Food and Drug Administration
Center for Drug Evaluation and Research
Office Building 2

Final Presentation

April 13, 2009

AE Senior Thesis

COMPOSED BY:

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structural option

ADVISOR:

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Outline

- BUILDING INFORMATION
- STRUCTURAL DEPTH
    - STEEL REDESIGN
    - PROGRESSIVE COLLAPSE
- ENCLOSURE BREADTH
- CONCLUSIONS

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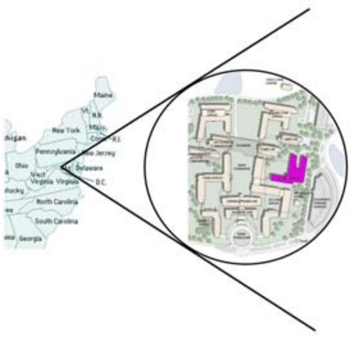
- Center for Drug Evaluation and Research (CDER)
- 6-Story research office building
- Located in White Oak, MD



Site Location and Campus

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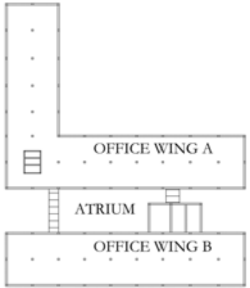

Existing Typical Plan


Interior Atrium

- Two office wings connected by open atrium
- Consistency throughout CDER2
- Offices with a view

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CDER2 Elevation

- Office wings employ brick façade w/ punch windows
- Accent aluminum panel and mullion system
- Atrium glass curtain wall

Interior Atrium

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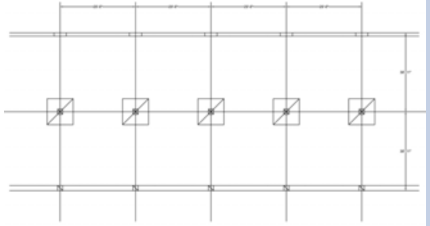

Frame Layout

- Approx. 30′x30′ bays
- Two-way flat slab floor system
- 9.4″ floor with 7″ drop panels

Existing Typical Plan

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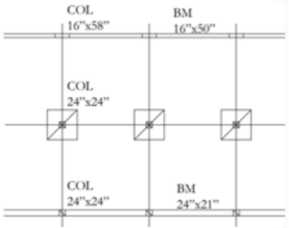

Existing Typical Sizes

- Concrete moment frame with perimeter beams
- Two main column geometries
- Uniform grid spacing

Existing Typical Plan

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For my thesis…

-Alternate structural steel framing system explored

-Progressive collapse concerns considered

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Loads:

Office:	SDL = 20psf (mechanical, ceiling, access floor) LL = 80psf
Public/Egress:	SDL = 20psf (mechanical, ceiling, access floor) LL = 100psf
Roof:	SDL = 42psf (mechanical, ceiling, roofing, insulation, paver) LL = 32psf

Load Combinations:

1) $1.4(D + F)$
2) $1.2(D + F + T) + 1.6(L + H) + 0.5(Lr \text{ or } S \text{ or } R)$
3) $1.2D + 1.6(Lr \text{ or } S \text{ or } R) + (L \text{ or } 0.8W)$
4) $1.2D + 1.6W + L + 0.5(Lr \text{ or } S \text{ or } R)$
5) $1.2D + 1.0E + L + 0.2S$
6) $0.9D + 1.6W + 1.6H$
7) $0.9D + 1.0E + 1.6H$

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- Vulcraft Floor Deck Catalog

- 2VLI 2", 20 guage metal deck selected

- Size controlled by construction loading

2VLI 2" Dimensions

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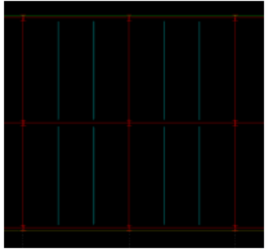
- Steel moment frame system utilized
  - Beams gravity only (blue)
  - Girders + Columns makeup the frames
- 30'x30' bay size remained



Typical Frame Layout

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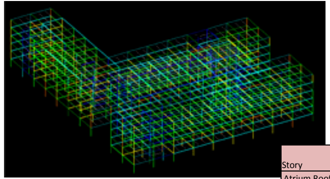
- Wind and Seismic lateral loads

Wind Speed =	90mph	Site Class =	C	Fa =	1.2
Kd =	0.85	Importance =	1	Fv =	1.7
Occupancy =	II	Ss =	0.155g	TL =	8.0s
Importance =	1	S1 =	0.050g	R =	3
Exposure =	B				



