Honoring Bruce Suprenant: Concrete Construction Contributions

"Concrete: It's A Natural Product"

Presented by James Klinger

ACI 318 Sub-A (voting member)
ACI 117 (associate member)
ACI 134 (voting member)
ACI CLC (voting member)

Hotline Operator: ASCC Technical Division
3rd Year Apprentice to Bruce Suprenant

ASCC TECHNICAL DIVISION

ACI'S NEW HONORARY MEMBERS

3/17/2022

ACI will bestow its highest honor – ACI Honorary Membership – on the following individuals at the ACI Concrete Convention March 27 – 31, 2022:

- Bev Garnant
- Lawrence F. Kahn
- Luke M. Snell
- Roberto Stark
- William E. Rushing, Jr.

According to ACI's Bylaws, "An Honorary Member shall be a person of eminence in the field of the Institute's interest or one who has performed extraordinary meritorious service to the Institute."

ACI is grateful to all its Honorary Members for their extraordinary contributions. Their dedication, leadership, and service to the Institute provide the backbone for continuous advancement within ACI and throughout the greater concrete community.

Bev Garnant

Thank you, Bev…

Honoring Bruce Suprenant Concrete Construction Contributions

ACI 2023 Spring Convention (San Francisco, CA) Tuesday, April 4th / Location: Yosemite C				Speaker	Presentation Title	Time
PART 1	**Moderator:** Oscar Antommattei	8:30-8:40 am	1	**Bev Garnant**	*Introduction*	10
		8:40-9:00 am	2	**Jim Klinger**	*Celebrating Bruce: Concrete the Natural Product*	20
		9:00-9:20 am	3	**Cary Kopczynski**	*Concrete Industry Productivity Takes the Spotlight: ACI's Newest Center of Knowledge*	20
		9:20-9:40 am	4	**Mike Ahern**	*Understanding ACI 117 Construction Tolerances and Tools*	20
		9:40-10:05 am	5	**Peter Craig**	*Bruce Suprenant - Author, Teacher, Influencer, Friend*	25
		10:05-10:30 am	6	**Kevin MacDonald**	*Cold Weather with Hot and Flat Concrete*	25
PART 2	**Moderator:** Mike Hernandez	11:00-11:25 am	7	**Colin Lobo**	*Contractors and Producers - We CAN get along!*	25
		11:25-11:50 am	8	**Chris Forster**	*Concrete Exposed*	25
		11:50-12:10 am	9	**Mike Hernandez**	*Suprenant: The Self-Performed Work Leader*	20
		12:10-12:35 am	10	**Eamonn Connollly**	*Expect Compressive Strength Test Results Less than Specified Strength on Every Project*	25
		12:35-1:00 am	11	**Ken Hover**	*Myth and Misinterpretation of "Overdesign"*	25
PART 3	**Moderator:** Kevin MacDonald	1:30-1:55 pm	12	**Eldon Tipping**	*Producing Level Slab-on-Metal Deck Floors*	25
		1:55-2:20pm	13	**Ron Kozikowski**	*Lightweight Concrete Delamination: Causes, Identification, Repairs and Solutions*	25
		2:20-2:40pm	14	**Lloyd Keller**	*ACI 134 Constructability*	20
		2:40-3:05pm	15	**Scott Tarr**	*Improving Design and Construction of Concrete Slabs-on-Ground*	25
		3:05-3:30pm	16	**Heather Brown**	*Understanding the value of low tech research and executing projects with undergraduate students*	25
PART 4	**Moderator:** Jim Cornell	4:00-4:25pm	17	**Mike Schneider**	*The National Veteran Memorial Museum*	25
		4:25-4:50pm	18	**Leo Zhang**	*A 3D Laser Scanning Study on Slab-on-Grade: How Bruce mentors and guides young professionals*	25
		4:50-5:10pm	19	**Chad Hensley**	*Constructability - Streamline the Design*	20
		5:10-5:35pm	20	**Tarek Khan**	*What it Takes to Make Good High Performance Concrete*	25
		5:35-6:00pm	21	**Oscar Antommattei**	*The Value of Knowledge in the Construction Practice*	25

Concrete: It's All About Luck

You always have to try try to position yourself to get lucky…

The harder you work, the luckier you get

Miller and Long, KCE Structural Engineers, PC, Martin Middlebrook and Louie, Conco

World of Concrete

ASCC booth…~2017

THE WORLD'S GATHERING PLACE FOR ADVANCING CONCRETE

aci CONCRETE CONVENTION

The ASCC Dream Team: Bruce Suprenant…Ward Malisch…Bev Garnant

THE WORLD'S GATHERING PLACE FOR ADVANCING CONCRETE

aci CONCRETE CONVENTION

Prime directive:

Safety First!

ASCC

TECHNICAL DIVISION

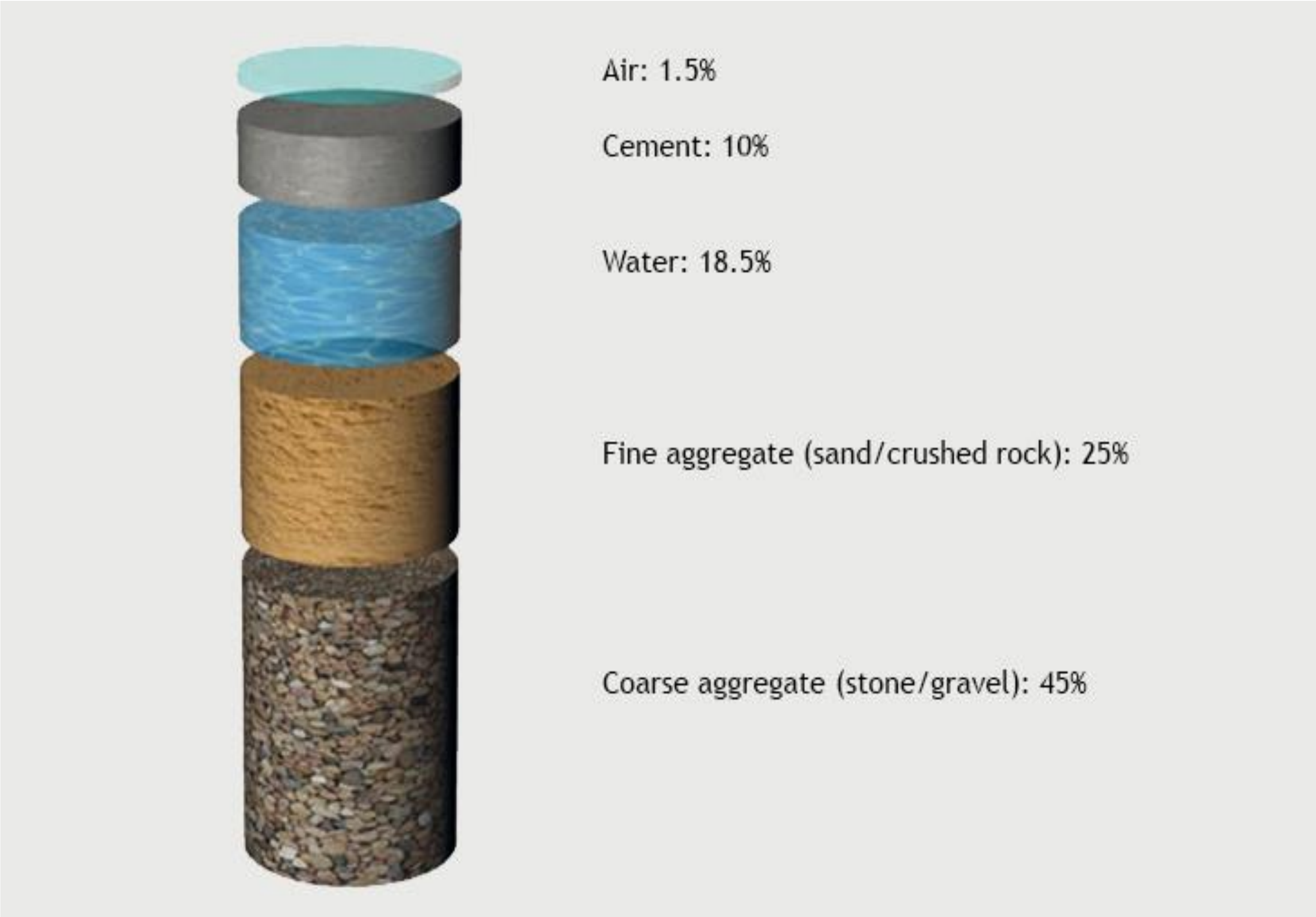
Have fun!

aci CONCRETE CONVENTION

Thanks to Bruce…

It is possible to mix safety and humor…

Huge stuffed pig…along with a bike safety manual…



Concrete is a natural product…

Current supply chain conditions…

Exposed concrete basement wall...high-end residence...

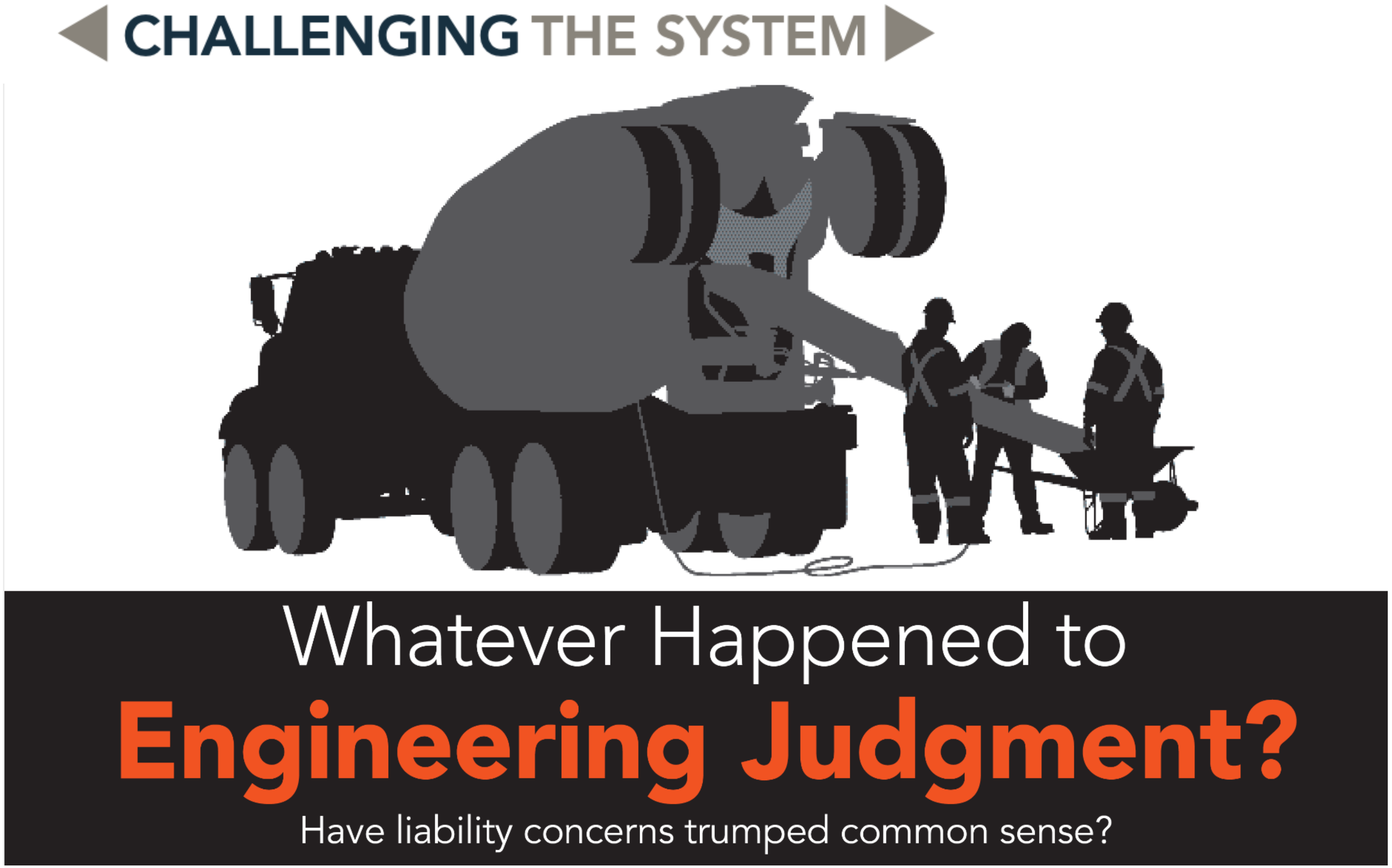
The homeowner wants to know why his walls are a study in mottled blue and grey...

