

tom yost

BAE/MAE - structural option

granby tower

norfolk, virginia
senior thesis presentation
14 april 2008

granby tower

norfolk, virginia

- building overview
- proposal
- goals
- depth
 - gravity system redesign
- breadth study
 - reduction in construction schedule
 - cost analysis
- conclusion/recommendation

granby tower

norfolk, virginia

- 34 story post-modern mixed-use high-rise
 - 302 luxury condominiums
 - offices
 - shops
 - parking garage
- square footage: 781,479
- site area: 2.32 acres
- project cost: \$181,000,000
- original project duration: Sept 2005 – Nov 2009
 - Construction delayed since 18 September 2007

granby tower

norfolk, virginia

- location: 515 Granby Street
 - views of downtown Norfolk and Elizabeth River



granby tower

norfolk, virginia

- owner: Marathon Development / 515 Granby, LLC.
- architect: Humphreys & Partners Architects, LP.
- structural: Abiouness, Cross and Bradshaw, Inc.
- project management: Turner Construction Co.

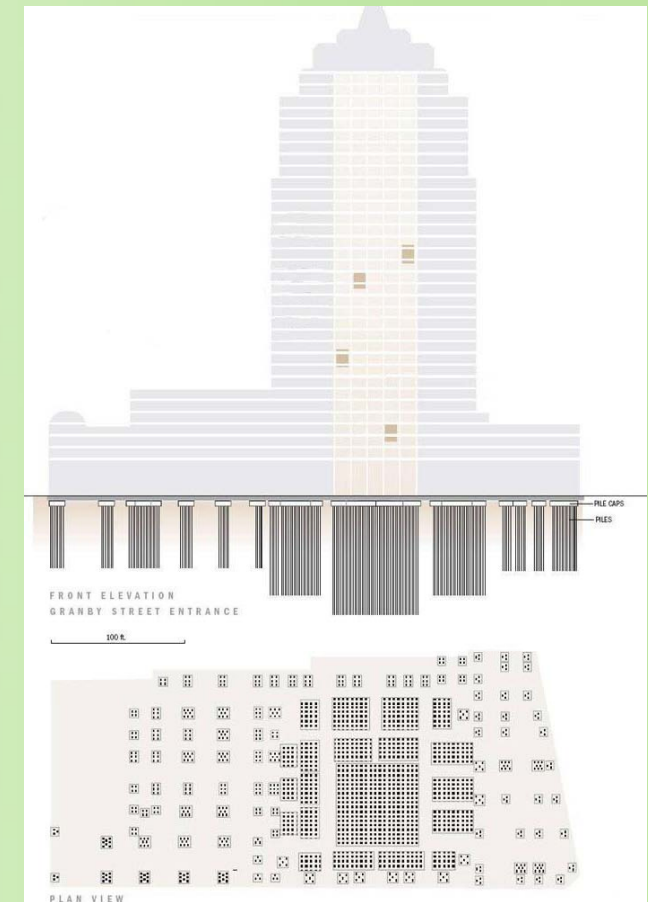


overview

granby tower

norfolk, virginia

- existing foundation
 - 12" & 14" square, precast, pre-stressed conc piles
 - over 1200 piles throughout site
 - 255 – 14" SPPC piles with 10' thick pile cap support shear wall core.
 - 156 tension piles



granby tower

norfolk, virginia

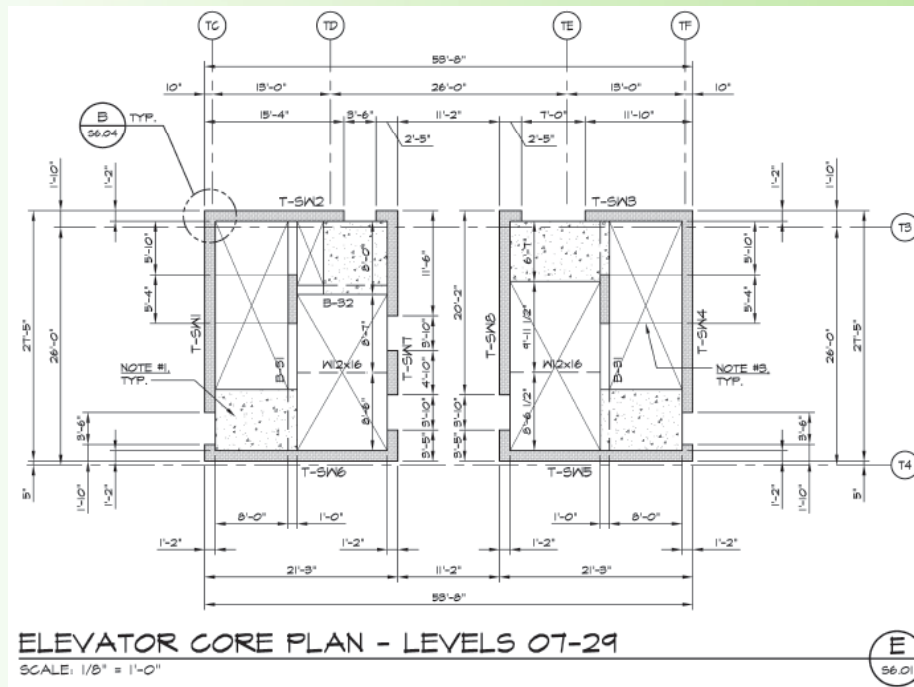
- existing floor system
 - 8" two-way post-tensioned flat plate
 - $f'c = 5000$ psi
 - $\frac{1}{2}$ " \emptyset 7-wire, low relaxation strand
 - 1 day to post-tensioning per floor
 - 46 days shoring time
- existing columns
 - cast-in-place square or rectangular columns
 - $f'c = 6500$ psi (base to level 6)
 - $f'c = 5000$ psi (level 7 and up)

overview

granby tower

norfolk, virginia

- existing lateral system
 - ordinary reinforced concrete shear wall cores
 - base to level 6: 24" thick, $f'c = 8000$ psi
 - level 7 to level 23: 14" thick, $f'c = 6000$ psi
 - level 24 to level 34: 14" thick, $f'c = 5000$ psi
 - typical boundary element reinforcement: (10) #10



granby tower

norfolk, virginia

- construction delay
 - construction stopped 18 september 2007
 - initial investor reneged loan commitment
 - less stringent lending laws led to abundance of sub-prime lending and resulted in foreclosures
 - economic recession due to housing slump
 - tightening credit requirements
 - need new investor to secure bank loan
 - need 70% of units sold for loan
 - Almost 50% of units sold
 - Remaining units require “jumbo” mortgage

proposal summary

- gravity system redesign
 - Girder-Slab system
 - keep original design for lower 7 floors
 - allows time to finish redesign
 - minimal disturbance to foundations
 - original system best for parking garage
 - allows for steel and precast procurement
 - check shear wall reinforcement

