DETAILING POSSIBILITIES OF FIBRE CONCRETE SLABS ON GROUND

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Abstract

Fibre reinforced concrete slabs on ground are important component in today's construction industry; for warehouses, production halls, concrete roads, airports, and similar applications of elastic embedded concrete slabs on ground. The field of application range from low loaded retail areas to heavily loaded slabs in the industry, from cold-storage buildings to heated floors in production facilities. Additional to the used cutting of small size joint spacing with areas of about 50 m^2, the excellent load bearing and deformation capacity, combined with the time and cost saving, led to the new challenges joint-less slabs up to 3000 m^2. Fibre concrete industrial slabs on ground can be combined perfectly with various surface systems: varying from spreaded surface hardeners to coatings of artificial resins. Durable industrial slabs on ground request detailed engineering and design, high quality products with industrial dispensing of fibres and the performance of skilled craftsmanship.

Keywords: Sla on ground, Concrete; Fibres; Reinforcement; Shrinkage; Joint; Joint-less; Coating; Design; Detailing

1 Introduction

The slab on ground is a slab supported by ground, whose main purpose is to support the applied loads by bearing on ground. The slab may be uniform or variable thickness, and may include stiffening elements such as ribs or beams. The concrete slab may be unreinforced, reinforced by fibres and/or reinforcing steel or post- tensioned steel. The fibres, reinforcement or post-tensioned steel may be provided to limit crack widths or minimize cracking resulting from shrinkage and temperature restraint and the applied loads.

The design of slabs on ground depends on the interaction between the concrete slab and supporting materials. Slab on ground failures usually occurs because a proper support system was not achieved. The slab support system consists of a subgrade, usually a base and sometimes a subbase – see Fig. 1. Soils in the subgrade are generally the ultimate supporting materials. If the existing soil has uniform strength and other necessary properties to support the slab, the slab may be placed directly on the existing subgrade. To improve surface or to elevate the floor level, controlled fill using on site or imported soils is usually required. For the decision whether to use the existing subgrade in its in-place condition, or improve it by compaction or stabilization, use a subbase and a base course, it is necessary to have information from the geotechnical engineering investigations.

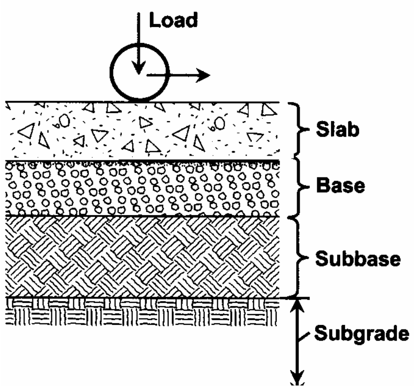
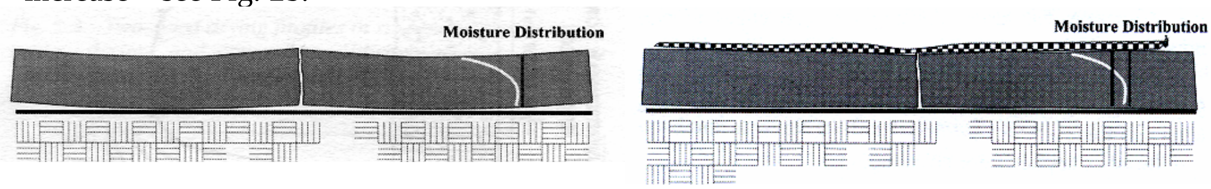


Fig. 1 Slab support system

Very important question for the project is, when use the vapour retarder (barrier) and its location and when use vapour sensitive coverings. Excess water in the slab not taken up for by chemical action will evaporate through the top of the slab until equilibrium is reached with ambient humidity. Additionally moisture can transpire from the subgrade and through the slab. If the base material is saturated or near saturation and there is no hydrostatic pressure, moisture can be transmitted into the slab by capillary action of the interconnected voids in the concrete. Positive subgrade drainage is necessary where water would otherwise reach the slab base. Although vapour retarders (barriers) can substantially reduce vapour transmission through the slab, some water vapour will transpire through the slab, if the vapour pressure above the slab is less than the bellow the slab. The vapour pressure is the function of relative humidity and temperature. The vapour drive is from high to low humidity and from warm to cold temperatures. The time required for changes in moisture distribution within the concrete slabs has an effect on slab curling and joint bulging.