Slag “greening” effect…normal and temporary

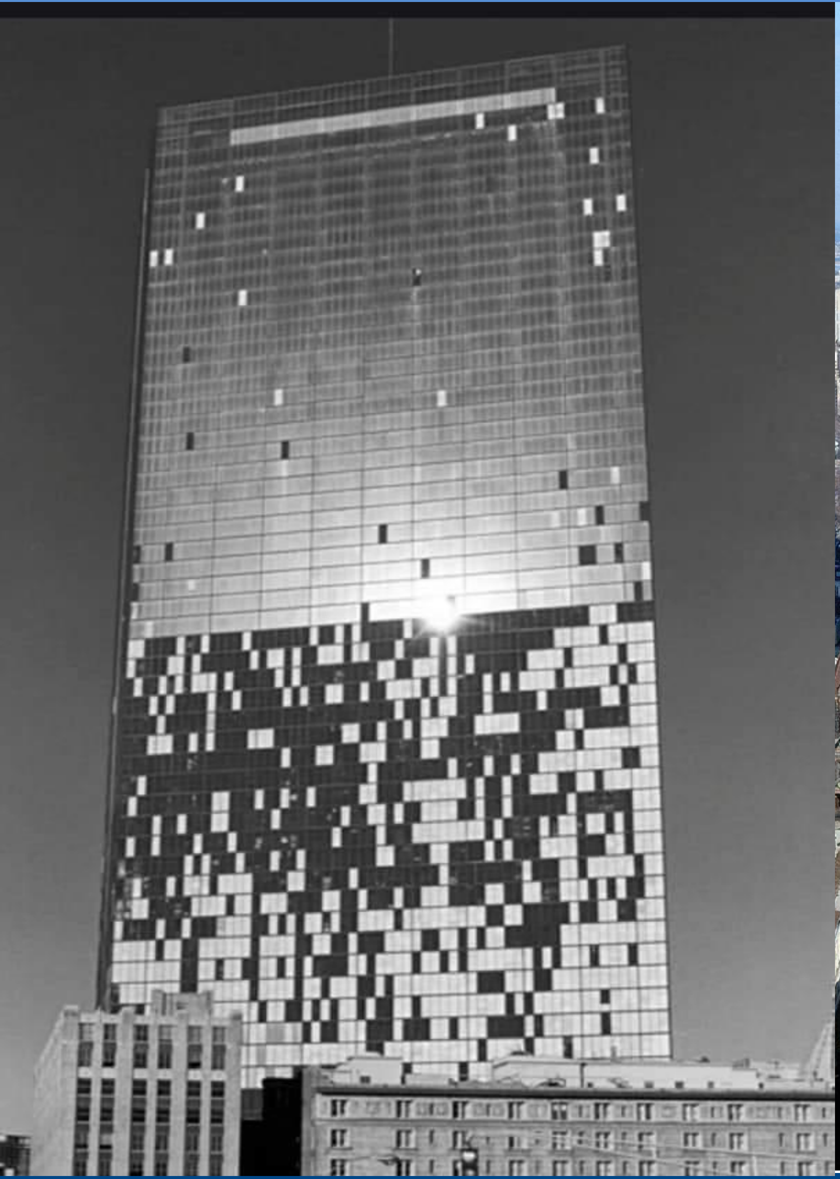
Back in the days of slide rules and IBM punch cards…

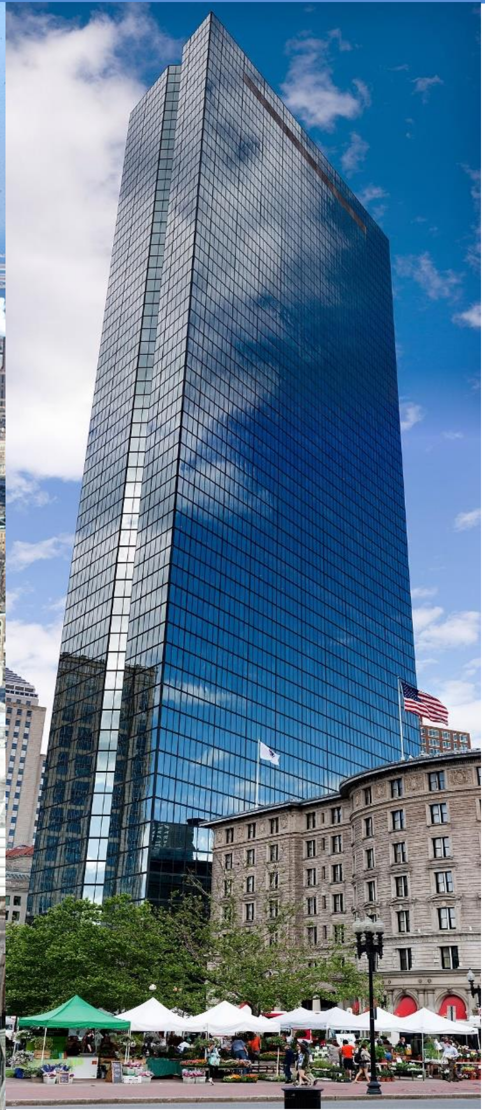
$$1.4D + 1.7L = U$$

Why? Concrete is a natural product



Use your experience to help others see the light…





A Study in Two Classics…

Bruce Style…

“Plywood Palace”

than had been publicly known. The science of testing for the effects of wind, which has become quite sophisticated in the last decade, was relatively primative in the years when the Hancock Tower was designed, and neither engineers nor building codes took into account the effect of gravity on a building that had already begun to sway slightly in the wind. Mr. LeMessurier reveals here that Bruno Thurlimann, a Swiss engineer who was an expert on steel structures, and A. G. Davenport, a Canadian expert on wind engineering, discovered a problem with the Hancock Tower far more dangerous than the falling windows - the unnerving possibility that in certain wind conditions the Hancock Tower had some risk of total collapse.

Even more bizarre than the simple fact of collapse was the specific kind of collapse the engineers envisioned - that the tower's narrow end could fall, not its long end, as if a book standing upright fell on its binding, not on its face. The

Look again!...

"You gotta cure claustrophobia…"

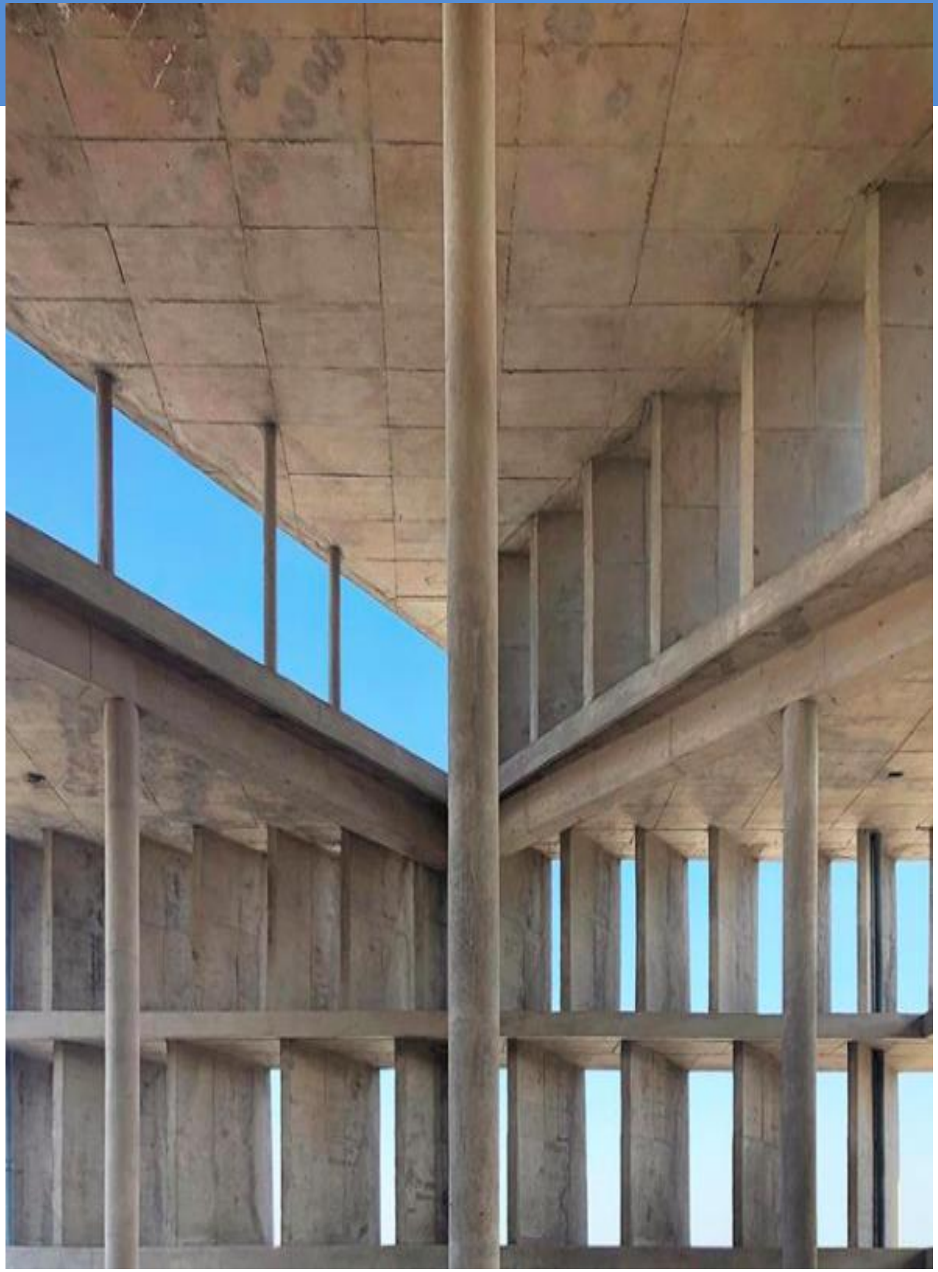
Bruce says "Always think outside the box…"

A Study in Two Classics…Bruce Style

"Tower of Shadows"... Chandigarh, India

Le Corbusier: "City Planner"… personally oversaw construction at the jobsite. He wanted the concrete to be as-cast, "warts and all"...there are accounts that say Le Corbusier often berated the concrete contractor for stripping formwork and then patching the surfaces…

Let's look inside…



Sure enough…as-cast finish…ACI Class B, perhaps…

Formwork design is first-rate…

Classic exposed concrete masterpiece…

Bruce says…look again!

Another classic beauty…textbook curling crack field pattern…

Walvis Bay, Namibia...

Rare rainfall...in one of the driest places on earth...

Photo by Rod Rankine, Pr Eng

Classic case of curling…

Rod Rankine <rod.rankine@telkomsa.net>
To: Jim Klinger
Sun 2/26/2023 12:20 AM

Hi Jim,

You are welcome to use it with pleasure – attached is the original high res. The image was taken on Thursday afternoon before Easter just after a very rare rainfall even in Walvis Bay Namibia – one of the driest places in the world.

The curling is extreme. I suspect part of the reason is that it was constructed on top of a gypsum base and there is probably some expansion from below (from sulfates) as well as shrinkage on top.

I'd love a copy of your article if you remember please.

Please send my best wishes to Bruce. I have never met him in person but I've been an avid reader of his articles on concrete groundslabs for man many years.

Kind regards

Roderick G.D. Rankine Pr.Eng

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This email was sent by solar power

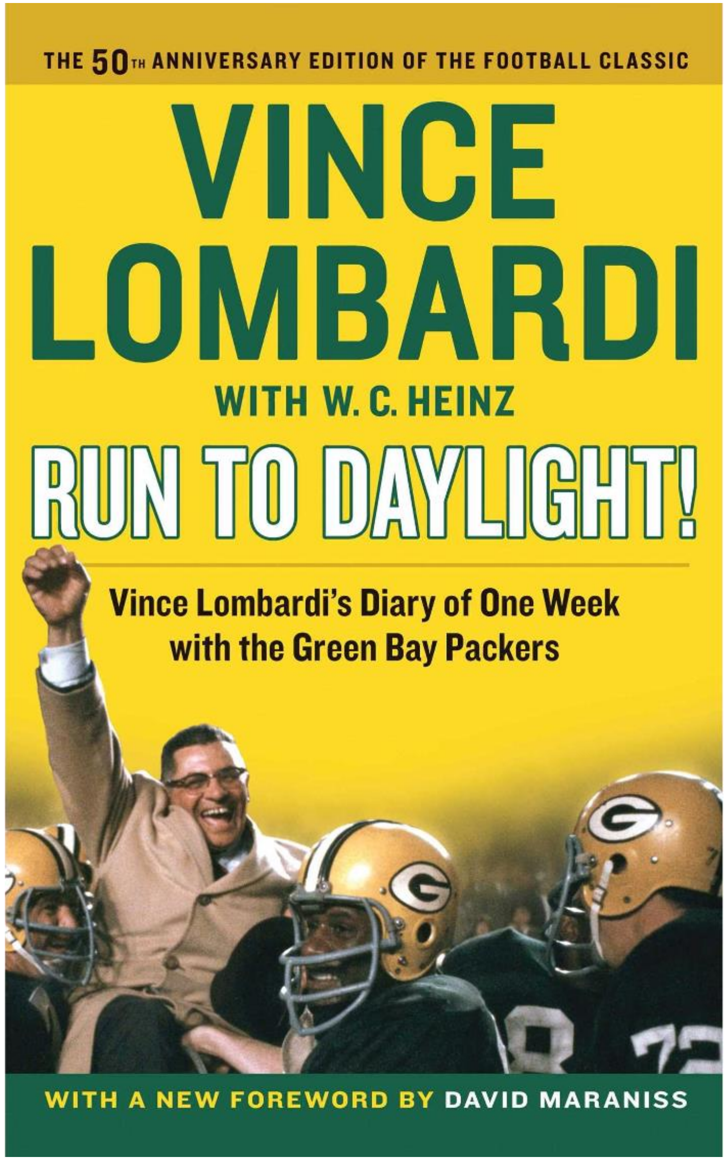
Please note: I do not receive emails on my cellular telephone. For urgent matters please contact me on my mobile phone.

Fan mail from South Africa…

Please send my best wishes to Bruce. I have never met him in person but I've been an avid reader of his articles on concrete groundslabs for man many years.

Kind regards

Roderick G.D. Rankine Pr.Eng



6.3.12 *Final acceptance of architectural concrete*—Upon completion of architectural concrete, including surface repairs and patching of tie holes, final acceptance is based on matching the architectural cast-in place concrete with accepted field mockup when viewed at 20 ft in daylight. Defective Work not conforming to Contract Documents, including repair areas not accepted, shall be removed and replaced.

