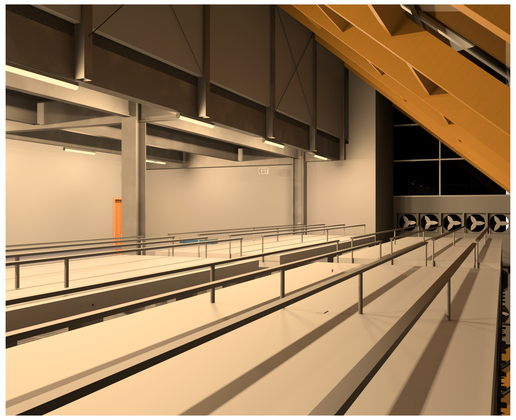
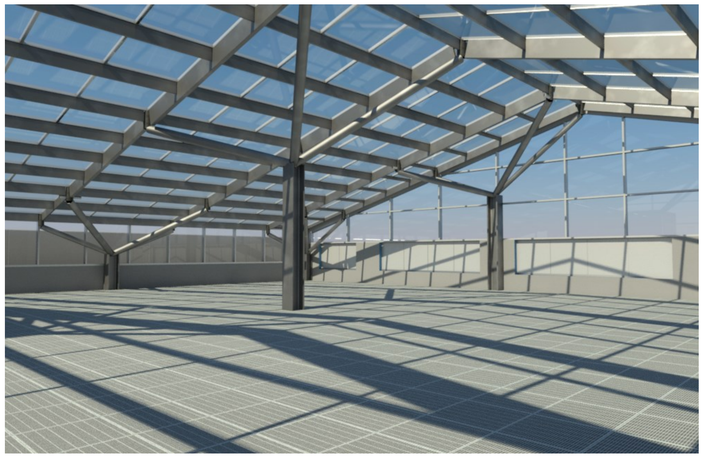
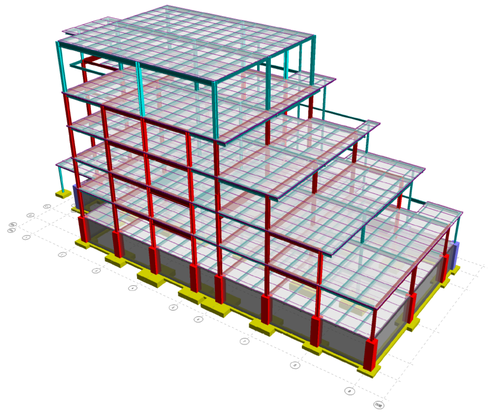
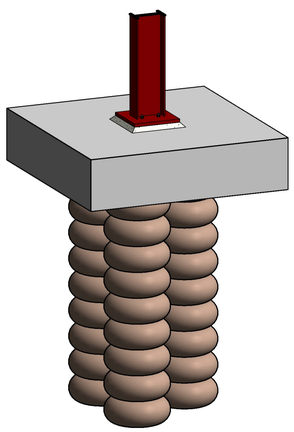








Growing Power Headquarters

Milwaukee , WI

AEI Team 04-2015

Structural Engineering—Design Overview

Gravity: The gravity load resisting system for the Growing Power headquarters is comprised of a composite structural steel floor system to minimize structural member depth and structural self-weight. This aided the foundation system design, in addition to the integration and coordination of the various building systems.

Lateral: The lateral force resisting system consists of steel moment frames, developed utilizing virtual work and member stiffness. The system facilitates the adaptation of the design to future Growing Power locations by enabling select members to be re-sized as needed, while maintaining the system configuration. The lateral force resisting system addresses the wind, seismic, and gravity forces in Milwaukee effectively, while investigation was also conducted for Miami loading conditions.

Transfer Girders: The custom transfer girders were developed to clear-span the building in order to provide Growing Power with a column-free gathering space. The members were designed as W36x361 girders with A527 Gr. 50 steel cover plates.

Foundation: The Geopier® soil reinforcement system selected for the foundation system improved the allowable soil bearing capacity from the in-situ conditions of 1,500 psf. As such, column and strip footings were able to be designed based on an effective soil bearing capacity of 6,000 psf.

Greenhouses: The custom greenhouses not only contain the heart of Growing Power's operations, but also act as an architectural accent facing the street. As such, the custom greenhouses were a critical area to provide efficient design, accomplished through interdisciplinary coordination and collaboration. The cascading greenhouse roof structures were designed with glulam, a renewable engineered wood product, which provides an innovative structural design, as well as a reflection of Growing Power's sustainable values. The top greenhouse roof structure utilized tree-columns to minimize structural member sizes in addition to minimizing the number of columns encroaching upon the growing space floor area. The raise access floor grate system facilitated systems integration and coordination by enabling MEP systems to run in a plenum space. The grate system is supported by a floor composed of the structural slab, waterproofing membrane, sloped topping slab, and bi-level drains to ensure proper drainage and waterproofing to protect the structure, and the building as a whole.

Façade: The rainscreen façade system provides a flexible design that can be easily adapted to future Growing Power locations. The cold-formed steel backup studs were easily modified for the differing loading conditions in Milwaukee and Miami by altering stud depth, gage, and spacing.

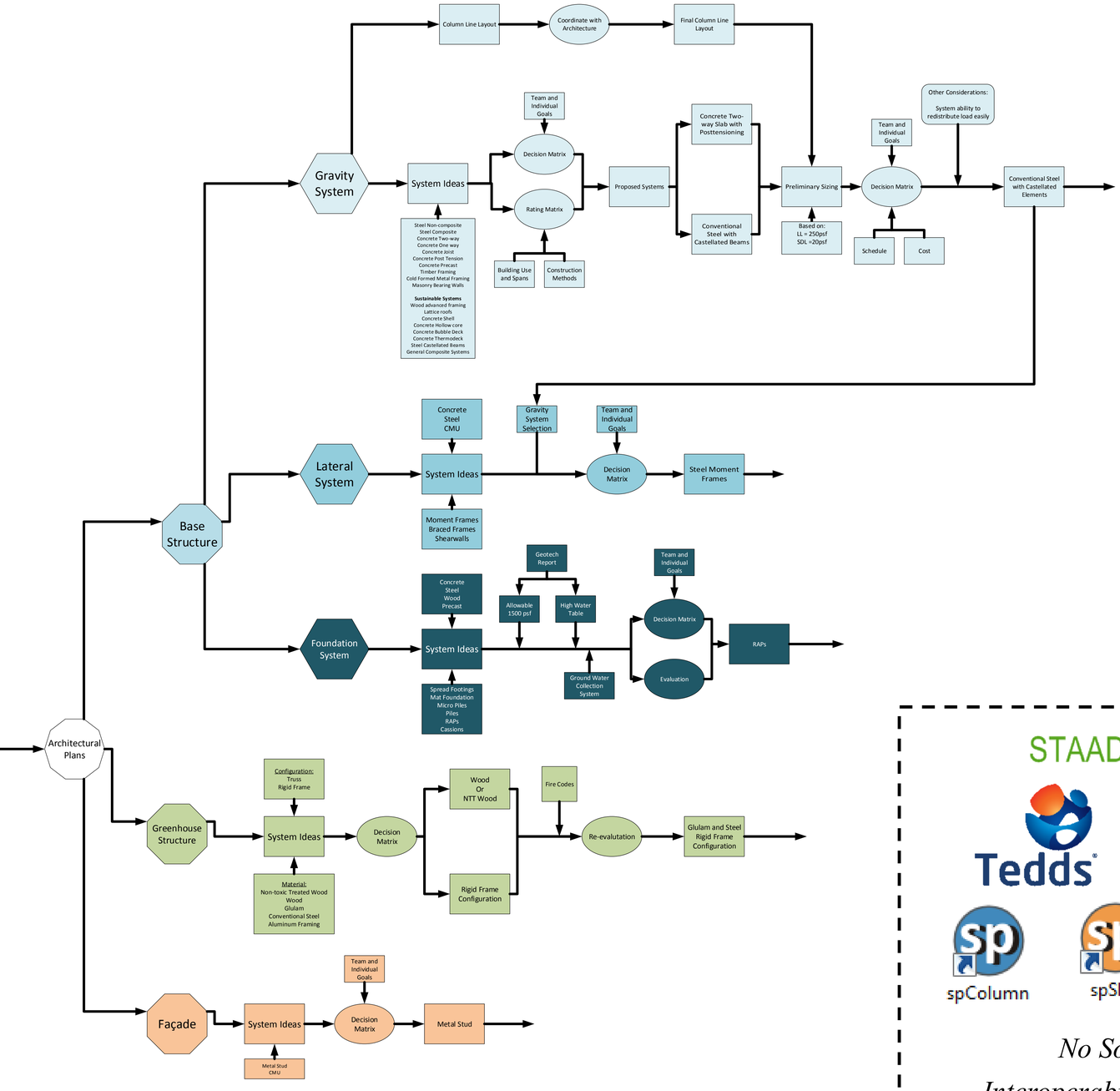
Prototype: The structural design components were developed in a manner to provide Growing Power with a prototype to utilize as it expands and grows to other communities through the nation.

