Bay Area Pervious Concrete Technical Services Division

Pervious Concrete and Rebar

Goal

Rebar is commonly specified and used in many regular concrete flatwork applications for crack control and in some areas of the country considered the sign of a high quality installation. Naturally, the question of rebar usage in pervious concrete is one that comes up often. The most logical response to the question is: No, we cannot use rebar because it will be exposed to water, ~~quickly~~ rust and damage the slab. For some that reply is satisfactory, but others feel uncomfortable with no rebar in the slab and question the ability of a pervious concrete slab to perform adequately without reinforcement.

The goal of this paper is to provide specifiers, owners and installers with an understanding of the challenges and issues related to rebar use of any kind, be it steel, epoxy coated or fiberglass reinforced in pervious concrete, why it ***should*** not be used, and why it does not ***need*** to be used.

The specific applications covered in this paper are non-structural slabs on grade (SOG), i.e.: parking lots, sidewalks, driveways, courtyards, etc. The information contained herein applies equally to welded wire mesh (WWM).

The role of rebar in slabs on grade (SOG)

When used in a SOG, the primary purpose of rebar is not structural, but to minimize the width of shrinkage cracks and or vertical displacement. Rebar in SOG is considered secondary reinforcement as it does not increase the compressive or flexural strength of the slab. The role of secondary steel reinforcement is often misunderstood as having structural value and can rarely be justified in flatwork of appropriate thickness and mix design that is properly installed and jointed.

Types of Rebar and how they perform in Pervious Concrete

Steel Rebar

Steel is the most commonly used type of rebar and the least compatible with pervious due to the potential for damage to the slab from the increase in volume (expansion) of the steel as it oxidizes (rust). Rust can expand up to seven times the original thickness of the metal. The force of this expansion, if confined, can reach as high as 9,000psi. Contrast this to normal concrete which is only 3,000 or 4,000psi in compression and less than 1,000psi in tensile strength. The effect of this rust expansion and its

Figure 1

damage to structures, as illustrated in figure 1, is known as "rust jacking." * (The Power of Rust (CBI Consulting blog) July 12, 2013 By Robert G. Wilkin, P.E., SECB)

Adequate concrete cover protects the reinforcing steel in regular concrete from excessive moisture or chemical corrosion (think deicing salts). In a pervious concrete slab however, we are *intentionally* introducing water into the interior of the slab and any embedded steel would be exposed to generous amounts of water and or salts during every rain or snow melt event. This would serve to greatly increase the risk (verses regular concrete) of rebar oxidation (rust), expansion and the associated damage.

Epoxy coated Rebar

Epoxy coated rebar will certainly perform better as the impervious coating will protect the steel from moisture however, contrary to common belief that protection is not absolute. Considerable care must be taken in the shipping, handling and installation of epoxy coated rebar as the coating can be easily damaged. The epoxy coating has limited flexibility and common ninety-degree (or more) bends will likely result in damage to the coating as seen in figure 2. In addition, field cuts of the bars expose the steel which present a particular challenge. Field patching of both cut ends and damaged areas is possible but difficult to do effectively, assuming you can find and access all the damaged areas, and inferior to the original coating.

Figure 2

If a damaged epoxy coated rebar is used in regular concrete and has proper coverage, ideally 3" from face of slab, and the concrete is of sufficient density, exposure of the rebar to moisture and chemicals will be minimal and likely not present a problem. However, if used in a pervious concrete slab, regardless of the distance from the surface, the damaged rebar would be directly exposed to moisture during every rain event (not to mention every time a nearby sprinkler turned on). From a research paper titled "*CORROSION PERFORMANCE OF EPOXY-COATED REINFORCEMENT"* conducted for the Texas Department of Transportation:

Quality and consolidation of the surrounding concrete had an important influence on the corrosion of epoxy-coated bars. More corrosion was observed at surfaces surrounded by less dense, very porous concrete with more and larger voids.

Pay particular note to this part: "…***less dense, very porous concrete with more and larger voids***". This is in fact the very definition of pervious concrete. In other words the very conditions that research has shown will lead to poor performance of epoxy rebar is exactly the conditions it would intentionally experience in a pervious slab.

Fiberglass (RFB) /Stainless Steel

Fiberglass or stainless steel rebar would seem to be the obvious solution to the challenges outlined above as moisture is simply not an issue for these materials. Fiberglass seems particularly appealing as it is not susceptible to corrosion, is 2x the strength of steel, one quarter the weight and has a higher modulus of elasticity. Yet with all that going it fiberglass rebar, and in fact any rebar, still presents a problem.

Why rebar of any type should not be used in Pervious Concrete

The information and challenges presented so far not withstanding, there are additional problems involved with attempting to use rebar with pervious concrete in regards to placement challenges.

These problems occur in two primary areas; compaction around the rebar and concrete delivery methods, both of which can have a dramatic and detrimental effect on the integrity and strength of the finished slab.

