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Structural Option
Senior Thesis
Spring 2006

THE 400

Bremerton, WA

Scope of Presentation

- Introduction
  - Building Description
  - Problem Statement
- Blast Resistant Design (Navy nearby)
  - Causes and Types of Attacks
  - The Explosion Itself
  - Cost Implications
  - Designing Against a Blast
  - Glass as a Lethal Weapon

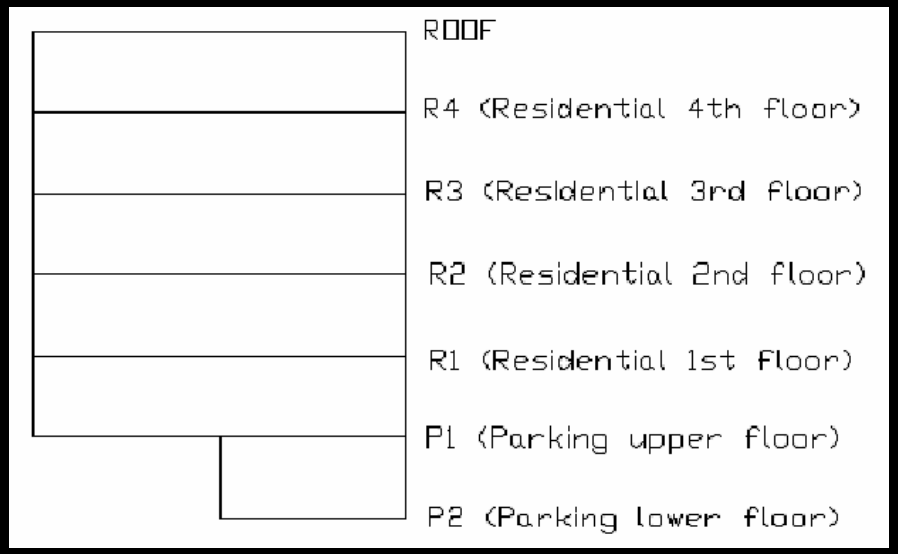
Scope of Presentation

- Blast Resistant Design of The 400
  - Floor plan Considered
  - Design Loading and Combinations
  - Removing a Column
  - Recommendations for The 400
- Conclusions
  - Summary and Conclusions
  - Recommended References

INTRODUCTION

Building Description

- Waterfront Condominium (124,000 sq. ft.)
- 4 Stories Residential (about 21,000 sq. ft.)
  - Non-composite Steel Deck
  - ½" Metal Form Deck; 2 ½" Concrete Topping
- 2 Stories Parking (about 15,000 sq. ft.)
  - Slab-on-grade
  - Post-tensioned Slab
- Lateral System
  - 12" Concrete Shear Walls



