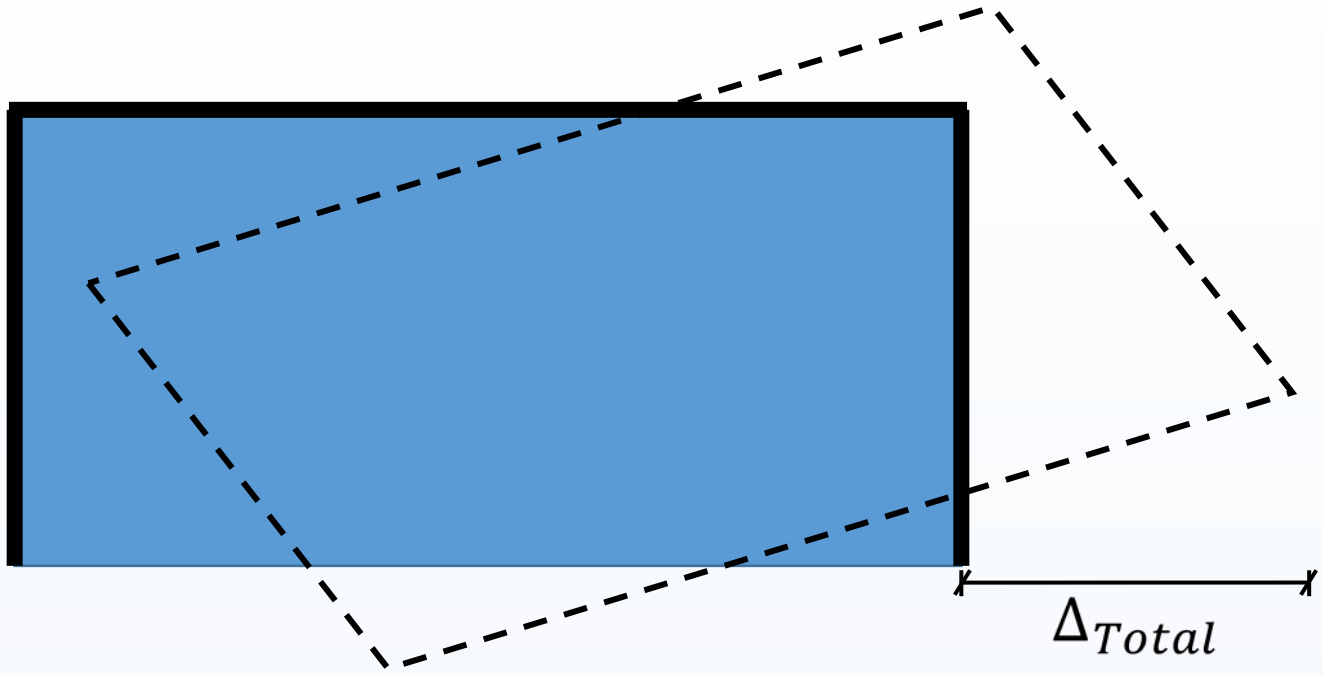
Deflection on Open Line due to Back Wall Deflection



2nd Story Plan View

Total Deflection on Open Line due to Diaphragm Shear Deformation

Buildings subject to the ordinance were not designed for this condition. The drift is excessive on the open line.



2nd Story Plan View

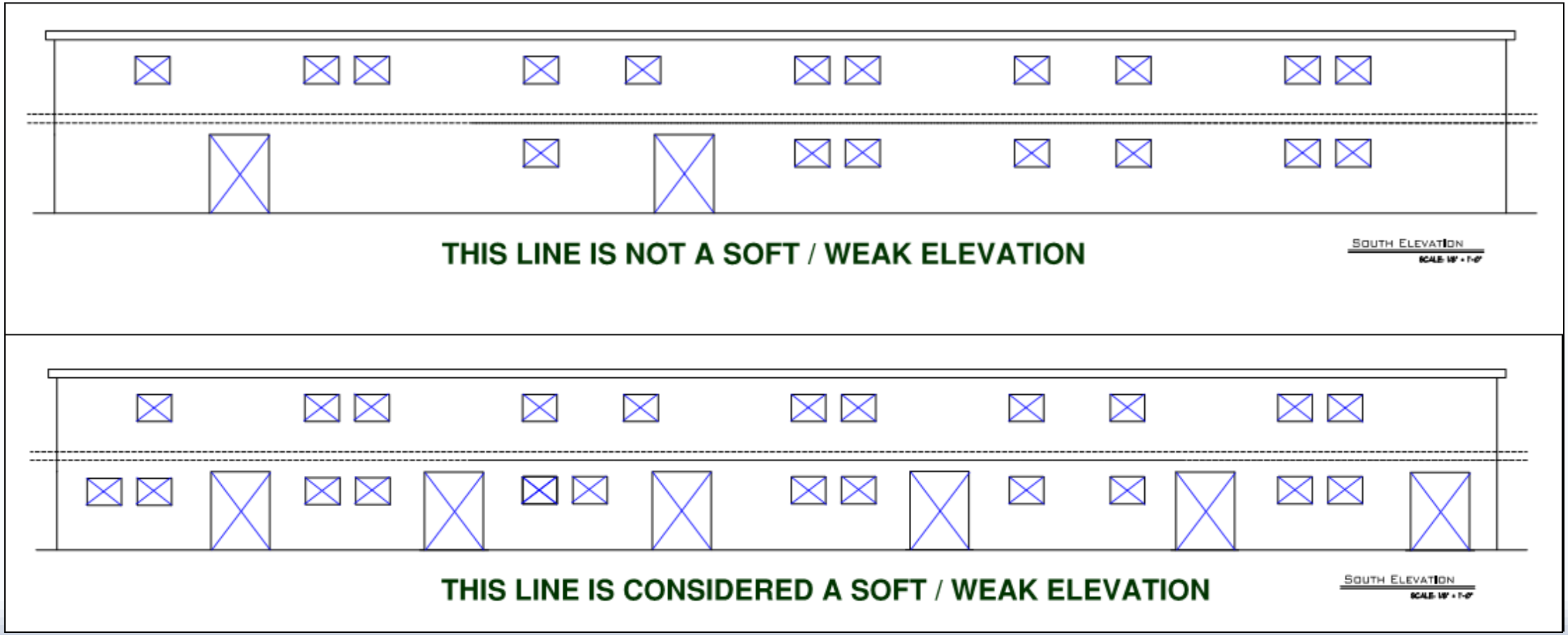
§91.9303 Definitions

Soft Wall Line: "… a soft wall line may be defined as **a wall line** in a story where the wall stiffness is less than **70 percent of the stiffness of the exterior wall above** for the direction under consideration."

Weak Wall Line: "**a wall line** at the **ground floor** where the wall strength is less than **80 percent of the strength of the wall above** in the direction under consideration."

Tuck under parking only in part of the line

Soft / Weak Wall Lines



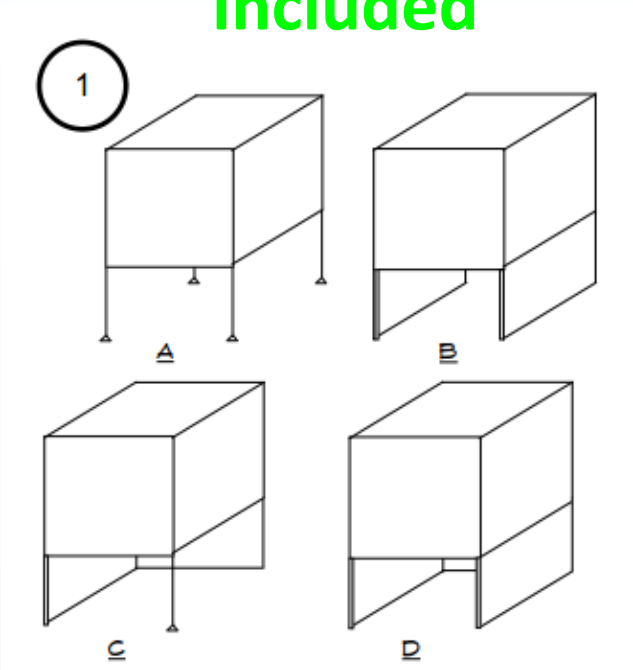
§91.9303 Definitions

Ground Floor:

"is any floor within the wood-frame portion of a building whose elevation is **immediately accessible from an adjacent grade by vehicles or pedestrians**. The ground floor portion of the structure does ***not*** include any floor that is completely below adjacent grades"