goals

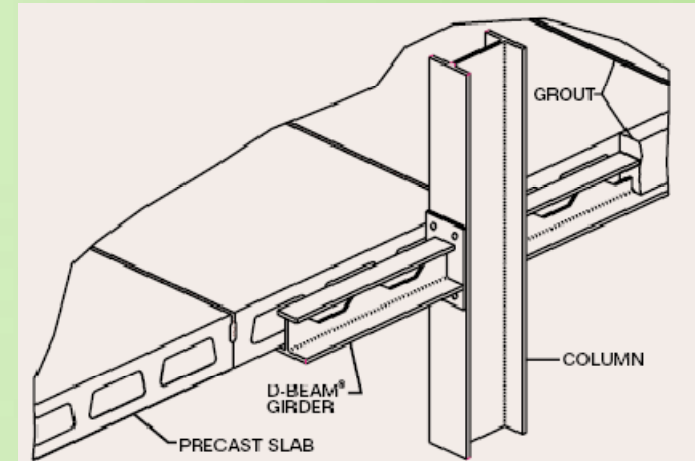
goals

- prove applicability of Girder-Slab system
 - keep minimum floor depth
 - realize benefits of steel construction
- decrease construction schedule
 - catch up on delayed schedule
 - save on construction loans
- save money

girder-slab system



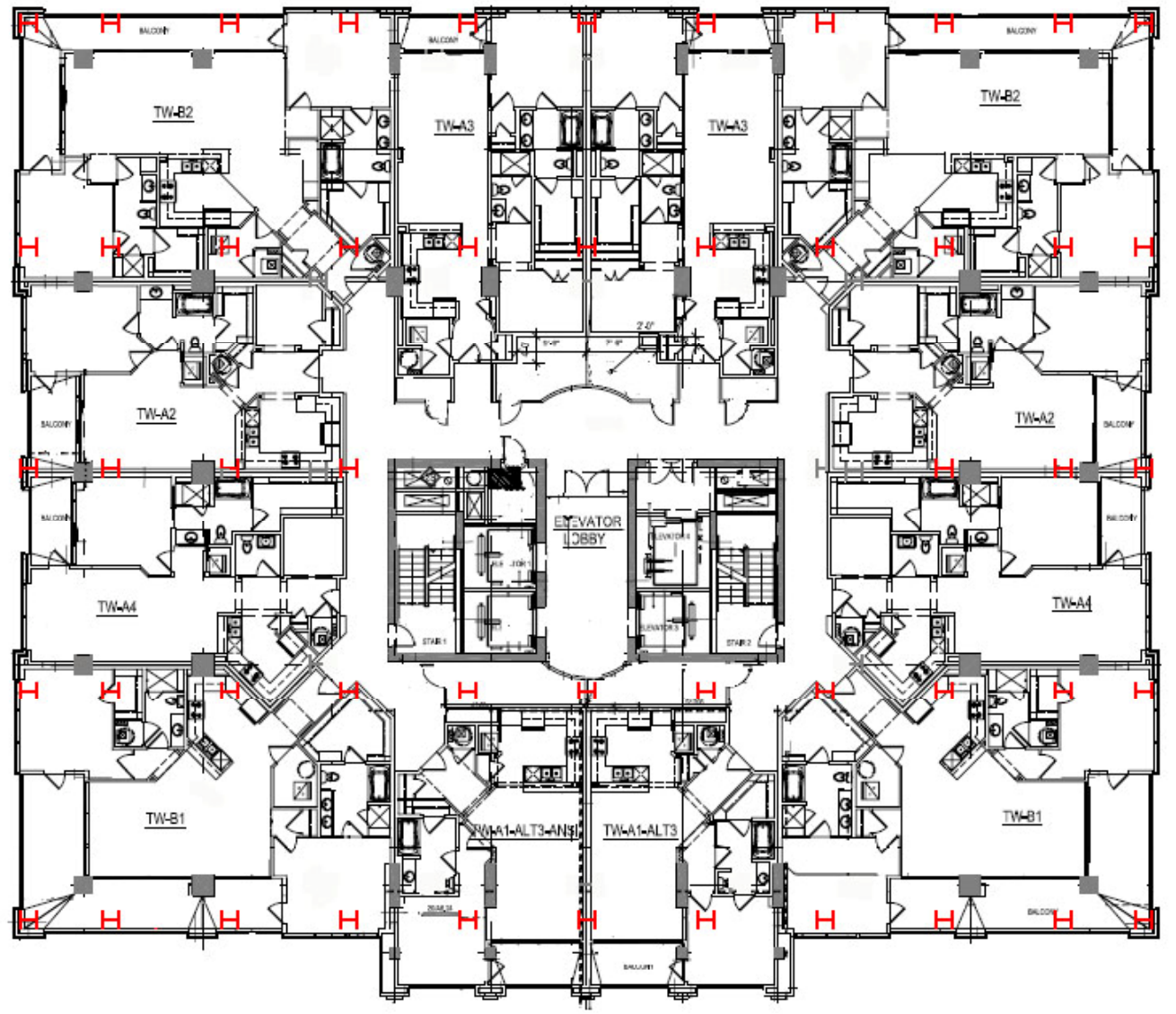
- composite steel and pre-cast system
 - open-web dissymmetric beams
- benefits
 - shallow floor depth
 - speed of steel construction
 - no shoring with precast
 - lighter system than existing
- limitations
 - max D-Beam span 18'
 - regular bays