Images: (Clockwise from top-left)

1. AEI Team 4's Growing Power headquarters design with highlighted structure
2. Cascading greenhouse custom glulam roof structure at night.
3. RAM Structural System model.
4. Gathering space without columns, facilitated by the custom transfer girders.
5. Geopiers® used to address the in-situ soil bearing capacity.
6. Tree-columns designed for the custom top greenhouse roof structure.

TBD Engineering | Process Maps

System Selection Process Map



A process map was created to track various options & input throughout the design process, which helped document the reasons & factors that contributed to each decision & system selection in the various areas of the structural design.

Software Interaction

Revit: Modeling software to develop overall structural model and facilitate interdisciplinary coordination.

AutoCAD: Utilized as a transition between Revit and the various structural modeling programs. In addition, it was used to create models of structural framing to be included in lighting studies of the greenhouses.

Bentley Software Family: RAM Structural System was used for analysis and design of the gravity, lateral, and foundation systems. Due to sloped greenhouse framing, it was unable to continuously sync with Revit. RAM Concept was utilized to analyze and design the concrete alternative design. RAM Connections facilitated steel connection design. RAM Elements was used to develop the custom transfer girders.

SAP 2000: Used for analysis of the tree-columns in the top greenhouse. In addition, it was utilized for an independent analysis model for the moment frame that contains one of the custom transfer girders.

ETABS: Utilized to develop an overall lateral system model to verify analysis & design results from other programs.

TEDDS: Used for preliminary design of column base plates.

STAAD: Used to model, analyze, and verify the various components of the cascading greenhouse design.

AISIWIN: Used for analysis and design of cold-formed steel stud backup walls for the rainscreen façade.

Excel: Utilized to create spreadsheets to aid in the design, data tracking, and presentation of the structural design.

spSlab and spColumn: Used to conduct analysis and verification of the concrete alternative design.