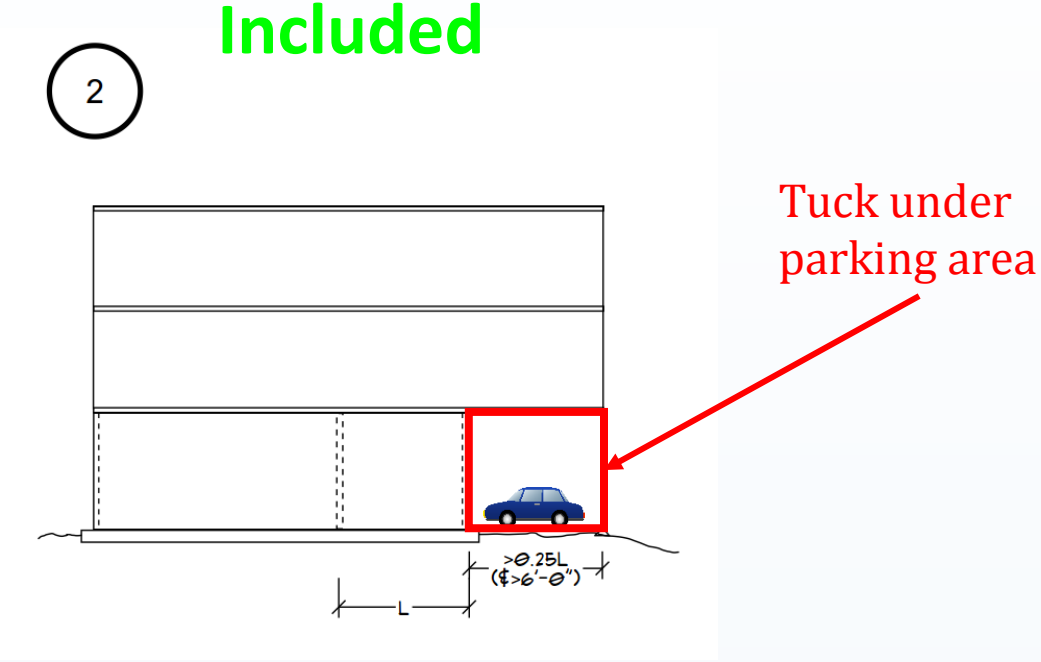
Targeted Buildings

Included



Classic open lines

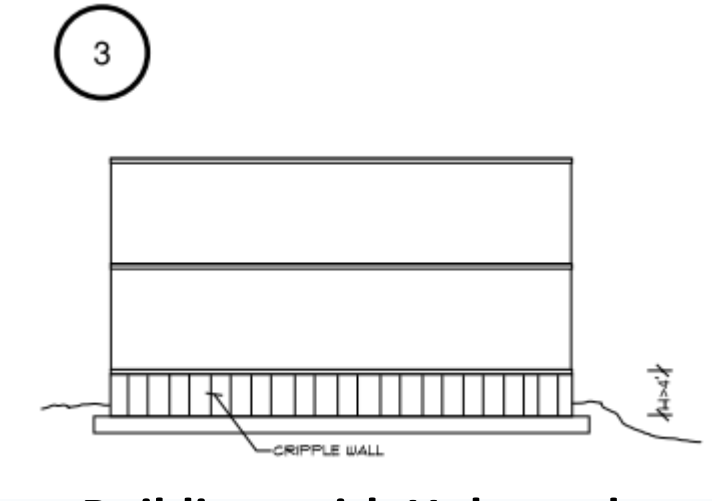
Included



Cantilever Diaphragm

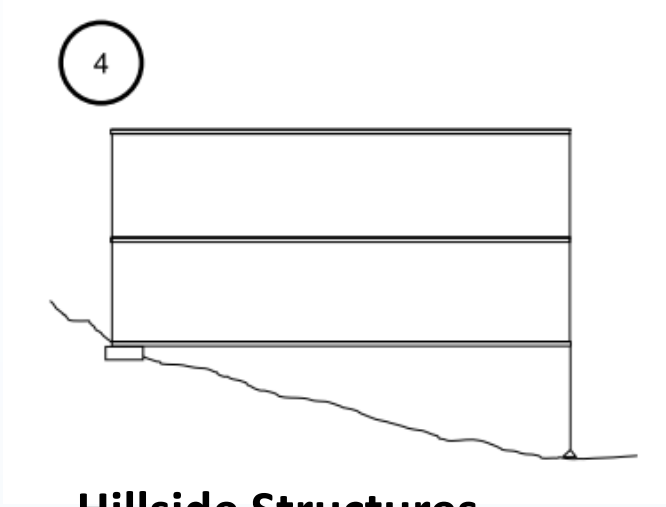
Targeted Buildings continued…

Not Included



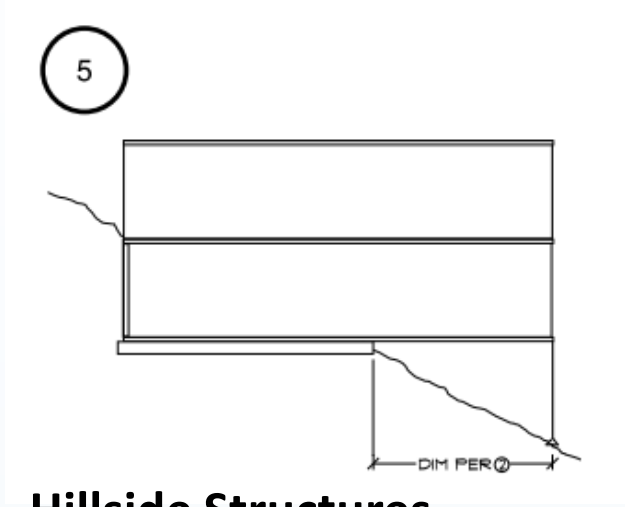
Buildings with Unbraced Cripple Wall

Included*



Hillside Structures with Open Lines

Included*



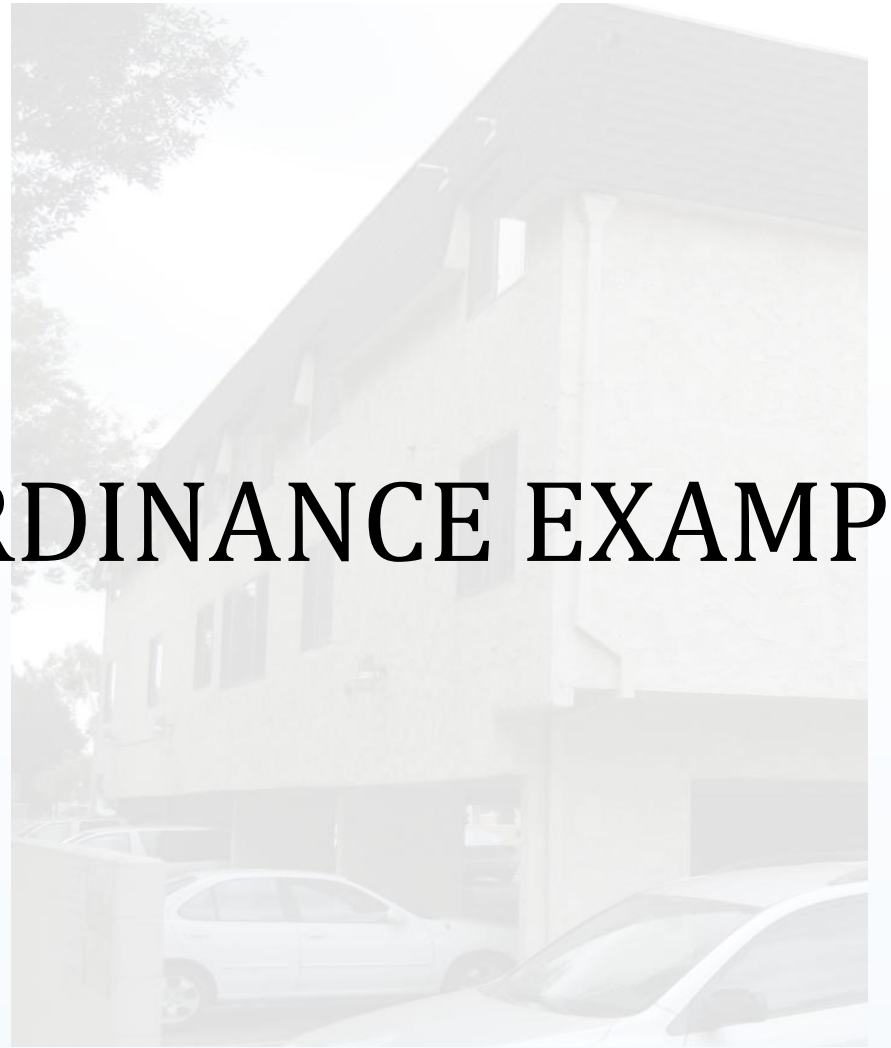
Hillside Structures with Open Lines at Partial Ground Floor Level

Hillside structures to meet requirements of Division 94

Allowable Methodologies

1. Prescriptive design based on the Ordinance (99% cases)
2. ASCE 41-13?
3. FEMA P807?

91.9309.5. Alternate Analysis, Base Shear and Design Parameters. Pursuant to Section 91.104.2.6, the Department may approve alternate design methodologies that improve the whole first story seismic performance that are at least equivalent to those prescribed by this division and that achieve the life safety objectives established by this division.



ORDINANCE EXAMPLE

Open Front Structure Being Analyzed

Open Front Line

- Open Front View from Left
- Open Front View from Right

Soft/Weak Line in Plan View

1. Identify the open line being analyzed.

2. Identify other irregularities that may require additional mitigation set forth by either the ordinance or ASCE 7-10 per §91.9309.4.

3. If a structure with 3 or more stories has an irregularity, additional design considerations may be required.

Horizontal Irregularities

91.9309.4. Horizontal Structural Irregularities in Buildings with Three or More Stories. Structures with three or more stories having horizontal structural irregularities of either type 2, 3, 4, or 5 listed in ASCE 7, "Horizontal Structural Irregularities" Table, shall be altered to meet the additional requirements of those sections referenced in the table for the entire story with weak or open wall lines.

2.	**Reentrant Corner Irregularity:** Reentrant corner irregularity is defined to exist where both plan projections of the structure beyond a reentrant corner are greater than 15% of the plan dimension of the structure in the given direction.
3.	**Diaphragm Discontinuity Irregularity:** Diaphragm discontinuity irregularity is defined to exist where there is a diaphragm with an abrupt discontinuity or variation in stiffness, including one having a cutout or open area greater than 50% of the gross enclosed diaphragm area, or a change in effective diaphragm stiffness of more than 50% from one story to the next.
4.	**Out-of-Plane Offset Irregularity:** Out-of-plane offset irregularity is defined to exist where there is a discontinuity in a lateral force-resistance path, such as an out-of-plane offset of at least one of the vertical elements.
5.	**Nonparallel System Irregularity:** Nonparallel system irregularity is defined to exist where vertical lateral force-resisting elements are not parallel to the major orthogonal axes of the seismic force-resisting system.

