ACI Spring Session
San Francisco

Bruce Suprenant Session

ACI 134 Constructability

Lloyd Keller ACI 134

Session Outline

1. **Definition of Constructability**
2. **Barriers to Constructability**
3. **Examples of non-constructable conflicts**
4. **Genesis of ACI 134 on Constructability**
5. **Format and Methods of Communication**
6. **Summary**

Some Definitions

1. ACI 134 Definition
   1. "The effective and timely integration of concrete construction knowledge into the planning, design, and construction of a project to achieve the overall objectives with the goal of optimizing time, safety, and cost while maintaining the target level of quality."
   2. Was balloted and negatives resolved at ACI meeting in Dallas

Constructability

3 languages

Article Talk

Read Edit View history

From Wikipedia, the free encyclopedia

For other uses, see Constructibility.

Constructability (or **buildability**) is a concept that denotes ease of construction. It can be central to project management techniques to review construction processes from start to finish during pre-construction phase. Buildability assessment is employed to identify obstacles before a project is actually built to reduce or prevent errors, delays, and cost overruns.[1]

CII defines constructibility as “the optimal use of construction knowledge and experience in planning, design, procurement, and field operations to achieve overall project objectives”.[2]

The term "constructability" can also define the ease and efficiency with which structures can be built. The more constructible a structure is, the more economical it will be.[3] Constructability is in part a reflection of the quality of the design documents; that is, if the design documents are difficult to understand and interpret, the project will be difficult to build.[4]

The term refers to:

- the extent to which the design of the building facilitates ease of construction, subject to the overall requirements for the completed building (CIRIA [5] definition).[6]
- the effective and timely integration of construction knowledge into the conceptual planning, design, construction, and field operations of a project to achieve the overall project objectives in the best possible time and accuracy at the most cost-effective levels (CII definition).[7]
- the integration of construction knowledge in the project delivery process and balancing the various project and environmental constraints to achieve the project goals and building performance at the optimal level.(CIIA[8] definition).[9]

Some Definitions cont

2. ICRI Definition (International Concrete Repair Institute)

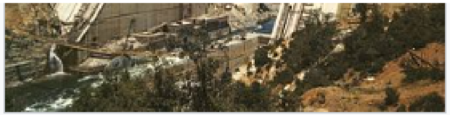
5.0 Constructability

Before finalizing the selection of the repair material and the application procedure, check the system's constructability. To determine constructability, the following questions should be addressed:

- *Can repair be performed within the constraints specified by the Design Professional and the Owner?*
- *Will the specified application technique allow the repairs to go into service within the time specified?*
- *Is the working environment conducive to the specified application method?*
- *Are experienced repair contractors available for the specified application method?*

If the answer to any of these questions is "no" or "maybe", then the choice of repair material and application method should be reassessed.

Construction processes [edit]



Shasta Dam under construction in June 1942

The National Cement Share Company of Ethiopia's new plant in Dire Dawa

Some construction projects are small renovations or repair jobs, like repainting or fixing leaks, where the owner may act as designer, paymaster and laborer for the entire project. However, more complex or ambitious projects usually require additional multi-disciplinary expertise and manpower, so the owner may commission one or more specialist businesses to undertake detailed planning, design, construction and handover of the work. Often the owner will appoint one business to oversee the project (this may be a designer, a contractor, a construction manager, or other advisors); such specialists are normally appointed for their expertise in project delivery, and will help the owner define the project brief, agree on a budget and schedule, liaise with relevant public authorities, and procure the services of other specialists (the supply chain, comprising subcontractors). Contracts are agreed for the delivery of services by all businesses, alongside other detailed plans aimed at ensuring legal, timely, on-budget and safe delivery of the specified works.

Design, finance, and legal aspects overlap and interrelate. The design must be not only structurally sound and appropriate for the use and location, but must also be financially possible to build, and legal to use. The financial structure must be adequate to build the design provided, and must pay amounts that are legally owed. Legal structures integrate design with other activities, and enforce financial and other construction processes.

These processes also affect procurement strategies. Clients may, for example, appoint a business to design the project, after which a competitive process is undertaken to appoint a lead contractor to construct the asset (design–bid–build); they may appoint a business to lead both design and construction (design-build); or they may directly appoint a designer, contractor and specialist subcontractors (construction management).[14] Some forms of procurement emphasize collaborative relationships (partnering, alliancing) between the client, the contractor, and other stakeholders within a construction project, seeking to ameliorate often highly competitive and adversarial industry practices.

Early Involvement by the Construction Team Optimizes the Resources and Solutions for a Cost Effective Project

Barriers to a constructable solution


OKAY, SO NONE OF US LIKE IT BUT IT'S THE ONLY THING WE CAN ALL AGREE ON.

Conflicting Messages in Documents

2.4 CONCRETE MIXES

.1 Concrete mixes are to be designed in accordance with the Performance Alternative outlined in Table 5 of CSA A23.1. The mixes are to be designed such that they will be homogeneous, uniformly workable, and readily placeable into corners and angles of forms and around reinforcement by methods of placing and consolidation employed on the work, but without permitting materials to segregate or excessive free water to collect on the surface. The concrete, when hardened, shall have the qualities specified. When designing the mixes the concrete supplier shall be cognizant of the curing requirements outlined in the contract documents and CSA A23.1. If a particular concrete mix requires curing in addition to that specified, the Contractor shall be responsible for providing this additional curing.