7.2—Overall impression

Make the evaluation under normal lighting conditions from a minimum distance of 20 ft (6 m) or greater, that is perpendicular to the concrete surface to be viewed. This viewing distance allows one to evaluate of the overall appearance of the structure has been achieved.

Sunlight striking a concrete surface at an acute angle will amplify the appearance of irregularities, so evaluations under these conditions should be avoided. The appropriate viewing distance is equal to the distance that allows the entire building, the building's essential parts, or both, to be viewed in their entirety. The individual design features should be recognizable. For architectural concrete, refer to ACI 303R-12.

Hotel Casa TO

Puerto Escondido, Mexico

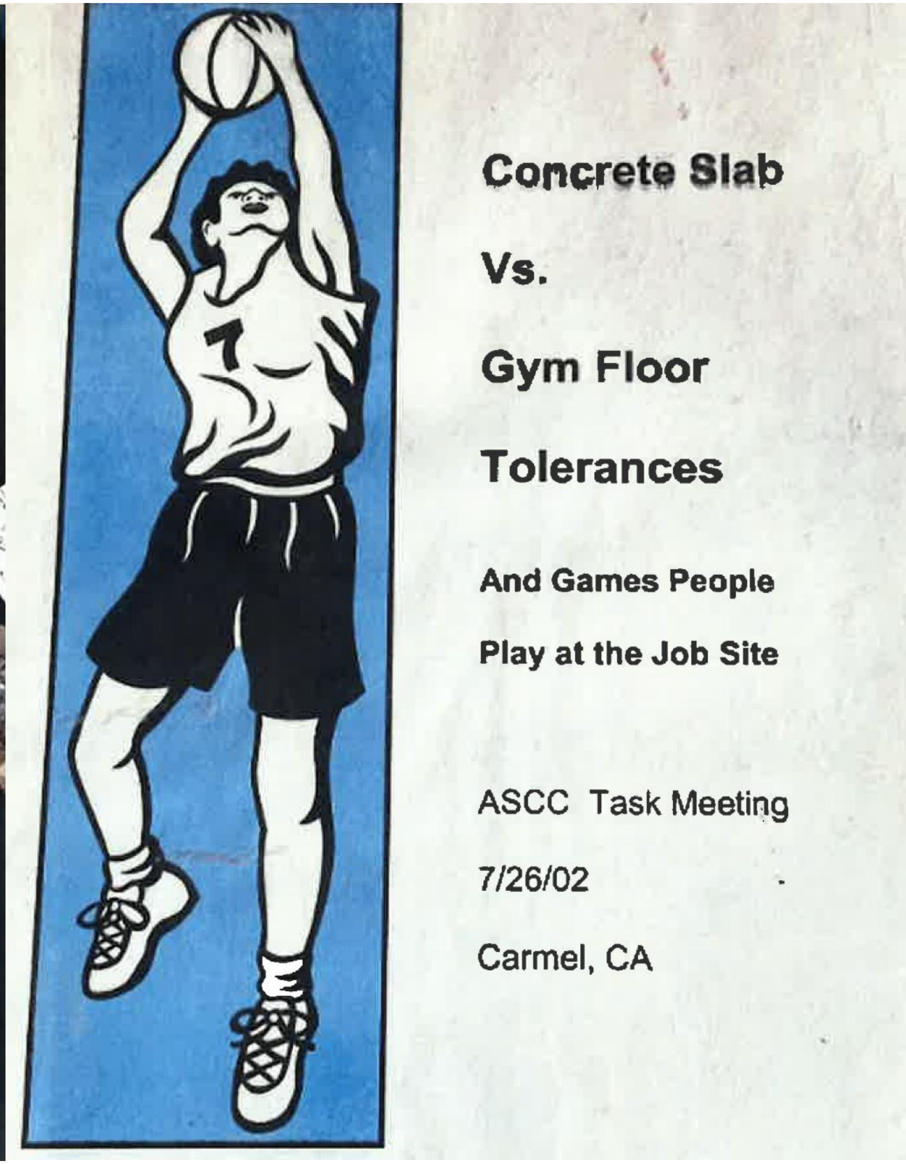
Photo credit: designboom
Jaime Navarro Photography

Obviously the Owner agreed with the Lombardi rule…

1355 Market Street
San Francisco

BFF concrete placed in 1937

Pictured: Rahul Ligma, Elon Musk, David Johnson...at Twitter HQ



Collaboration

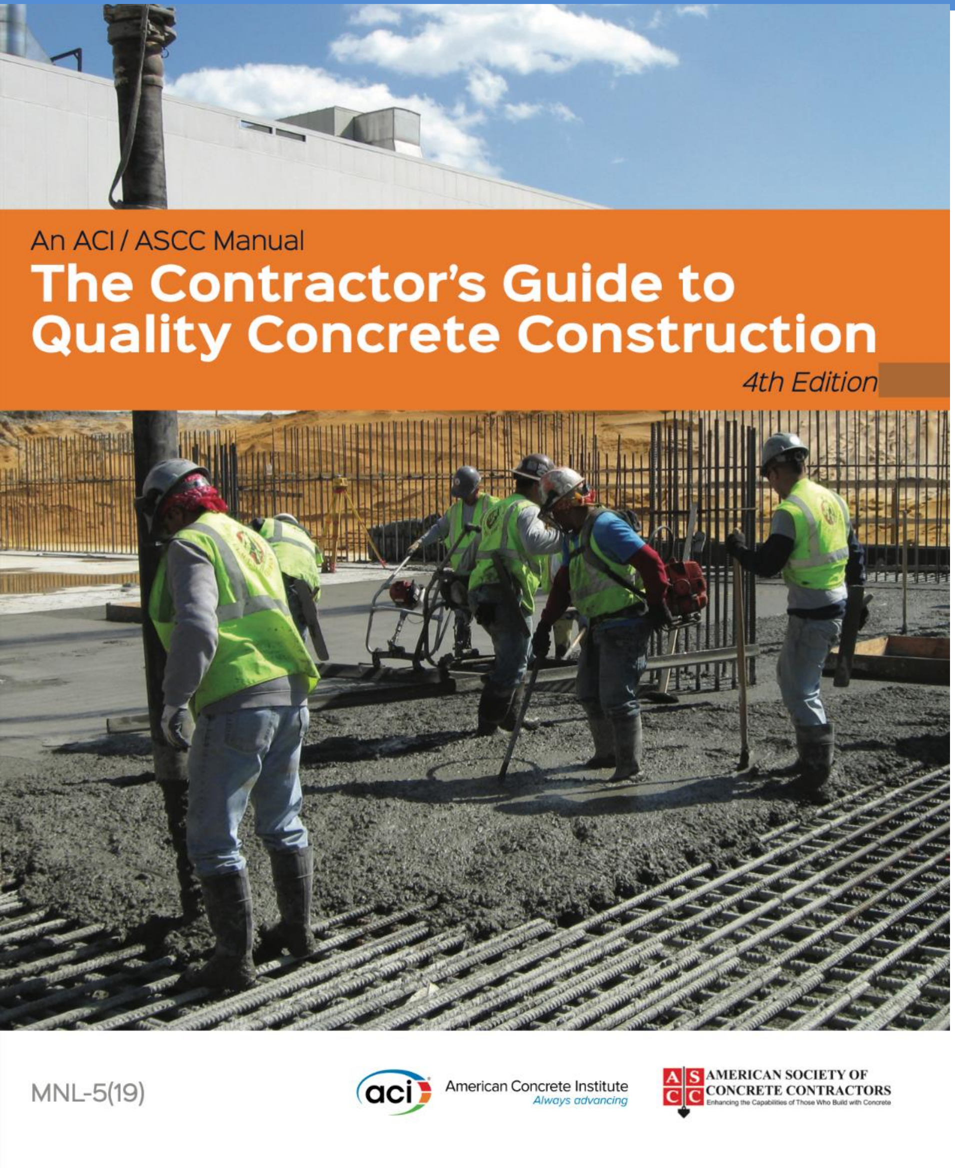
Among disciplines in the design office…

Among trades in the field…

ASCC Position Statements

Concrete International

Articles…ACI Q&A



Collaboration with ACI

ACI/ASCC Committee 117: Tolerances

Collaboration

Among trades to benefit the Owner

Division 3 versus Division 9 Floor Flatness Tolerances

ASCC Position Statement #6

Division 3 specifications for concrete floor flatness typically include F_F requirements. The specifications also require that floor tolerance measurements be taken in accordance with ASTM E 1155-96, "Standard Test Method for Determining F_F Floor Flatness and F_L Floor Levelness Numbers." Thus, the F-number measurements for meeting Division 3 requirements incorporate the following:

- Point elevations measured at regular 12 in. (300 mm) intervals along each line;
- Measurement lines distributed uniformly across the test section;
- Minimum number of readings required for statistical approach;
- Measurement lines not within 2 ft (0.6 m) of any slab boundary, construction joint, isolation joint, block-out, penetration, or other similar discontinuity; and
- Flatness measured within 72 hrs. of concrete placement.

Division 9 specifications for concrete floors to receive a floor covering typically provide floor flatness requirements in terms of an allowable gap under an unleveled straightedge. There is no ASTM procedure for this measurement. Straightedge measurements for Division 9 incorporate the following:

- Continuous measurement at any gap under the straightedge;
- Indefinite number of straightedge locations on the floor;
- No minimum or maximum number of readings;
- Measurements typically made with the straightedge crossing construction joints or column block-outs, and near penetrations; and
- Measurements made just prior to floor covering installation, which can be from 4 to 18 months after concrete placement.

Division 3 and 9 floor flatness tolerances are obviously not compatible. There is only a rough correlation between F_F numbers and the gap under a straightedge. F-number measurements don't include flatness variations indicated by straightedges placed across construction joints and column block-outs. And floor flatness changes with time (due to curling) make it impossible to predict the flatness when floor coverings are installed, based on F_F measurements made soon after concrete placement.

Despite this incompatibility of tolerance-measuring methods, some specifiers believe concrete contractors should be responsible for taking corrective action when Division 9 floor flatness requirements aren't met. To further complicate this issue, concrete contractors seldom receive Division 9 specification requirements when bidding. The floor covering often isn't chosen—and Division 9 isn't written—until after the concrete contract is signed, and sometimes until after the concrete is placed.

Concrete contractors are responsible for meeting the requirements of Division 3 specifications for floor flatness. To reduce the effect of curling on floor flatness, ASCC contractors suggest that the engineer consider using 0.5% reinforcing steel (both ways) and placed within the top half of the slab. Whether reinforcing is used or not, ASCC, NWFA, FCICA, IMI, BAC, TCAA and NTCA suggest that the owner provide a bid allowance, established by the A/E and based on the floor covering requirements, for any necessary grinding and patching to close the gap between Division 3 tolerances and Division 9 tolerances. Providing an allowance enables the owner to compare floor covering bids on an equal basis. Any unused allowance money is returned to the owner.

If you have any questions, contact your ASCC concrete contractor, the ASCC Technical Hotline at (800) 331-0668, the NWFA at (800) 422-4556, FCICA at (248) 661-5015, IMI at (410) 280-1305, BAC at (202) 783-3788, TCAA at (816) 868-9300 or the NTCA at (601) 939-2071.

<u>Update:</u> Section 4.8.6 of ACI 117-10, "Specifications for Tolerances for Concrete Construction and Materials and Commentary," contains minimum sampling requirements for testing surface flatness evaluated by using a straightedge. ASTM E1155-96 (2008) supersedes ASTM E1155-96 but contains the same requirements.

(08-11 update replaces 04-09 revision)

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Revised 04/09

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Revised - 04/2009 ASC

Tolerance incompatibility between steel and concrete

History of ACI Anchor Bolt Tolerances

ACI anchor bolt tolerances have varied from quite tight, to overly loose, and back to reasonably tight as shown by the following history.

Nichols 1940

For the location of anchor bolts for structural steel, machinery and the like, unless provided with sleeves or other means for adjustment: .... 1/4 in.

Spacing of such bolts in a group........ 1/8 in.

ACI 347-62; ACI 347-68; ACI 347-78

None

ACI 301-84; ACI 301-89

None

ACI 117-81

6.4 *Embedded materials*

6.4.1 Tolerance from specified clearance relative to reinforcing .... ±1 in.*

6.4.2 Tolerance from specified location........ ±1/4 in.

*But not less than diameter of the reinforcing bar.

ACI 117-90

2.3 Placement of embedded items

2.3.1 Clearance to reinforcement the greater of the bar diameter or .... 1 in.

2.3.2 Vertical alignment, lateral alignment, and level alignment .... 1 in.

ACI 117-06

2.3.4 *Anchor bolts in concrete*

2.3.4.1 *Top of anchor bolt from specified elevation*

Vertical deviation .... ±1/2 in.

2.3.4.2 *Centerline of individual anchor bolts from specified location*

Horizontal deviation for 3/4 in. and 7/8 in. bolts........ ±1/4 in.

for 1 in., 1-1/4 in., and 1-1/2 in. bolts .... ±3/8 in.

for 1-3/4 in., 2 in., and 2-1/2 in. bolts .... ±1/2 in.

installed, this statement may allow no tolerance for the concrete contractor who sets the plates. An example of this is shown in the section on "Inadequate connection consideration" in this chapter. Cooperative efforts by committees from ASCC, ACI, and AISC can perhaps result in tolerances for embedded plates that meet the needs and capabilities of both the concrete contractor and the steel erector.

We could find no published data that compare the plan and as-built locations of embedded plates and references the data to tolerances. Based on PCI embedded plate tolerances, the ACI tolerances appear to be reasonable. However, the evaluation of field data is the preferred approach to quantifying the achievability of such tolerances.

