Study on The Improvement of Thermal Performance of Curtain Wall Spandrels

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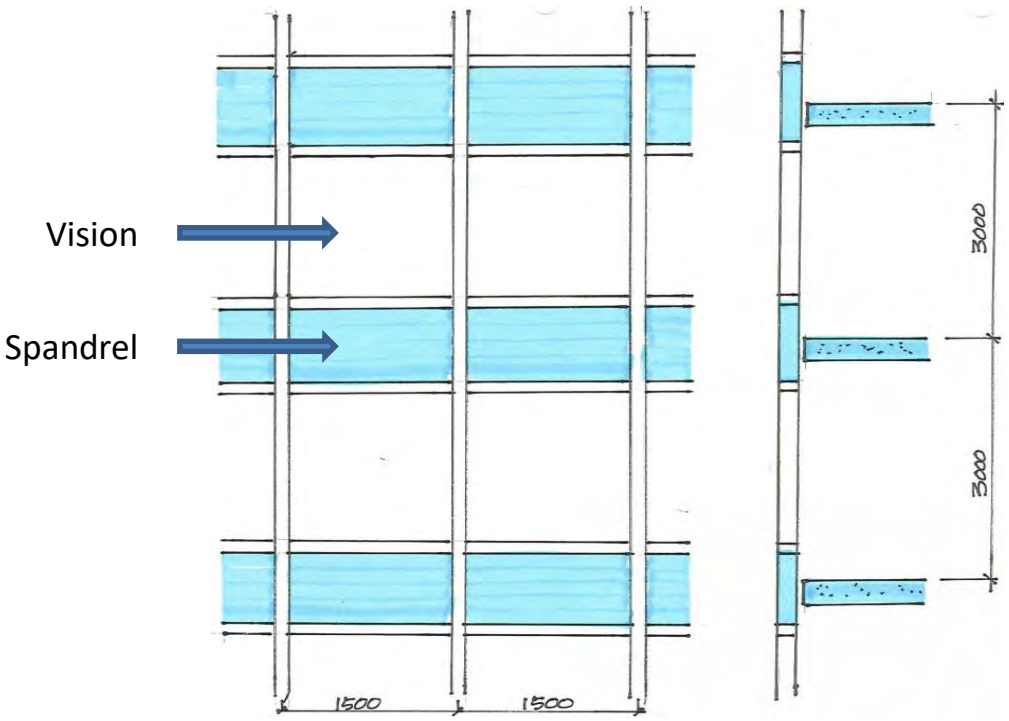
BUSQUE ENGINEERING
Building Envelope and Roofing Consultants

Curtain Walls

- Vision
- Spandrel
  - Opaque



Window to Wall Ratio (WWR)

- The total vertical fenestration area shall be less than 40% of the gross wall area.
  (*ASHREA 90.1, 5.5.4.2.1)*
- WWR ≤ 40%

Curtain Wall:

Vision:	≤40%
Spandrel:	≥60%

WWR

- Curtain walls

Vision:	70%-80%
Spandrel:	20%-30%

Trump Tower:

WWR 80%

Requirement of U (R) Values

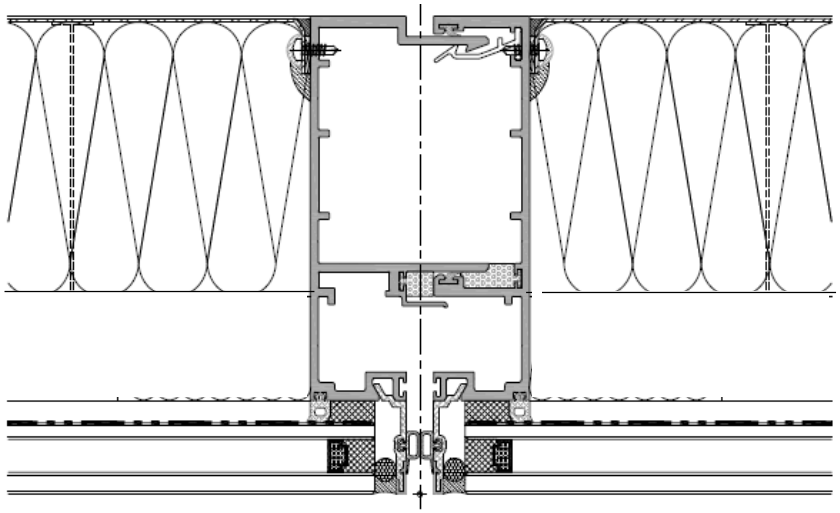
- Trump Tower:
  - Vision: R3.1
  - Spandrel: R4
- Examples of two curtain wall projects

