

Beware of Structural Designs that Use Reinforcing Steel for Shrinkage and Temperature Crack Control

Shrinkage and temperature reinforcement requirements for design of reinforced concrete structures have been included in the ACI building code since 1928, and haven't changed much in nearly 85 years. The ACI 318-14 Commentary states that the amounts of shrinkage and temperature reinforcement specified for deformed bars and welded-wire fabric are empirical, but have been used satisfactorily for many years.

Reinforcing steel to control cracks due to shrinkage and temperature is used for structural slabs and walls. For Grade 60 reinforcement, the minimum ratio of reinforcement area to gross concrete area is 0.0018. So for a 12- inch thick by 12- inch wall or slab section, the amount of steel needed to control shrinkage and temperature cracks is $0.0018 \times 12 \times 12 = 0.26 \text{ in}^2$. Thus a #5 bars which provide an area of 0.31 in^2 , would be needed.

While the Code says this has long been used satisfactorily – contractors are finding that current owners aren't satisfied with this level of crack control. When the owner isn't satisfied, he asks the engineer for an explanation, and the engineer replies that he designed it according to Code. This explanation seems reasonable to the owner as he believes the Code wouldn't allow this level of cracking. Thus the owner believes that the contractor is responsible for his lack of satisfaction, and seeks remediation.

We are seeing more and more of this issue between what is being designed for crack control – to the Code, and what owners expect crack control to be. Contractors are stuck in the middle. Fortunately, there is an ACI document that contractors can show the owner to extract themselves from the middle. ACI 224R-01 “Control of Cracking of Concrete Structures” states:

“The minimum amount and spacing of reinforcement to be used in structural floors, roof slabs, and walls for control of temperature and shrinkage cracking is given in ACI 318 or in ACI 350. The minimum-reinforcement percentage, which is between 0.18 and 0.20%, does not normally control cracks to within generally acceptable design limits. To control cracks to a more acceptable level, the percentage requirement needs to exceed about 0.60%”.

This document says that the shrinkage and temperature reinforcement needs to be about three times more than the Code minimum to obtain acceptable crack widths. This can be eye-opening to the owner. The engineer should discuss with the owner the crack expectations and the cost of meeting those expectations during the design phase. When the discussion doesn't take place, irritation during construction is directed at the contractor.

Based on my experience over the last 10 years, I agree with ACI 224. Owners are now consistently demanding more serviceable concrete structures – better control of cracking and deflections. What may have satisfied owners in the past with respect to the Code minimum reinforcing for crack control--- is certainly not satisfying them today. It's time to reconsider “Code Minimum” designs.