

# Why Steel Reinforcement is Needed in Concrete Slabs

by Roy Reiterman

**P**eople are being misinformed about steel reinforcement in concrete structures. Over the last five years or more, there has been a considerable amount of advertising in the various concrete industry trade magazines alluding to the placing of concrete without steel reinforcement.

Part of this advertising has stated that steel reinforcement can be left out and compensated with admixtures and enhancers? or just use plain (unreinforced) concrete. Much of this advertising is misleading.

Architects and engineers are specifying steel reinforcement and the reinforcing is being removed in the field. Some people are unaware that there is no substitute for concrete steel reinforcement. While supplemental admixtures may be included along with the reinforcement, the two materials do different things in the concrete.

## The design/construction principal is responsible to the owners

The design professional has a responsibility to the owners to insure that there are no substitutions for specified materials in the field. Contractor/owner conflicts over failures with plain concrete slabs are being reported more frequently than ever before.

These reports indicate that extensive cracking develops over time and displacement is occurring. Owners are stating they are not getting what was promised in the way of protection from wide cracks, the surface quality is poor and difficult to finish, and they do not want to incur excessive maintenance costs to repair unravel joints and cracks. They are spending a lot of money, either in tearing up and replace

ing with steel reinforced concrete or placing additional concrete topping to repair the poor quality surfaces.

Some contractors have advised us that they have tried plain concrete with and without admixtures and will not use it again for various reasons. The most important reason is that the contractors are surprised when the concrete still cracks and many of the cracks are very wide. There is settlement at the cracks and joints. More intermediate cracks are occurring. These problems increase maintenance costs for the owners.

## What some are saying about steel reinforcement

It appears that many people are hearing what's wrong with steel reinforcement. Of course, it is like anything that has been around for a long time—we tend to have more knowledge about that material (and sometimes more bad news than good news). Concrete steel reinforcing has been in the construction marketplace over 100 years, and we have heard a lot of good news. While most people know that all steel reinforcement must be properly positioned in the concrete and be provided with sufficient cover, some steel ends up in the wrong place.

In a slab on grade with one layer of reinforcement the bar mats or flat welded wire sheets should be placed on supports 1/3 the depth from the top of the slab or a minimum concrete cover of 2 in. (51 mm). Many experts believe that the steel area should be reduced or terminated with slip steel dowels used at the control and construction joints to allow for free contraction and load transfer at those locations. The steel reinforcement industry believes these are good rules to follow, especially when large concentrated loads are applied to floors.

## What's wrong with just using plain concrete slabs and paving?

It is true that we are getting much higher quality and strength in concrete mix designs today. It is also true that all concrete

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will crack. We plan for some shrinkage to take place at control and construction joints, but many times the slab has already “decided” to crack more randomly or at intermediate locations. If the steel reinforcement is left out and the subgrade settles there is nothing to prevent the cracks from widening or the slab from settling or displacing.

The real questions become: What about added reserve strength when the slab cracks? How can one guard against wide cracks and help maintain aggregate interlock, keeping the slab in one plane? The only answer is to use steel reinforcement—the ingredient that will help provide solutions to those questions.

## Reducing concrete thickness with steel reinforcement

Some proponents of plain concrete claim that since various admixtures increase the strength of the concrete, one may reduce the slab thickness and the number of contraction joints, thus saving money compared to steel reinforced slabs. With concrete steel reinforcement one can reduce slab thickness by just replacing the strength of a thicker slab with the strength of the steel. Once there is a well-graded and compacted subbase, one may want to consider the strength of steel reinforcement as contributing to the moment capacity of slabs and paving.<sup>2,3</sup>

Some believe that a considerable area of steel reinforcement is necessary to provide structural support. That may be true for the uncracked concrete theory. When we deal with the cracked concrete theory in slabs and paving on grade (since the concrete is usually well supported uniformly), properly positioned steel reinforcement in concrete<sup>4</sup> will greatly improve the structural performance.

To develop an area of steel for a reduced cross sectional area of slab or paving—say a 1 in. (25 mm) or 2 in. (51 mm) difference—we can use the difference in the cracking moments of two slab thicknesses and say the moment capacity of the steel reinforcement will replace the difference in the two moment capacities of the concrete. Even single layers of steel reinforcement will provide the reserve strength to maintain the thicker slab loading after the concrete cracks. As a bonus, steel provides the necessary temperature and shrinkage protection as well as crack width control.

Of course, fewer control joints can be a consideration when steel reinforcement is used. More economical designs may be achieved with these ideas in mind.

## A message for the specification writer

It can be stated “When an area of steel reinforcement is used to calculate the strength of slabs, increases in mechanical properties, particularly higher moment capacities, can result in reduced slab thicknesses and increased control joint spacings.” Therefore, dollars are saved for the owners.

## How much strength is added with steel reinforcement?

Let us calculate the cracking moment or critical moment of 4000 psi (28 MPa) concrete for a 4 in. (100 mm) slab. The  $M_{cr} = 1.52$  kip-ft (2.1 kN-m). Then calculate the moment capacity of the lightest cross sectional area of welded wire reinforcement with the standard equation written:

•  $M_{steel} = A_s \phi_f y_s (0.9d)$ , use  $d = t/2$  for one layer of steel.

- The area of 6 x 6-W I .4 x W 1.4 is 0.028 in.<sup>2</sup> /ft of concrete cross section.
- $M_{steel} = 0.25$  kip-ft (0.34 kN-m).
- That moment capacity is 16 percent of the cracking moment of the 4 in. (100 mm) slab.

We can take it one more step and develop the moment applied ( $M_{app}$ ) for one wheel of a 3200 lb (1450 kg) automobile. Using PCA’s wheel load chart, we would find that the stress in the slab is 48 ksi (330 MPa) and therefore the  $M_{app} = 0.24$  kip-ft, or very close to the  $M_{steel}$  calculated above. This is a fair comparison demonstrating that just minimum reinforcement steel in a concrete cross section does provide reserve strength subsequent to cracking.

## Benefits of steel reinforced concrete slabs

Here are the benefits of steel reinforced concrete slabs:

- Steel reinforcing is simple to place.
- Steel reinforcing reduces random cracking.
- Steel reinforcing reduces and controls crack width and helps maintain aggregate interlock.
- Displacement and curling can be minimized when steel reinforced concrete is provided.
- Strength is increased with steel reinforced concrete—even the smallest cross sectional area of steel reinforcement will provide reserve strength of 16 percent and more.
- Most importantly, steel reinforcement saves money over the life of the slab.
- Finally, admixtures are not an alternative to steel reinforcement; they both do different things in the concrete. Therefore, admixtures cannot be substituted for steel reinforcement.

The steel reinforcement industry is dedicated to providing quality steel reinforcement to the construction industry. It is also essential that steel reinforcement be sized, spaced, and placed properly. It is vital to have a well-graded and compacted granular subbase.

Of course, total quality can only be achieved when well qualified suppliers and contractors are on the construction sites.

## References

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