RAM Model – Standard Loading

Story	Height (ft)	Shear (k)	Drift (in)	Allowable Drift (in)	Displ (in)	Allowable Disp (in)	Check
Atrium Roof	84	18.9	0.01	0.4	0.68	2.8	OK
Roof	72	44.9	0.03	0.4	0.67	2.4	OK
6	60	51.8	0.09	0.4	0.64	2	OK
5	48	49.8	0.12	0.4	0.55	1.6	OK
4	36	47.4	0.15	0.4	0.43	1.2	OK
3	24	44.5	0.15	0.4	0.28	0.8	OK
2	12	42.0	0.13	0.4	0.13	0.4	OK
	Total	299.2					

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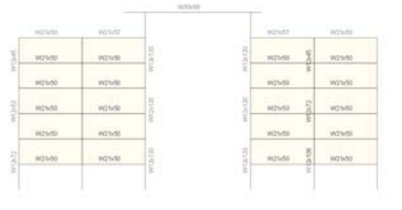
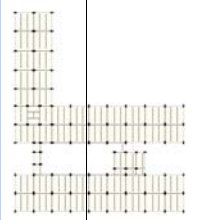
- Steel moment frame sizes

typical gravity beam =	W16x26
typical interior girder =	W21x57, W21x50
typical exterior girder =	W21x50
base interior column =	W12x106
base exterior column =	W12x72
base atrium column =	W12x120



Typical Section w/ Member Sizes



New Steel Plan

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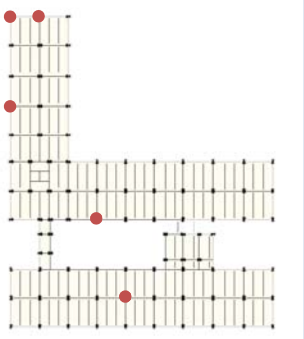
- AP, linear static analysis
- Removal of critical load bearing element

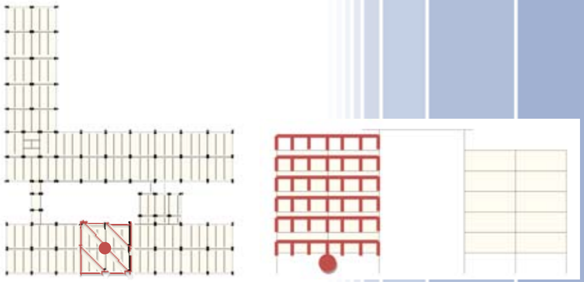


Critical Column Locations

Outline

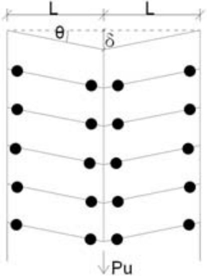
- Building Information
- Structural Depth
  - Steel Redesign
  - **Progressive Collapse**
- Enclosure Breadth
- Conclusions

- Loading critical bays:
  2.0 [(0.9 or 1.2)D + (0.5L or 0.2S)] + 0.2W
- Loading all other bays
  (0.9 or 1.2)D + (0.5L or 0.2S) + 0.2W



Critical Loading

- Virtual work for preliminary girder sizes



P * δ = ∑Mp * Θ

δ = L * Θ

P = ∑Mp * Θ / δ

P = ∑Mp * 1/L   Note: L for all girders is the same

P * L = ∑Mp

P * L = N * Mp   N = # plastic hinges (●)

Mp = P * L / N

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- Strong column, weak beam requirement

$\sum Mpc / \sum Mpb > 1.0$

$\sum Mpc = \sum Zc\,(Fy - Pu/Ag)$ (column)
$\sum Mpb = \sum (1.1\,Ry\,Fy\,Zb + Muv)$ (beam)

- Moment frame sizes based on virtual work

typical gravity beam =	W18x35
typical interior girder =	W21x83
typical exterior girder =	W21x57, W21x62
base interior column =	W14x233
base exterior column =	W14x233, W14x159
base atrium column =	W14x233

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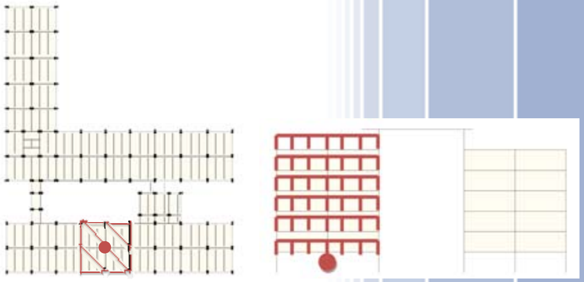
- RAM elastic design and analysis
- Considers same loading as virtual work

