Hyatt Regency
Pittsburgh International Airport

Hiro McNulty
Structural Option

AE Senior Thesis
Spring 2006

Outline

- Background Information
- Existing Structural Conditions
- Proposal and Design Criteria
- New Structural Design
- Fire Protection Study
- Construction Management Analysis
- Conclusions and Recommendations

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Background Information

Project Team

- Owner: **Dauphin County General Authority**
- Architects: *Primary* - **L. Robert Kimball & Associates**
  Associate - **Thompson, Ventulett, Stainback, and Associates**
- Structural Engineers: **DeSimone Consulting Engineers**
- MEP Engineers: **L. Robert Kimball & Associates**
- Electrical Engineers: **L. Robert Kimball & Associates**
- General Contractor: **Dick Corporation**

Background Information

- Only hotel located on airport property
- 275,000 square feet
- 12 story hotel tower (*approx. 17,000 sq. ft. per floor*)
- Tower features 336 guest rooms
- 2 story conference center (*approx. 75,000 sq. ft.*)
- Estimated cost: $33 million
- Construction: November 1998 - May 2000

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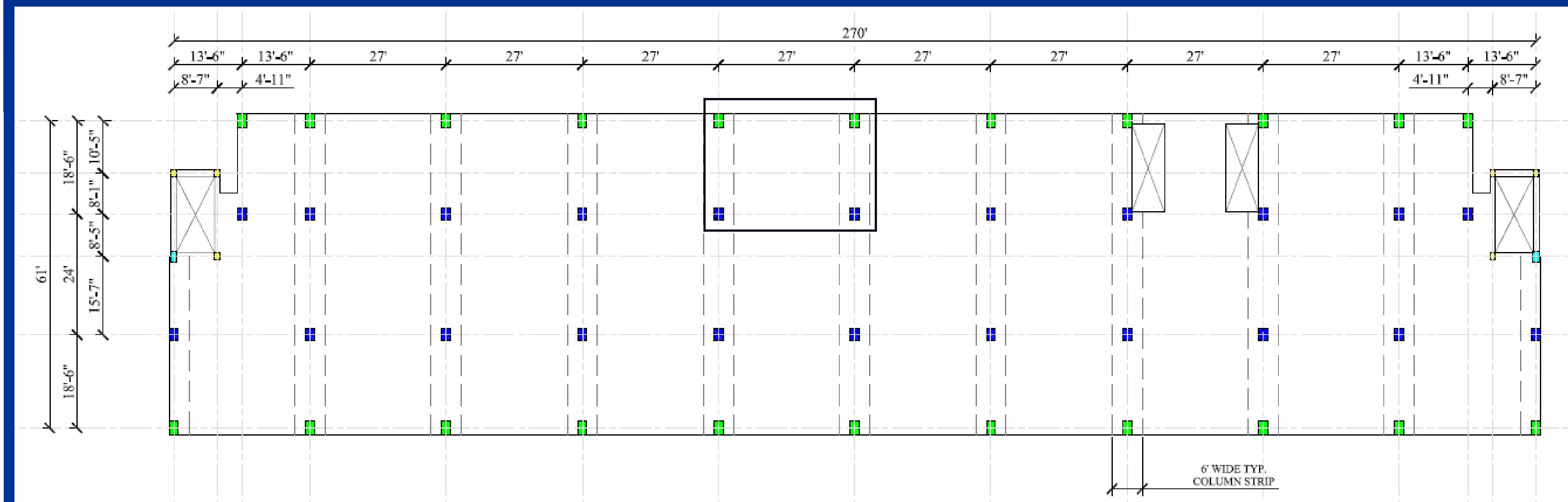
Existing Structural Conditions

- *Conference Center is not the main emphasis of the depth work. As such, it will not be covered in this presentation.*
- The Hotel tower is framed with cast-in-place concrete columns with a filigree floor slab.
- The concrete moment framing serves both as the lateral load resisting system as well as the main gravity system.

Existing Structural Conditions

- 6’ wide, 8” deep solid column strips are oriented N-S on the typical tower plans.
- The floor slab consists of an 8” thick filigree slab with polystyrene voids between column strips.
- There are 44 columns in the typical tower floor with typical sizes of 22” x 28” and 22” x 32”.
- 12”-24” wide, 18” deep cast-in-place concrete beams form the perimeter of the typical floor plan.
- Typical 10’ floor-to-floor height for main guest floors.
- Overall existing building height of 140’ from ground level to roof level.