STAAD.Pro V8*i*

Tedds®

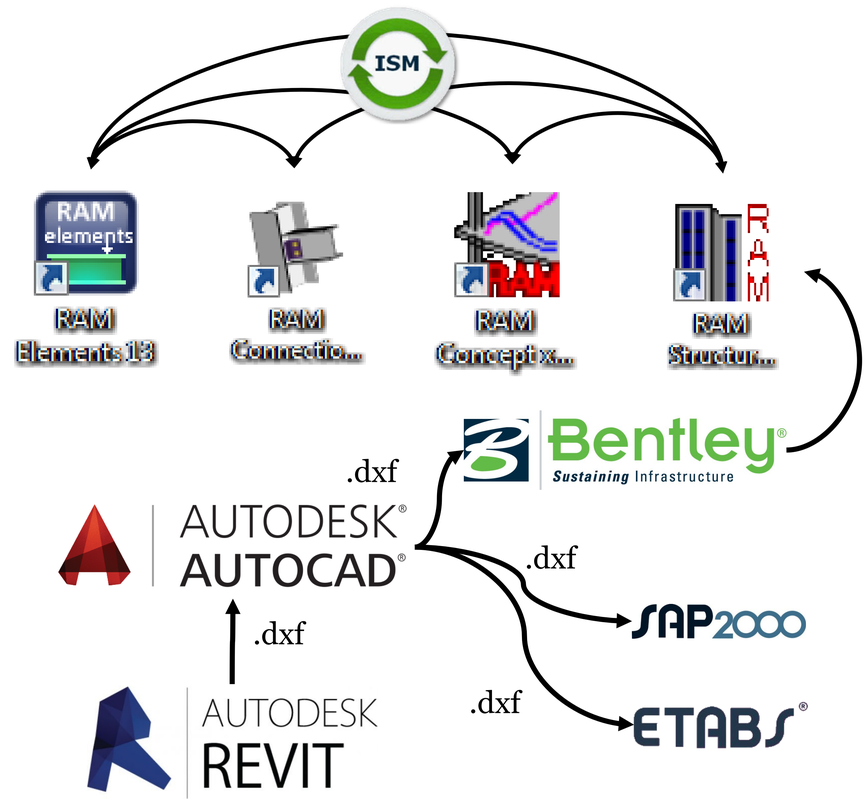
Microsoft® Excel

spColumn

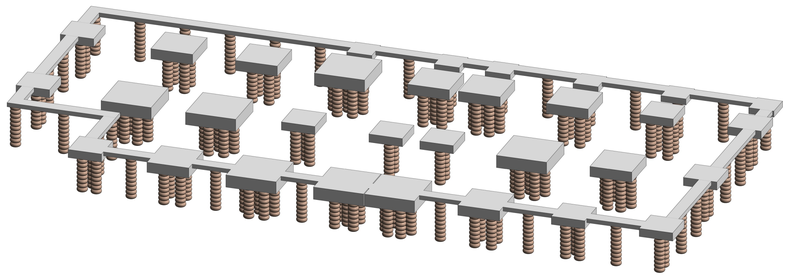
spSlab

AISIWIN

No Software Interoperability Available



TBD ENGINEERING | FOUNDATION PLAN

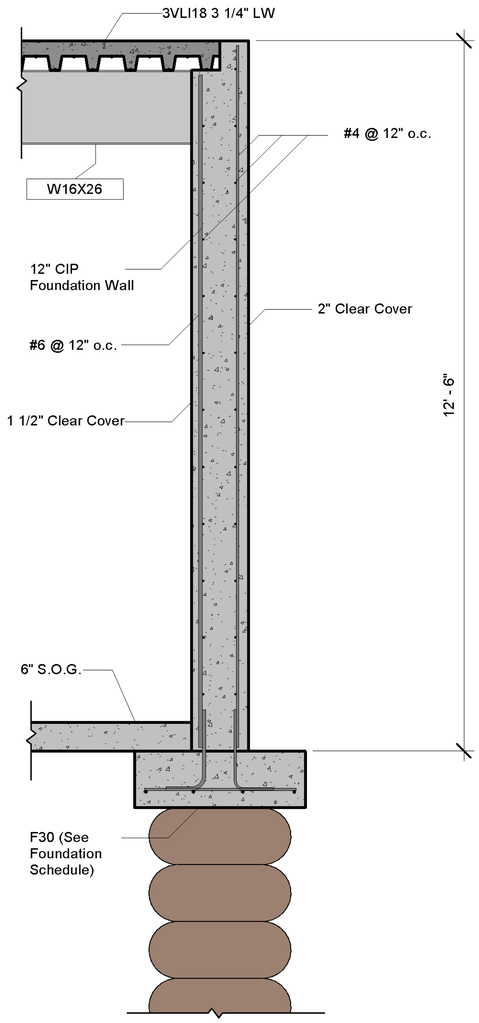


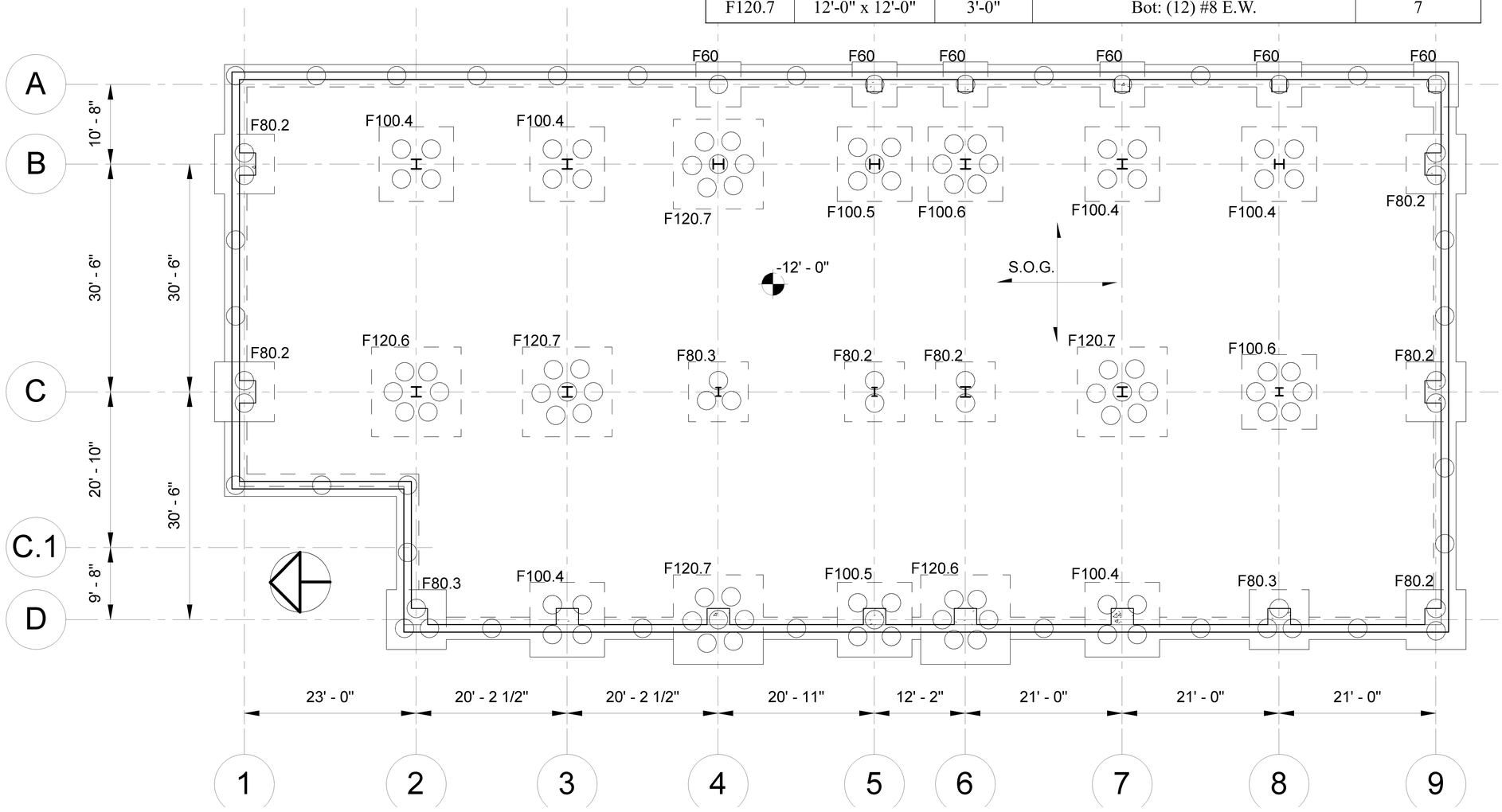
FOUNDATION PLAN NOTES:

1) T/SLAB ELEVATION = -12’-0” U.N.O.
2) FOOTING CONSTRUCTION = (f’c = 3000 psi, GRADE 60 REINFORCING).
3) FOUNDATION WALL CONSTRUCTION = (f’c = 3000 psi, GRADE 60 REINFORCING).
4) SOIL BEARING CAPACITY W/ GEOPIER = 6000 psf.

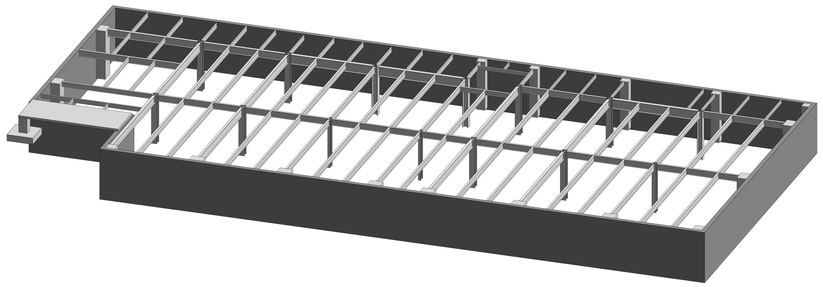
FOOTING SCHEDULE

Mark	Size	Thickness	Reinforcing	# of Geopiers
F30	3’-0”	1’-0”	(4) #4 Long. / #4 @ 18”o.c. Tranv.	@ 12’ o.c.
F60	6'-0" x 6'-0"	1'-6"	Bot: (12) #4 E.W.	1
F80.2	8'-0" x 8'-0"	2'-0"	Bot: (10) #6 E.W.	2
F80.3	8'-0" x 8'-0"	2'-0"	Bot: (10) #6 E.W.	3
F100.4	10'-0" x 10'-0"	2'-6"	Bot: (15) #6 E.W.	4
F100.5	10'-0" x 10'-0"	2'-6"	Bot: (15) #6 E.W.	5
F100.6	10'-0" x 10'-0"	2'-6"	Bot: (15) #6 E.W.	6
F120.6	12'-0" x 12'-0"	3'-0"	Bot: (12) #8 E.W.	6
F120.7	12'-0" x 12'-0"	3'-0"	Bot: (12) #8 E.W.	7



