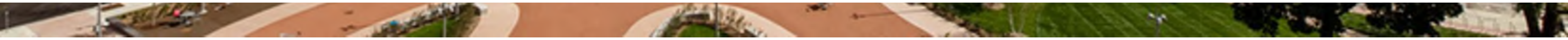
DOWNTOWN EAST



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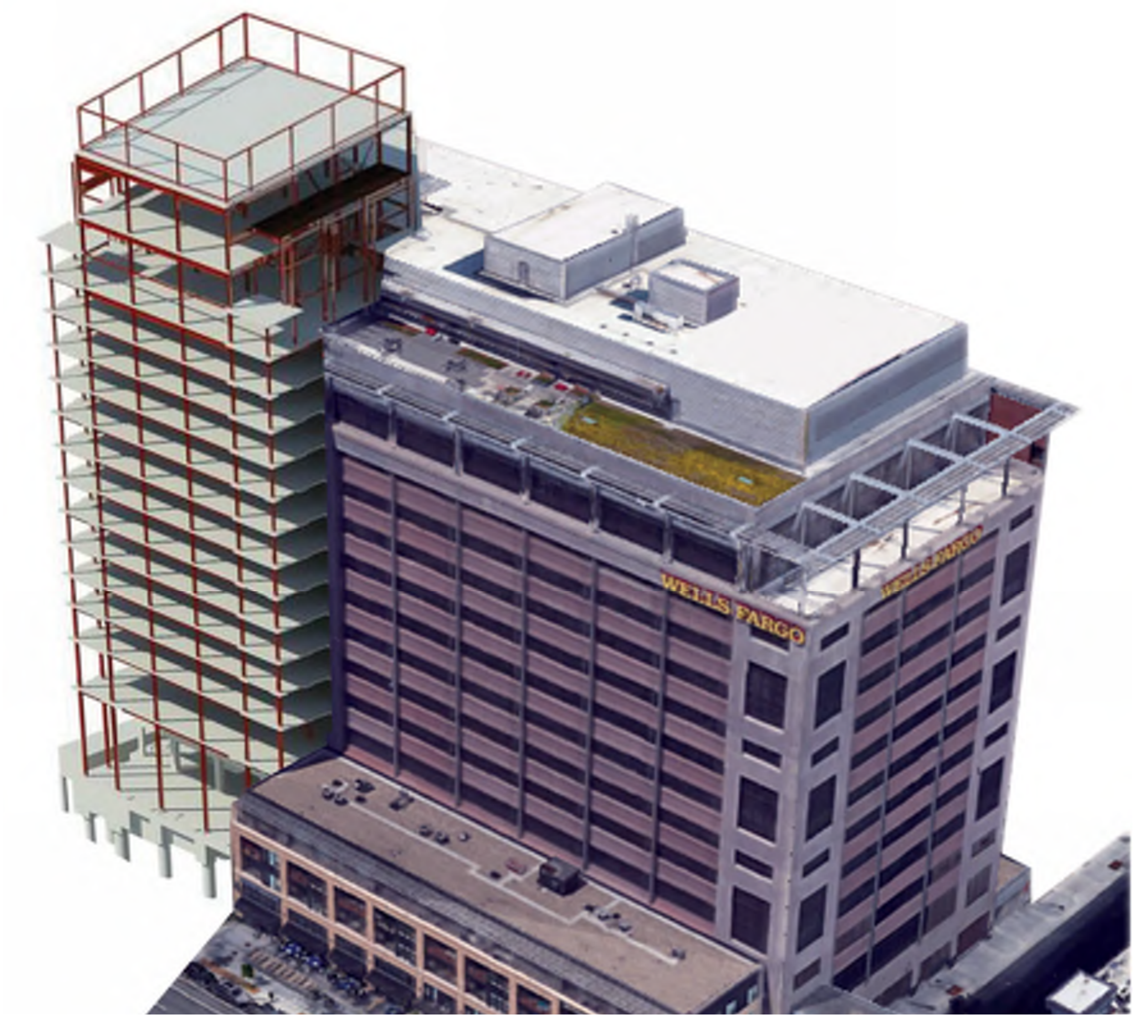
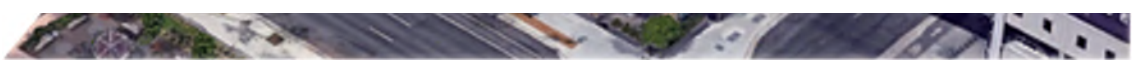
STRUCTURAL ENGINEERING