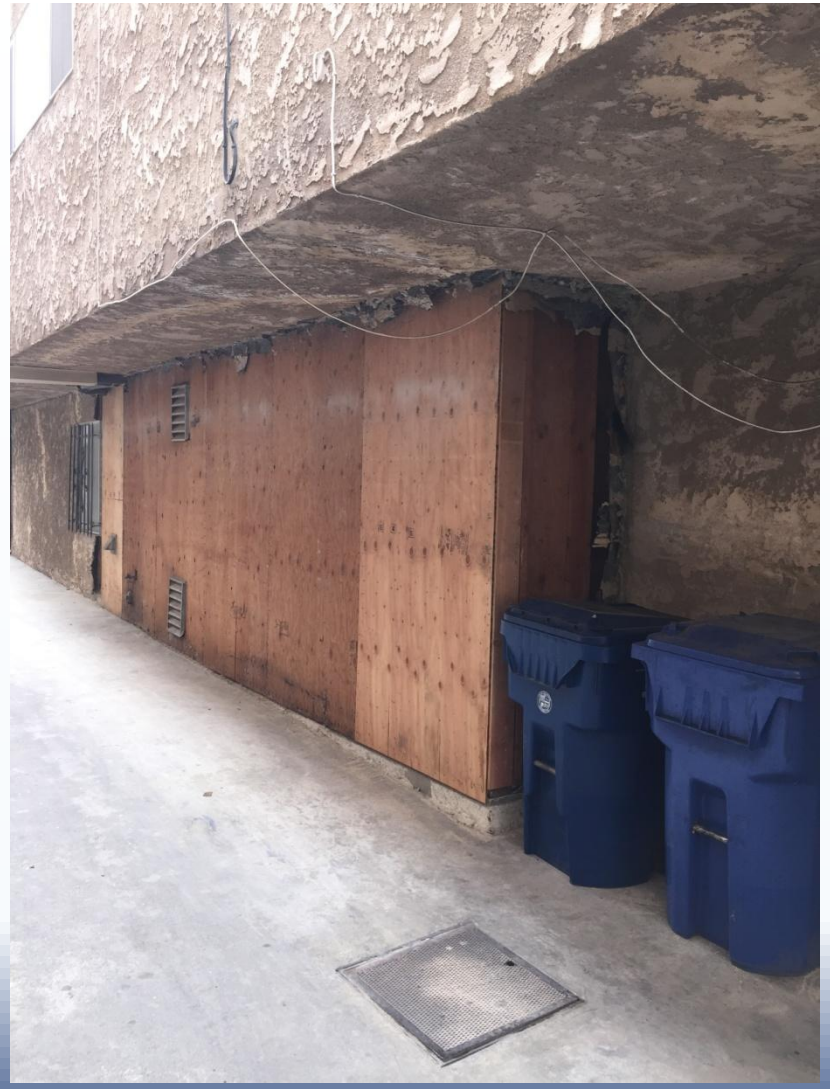
Investigate Existing Building's Lateral System

1. Material used for the sheathing on the levels above the open line?

   For example, Stucco, Plaster, Let-in brace, Plywood (if so nailing pattern)

2. If existing drawings are available the lateral system should be easy to determine. This may not be typical. Usually some destructive testing will be required prior to starting the design.

3. For the design example we have assumed a **STUCCO** shear wall.



Existing Load Take Off

Using either existing drawings or by performing exploratory field investigations determine appropriate estimates for the roof and floor loads on the existing structure.

Roof Loads

Dead Loads	Gravity
Comp Roofing	2.5 psf
Plywood Sheathing	2.5
Insulation	1.0
Framing	3.50
Ceiling	3.0
Misc	0.5
Total Dead Load	**13.0 psf**
Roof Live Load =	**20.0 psf**

1st & 2nd Floor Loads

Dead Loads	Gravity
Flooring	4.0 psf
Plywood Sheathing	2.5
Framing	4.0
Ceiling	3.00
Partition	10.0
Misc	1.5
Floor Dead Load =	**25.0 psf**
Floor Live Load =	**40.0 psf**

Allowable Systems

Compatible Systems:

- Plywood Shear Wall
- Moment Frames

Incompatible Systems (too stiff):

- Braced Frames
- Concrete Shear Walls
- CMU Shear Walls

Other systems may be used with approved engineering analysis using a 3D model

Line Retrofit

- The line should be retrofitted in a way that it does not contribute to a soft or weak line.
- The strength and drift capacity of the upper levels must be considered and destructive investigation is required if there are no existing drawings.
- The Prescriptive Method allows the Design Professional to use R=3.5 and a drift limit of 2% to meet the strength and drift requirements without destructive investigation. See Los Angeles Information Bulletin P/BC 2014-137.

Proposed Two-Bay Steel Moment Frame

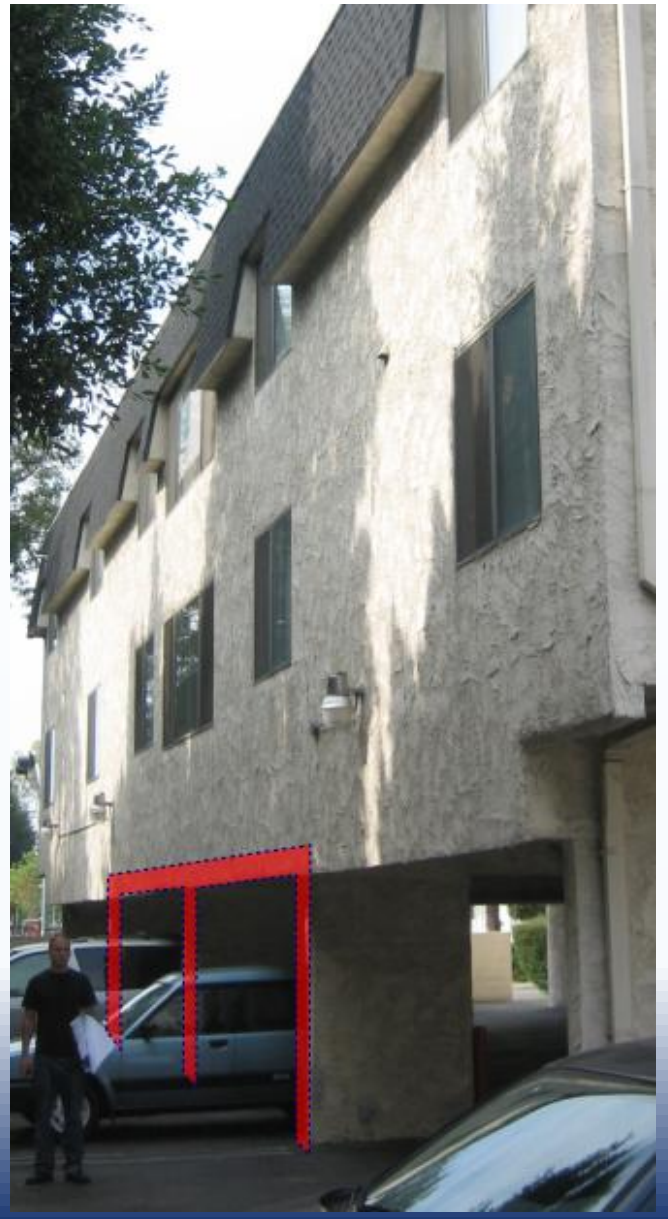
1. Frame will be mounted on the outside of the structure.