Existing Structural Conditions

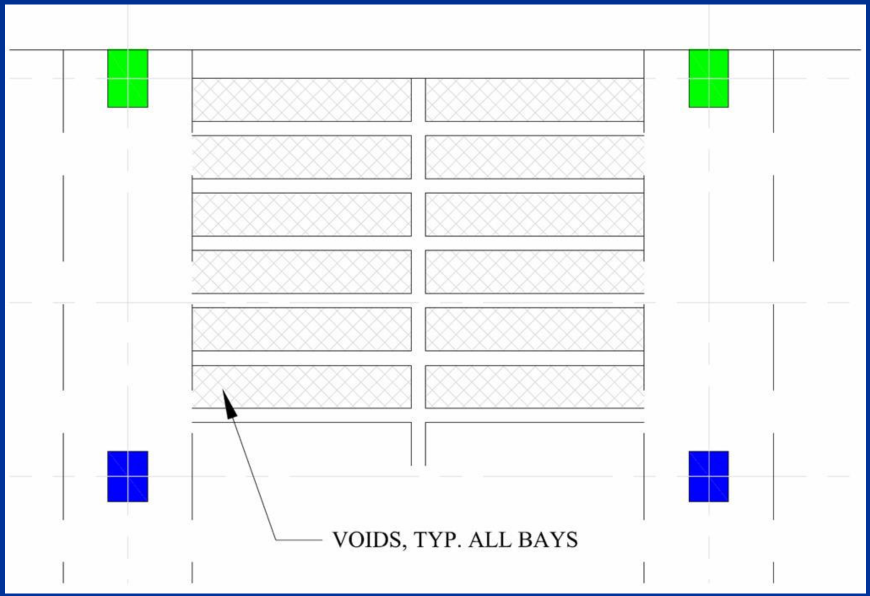


Typical Tower Floor Plan

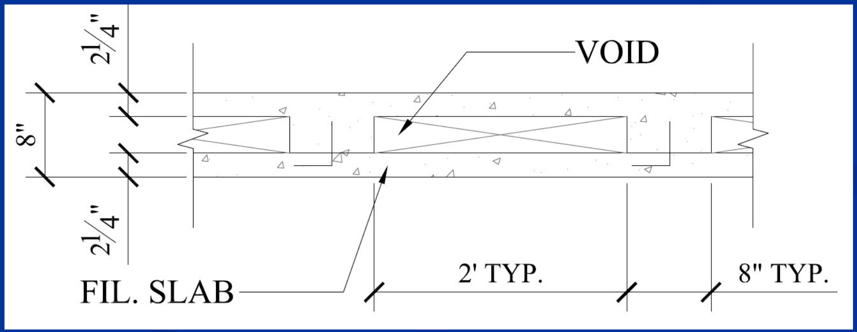
Typical bay sizes are: 27’-0” x 18’-6”

27’-0” x 24’-0”