PRESENTED BY

Ryan Bonniwell
Partner



OVERVIEW



SITE PLAN

MSFA RAMP

MILLWRIGHT BUILDING

WELLS FARGO OFFICES

WELLS FARGO OFFICES

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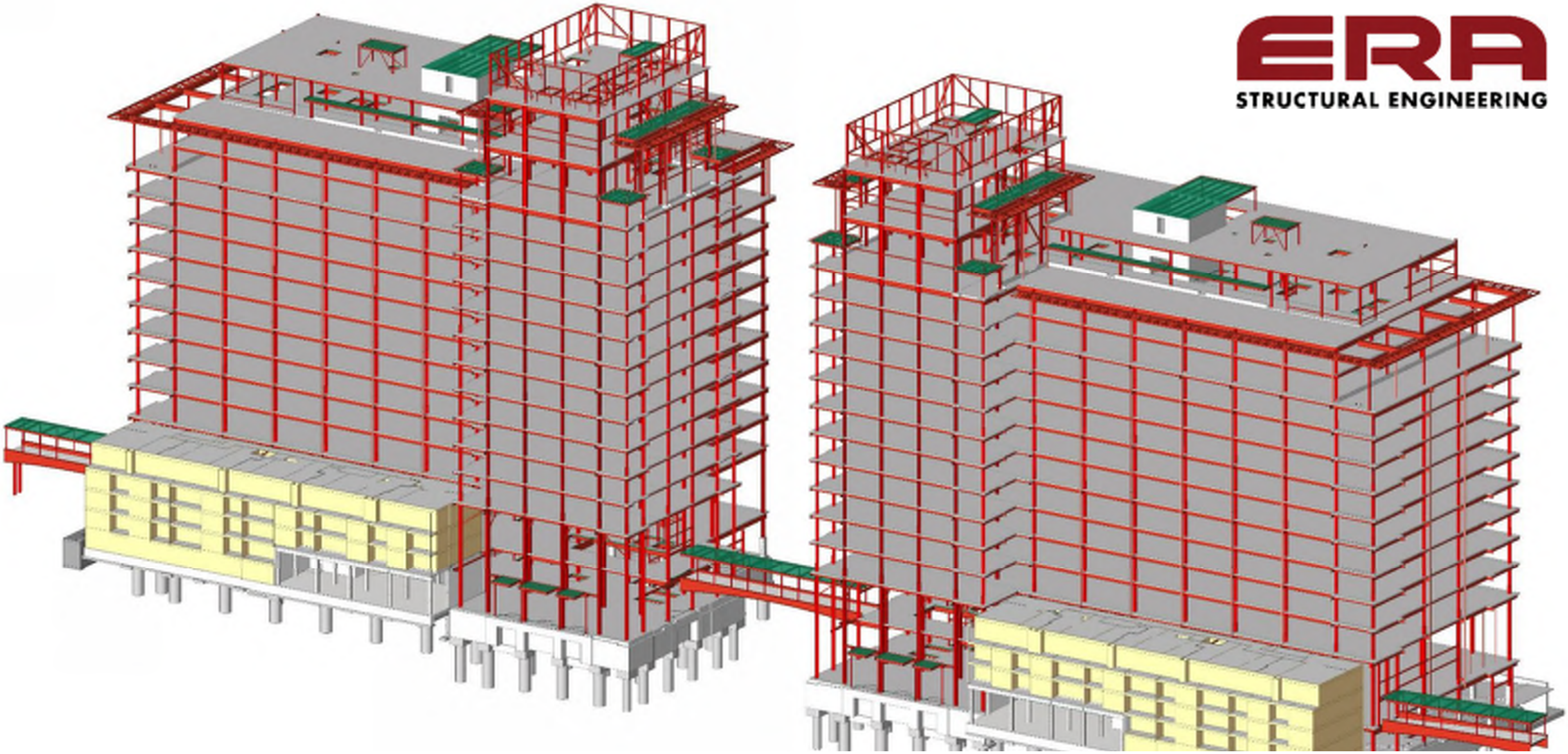
TEAM

- ARCHITECT: RYAN A+E
- GENERAL CONTRACTOR: RYAN COMPANIES
- STEEL FABRICATOR: LEJEUNE STEEL

HIGHLIGHTS

- Two 17-story office buildings totaling 1.2 Million SF
- Part of 5-block development including retail, hotel, residential and park
- Skyway connection from US Bank Stadium to Downtown
- Total development cost of $700 Million