Initial <vs> Final Research

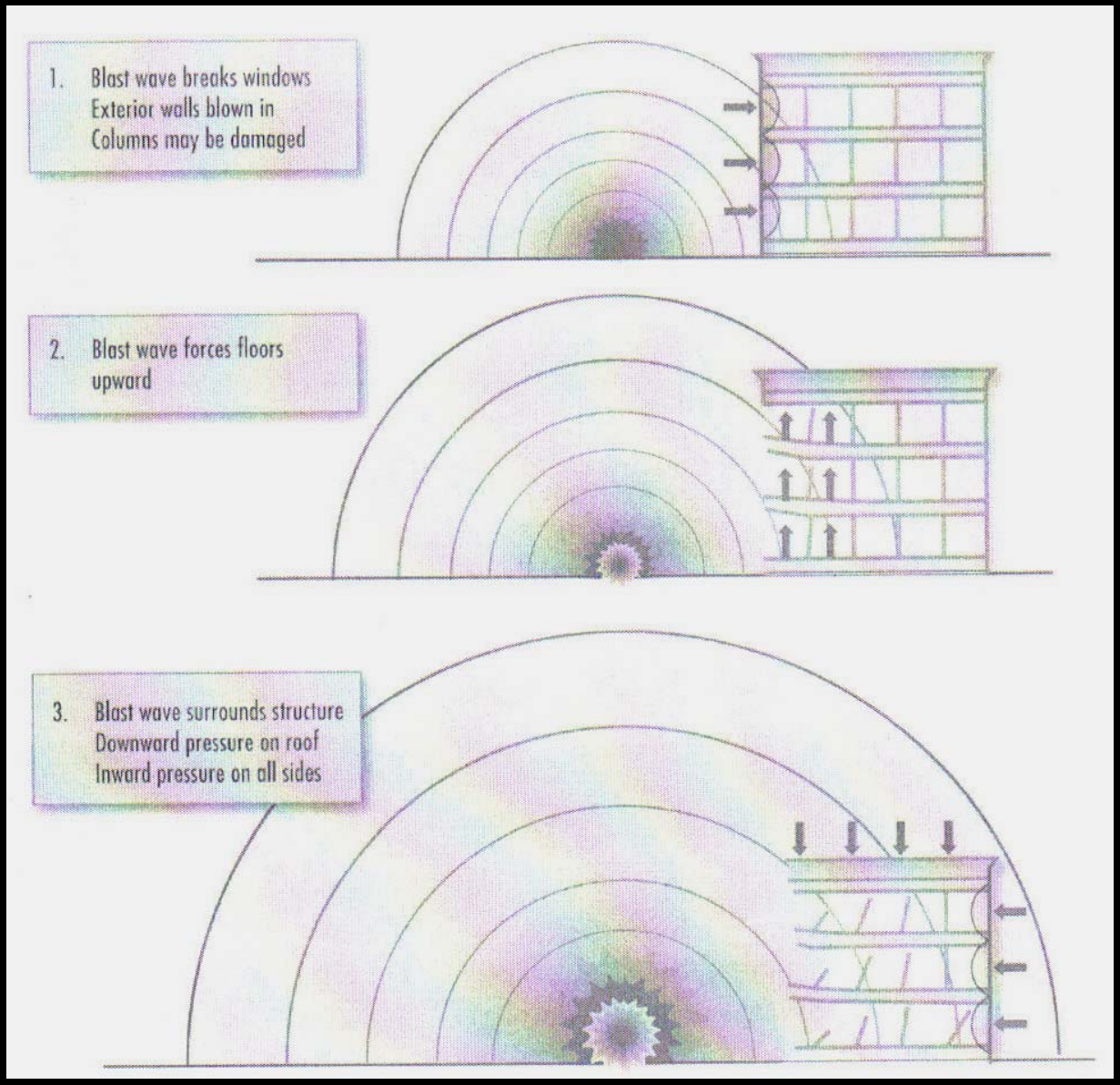
Initial	*Final*
Determine Possible Blasts for Bremerton, WA	Determine Possible Blasts for ***all areas***
Determine Loads and locations for Potential Attack	Determine Loads and locations for Potential Attack
Determine Critical Load Cases	***Cannot Determine Critical Load Cases***
Redesign Structure for Blast Loading	Redesign Structure for Blast Loading
Determine Cost Comparison for Old and New Designs	Determine Cost Comparison for Old and New Designs

BLAST RESISTANT DESIGN

Causes and Types of Attacks

- Causes
  - Exert political pressure
  - Make symbolic statement
- Types of Attacks
  - Vehicle-transported bomb
    - Most common and critical
    - Lower level causes most damage
  - Mail bomb
  - Briefcase/small package bomb
  - Aerial attack (virtually no defense)
  - Nuclear attack (virtually no defense)

The Explosion Itself



Cost Implications

- National Research Council
  - 250,000 square feet
  - Rentable space; 5-year leases