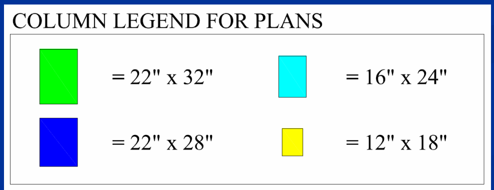
Existing Structural Conditions



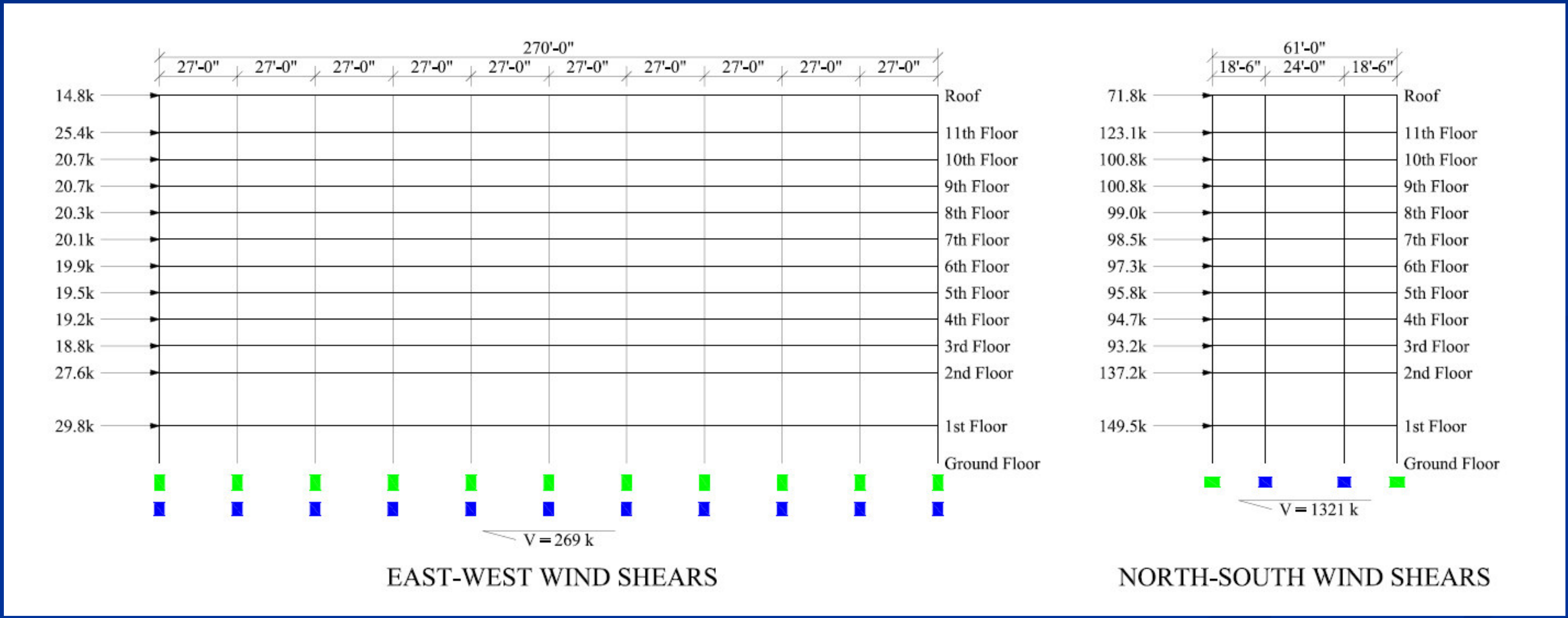
Void Layout Plan



Section Through Voids



Existing Structural Conditions

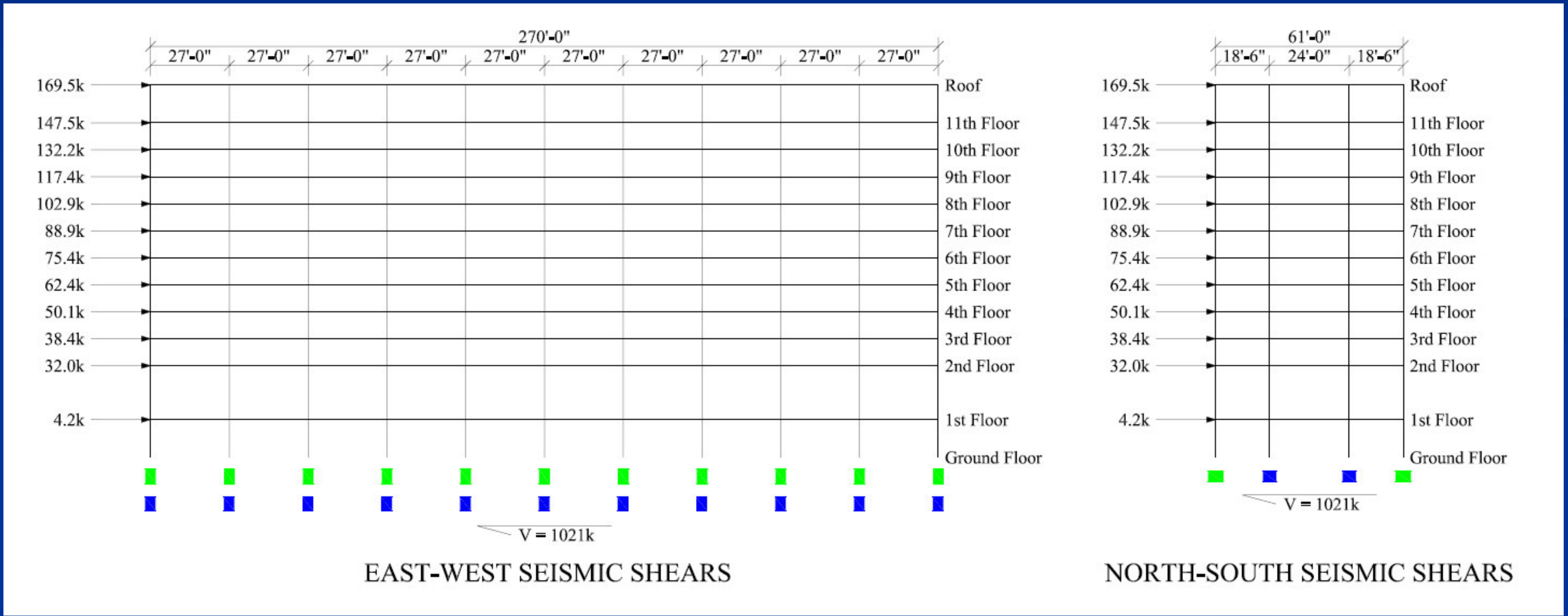


Wind loads as calculated using the ASCE 7-02 Analytical Procedure.

Based on 12-story, 140' building height.

Story shears determined from tributary area of wind pressures on each level.

Existing Structural Conditions



Seismic loads as calculated using the ASCE 7-02 Equivalent Lateral Force Procedure.

Based on 12-story, 140’ building height, Site Class D (based on the geotechnical report).

Base shear calculated based on calculated building weight and then distributed to floors based on weight and height of each level.

Existing Structural Conditions

Wind Base Shear		Seismic Base Shear	
North-South	East-West	North-South	East-West
1321 k	269 k	1021 k	**1021 k**

- Based on the large weight of the building, the seismic shears in the East-West direction are around 4 times as large as the wind loads in that direction.
- Building weight (of structural elements) for concrete framing calculated to be 22,700 kips.

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Proposal and Design Criteria

- From analyzing the existing structural conditions, the seismic loading for the location was very large for its location.
- Ground motion acceleration is based on a response spectra for given geographical regions.
- Pittsburgh, PA has:
  0.2-second spectral response acceleration of 12.7% gravity.
  1-second spectral response acceleration of 5.4% gravity.
- In comparison, areas of California have upwards of:

  0.2-second spectral response acceleration of 150% gravity.
  1-second spectral response acceleration of 60% gravity.

Proposal and Design Criteria

- The main goal of the new design was to reduce the weight of the building to allow the wind loading to control the design, by creating a design implementing structural steel framing.
- In addition to simply changing the framing type, strict design criteria were established to avoid architectural changes and problems with the structure.

Proposal and Design Criteria

- The main design criterion were regulations from the Federal Aviation Administration (FAA) for building height of structures in proximity to an airport.
- *FAA Advisory Circular AC 150/5190-4A.*
- *FAR Part 77, Objects Affecting Navigable Airspace.*
- From conversation with the architectural project manager, the building currently meets these regulations; however, greatly increasing the building height would not be permissible.