Based on our experience, embedded plate problems are often caused by:

- Inadequate sizing of the plate
- Inadequate connection details

Inadequate plate size

Because ACI 117-06 tolerances allow ±1 in., in plate location, the plate should be oversized by this amount to allow the connection to fit even if the plate is at the extreme tolerance value. Some engineers and detailers oversize the plates by only 1/4 to 1/2 in., which isn't enough to allow for the full ACI location tolerances and still have room for welds on the embedded plate.

Inadequate connection consideration

Differing tolerances for concrete and steel construction have created disputes on buildings with a concrete core and a steel frame connected to the core. Difficulties in attaching steel members to embedded plates may be attributed to an out-of-tolerance concrete core, or to the plates being set out of tolerance. As will be shown, however, setting the concrete core and embedded plates at exactly the plan location might not solve fit-up problems. The steel member might still not fit as a result of steel erection tolerances

History of ACI Tolerances for Embedded Items

Until ACI 117-06 was published, the embedded items category included anchor bolts, so up to the year 2006, this history essentially repeats the tolerances shown in the history of ACI anchor bolt tolerances except for Nichols' recommendations.

Nichols 1940

The location of bolts, inserts and fastenings........ 1/2 in.

ACI 347-62; ACI 347-68; ACI 347-78

None

ACI 301-84; ACI 301-89

None

ACI 117-81

6.4 *Embedded materials*

6.4.1 Tolerance from specified clearance relative to reinforcing .... ±1 in.*

6.4.2 Tolerance from specified location........ ±1/4 in.

*But not less than diameter of the reinforcing bar.

ACI 117-90

2.3 Placement of embedded items

2.3.1 Clearance to reinforcement the greater of the bar diameter of .... ±1 in.

2.3.2 Vertical alignment, lateral alignment, and level alignment .... ±1 in.

ACI 117-06

2.3 Placement of embedded items, excluding dowels in slabs-on-ground

2.3.1 Clear distance to nearest reinforcement shall be the greater of the bar diameter or .... 1 in.

2.3.2 Centerline of assembly form specified location

Horizontal deviation........ ±1 in.

Vertical deviation .... ±1 in.

2.3.3 Surface of assembly from specified plane

Assembly dimension 12 in. or smaller...... ±1/2 in. per 12 in.

Assembly dimension greater than 12 in. .... ±1/2 in.

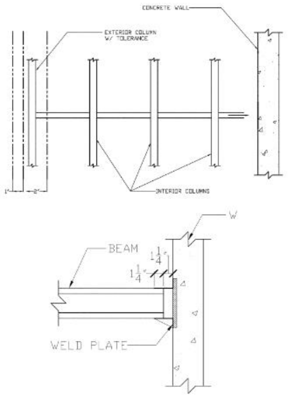


Fig. 12.1—For structures with steel framing members attached to a concrete core, exterior steel columns are typically placed first. The first row of interior columns is then set, with beam lengths and connection details establishing those column locations. Construction progresses in this manner toward the concrete core wall. The location tolerance for the exterior columns (+1 in. and –2 in.) can be carried to the core. Thus, even if the core was in the exact theoretical position, the final steel beam could be up to 1 in. short of the weld plate or 2 in. too long due to steel erection tolerances. The connections between structural steel frames and concrete cores must be designed to accommodate the combined steel erector and concrete contractor tolerances. That combined tolerance is roughly ±1-1/4 in.

For a steel frame-concrete core building, one construction scenario includes the following sequence:

A. The concrete core with the embed plates is constructed first.

B. Concrete column foundations are constructed with the anchor bolts installed.

C. Setting of structural steel columns begins after two to four stories of the concrete core have been completed.

D. Steel erector starts placing the columns with the exterior or perimeter of the building as the starting point.

a. The location tolerance in the "AISC Code of Standard Practice" applies only to the exterior or perimeter columns. As mentioned in Chapter 3, AISC specifies only plumb and bow tolerances for interior columns, and doesn't include a location tolerance. To meet the location tolerances, the steel erector always starts at the outside of the building and ensures that exterior columns are within +1 in. and –2 in. of the established column line set by the foundation and anchor bolt locations for the first 20 floors and then +2 in. and –3 in. above the 36th floor.

b. The correct exterior steel framing location is critical to the appropriate alignment of the façade. To minimize the steel erector's conflicts with the façade installation, starting at the exterior also makes sense.

c. With exterior columns located and braced, interior columns can be set and beams can be set between the columns. The beams are a fixed length and manufactured with tight tolerances, and when attached to the exterior columns they establish the interior column location at the connected end of the beam. Thus, location of the interior columns is dictated by the beam length and the connection detail.

E. The interior column erection and steel beam placement and connection continues across the building, progressing from the exterior to the interior concrete core wall.

F. When the interior column closest to the concrete core is placed and the steel beam is attached to it, the other end of the beam often doesn't fit up with the weld plate. The reason for the misfit is as follows.

The steel erector started placing columns at the exterior using a location tolerance of +1 in. and –2 in. for framing heights less than 20 stories. Using that tolerance at the exterior and connecting the fabricated beams to the column typically carries that tolerance to the interior to match with the plates embedded in the concrete core (see Fig. 12.1). Thus, even if the concrete core were in the exact theoretical position, the steel member could be 1 in. short of the plate or 2 in. long (past the plate). This lack of fit is a direct result of the steel erection tolerances—not the tolerance on concrete core location or the plate.

For building heights less than 10 stories, the location tolerance for plates set in a concrete core is about ±1 in. For building heights less than 20 stories, the steel tolerance is about ±1½ in. Combining these tolerances statistically results in a standard deviation of 0.60 in. For a connection to fit 95% of the time without field modifications, the connection must be able to accommodate a location tolerance of ±1¼ in.

Connections between structural steel and concrete cores must be designed to accommodate the combined steel erector and concrete contractor tolerances to avoid the increased costs of field modifications.

Plates embedded in walls or columns

ACI 117-06 specifies the tolerance for these plates in terms of variation in "surface of assembly from specified plane." PCI specifications refer to a tolerance on tipping and flushness with respect to the plane of the product. The ACI requirement is ambiguous because the tolerance could be interpreted to apply to an allowable variation from the plane *specified in the*

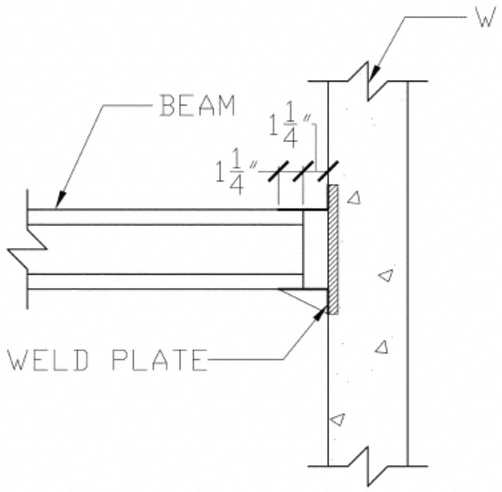


Fig. 12.1—For structures with steel framing members attached to a concrete core, exterior steel columns are typically placed first. The first row of interior columns is then set, with beam lengths and connection details establishing those column locations. Construction progresses in this manner toward the concrete core wall. The location tolerance for the exterior columns (+1 in. and –2 in.) can be carried to the core. Thus, even if the core was in the exact theoretical position, the final steel beam could be up to 1 in. short of the weld plate or 2 in. too long due to steel erection tolerances. The connections between structural steel frames and concrete cores must be designed to accommodate the combined steel erector and concrete contractor tolerances. That combined tolerance is roughly ±1-1/4 in.

Collaboration…

Anchor bolt tolerances

ASCC…ACI…AISC

CHALLENGING THE SYSTEM

A Tolerance Compatibility SUCCESS

ASCC, ACI and AISC anchor bolt placement tolerances are now identical.

Tolerance compatibility between concrete and other building components that interface with it has been a costly problem because off the cost of remedial work and the negative effect on schedule. At the root of the problem are varying dimensional tolerances for concrete members and for concrete and the abutting components—whether anchor bolts or other building components.

TOLERANCE CONFLICTS FOR ANCHOR BOLTS IN 2004

The American Society of Concrete Contractors (ASCC) developed Position Statement No. 14 "Anchor Bolt Tolerances" that was published in ACI's *Concrete International* in February 2004. In that document, ASCC recommended the following anchor bolt location tolerances:

- 3/4- and 7/8-in.-diameter bolts: ±1/4 in.
- 1-, 1-1/4-, and 1-1/2-in.-diameter bolts: ±3/8 in.; and
- 1-3/4, 2-, and 2-1/2-in.-diameter bolts: ±1/2 in.

At that time, the American Institute for Steel Construction (AISC) had anchor rod (same definition as anchor bolt) tolerances in their AISC 303 "Code of Standard Practice for Steel Buildings and Bridges". AISC required that the variation in location of anchor rods from the dimensions shown in the Embedment Drawings shall be as follows:

A) The variation in dimension between the centers of any two Anchor Rods within an Anchor-Rod Group shall be equal to or less than 1/8 in.

B) The variation in dimension between the centers of adjacent Anchor-Rod Groups shall be equal to or less than 1/4 in.

C) The variation in elevation of the tops of Anchor Rods shall be equal to or less than plus or minus 1/2 in.

D) The accumulated variation in dimension between centers of Anchor-Rod Groups along the Column Line through multiple Anchor-Rod Groups shall be equal to or less than 1/4 in. per 100 ft, but not to exceed a total of 1 in.

E) The variation in dimension from the center of any Anchor-Rod Group to the Column Line through that group shall be equal to or less than 1/4 in.

American Society of Concrete Contractors

Position Statement #14

Anchor Bolt Tolerances

The American Society of Concrete Contractors (ASCC) developed Position Statement No. 14 "Anchor Bolt Tolerances".

The American Concrete Institute's "Specifications for Tolerances for Concrete Construction and Materials (ACI 117-90)" did not include specific tolerances for anchor bolts but contained the following tolerance for

aci CONCRETE CONVENTION

Actual case study...

“Dear Concrete Contractor:

See attached sheet titled “Floor Flatness Survey” conducted using a laser scanner...

Now you owe us cash...to be deducted from your retention...”

Signed, Your GC

ASCC Laser Scanning Study

ASCC 3-D Laser Scanning Study

Part 1: Eight participants used scanners to determine target coordinates

by William Paul, Jim Klinger, and Bruce Suprenant

F-numbers and Textured Concrete Surface Finishes

Parking structures and parking lots with swirl and broom finishes

by Lingfeng (Leo) Zhang, James Klinger, and Bruce A. Suprenant

Slab-on-Ground Thickness Measurement

A comparison of data collected using laser scanning, ground-penetrating radar, impact-echo, and coring methods

by Lingfeng (Leo) Zhang, James Klinger, and Bruce A. Suprenant

Presenting Laser Scan Results for Slabs-on-Ground

Deliverables tailored to the user's perspective

by Lingfeng (Leo) Zhang, James Klinger, and Bruce A. Suprenant

ASCC 3-D Laser Scanning Study

Part 2: Eight participants used scanners to determine F-numbers

by Will Paul, Jim Klinger, and Bruce Suprenant

Joint ACI-ASCC Committee 117, Tolerances, is preparing a new document, "Guide to the Use of 3-D Laser Scanning for Concrete Tolerances." In anticipation of that document, the American Society of Concrete Contractors (ASCC) organized a study to evaluate laser scanning for concrete quality assurance applications. The study was conducted on a construction site in Walnut Creek, CA, on October 6-7, 2018. Eight participants (each comprising one to three individuals) scanned portions of the project to compare against independently obtained reference data. The first part of this study, focusing on the accuracy of laser scanning target coordinates, was reported in *Concrete International* in January 2019.[1] Details on the concrete structure at the podium and ground levels used in this study are found in that article.

Study Objectives

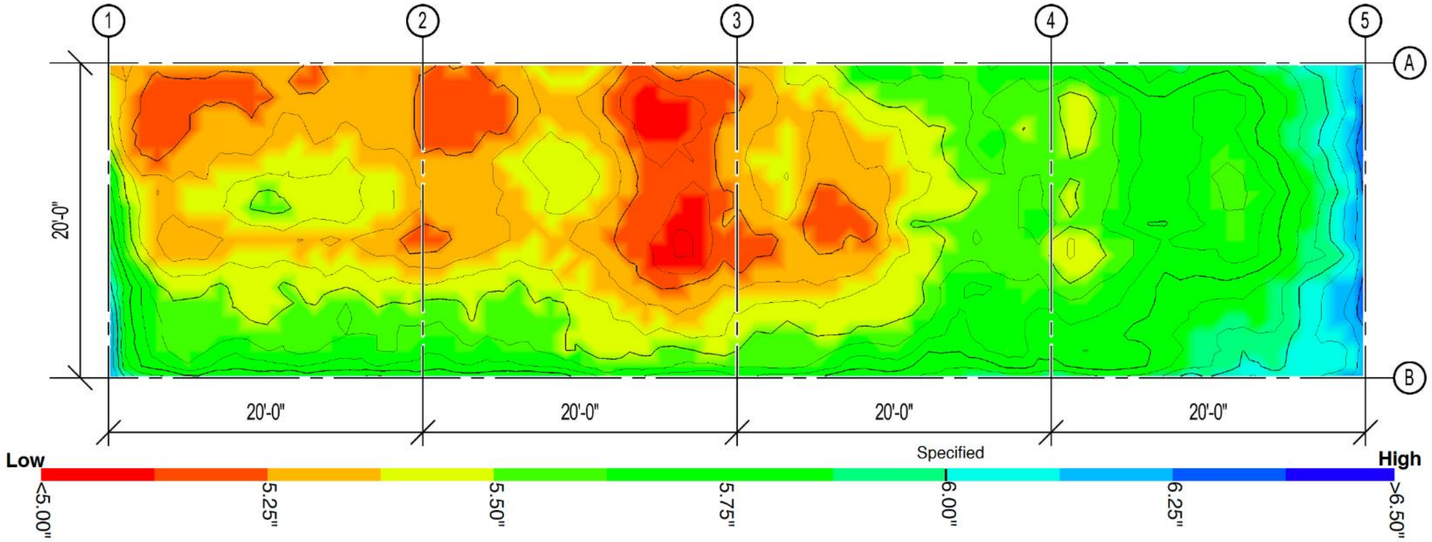
The second part of the study focused on the use of laser scanning technology to evaluate floor flatness and levelness, and it consisted of three parts:

- Taking laser scanner measurements to determine F-numbers in accordance with ASTM E1155, "Standard Test Method for Determining F_F Floor Flatness and F_L Floor Levelness Numbers";
- Comparing F-numbers obtained by laser imaging devices to those obtained by a Type II device (Dipstick®); and
- Evaluating repeatability and reproducibility of F-numbers by laser scanning.