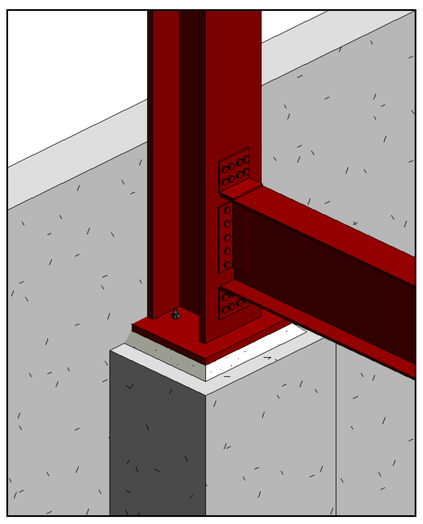


TBD ENGINEERING | FIRST FLOOR FRAMING PLAN

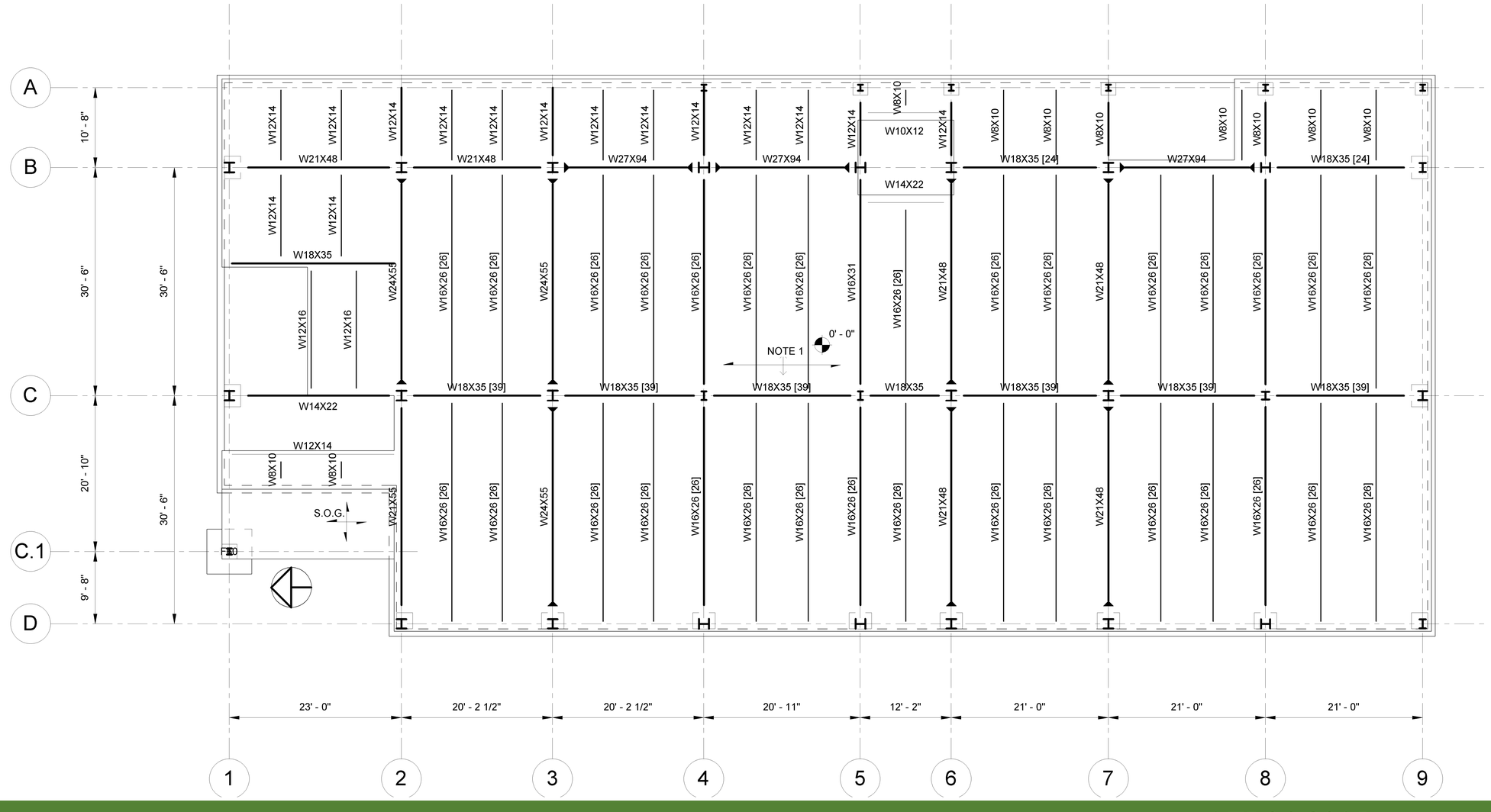


FIRST FLOOR FRAMING PLAN NOTES:

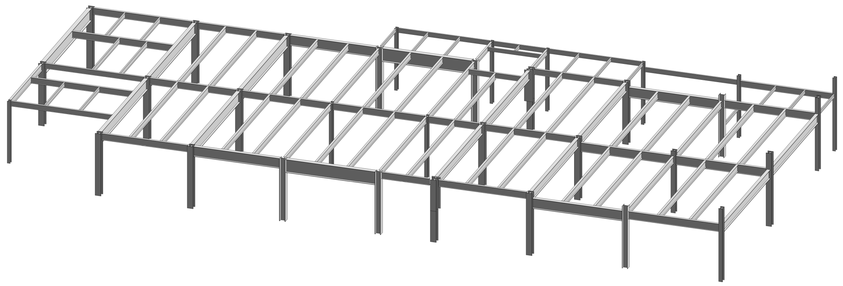
1) TYP. FLOOR CONSTRUCTION = LW. CONC. (f'c = 4000 psi @ 28 DAYS) ON DECK (3" 18 GAGE GALVANIZED COMPOSITE FLOOR DECK- VULCRAFT OR APPROVED EQUIVALENT).
2) T/SLAB ELEVATION = 0'-0" U.N.O.
3) T/STEEL = - 0'-6 1/4" FROM T/SLAB U.N.O.
4) STEEL = ASTM-A992.
5) BEAM NOTATION = SECTION [STUDS] (CAMBER).
6) (4) ANCHOR BOLTS TYP. PER COLUMN BASE PLATE.



TYPICAL STEEL COLUMN
TO CONCRETE PIER
INTERFACE DETAIL



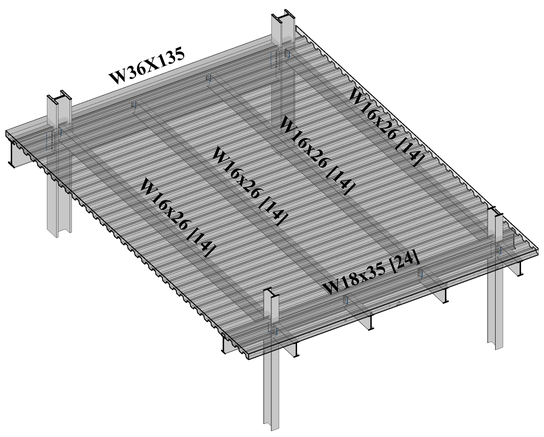
TBD ENGINEERING | SECOND FLOOR FRAMING PLAN



SECOND FLOOR FRAMING PLAN NOTES:

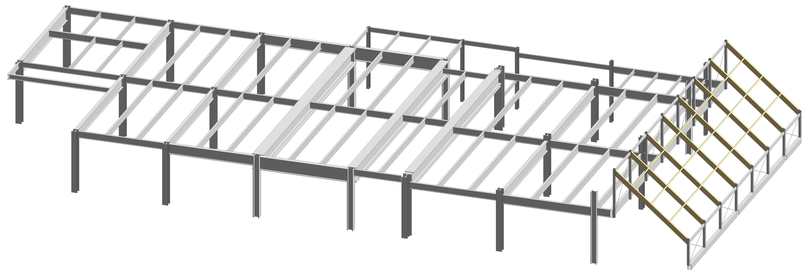
1) TYP. FLOOR CONSTRUCTION = LW. CONC. (f'c = 4000 psi @ 28 DAYS) ON DECK (3" 18 GAGE GALVANIZED COMPOSITE FLOOR DECK - VULCRAFT OR APPROVED EQUIVALENT). TOTAL SLAB THICKNESS = 6 1/4".
2) GREENHOUSE FLOOR CONSTRUCTION = LW. CONC. (f'c = 4000 psi @ 28 DAYS) ON DECK (3" 18 GAGE GALVANIZED COMPOSITE FLOOR DECK- VULCRAFT OR APPROVED EQUIVALENT). STRUC. SLAB THICKNESS = 6 1/4".
   PLACE WATERPROOFING MEMBRANE ON TOP OF STRUC. SLAB FOLLOWED BY 2" LW. CONC. SLAB W/ FIBEROUS REINFORCING.
3) TYP. ROOF CONSTRUCTION = 1.5" 20 GAGE WIDE RIB GALVANIZED ROOF DECK- VULCRAFT OR APPROVED EQUIVALENT.
4) T/SLAB ELEVATION = VARIES. NOTED ON PLAN.
5) T/STEEL = - 0'-6 1/4" FROM T/SLAB U.N.O.
6) STEEL = ASTM-A992.
7) BEAM NOTATION = SECTION [STUDS] (CAMBER).

FLOOR CONSTRUCTION
VULCRAFT 3VLI18 - 3 1/4" SLAB



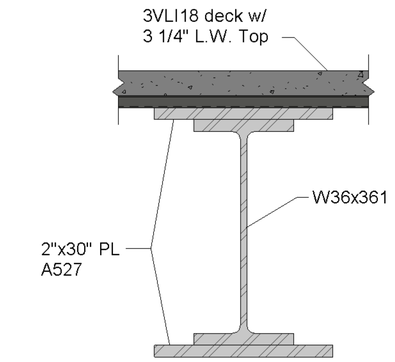
TYPICAL FLOOR BAY
NOTE : FLOOR IS TRANSPARENT

TBD ENGINEERING | THIRD FLOOR FRAMING PLAN

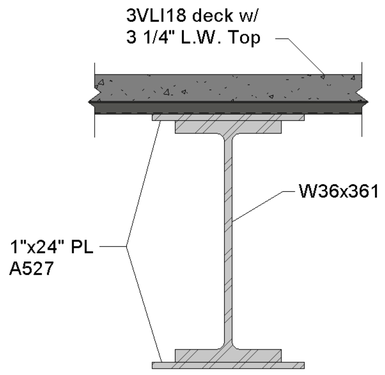


THIRD FLOOR FRAMING PLAN NOTES:

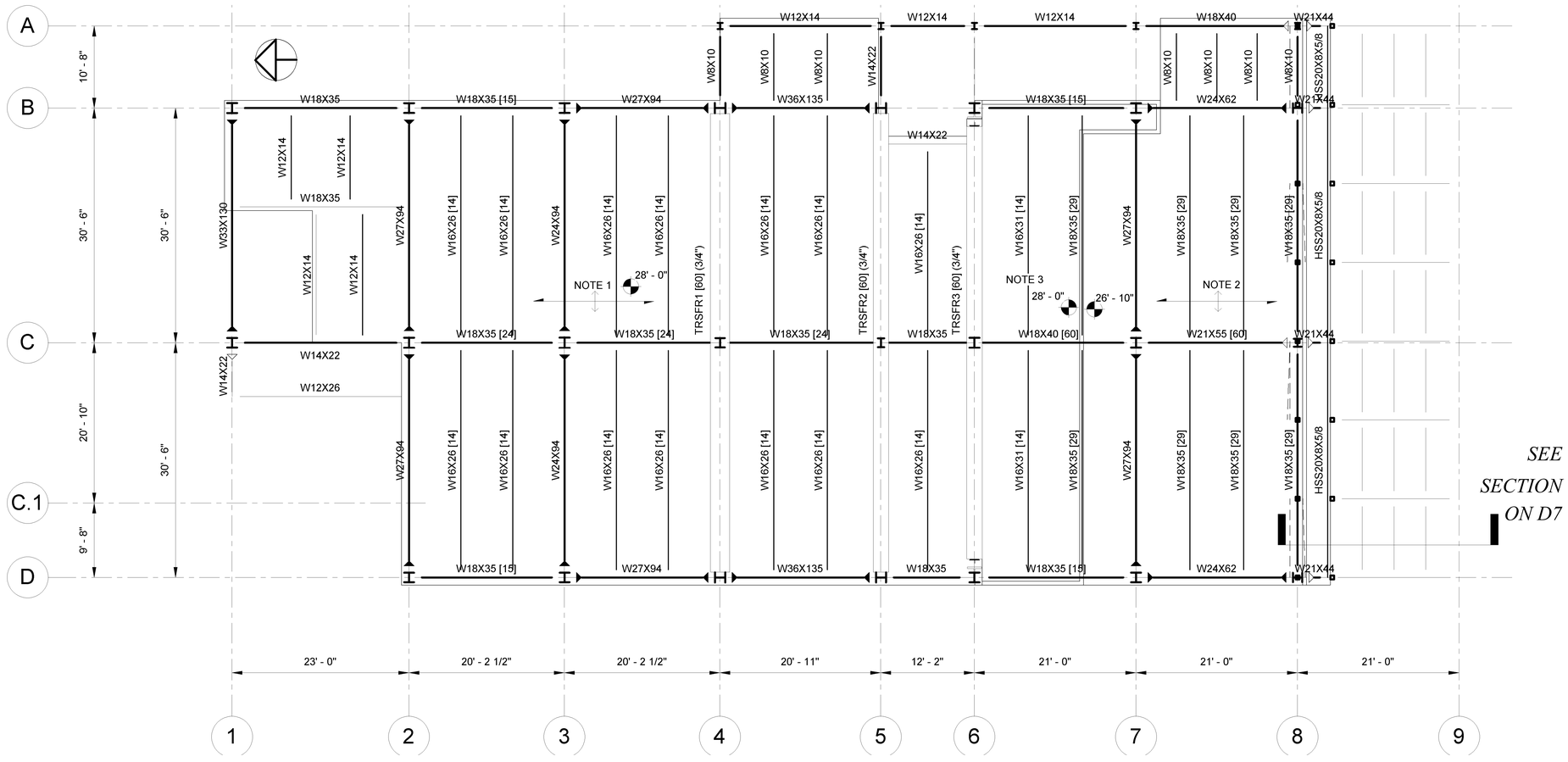
1) TYP. FLOOR CONSTRUCTION = LW. CONC. (f'c = 4000 psi @ 28 DAYS) ON DECK (3" 18 GAGE GALVANIZED COMPOSITE FLOOR DECK - VULCRAFT OR APPROVED EQUIVALENT). TOTAL SLAB THICKNESS = 6 1/4".
2) GREENHOUSE FLOOR CONSTRUCTION = LW. CONC. (f'c = 4000 psi @ 28 DAYS) ON DECK (3" 18 GAGE GALVANIZED COMPOSITE FLOOR DECK- VULCRAFT OR APPROVED EQUIVALENT). STRUC. SLAB THICKNESS = 6 1/4".
   PLACE WATERPROOFING MEMBRANE ON TOP OF STRUC. SLAB FOLLOWED BY 2" LW. CONC. SLAB W/ FIBEROUS REINFORCING.
3) TRANSITION FLOOR CONSTRUCTION = LW. CONC. (f'c = 4000 psi @ 28 DAYS) ON DECK (3" 18 GAGE GALVANIZED COMPOSITE FLOOR DECK- VULCRAFT OR APPROVED EQUIVALENT). STRUC. SLAB THICKNESS = 6 1/4".
   PLACE 10 3/4" RIGID INSULATION ON TOP OF STRUC. SLAB FOLLOWED BY 3 1/4" LW. CONC. SLAB.
   PLACE 6" WIDE CONC. CURB AT EDGE OF SLAB.
4) T/SLAB ELEVATION = VARIES. NOTED ON PLAN.
5) T/STEEL = - 0'-6 1/4" FROM T/SLAB U.N.O.
6) STEEL = ASTM-A992.
7) BEAM NOTATION = SECTION [STUDS] (CAMBER).



