The AlphaJoint and BetaJoint in action

(Photo: Permaban)

Figure 1: Two 10mm-wide, flat, sharp-edged strips provide the arris armouring with the diamond dowel providing the load transfer for ground-bearing slabs.

The importance of providing proper joint armouring and load transfer at free contraction joints was outlined in an article featured last year in *CONCRETE* magazine[1]. This article re-examines the individual important criteria of joint armouring and load transfer and considers alternative load transfer mechanisms for sawn joints and the potential for eliminating the fabric used in ground-bearing slabs.

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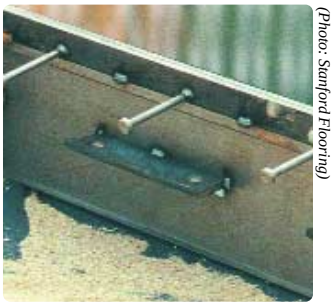
The steel top edge should be 10mm flat cold-drawn steel with a sharp edge each side of the joint to provide a level transition for wheels passing over the joint from one slab to the other (see Figure 1). The load transfer mechanism should be discontinuous, i.e. dowels at strategic centres. The dowel must provide the correct amount of load transfer between adjacent slabs and allow two-way horizontal movement but should not allow vertical movement (see Figure 2).



(Photo: Stanford Flooring)

Figure 2: The large Alpha dowel for suspended floors and large joint openings.

Testing joint systems

Testing of joint systems has shown that a continuous joint profile builds a weakness into the slab, as the depth of concrete is effectively reduced by the profile produced in the concrete, thus reducing the available depth to resist burst out forces to approximately one-third of the slab depth. This effect will become more prominent as the slab thickness reduces.

When manufacturing a profile, it is difficult to hold tolerance between two mating faces at the 5mm thickness of the profile. Any disparity in this fit between the two faces will result in vertical deflection of the joint, leading to degradation and breakdown of the joint arris. Research undertaken at both Loughborough University, UK[2], and Queensland University of Technology, Australia[3], has shown that even vertical movement as small as 0.1mm will result in degradation of the joint face.

(Photo: Stanford Flooring)

Figure 3: Reusable adjustable formwork fixing.

Fixing formwork

The fixing system should be easily adjustable to allow the joint to be set properly for line and final level. It is also important that the final level can be readjusted, if necessary, once the concrete has been placed and final level checks are being taken. Building owners worldwide are demanding these criteria be met, as they are only too well aware that poorly performing joints are a problem for the efficient running of their facility, increasing breakdowns and damage to forklift trucks and the floor. Figure 3 shows the simplicity of installation and the straightness of joint line that can be achieved.The only joints in the total 80,000m^2 were the free movement joints for each day's pour occurring approximately every 45m.

Nominally reinforced ground-bearing slabs

The joint described above is used as the only formed joint on ground-bearing slabs, but other improvements can be considered for this type of slab. In the UK, to facilitate the use of the laser screed, the reinforcing fabric has moved from the top to the bottom of the slab with 50mm bottom cover, generally using an A142 fabric, i.e. 6mm on 6mm diameter at 200mm centres. It was assumed that these sawn joints would open slightly at each joint and were positioned at approximately 5–6m centres in both directions. The reinforcement would yield slightly as the joint opened by up to approximately 2mm. This method is known as a 'nominally reinforced' ground-bearing slab (see Figure 4).

Results from the use of fabric

Several questions arise with the use of this fabric:

- Does the sawn joint open?
- Does the placing of the fabric at 50mm from the bottom of the slab and passing through the sawn joint position now effectively tie the bottom of the slab leaving the top of the slab with nothing to restrain the width of the joint opening?
- Has this created a greater potential for curling of the slab?
- What use does the fabric have within the body of the slab?

Throughout Europe and America the commercial and industrial property development market is facing a steel shortage. The resultant cost increases for steel reinforcement are therefore passed on from the floor contractor to the building owner. The feasibility of eliminating the reinforcement from the body of the slab in nominally reinforced slabs on ground should be considered, together with providing more effective load transfer with dowels at the sawn joints.

The American Concrete Institute's *Guide for concrete floor and slab construction* (AC1302-1R-04)[4] states that "In areas subjected to hard wheeled traffic, heavy loadings, or both, joints with dowels are recommended." In January 2005, the Fédération Française du Bâtiment is issuing a new standard for floor construction which will require all sawn joints to be adequately dowelled[5].

Re-evaluating steel usage

Engineers and contractors continue to use traditional

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design methods for slabs on ground incorporating reinforcing fabric. This fabric does not prevent concrete cracking because it is dormant until the concrete cracks. Once cracking occurs, the reinforcement comes to life and tries to prevent the crack opening further.

