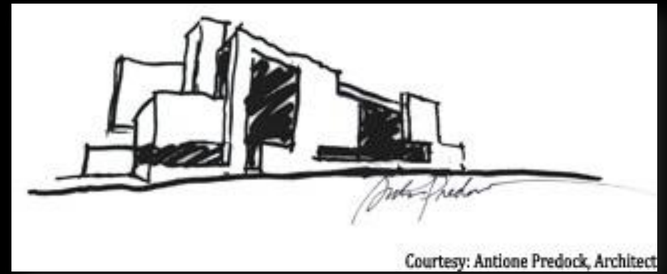
UNM SA+P

University of New Mexico
School of Architecture and Planning

GEORGE PEARL HALL

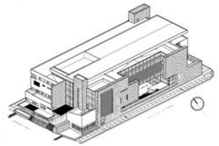


Nicole Trujillo | Structural Option

Senior Thesis 2012

Faculty Advisor: Dr. Richard Behr

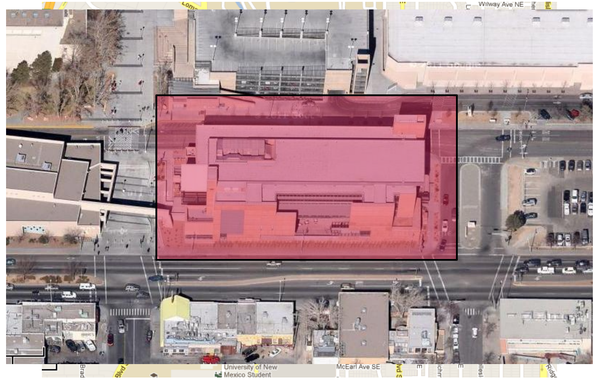
- **Building Introduction**
- Existing Structural System
- Design Goal
- System Redesign #1
- System Redesign #2
- Comparison of Designs
- Architecture Breadth
- Mechanical Breadth
- Conclusion



BUILDING INTRODUCTION

- **Location:** Albuquerque, NM
- **Function:** Architecture School
- **Size:** 108,000 GSF
- **Height:** 71.83 Feet
- **Construction:** Nov 2005 - Sept 2007
- **Project Cost:** $29 Million
- **Delivery:** Design-bid-build

SITE MAP



(Google Maps)

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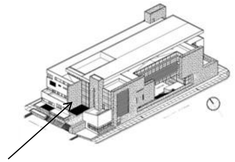

(Courtesy of Jon Anderson Architects)

PROJECT TEAM

- **Owner:** University of New Mexico
- **Design Architect:** Antoine Predock
- **Executive Architect:** Jon Anderson
- **Structural Engineer:** Chavez-Grieves
- **MEP Engineer:** Bridges & Paxton
- **Civil Engineer:** Jeff Mortensen & Assoc.
- **General Contractor:** Jaynes
- **Mechanical Contractor:** Yearout Mechanical
- **Electrical Contractor:** McDade-Woodcock

(Courtesy of Jon Anderson Architects)

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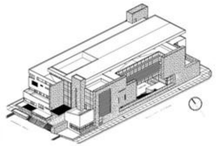

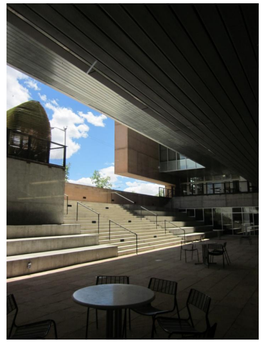

ARCHITECTURAL FEATURES

- "Students educated through the architecture"
- Shading devices used on the south end of the building
- 96-foot long steel trusses
- Breezeway located at the center of the building

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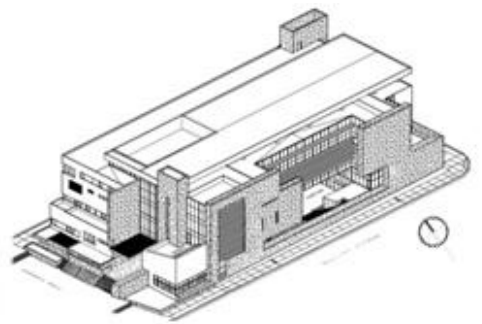


LAYOUT

- [illegible] Level 4

1 Lobby

2 Studio / 4 Computer Lab

[illegible]