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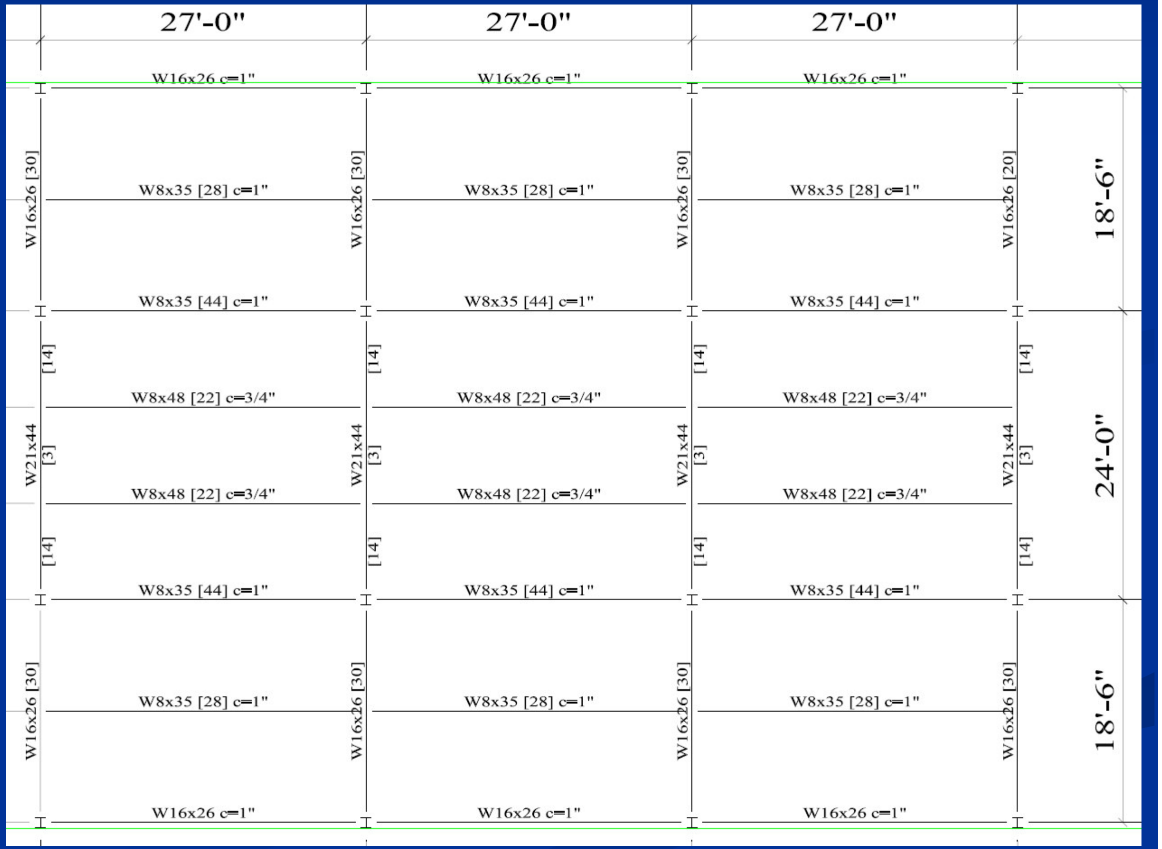
New Structural Design

- The new structural design updated the code requirements from BOCA 1996 to IBC 2003.
- Design completed from a combination of hand calculations and a computer model in RAM Structural Systems.
- Framing selected to minimize impact on architecture and to meet design criterion for building height.

New Structural Design

- Floor is a composite steel framing with 3½" slab thickness. (1.5" decking with 2" slab above flutes.)
- Cambers shown to meet:
  $^{\ell}/_{360}$ live load deflection
  $^{\ell}/_{240}$ dead + live load defl.
- Shear stud locations shown to achieve composite strength required.
- Beams equally spaced between columns.
- 1' height added to main guest floors.



