




American Concrete Institute®
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Analysis and Design Issues in Liquid-Containing Concrete Structures

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Proposed Changes to Shrinkage and Temperature Reinforcement Requirements in ACI 350

Steven R. Close, PE

Toronto, Fall 2012 ACI Convention



Or is the Solution New Thinking on Shrinkage and Temperature Reinforcement for Environmental Structures (ACI 350)?

This Thinking is Not New

- ▣ It's been a part of 350 documents since the mid 1990s (350.2R-95 Hazardous Materials)

This is Not New


- ▣ Has not been introduced because of the "rules"
- ▣ For developing the original C&C 350-01
 - Must reflect 350R-89
- ▣ And the first revision, 350-06
 - No new business - catch up to 318 only

This is Not New

- ▣ 350 C (Reinforcement) has been working on this since before 2006
- ▣ Balloted by Main Committee in 2009

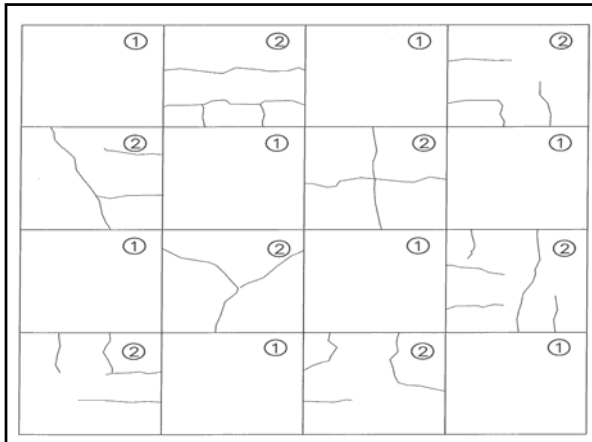
Where Does This "New Thinking" Come From?

- ▣ Field Observations
 - Vertical wall cracks much closer than the presently indicated "distances between movement dissipating joints" (30, 40 and 50 ft)



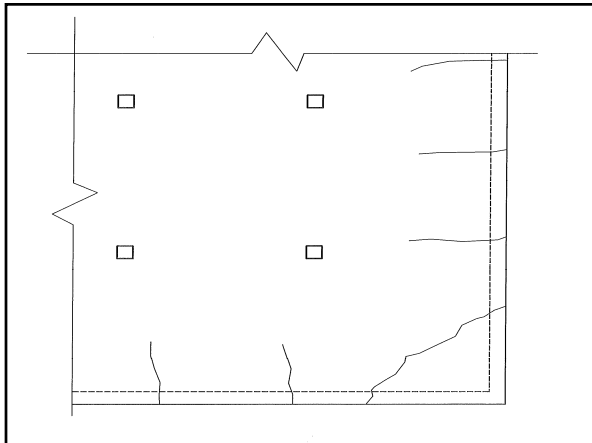
Where Does This "New Thinking" Come From?

- ▣ Field Observations
 - Cracks in "checkerboard" placed SOGs



Where Does This "New Thinking" Come From?

- Field Observations
 - "Corner cracks" in suspended slabs



Where Does This "New Thinking" Come From?

- Field Observations
 - Cracks ending at construction joints



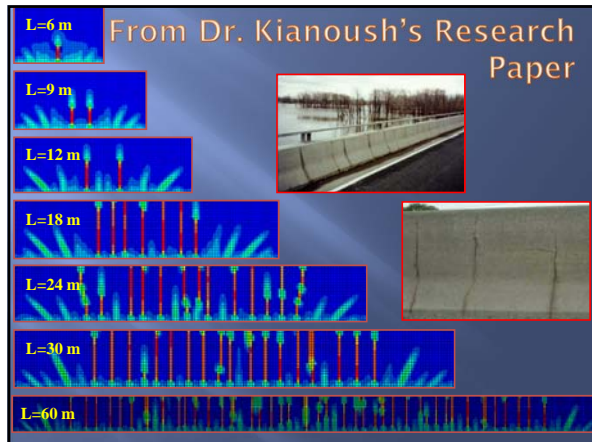
Where Does This "New Thinking" Come From?

- Field Observations
 - No cracks in walls to be prestressed, even after months until application of horizontal or circumferential prestressing



Where Does This "New Thinking" Come From?

- Research
 - Dr. Reza Kianoush



Conclusion: The "Old Thinking"
(Shrinkage and Temperature Reinforcement Should Be Tied to Distance Between Movement Dissipating Joints)

Doesn't "Fit" What We're Seeing in the Field.

What is the New Thinking?

Shrinkage Cracks can't be prevented in all cases, but they may be able to be "controlled" to where we have a larger number of cracks small enough to not seep (0.1mm).

What is the New Thinking?

Tie reinforcement levels to "amount of restraint"

Not distances between movement joints (except 20 ft and under).

What is the New Thinking?