While ASTM E1155 states that a laser imaging device may be used to collect data for F-numbers, that standard's precision and bias statement applies only for Type II devices. Thus, a major goal of the work was to provide data in support of development of a

Fig. 1: The yellow shaded area indicates the portion of the podium level slab where 12 sample measurements lines were marked for use in F-number analysis. The lines varied in length from 20 to 35 ft (6 to 11 m). Point coordinates of the start and end of each line were measured using a total station, and these coordinates were provided to each participant. Eight participants performed a laser scan on the lines on two separate days and provided composite F-numbers determined per ASTM E1155 in addition to information on each sample measurement line. For comparison, a Type II device (Dipstick®) was used to collect data twice on the same sample measurement lines

“Heat map” presentation



Concrete Top Surface Contours - Plan View

INFORMATION

Laser Scanning Notes

Equipment and Software
•Leica P40 3D Laser Scanner (1851533) - Check/Adjust on December 6, 2021.
•Leica GZT21 4.5" Black/White Targets - Calibration on December 22, 2021.
•Leica Cyclone software.
•Autodesk Civil3D software.
Data Acquisition Parameters
•Four permanent control points were used for concrete surface scans, and these control points were same as those being used for base scans.
•Three scans were performed for concrete surface surveys with distance of 25 ft between each scan. Instrument setup height was approximately 6 ft.
Registration
•Point cloud registration was performed with targets with an error of 0.006 ft (0.07 in).
•Concrete surface scans were registered with same four control points.
Quality Control
•Point cloud was sliced and virtually checked in addition to registration error report.
Survey Date
•Concrete was placed on January 3, 2022.
•Concrete top surface was scanned on January 4, 2022.
Data Collection Environment
•Concrete surface was damp but broomed prior to scanning.
•Weather was in the 60's and cloudy.
Data Manipulation
•Concrete top surface elevation measurements were sampled on a 1 ft. grid.
•Contour major spacing was at 1/4" and minor spacing was at 1/8".
•Project local coordinate origin(0,0,0) was set on base at corner of grids A/5.
•Slope correction at 1/8 inch per 1 ft has been applied to concrete top surface elevation numbers.

Project Specification Requirements
•Slab-on-grade to be 20 ft by 80 ft by 6-inch thick.
•Top concrete surface elevation tolerance shall be measured by laser scanning.

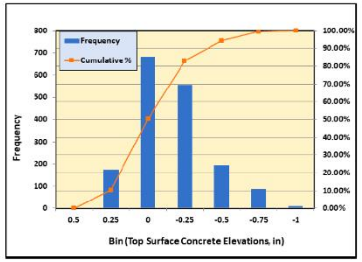
Applicable ACI 117 Tolerances
•ACI 117-10 (reapproved 2015) Specifications for Tolerances for Concrete Construction and Materials.
•Section 4.4.1—Top surface of slabs-on-ground ±3/4 in.

DATA ANALYSIS

Descriptive Statistics

Count	1701
Mean	-0.47
Standard Deviation	0.25
Maximum	0.34
Minimum	-0.95
Range	1.29

Histogram/Cumulative Frequency



ACI Top Surface Elevation Tolerance
None of the top surface is out of tolerance high (greater than +3/4 in) and about 10% of the area is out of tolerance low (greater than -3/4 in).

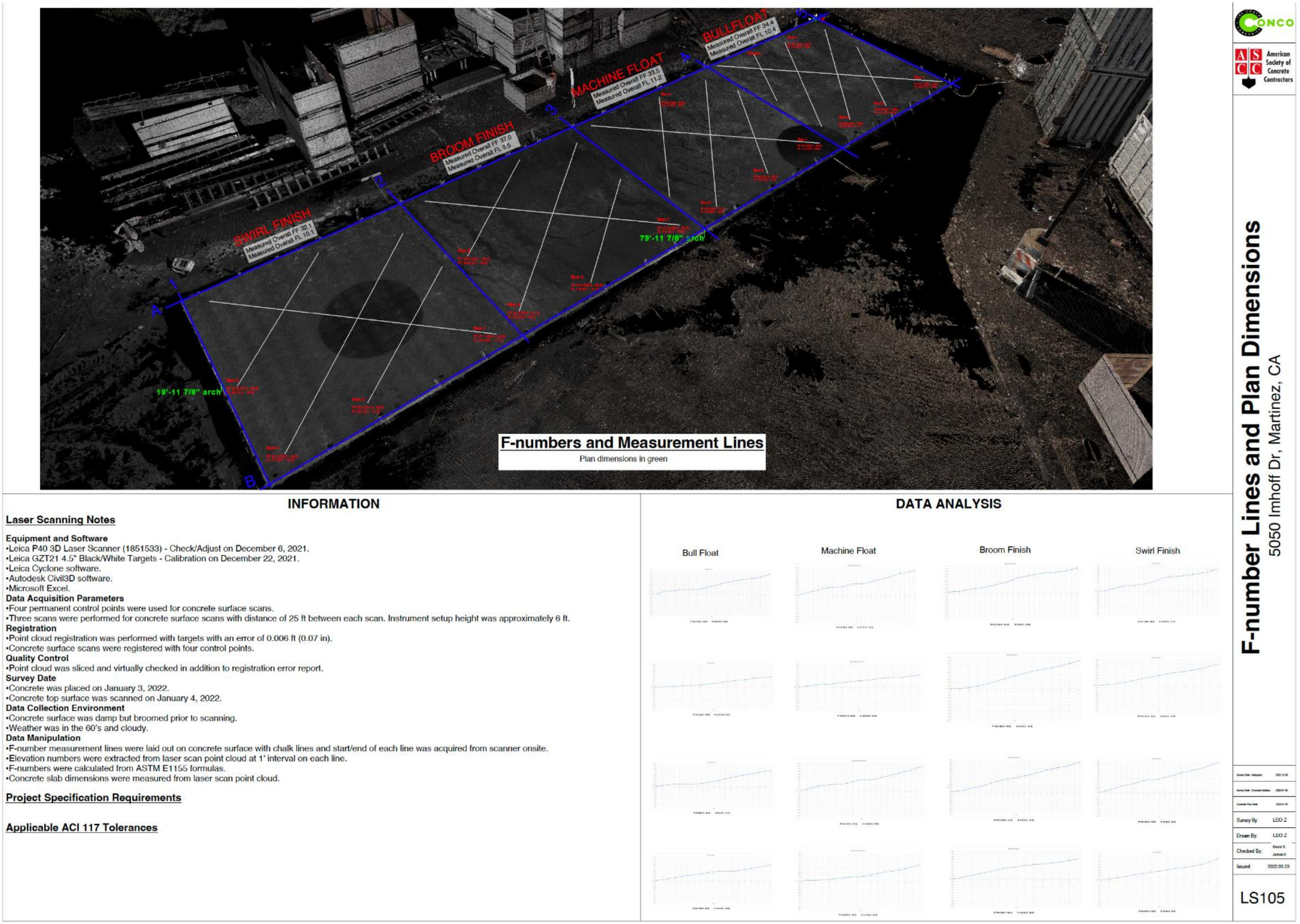
Concrete Quantity
The average top surface elevation is low by -0.47 in, which might result in a thin slab. However, the average base elevation is low by -0.34 in. Thus the thickness could be lower than specified by about (0.47 – 0.34 = 0.13) 1/8 in.

CONCRETE TOP SURFACE ELEVATIONS
5050 Imhoff Dr, Martinez, CA

Survey By: LEO Z
Drawn By: LEO Z
Checked By:
Issued: 2022.03.23

LS103

F-number presentation



THE WORLD'S GATHERING PLACE FOR ADVANCING CONCRETE

aci CONCRETE CONVENTION

Lesson #1 in reading architectural drawings…

Always check the deflected ceiling plan…

2 - 116

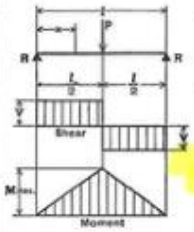
BEAM DIAGRAMS AND FORMULAS

For various static loading conditions

For meaning of symbols, see page 2-111.

Check units

7. SIMPLE BEAM—CONCENTRATED LOAD AT CENTER



Total Equiv. Uniform Load . . . . . . $= 2P$

$R = V$ . . . . $= \frac{P}{2}$

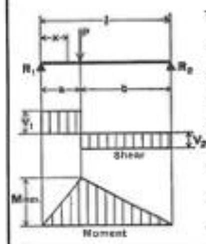
M max. (at point of load) . . . . . . $= \frac{Pl}{4}$

M_x (when $x < \frac{l}{2}$) . . . . . . $= \frac{Px}{2}$

Δmax. (at point of load) . . . . . . $= \frac{Pl^3}{48EI}$

Δ_x (when $x < \frac{l}{2}$) . . . . . . $= \frac{Px}{48EI}(3l^2 - 4x^2)$

8. SIMPLE BEAM—CONCENTRATED LOAD AT ANY POINT



Total Equiv. Uniform Load . . . . . . $= \frac{8Pab}{l^2}$

$R_1 = V_1$ (max. when $a < b$) . . . . $= \frac{Pb}{l}$

$R_2 = V_2$ (max. when $a > b$) . . . . $= \frac{Pa}{l}$

M max. (at point of load) . . . . $= \frac{Pab}{l}$

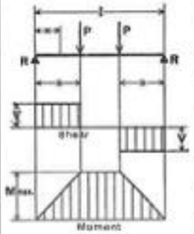
M_x (when $x < a$) . . . . $= \frac{Pbx}{l}$

Δmax. $\left(\text{at } x = \sqrt{\frac{a(a+2b)}{3}} \text{ when } a > b\right) = \frac{Pab(a+2b)\sqrt{3a(a+2b)}}{27EIl}$

Δa (at point of load) . . . . $= \frac{Pa^2b^2}{3EIl}$

Δ_x (when $x < a$) . . . . $= \frac{Pbx}{6EIl}(l^2 - b^2 - x^2)$

9. SIMPLE BEAM—TWO EQUAL CONCENTRATED LOADS SYMMETRICALLY PLACED



Total Equiv. Uniform Load . . . . . . $= \frac{8Pa}{l}$

$R = V$ . . . . $= P$

M max. (between loads) . . . . . $= Pa$

M_x (when $x < a$) . . . . . $= Px$

Δmax. (at center) . . . . $= \frac{Pa}{24EI}(3l^2 - 4a^2)$

Δ_x (when $x < a$) . . . . $= \frac{Px}{6EI}(3la - 3a^2 - x^2)$

Δ_x (when $x > a$ and $< (l - a)$) . . $= \frac{Pa}{6EI}(3lx - 3x^2 - a^2)$

MAX DEFLECTION =

$$\frac{P\ell^3}{48EI} = \Delta$$

ceteris paribus ...

if $\ell = 1$, $\Delta = 1^3 = 1$

if $\ell = 2$, $\Delta = 2^3 = 8$

∴ double the span, the deflection increases 8-fold

Example:

If span is 20′ and $\Delta = 1''$

at 40′, $\Delta = 2^3 = 8''$

Table 4.5—Estimated structural movements

Structural movements						
During construction, the structure will undergo normal types of movement and deflection. The following are estimates for the structure. Architectural finishes and nonstructural components must be detailed to accommodate these movements.						
A	**Midpanel vertical slab deflection**	**Initial**	**3 months**	**6 months**	**12 months**	**24 months**
	Corner panel	–3/4 in.	–1-1/2 in.	–1-5/8 in.	–1-3/4 in.	–2 in.
	Edge panel	–1/2 in.	–1 in.	–1-1/8 in.	–1-1/4 in.	–1-3/8 in.
	Interior panel	–3/8 in.	–3/4 in.	–7/8 in.	–1 in.	–1-1/8 in.
B	**Edge vertical deflection**	**Initial**	**3 months**	**6 months**	**12 months**	**24 months**
	Corner panel	–1/4 in.	–1/2 in.	–5/8 in.	–5/8 in.	–5/8 in.
	Edge panel	–1/8 in.	–1/4 in.	–1/4 in.	–3/8 in.	–3/8 in.
	Cantilever balcony slab (slab span parallel to framing span)	+1/8 in.	+1/4 in.	+1/4 in.	+3/8 in.	+3/8 in.
	Cantilever balcony slab (slab span perpendicular to framing span)	–1/4 in.	–1/2 in.	–5/8 in.	–5/8 in.	–5/8 in.
C	**Post-tensioning**	**Initial**	**3 months**	**6 months**	**12 months**	**24 months**
	Perimeter edge horizontal	0 in.	–3/4 in.	–7/8 in.	–1 in.	–1-1/8 in.
	Perimeter column tilt	0 in.	–3/4 in.	–7/8 in.	–1 in.	–1-1/8 in.
D	**Window/door header deflection**	**Initial**	**3 months**	**6 months**	**12 months**	**24 months**
	Openings in walls	–1/8 in.	–1/4 in.	–3/8 in.	–1/2 in.	–1/2 in.
	Slab-to-slab openings	See midpanel vertical slab deflections above.				
E	**Column shortening**	Not applicable to this building.				
	Individual column					
	Difference between columns					
F	**Foundation settlement**	Not applicable for this building.				
	Individual column					
	Difference between columns					

Notes:

1. Deflection estimates are for dead load plus construction load (estimated at 50 percent design live load).
2. In accordance with ACI 435R-95, "Control of Deflection in Structures," deflections are estimated within a range of 20 to 40 percent accuracy.
3. Long-term deflection multipliers based on ACI 318-08, Chapter 9, Section 9.5.2.5.
4. Deflection: downward is minus (–) and upward is plus (+).