depth

possible column layouts

- column layout 1



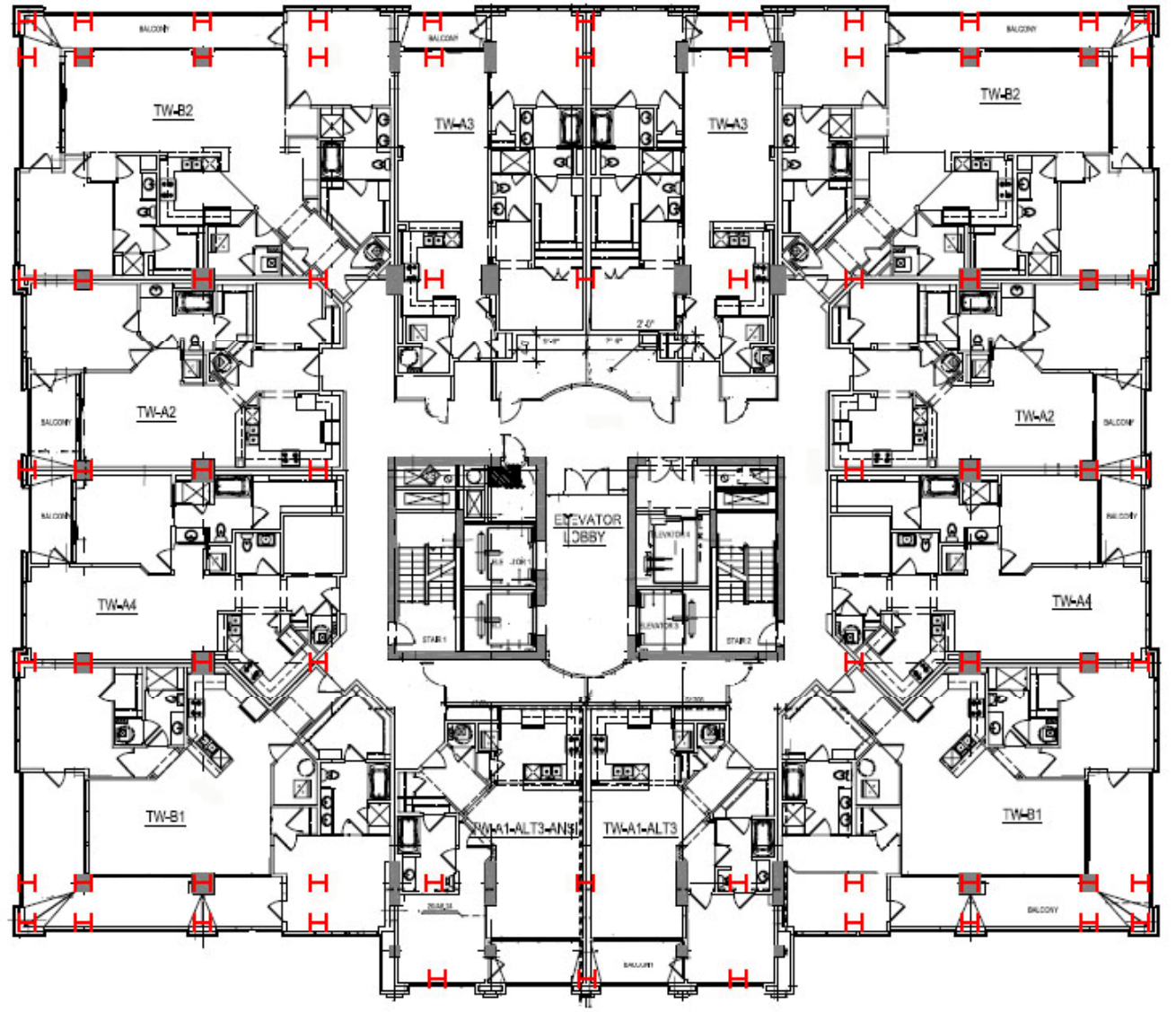
possible column layouts

- column layout 1
 - bay size: 16' x 30'
 - pros:
 - minimal architectural intrusion
 - simply supported condition for all planks
 - cons:
 - two-way transfer slab at 7th level
 - additional transfer level at 25th level
 - increased building height
 - increased cost

depth

possible column layouts

- column layout 2

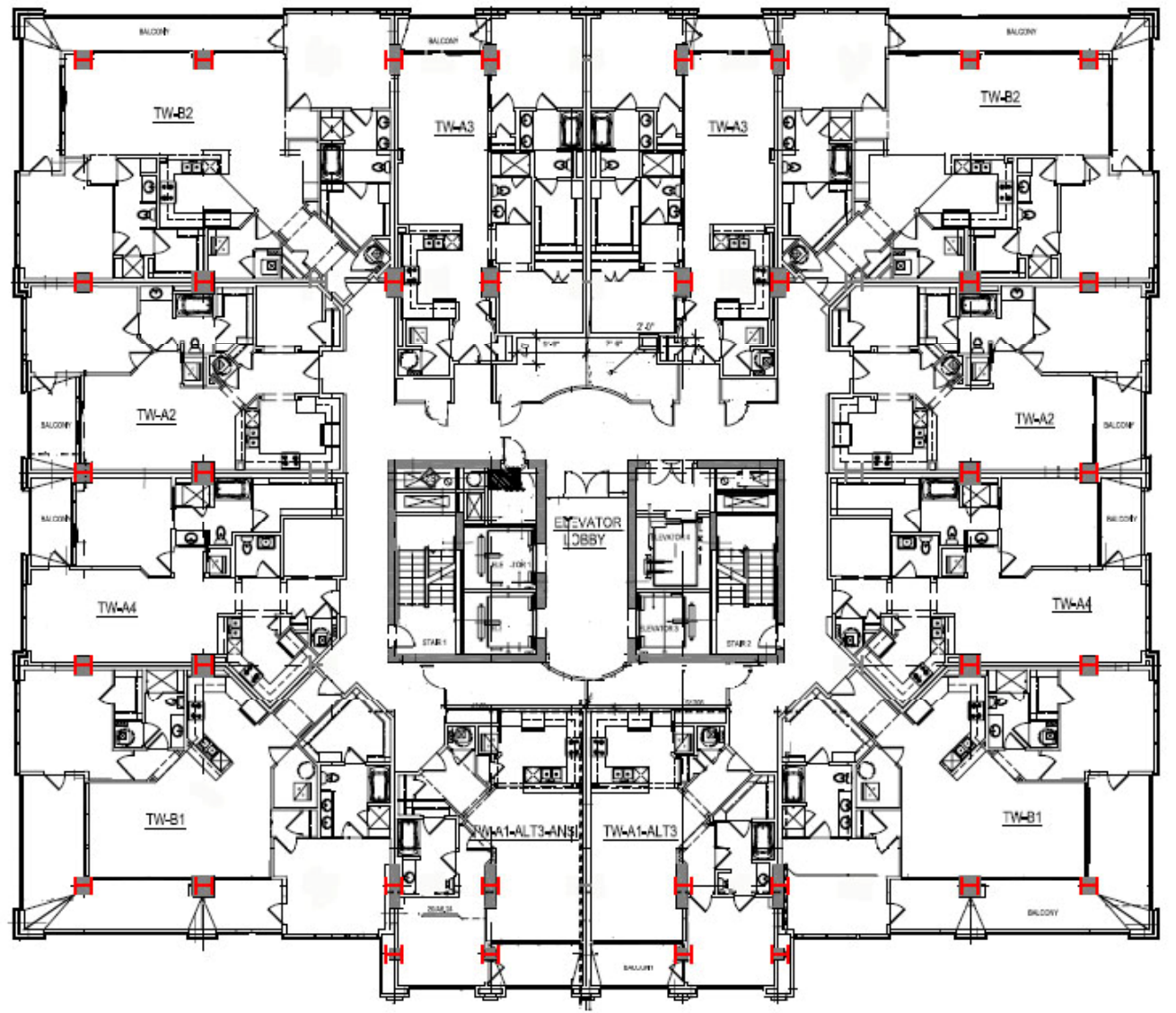


possible column layouts

- column layout 2
 - bay size: varying sizes
 - pros:
 - one-way transfer girders (instead of two-way)
 - simply supported condition for all planks
 - maintain column placement as building tapers
 - cons:
 - additional columns
 - increased architectural intrusion
 - increased building height
 - increased cost