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STRUCTURAL SYSTEM

STRUCTURAL SYSTEM

FLOORS

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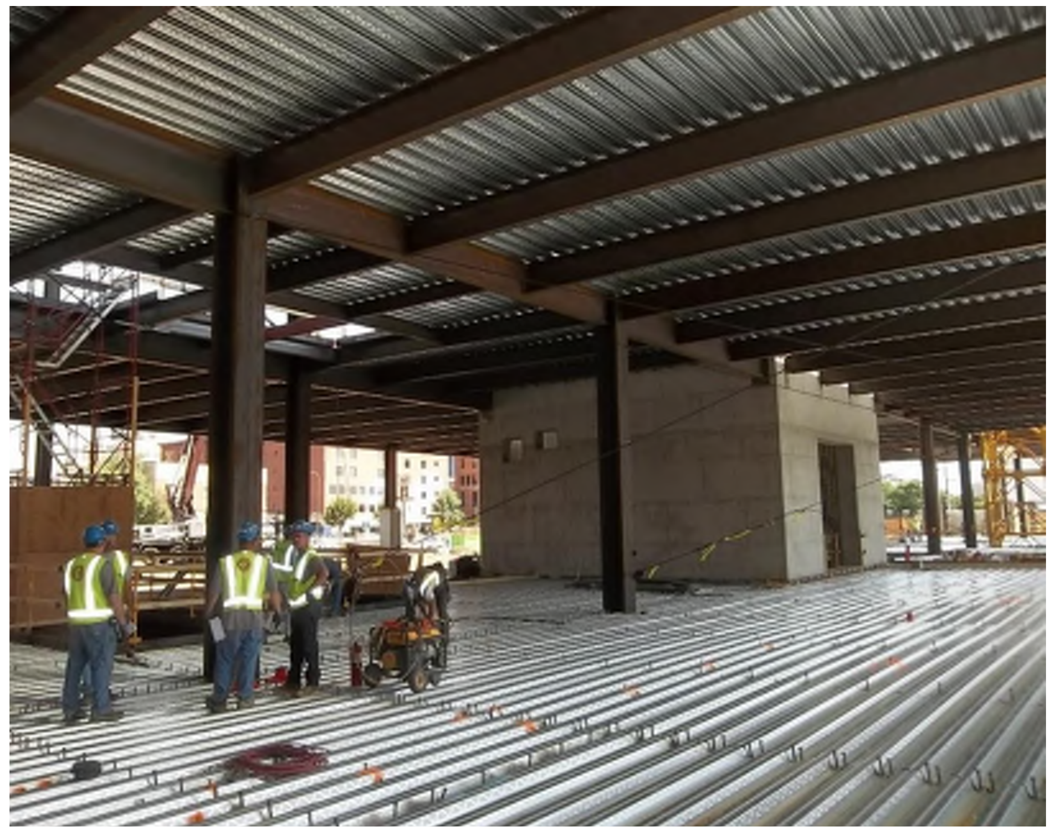

STRUCTURAL SYSTEM

LATERAL

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STRUCTURAL SYSTEM
FOUNDATION

STRUCTURAL SYSTEM
ROCK ANCHORS

STRUCTURAL SYSTEM

ROCK ANCHOR DESIGN

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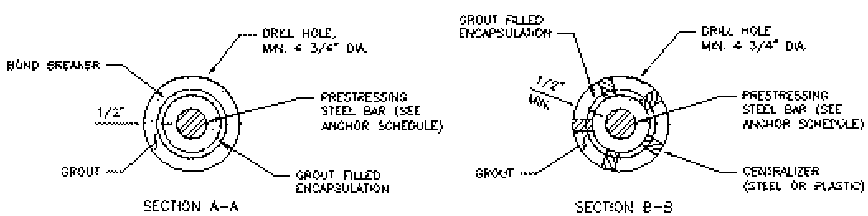
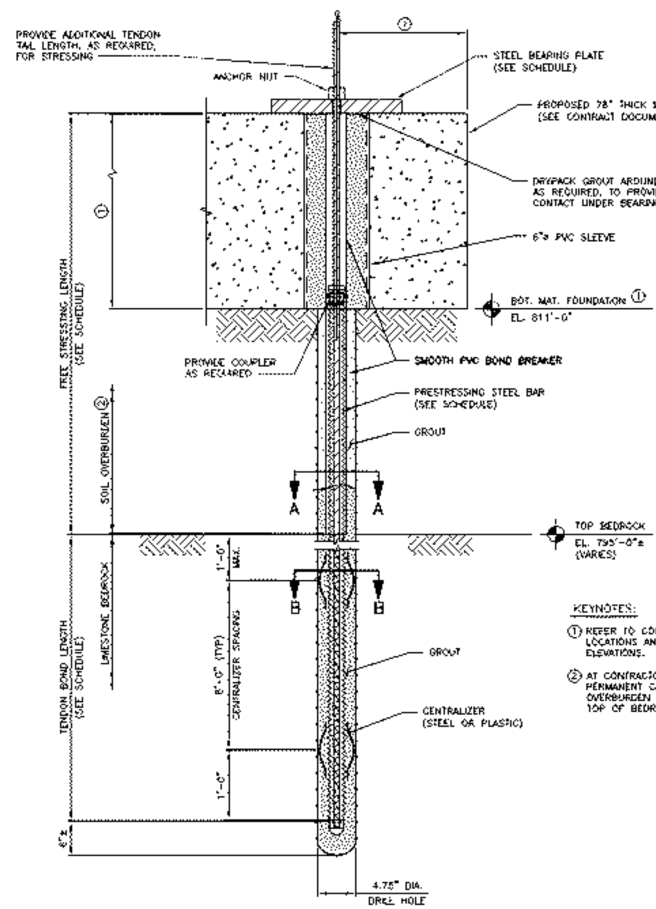


DETAIL - ROCK ANCHOR 1/1
N.T.S.