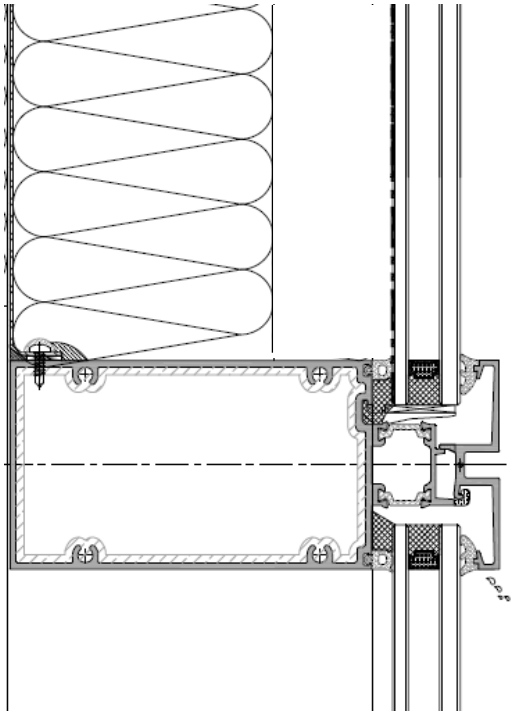
	Residential		Commercial	
	U-factor ($W/K.m^2$)	R-value ($ft^2.h.°F/Btu$)	U-factor ($W/K.m^2$)	R-value ($ft^2.h.°F/Btu$)
Vision	2.27	2.5	1.75	3.25
Spandrel	0.94	6.0	0.94	6.0
Overall	2.00	2.8	1.59	3.57

Overall U-factors and R-values are based on WWR 80%.

Conventional Spandrel

- Mineral wool insulation + G.M.S.





Conventional Spandrel

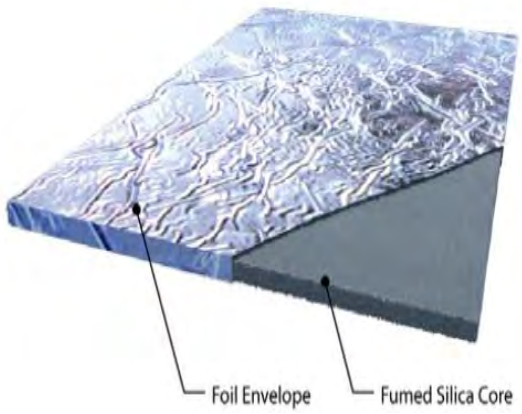
- Double spandrel IGU
  - Low-E coating on surface #2
  - 90% Argon filled
  - Warm edge spacer
  - Opaque coating on surface #4
- 4” mineral wool insulation (R4.2/inch)
- G.M.S. backpan

Center of spandrel			Overall of spandrel		
U_{cop}		R_{cop}	U_s		R_s
$W/m^2.k$	$BTU/h.ft^2.F$	$h.ft^2.F/BTU$	$W/m^2.k$	$BTU/h.ft^2.F$	$h.ft^2.F/BTU$
0.265	0.047	21.4	1.113	0.196	5.1

COP data and overall data refer to Jangho Curtain Wall’s curtain wall system.

