## Structural Breadth

Upon the redesign of the typical painting studio, the original clerestory design was switched to a skylight system. While this created the opportunity for a more uniform distribution of daylight, it also required modification to the existing system. The existing roof design made use of a 3" Type N Deep-Rib Steel Decking. The beams to be redesigned were assumed to be fully braced due to the metal decking and skylights. Therefore, sizing of members was based on the Steel Construction manual table 3-2.

Please note that the scope of this depth is limited to the resizing and cost analysis of the structural members only.

Design Roof Loads

1.   Dead Loads: (In accordance with IBC 2000, sections 1606 and 1605.3.1)
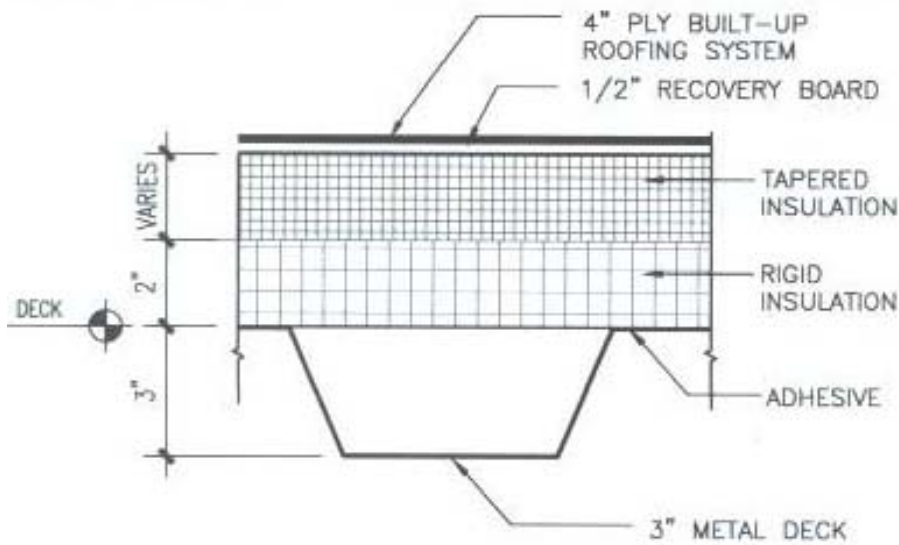
Roof Type A