possible column layouts

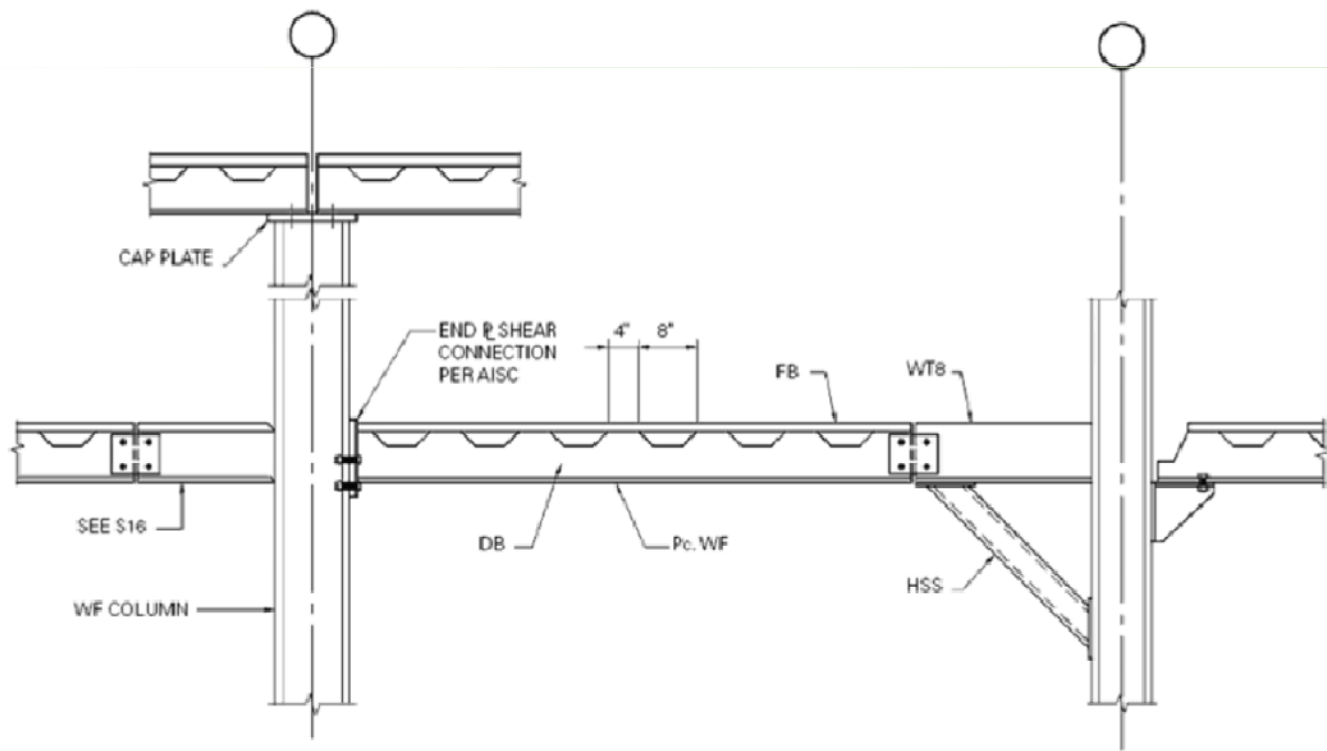
- column layout 3



special connections

Typical System Structural Details

S15



ENG. NOTE:
CHECK WEBSITE TECHNICAL
BULLETINS FAQ ON
CONNECTION DESIGN

ALTERNATE D-BEAM CONNECTIONS TO
WF COLUMNS

possible column layouts

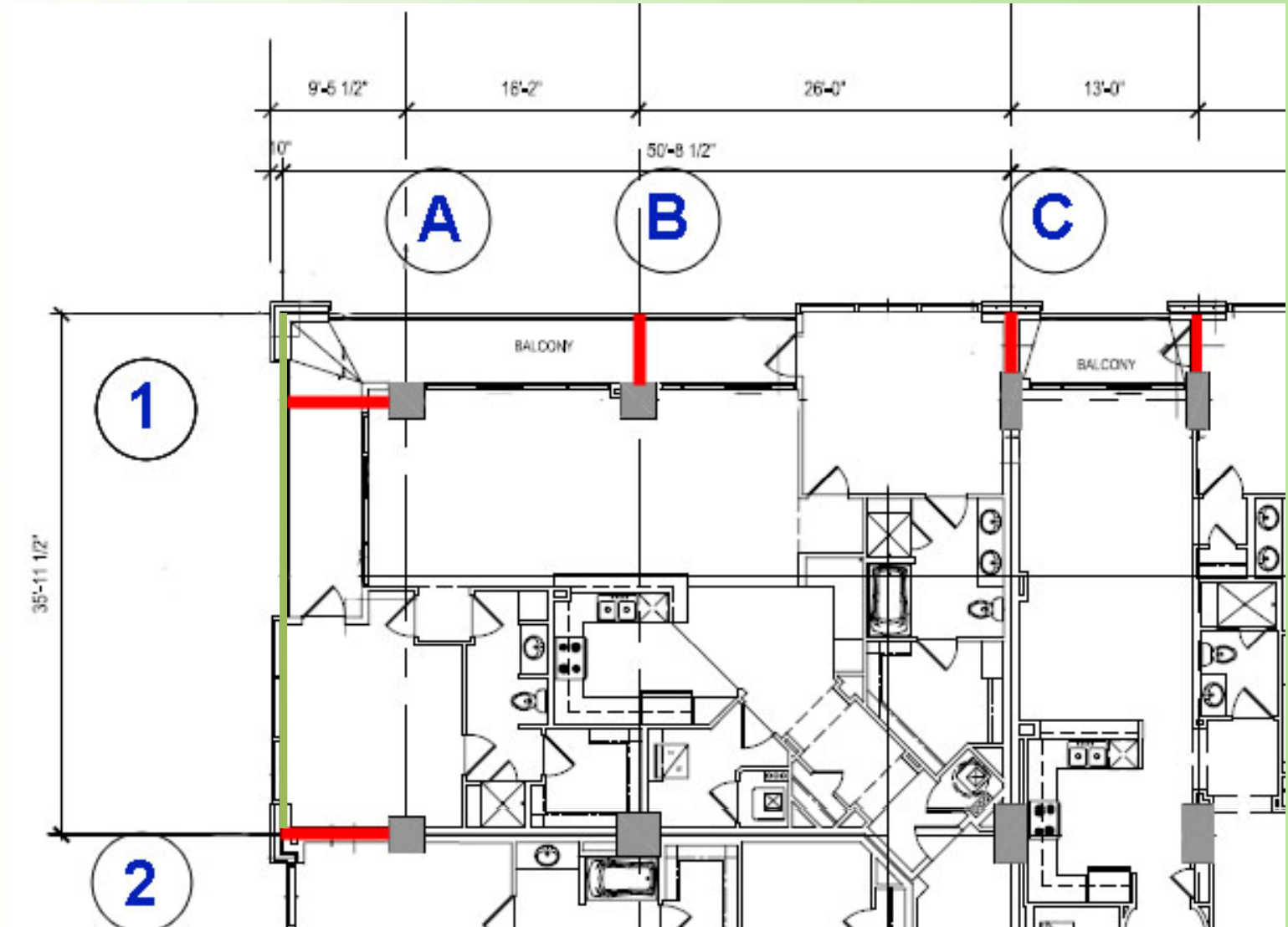
- column layout 3
 - bay size: original bays
 - pros:
 - no transfer girders required
 - no increase in building height
 - no architectural intrusion
 - cons:
 - costly moment connections
 - additional floor depth required at cantilevers