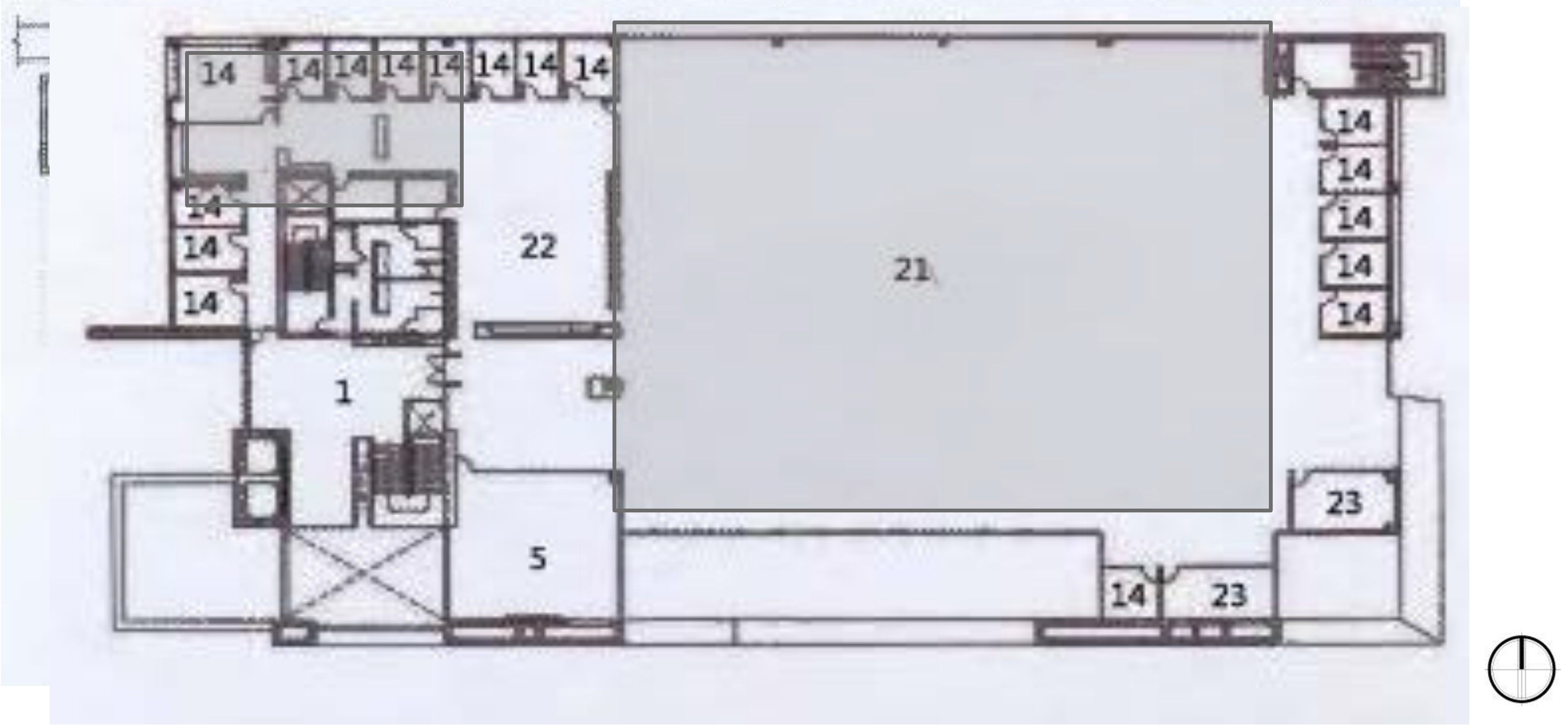
[illegible] Exhibition

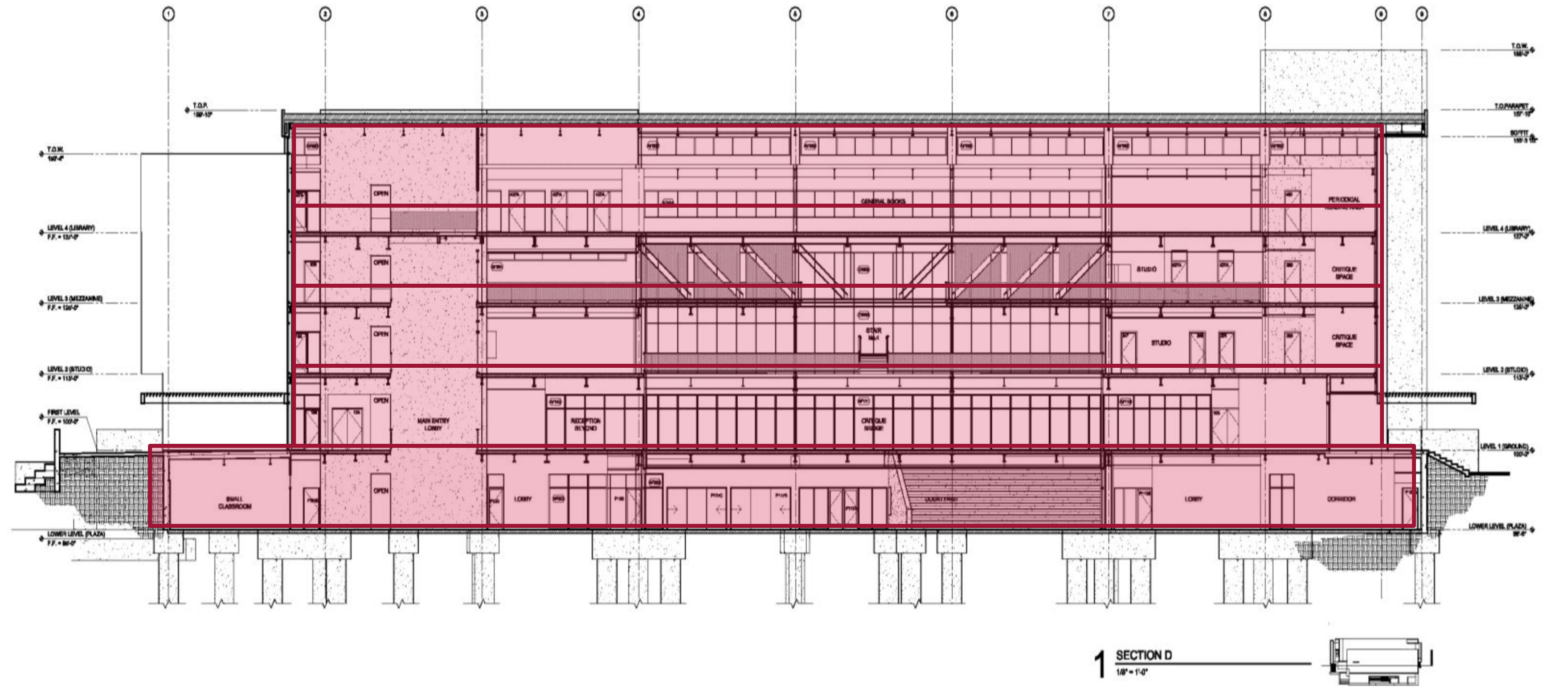
[illegible] Shelving

[illegible]

[illegible] Model Shop

[illegible]





(Courtesy of Jon Anderson Architects)

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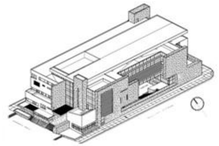
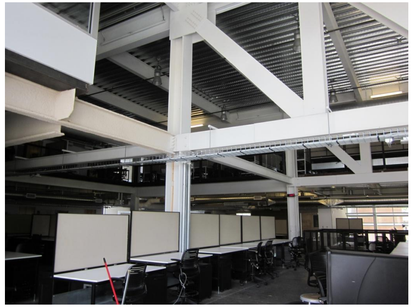
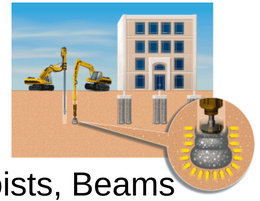
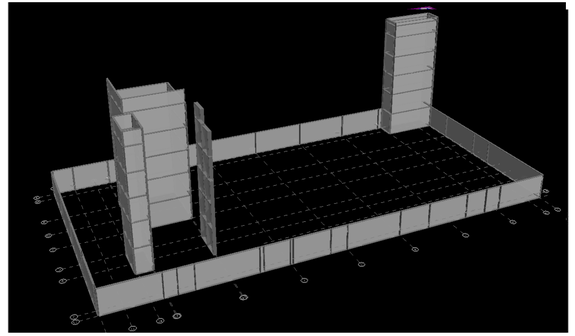




EXISTING STRUCTURAL SYSTEM



- **Foundation System:** Geopiers
- **Framing System:** Steel Columns, Joists, Beams
  - 32 ft by 30 ft bays
- **Floor System:** Concrete filled Metal Deck
- **Lateral System:** Special Reinforced Shear Walls



RAM Structural Model
(Courtesy of Chavez-Grieves Consulting Engineers)

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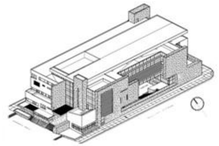

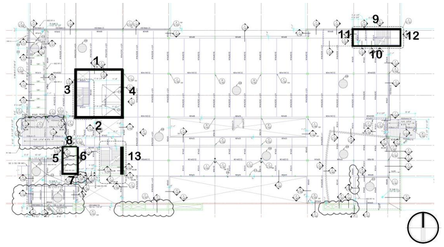

Seismic Design Category D

EXISTING LATERAL SYSTEM

Horizontal Structural Irregularities

Type	Irregularity	Comment	Status
1a	Torsional	**Design forces for lateral force connections to be increased 25% in Design Categories D.**	**Not Good**
2	Reentrant Corner	This irregularity does exist.	Not Good
3	Diaphragm Discontinuity	Irregularity does exist. Design forces for lateral force connections to be increased 25% in Design Categories D.	Not Good
4	Out of plane Offsets	No vertical element out of plane offsets exists.	Good
5	Non Parallel System	All lateral force resisting systems are parallel to the orthogonal axes.	Good