Metal Decking - 2.71 PSF

½" Recovery Board – 0.65PSF

Tapered Insulation – 1.0 PSF

Rigid Insulation – 0.8PSF

Skylight – 10psf

Note: Value Calculated from Vulcraft decking see appendix F for cut sheet

2.   Live Loads: (In accordance with IBC 2000, sections 1607 and 1605.3.1)

20PSF

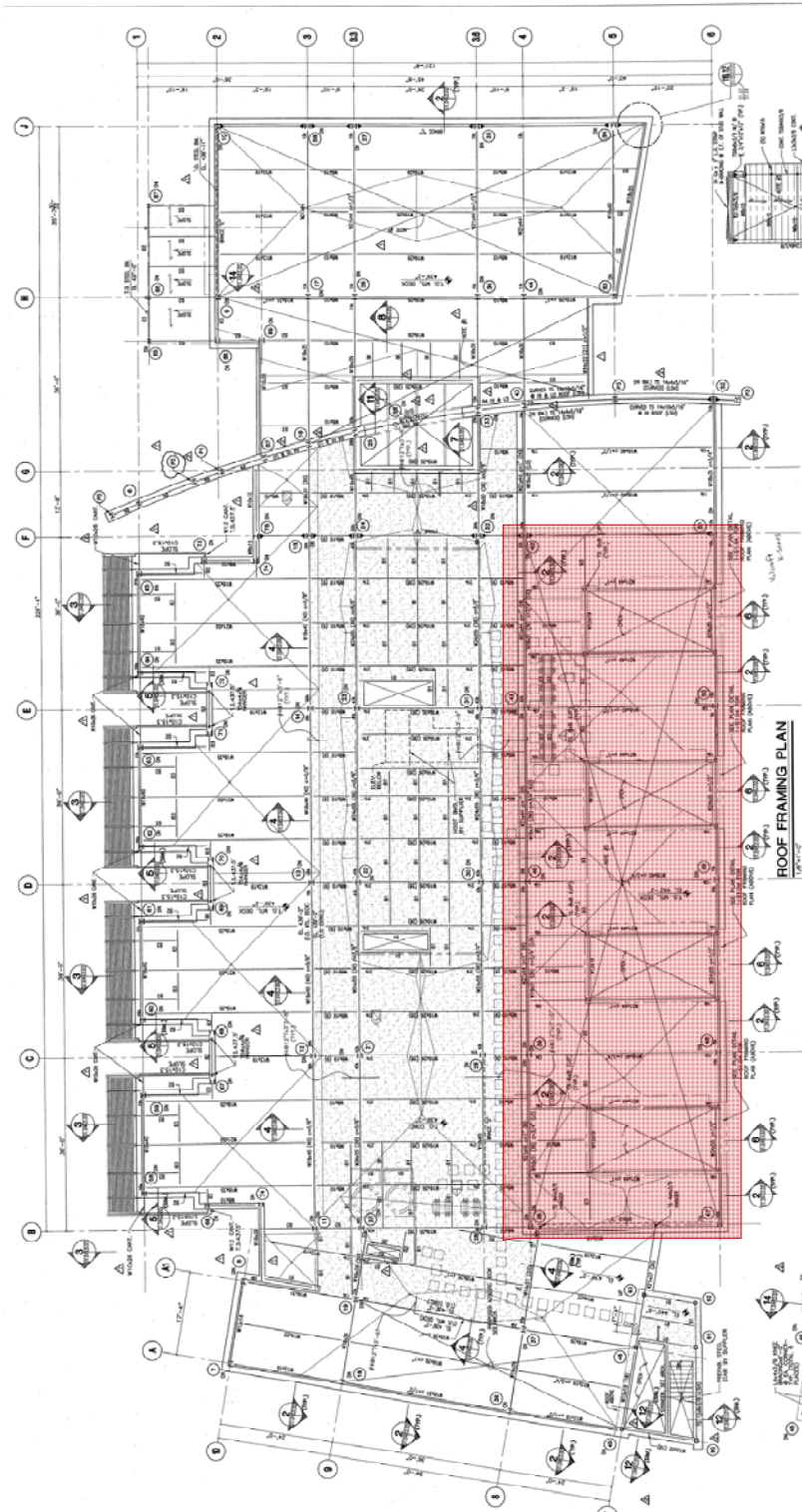3.   Snow Load (In accordance with IBC 2003 section 1608.2)