"Reduced Restraint"

- For vertical wall reinforcement (except near Construction Joints)
- Where measures are taken to reduce restraint of shrinkage and temperature shortening

What is the New Thinking?

"Maximum Restraint"

- Where shrinkage and temperature shortening is prevented by ties to previously placed concrete

What is the New Thinking?

“Normal Restraint”

- Anywhere not defined as “Reduced” or “Maximum” Restraint
 - Slabs on soil away from construction joints
 - Horizontal reinforcement in walls, away from bottom construction joints

What Are The New Amounts?

- Similar to the prior amounts, “depending” ...

What Are The New Amounts?

Normal Restraint

- Designed around 0.42%
 - #5s at 12 inches o.c. each face in a 12-in. section
 - 15mm bars at 300mm o.c. each face in a 300mm section

What Are The New Amounts?

Maximum Restraint

- Double the “Normal Restraint” values

What Are The New Amounts?

Reduced restraint

- Starting at 0.28%
 - #4s at 12 inches o.c. in a 4-inch slab
 - 13mm bars at 300mm o.c. in a 100mm slab

What Are The New Amounts?

Varies with Bar Size

- Smaller bars closer together “control” crack widths better than the same percentage with bigger bars farther apart



Examples of the Varying Restraint Conditions in Everyday Construction

Restraining Slab Penetrations

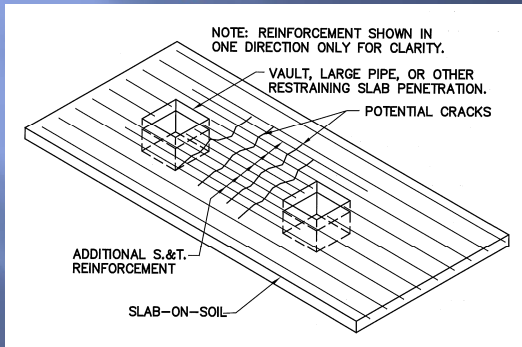


FIG. R12.13.1.2

Restraint areas in Walls

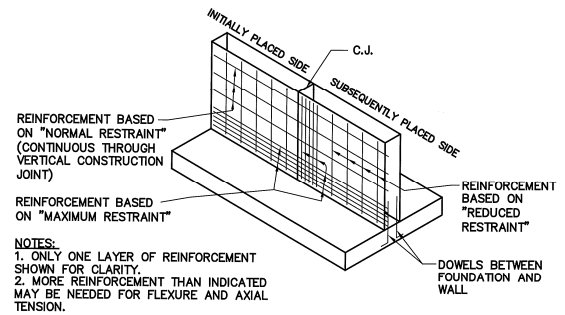


FIG. R12.13.2.4.(a)

Temporary Reduction of Restraint in Walls

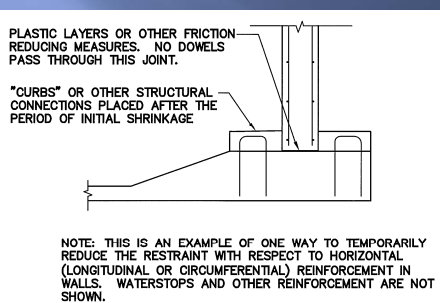


FIG. R12.13.2.4.(b)

Typical Circular Floor Example

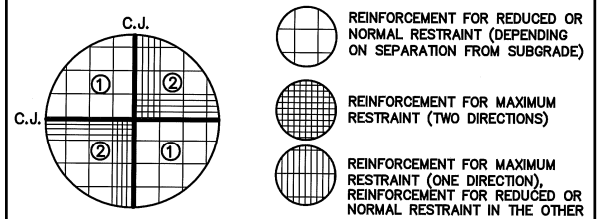
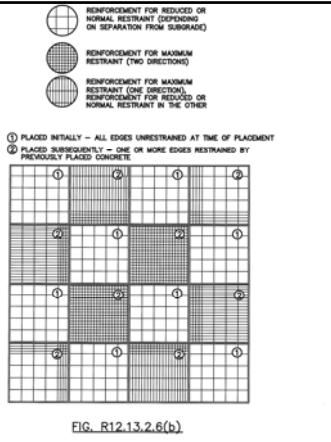
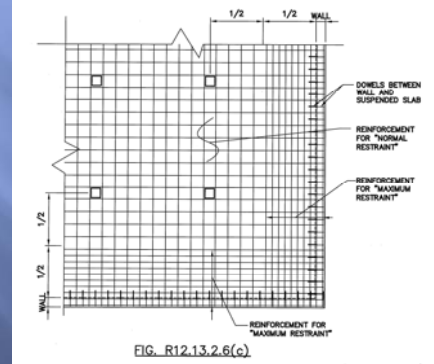


FIG. R12.13.2.6(a)

Floor Placed
"Checker-Board"
Style Example



Typical Roof Slab Example



Thank you for your attention!

Questions?

Discussion?