2. Enlarged pad footings for the moment frame column supports.

3. New grade beams or tie beams connecting the footings together for shear transfer and/or base fixity.

4. Frame bracing shall be designed and installed as required per the AISC specifications.

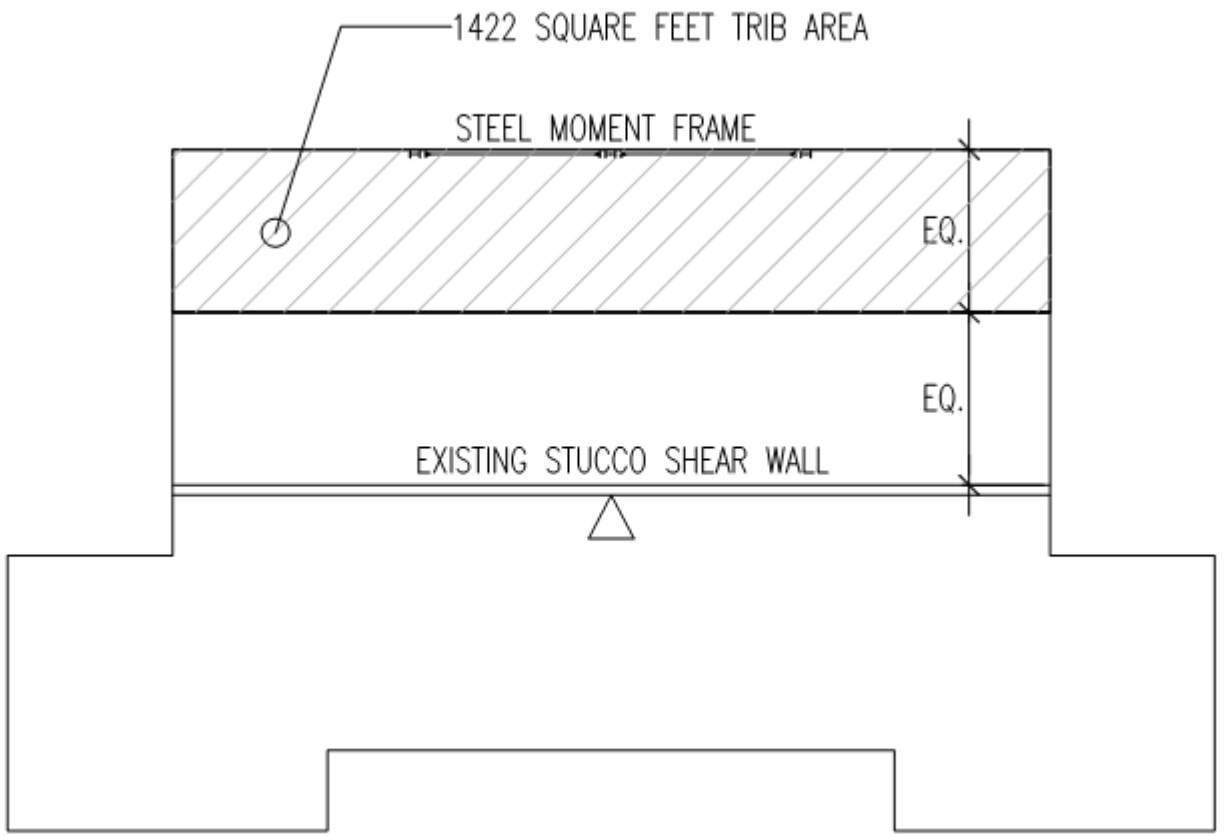
5. Collector elements shall be added or strengthened to comply with ASCE7.



Schematic Plan View of Lateral Systems

1. Determine the first line of lateral resistance beyond the open front line.

2. Determine the tributary area to moment frame. Assuming a flexible diaphragm for the analysis.



Determine Seismic Demand to Open Line

Design Force=0.75*(ASCE 7-10 Determined Force)

Common Systems above Open Line		R	Ω_0	C_d
15. Light-frame (wood) walls sheathed with wood structural panels rated for shear resistance or steel sheets	14.1 and 14.5	6½	3	4
Other sheathing materials		**3.5**	**3**	**3**

12.2.3.1* R, C_d, *and* Ω_0 *Values for Vertical Combinations

Where a structure has a vertical combination in the same direction, the following requirements shall apply:

1. Where the lower system has a lower Response Modification Coefficient, *R*, the design coefficients (*R*, Ω_0, and C_d) for the upper system are permitted to be used to calculate the forces and drifts of the upper system. For the design of the lower system, the design coefficients (*R*, Ω_0, and C_d) for the lower system shall be used. Forces transferred from the upper system to the lower system shall be increased by multiplying by the ratio of the higher response modification coefficient to the lower response modification coefficient.
2. Where the upper system has a lower Response Modification Coefficient, the Design Coefficients (*R*, Ω_0, and C_d) for the upper system shall be used for both systems.

EXCEPTIONS:

1. Rooftop structures not exceeding two stories in height and 10 percent of the total structure weight.
2. Other supported structural systems with a weight equal to or less than 10 percent of the weight of the structure.
3. Detached one- and two-family dwellings of light-frame construction.

Design Force with R=3.5 for Stucco Shear Walls

Seismic Weight (W) = 129 kips

$C_s = 0.75 \times S_{DS}/R$ where:

0.75 is the force reduction factor per the Ordinance

$S_{DS} = 1.45$

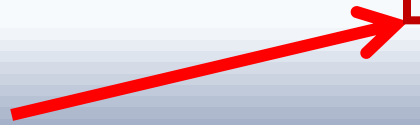
R = 3.5 for stucco walls lateral system above the open line

(R value per Los Angeles Bulletin P/BC 2014-137)

$C_s = 0.311$

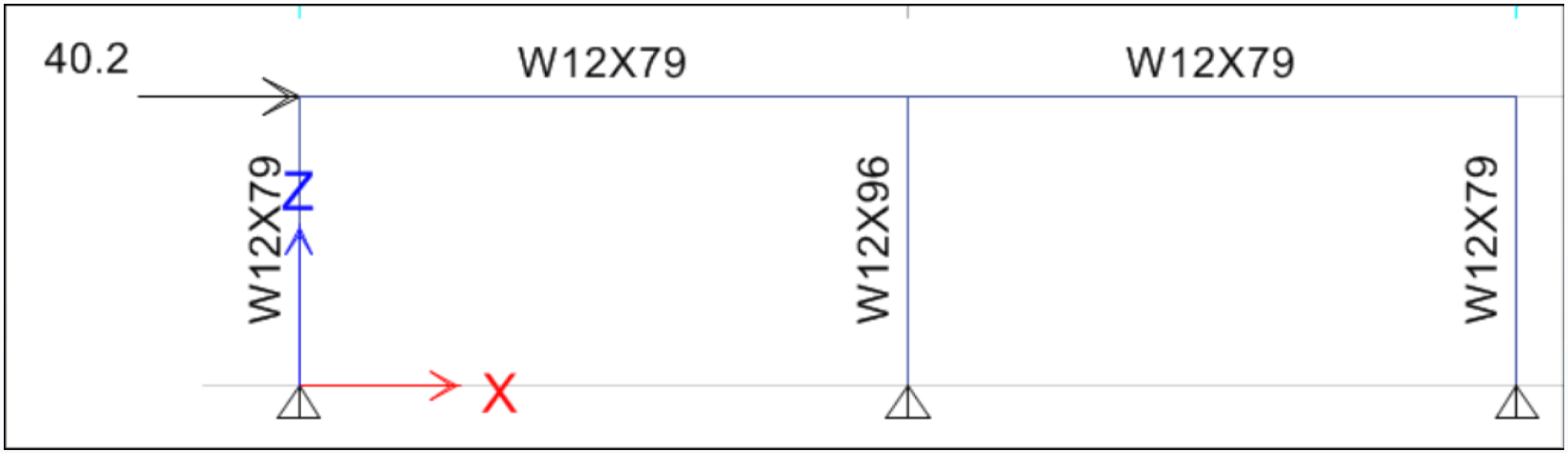
Shear Demand Along the Open Line

$V = C_s \times W = 0.311 \times 129$ kips = **40.2 kips (Prescriptive Approach Design Force)**



Design Frame Based on Governing Seismic Force

- Maximum design force = 40.2 kips



Allowable Column Sizes

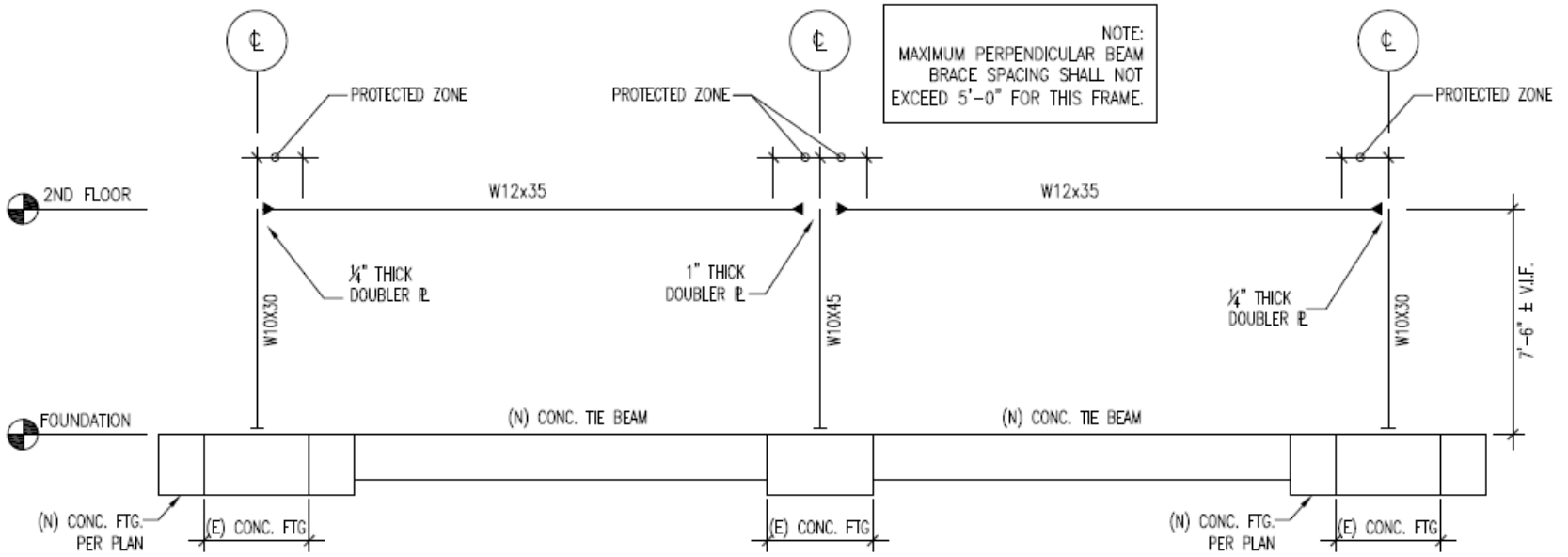
- The column width shall be kept at a minimum as it will affect the parking stall widths and tenants accessibility.

- Many of these structures will require a modification from the city since the stall width will be less than allowed by current city standards.