.2 Use ready-mix concrete. Proportion concrete in accordance with CSA A23.1, for exposures specified. Use a water-reducing agent in all concrete. Obtain approval [redacted] and the Consultant for the use of admixtures other than water-reducing and air entraining agents.

.3 If any batch of concrete fails to meet slump or air content specifications, attempts at mitigation shall be limited to adjusting the quantities of superplasticizer and air entraining admixtures at Site. Only one check test shall be permitted. Any concrete batch confirmed to be unacceptable by slump, air content or temperature testing shall be rejected.

.4 Unless otherwise specified, the temperature of concrete containing silica fume shall be between 10 degrees Celsius and 20 degrees Celsius at discharge. Unless otherwise specified, the temperature of all other classes of concrete shall be between 10 degrees Celsius and 25 Degrees Celsius at discharge.

.5 Supplementary cementing materials: Conform to the directions of the fly ash manufacturers for the proportioning and mixing of concrete. Except as otherwise required, limit fly ash content to no more than 30% of total cementitious content. For fly-ash and silica fume combinations, the sum of silica fume and fly ash by mass of cementing materials to be between 17 to 20%. Limit silica fume by mass of cementing materials to between 6 to 8%. The limit on supplementary cementing materials may be increased for Class N exposure concrete provided that the effects of the resulting concrete properties, including finishing, rate of early-age strength gain, curing and protection, are considered by the Contractor and a letter describing these effects and any special construction procedures is submitted for review with the mix design. Use of

means.

.4 Extend curing and protection period until concrete has reached following strength levels for structural safety:

.1 Framed slabs and beams: 70% of specified 28 day strength.

.2 Columns, walls, piers and footings: 50% of specified 28 day strength.

.5 The temperature of the centre of in-situ concrete shall not fall below 10 degrees Celsius or exceed 60 degrees Celsius and the temperature difference between the centre and the surface, as well as the temperature differential between top and bottom surfaces, shall not exceed 20 degrees Celsius.

.1 To monitor the temperature of mass concrete, including any concrete pour with a minimum dimension greater than 2 m, thermocouples shall be installed in the pour as follows:

.1 two thermocouples shall be placed at each side face (four total) and two thermocouples placed at the center; for a total of 6 per set; and

.2 one set of thermocouples shall be placed in each pour for each 2 m of pour length where the pour length is the maximum dimension of the pour.

.2 The temperatures shall be monitored and recorded every four hours for the first 72 hours after concrete placement and every 8 hours thereafter for the remainder of the specified cure period. Whatever means and actions necessary to ensure that the concrete temperature and the temperature differences within the concrete remain within the limits specified shall be taken.

wythe where masonry abuts concrete.

3.3 SEPARATION STRIPS

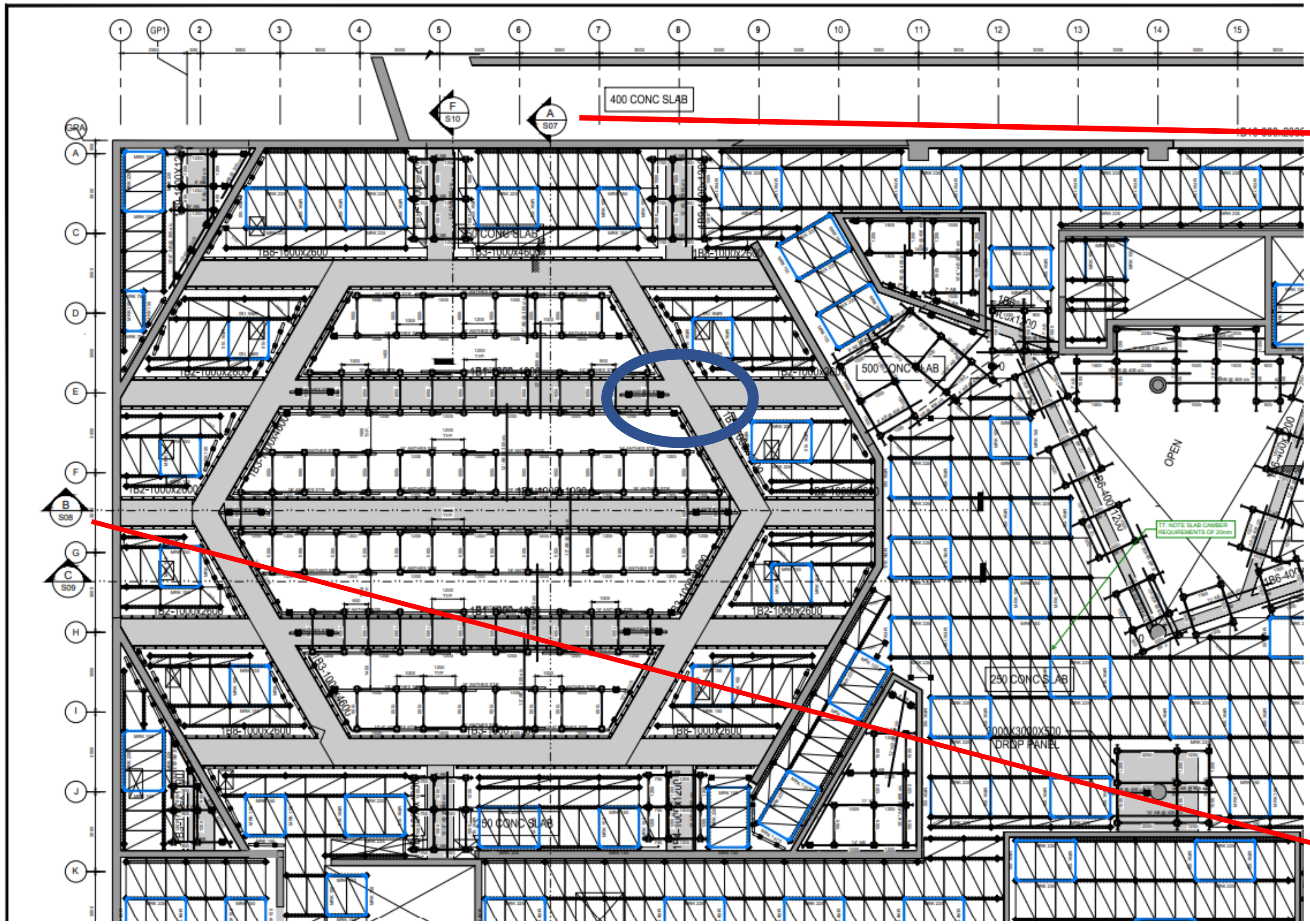
.1 Maintain bays containing separation strips and each adjacent bay fully formed and shored until the strip is complete, and has reached its 28 day specified strength. Ensure that the forms and shores are designed so that no settlement of the forms occur during the period that the strip is open.