KEYNOTES:

1. REFER TO CONTRACT DOCUMENTS FOR ANCHOR LOCATIONS AND MAT FOUNDATION DIMENSIONS AND ELEVATIONS.
2. AT CONTRACTOR'S OPTION, TEMPORARY OR PERMANENT CASING MAY BE USED IN THE OVERBURDEN SOILS TO FACILITATE DRILLING TO THE TOP OF BEDROCK.

STRUCTURAL SYSTEM
ROCK ANCHOR INSTALLATION

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FLOOR LEVELNESS

WHY LEVEL FLOORS

Who wants level floors?

- Owners
- Architects
- Contractors
- Us

Everyone but the gypcrete supplier.

UN-LEVEL ISSUES

Potential issues:

- Moveable partitions
- Sliding doors
- Glass handrails
- Furniture
- Finishes

Anything designed with less than ½" of adjustability

LEVELNESS VS FLATNESS

FF/FL

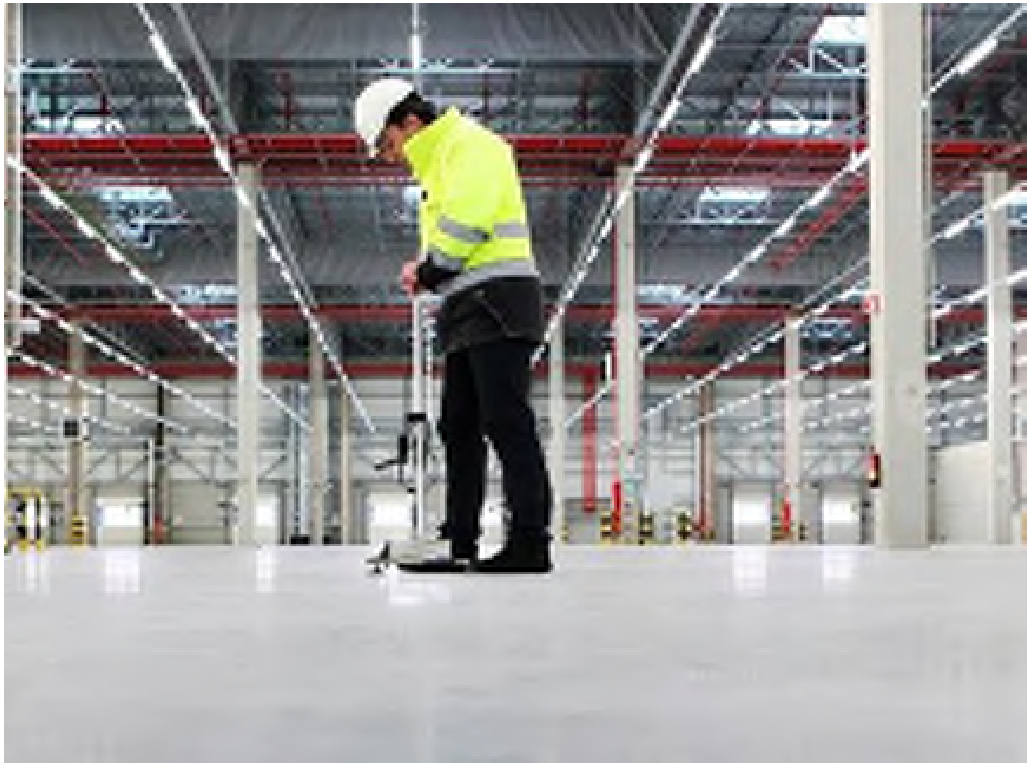
"Flatness can be described as bumpiness of the floor and is the degree to which a floor surface is smooth or plane. Levelness is the degree to which a floor surface parallels the slope established on the project drawings."

- *ACI 117-06 Tolerances for Concrete Construction*

LEVELNESS VS FLATNESS

FF/FL

Levelness not generally applicable to supported floors.



COMPOSITE FLOORS

Why is levelness not applicable?