30 PSF snow load

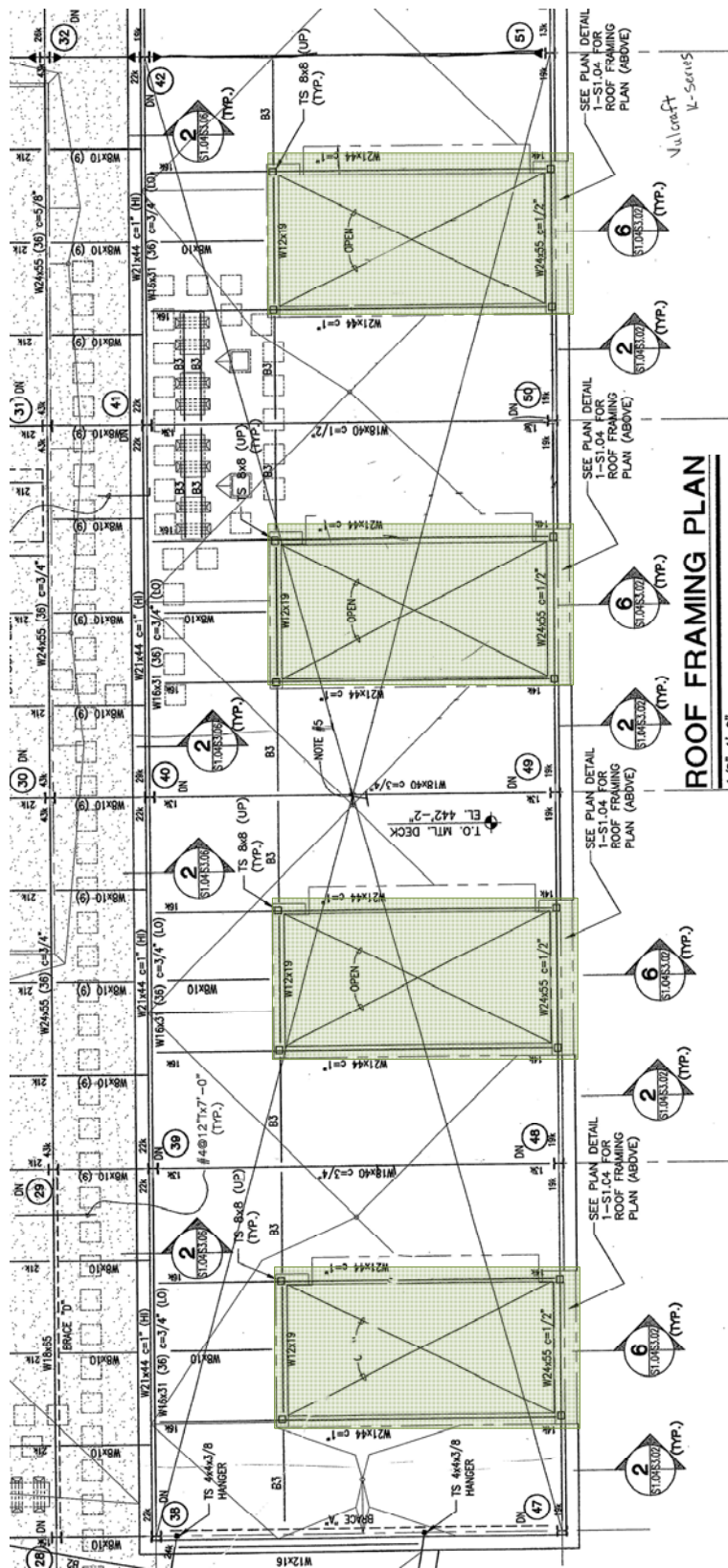Design Load = 1.2D + 1.6S + 0.5L

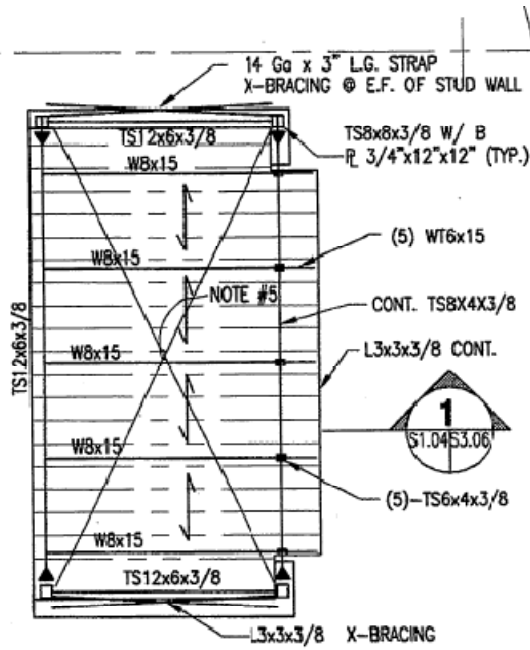= 1.2(5.16) + 1.6 (30) + 0.5(20)