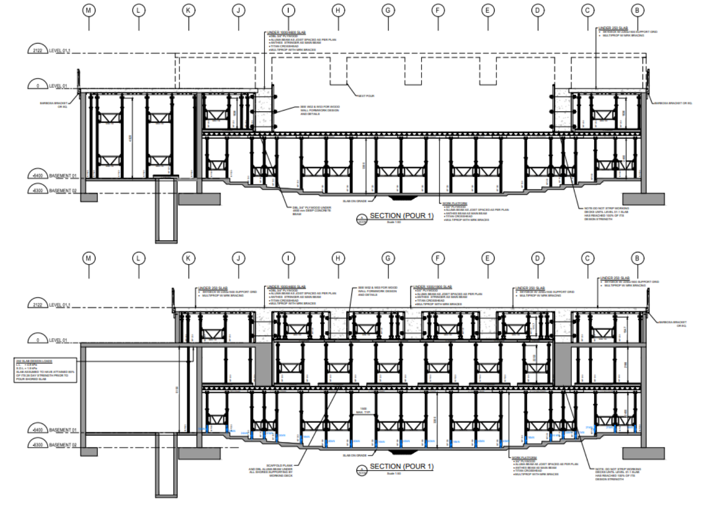
Scarcity of Resources in Local Regions

Examples where Rebar Congestion affected the process

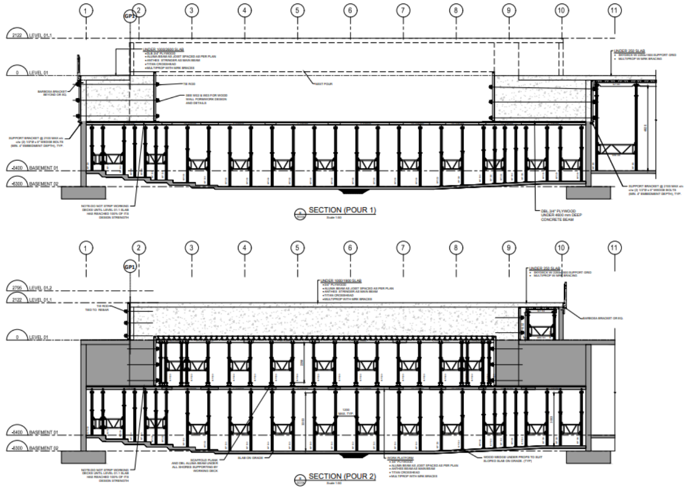
Example 1 – Rebar Congestion Work Around

Classrooms such as the 500 seat in-the-round 'Campfire' and the group-oriented banquet seating 210 seat 'Collaboratorium' allows for collaborative discourse and group work.





Section A - A



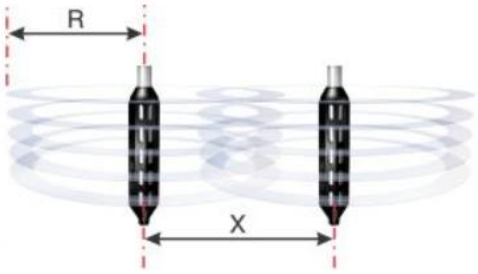
Section B - B

All dimensions shown are nominal, actual dimensions may vary. Call for details.

All Oztec vibrators meet or exceed ACI specification #309

Wheelbarrow (Briggs & Stratton/Honda)
GV-5W – 5/5.5 2 1/2" 2 3/4"

Radius of Action - The most important bit of information needed for complete consolidation.
Radius of Action is the distance from the center of the vibrator to the outer edge, where complete consolidation takes place (see diagram).
For quality concrete Oztec lists conservative values for "Radius of Action". Complete consolidation is necessary for low slump concrete with close meshed reinforcement bars, high strength concrete and architectural concrete.
Radius of Action can be twice the listed values when slump is high or super plastisizers are used. It is important these values are used only as a general guide. Specifications are subject to change.