Allowable Beam Sizes

- Each project may have different tolerances for the allowable moment frame beam depth.
- Typically a W12x or W14x will fit, but the engineer of record shall perform a structural observation to field verify the allowable beam depths prior to the design.
- It is ideal to match the existing beam depth and install with the bottom flanges of both beams flush.
- Deeper beams are structurally acceptable, if minimum clearance heights have been confirm with in field measurements.

Typical Moment Frame Elevation



NOTE:

1.CONTRACTOR TO FIELD VERIFY ALL DIMENSIONS PRIOR TO FABRICATION.

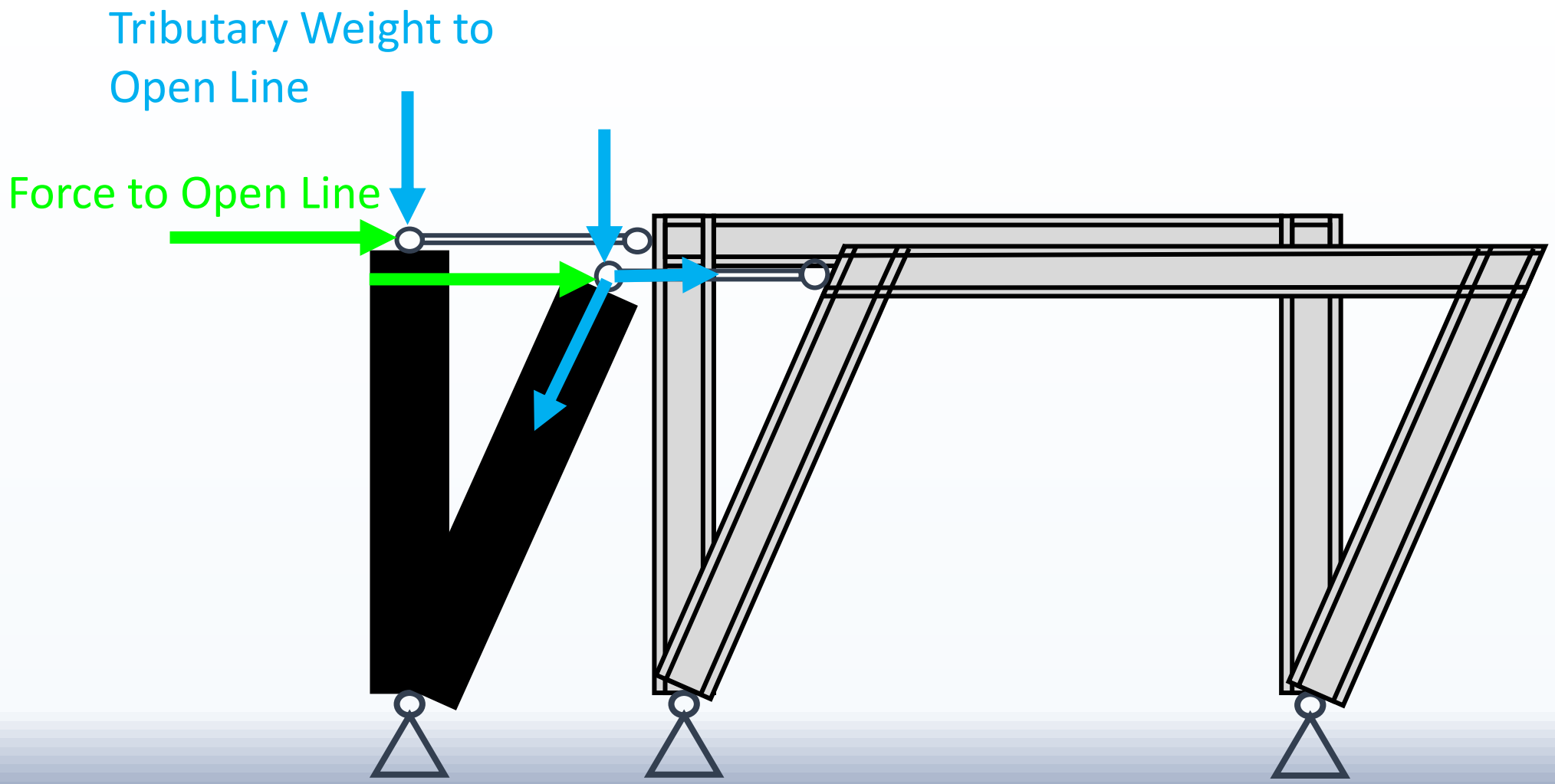
2. REFER TO SPECIFICATIONS, TABLES, AND NOTES ON TYPICAL DETAILS FOR STANDARD QUALITY ASSURANCE PLAN FOR STEEL MOMENT FRAMES.

STEEL MOMENT FRAME ELEVATION, 2 BAYS

SCALE: ¼"=1'-0"

1
-

P-Delta effects (Leaning Column)



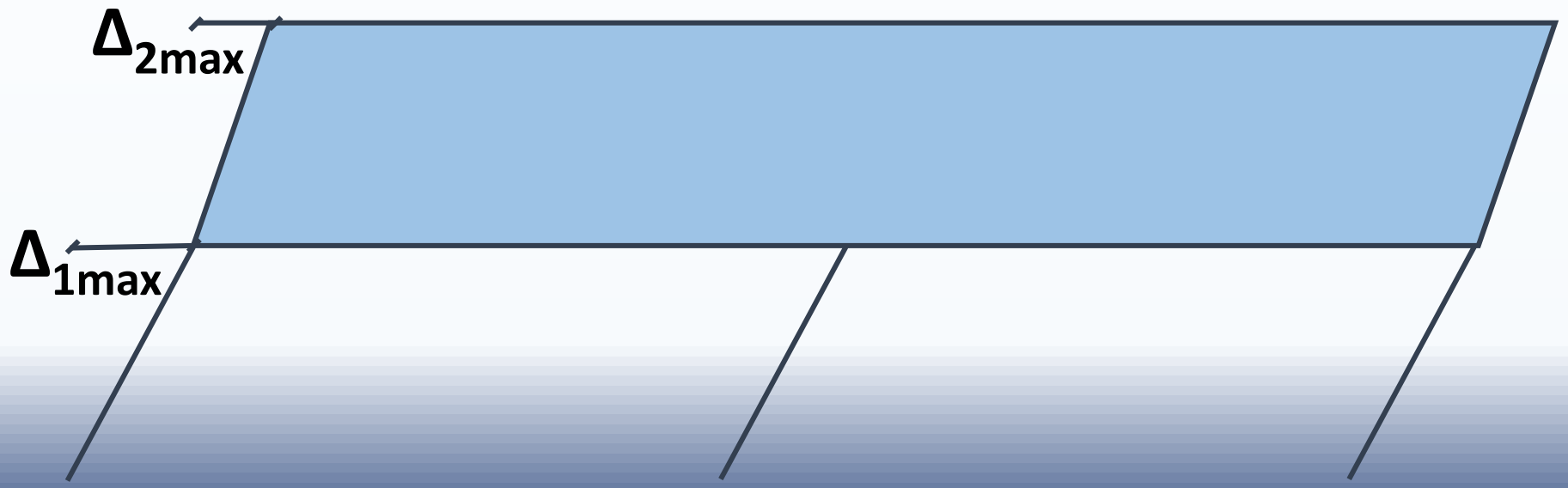
Drift Limit on Open Line

- **Plywood shear wall lateral system above the open line.**

$\Delta_{1max} = \Delta_{2max} / 0.7 < 0.025*h$

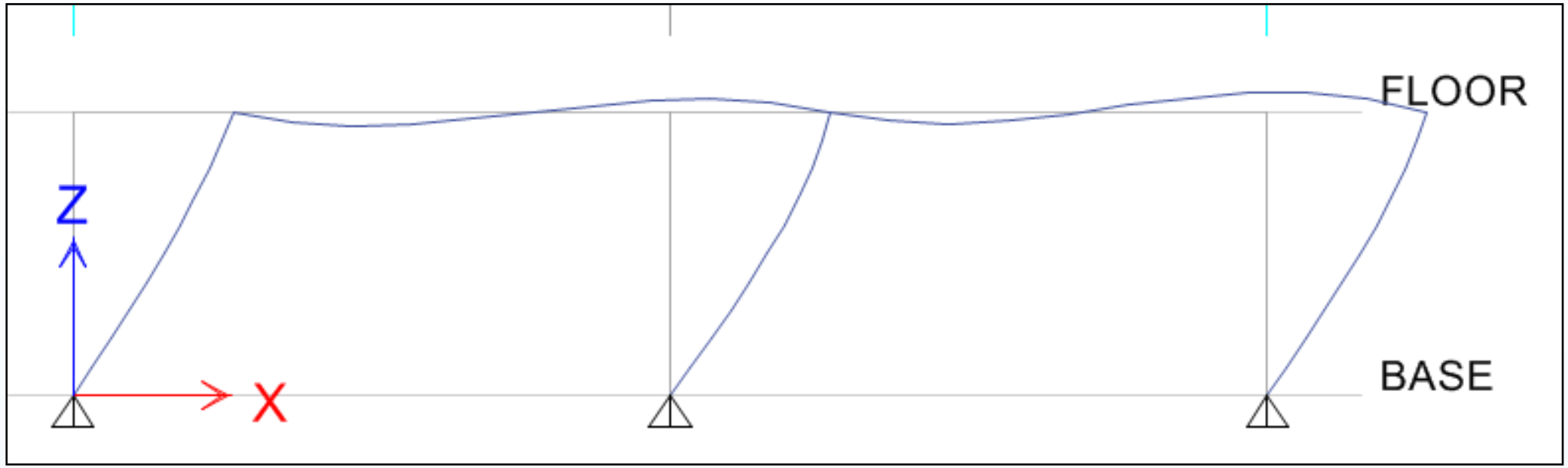
- **Other shear wall lateral system above the open line.**