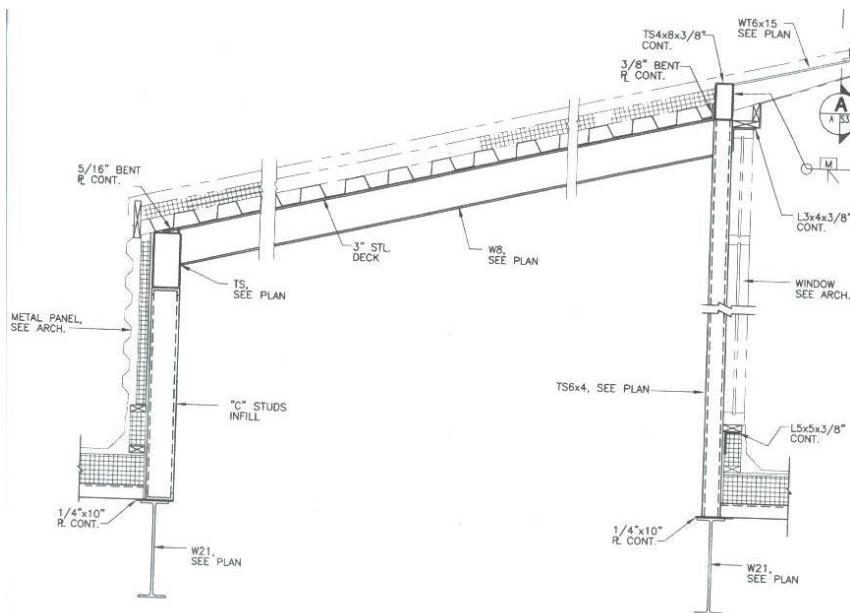= 64.2 PSF

Existing Roof Framing Plan

■ Modified Area

Existing Roof Framing Part Plan

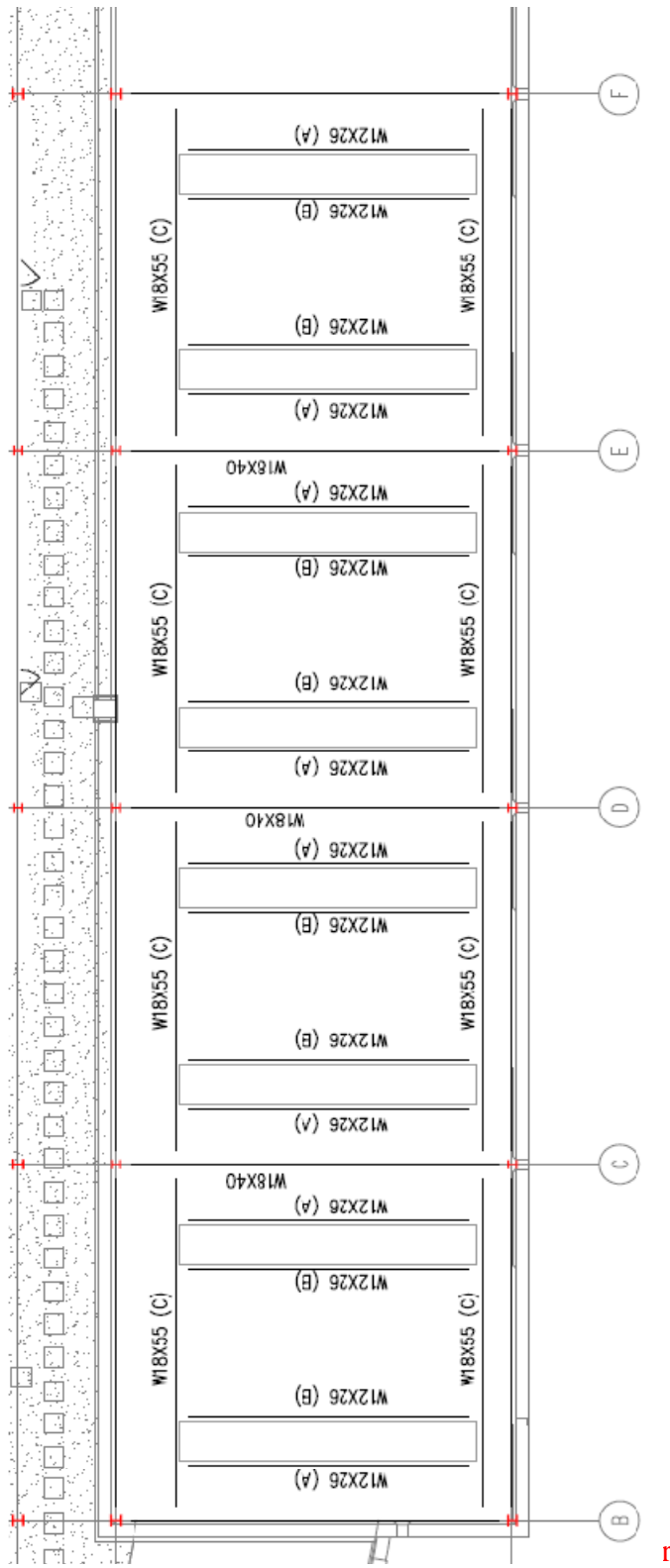Clerestory Framing Detail

Existing Clerestory Framing Detail

PLAN DETAIL 1-S1.04

SECTION
SCALE 3/4"=1'-0"

Revised Roof Framing Part Plan

Beam Schedule

Joist Member Sizing (Assuming Moment Controls)

Member	Design Load (PSF)	Tributary Area (ft)	Braced Length (ft)	Design Shear (kips)	Design Moment (kip ft)	Member Size	Moment of Inertia (in⁴)	Available Shear (kips)	Available Moment (kip ft)	Max Allowed Deflection (LL/360) in.	Live Deflection (in)	Max Allowed Deflection (Total/240) (in)	Total Load Deflection (in)
Joist A	64.20	5.08	30.00	4.89	36.71	W10x12	53.80	56.30	46.90	1.00	1.78	1.50	2.09
Joist B	64.20	9.95	30.00	9.58	71.86	W12x16	103.00	79.10	75.40	1.00	1.82	1.50	2.13

All members are controlled by deflection