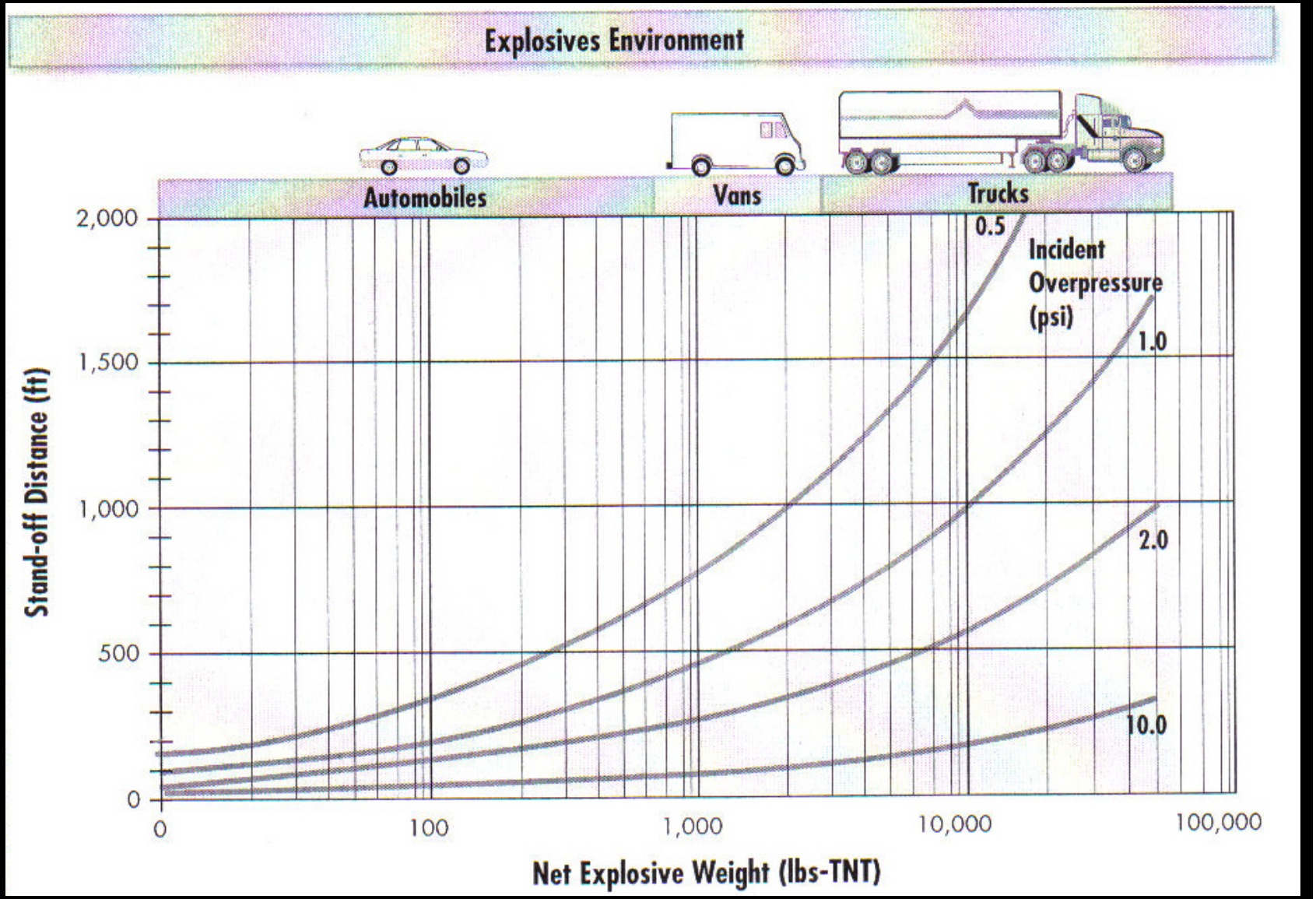
NON-BLAST RESISTANT: $83.50 per square foot