R - Radius of Action
X - Insertion Spacing

Head Diameter	Radius of Action (R- inches)	X = 1 1/2 Times Radius of Action	Amplitude Centerline to Side (inches)	Centrifugal Force (pounds)	Compaction Rate (cu. yds. / hour)
		Steel Heads			
3/4"	3	5	0.03	155	1-3
1"	4	6	0.04	220	2-4
1 1/4"	5	8	0.04	510	2-5
1 1/2"	6	9	0.05	920	5-8
1 3/4"	9	14	0.08	1200	8-16
2"	11	17	0.075	1500	12-20
2 1/2"	13	20	0.08	1850	23-30
		Rubber Heads			
1 7/8"	11	16	0.09	1400	10-18
2 1/2"	14	20	0.12	1900	14-22
2 3/4"	18	27	0.12	2100	25-35
2 3/4" short	15	22	0.12	1100	9-15

All dimensions shown are nominal, actual dimensions may vary. Call for details.

Concrete Placement Campfire Beam

Original Plan use Conventional Vibrated Concrete

- 2 pumps being used
  - Placing rate 100 yards per hour
  - 525 yards total volume
- Maximum vibrator size to clear reinforcing
  - ¾”
  - Would require 30 – 50 vibrators inserted at 5” o.c.
- Pour height lift 1 9’
- Pour height lift 2 7’

Final Plan using SCC

Hi Rich,

As discussed in today's meeting please see comments below and adjustments to take place.

-Please adjust mixes to allow for 3hr workability
-Adjust sure flow mix slump to 700mm and 90m
-Adjust Mix 3 to 150mm slump
- Placing temps to be 22-25 degrees
-texts for retempering and QA/QC on site during pour
-Site logistics review tomorrow for trucks and pump set up.
- 80m/hr is the goal 60-80m per hr possibility during traffic CBM to check number of track dedicated to pour.

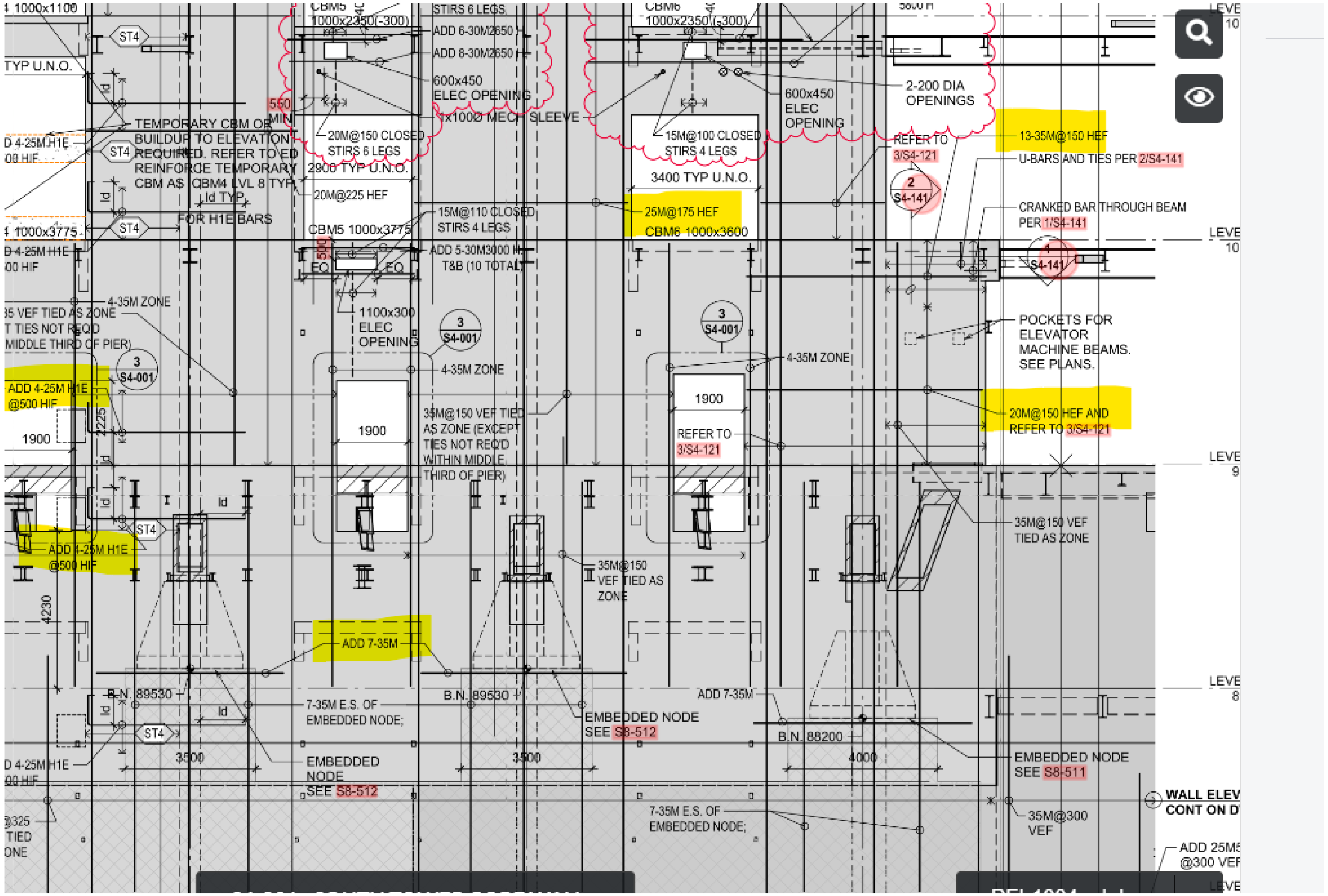
Please let me know if there is anything I am missing or if you have any questions or concerns.