20psf used for Live load deflection calculation

*** 35.16psf used for total load deflection calculation*

Calculation to find necessary Moment of Inertia to satisfy deflection

Member	Live Max Deflection (L/360) in.	Required Moment of Inertia (in⁴)	Total Load Max Deflection (L/240) in.	Required Moment of Inertia (in4)	Member Size	Moment of Inertia	Available Shear (kips)	Available Moment (kip ft)	Design Shear (kips)	Design Moment (kip ft)
Joist A	1.00	95.83	1.50	74.88	*W12x26	204.00	84.30	140.00	4.89	36.71
Joist B	1.00	187.59	1.50	146.57	*W12x26	204.00	84.30	140.00	9.58	71.86

While a w14x 22 would be a more structural economical solution, a w12x26 was selected to limit the depth of the beam.
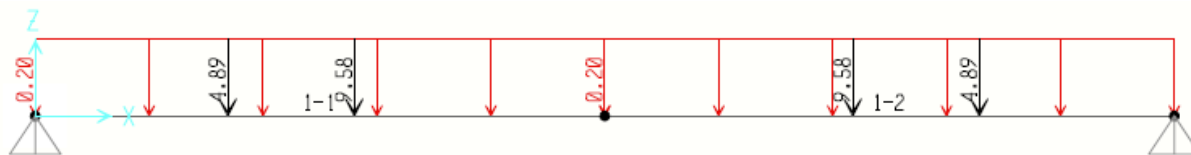
Girder Design "C" (SAP2000 ver.11)

W18x55 Selected

Available Shear = 212 kips
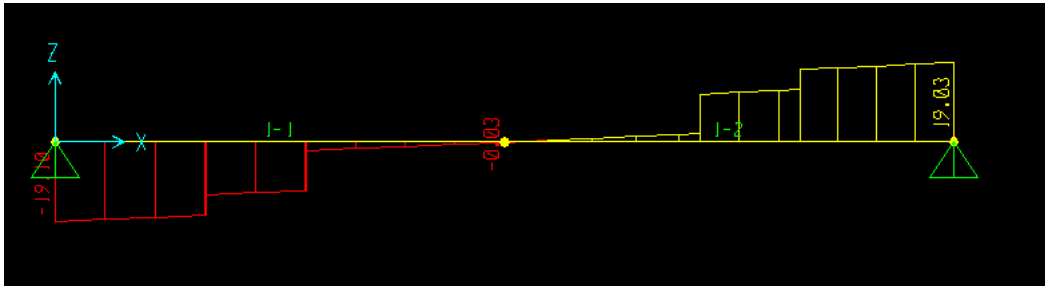
Available Moment = 420 ft • k