column layout 3 – best option

depth

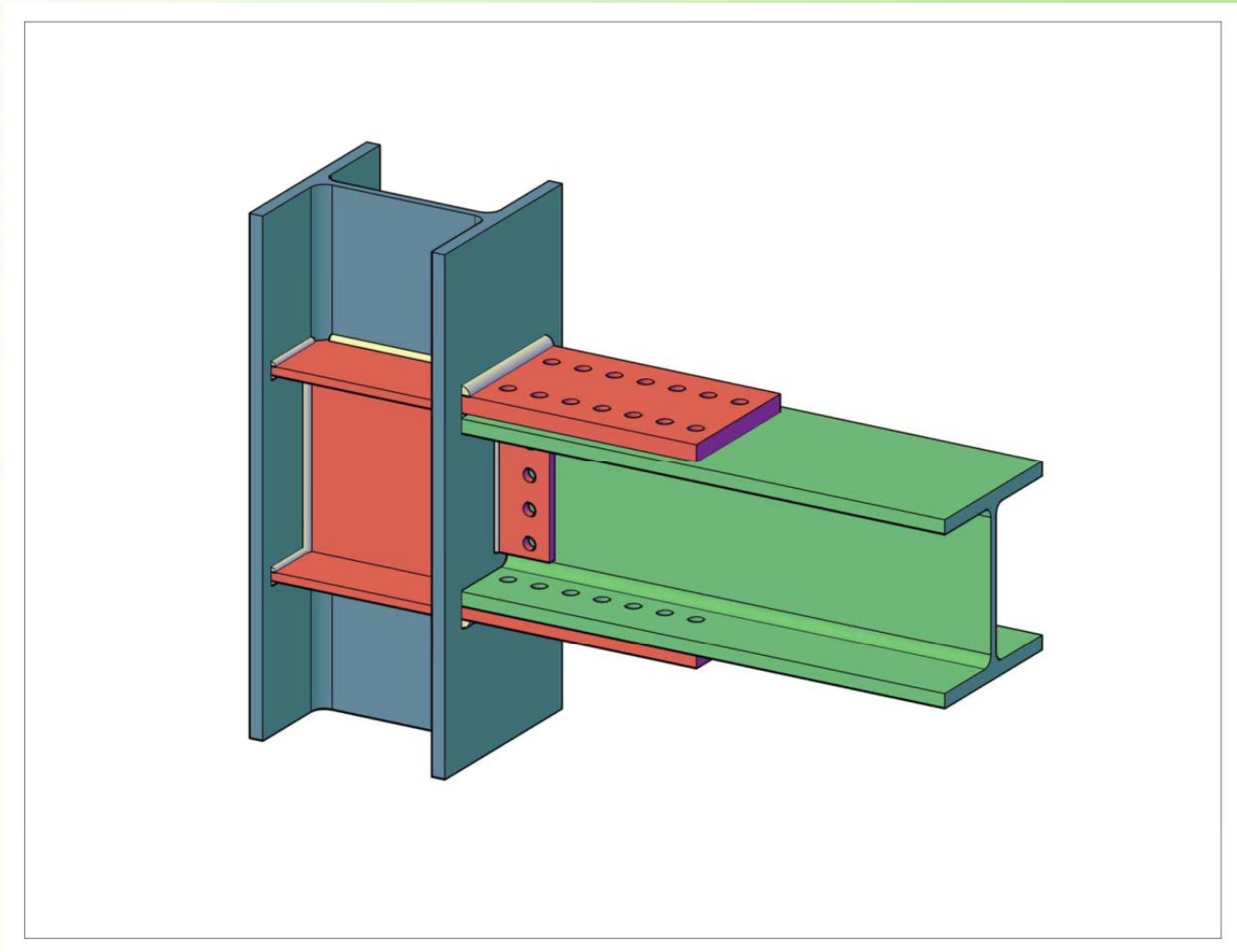
cantilevers

- levels 8 through 24



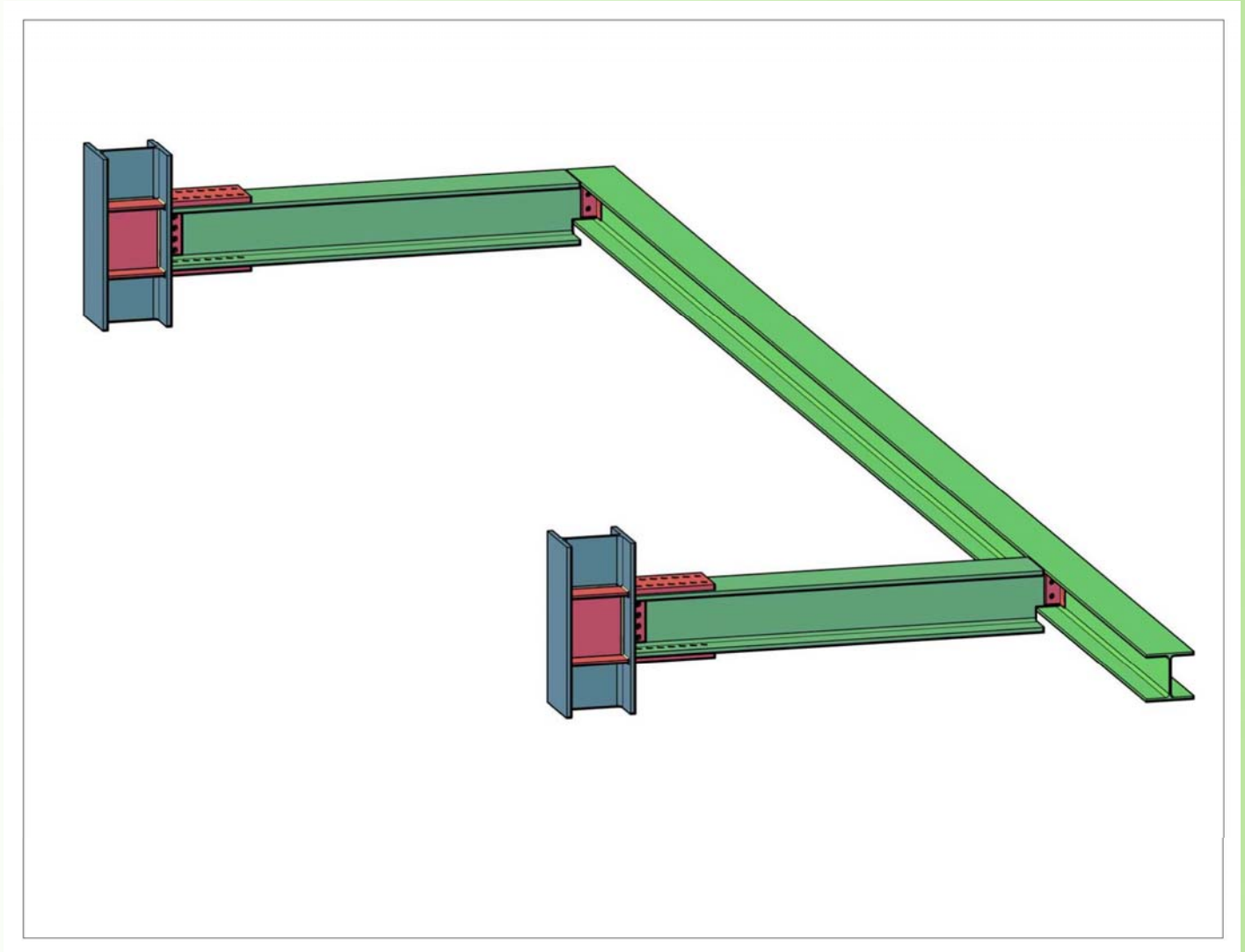
cantilevers

- moment connection
 - economy in mind – no field welds