Show Photos of Campfire Core walls and Design drawings with lack of attention to Placing and rebar congestion

Supporting stage 1 beams framed to Ring Structure

2nd stage North South Roof Supporting beams

Example 2 Horizontal Rebar Congestion at Core wall step-backs




From: suprenant@comcast.net <suprenant@comcast.net>
Sent: March 17, 2023 3:15 PM
To: Lloyd Keller <lkeller@ellisdon.com>
Cc: Bev Garnant <bgarnant@ascconline.org>
Subject: RE: San Francisco - Special Sessions

Hi Lloyd

In 2016, Bev and I were on CLC, she was Chair, and I was a member. AISC, ASCE, AASHTO, FHWA, and others had constructability committees and documents, but ACI seemed behind the industry curve on the topic. CLC agreed that we needed a constructability committee. I drafted the proposal, got CLC approval, and then it went to TAC. I was also on TAC at the time, so I explained the purpose and answered any questions. TAC voted to approve the formation of that committee. And in true TAC fashion, since I had proposed the committee and was on TAC, I was unanimously voted to be the TAC liaison to ACI 134. Because of his experience as Chair of ACI 301, we proposed Mr. Cornell as the first chair. And the rest, as they say, is history. The first ACI 134 meeting was in Anaheim in October 2017.

A few years after that, ASCC recognized it could accomplish different things at different speeds than ACI 134 and started an ASCC constructability committee. The first meeting was in July 2021. One of our first big items, as you mentioned, was on reinforcement congestion. Other items currently underway include (a) puddling, (b) top of column elevations in slabs, and (c) constructability considerations for anchor bolts in foundations.

Communication Awareness – ACI Sessions

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Preliminary Session Request Form

ACI 134 - Constructability

Type of Session	Technical Session	TAC
Person Submitting Request	Lloyd	Keller
Member #	102117	
Sponsoring Committee 1	ACI 134	Constructability
Sponsoring Committee 2	ACI 207	Mass Concrete
Sponsoring Committee 3	ACI 201	Durability
Jointly Sponsored by International Organization	No	
Convention and Date	Boston	Oct 29 – Nov2 2023
Session Length	2 hours	
Number of Sessions	1	
Day and Time Requested	Tuesday	Morning
Session Moderator	Lloyd Keller	
Name	Lloyd	Keller
Title	Consultant	
Affiliation		
Mailing Address	90 William Street	
	Niagara on the Lake	Ontario
	L0S 1J0	
Phone Number	416-624-3136	
Email Address	lkeller@ellisdon.com	
Title of Session	Prescriptive or Performance? What is the state of the industry and what are the examples of a positive movement towards collaboration?	

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ACI 134 - Constructability

On many infrastructure projects, specifiers do not appreciate the need to move to performance type documents and are combining prescriptive with performance creating confusion and contradictory messages. Some visionary regulatory groups are moving much more towards a performance perspective or their documents or at least include a process to allow for changes in the process to accommodate innovation and performance benefits away from traditional prescriptive constraints.

The speakers will provide examples of performance measures and thresholds and of guidelines for improvisation that have been adopted to reduce the incompatibilities in documents that limit the constructability, innovation and at the same time increase cost and efficiency. Perspectives will be presented by a broad base of stakeholders in the project delivery process.

Probable Topics and Potential Speakers

The Road Not Taken, A look at Performance based Specifications from the point of view of a Canadian Ready-Mix Producer.	Bryan Schulz, Sr. Manager Technical Services, Votorantim, Toronto
Sustainability as a Performance Requirement: Carbon Emissions Reductions	Jolene Mclaughlin Director, Corporate Sustainability EllisDon Corporation, Toronto
Performance Specifications: It starts with Education.	Dr James Wilde, Texas State University
Canadian Performance Specifications Including Recent Developments in Performance Tests and Limits.	Doug Hooton Professor Emeritus University of Toronto
Advances in Performance Based Specifications for Mitigation of Shrinkage Cracking	Matthew D'Ambrosia Principal MJ2 Consulting
Evaluating the performance barriers across North America. Are we all on the same page?	Stacia Van Zetten

ACI Convention Mini-Sessions

MINI SESSION: Constructability: Hot Topics, Recent Developments & Case Studies

Moderators:

Jan Vosahlik (jvosahlik@ctlgroup.com), CTLGroup
Stacia Van Zetten (stacia@exacttechnology.com), EXACT Technology Corporation
Sponsoring Committee: 134

This mini session is a recurring event focused on the latest developments, case studies, and lessons learned in the area of concrete constructability. Arguably, constructability is one of the most overlooked components of concrete project design and planning. Yet if not properly addressed, it can result in a variety of issues during the construction phase of the project, including negative impacts on the project schedule and budget. Often, the devil lies in the details when it comes to constructible projects. This session will aim at discussing a variety of constructability-related topics that will be based on real-world experiences and case studies.

Learning Objectives:
(1) Recognize recent developments in the area of concrete constructability;
(2) Describe frequent issues occurring on concrete projects that negatively impact constructability, schedules, and project budgets;
(3) Identify potential constructability pain points and acquire proven strategies to prevent them from occurring;
(4) Understand the design behind complicated project elements and alternative methods to construct them.