$\Delta_{1max} = \Delta_{2max} / 0.7 < 0.020*h$



Design Frame Based on Governing Seismic Force

- Maximum deflection = 0.70” x (Cd = 3) = 2.10”
- Maximum allowable deflection = (9.25ft) x (12in/ft) x (2%) = 2.22” … OK



Collector Design

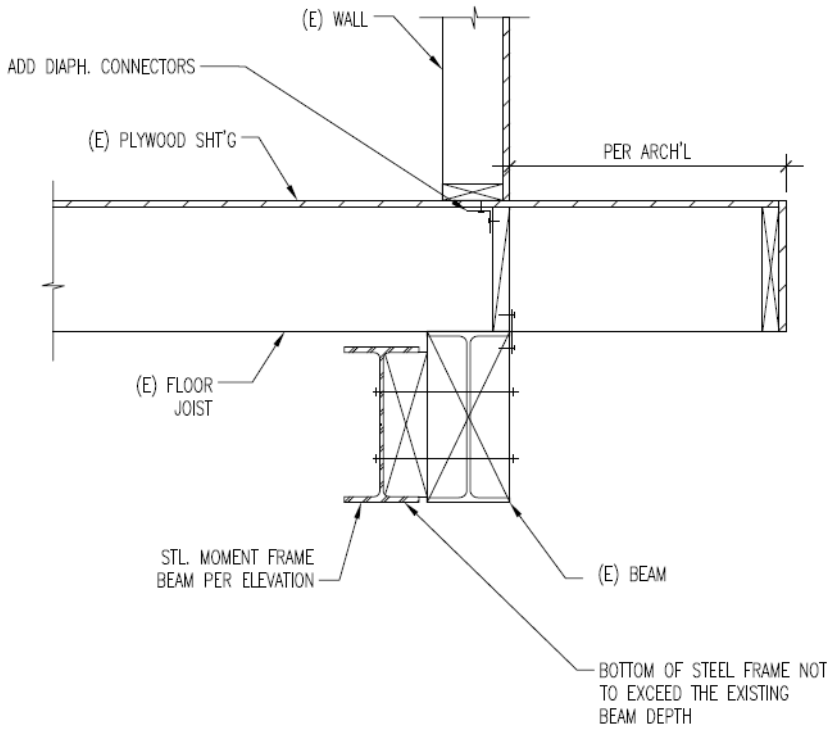
- A continuous collector that brings forces to the system used to retrofit the open line must be designed as part of a complete load path.
- The Over Strength Factor for the governing lateral force resisting system shall be used unless the design of the frame is a capacity based design.
- If irregularities occurs the design forces shall be multiplied by 1.25 per ASCE 7-10 section 12.3.3.4

12.3.3.4 Increase in Forces Due to Irregularities for Seismic Design Categories D through F

For structures assigned to Seismic Design Category D, E, or F and having a horizontal structural irregularity of Type 1a, 1b, 2, 3, or 4 in Table 12.3-1 or a vertical structural irregularity of Type 4 in Table 12.3-2, the design forces determined from Section 12.10.1.1 shall be increased 25 percent for the following elements of the seismic force-resisting system:

1. Connections of diaphragms to vertical elements and to collectors.
2. Collectors and their connections, including connections to vertical elements, of the seismic force-resisting system.

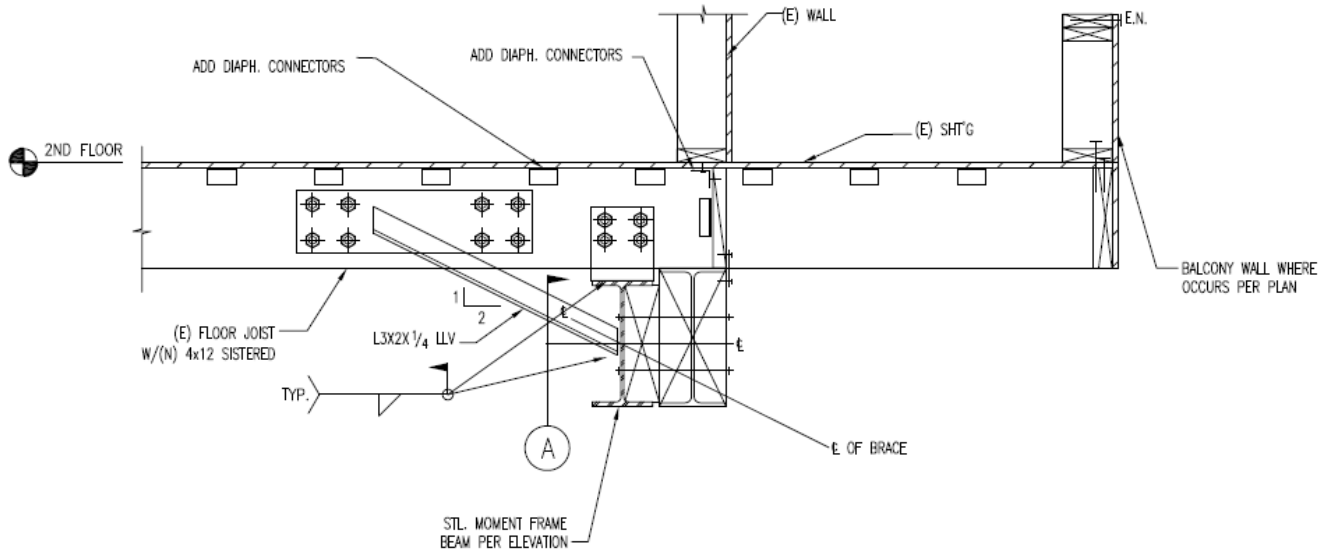
Connections @ Moment Frame



SECTION @ MOMENT FRAME BEAM BETWEEN BRACE LOCATIONS

2

SCALE: N.T.S.



MOMENT FRAME SECTION @ PLASTIC HINGE & NODAL BRACING

3

SCALE: N.T.S.

Foundations

Proper fixity assumptions

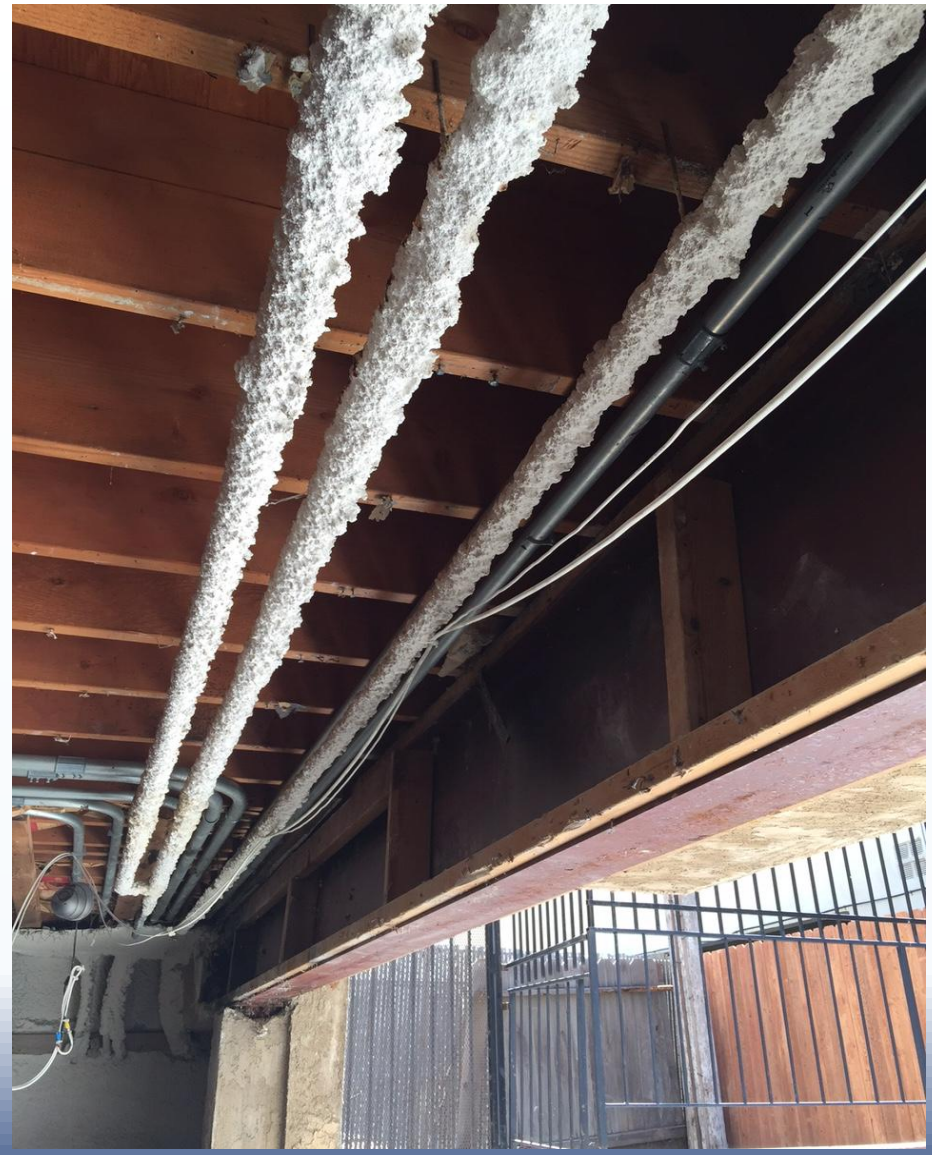
- Pinned base
  - Surface Base Plate
- Fixed base
  - Embedded column
    - Grade beam must be designed for resulting internal forces

Sliding, Bearing, and Overturning

- Default values for soil coefficient of friction, allowable vertical bearing pressure, and allowable lateral bearing pressure can be found in CBC §1806
- The alternative procedure in ASCE 41-13 §8.4.1.1 to determine allowable bearing pressure values can be used with the approval of the city official
- If a portion of the existing foundations of the building are demolished, the engineer must ensure that the bearing pressure beneath the remainder of the existing foundation is acceptable or proper shoring must be provided.