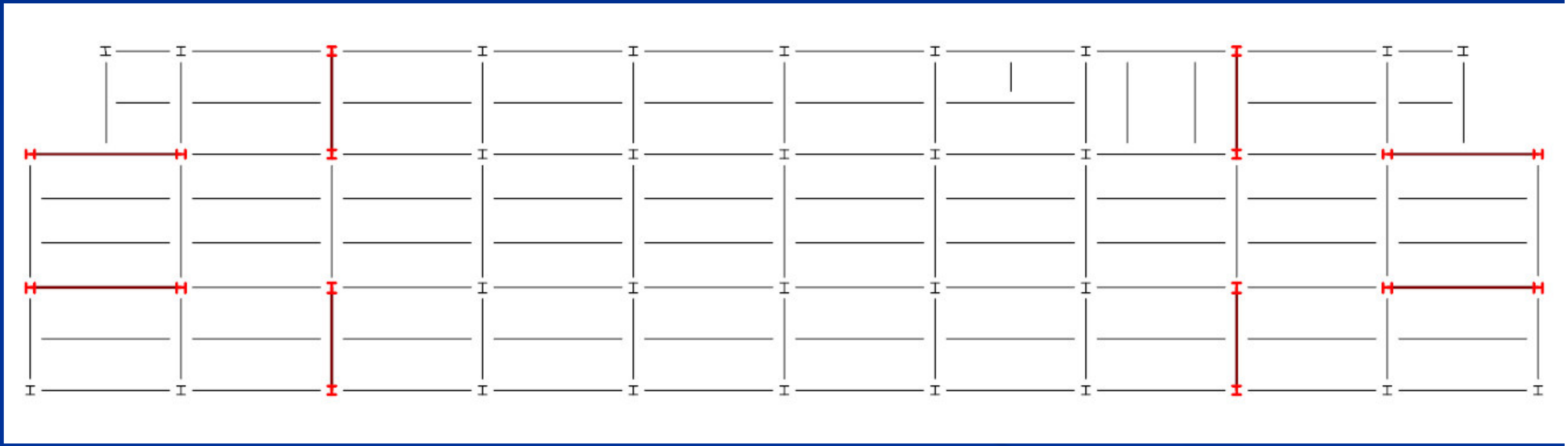
Typical Layout of Bays on Guest Floors

New Structural Design

- Columns splices specified every 3 levels.
- Total new building height is 150’, a 10’ increase from the original design.
- Typical Sizes indicated in table below are for gravity columns in typical bays as shown in last slide.

Levels	Min Size Used	Max Size Used	Length
9,10,Roof	W14x43	W14x53	37’
6,7,8	W14x53	W14x90	33’
3,4,5	W14x61	W14x120	33’
Main,2	W14x90	W14x159	31’
Ground	W14x90	W14x159	16’