Vacuum Insulation Panel (VIP)

- VIP is a high-efficiency insulation product
- Consists of a core material with small pores,
- Enclosed in a thin laminate film
- R39/inch



VIP in IGU

- Pre-manufactured in IGU
- In Double or Triple IGU
- Multiple VIPs in an IGU

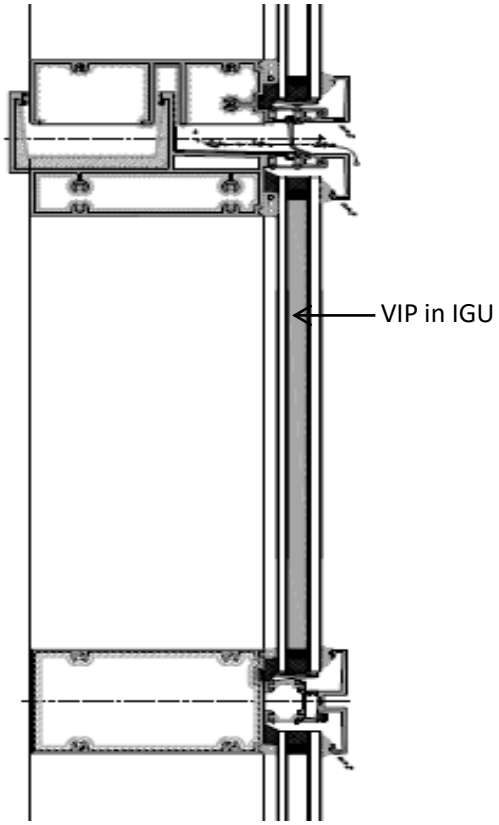
Effective R-Values of IGU with VIP

IGU Thickness (inch)	VIP Thickness (inch)	COP R-value (ft2.hr.F/Btu)	Overall R-value (ft2.hr.F/Btu)
1	5/8	21.80	10.84
1-1/8	5/8	21.80	10.67

Data refers to Dow Corning.

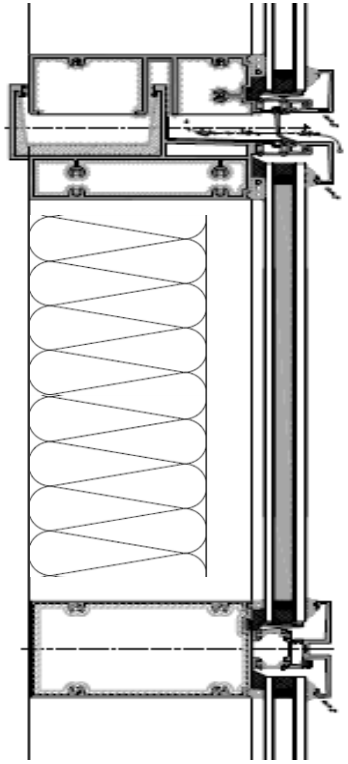
Vacuum Insulation Panel (VIP) Spandrel

- VIP integrated into Curtain walls



Combined Conventional and VIP Spandrel

- VIP + Mineral wool insulation + Backpan



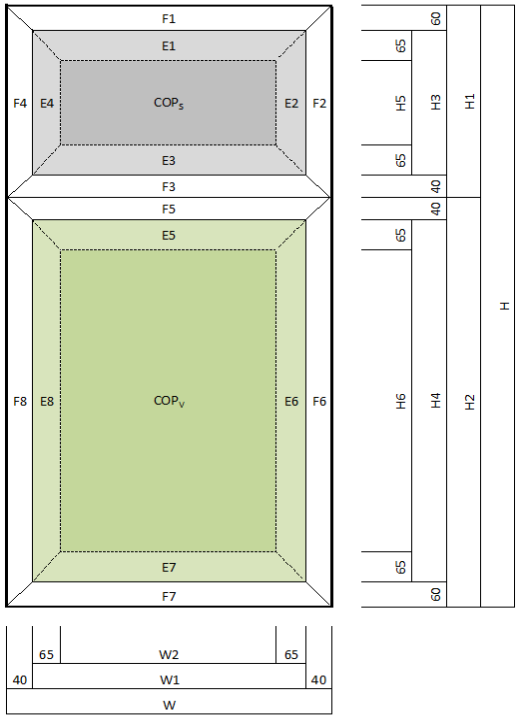
Modeling with THERM

- Per NFRC 100

$$Ut = \frac{[\sum(\mathrm{Uf} * \mathrm{Af}) + \sum(\mathrm{Ue} * \mathrm{Ae}) + \sum(\mathrm{Ucop} * \mathrm{Acop})]}{\mathrm{At}}$$