- Steel tolerances
  - fabrication,
  - erection,
  - camber
- Environmental conditions
- Material Variability
- Concrete placement method
- Concrete Shrinkage
- DEFLECTION

NOTE ON TOLERANCE

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Camber is measured with beam laid flat in the shop

- 45ft beam specified with 3" camber could have as little as 2 ¼" within tolerance
- Vertical erection tolerance at beam connection is 3/8

6.4.4. For beams that are specified in the *contract documents* with camber, beams received by the *fabricator* with 75% of the specified camber shall require no further cambering. Otherwise, the variation in camber shall be as follows:

(a) For beams that are equal to or less than 50 ft [15 000 mm] in length, the variation shall be equal to or less than minus zero / plus ½ in. [13 mm].
(b) For beams that are greater than 50 ft [15 000 mm] in length, the variation shall be equal to or less than minus zero / plus ½ in. plus ⅛ in. for each 10 ft or fraction thereof [13 mm plus 3 mm for each 3 000 mm or fraction thereof] in excess of 50 ft [15 000 mm] in length.

For the purpose of inspection, camber shall be measured in the *fabricator's* shop in the unstressed condition.

Commentary:
There is no known way to inspect beam camber after the beam is received in the field because of factors that include:

(a) The release of stresses in members over time and in varying applications;
(b) The effects of the dead weight of the member;
(c) The restraint caused by the end *connections* in the erected state; and,
(d) The effects of additional dead load that may ultimately be intended to be applied, if any.

Therefore, inspection of the *fabricator's* work on beam camber must be done in the fabrication shop in the unstressed condition.

CAMBER

FLOOR FRAMING

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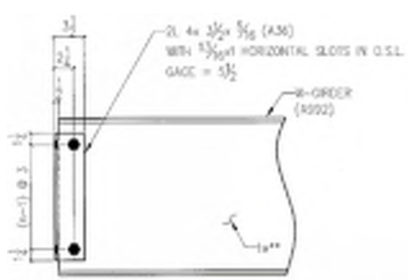
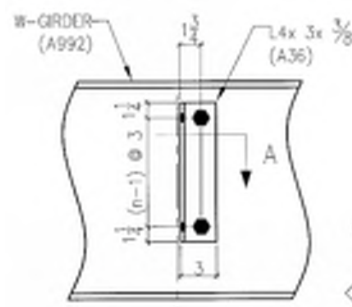
Wells Fargo – Downtown East

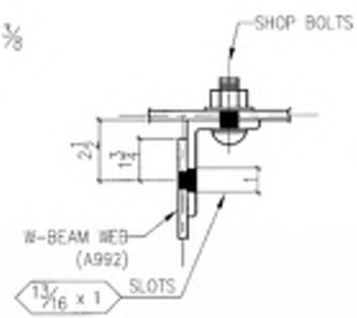
- 30' x 47'-32'-47'
- Adjusted Camber at columns
- Decided to polish floors after they were mostly poured

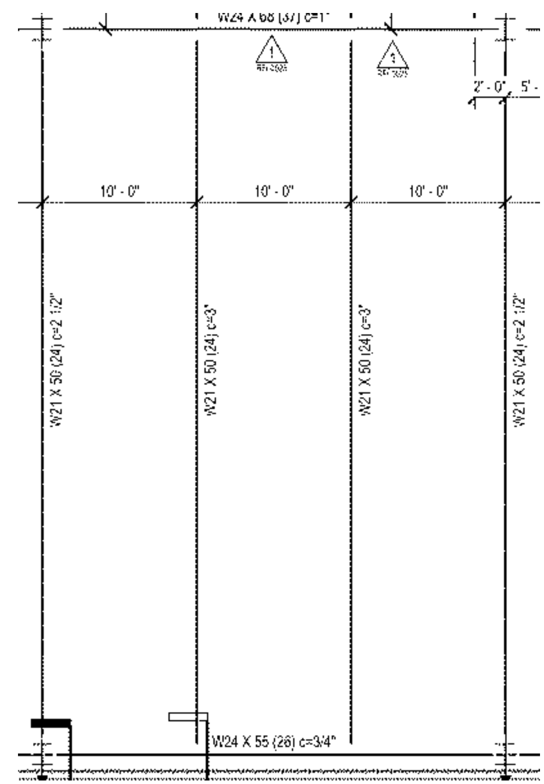
ADJUSTING CAMBER

- Purlins that frame to columns are shorter by the column depth than mid-bay purlins (14 ½" for W14x120 – 20 ¼" for W14x550)
- Connections are typically shear tabs or single angles at girders, double angles at columns
- Stiffness of supporting member restrains end rotation









ADJUSTING CAMBER

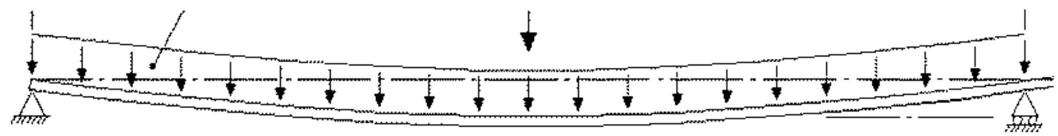
ERA STRUCTURAL ENGINEERING

Deflection Calcs for 47ft purlin

Mid-Bay:
Δ = 3.194" (initial load)