Please see below information for our speakers for the ACI 134 Mini Session in San Francisco at the Spring 2023 Conventio

80% — + Rese

1:
"Integrating Constructability to Concrete Pavements in Hot Weather Climates"
Presented by Anabel Merejildo
Email: anabelnms@hotmail.com
Cell: 787-518-9333

2:
"ACI 239 F – Ultra High Performance Concrete; Synergy between Sustainability and Constructability"
Presented by Bill Kulish
Email: Bill@Steelike.com
Cell: 609-703-2020

3:
"Match-Curing in the Field: Removing the Unknowns From In-Place Strength"
Presented by Dale Gillham
Email: dale@exacttechnology.com
Cell: 407-929-9283

4.
"Concrete Tolerance Considerations for Design Professionals"
Presented by Mike Hernandez
Email: Mike@All-Phaseconcrete.com
Cell: 720-203-6407

5.
"Cement Shortages and How to Talk About It – The Longer You Wait, the Harder It Gets"
Presented by Keila Lombardozzi
Email: keilal@dpr.com
Cell: 602-309-3451

6.
"Constructability in Education"
Presented by Dr. Tony Lamanna
Email: drtony@asu.edu
Cell: 480-727-0155

Erica Stone, **Staff**

Constructability

Co-Chairs: Bruce Suprenant & Jim Klinger, **Staff**

Oscar Antommattei, **Kiewit**
Eamonn Connolly, **McHugh Concrete Construction**
Aron Csont, **Barton Malow**
Michael Damme, **Sundt Construction**
Dave Defauw, **Barton Malow Co.**
Jim Dick, **Charles Pankow Builders**
Kevin MacDonald, **Beton Consulting Engineers**
Guy McGriff, **Keystone Structural Concrete**
John Paleologos, **Miller & Long Co.**
Trevor Prater, **Swinerton Builders**
Terry Swayne, **Wayne Brothers Companies**
Kevin Timken, **Ceco Concrete Construction**
Bev Garnant, **Staff**
Joe Whiteman, **Staff**

Concrete Executive Leadership Forum

To provide a "world class" event at a unique destination, that impacts all attendees through the exchange of information, education, fellowship, and relaxation.

Chair: T.R. Kunesh, **Somero Enterprises**

Nick Adams, **The Euclid Chemical Company**
Wayne Albanelli, **Albanelli Cement Contractors**
Linda Dalrymple, **North Coast Concrete**
Aaron Gregory, **Gregory Construction**
Maizer Ouijdani, **Gonsalves & Santucci dba Conco**
Chris Plue, **Webcor Concrete**
Doug Rhiel, **Schwing America**
Ashley Stamper, **DANKO Concrete Construction**
John Yuncza, **Somero Enterprises**
Bev Garnant, **Staff**
Erica Stone, **Staff**

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

design with other disciplines,"[21] including the mechanical and electrical requirements. When coordination does not take place during the design phase, congestion can occur. Coordination of different disciplines' work is necessary during the design phase, or extra cost and schedule delays will occur at construction.

Reinforcement Density to Trigger Early Design Review

Munshi and Saini[22] concluded that nuclear construction has reached a point where the amount of reinforcement required can seriously threaten the viability of power plant construction. They indicated that very dense cages (No. 11 or larger bundled within closely spaced ties/hairpins) with reinforcing bar densities of over 400 lb/yd³ of concrete were common. And that current nuclear construction has experienced this issue and is faced with serious implications on cost, schedule, and long-term performance of the concrete.

Certainly, reinforcement required in building construction, especially for seismic design, has also reached a critical level. Reinforcing bar densities for mat foundations are approaching 600 lb/yd³ and walls are 700 to 800 lb/yd³ (Fig. 8). One wall in a nonseismic region is close to 1000 lb/yd³ of reinforcement. When determined in the field, these levels of bar density require contractors to work with the engineer to redesign the reinforcement layout, resulting in extra cost and delays.

Munshi and Saini proposed that bar density be used as an early trigger review:

"To facilitate early insight and course correction before it is too late, it is advisable to include a detailed review of the design developments in early stages of design to ensure that the design criteria, assumptions, processes, and methods are yielding reasonable design and reinforcement. A review of the rebar densities should be carried out at this early stage to help identify potential areas of high rebar densities that need to be critically evaluated to understand the root cause and corrected in time before the design is finalized. As a matter of general rule of thumb, rebar densities exceeding 200 lb/yd³ can be used as a trigger point to evaluate the designs at early stages."[22]

It is unclear why Munshi and Saini[22] chose 200 lb/yd³ as a trigger point to evaluate designs. For some building construction, this limit might result in a congestion review of every member. Based on our experience, the ASCC Constructability Committee chose to identify trigger reinforcement densities by element, as shown in Table 4.

Proposed Code and Commentary Provisions

The ASCC Constructability Committee is proposing ACI 318 Code and Commentary provisions related to constructability with respect to reinforcement congestion. These proposed changes, especially in a design-bid-build delivery system, should resolve congestion issues, thus avoiding countless requests for information (RFIs).

Proposed ACI 318 Code and Commentary provisions to improve constructability include:

Code

Reinforcement detailing

Selection of reinforcement size, spacing, cover, and other details 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.

Commentary

Reinforcement detailing

Code requirements often refer to minimum or maximum values. Good design practice (ACI 315) generally strives to avoid the indiscriminate use of minimum Code values without considering constructability. Constructability is an important part of providing the owner with a structure within cost, schedule, and quality constraints.