Slabs on ground are generally saw-cut every 5–6m. The 1970s publication, *Concrete ground floors*[6], stated "where slabs are to be unreinforced, the spacing of contraction joints should not exceed 6m." It was, therefore, clear 30 years ago that it was unnecessary to reinforce the slab if joints were closer than 6m. However, it is necessary to make sure that there is proper load transfer at joints for slabs exposed to wheeled traffic. Sharing loads across joints from one slab panel to the next reduces slab stresses and lessens joint damage by minimising differential deflection across the joint, most importantly to prevent spalling of the joint arris. Spalled arrises damage vehicles traversing them which, in turn, cause further damage to the joint arris, leading to spiralling degeneration.

There is evidence that sawn joints are only opening marginally, if at all, with nominally reinforced ground-bearing slabs and all movement is taking place at the free contraction joints (see Figure 5).

The previously described concept of using a continuous nominal light reinforcement such as A142 to provide joint load transfer makes economic sense only when the cost of continuous reinforcing is less than that of providing another form of load transfer mechanism. Where this cost advantage is not apparent, reinforcement in the middle of the bay can be relocated to the joints.

Some slab designers and contractors are now adopting what is called 'strategic reinforcement' by using plate dowel baskets at all sawn contraction joints and eliminating fabric reinforcement (see Figure 6). This provides the following potential advantages:

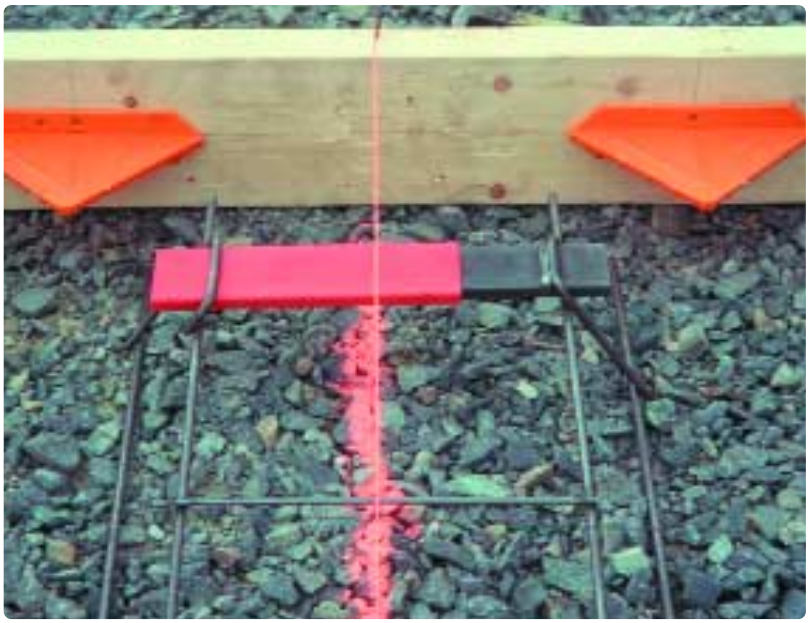
- plate dowel baskets can be installed more quickly and simply (while placing and laser screeding the concrete) rather than having to chair up the reinforcement during concreting
- compared to a full fabric installation, using plate dowel baskets reduces tripping hazard during construction

(Photo: Permaban North America)

Figure 4: Nominally reinforced with A142 fabric.

(Photo: Permaban)

Figure 5: A formed joint on a ground-bearing slab showing a 25mm opening.



(Photo: Permaban North America)

Figure 6: Rectangular plate dowel basket used with diamond dowels at formed joints.

- plate dowels with sleeves allow horizontal movement in two directions as the slab shrinks, eliminating the restraint to the adjacent slab along the joint line. This reduces the possibility of random cracking caused by the restraint of the fabric or conventional round dowels
- reduced potential for the slab to crack at joint intersections.

Concluding remarks

It is a matter for debate as to whether it is possible to overcome the cost increases incurred as a result of the price rise in steel by eliminating the fabric reinforcement from slabs on ground. By providing double 10mm-wide joint arris protection with diamond dowels for the formed free-movement joints and plate dowels in the sawn joints, horizontal movement in both directions will be provided along with better resistance to vertical displacement. The result will be the production of economical, durable, lower-maintenance floors, as desired by owners, while optimising the amount of steel reinforcement required. Appendix E of Concrete Society Technical Report 34 *Design with steel fabric reinforcement*[7] suggests that reinforcing fabric can be taken into account when calculating slab thickness. If designers are using an A142 fabric to reduce the thickness of the slab, it follows that the equation they have to consider is the potential cost saving of a reduced-thickness slab and the reliance on the adequacy of 6mm-diameter wire to provide their load transfer. ■

References:

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