Where:

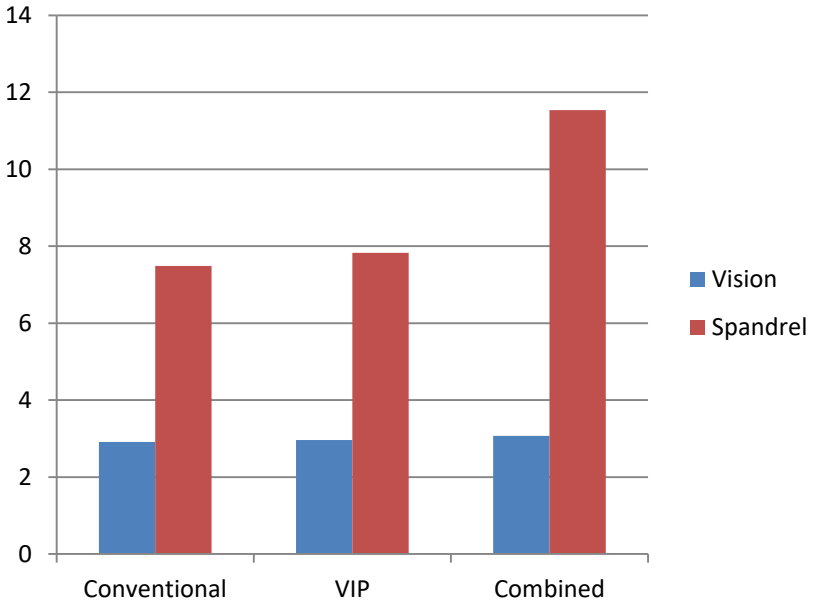
$U_t =$	Total product U-factor, W/m^2-°K.
$A_t =$	Projected fenestration product area, m^2.
$U_f =$	Frame U-factor, W/m^2-°K.
$A_f =$	Frame area, m^2.
$U_e =$	Edge-of-panel U-factor, W/m^2-°K.
$A_e =$	Edge-of-panel area, m^2.
$U_{cop} =$	Center-of-panel U-factor, W/m^2-°K.
$A_{cop} =$	Center-of-panel Area, m^2.



Comparison at Particular WWR

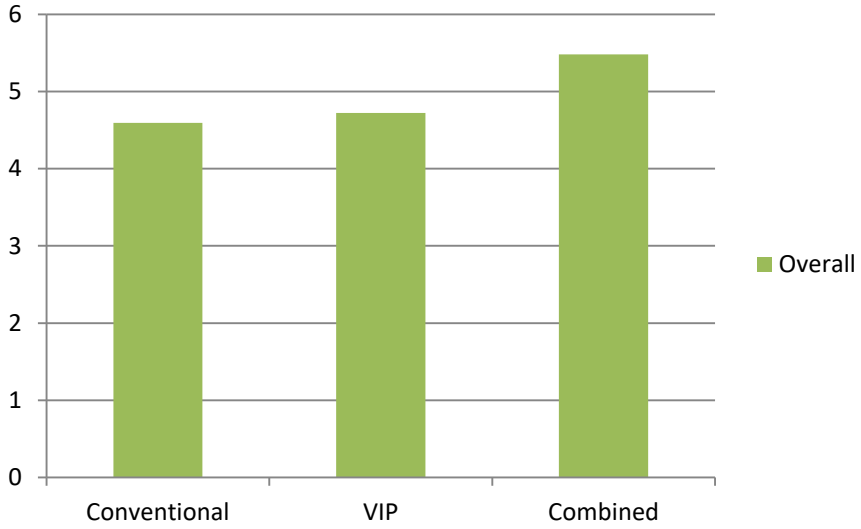
- Spandrel R-values @ WWR 40%

- Vision
  - around R3
- Spandrel
  - Conventional R7.48
  - VIP R7.83
  - Combined R11.54



