

Syed Uzair Ullah

From: Satyendra K. Ghosh [skghoshinc@gmail.com]
Sent: Thursday, August 06, 2009 12:48 AM
To: Syed Uzair Ullah
Subject: Re:

Dear Syed:

I thought, for once, the ACI 318-08 requirement you are concerned about is fairly clearly stated. I think you and your colleagues are agonizing quite a bit about an ambiguity that, I do not believe, exists. 0.0018bh is the total amount of reinforcement you provide in each orthogonal direction of a structural slab or footing - it is not 0.0018bh per face. This becomes abundantly clear if you refer to the new commentary we have placed under Section R15.10.4, which applies specifically to combined footings and mats. Section 7.12 gives you shrinkage and temperature reinforcement. There should be no expectation that this reinforcement would prevent sudden flexural failure. I do not believe that ACI 318 has tried to produce such an impression. Section 10.5.4 essentially says that if you have provided the minimum shrinkage and temperature reinforcement required by Section 7.12, you shall be deemed to have satisfied the minimum flexural reinforcement requirement of Section 10.5. I wouldn't want you to read too much into the change in the wording of Section 10.5.4 between ACI 318-02 and ACI 318-05. For ACI 318-05, it was decided to use notation in place of verbiage, whenever that is practicable. That's what you see reflected in the ACI 318-05 requirement, which is no different from the corresponding ACI 318-02 requirement.

Hope this answers all your questions.

S. K. Ghosh

Syed Uzair Ullah wrote:

Dr Ghosh,

Recently we have been discussing the topic of minimum flexural reinforcement for slabs and footings. Our understanding is that minimum flexural reinforcement is governed by Section 10.5. Further 10.5.4 states that structural slabs and footings are also governed by Section 7.12 which defines the minimum reinforcement needed for shrinkage and temperature. Pre 2008 ACI codes were not very clear about the placement of temperature and shrinkage reinforcement, ACI 318-08 section R7.12.2 for the first time made it clear that shrinkage reinforcement can be allocated between the two faces as deemed appropriate. Since at no point Section 10.5 defines a definite lower limit of reinforcement other than 10.5.1, 10.5.2 & 10.5.3 we interpreted that we can distribute the temperature and shrinkage reinforcement of Section 7.12 equally between top and bottom faces as mentioned in ACI 318-08 section R7.12.2. While being in compliance with 10.5.1, 5.2 & 5.3

Some of our team members have a different opinion; they believe that we need to provide Reinforcement as per Section 7.12.2.1 (0.0018bh) on each tension face (Top and Bottom), in order to comply with 10.5.4. Or in other words they believe that reinforcement defined by 7.12.2.1 is the absolute minimum flexural reinforcement in order to prevent sudden collapse and to ensure a ductile behaviour. They assume that 0.0018bh reinforcement will provide enough capacity that the strength of cracked section will be greater than uncracked section.

I decided to test this assumption and found interesting results. At no point the Φ -Mn (provided by 0.0018bh Steel) is greater than the capacity of uncracked section. This is only possible when 2000 psi concrete is used further I decided to test the actual minimum reinforcement clause 10.5.1 of ACI 318, I found that reinforcement by Eq 10-3 yields a Φ -Mn 40% greater than M_{cr} and varying concrete strength has no effect on the ratio of Φ -Mn vs M_{cr} . Our conclusion was that Section 7.12 is not intended to govern minimum flexural reinforcement; it only controls reinforcement due to

temperature and shrinkage. Please see attached calculations.

At this point I would like to emphasize the difference between ACI 318-02 and ACI 318-05/08

ACI 318-02

10.5.4 "For structural slabs and footings of uniform thickness the minimum area of tensile reinforcement in the direction of span shall be same as that required by 7.12...."

ACI 318-05/08

10.5.4 "For structural slabs and footings of uniform thickness, A_s, \min in the direction of span shall be the same as that required by 7.12...."

My understanding is that, ACI 318-05/08 replaced "Tensile Reinforcement" with " A_s, \min in the direction of span" in order to allow us not to use reinforcement of $0.0018bh$ at each tension face if it is not needed as per 10.5.1, 10.5.2 & 10.5.3. Instead of that we have to provide the total reinforcement $Top+Bottom = A_s, \min$ in the direction of span.

Further assuming my interpretation being incorrect, If $0.0018bh$ is the absolute minimum for flexure (Tensile Reinforcement) to prevent a sudden failure then I don't understand why it is not applicable to beams which are the primary the flexural members? This means that I can design a beam section as per 10.5.1, 10.5.2 & 10.5.3 and can provide flexural reinforcement which can be less than $0.0018bh$ while if I am designing the same section as a 2-Pile Pile Cap, I need to provide a minimum of $0.0018bh$ for flexure to avoid sudden failure. This dont seems to be logical to me.

I am hope full that your expert advice will resolve this issue and will get us a clear understanding of ACI section 10.5.4 and section 7.12. We will be great full of yours for help.

Regards

Syed Uzair Ullah

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