Moment of Inertia = 890 in⁴

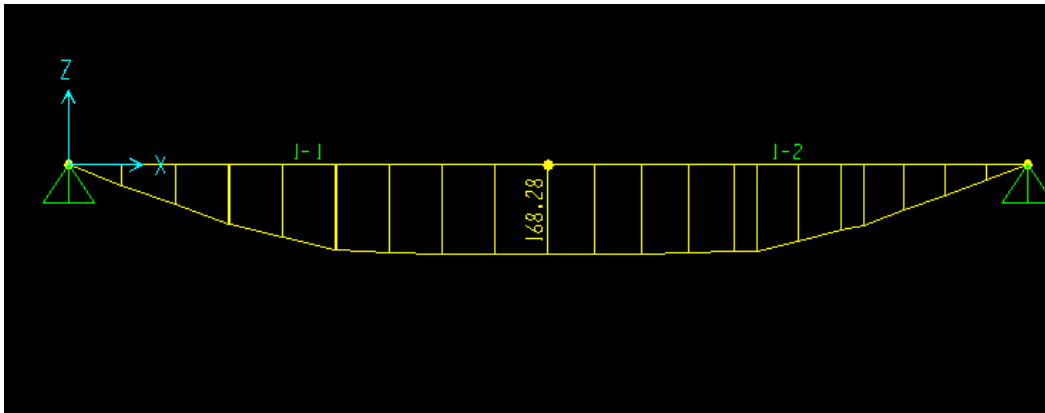*black loads indicate point loads from joists "A" & "B" onto Girder

* Red load indicates uniform distributed load of roof framing
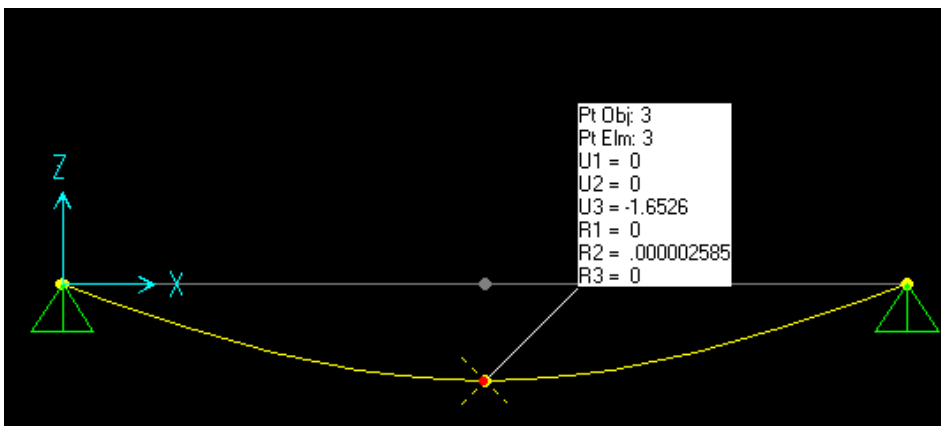
Shear Diagram