@ Col (W14x120)
Δ = 2.878" (initial load)

Change of 5/16" (10%)



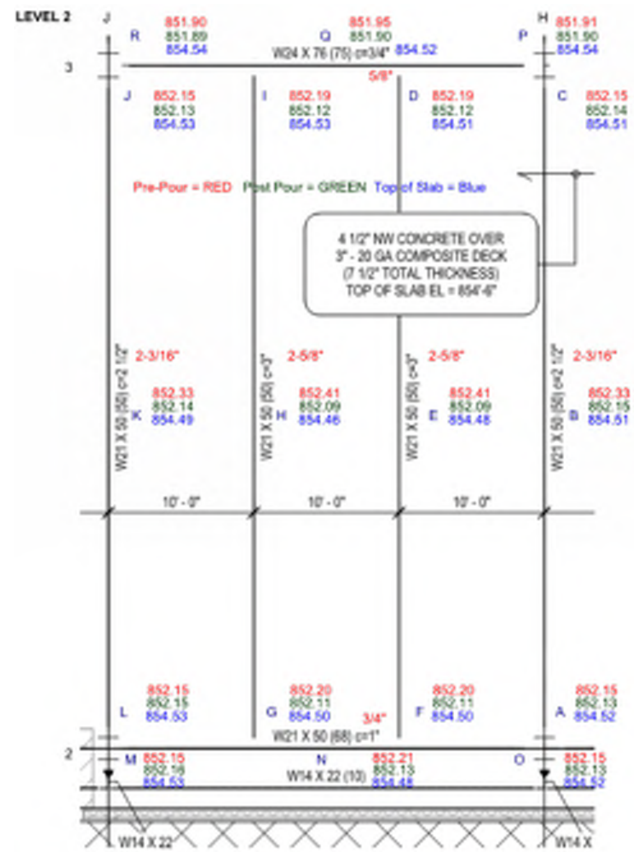
Contribution of connection and backup member is difficult to calculate and connection is typically deferred. Experience shows that this reduces the deflection by about 20% relative to a mid-bay purlin.

The result is a +/- 30% reduction in camber at the columns, or about 1" on a 45ft bay.

OUTCOMES

Steel was surveyed before and after pour, along with top of slab elevation in two test bays.

Top of slab elevations were generally within ½" and after the first two floors, the surveys were not performed.



OUTCOMES – LONG TERM

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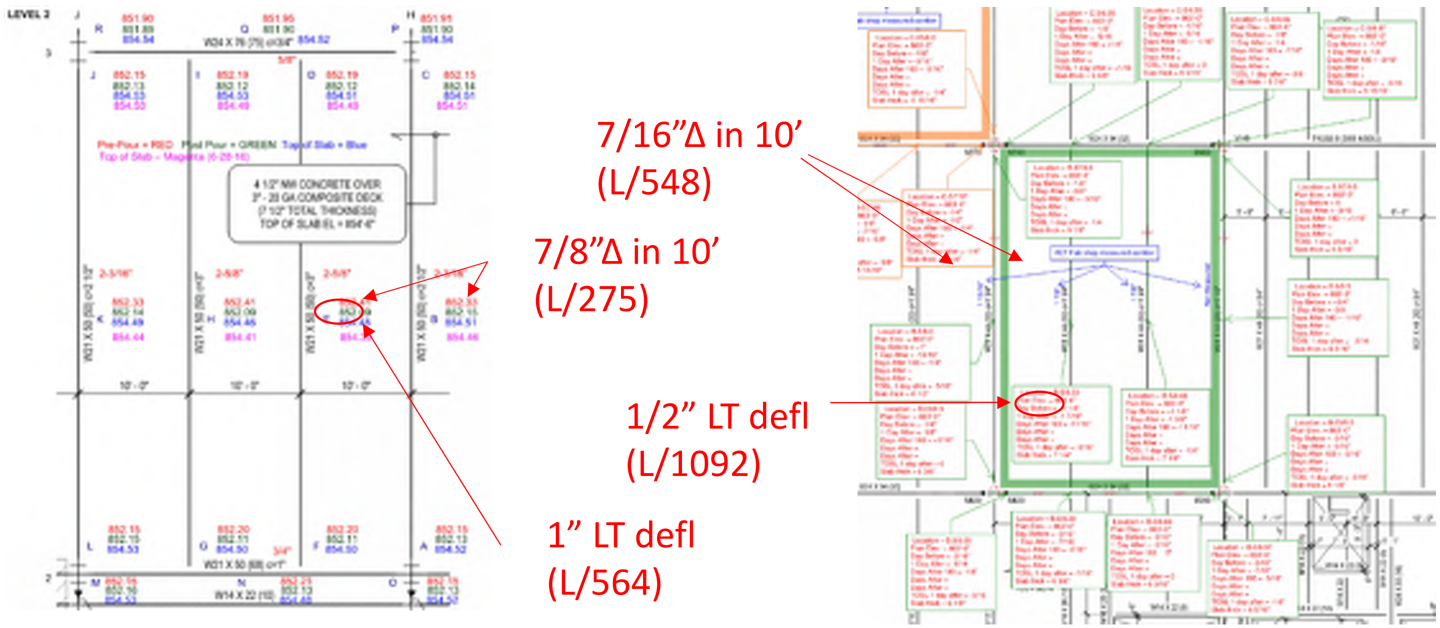
During construction of Millwright, WF build-out occurred at Skyway Level
(21 months after slab pour)
Long-term deflections of ½" to 1"
Millwright Surveyed at 180 days and found ½" – ¾"