Obstructions

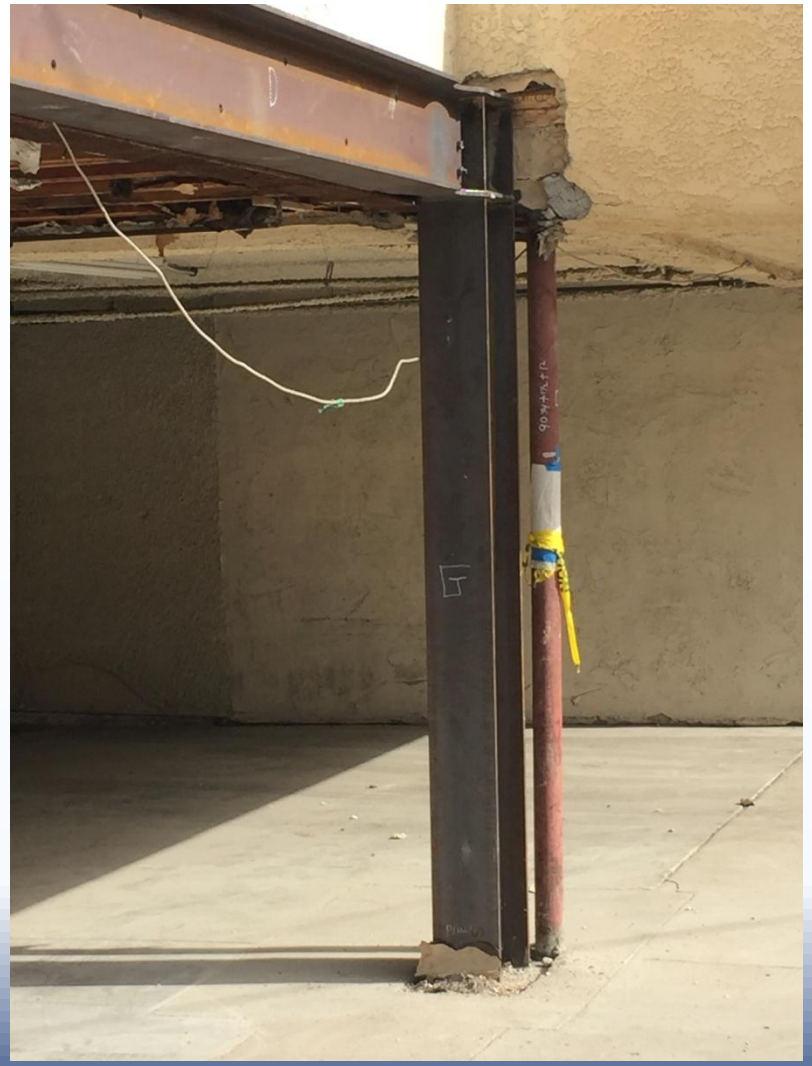
Existing non-structural objects must be accounted for in the design



Retrofit In Construction

Another Example

Steel MF Column & Existing Gravity Column



Steel MF Column & Existing Gravity Column

Steel MF Behind Existing Columns

Plywood Shear Wall Strengthening

Finished Foundations

Completed Retrofit

Completed Retrofit

Timeframes

- SEAOSC Example: Expected to be released fall 2016
- Ordinance Amendments: LADBS to determine
- Information Bulletin: P/BC 2014-137
- Issue Notices by Priorities:

LABD Issues Notices

a) Demonstrate "Good as Is"
b) Analysis + Retrofit Plans
c) Demo Plans

Obtain Permit

Complete Retrofit

Year 0 | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7

APPEALS
- Appeal within 60 days
- Appeal Decision 60 days After Appeal

Priority I.	Buildings containing 16 or more dwelling units.
Priority II.	Buildings with three stories or more, containing fewer than 16 dwelling units.
Priority III.	Buildings not falling within the definition of Priority I or II.

Other Considerations

91.9307.1. Notification to Tenants and Occupants. When the Department determines that a building falls within the scope of this division, the owner shall advise all current and prospective residential and non-residential tenants, subtenants, lessees, sublessees, or any other person(s) entitled to the use and/or occupancy of the building of such determination. With respect to current and prospective residential tenants, subtenants, lessees, sublessees, or other person(s) entitled to the use and/or occupancy of the building, the property owner shall advise such persons of the Department's determination in a method and written format approved and promulgated by the Los Angeles Housing and Community Investment Department. With respect to current and prospective non-residential tenants, subtenants, lessees, sublessees, or other person(s) entitled to the use and/or occupancy of the building, the owner shall advise such persons of the Department's determination in a method and written format approved and promulgated by the Department.

Other Considerations

LOCAL JUNE 25, 2010

Appeal lost in quake deaths

By Tonya Strickland and AnnMarie Cornejo - tstrickland@thetribunenews.com; acornejo@thetribunenews.com

Property owners are ultimately liable if they wait to retrofit their unreinforced buildings, regardless of whether they plan to meet a deadline for earthquake strengthening, the 2nd District Court of Appeal ruled this week.

The case clarifies for the first time the expectations on building owners throughout California, officials said.

The Ventura-based appellate court on Monday ruled against Mary Mastagni of Paso Robles, who had appealed the 2008 judgment against her over the collapse of the Acorn Building that killed two women during the 2003 San Simeon Earthquake.

Jennifer Myrick, 20, and Marilyn Frost-Zafuto, 55, both worked in a clothing shop in the Acorn Building in downtown Paso Robles. They were crushed by falling bricks as the building collapsed.

In finding for the plaintiffs in 2008, the Superior Court jury decided Mastagni and several trusts and businesses owned by her family were responsible for the 111-year-old Acorn

Deloitte.

“Resilience by Design”
The Los Angeles Earthquake Retrofit Law

July 12, 2016

“Resilience by Design” and the Los Angeles Earthquake Retrofit Law

Your speaker today:

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BS Civil Engineering / Environmental Science – Tufts University

MS Structural and Earthquake Engineering – Stanford University

MS Business Management – Massachusetts Institute of Technology

“Resilience by Design” and the Los Angeles Earthquake Retrofit Law

Topics for today’s discussion:

- Background – Why this matters
- The Los Angeles Earthquake Retrofit Law
  - What buildings are affected by the new law?
  - What does the new law require?
  - What are its potential cost impacts?
- Technical concepts and issues
- Takeaways from today’s presentation

“Resilience by Design” and the Los Angeles Earthquake Retrofit Law

Background – Why this matters

- California: the world’s 8th largest economy (surpassing Italy, India, Russia):
  - **2014 GDP = $2.3 Trillion**
- Los Angeles: the world’s 16th largest economy (surpassing Turkey, Saudi Arabia, Argentina, Netherlands)
  - **2014 GDP = $870 Million**
- Estimated effects of a Richter Magnitude 7.8 Earthquake in Los Angeles are approximately:
  - 1,800 fatalities
  - Estimated economic losses:

    $ 48 billion in property damage due to building shaking
    $ 65 billion in property damage due to fire
    $ 96 billion in business interruption costs
    $ 4 billion in losses due to traffic delays

    $ 213 billion

“Resilience by Design” and the Los Angeles Earthquake Retrofit Law

The New Law

- What’s it Intent?
  - Seismic Vulnerability
  - Protect human life
  - Improve capacity to respond to earthquake events
  - Quick recovery from earthquake events
  - Protect the economy

- Timeline of events:
  - **January 2014:** LA Times article publishes results of UC Berkeley study of unsafe concrete buildings in Los Angeles
  - **December 2014:** LA Mayor Garcetti issues “Resilience by Design” report
  - **October 2015:** Garcetti signs Earthquake Retrofit Law
  - **February 2016:** Earthquake Retrofit Law in effect

“Resilience by Design” and the Los Angeles Earthquake Retrofit Law

The Los Angeles Earthquake Retrofit Law:

What buildings and systems are affected by the new law?