LINEAR DYNAMIC
MODAL RESPONSE SPECTRUM ANALYSIS REQUIRED

Vertical Structural Irregularities

Type	Irregularity	Comment	Status
1a	Stiffness-Soft Story	**Soft Story on Level 3 and 2.**	**Not Good**
2	Weight (Mass)	The library on Level 4 causes more than 1.5 story weight of Level 3.	Not Good
3	Vertical Geometric	Each shear wall is rectangular in elevation.	Good
4	In-Plane Discontinuity of Vertical Lateral Force Resisting Element	Each shear wall is continuous.	Good
5a,b	Discontinuity in Lateral Strength	14 out of 16 shear walls have no to small openings.	Good

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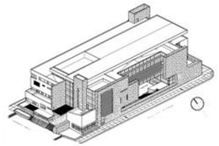
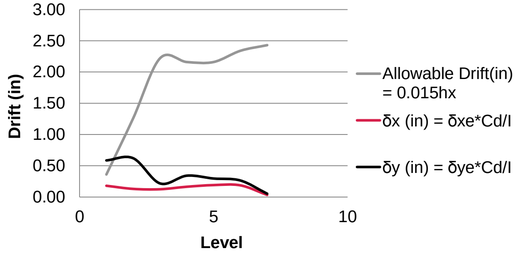


LOAD COMBINATIONS

1. 1.4(D + F)
2. 1.2(D+F+T) + 1.6(L+H) + 0.5(Lr, S, R)
3. 1.2D + 1.6(Lr or S or R) + (L or 0.8W)
4. 1.2D + 1.6W + L + 0.5(Lr or S or R)
5. **1.2D + 1.0E + L + 0.2S**
6. 0.9D + 1.6W + 1.6H
7. 0.9D + 1.0E + 1.6H

Seismic Story Drift ASCE 7-05

Existing Special Reinforced Shear Walls



$$\delta x = \delta xe * Cd/I$$

Number of Modes	15 modes
Modal Response Parameters	Amplified drift
Combined Response Parameters	Sum of the Squares Method (SRSS)
Scaling Design Values of Combined Response	Scaled Member Force = 0.85*(Vbase/Vt)*Member Force
Horizontal Shear Distribution	Amplification of torsion is not required where accidental torsional effects are included in the dynamic analysis model.
P-Delta Effects	Were taken into consideration in ETABS model

Check	Comment	Status
Controlling Load Case	North- South Direction Base Shear **Wind: 407 kips** **Seismic: 1631 kips**	**SEISMIC**
Torsion Inherent and accidental torsion	Torsion Inherent and accidental torsion were both taken into account in the ETABS Model	**NOT OK**
Redundancy	Structure is assigned to SDC D, therefore value for ρ is allowed to be taken as **1.3** per ASCE 7-05	OK
Member Spot Checks	Member sizes meet strength requirements.	OK
Story Drift	Drift requirements are met in both orthogonal directions OK	OK

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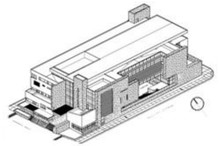
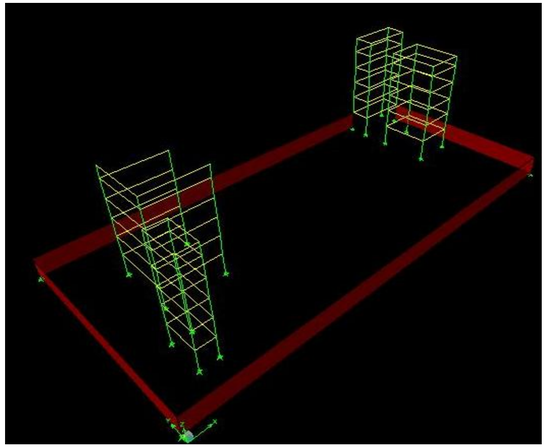


DESIGN GOAL

- Reduce the cost of the lateral system.
- Use ETABS to design and check by hand.

PROPOSED SOLUTION

- **System #1:** Modified Special Reinforced Shear Walls
- **System #2a:** Special Concentric Braced Frames (SCBF)
- **System#2b:** Special Moment Frame system (SMF)



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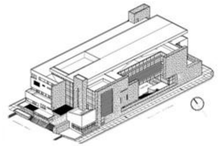
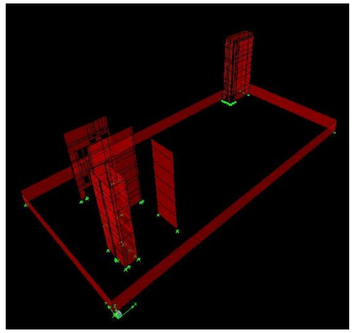
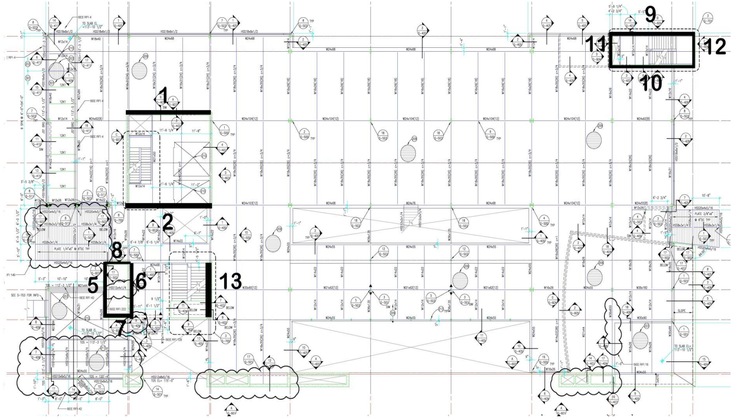