SHRINKAGE

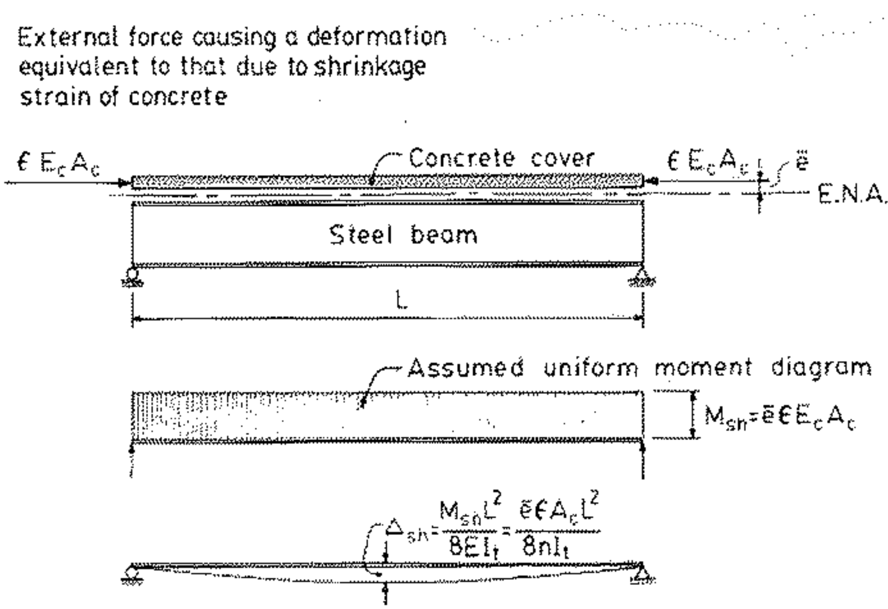


Figure 4.E5
Shrinkage Deflection of Composite Beams
(by analysing the structure as an eccentrically loaded column)

Shrinkage effect on composite beams

- Shrinkage is variable
- Deck restrains free shrinkage by about 25%
- 1/3 of shrinkage occurs in first month, 90% in first year
- Typically assume ε = 0.0003

For 45' purlin, Δsh = 1/2"
(+/- 15% of Δinitial – L/1100)
For 30' purlin, Δsh = 5/16"
(+/- 15% of Δinitial – L/1100)

CAMBER

Design Guide 36

Design Considerations for Camber

Smarter.
Stronger.
Steel.

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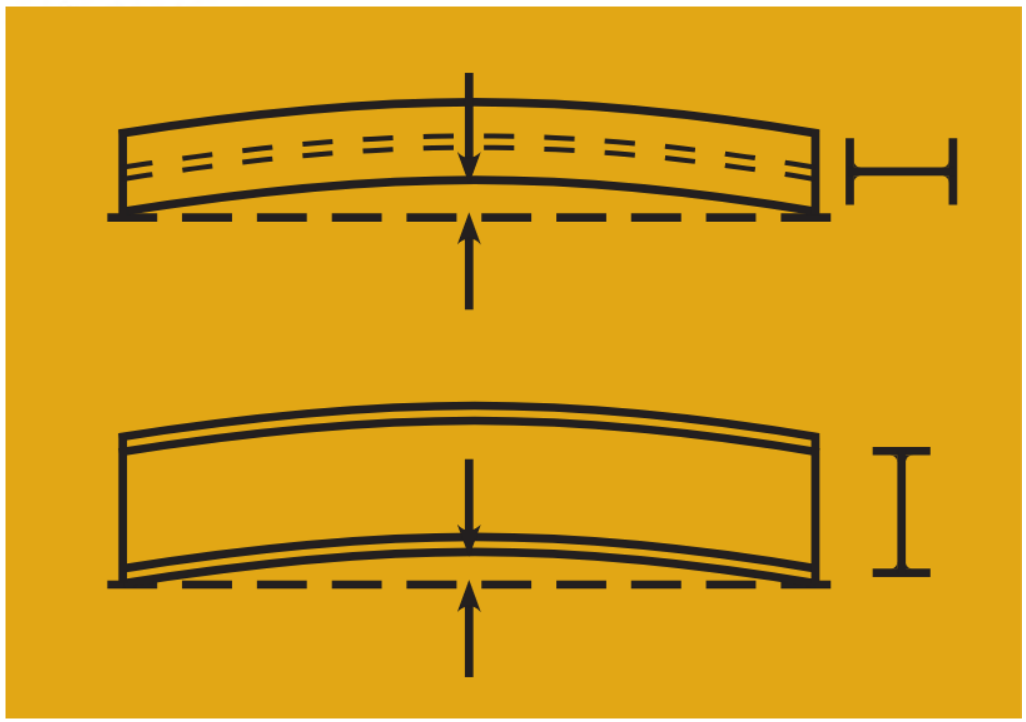