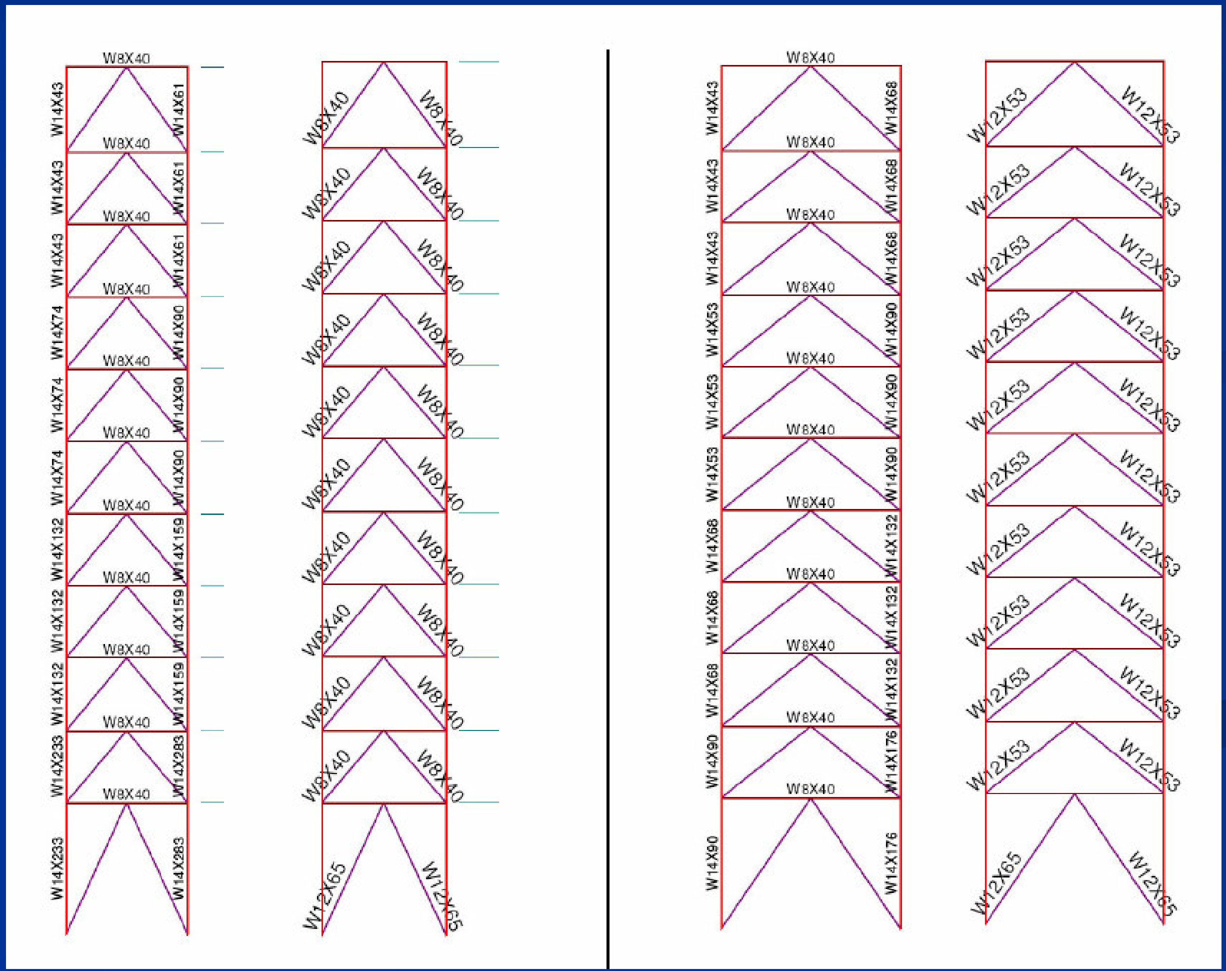
New Structural Design



- Braced frame locations shown on typical floor plan.
- Chevron-braced frames were selected to minimize impact on floor plan and allow openings.

New Structural Design

- Braced frame elevations.
- North-South frames (left)
- East-West frames (right)