2.0 [(0.9 or 1.2)D + (0.5L or 0.2S)] + 0.2W for immediately affected bays

(0.9 or 1.2)D + (0.5L or 0.2S) + 0.2W for all other bays (Figure 16, 17)



Critical Loading

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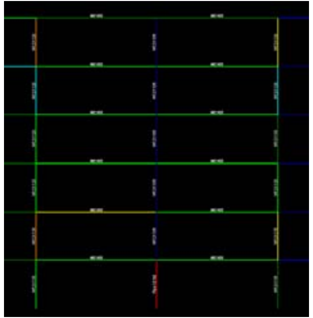
- "Blasting-out" a column in RAM = a very small pipe



RAM Failed ½" STD Pipe (red)

- Steel moment frame sizes

typical gravity beam =	W18x35
typical interior girder =	W21x122
typical exterior girder =	W21x83, W21x73
base interior column =	W12x190
base exterior column =	W12x170
base atrium column =	W14x176

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- Structure designed to minimize injuries to the occupants, not the building itself
- Following the same thinking, other building systems should also be considered
- ASTM F 2248-03
  - Provides procedure to determine equivalent 3-second blast pressure
- ASTM E 1300-04
  - Provides procedure to determine glass load resistance
- Both lites laminated, no "sacrificial lite"

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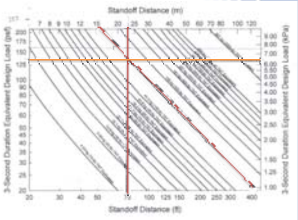

- Equivalent blast pressure requires charge size in TNT lb and a standoff distance

Device	Description	Charge Weight (TNT Equiv. lbs)
	Pipe Bomb	5
	Suitcase	50
	Compact Sedan	220
	Full Size Sedan	500
	Passenger / Cargo Van	1,000
	Box Truck	4,000
	Semi-Trailer	40,000

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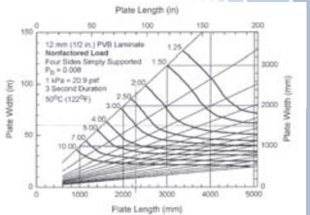

- Various charts for thicknesses and glass type
- Enter chart with opening dimensions
- Final designs:
  - Atrium = (2) 3/16″ heat strengthened, laminated insulating glass unit
  - Office = (2) 1/4″ heat strengthened, laminated insulating glass units

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- Thermal resistance determined by comparing the conductance values of IGU components

MATERIAL	THICKNESS (m)	CONDUCTIVITY (W/m-K)	CONDUCTANCE (W/m^2-K)	RESISTANCE	
air film	n/a	n/a	23	0.043	Assume: Emissivity = 0.9
glass	0.008	0.8	100	0.010	
air space	0.02	n/a	1.75	0.571	Assume: Emissivity = 0.05
glass	0.008	0.8	100	0.010	
air film	n/a	n/a	8.3	0.120	
			Total =	0.755	
			U =	1.324	(W/m^2-K)

Curtain Wall Conductance

- Heat change considered for summer and winter conditions

	Summer		Winter
Tout =	35 ⁰C	Tout =	-9.4 ⁰C
Tin =	23.9 ⁰C	Tin =	21.1 ⁰C

HEAT CHANGE Q				
AREA (m^2)	ΔT (K)	R (m^2-K/W)	Q (W)	
3.375	11.1	0.755	28	per unit
182	11.1	0.755	2673	system

Curtain Wall Summer Conditions

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- Considering standard loading only, the alternate steel moment frame system provides an efficient option

- At this point, the only progressive collapse design which can be safely recommended is the RAM elastic design.

- However, this method is extremely conservative and is an inefficient design. As a result, I recommend the current concrete system or more plastic analysis of the proposed steel system.

- For increased occupant safety, I recommend the employment of the laminated blast safety glass

- MAE Discussion

AE 597a - use of RAM Structural System
- virtual work for girder estimation

AE 534 - discussion of progressive collapse
- discussion of blast resistant glass

AE 534 - design of blast resistant glass
- heat transfer analysis

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- Acknowledgements

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? Questions ?