RECOMMENDATIONS

- Have early discussions with the design team and construction team
- Understand and communicate owner expectations
- Identify floor finish early and understand impact
- Discuss potential costs and savings
- Ask contractor what they believe is achievable
- Test camber at the shop and survey steel prior to pour to head off potential issues

RECOMMENDATIONS

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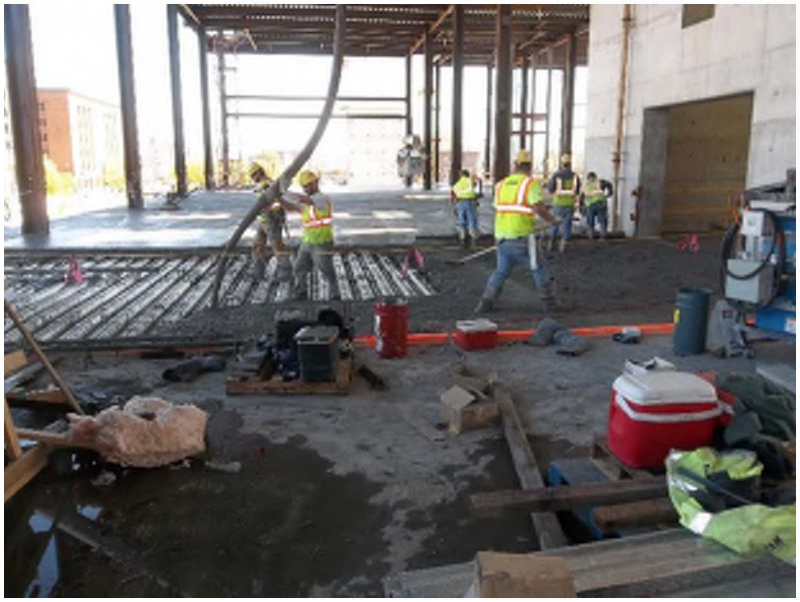
For uniform thickness slab (generally lowest up-front cost)

- Screed from cambered beams
- Camber for 115% DL (based on shrinkage calc)
- Design steel for specified slab thickness + construction LL
- Adjust camber at purlins framing to column flanges




HOW NOT TO
CAMBER A BEAM
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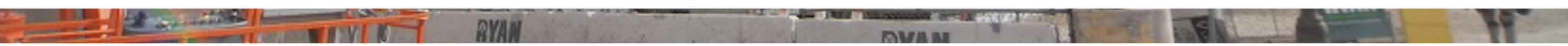
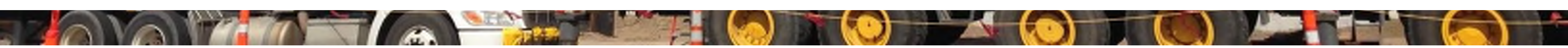
COLUMN SHORTENING




DLI

COLUMN SHORTENING



FUN SHRINKAGE FACT

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The Banging Bold Syndrome:

Unexpected loud noises can cause high anxiety for building owners and tenants

- Beam is not truly simply-supported
- Shrinkage acts along the length of the building
- Bolts designed for bearing are torqued to the level that creates friction between the beam web and connection (more than "snug tight"
- When shrinkage strains build to a level that overcomes the friction, the result is a sudden release of energy as the bolt slips, creating a loud "bang"
- Unsettling but not structurally concerning

ARCHITECTURAL STEEL

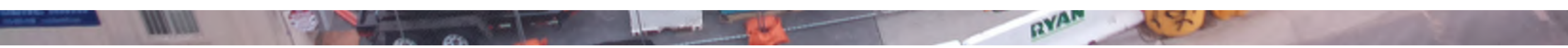
ARCHITECTURAL STEEL

ARCHITECTURAL STEEL

SKYWAYS

4TH AND PARK

4TH AND PARK




QUESTIONS/COMMENTS
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