To allow for tolerances on fabrication and placement of reinforcement, consider selecting: (a) the beam/girder at least

Fig. 8: Reinforcing bar density for this member was close to 800 lb/yd³. After this was built, the engineer changed bar sizes, bundled bars, and rearranged splices so there was access for concrete placement

Table 4:
Reinforcement densities trigger points by element

Concrete element	Reinforcement density, lb/yd³
Beams/girders	350/400
Columns	400
Footings, spread	250
Foundations, mat	300
Grade beams	300
Slabs	200
Walls	300
Walls, shear	400

1 in. per ft (of beam/girder width) larger than the minimum required; or (b) the beam/girder at least 2 in. larger on each side than the intersecting column to allow outermost horizontal bars in the beam/girder to pass by the vertical longitudinal bars with minimal interference.[10]

To allow for adequate consolidation of the concrete, consider providing access for a 5 in. diameter pump hose at regular spacings and designing a concrete mixture that is compatible with the concrete placement insertion spacing. A mockup may be necessary to evaluate this combination of parameters. The pump access intervals should be shown in the construction documents.

To allow for adequate consolidation of the concrete, consider providing a 4 in. square opening for an internal vibrator with a head diameter of 2-1/2 in. to reach through to the bottom of the beam/girder[16] for at least one location per 16 in. of beam/girder width and sufficient openings for internal vibration insertions at a maximum spacing of 16 in. on-center.[6,10]

The structural drawings should show the placing sequence, especially the layering of beam-to-beam and beam-to-girder intersections, with consideration to intersecting beam and girder depths and concrete cover for each of the intersecting members.[8]

Coordination of different design disciplines in the early design phase is recommended[21] to minimize congestion that would adversely affect reinforcement and concrete placement and consolidation.

Commentary References

ACI 309R-05—Guide for Consolidation of Concrete

ACI 315-18—Guide to Presenting Reinforcing Steel Design Details

CRSI 10-DG-STRUCTURES —Design Guide for Economical Reinforced Concrete Structures, 2016

Schaefer, S.E., "Coordinated and Complete Construction Documents—CASE's Answer to 'Botched Plans'," *STRUCTURE* magazine, Feb. 2004, pp. 27-29.

ASCC Constructability Committee:
Oscar Antommattei, Kiewit
Brian Carson, Osburn Contractors
Eamonn Connolly, McHugh Concrete Construction, Inc.
Aron Csont, Barton Malow
Michael Damme, Sundt Construction, Inc.
Jim Dick, Charles Pankow Builders
Ralph Jessop, Phaze Concrete, Inc.
Jim Klinger, American Society of Concrete Contractors
Kevin MacDonald, Beton Consulting Engineers, LLC
Guy McGriff, Keystone Structural Concrete, LLC
John Paleologos, Miller & Long Co., Inc.
Trevor Prater, Swinerton Builders

The Designer's Responsibility

Wyllie and LaPlante[23] offer suggestions to other structural engineers on their obligation to design and detail reinforced concrete structures so the contractor and reinforcing steel subcontractor can build them as easily and economically as possible. The authors state that it has been their experience that a well-detailed set of drawings, where constructability issues have been addressed, results in lower bid prices.