BLAST RESISTANT: $86.63 per square foot

5% increased cost

3.5% increased lease premium

Designing Against a Blast

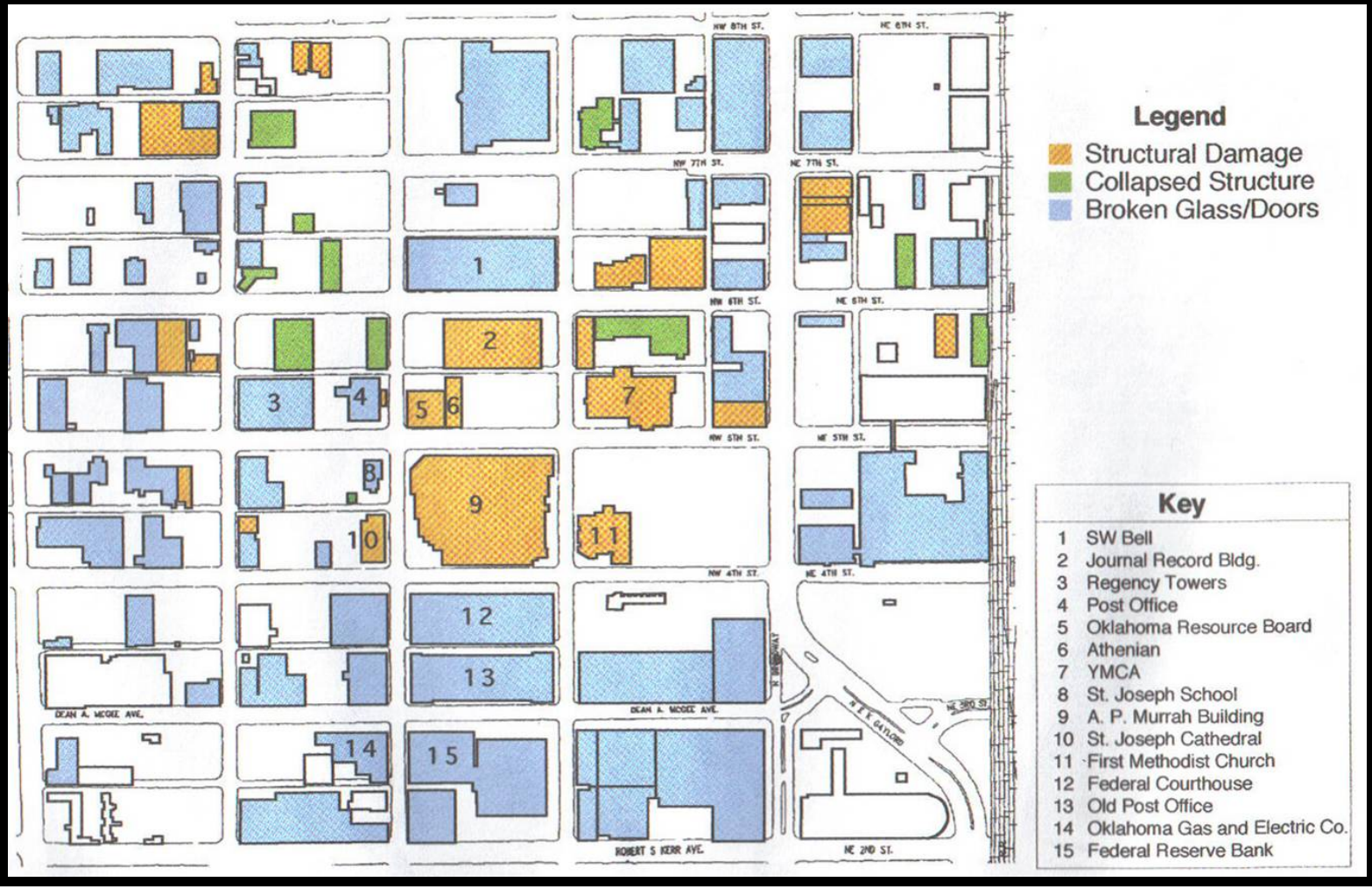


General Recommendations

- Continuous Reinforcement
- Redundant Structure
- Spirally Reinforced Columns
- Increased Design Load
- Staggered Lap Splices
- Ductile Steel Connections
- Minimal Column Spacing
- Fully-grouted CMU (if masonry used)
- Tied Horizontal and Roof Diaphragms