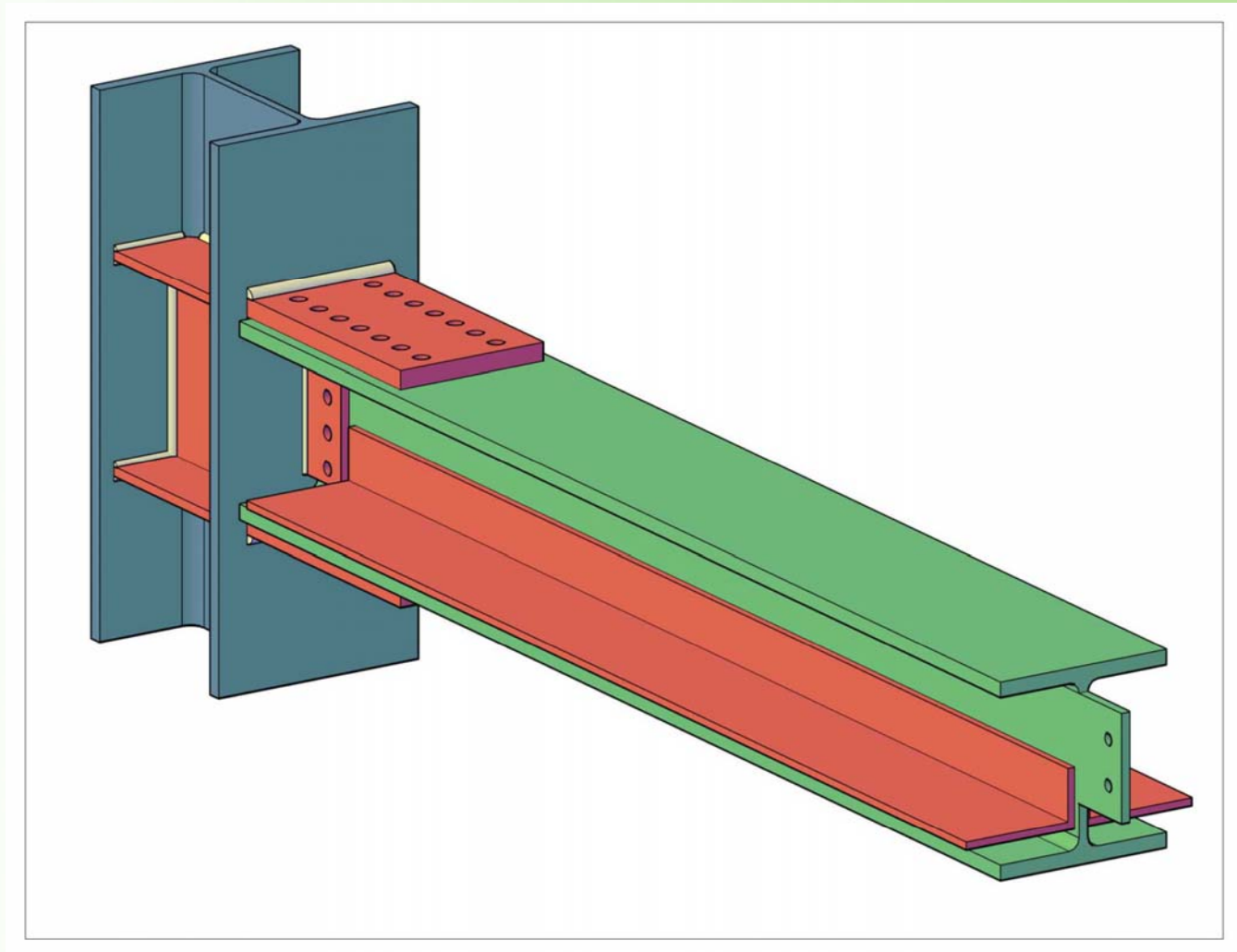
cantilevers

- cantilevered beam between A1 & A2

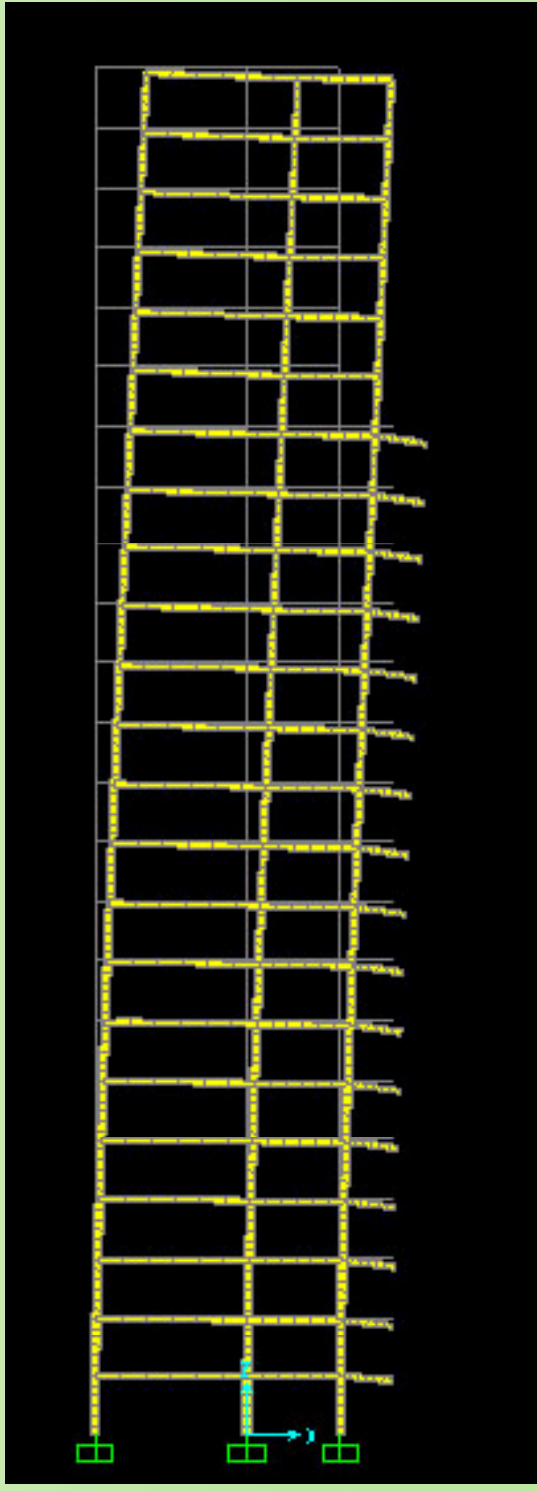
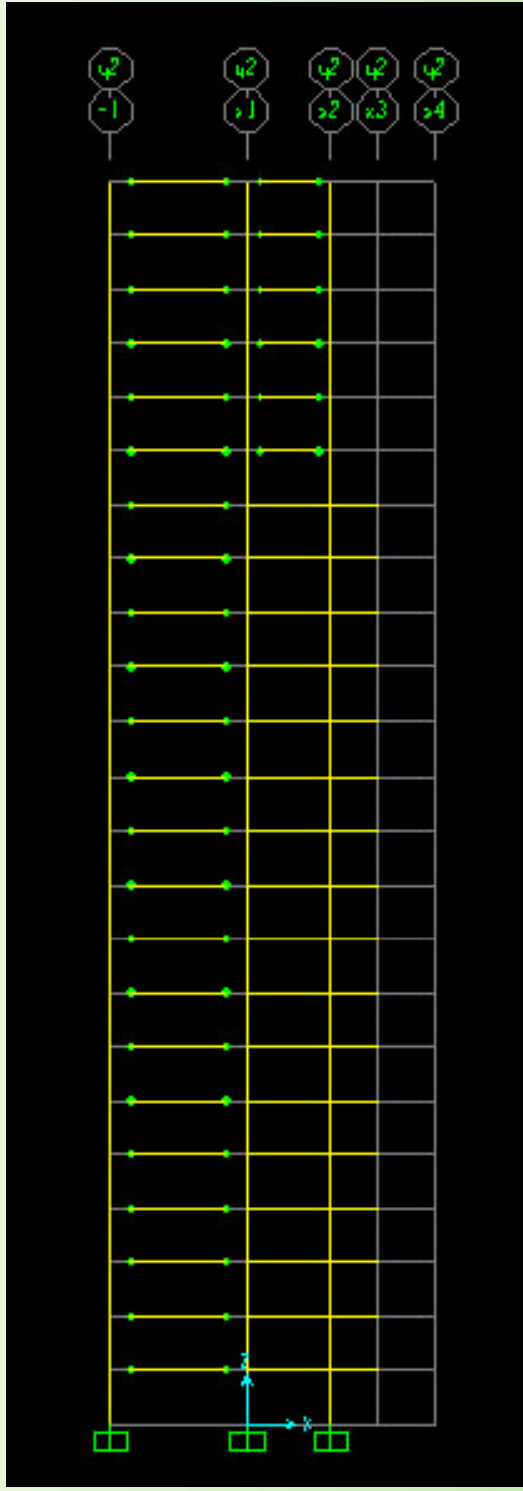
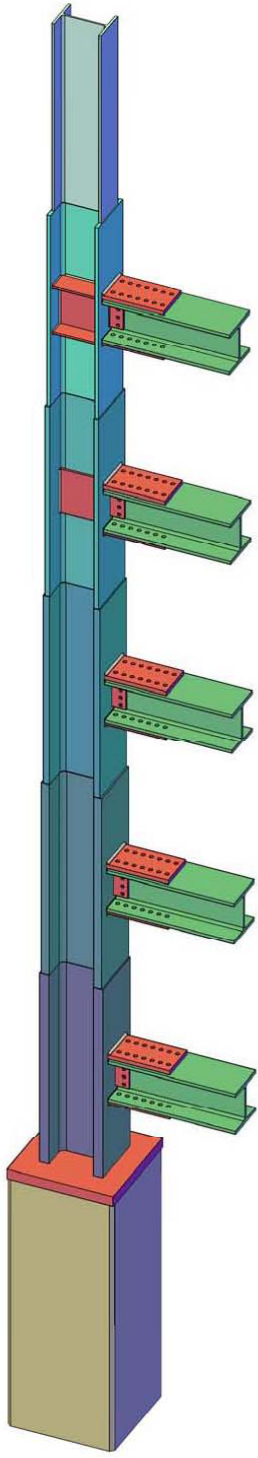