References

1. ACI Committee 318, "Commentary on Building Code Requirements for Reinforced Concrete (ACI 318-83)," ACI 318R-83, American Concrete Institute, Farmington Hills, MI, 1983, 155 pp.
2. ACI Committee 318, "Building Code Requirements for Structural Concrete (ACI 318-99) and Commentary (ACI 318R-99)," American Concrete Institute, Farmington Hills, MI, 1999, 391 pp.
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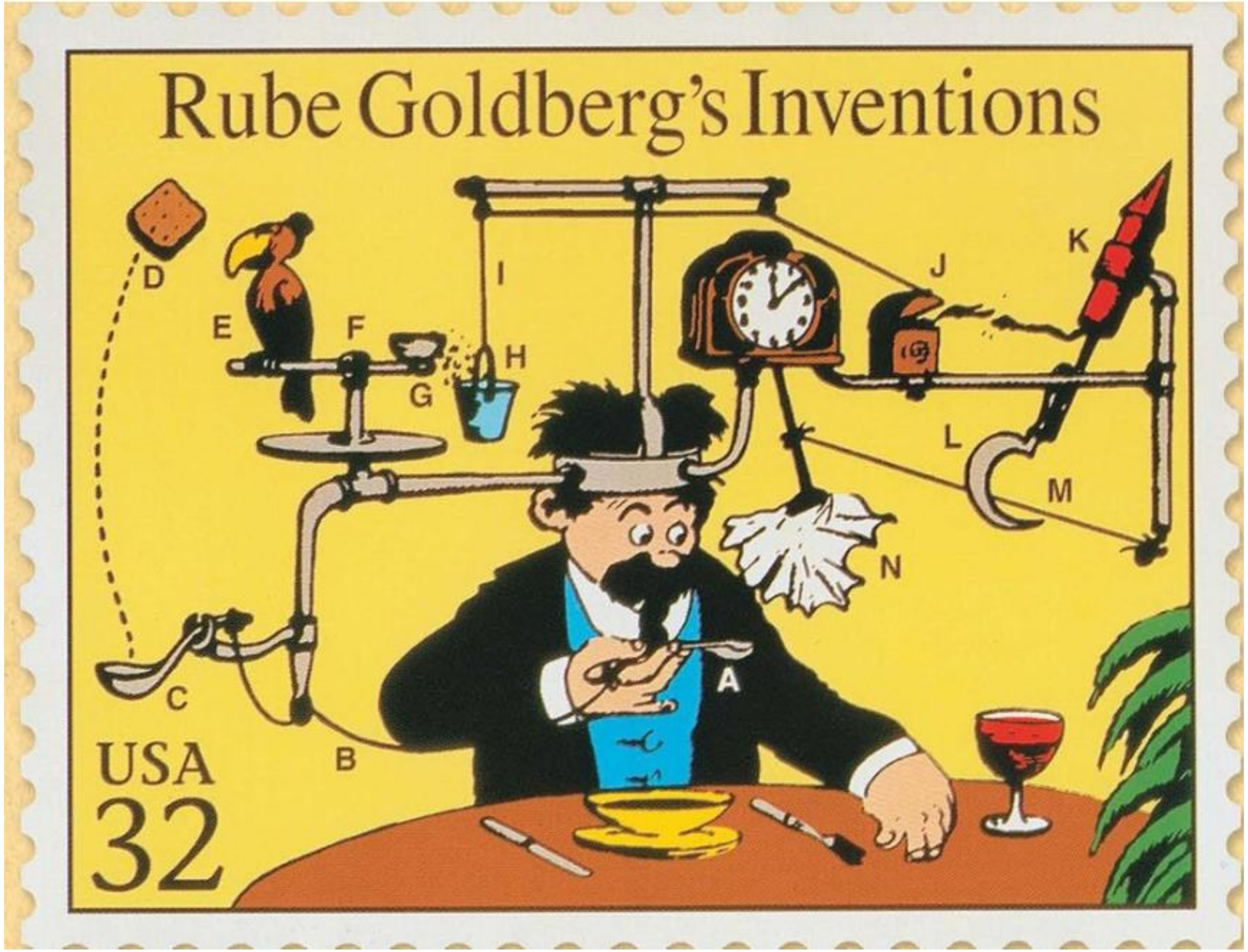
Summary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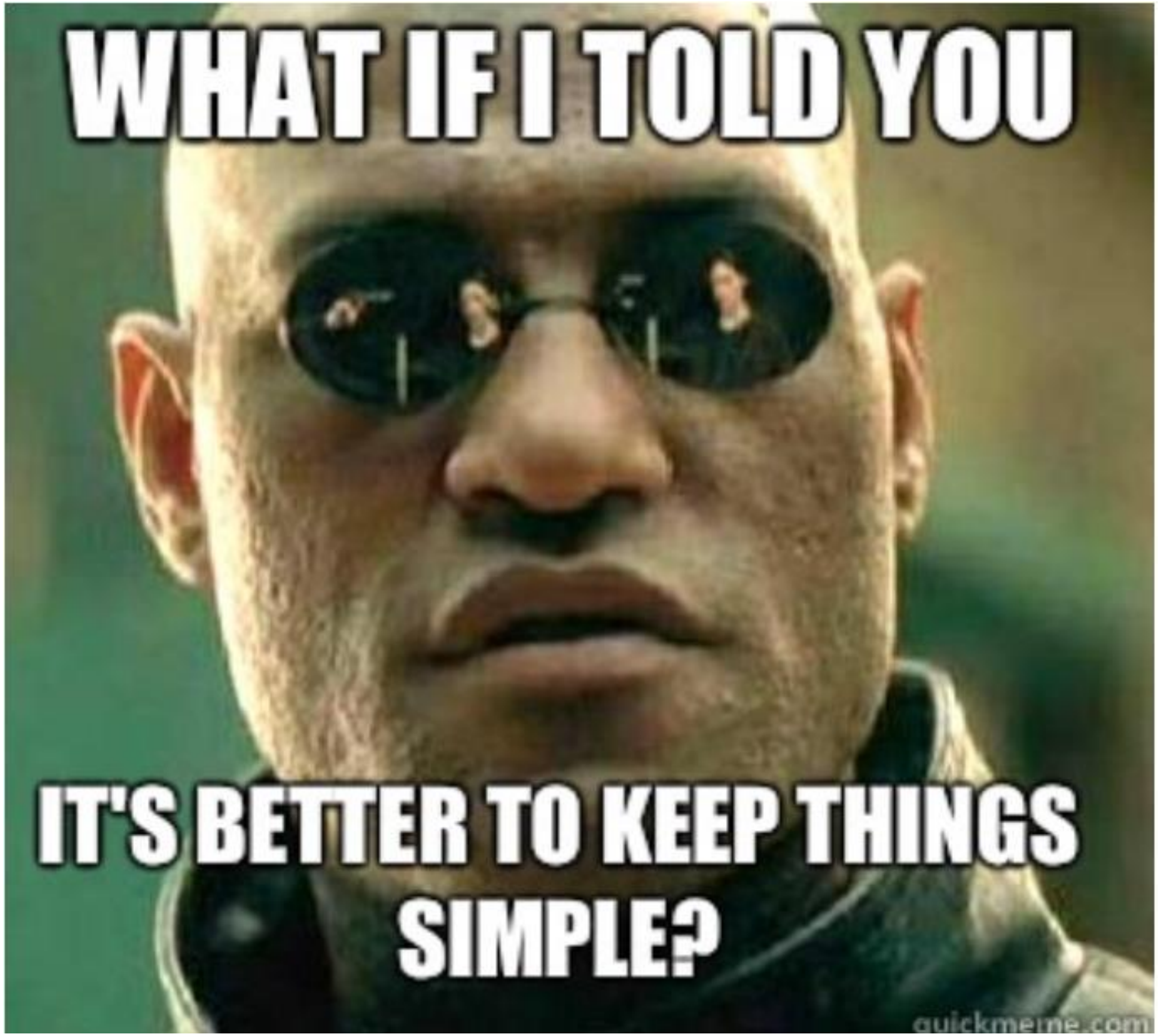
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