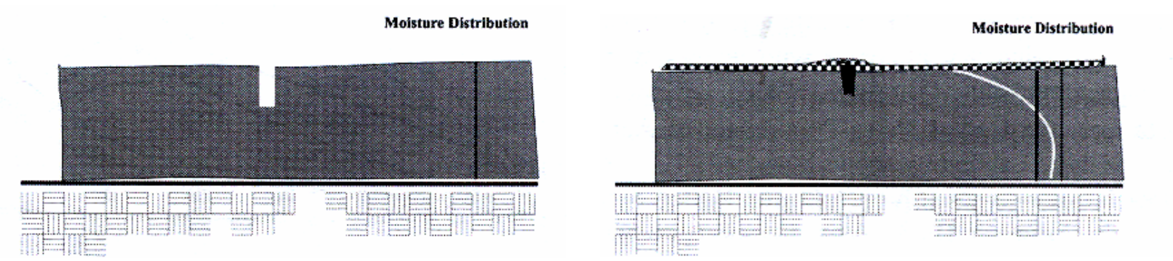
Concrete shrinks when it loses moisture, and expands when it gets moisture. When the top of a slab loses more moisture than the bottom, the differential shrinkage causes edges and corners of the slab to deflect upward. This is called curling or warping – see Fig. 2a. When a floor covering is installed, the moisture profiles changes, with moisture moving from the bottom to the top of the slab. This reduced, and may eliminate, the in initial curling deflection because the concrete at the top expands and the moisture content increase – see Fig. 2b.



a) b)

Fig. 2 a) Curling of the slab; b) Slab after installed floor covering

To minimize the random cracking, contraction joints in floors are in some cases used. After placing the concrete it is necessary start with the curing. These contraction joints must be cut before drying has occurred – usually either after final finishing or without 6 to 12 hours after – see Fig. 3a. It is recommended the saw cut with V shaped geometry, with the top opening wider than in bottom. The saw cut is filled before the final floor covering is placed. Moisture redistributes, concrete expands pushing joint filler up – see Fig. 3b.



a) b)

Fig. 3 a) Cut contraction joint; b) Slab after installed floor covering

It results from the previous, that the use and the location of vapour retarders (barriers) and the floor coverings require careful consideration – see Fig. 4.

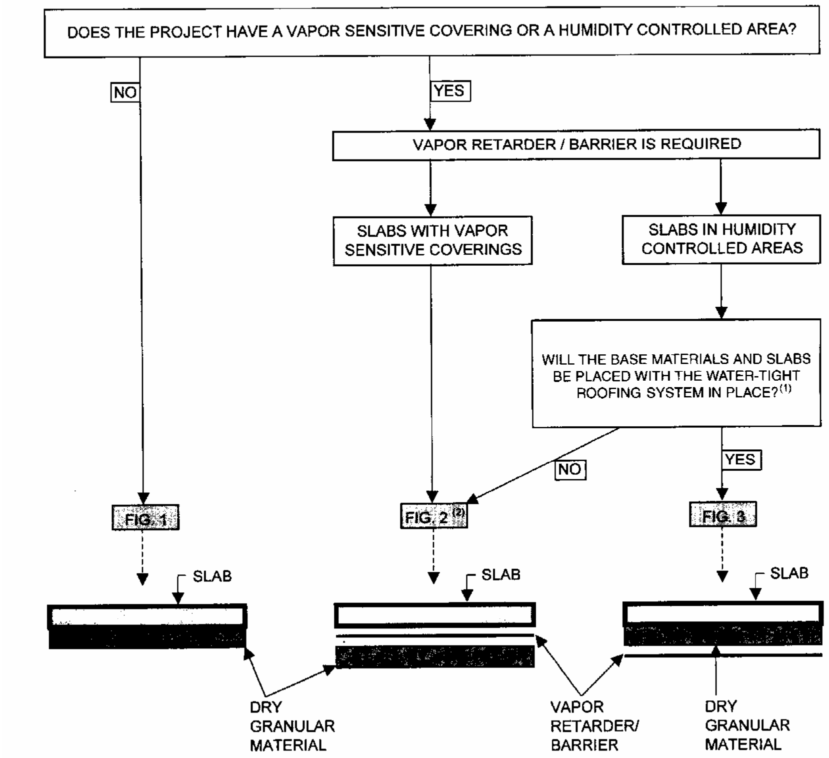


Fig. 4 Decision flowchart to determine if the vapour retarder (barrier) is required and where it is to placed