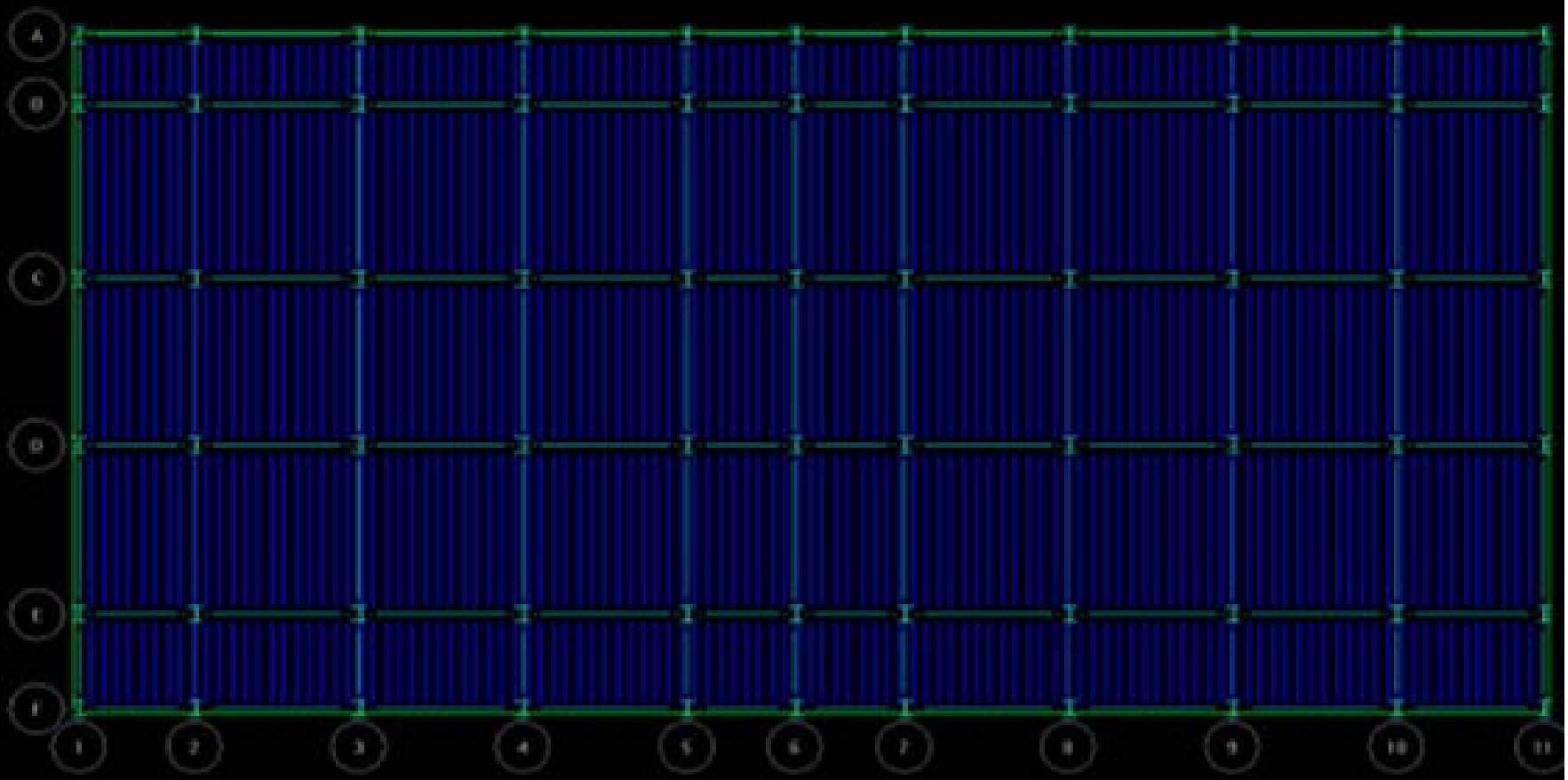
Glass as a Lethal Weapon

- Glass Missiles
- Surrounding Buildings



BLAST RESISTANT DESIGN OF THE 400

Floorplan Considered



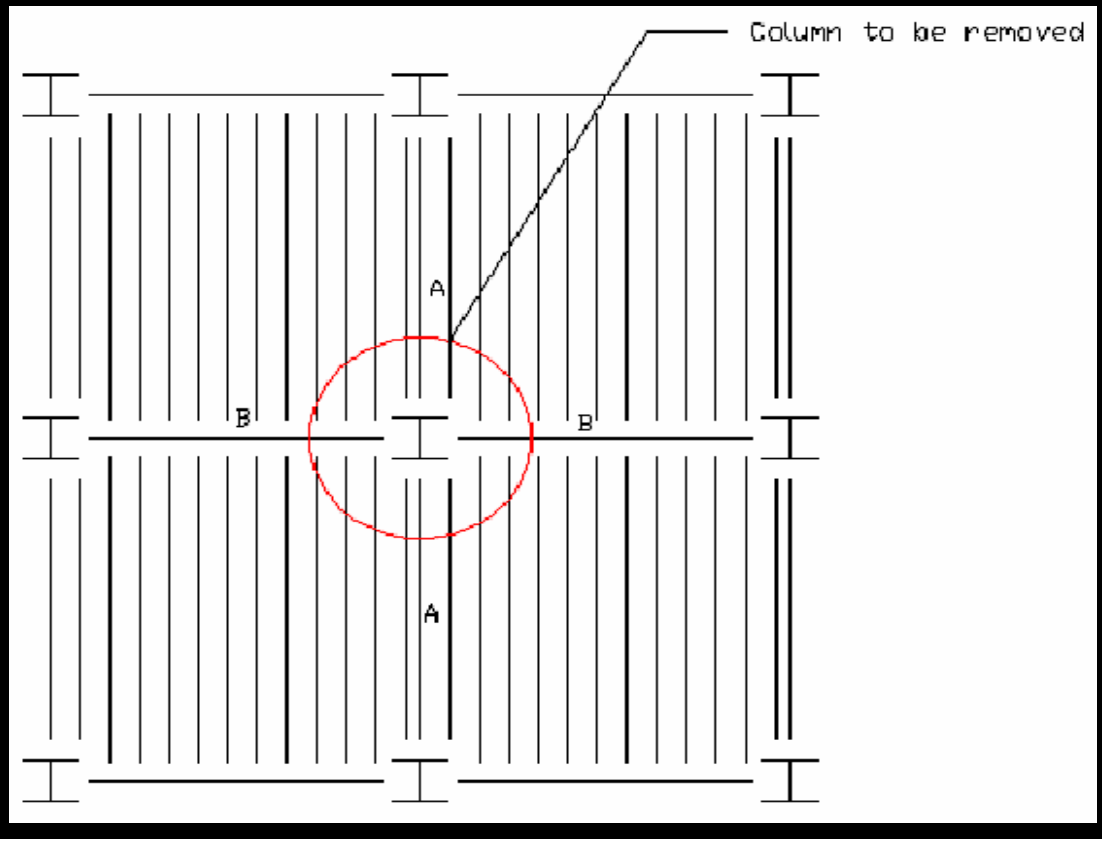
Design Loads & Combinations

- Live Loads
  - Parking: 40 psf
  - Residential: 40 psf
  - Roof: 25 psf
- Dead Loads
  - Parking: 100 psf
  - Residential: 52 psf
  - Roof: 52 psf
  - Perimeter Wall: 15 psf