TRSFR1



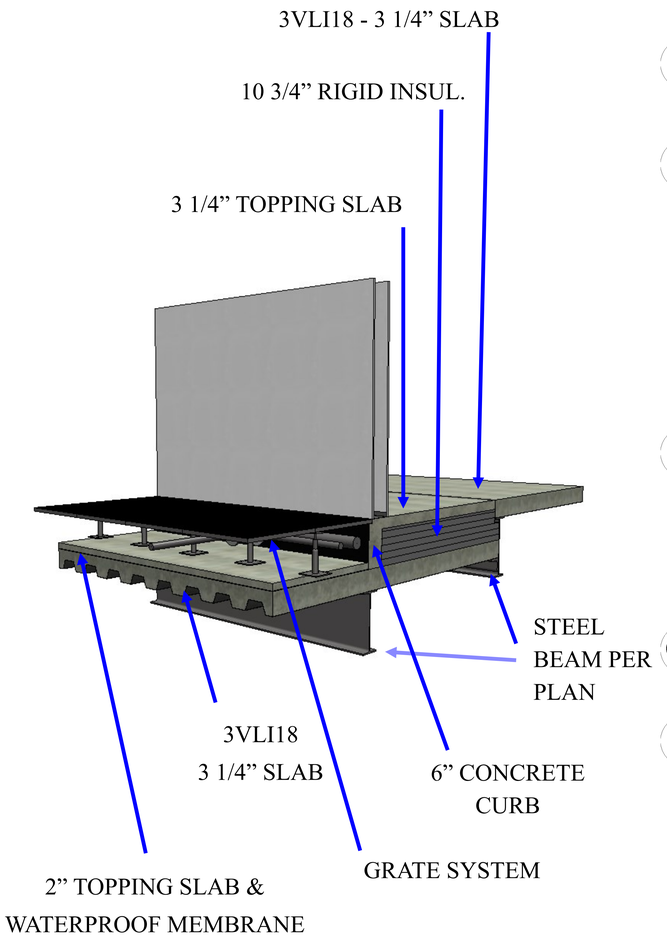
TRSFR2 AND TRSFR3

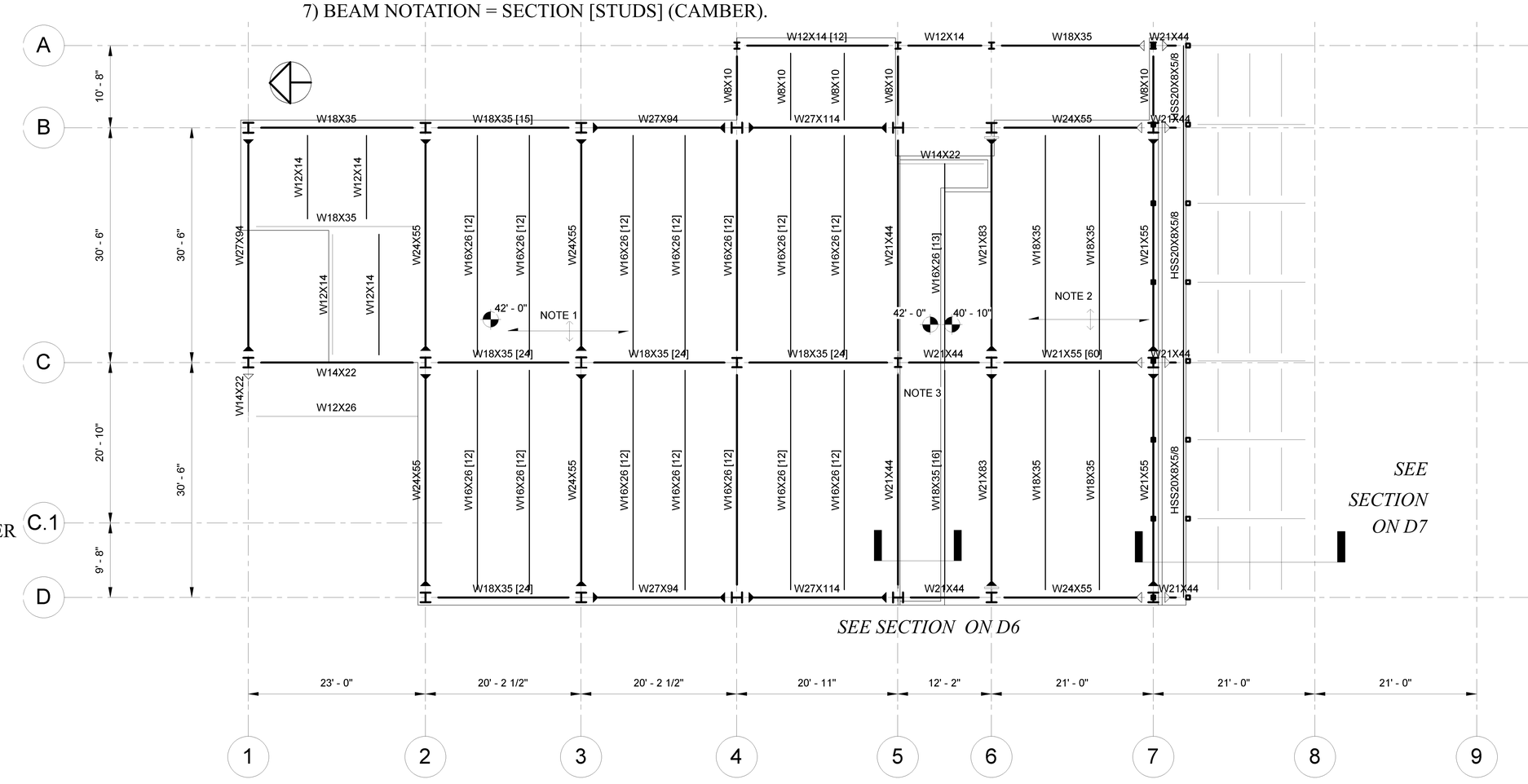


TBD ENGINEERING | FOURTH FLOOR FRAMING PLAN

FOURTH FLOOR FRAMING PLAN NOTES:

1) TYP. FLOOR CONSTRUCTION = LW. CONC. (f'c = 4000 psi @ 28 DAYS) ON DECK (3" 18 GAGE GALVANIZED COMPOSITE FLOOR DECK - VULCRAFT OR APPROVED EQUIVALENT). TOTAL SLAB THICKNESS = 6 1/4".
2) GREENHOUSE FLOOR CONSTRUCTION = LW. CONC. (f'c = 4000 psi @ 28 DAYS) ON DECK (3" 18 GAGE GALVANIZED COMPOSITE FLOOR DECK- VULCRAFT OR APPROVED EQUIVALENT). STRUC. SLAB THICKNESS = 6 1/4".
   PLACE WATERPROOFING MEMBRANE ON TOP OF STRUC. SLAB FOLLOWED BY 2" LW. CONC. SLAB W/ FIBEROUS REINFORCING.
3) TRANSITION FLOOR CONSTRUCTION = LW. CONC. (f'c = 4000 psi @ 28 DAYS) ON DECK (3" 18 GAGE GALVANIZED COMPOSITE FLOOR DECK- VULCRAFT OR APPROVED EQUIVALENT). STRUC. SLAB THICKNESS = 6 1/4".
   PLACE 10 3/4" RIGID INSULATION ON TOP OF STRUC. SLAB FOLLOWED BY 3 1/4" LW. CONC. SLAB.
   PLACE 6" WIDE CONC. CURB AT EDGE OF SLAB.
4) T/SLAB ELEVATION = VARIES. NOTED ON PLAN.
5) T/STEEL = - 0'-6 1/4" FROM T/SLAB U.N.O.
6) STEEL = ASTM-A992.
7) BEAM NOTATION = SECTION [STUDS] (CAMBER).

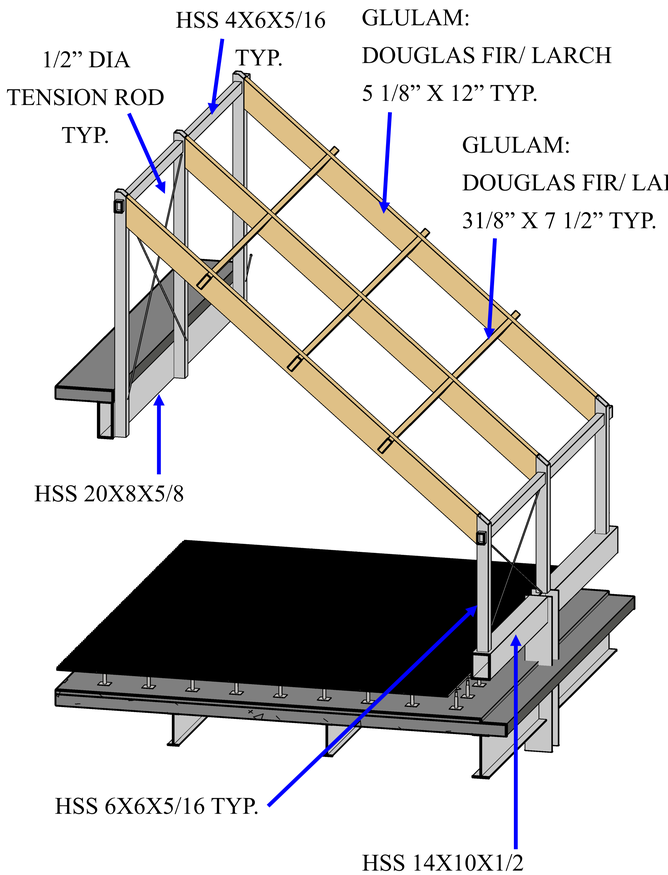


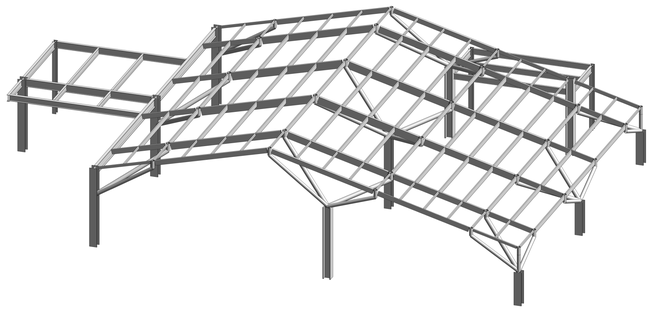


TBD ENGINEERING | FIFTH FLOOR FRAMING PLAN

FIFTH FLOOR FRAMING PLAN NOTES:

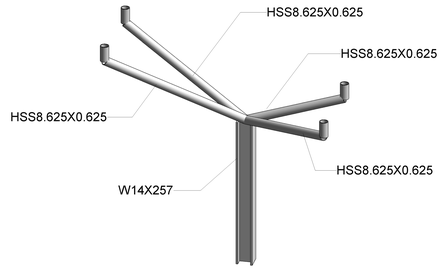
1) GREENHOUSE FLOOR CONSTRUCTION = LW. CONC. (f'c = 4000 psi @ 28 DAYS) ON DECK (3" 18 GAGE GALVANIZED COMPOSITE FLOOR DECK- VULCRAFT OR APPROVED EQUIVALENT). STRUC. SLAB THICKNESS = 6 1/4".
   PLACE WATERPROOFING MEMBRANE ON TOP OF STRUC. SLAB FOLLOWED BY 2" LW. CONC. SLAB W/ FIBEROUS REINFORCING.
2) TYP. FLOOR CONSTRUCTION = LW. CONC. (f'c = 4000 psi @ 28 DAYS) ON DECK (3" 18 GAGE GALVANIZED COMPOSITE FLOOR DECK - VULCRAFT OR APPROVED EQUIVALENT). TOTAL SLAB THICKNESS = 6 1/4".
3) T/SLAB ELEVATION = VARIES. NOTED ON PLAN.
4) T/STEEL = - 0'-6 1/4" FROM T/SLAB U.N.O.
5) STEEL = ASTM-A992.
6) BEAM NOTATION = SECTION [STUDS] (CAMBER).



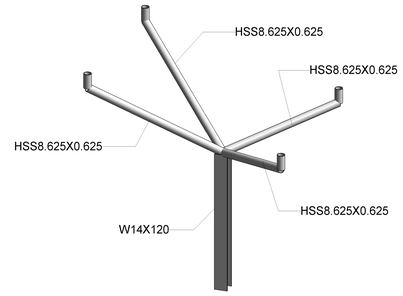


ROOF FRAMING PLAN NOTES:

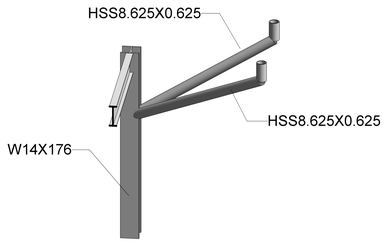
1) TYP. ROOF CONSTRUCTION = 1.5” 20 GAGE WIDE RIB GALVANIZED ROOF DECK (VULCRAFT OR APPROVED EQUIVALENT).
2) T/DECK ELEVATION = VARIES. NOTED ON PLAN.
3) T/STEEL = - 0’-1 1/2” FROM T/DECK U.N.O.
4) STEEL: W SHAPES = ASTM-A992.
   HSS RECT = ASTM-A500 GRADE B 46.
   HSS ROUND = ASTM-A500 GRADE B 42.
5) BEAM NOTATION = SECTION [STUDS] (CAMBER).