Comparison at Particular WWR

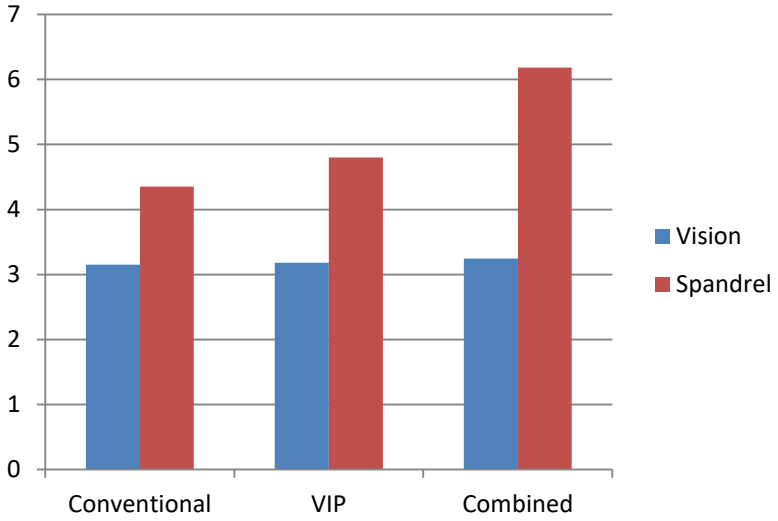
- Overall R-values @ WWR 40%
  - Conventional R4.60
  - Combined R5.48
  - Increase 19%