SHEAR WALL MODIFIED DESIGN

- **Advantage:** designed using existing reinforcement
- **Disadvantage:** more expensive
- **Seismic Design Provisions:**
  - ACI 318-08 Chapter 22



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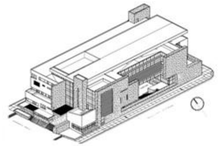
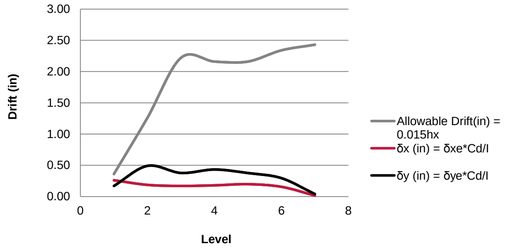


Seismic Story Drift ASCE 7-05
Modified Special Reinforced Shear Walls



SHEAR WALL MODIFIED DESIGN

- **Seismic Forces Increased from Existing Design**
- **Walls 1, 2, and 5**: thickness increase from **12 in.** to **18 in.**
- **Serviceability: – satisfied**
  - **X Direction** – Average 78% Less than Allowable
  - **Y Direction** – Average 71% Less than Allowable
- **Strength:** P-M Interaction Diagram **satisfied**

Seismic Forces E-W Direction, X

	Existing Lateral System	System Redesign #1
R	6	6
Cs	0.106	0.106
Story Forces (k)		
Stair 3	7	7
High Roof	155	158
Low Roof	229	229
4	665	680
3	237	240
2	274	279
1	197	201
Base Shear	**1764**	**1792**

1.58% Larger Base Shear

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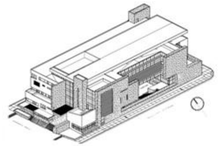
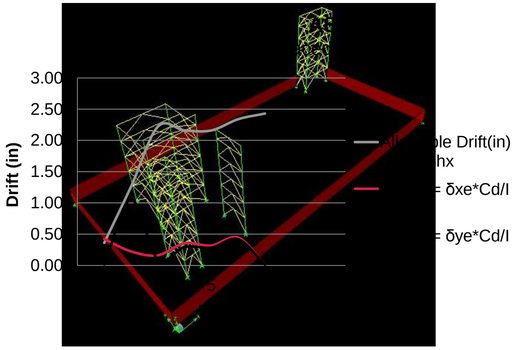
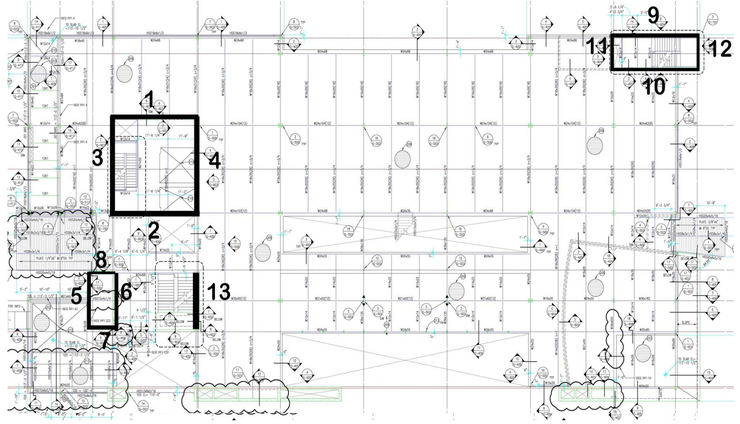




BRACED FRAME DESIGN

Inverted V Brace

- **Advantages:** small members/sections required
- **Disadvantages:** obstruction of circulation within building
  - Frames were placed in the same location as the shear walls
- **Seismic Provisions:**
  - **AISC 341-05:** seismic compact section criteria not met, beam-column moment ratio