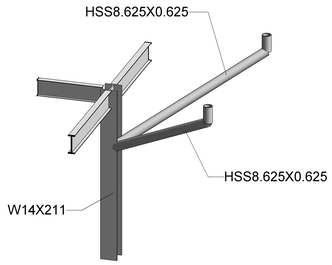
TC D



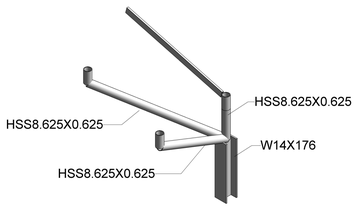
TC E



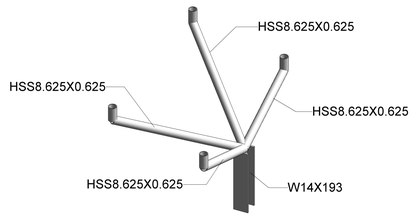
TC A



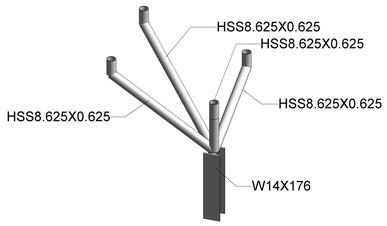
TC B



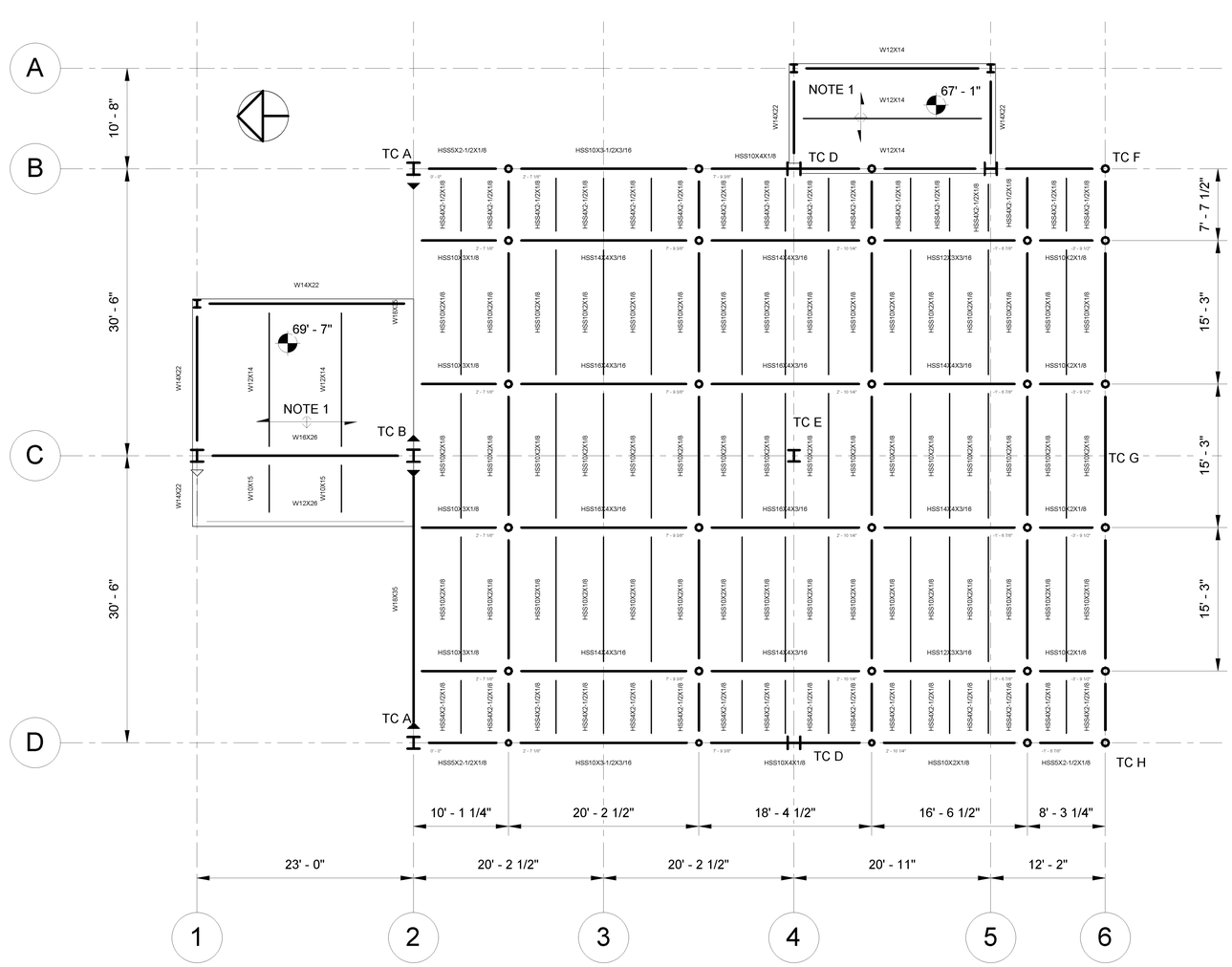
TC F



TC G



TC H



	A-4	A-5	A-6	A-7	A-8	A-9	B-1	B-2	B-3	B-4	B-5	B-7, C-7	B-8	B-9, D-9	C-1
06- LOW ROOF T.S.															
69' - 5 1/2" 05- FIFTH FLOOR S T.S															
55' - 5 3/4" 04- FOURTH FLOOR S T.S.	W10X33	W10X33						W14X176		W14X257	W14X193				W14X159
41' - 5 3/4" 03- THIRD FLOOR S T.S.			W10X33				W14X193		W14X176			W14X159			
27' - 5 3/4" 02- SECOND FLOOR S T.S.				W10X33									W14X120	W14X82	
13' - 5 3/4" 01- FIRST FLOOR S T.S.	W10X33	W10X33	W10X33		W10X33	W10X33	W14X193	W14X176	W14X176	W14X257	W14X193	W14X159			W14X159
-0' - 6 1/4" 00- BASEMENT S															
-12' - 0"															

	C-2	C-3	C-4	C-5	C-6	C-8	C-9	C.1-1	D-2	D-3	D-4	D-5	D-6	D-7	D-8
06- LOW ROOF T.S.															
69' - 5 1/2" 05- FIFTH FLOOR S T.S															
55' - 5 3/4" 04- FOURTH FLOOR S T.S.	W14X211		W14X120		W14X193				W14X145		W14X233		W14X176		
41' - 5 3/4" 03- THIRD FLOOR S T.S.		W14X233		W14X61						W14X145		W14X193			
27' - 5 3/4" 02- SECOND FLOOR S T.S.													W14X176	W14X159	
13' - 5 3/4" 01- FIRST FLOOR S T.S.	W14X211	W14X233				W12X72	W14X109	W10X33	W14X145	W14X145	W14X233	W14X193			W14X120
-0' - 6 1/4" 00- BASEMENT S			W14X48	W14X48	W14X233										
-12' - 0"															