1. Pre-1980 “soft-first-story” buildings
2. Pre-1980 “non-ductile reinforced concrete” buildings
3. Telecommunications infrastructure
   - Cellular Towers
   - Internet Maintenance
   - Data Centers
   - Earthquake Early Warning system
4. Water system infrastructure
   - Firefighting Water Supply
   - Aqueducts, dams, reservoirs, local systems
   - Water transit systems: Seismic Resilient Pipe Network

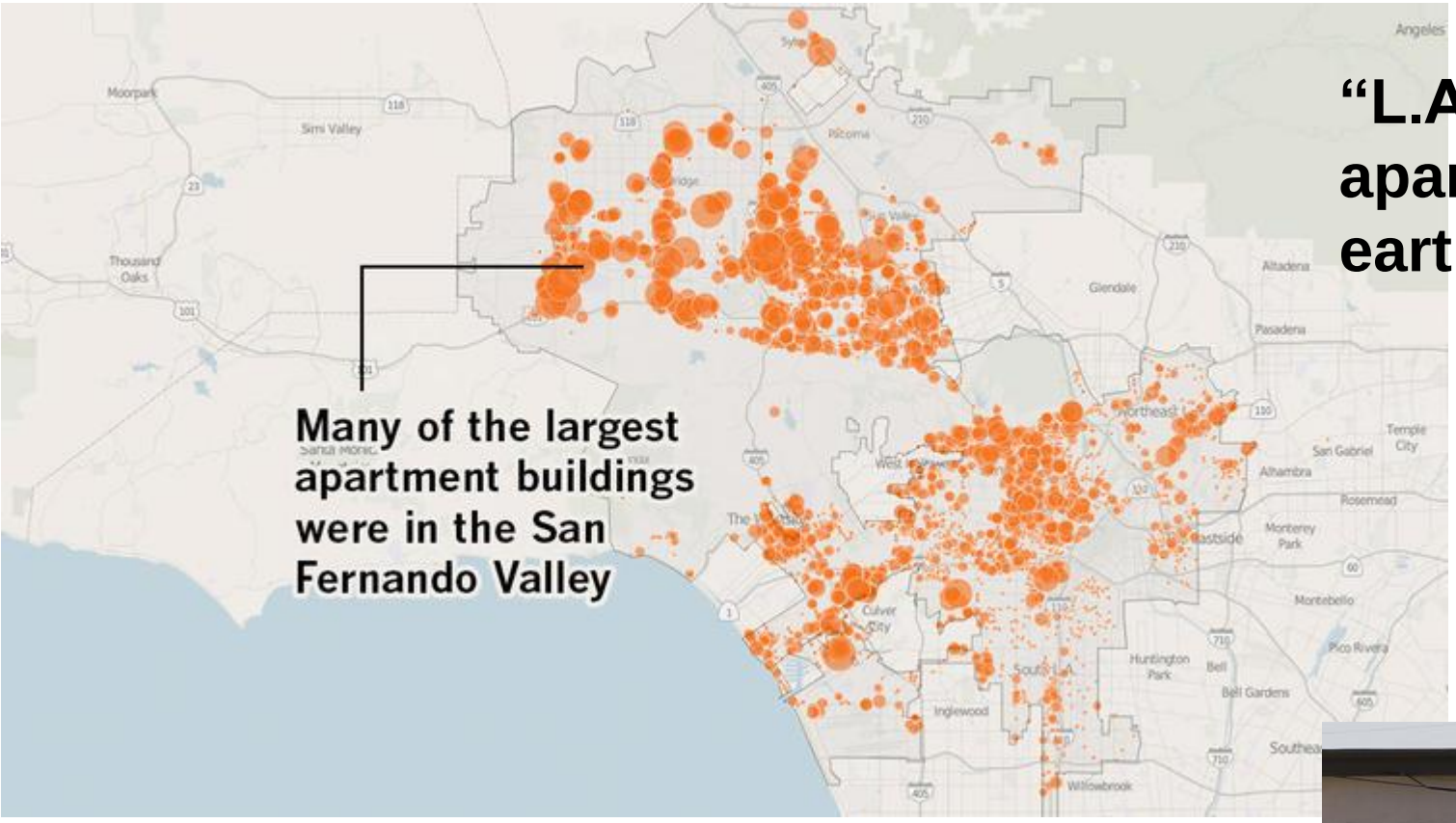
The Los Angeles Earthquake Retrofit Law:

What does the new law require?

Mandatory seismic retrofitting for:

1. Pre-1980 soft-story buildings (7-year horizon)
   - LA Department of Building and Safety (LADBS) has identified **13,500 soft-story buildings**
   - **2016-2017:** Building owners have ONE year to determine retrofit status
   - **2017-2018:** Owners have ONE additional year to acquire necessary retrofit permits
   - **2018-2022:** Owners have an additional FIVE years to perform building retrofits

2. Pre-1980 non-ductile reinforced concrete buildings (25-year horizon)
   - LADBS has identified **1,500 non-ductile reinforced concrete buildings**
   - **2016-2019:** Building owners have THREE years to begin the assessment process
   - **2019-2029:** Owners have TEN additional years to determine retrofit status
   - **2029-2041:** Owners have an additional TWELVE years to perform building retrofits



“L.A. releases addresses of 13,500 apartments and condos likely to need earthquake retrofitting”

Los Angeles Times
April 15, 2016

“Resilience by Design” and the Los Angeles Earthquake Retrofit Law

The Los Angeles Earthquake Retrofit Law:

What are the potential cost impacts?

- If each building requires $100,000 (assessment, design, permits, construction), then buildings alone would cost:

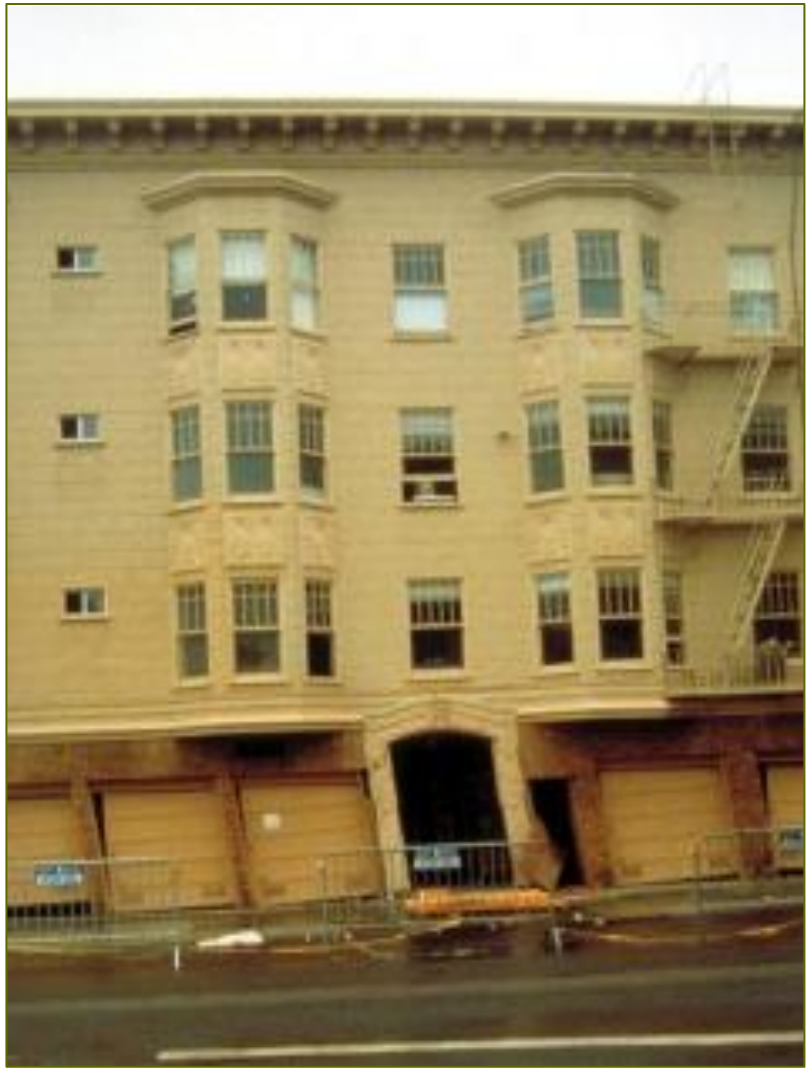
15,000 x $100,000 = $1,500,000,000

- How might the Program be Financed?
  - Directly from building owners
  - Tenants
  - Rate Payers (water, sewer, power, telecommunications)
  - Statewide Seismic Resilience Bond Measure

“Resilience by Design” and the Los Angeles Earthquake Retrofit Law

Technical Concepts and Issues:

- **Soft-Story Buildings:**
  - Large openings on bottom floor(s)
  - Abrupt changes in building rigidity
  - Leads to localized floor collapse and pancaked collapse from floors above
  - Often found in apartment buildings, mixed-use commercial blocks
  - Dates to 1950s and 1960s
  - Soft-stories are relatively easy to identify
  - Phenomenon is understood and remedies are straight-forward, relatively inexpensive, and non-disruptive



http://resilience.abag.ca.gov/housing/softstory/

“Resilience by Design” and the Los Angeles Earthquake Retrofit Law

Technical Concepts and Issues:

- **Non-Ductile Reinforced Concrete Buildings:**
  - Brittle nature leads does not absorb seismic shaking
  - Lack of elasticity leads to catastrophic structural collapse
  - Found in apartment buildings, office buildings, schools, hospitals, warehouses
  - Dates to 1950s and 1960s
  - Non-ductile R/C buildings are not easily detectable
  - Phenomenon is complex and non-straight-forward
  - Repairs are tailor-fit, expensive, time-consuming, disruptive

http://resilience.abag.ca.gov/commercial-building-types/

Technical Concepts and Issues:

- **Telecommunications Infrastructure:**
  - Cellular Towers
  - Solar-powered Internet Maintenance
  - Data Centers
- **Water System Infrastructure**
  - Firefighting Water Supply
  - Aqueducts, dams, reservoirs, local systems
  - Water transit systems: Seismic Resilient Pipe Network

Takeaways from Today’s Presentation:

- **Strengthening Our Buildings**
  - Buildings require inspection and appraisal, whether they require retrofit repairs or not
  - Estimated that 1.2 million buildings exist in Los Angeles
- **What’s next?**
  1. Need for increased inspection and appraisal services
  2. Engineers and cost estimators are needed to perform many inspections
  3. Engineers and estimators view ‘valuation’ in a different way than appraisers
  4. Resilience program will be document-intensive and require robust management of repair progress, budgets, costs, and completion

Deloitte.

"Resilience by Design" and the Los Angeles Earthquake Retrofit Law

Questions?

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