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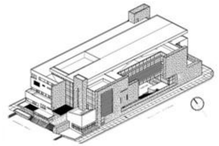
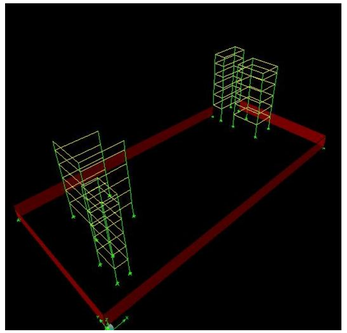
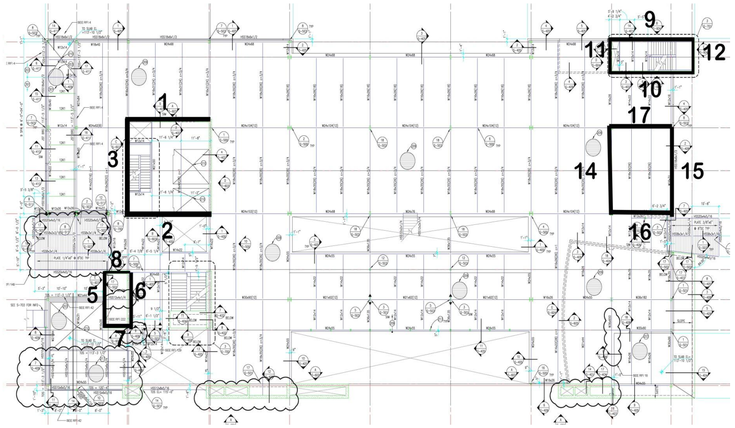




MOMENT FRAME DESIGN

- **Advantages:** provides the most flexible floor plan
- **Disadvantages:** expensive due to connections and larger member sizes
- **Seismic Provisions:**
  - **AISC 341-05**
  - **FEMA 350**
  - **Reduced Beam Section:** Strong Column-Weak Beam
  - **Direct Analysis Method:** effective length factor, K=1.0



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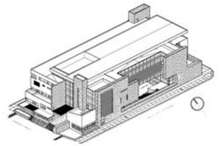
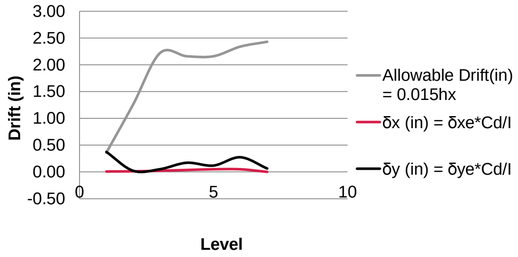


Seismic Story Drift ASCE 7-05
Special Moment Frames



MOMENT FRAME DESIGN

- **Seismic Forces Decreased from Existing Design**
- **Typical Member Sizes:**
  - **Beams:** W18 x 128, W24x370
  - **Columns:** W14 x 730
- **Serviceability: – satisfied**
  - **X Direction** – Average 98% Less than Allowable
  - **Y Direction** – Average 56% Less than Allowable

Seismic Forces E-W Direction, X

	Existing Lateral System	System Redesign #2b
R	6	8
Cs	0.106	0.048
Story Forces (k)		
Stair 3	7	1
High Roof	155	51
Low Roof	229	55
4	665	263
3	237	74
2	274	99
1	197	42
Base Shear	**1764**	**585**

Decrease in Base Shear

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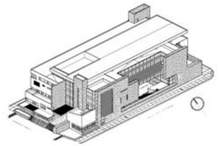
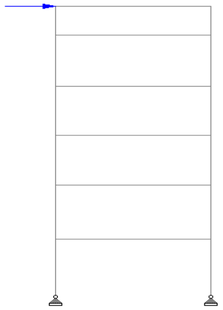
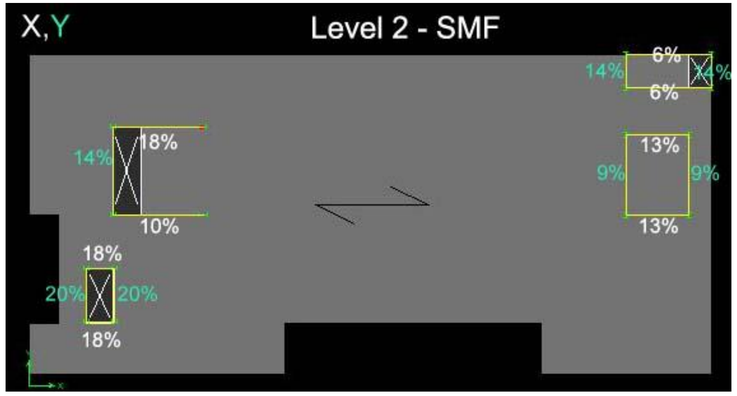




MOMENT FRAME DESIGN

- **Relative Stiffness :** 1 kip load applied to each frame in STAAD.Pro
  - Measured Deflection
  - Stiffness = Deflection/Force
- **Member Check:** Frame 11 because it carries 14% load in Y direction
  - **Strength:** Unity Equation – **satisfied**