Comparison at Particular WWR

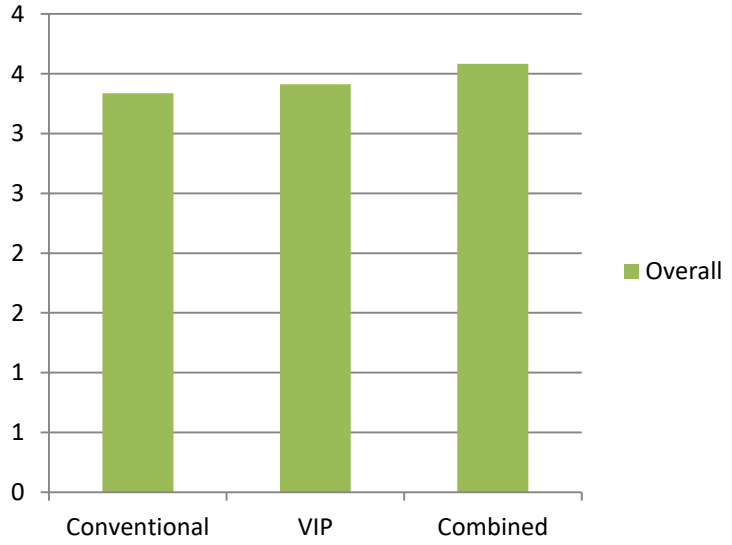
- Spandrel R-values @ WWR 80%

- Spandrel
  - Conventional R4.35
  - VIP R4.8
  - Combined R6.19



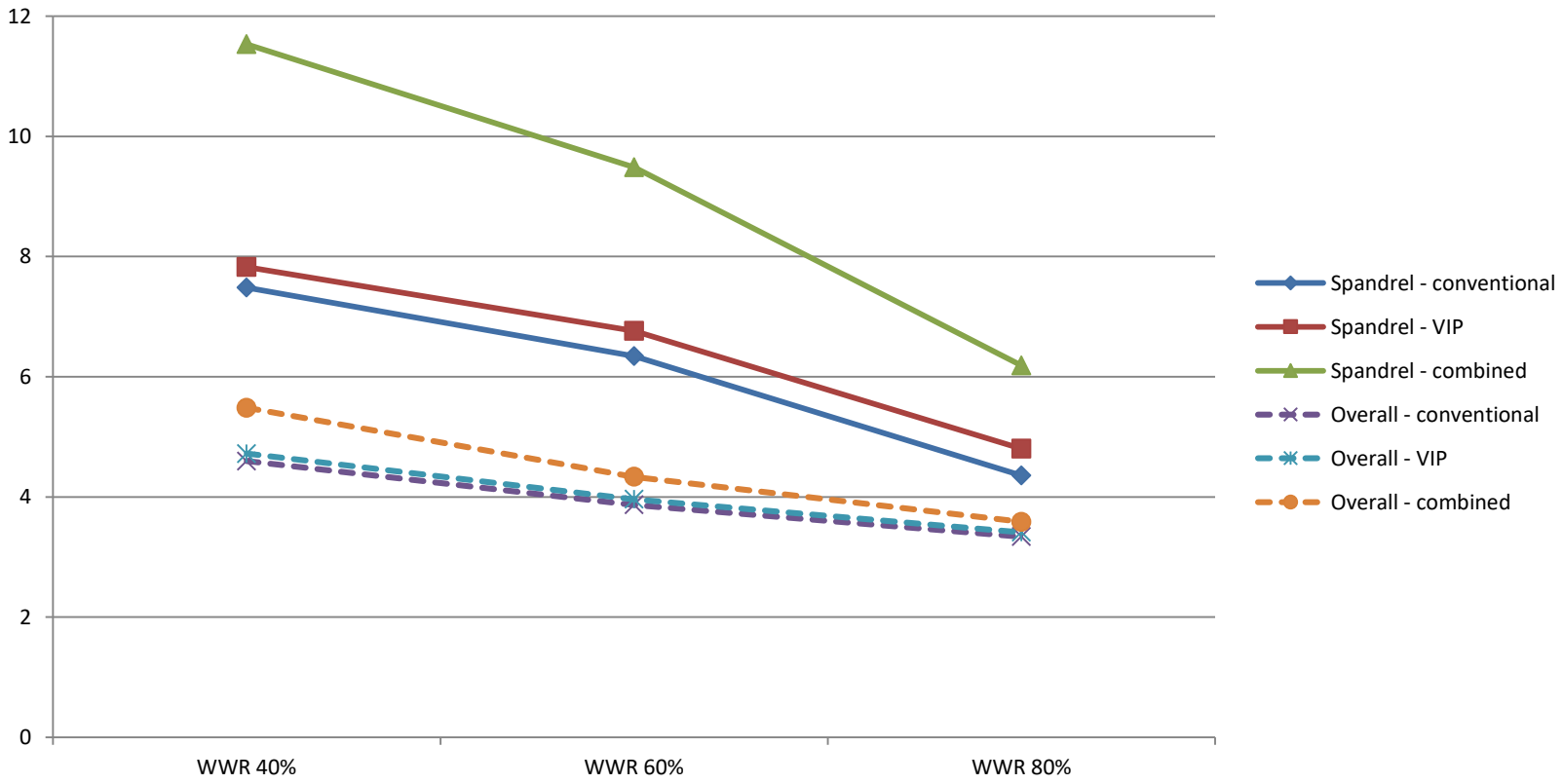
Comparison at Particular WWR

- Overall R-values @ WWR 80%
  - Conventional R3.34
  - Combined R3.58
  - Increase 7%