Table 4.5—Estimated structural movements

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During construction, the structure will undergo normal types of movement and deflection. The following are estimates for the structure. Architectural finishes and nonstructural components must be detailed to accommodate these movements.						
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	Edge panel	–1/2 in.	–1 in.	–1-1/8 in.	–1-1/4 in.	–1-3/8 in.
	Interior panel	–3/8 in.	–3/4 in.	–7/8 in.	–1 in.	–1-1/8 in.
B	**Edge vertical deflection**	**Initial**	**3 months**	**6 months**	**12 months**	**24 months**
	Corner panel	–1/4 in.	–1/2 in.	–5/8 in.	–5/8 in.	–5/8 in.
	Edge panel	–1/8 in.	–1/4 in.	–1/4 in.	–3/8 in.	–3/8 in.
	Cantilever balcony slab (slab span parallel to framing span)	+1/8 in.	+1/4 in.	+1/4 in.	+3/8 in.	+3/8 in.
	Cantilever balcony slab (slab span perpendicular to framing span)	–1/4 in.	–1/2 in.	–5/8 in.	–5/8 in.	–5/8 in.
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President's
Memo

Rules vs. Plays

Cary S. Kopczynski
ACI President

I would like to use the July President's Memo to set the stage for a topic you will hear more about over the coming year. I will begin with a sports analogy because sports are useful for clarifying abstract ideas.

Imagine two football teams. One team consists of the league's star players and the other is composed of the league's best referees. Now imagine that they play a game. Which team wins? The players, of course. The referees have a better and more nuanced understanding of the rules, but their good understanding does not translate into good play on the field. To play football or any other sport, a working understanding of the rules is necessary, but well-developed skills for playing the game are critical for success.

Turn your attention now to ACI. We publish some of the best codes and standards in the world. ACI 318, for example, is a globally dominant building code used in many countries and on several continents. Nevertheless, it is a rulebook, not a playbook. It contains the basic requirements—the rules—necessary for protecting the public and for creating safe and serviceable structures. It does not, and should not, contain the "plays" necessary for creating good structural design. The plays are left up to the designer and require a different set of skills.

It takes time and effort to develop these skills because designing efficient and effective concrete structures is difficult. Unlike homogeneous materials such as steel and wood, concrete structures involve a combination of concrete and various forms of reinforcing bar, wire, cable, and fiber. Further, the constituent materials of concrete—aggregates, cement, water, and admixtures—vary from one location to another, and the behavior of concrete under load can be time dependent. Because of all this and more, designing concrete structures can be complicated.

The construction of concrete structures is equally challenging. And it is made even more challenging when communication between the design and construction teams breaks down or when lines of communication are never created in the first place. Inadequate communication leads to key decisions being made in a vacuum, without the

President's
Memo

Improving Constructability

http://master-builders-solutions.com/en-us

Cary S. Kopczynski
ACI President

The Second Law of Thermodynamics holds that there is a tendency for any isolated natural system to degenerate into increasing disorder, or entropy. This physical law is thought to apply throughout the universe and is not subject to human intervention. A similar phenomenon seems to occur with human life in general. It tends toward complexity unless we continually confront it. Have you ever postponed something, thinking that "next year things will be simpler, and I'll have more free time"? When next year comes, your to-do list has grown and your life has become more complicated. Instead of having more free time, you have less! The good news is that if we DO continually confront complexity, we can do battle with entropy and bring more order to our lives and organizations.

This principle holds true in the concrete industry. Buildings and other structures are growing steadily more elaborate and more complicated. For some structures, this complexity is unavoidable: it's due to the inherent nature of the architectural design, or to site constraints or other factors. For other structures, however, the added complication is unnecessary. Many things play a role in causing it—the growth in codes and standards, insufficient coordination among team members, and steadily increasing analytical power that allows unnecessary complication to creep in, to name a few. Nevertheless, it's important that designers, builders, and other stakeholders in the design and construction process recognize and confront this trend. It is at least partly responsible for the stagnated construction productivity our industry has experienced over the last several decades.

I've written about the construction productivity challenge in my past President's Memos. I've also discussed how ACI is embarking on a new initiative to confront it. A task group I chaired in 2020 developed many recommendations regarding how ACI could leverage its resources to improve construction productivity, with a focus on concrete construction. And the first place we're targeting our effort is on improving the constructability of structural design.

Simply put, constructability involves incorporating construction knowledge into the design process to improve construction productivity. When architects and engineers acquire a working knowledge of construction and then collaborate with the contractor and subcontractors during design, magic happens. Construction schedules shorten and costs drop, with no compromise in quality. In fact, quality arguably increases when designs are simplified and made more constructable. Complicated and intricate designs are more difficult to build and hence increase the likelihood of construction errors. Conversely, designs that are simplified and made more constructable, by coordinating their systems, layout, and detailing with the contractor, are less likely to result in construction mistakes. Simplicity is golden.

To assist structural designers in learning the ins and outs of constructability, ACI now has on its agenda the goal of offering a certificate training program on this very topic. This new program will include training modules that will provide designers with a working knowledge of formwork, reinforcing bar detailing, specifying concrete, differences in the way designs should be approached as a function of project delivery type, and many more subjects. Guiding the content in the preparation of each of these new educational sessions will be the objective of improving the constructability of structural design and, in the process, the collaboration between designers and builders. This will automatically result in improved construction productivity and bring us closer to our long-term objective of realizing the full productivity potential of modern construction systems on as many projects as possible.

It's too soon to say exactly when this new certificate program will be rolled out. It's in development now with very good people working on it and will become available later this year. When it does, I encourage you to consider it if you're involved in structural design in any way. You'll emerge from the training with a working knowledge of construction and a better understanding of contractors' needs. It will improve your daily design decisions and, in the process, move construction productivity in a positive direction.

It's easy to make things difficult. It's difficult to make them easy. But the effort is worth it because simplicity is golden. And in a nutshell, that's the essence of constructability—making designs as simple and straightforward as possible, consistent with meeting other design objectives.

Cary S. Kopczynski

Simply put, constructability involves incorporating construction knowledge into the design process to improve construction productivity. When architects and engineers acquire a working knowledge of construction and then collaborate with the contractor and subcontractors during design, magic happens. Construction schedules shorten and costs drop, with no compromise in quality. In fact, quality arguably increases when designs are simplified and made more constructable. Complicated and intricate designs are more difficult to build and hence increase the likelihood of construction errors. Conversely, designs that are simplified and made more constructable, by coordinating their systems, layout, and detailing with the contractor, are less likely to result in construction mistakes. Simplicity is golden.

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1.1.3 A series of preconstruction tolerance coordination meetings shall be scheduled and held prior to the commencement of the Work. The Contractor, subcontractors, material suppliers, and other key parties shall attend. All parties shall be given the opportunity to identify any tolerance questions and conflicts that are applicable to the work with materials, prefabricated elements, and Work assembled/installed in the field by the Contractor.

R1.1.3 Preconstruction tolerance coordination meetings provide an opportunity for key participants to identify and to resolve tolerance compatibility issues prior to construction.

ACI 117-10

1.6—Preconstruction conference

ACI 301-20

1.6.1 If specified, schedule and attend preconstruction conference with Architect/Engineer, Owner, or Owner's Representative to review project requirements, acceptance criteria, and responsibilities.

AIA A201-2017

§ 4.2.4 COMMUNICATIONS FACILITATING CONTRACT ADMINISTRATION

Except as otherwise provided in the Contract Documents or when direct communications have been specially authorized, the Owner and Contractor shall endeavor to communicate with each other through the Architect about matters arising out of or relating to the Contract. Communications by and with the Architect's consultants shall be through the Architect. Communications by and with Subcontractors and material suppliers shall be through the Contractor. Communications by and with separate contractors shall be through the Owner.

MAINTENANCE REQUIREMENTS

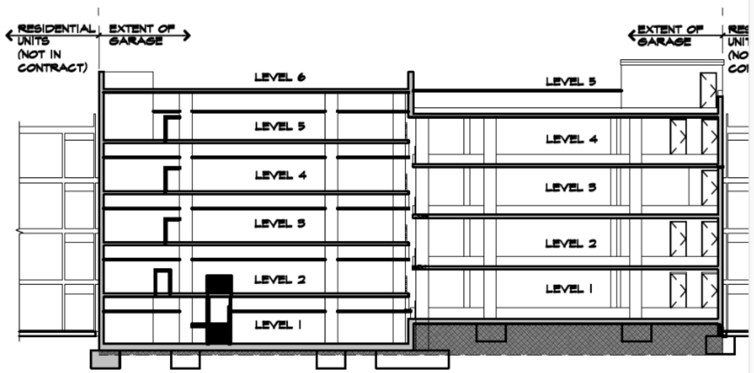
1. THE ENTIRE CONCRETE FRAME, INCLUDING ELEVATED SLABS, COLUMNS, BEAMS, WALLS, SLAB–ON–GRADES REQUIRE STRICT MAINTENANCE IN ORDER TO REMAIN SERVICEABLE AND SAFE.
2. DETAILS OF THE MAINTENANCE PROGRAM APPLICABLE TO THIS PROJECT MUST BE COMPILED BY THE OWNER AND SUBMITTED TO THE FACILITY MAINTENANCE DEPARTMENT.
3. AS A GUIDE THE FOLLOWING REFERENCES MAY BE CONSULTED AS MINIMUM REQUIREMENT: "PARKING STRUCTURES" BY ANTHONY P. CHREST AND SAM BHUYAN (CHAPTER 9, TITLED MAINTENANCE) ISBN 0–442–20655–0.
4. GUIDE FOR STRUCTURAL MAINTENANCE OF PARKING STRUCTURES, REPORTED BY ACI COMMITTEE 362 (ACI 362.2R–00)

SPECIAL NOTES TO OWNER

1. UNDER NORMAL CONDITIONS, AND FOR CONVENTIONAL BUILDINGS SUCH AS THE SUBJECT PROJECT, REINFORCED CONCRETE AS WELL AS POST–TENSIONED CONCRETE DEVELOP CRACKS. THE CRACKS ARE DUE TO INHERENT SHRINKAGE OF CONCRETE, CREEP AND RESTRAINING EFFECTS OF VERTICAL AND OTHER STRUCTURAL ELEMENTS TO WHICH THE BEAMS/SLABS ARE TIED.
2. THE CRACKS FORMED ARE NORMALLY COSMETIC. THE SLAB MAINTAINS ITS SERVICEABILITY AND STRENGTH REQUIREMENTS. DUE TO SPECIAL FEATURES OF UNBONDED POST–TENSIONING, IT IS POSSIBLE THAT A NUMBER OF HAIRLINE CRACKS, WHICH WOULD NORMALLY SPREAD OVER A WIDE AREA, WILL INTEGRATE INTO A SINGLE CRACK WITH A WIDTH EXCEEDING 0.01 INCH. IT IS EMPHASIZED THAT ALTHOUGH SPECIAL EFFORT IS MADE TO REDUCE THE POTENTIAL CAUSES AND NUMBER OF SUCH CRACKS, IT IS NOT PRACTICAL TO PROVIDE TOTAL ARTICULATION BETWEEN THE FLOOR SYSTEM AND ITS SUPPORTS AND THEREBY ACHIEVE COMPLETE INHIBITION OF ALL CRACKS.
3. MOST SUCH CRACKS DEVELOP OVER THE FIRST THREE YEARS OF THE LIFE OF THE FLOOR SYSTEM. CRACKS WHICH ARE WIDER THAN 0.01 INCH MAY NEED TO BE PRESSURE EPOXIED. REFER TO THE NOTES UNDER "ALLOWANCES".
4. THE OBJECT OF THE JOINTS PROVIDED IS TO ALLOW MOVEMENT. MOVEMENTS DUE TO CREEP AND SHRINKAGE MAY BE NOTICEABLE AT JOINTS UP TO TWO YEARS AFTER CONSTRUCTION, BEYOND WHICH MOVEMENTS DUE TO VARIATIONS IN TEMPERATURE WILL PERSIST.