cantilevers

- cantilever A1 & B1
 - angle welded to web for low profile

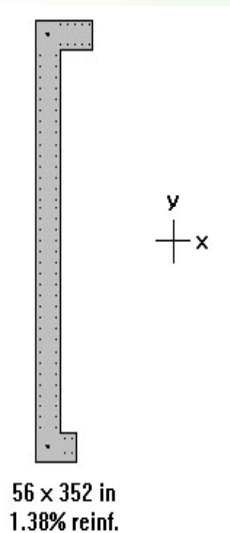


depth

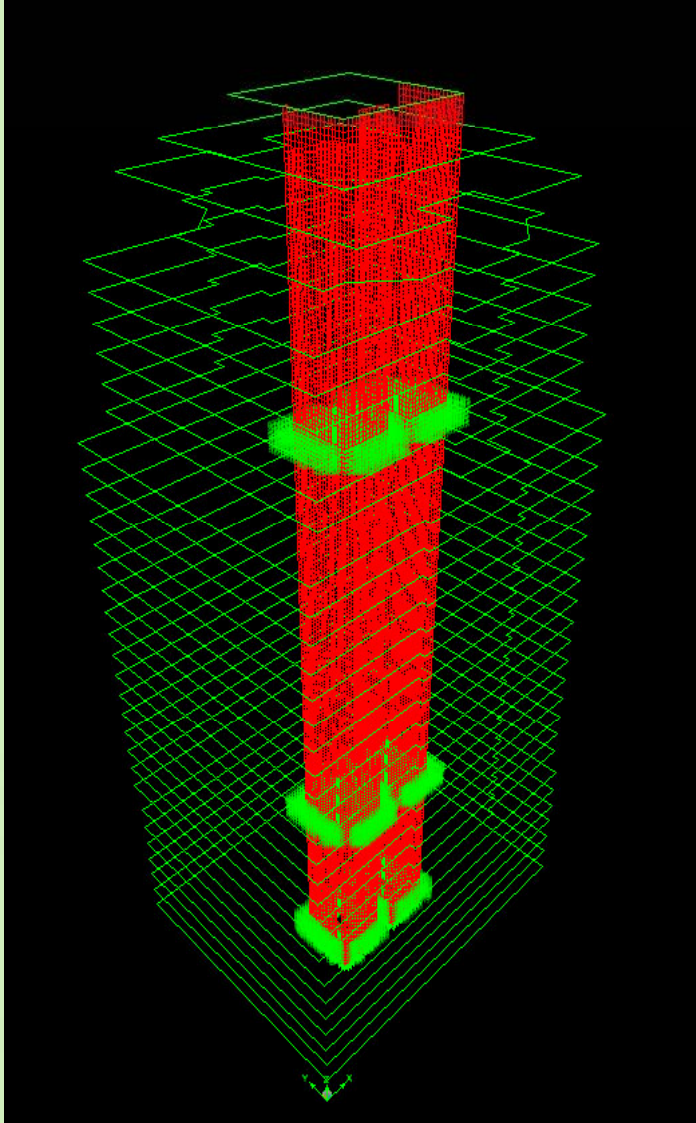


lateral analysis

- ETABS
 - considered additional wind cases from ASCE 7-05, figure 6-9
 - assigned piers
 - pier forces checked with PCAColumn



boundary elements okay



construction schedule

- existing schedule
 - duration: 353 days (level 8 to substantial completion)
 - typical floor duration: 192 days
 - 46 days shoring time required
 - 8 day floor schedule
- proposed schedule
 - duration: 266 days (87 day reduction)
 - typical floor duration: 129 days
 - girder-slab erection pace: 5000 SF/day
 - 5 day floor schedule
 - change in crew sizes
 - shear walls: 8 days per two levels (4 days/level)

cost analysis

- existing system
 - RS Means
 - local pricing

- proposed system
 - Girder-Slab Technologies
 - RS Means

| CONCRETE SYSTEM | |
|-----------------|------------------------|
| Columns | \$1,368,412.91 |
| Placing | \$73,201.13 |
| Slab | \$8,609,845.50 |
| Placing | \$363,526.81 |
| Total | \$10,414,986.35 |

| STEEL SYSTEM | |
|------------------------|------------------------|
| Columns | \$2,481,651.41 |
| D Beams | \$1,026,992.48 |
| W Shapes | \$1,800,467.37 |
| Planks | \$6,044,111.54 |
| Grouting | \$774,886.10 |
| Topping | \$1,139,538.38 |
| Mom Con | \$579,700.00 |
| Total | \$13,847,347.28 |
| GS Licensing Fee: +10% | |
| TOTAL | \$15,232,082.01 |

cost analysis

- savings due to scheduling
 - general conditions
 - 4 month savings = \$1.2M
 - construction loan
 - 4 months of \$140M loan at 12% per year = \$5.6M
(at end of project)

- overall system cost

| NET REDESIGN COST | |
|-------------------|------------------------|
| Steel | \$15,232,082.01 |
| Concrete | (\$10,414,986.35) |
| GC | (\$1,166,670.00) |
| Loan | (\$5,600,000.00) |
| TOTAL | -\$1,949,574.34 |

were goals met?