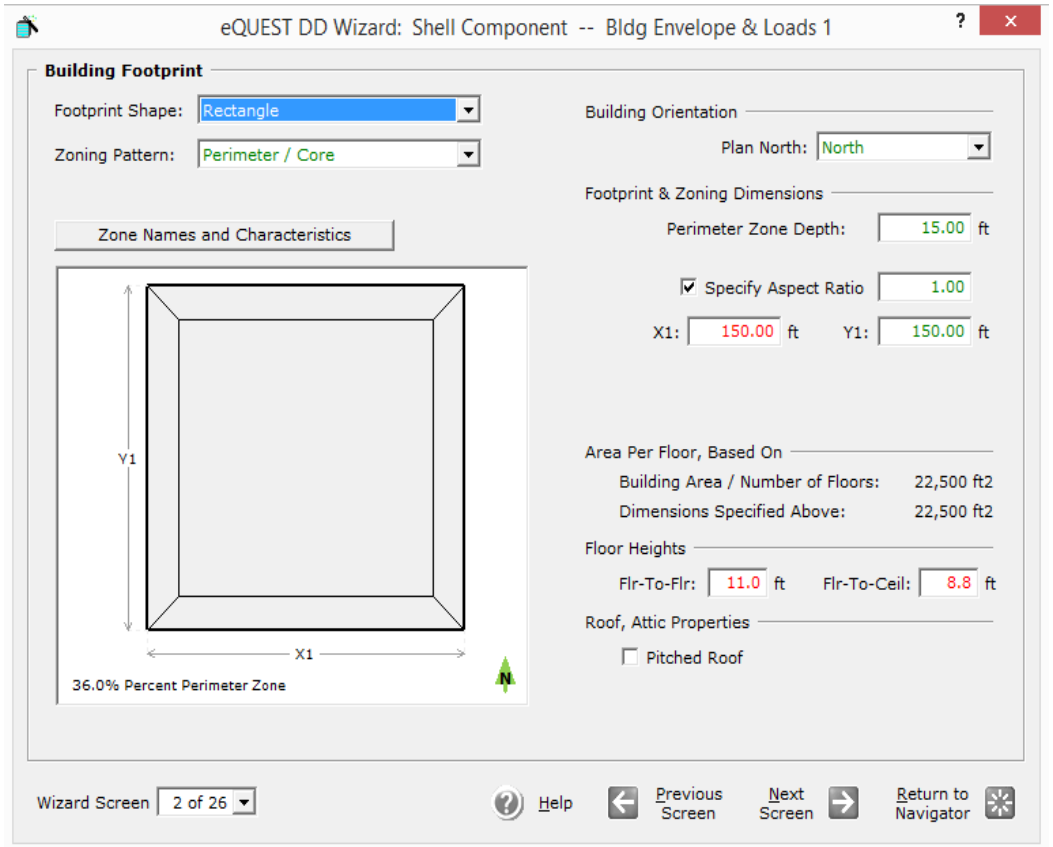


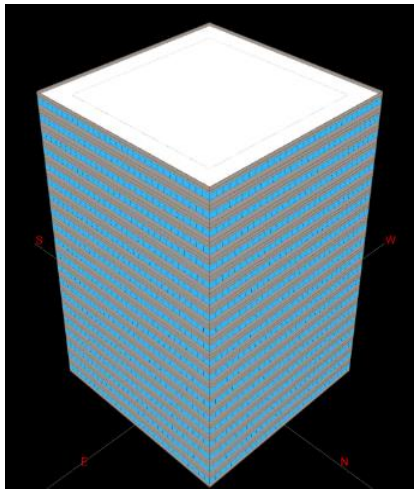
Effect of WWR on Spandrel and Curtain Wall thermal Resistance