LOADING

1. **GRAVITY:**
   - A. DEAD LOADS: CONCRETE 150 PCF
     7.5" SLAB 100 PSF
   - B. LIVE LOADS:
     1. PARKING 40 PSF NON–REDUCIBLE, 3,000 LBS CONCENTRATED
     2. CRASH WALL 6,000 LBS AT 18" ABOVE FLOOR

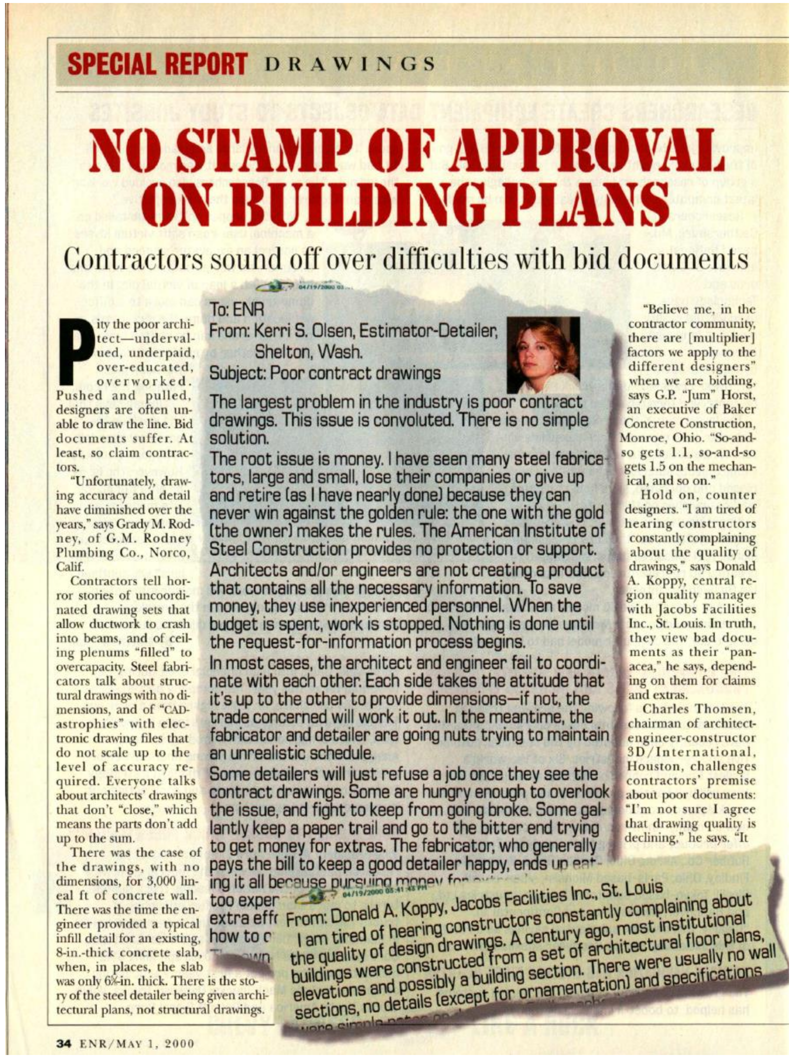


2. SEISMIC DESIGN: DESIGN IS IN ACCORDANCE TO CBC CHAPTER 16

DESCRIPTION	DATA
SEISMIC FORCE RESISTING SYSTEM	[illegible]

Collaboration…

The system worked!!



SPECIAL REPORT DRAWINGS

NO STAMP OF APPROVAL ON BUILDING PLANS

Contractors sound off over difficulties with bid documents

Pity the poor architect—undervalued, underpaid, over-educated, overworked. Pushed and pulled, designers are often unable to draw the line. Bid documents suffer. At least, so claim contractors.

"Unfortunately, drawing accuracy and detail have diminished over the years," says Grady M. Rodney, of G.M. Rodney Plumbing Co., Norco, Calif.

Contractors tell horror stories of uncoordinated drawing sets that allow ductwork to crash into beams, and of ceiling plenums "filled" to overcapacity. Steel fabricators talk about structural drawings with no dimensions, and of "CAD-astrophies" with electronic drawing files that do not scale up to the level of accuracy required. Everyone talks about architects' drawings that don't "close," which means the parts don't add up to the sum.

There was the case of the drawings, with no dimensions, for 3,000 lineal ft of concrete wall. There was the time the engineer provided a typical infill detail for an existing, 8-in.-thick concrete slab, when, in places, the slab was only 6⅝-in. thick. There is the story of the steel detailer being given architectural plans, not structural drawings.

To: ENR
From: Kerri S. Olsen, Estimator-Detailer, Shelton, Wash.
Subject: Poor contract drawings

The largest problem in the industry is poor contract drawings. This issue is convoluted. There is no simple solution.

The root issue is money. I have seen many steel fabricators, large and small, lose their companies or give up and retire (as I have nearly done) because they can never win against the golden rule: the one with the gold (the owner) makes the rules. The American Institute of Steel Construction provides no protection or support.

Architects and/or engineers are not creating a product that contains all the necessary information. To save money, they use inexperienced personnel. When the budget is spent, work is stopped. Nothing is done until the request-for-information process begins.

In most cases, the architect and engineer fail to coordinate with each other. Each side takes the attitude that it's up to the other to provide dimensions—if not, the trade concerned will work it out. In the meantime, the fabricator and detailer are going nuts trying to maintain an unrealistic schedule.

Some detailers will just refuse a job once they see the contract drawings. Some are hungry enough to overlook the issue, and fight to keep from going broke. Some gallantly keep a paper trail and go to the bitter end trying to get money for extras. The fabricator, who generally pays the bill to keep a good detailer happy, ends up eating it all because pursuing money for ... too exper... extra eff... how to c...

From: Donald A. Koppy, Jacobs Facilities Inc., St. Louis
I am tired of hearing constructors constantly complaining about the quality of design drawings. A century ago, most institutional buildings were constructed from a set of architectural floor plans, elevations and possibly a building section. There were usually no wall sections, no details (except for ornamentation) and specifications

"Believe me, in the contractor community, there are [multiplier] factors we apply to the different designers" when we are bidding, says G.P. "Jum" Horst, an executive of Baker Concrete Construction, Monroe, Ohio. "So-and-so gets 1.1, so-and-so gets 1.5 on the mechanical, and so on."

Hold on, counter designers. "I am tired of hearing constructors constantly complaining about the quality of drawings," says Donald A. Koppy, central region quality manager with Jacobs Facilities Inc., St. Louis. In truth, they view bad documents as their "panacea," he says, depending on them for claims and extras.

Charles Thomsen, chairman of architect-engineer-constructor 3D/International, Houston, challenges contractors' premise about poor documents: "I'm not sure I agree that drawing quality is declining," he says. "It

34 ENR/MAY 1, 2000

Here's a shocker…

ENR cover feature…

So 23 years ago, construction documents were flaky…

Meanwhile…

Back in 1886…

SPECIFICATIONS

FOR

PRACTICAL ARCHITECTURE

A GUIDE

TO THE

Architect, Engineer, Surveyor, and Builder,

WITH AN

ESSAY ON THE STRUCTURE AND SCIENCE OF MODERN BUILDINGS.

UPON THE BASIS OF THE WORK BY ALFRED BARTHOLOMEW, THOROUGHLY REVISED, CORRECTED, AND GREATLY ADDED TO,

BY

FREDERICK ROGERS,
ARCHITECT.

Second Edition, Revised, with Additions.

Capio Lumen

LONDON
CROSBY LOCKWOOD AND CO.
7, STATIONERS' HALL COURT, LUDGATE HILL
1886.

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PART I.

PART THE FIRST.

REMARKS ON THE STRUCTURE AND SCIENCE OF MODERN BUILDINGS.

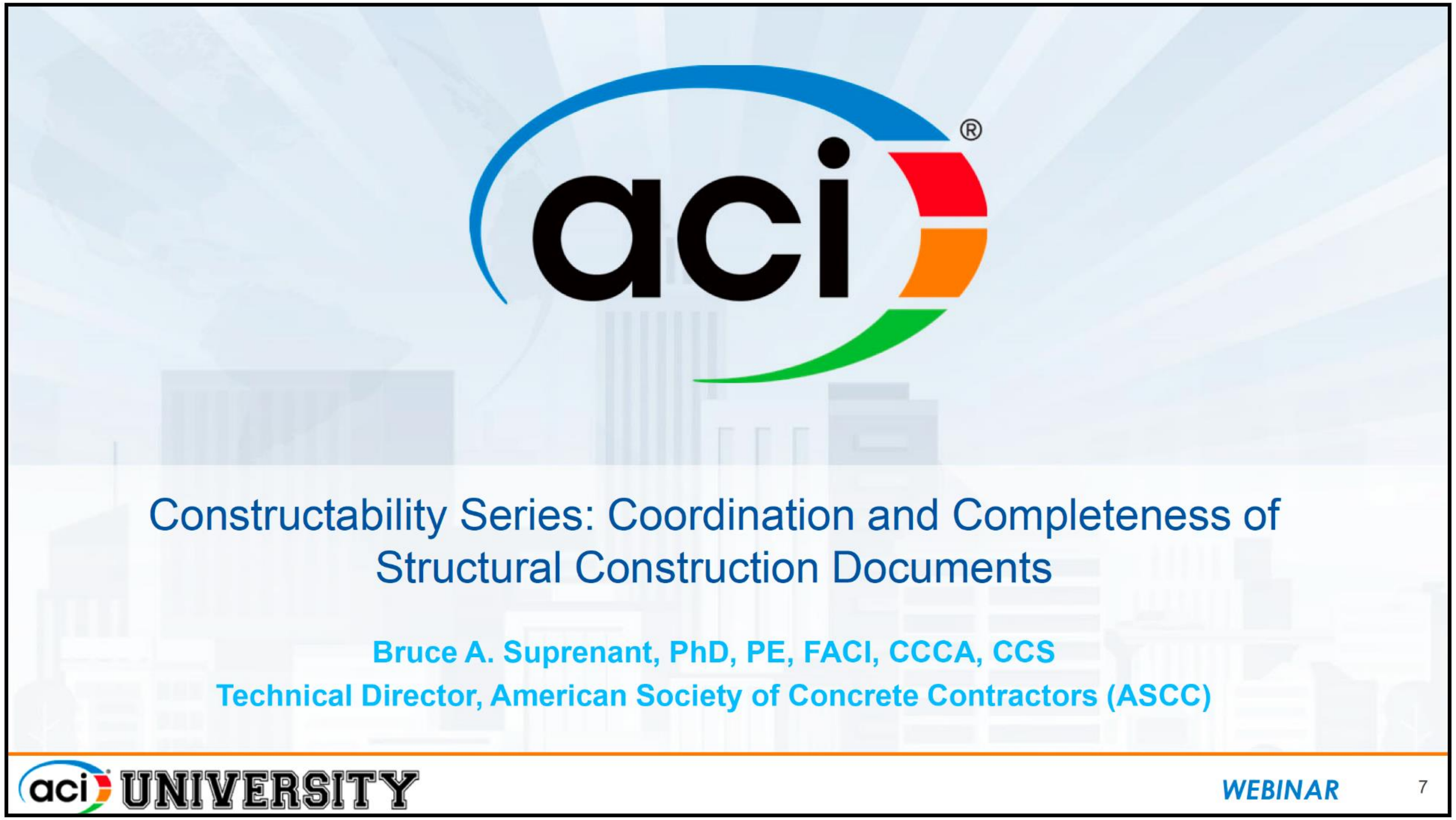
Of the exactness requisite in the practical profession of architecture, and how far it is influenced by the correctness of specifications and working-drawings.

THE whole course of practical architecture requires, in all its details, the most minute and indefatigable exactness of execution: the architect cannot plead therefore want of method and exactness in the measures which it is his business to take for the proper direction of the artificers who are to act in pursuance of his mandates; and hardly can he with any grace call to account those under him who have, perhaps, acted with more precision than himself.

While, from the great influx of young professors to the building art, there are now almost more professors than buildings to execute, it is to be lamented that out of that number so many have not received the benefit of an education so liberal as is required by an art needing such a fund of literary as well as practical knowledge. Without critical knowledge of the nature of the words, it is impossible that the practical architect can, in a specification, to be put into the builder's hands, so describe and so define his intentions that they can be executed. The author has seen many specifications which, besides having their sentences grossly ill-constructed and ungrammatical, were otherwise so obscure in their phraseology as to render it impossible to understand the intentions of the writers.

It should be the glory of an architect's specification that it be so clear that the builders, who are estimating from it the probable cost of the intended work, may have to ask no questions; that the specification contain an exact, comprehensive, and proper description of the work as it really *can* be, and as it *ought* to be executed, omitting nothing whatever which the architect's practical knowledge, experience, and foresight may tell him must be included in the work; that the words of it be so chosen and be so arranged that there be not the shadow of a doubt or ambiguity in any part of it, and that the whole of the intended work be completed without extra charge for things negligently omitted and without the possibility of a dispute upon the construction of any of the words of the specification.

B



Meanwhile…in 2023

Reinforcement Congestion in Cast-in-Place Concrete

Allowances for construction tolerances and for adequate placement and consolidation

by James Klinger, Oscar R. Antommattei, Aron Csont, Trevor Prater, Michael Damme, and Bruce A. Suprenant

Since its 1983 edition,[1] the ACI 318 Code Commentary has cautioned designers to avoid reinforcement congestion in earthquake-resistant structures. And since its 1999 edition,[2] the ACI 318 Code has required designers to consider fabrication and placement tolerances at anchorage zones for post-tensioning tendons. The relevant sections of ACI 318-19[3] state:

"**R18.2.2** Analysis and proportioning of structural members

In selecting member sizes for earthquake-resistant structures, it is important to consider constructability problems related to congestion of reinforcement. The design should be such that all reinforcement can be assembled and placed in the proper location and that concrete can be cast and consolidated properly. Using the upper limits of permitted reinforcement ratios may lead to construction problems."

"**25.9.5** Reinforcement detailing

25.9.5.1 Selection of reinforcement size, spacing, cover, and other details for anchorage zones shall make allowances for tolerances on fabrication and placement of reinforcement; for the size of aggregate; and for adequate placement and consolidation of the concrete."