New Structural Design

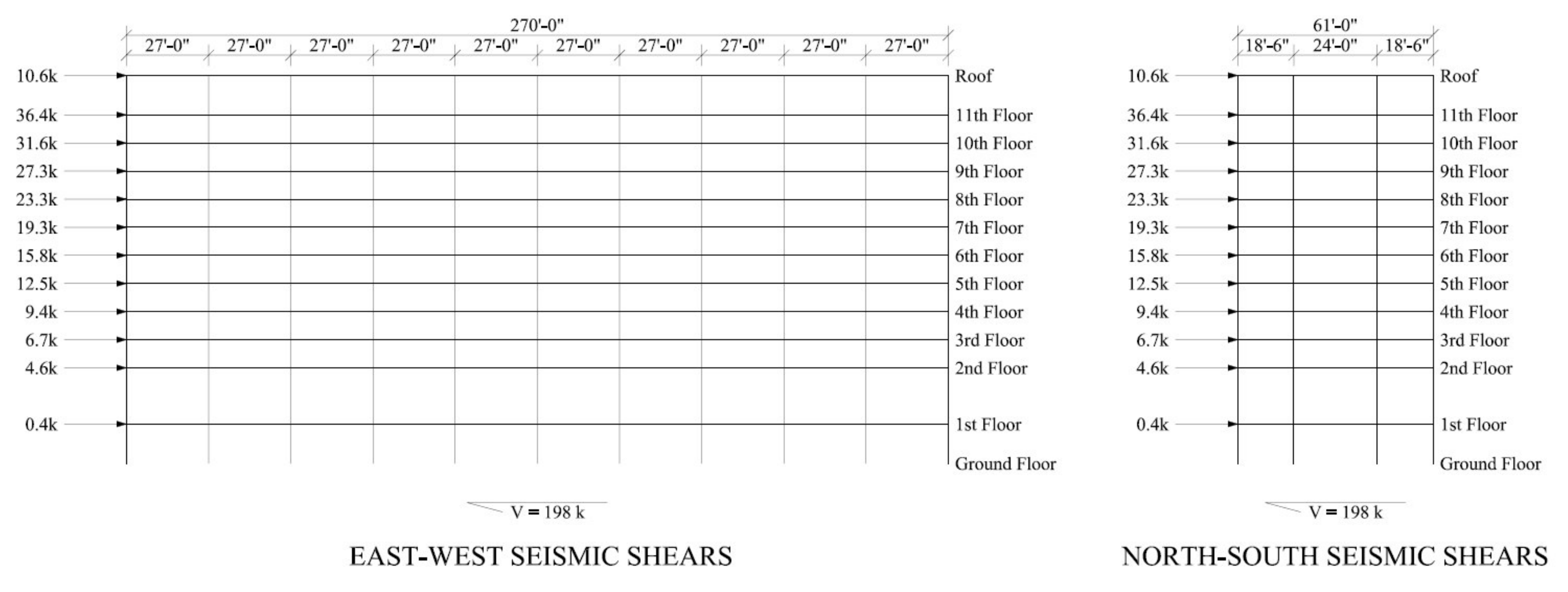
Impact on the Structure

- 10’ increase in height is less than a 10% total increase in building height, which is still viewed as unfavorable for the purpose of the height restrictions.
- However, the change of framing is shown to have a minimal impact on the height and can have a great impact on the weight of the building and the seismic loadings.

New Structural Design

- Slight increase in building height changes the wind loading. The increase is less than 30 kips in each direction, which is fairly insignificant.
- From the RAM model, a takeoff of the members was used to calculate the weight of the new structure.
- The new weight is calculated to be 7,400 kips.
- This is a decrease of over 15,000 kips.

New Structural Design



New seismic loads as calculated using the ASCE 7-02 Equivalent Lateral Force Procedure.

Based on 12-story, 150’ building height, Site Class D (based on geotechnical report), and new weight of 7400 kips.

New Structural Design

Vibration Analysis

- With the large decrease in weight, a vibration study was performed to determine if walking induced vibrations in the corridors would cause unfavorable conditions for guest rooms.
- Using AISC Design Guide 11, the floor acceleration was calculated to be 0.6% gravity, which is greater than the recommended limit of 0.5% gravity for offices, residences, and churches.
- The easiest way to remedy this problem would be to stiffen the beams framing under the guest rooms; however, by increasing member size and stiffness, the depth of the members would increase.
- Since the member sizes were selected for their depth, the results of this analysis will be considered in the final conclusions and recommendations.

New Structural Design

Resulting conclusions from the depth work:

- By choosing an alternate framing, in this case steel instead of concrete, you can greatly impact the seismic loading on a structure. The seismic loads were decreased to approximately 1/5 the original loads calculated.
- The building weight can greatly be reduced by changing from concrete to steel framing, in this case the weight was reduced to approximately 1/3 the original design weight.
- While keeping member sizes as small as possible, with the addition of the decking and slab, the thickness of the steel framing is still larger than the initial filigree system implemented.
- The lightweight steel framing, while reducing the overall building weight, can also induce other serviceability concerns with floor vibrations.

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Fire Protection Study

- To determine the required fireproofing measures for the steel framing, IBC 2003 requirements were used.
- Fireproofing type and spray thicknesses were determined using Grace Construction Products Monokote® MK-6® spray-on fireproofing and the required thickness values detailed in the Underwriter's Laboratory Online Certifications Directory.
- Steel beams require a 1" thick spray of UL Design No. N779 - 3 hour fire rating.
- Steel columns require, a 2½" thick spray of UL Design No. X772 - 3 hour fire rating (on an average sized column).
- Floor decking requires, a 5/8" thick spray of UL Design No. D780 - 2 hour fire rating.

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Construction Management Analysis

- Cost and time analyses were performed using R.S. Means Building Construction Cost Data 2006.

	Cost	Time
Original Design	$2,100,000	220 days
New Design	$2,900,000	205 days

- Concrete estimates (original design) were calculated based on the square footage of the filigree planks and the total cubic yards of cast-in-place concrete.
- Steel estimates (new design) were calculated based on the length of beams and columns, the number of shear studs, and the square footage of the slab and decking.

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Conclusions and Recommendations

- The new structural design supports the proposal that the building weight and seismic loads could be reduced by changing to steel framing.
- From the structural design and analysis procedure, it was determined that the new system could not entirely prevent increasing the floor depth; however, the new system has minimized the impact and only added 10 feet to the building height, less than a 10% overall increase.
- The lightweight framing may induce vibration problems in the guest rooms.
- Due to the increase in cost, building height, and vibration concerns, the new system does not seem to be the best choice for the Hyatt.
- However, it should be noted that the analyses have shown that for similar projects with less strict design criterion, especially those in higher seismic areas, the steel framing would very likely be a better choice.

Acknowledgements

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- My Friends and Family

Questions?