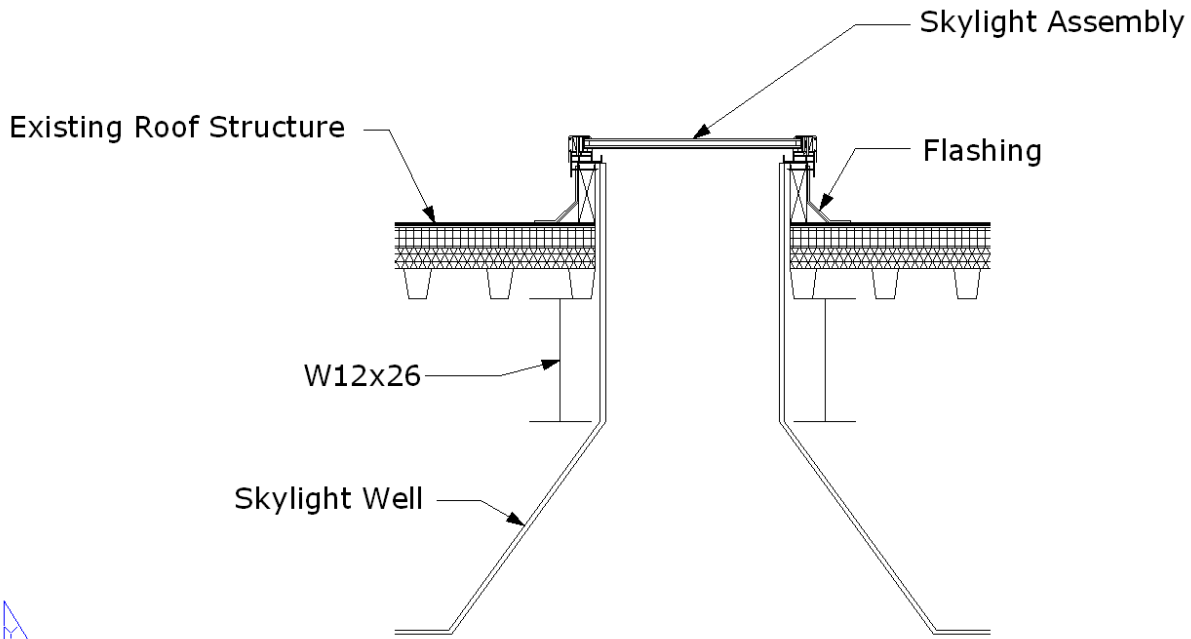**Max Shear= 19.03 kips <212 kips**

Moment Diagram

Max Moment = 168.28 ft • k < 420 ft • k

Deflection

Max Deflection = 1.653 in. < 1.8 in. Max Allowed L/240 (1.8inches =12*36/240)

Skylight Framing Detail

Financial Analysis

With the removal of clerestories and addition of members to frame the skylight, a financial analysis was performed, using a per tonnage cost of $3,800/ton of structural steel, to determine if the new system would cut steel costs. An 20% allowance of tonnage was included for connections in both systems. The following tables show the tonnage of each system and the associated cost.

Existing Framing System

Member Size	Linear Feet	Weight lb/linear ft	total weight (lbs)
w12x14(B3)	71.00	14.00	994.00
w21x44	320.00	44.00	14,080.00
w12x19	64.00	19.00	1,216.00
w18x40	120.00	40.00	4,800.00
w8x15	340.00	15.00	5,100.00
TS12x6x3/8	248.00	42.70	10,589.60
L3x3x3/8	264.00	7.17	1,892.88
TS8x4x3/8	88.00	27.40	2,411.20
WT6x15	53.30	15.00	799.50
TS6x4x3/8	150.00	22.30	3,345.00
	total tons		22.61
	*Connection Tonnage		4.52
	**Price/ton		3,800.00
	total Estimated Cost		103,120.25

New Framing System

Member Size	Linear Feet	weight (lbs)/linear ft	total Weight (lbs)
w12x26	480.00	26.00	12,480.00
w18x40	320.00	48.00	15,360.00
w18x55	288.00	55.00	15,840.00
	total tonage		21.84
	*Connection Tonage (20%)		4.368
	**Price/ton		3,800.00
	total estimated cost		99,590.40

Conclusion

The redesign of the existing roof framing system was done in response to the change in daylighting strategies. The goal of the redesigned system was to adequately frame the new skylights while minimizing any impact to the current design, constructability and cost. The redesigned system effectively meets these goals by maintaining the existing structural bays, decreasing the number and type of joints, and maintaining similar tonnage of steel. In addition to a slight decrease in steel costs, I feel the decrease in the number of joints and complexity of joints would add to the savings.