While the engineer is responsible for detailing reinforcement, we've been unable to find Commentary guidance on reasonable detailing practice or acceptability of details. Compliance is, therefore, open to subjective interpretation. However, it's clear that many designers are struggling to meet either the spirit of the Commentary or the letter of the Code (see Fig. 1).

In addition, constructability requirements and recommendations should not be limited only to earthquake-resistant structures or post-tensioning tendon anchorage zones. Engineers should provide an allowance for construction tolerances and consider the need for adequate placement and consolidation of concrete for all designs.

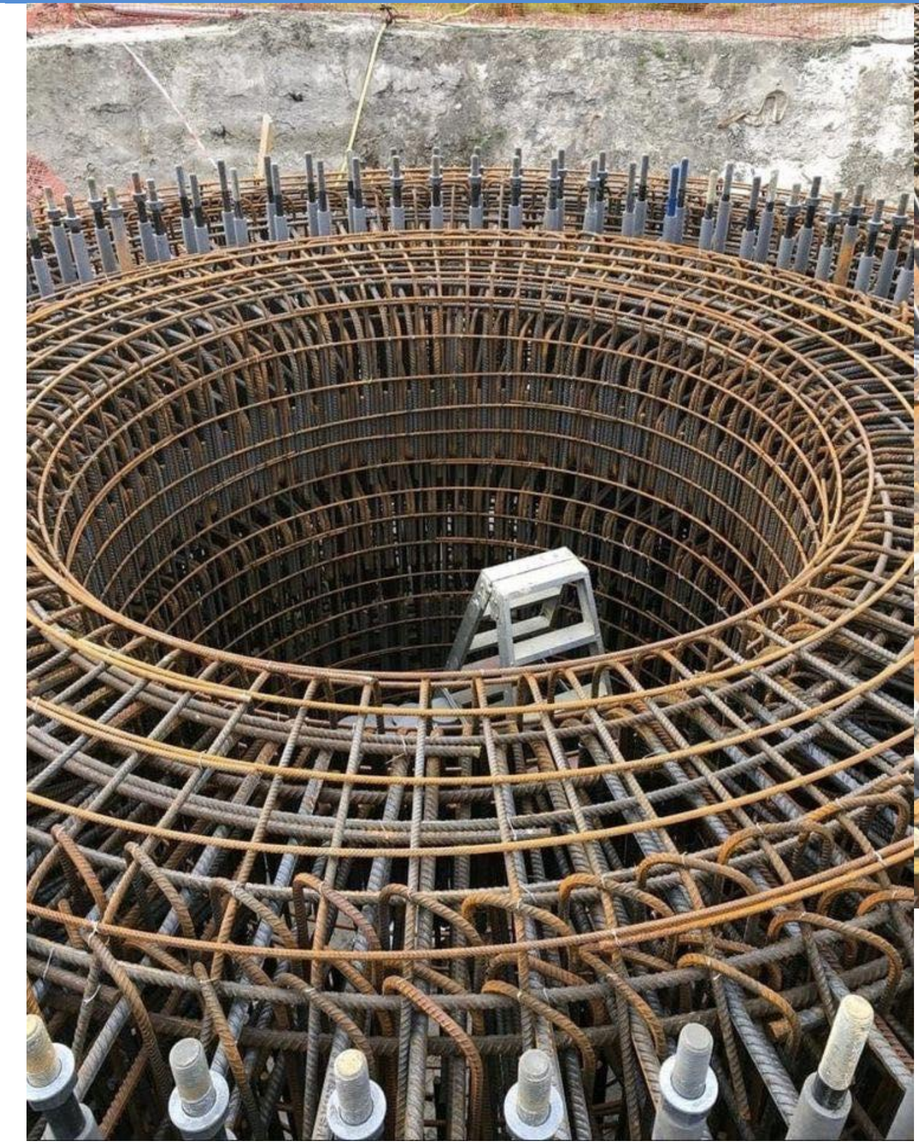
This article provides information on design and detailing prerequisites, reinforcement congestion economics, allowance recommendations related to congestion of reinforcement, and proposed Code and Commentary language with respect to constructability.

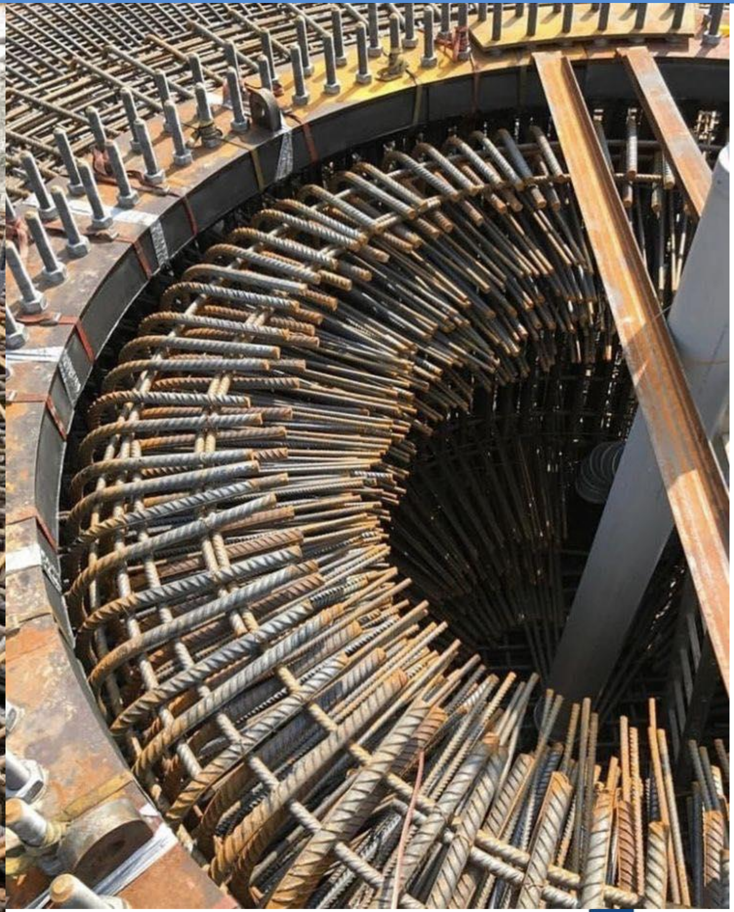
ACI 309R Constructability Recommendations for Design and Detailing

The ACI 318-77 Commentary, Section 5.4,[4] provided the first reference to ACI 309R[5]:

"Recommendations for consolidation of concrete are given in detail in 'Recommended Practice for Consolidation of

Fig. 1: Examples of reinforcement assemblies that created placement challenges for the contractor: (a) an earthquake-resistant wall; and (b) an anchorage zone for post-tensioning tendons





Where to place the vapor retarder

For slabs on grade, should the vapor retarder be located under a granular layer or directly under the concrete? Here are the pros and cons of each location.

BY BRUCE A. SUPRENANT AND WARD R. MALISCH

In the real estate industry, location is everything. The importance of location also applies to a hotly debated topic in the concrete industry—where to place the vapor retarder (or vapor barrier) for slabs on grade. Some specifiers require concrete to be placed directly on the vapor retarder, and others require placement of a granular blotter layer between the concrete and the vapor retarder. Advocates of each option argue that their preference results in a better concrete slab.

Like all engineering decisions, the location of a vapor retarder often is a compromise between minimizing water-vapor movement through the slab and providing the desired short- and long-term concrete properties. However, specifiers must consider the benefits and liabilities of the choice they make.

The case for a granular layer

Finishers prefer concrete placed on a granular base because the base absorbs mix water, shortens the bleeding period and allows floating to start earlier. Australian researchers noted that 4½-inch-slump concrete placed on a granular base lost its bleedwater sheen about two hours faster than the same concrete placed directly on a vapor barrier (Ref. 1).

Base conditions also affect concrete stiffening. In tests performed by The Aberdeen Group, 2½-inch-slump concrete was used for two 4x4-foot, 4-inch-thick slabs. One slab was placed directly on a vapor retarder and the other on a crushed-stone base. Technicians periodically set a steel-shot-filled rubber boot weighing 75 pounds on the surface and measured the footprint indentation (Fig. 1). Concrete on the stone base had stiffened enough after 90 minutes to allow a ¼-inch footprint

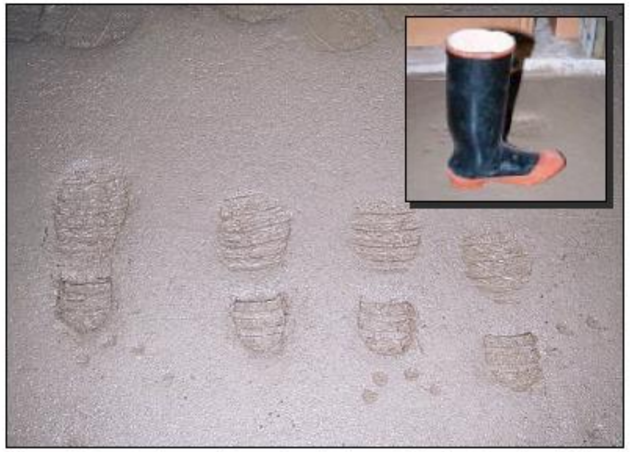
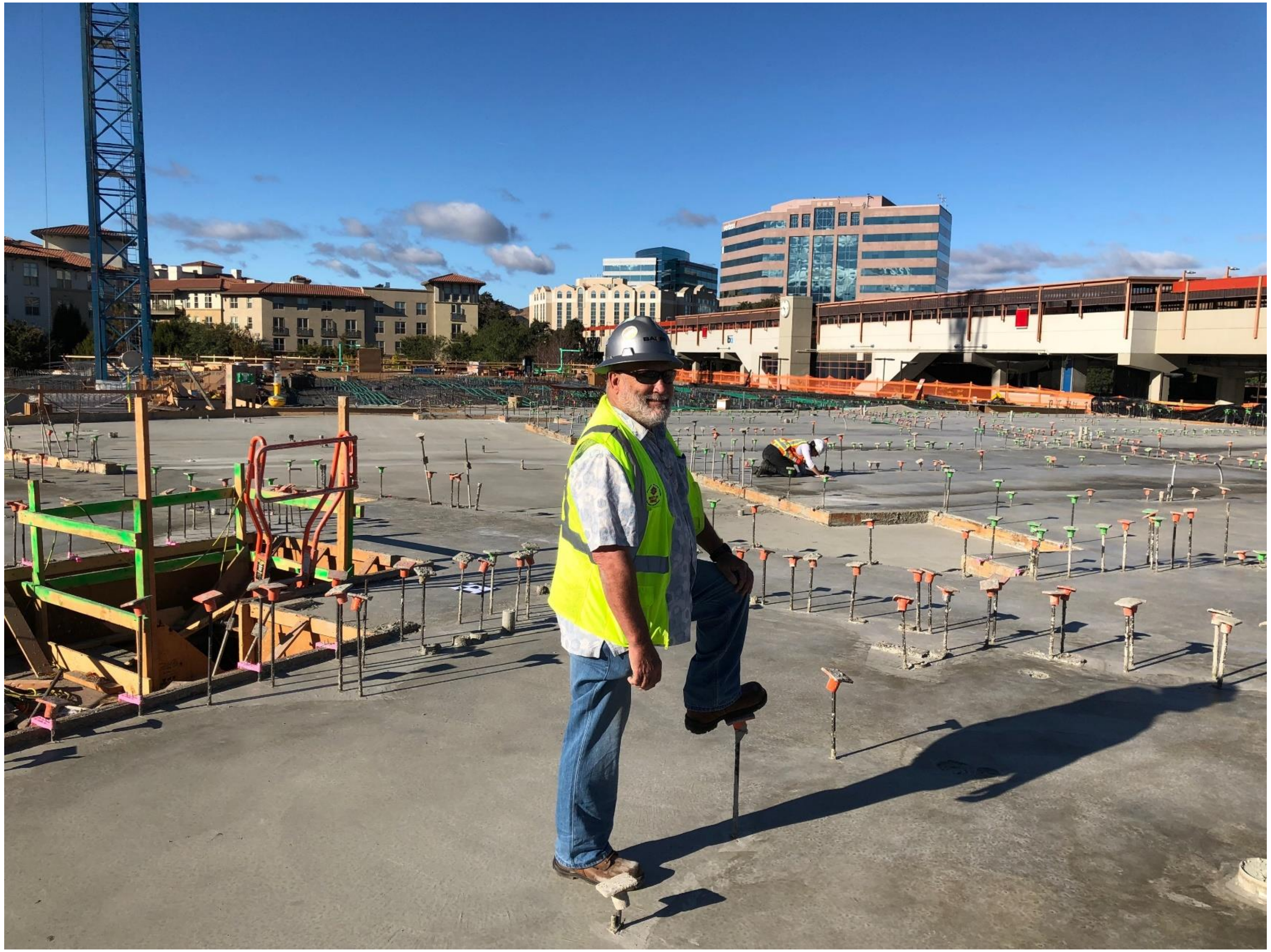


Figure 1. Concrete is generally considered to be ready for floating when finishers leave a ¼-inch-deep footprint in the surface. Using a boot filled with steel shot (inset) to produce footprints, we found that 2½-inch-slump concrete placed on a stone base was ready for floating about 45 minutes earlier than the same concrete placed directly on a vapor retarder.

Figure 1. Concrete is generally considered to be ready for floating when finishers leave a ¼-inch-deep footprint in the surface. Using a boot filled with steel shot (in-set) to produce footprints, we found that 2½-inch-slump concrete placed on a stone base was ready for floating about 45 minutes earlier than the same concrete placed directly on a vapor retarder.



Bruce Suprenant…

Kickin’ ass…leaving footprints