- R-values of spandrel only and overall curtain wall at different WWRs



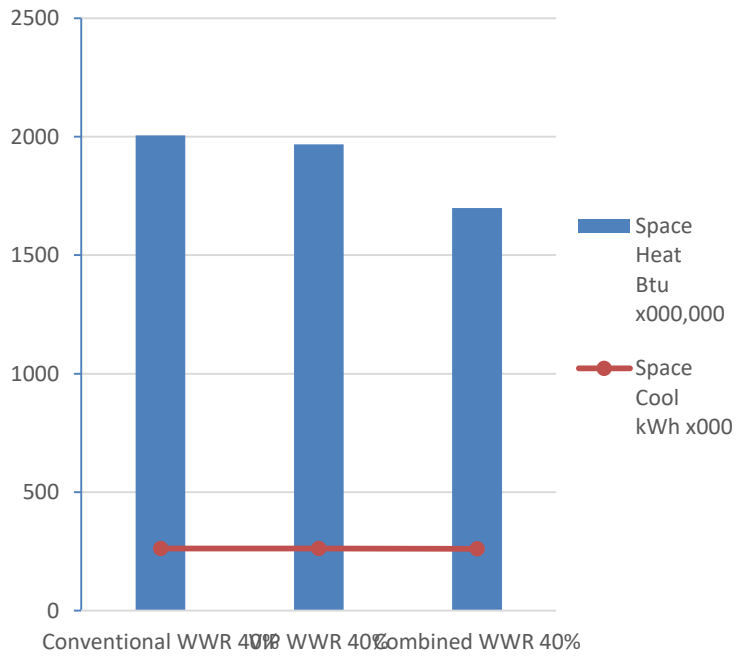
Modeling with eQuest





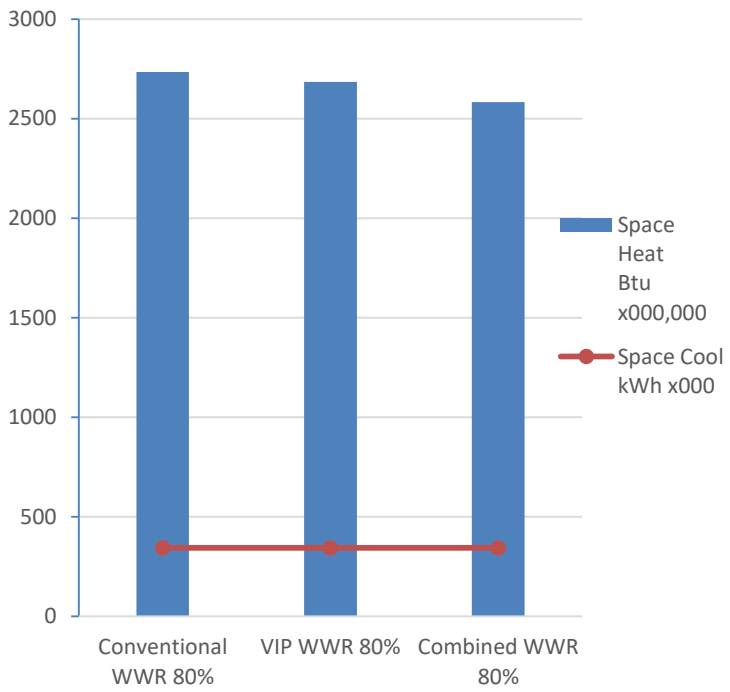
Effect of Spandrel System on Gas And Electric Consumption

- Spandrel R-values @ WWR 40%
- Electric consumption
  - Unchanged
- Gas consumption
  - Conventional 2005 Mbtu
  - VIP 1967 Mbu
  - Combined 1699 Mbtu
  - 15% saving



Effect of Spandrel System on Gas And Electric Consumption

- Spandrel R-values @ WWR 80%
- Electric consumption
  - Unchanged
- Gas consumption
  - Conventional 2734 Mbtu
  - VIP 2684 Mbu
  - Combined 2583 Mbtu
  - 6% saving



Effect of WWR on Gas Consumption

- Annual gas consumption @ different WWRs

Conclusions

- Through modeling with Therm
  - No significant difference between conventional spandrel and VIP spandrel
  - Increase of overall thermal resistance is NOT obvious
- Through modeling with eQuest
  - Similar trends
- Not recommended to upgrade a conventional spandrel to a VIP spandrel
  - VIP cost is much higher than mineral wool

Future Work

- Life Cycle Cost (LCC) analysis
- Proper vision to spandrel ratio
- More research for high thermal performance materials
- Thermal performance of vision
- …

Thank You

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