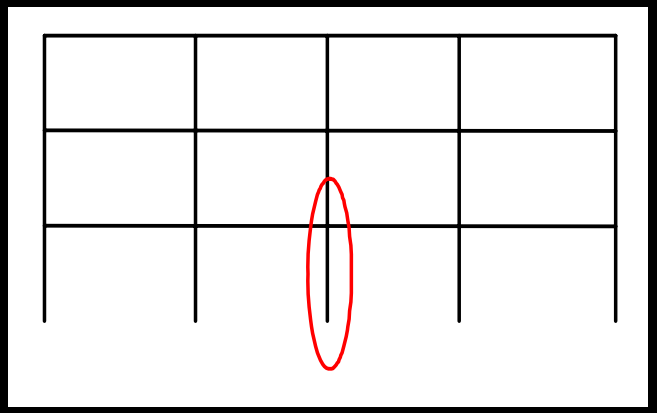
- DL + LL
  - W14x22
- 2 (DL + 0.25 LL)
  - W16x26
  - W24x55
- 2 (DL + LL)
  - W18x35
  - W24x62
  - W24x76

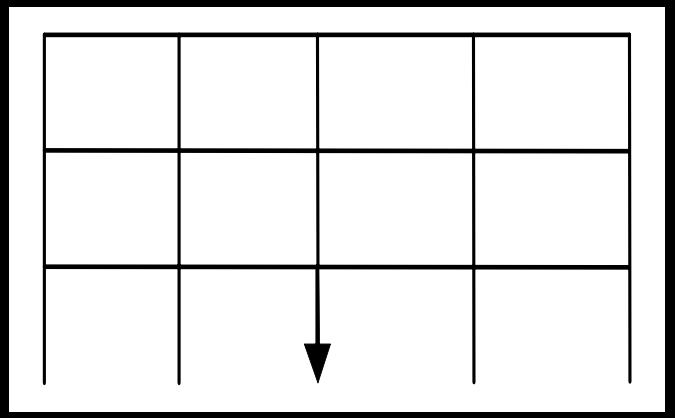
Removing a Column

- Remove a Column
  - Interior most critical
  - Underground parking/basement
- W or HSS Shapes



Removing a Column





- Nonlinear Static Pushover Approach
  - Only girders
    - Displacement: 65 inches
  - Girders and Joists
    - Displacement: 40 inches
    - Rotation: 7.45 degrees

Recommendations for The 400

- Initial Design
  - 5 bays x 10 bays
  - One design team
  - Standoff distance 0 feet
- Recommendations
  - Increase member sizes to resist 2 (DL + 0.25 LL)
  - Upgrade glazing
  - Eliminate parking; increases standoff distance to 15 feet

CONCLUSIONS

Summary and Conclusions

- Relatively New Phenomenon
  - No concrete design method
  - Engineering judgment
- Blast Loading
  - Varies with technology
- Rules of Thumb
  - 2 (DL + 0.25 LL) equivalent to removing a column
- CONNECTIONS!!!
- Bottom line = ***What are you willing to risk?***

Recommended References

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- The Federal Emergency Management Agency. “Explosive Blast." 3 Apr. 2006 <http://www.fema.gov/pdf/fima/428/fema428_ch4.pdf>.
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Acknowledgements

- Professionals
  - Charlie Carter of AISC
- Faculty
  - Dr. Hanagan
  - Professor Parfitt
- Friends and Family
  - Parents, siblings and Grandparents
  - Boyfriend Dave
  - Dave's Family

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QUESTIONS

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