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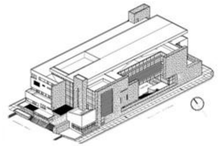
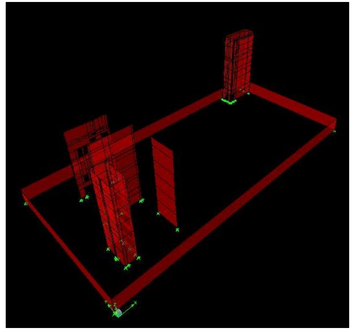
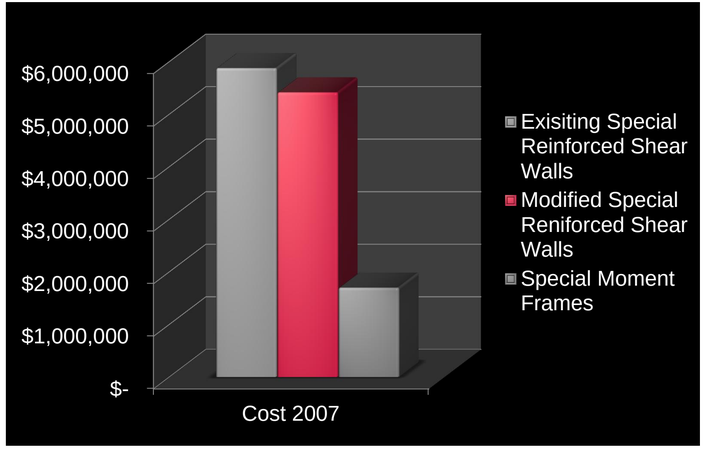
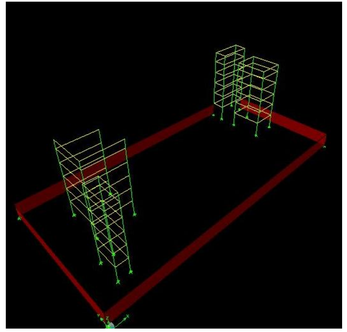
COMPARISON OF DESIGNS









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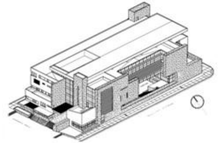
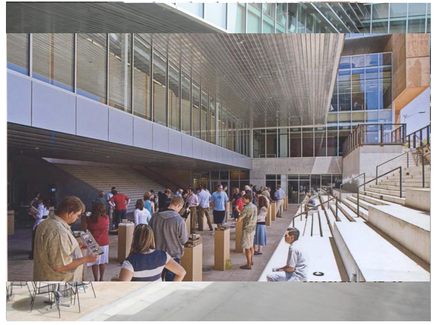
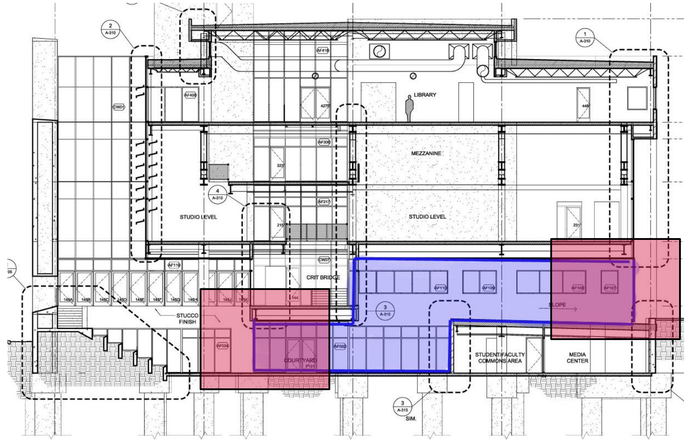




ARCHITECTURAL BREADTH
BREEZEWAY ENCLOSURE



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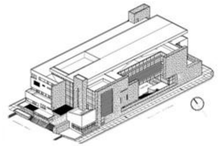
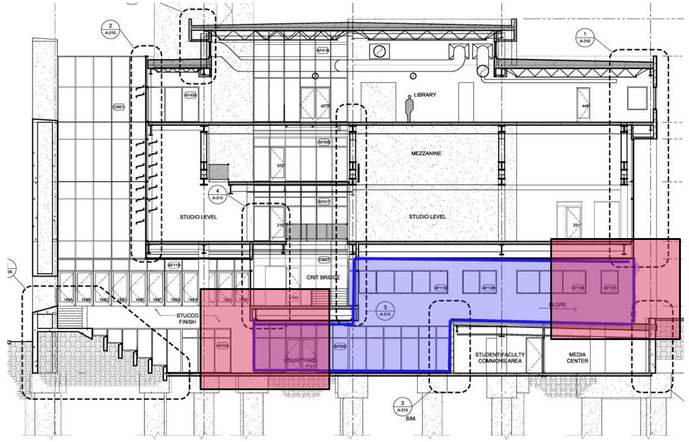


ARCHITECTURAL BREADTH
BREEZEWAY ENCLOSURE

Additional Glazing Area	2544 SF
Cost/SF of Viracon 3-54 Glazing	$8/SF
Total Cost of Glazing	**$2032**



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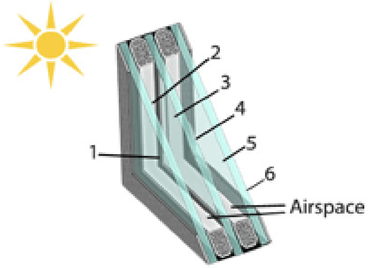
MECHANICAL BREADTH
GLAZING REPLACEMENT