Compaction around the bars

In a conventional concrete slab with rebar the concrete will readily flow and consolidate around the rebar. Pervious concrete however is a very low slump material which does not have the same flow characteristics of conventional concrete and needs to be mechanically compacted into place. This mechanical compaction typically takes place with a motorized roller which exerts a downward force on the concrete. As the pervious concrete is placed it separates as it encounters the rebar, but does not flow back together under the rebar, leaving a sizable gap as shown in figure 3. The only way to ensure the concrete is fully consolidated around the rebar is to manually hand pack the material using a wood or mag float but as you can imagine this would be both tedious and time consuming. To perform hand packing you could only fill the forms up to the rebar, hand pack around the bars, then fill the forms to the top in a second lift. Doing this would add considerably to the time it takes to get the material covered with the curing plastic which means we greatly increase the slab exposure time before covering. Since covering the slab in a timely manner to reduce moisture loss is critical to strength, this approach will lead to the opposite of the intended effect and reduce slab performance.

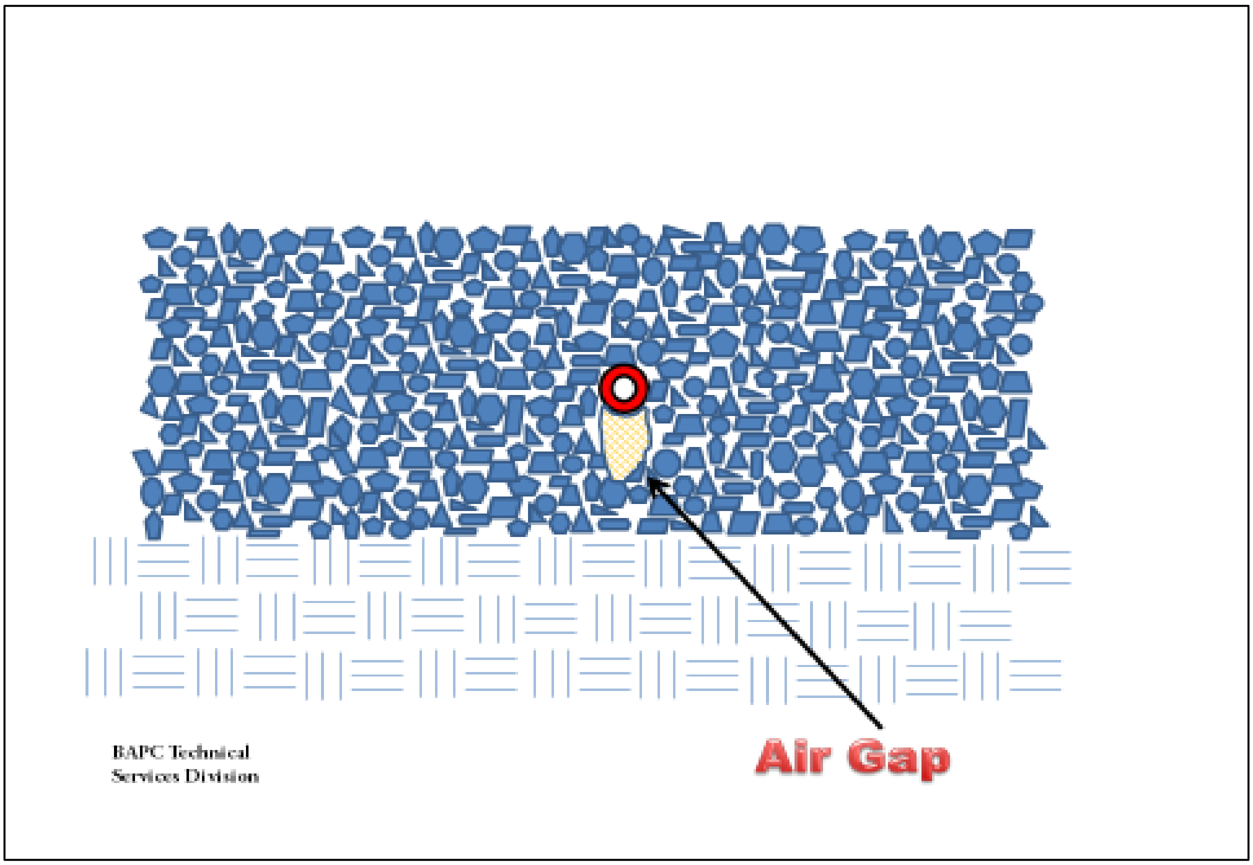

Figure 3

Delivery

Pervious concrete cannot be pumped which creates placement challenges. Most commonly the concrete truck is backed into the pour area and material delivered directly to the ground. When truck access is limited other delivery, methods are such as concrete buggies or skid steers are utilized. With a rebar mat on the ground however none of these methods would be possible. Using a telescoping belt is also a delivery method sometimes used with pervious concrete, and would not be affected by the rebar mat, but many sites do not have the space to accommodate such a machine and their use adds considerable cost.

IS REBAR NECESSARY ?

Steel reinforcement used in SOG to control cracks can actually increase the number of cracks by restraining shrinkage and creating additional stress forces within the slab. For this reason and others *ACI 330R Guide for Design of Concrete Parking Lots*, states that for a slab on grade designed with a proper section thickness and joint spacing “distributed steel reinforcement is not necessary.” This statement of course also applies to pervious concrete.

It is important to recognize that due to the challenges described in this paper using distributed steel reinforcement in a pervious concrete slab increases the potential for reduced performance, and as such should be avoided. In situation where additional performance is desired macro fibers such as *Forta-Ferro™* have been shown to provide significant improvements in crack control, toughness and durability in pervious concrete while having no negative effects.