- Girder-Slab system feasible redesign?
- decrease construction schedule?
- save money?

recommendation

- gravity system redesign
 - girder-slab applicable for upper 27 floors
 - allows for easy integration
 - minimal architectural intrusion
- construction schedule
 - reduced schedule by 87 days
 - time savings will aid in condo sales
- cost analysis
 - saved owner \$1.95M in construction costs

girder-slab system recommended for redesign

acknowledgements

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Brian Heart

“Captain” Kirk Stauffer

Phil “Fillet Weld” Frederick

Allen Sky Walker

And most of all, my family for supporting me and encouraging me to follow my dreams.

conclusion



questions?

conclusion

breadth

depth

goals

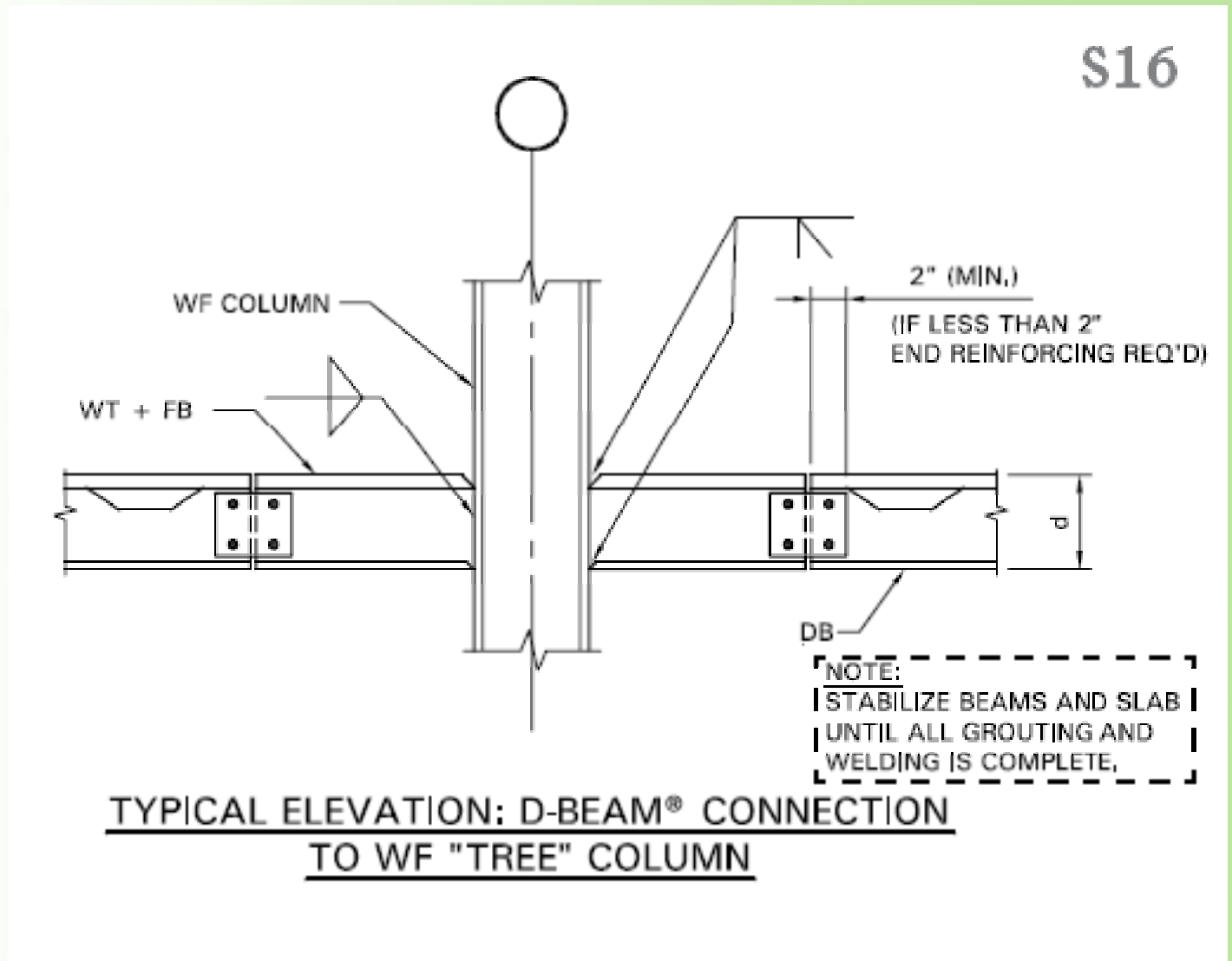
proposal

overview

introduction

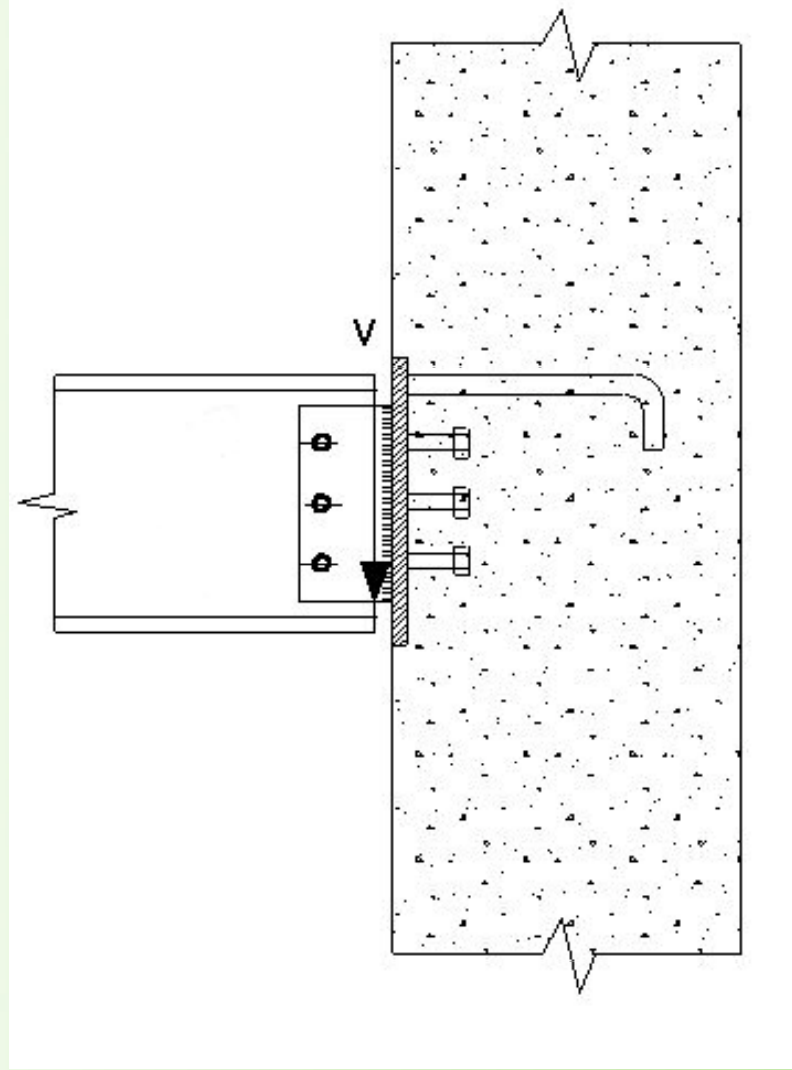
special connections

- girder-slab tree connection



special connections

- embedded plate at shear walls



breadth

construction schedule