Glazing	
Type	**U-Value**
VRE 3-54	0.25
VNE 1-30	0.18
VRE 1-63	0.13



Viracon Triple Insulating Glass with Argon Gas VRE 1-60

1/4" (6mm) clear VRE-60 #2
1/2" (13.2mm) argon space
1/4" (6mm) clear
1/2" (13.2mm) argon space
1/4" (6mm) clear

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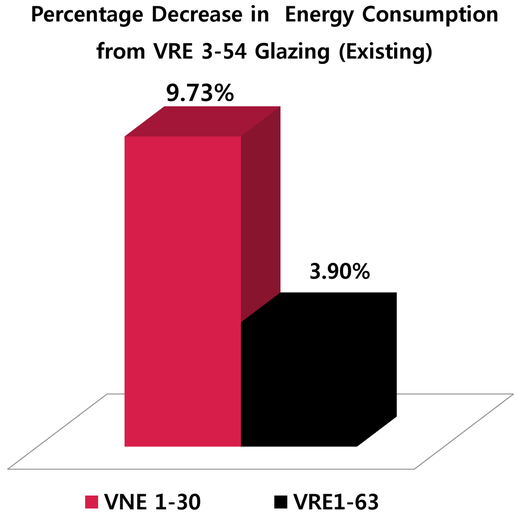
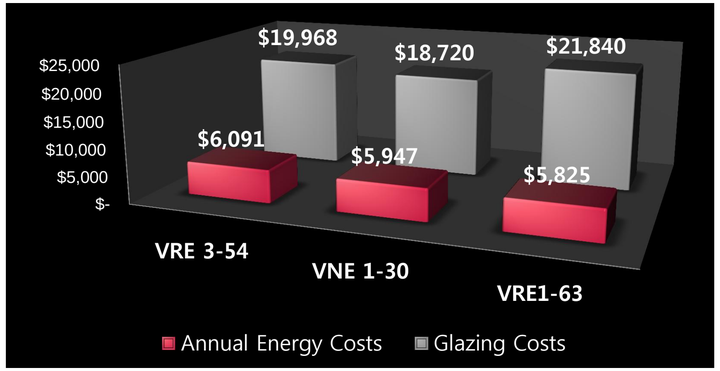
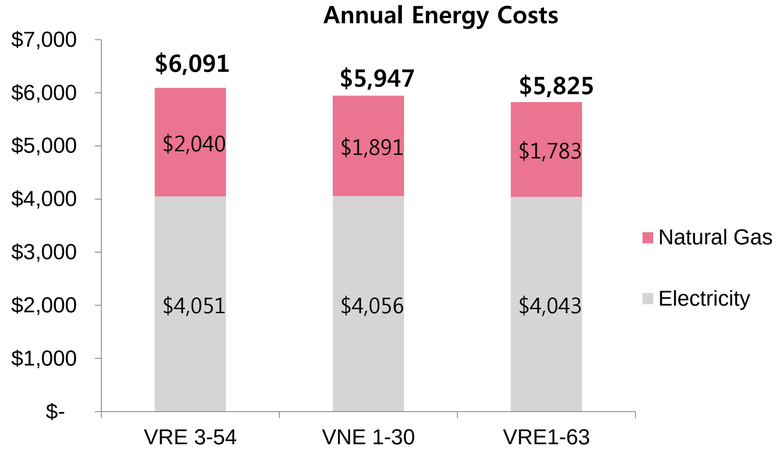


MECHANICAL BREADTH COST COMPARISON





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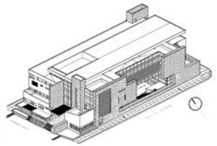
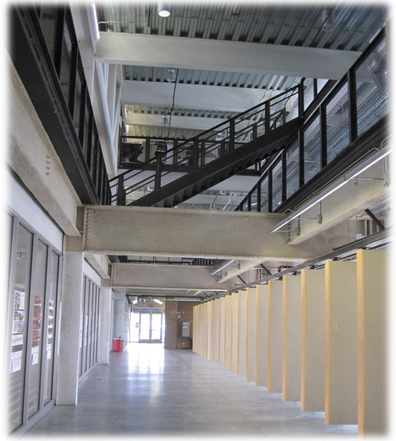


MECHANICAL BREADTH
VESTIBULE AND FAN ADDITION



CONCLUSION

Recommendations

- **Lateral System Redesign**
  - Lateral System #1 - Reduced Cost by 8%
  - Lateral System # 2b - Reduced Cost by 67%

- **Architectural Breadth**
  - $2032 material cost increase for glazing
  - Usable space for faculty offices and an enclosed courtyard

- **Mechanical Breadth**
  - VNE 1-30 glazing provides 9.73% decrease in energy consumption than existing
  - VNE 1-30 is less expensive in both energy and material costs than existing

Thank You

Thank you to all of my family and friends, especially my fiancé and my parents.

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Questions?