The special construction of slab on grade in cold-store buildings is used. The typical construction for this floor consists of a slab on a slip sheet on insulation on a vapour retarder (barrier) on either a soil base or a subslab – see Fig. 5. The slip sheet is typically a polyethylene film used as a break between the slab and insulation. The insulation may be in a single or multiple layers of extruded polystyrene board, rigid polyurethane board, or cellular glass board insulation. The vapour retarder (barrier) is under the insulation, a polyethylene film or bituminous materials have been used. For cold-store buildings the vapour retarders (barriers) are always installed on the warm side of the insulation.

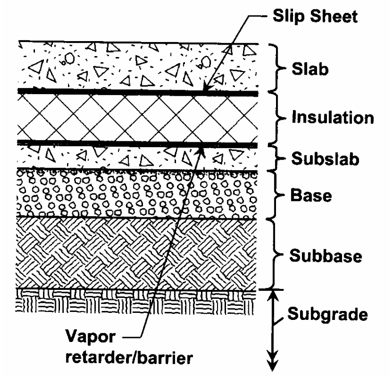


Fig. 5 Typical construction of slab on ground for cold-store building

2 Joints

Joints in slab on ground are usually used to limit the frequency and width cracks caused by volume changes. Generally, if limiting the number of joints or increasing the joint spacing can be accomplished without increasing the number of random cracks, floor maintenance will be reduced. It is necessary to avoid tying the slab to other elements of the structure. Restraint from any source, whether internal or external, will increase the potential for cracking.

It is recommended to classify the joints according to the movement that they allow, as follows: free-movement joints, restrain-movement joints, tied joins, isolation joints.

Free-movement joints are designed to provide a minimum of restraint to horizontal movements caused by drying shrinkage and temperature changes in the slab, while restricting relative vertical movement. Free–movement joins could be sawn, or formed – examples see Fig 6a, b.

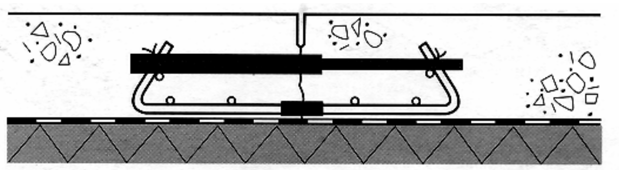


Fig. 6 a) Saw free-movement joint

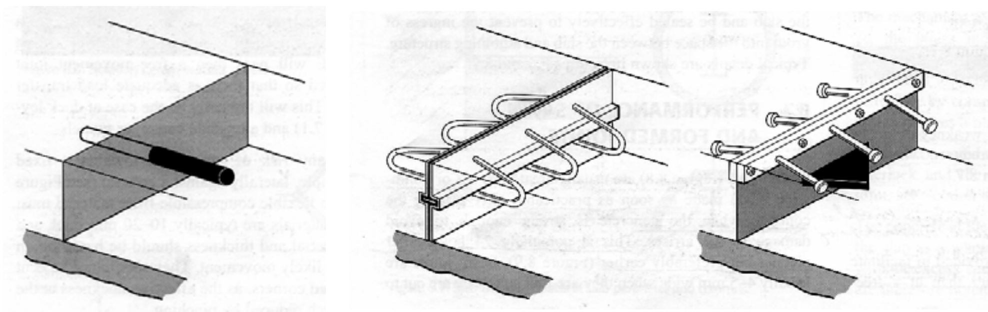


Fig. 6 b) Formed free-movement joint

Expansion joints are not normally used in internal floors, except those subject to above-ambient temperatures and to large temperature fluctuations. Usually the dominant movement is caused by drying shrinkage and ongoing thermal movements are much smaller. Cold store floors have greater thermal movements but the slabs do not expand beyond their as-constructed dimensions – the thermal expansion joints are not required. Expansion joints require for load transfer the de-bonded dowels or other mechanism.

Restraint-movement joints are provided to allow limited movement to relieve shrinkage-induced stresses at predetermined positions. Usually it is assumed, that the reinforcement is continuous across the joint. Restraint-movement joints could be sawn, or formed – see Fig 7.

Fig. 7 Sawn and formed restrained joint

The tied joints are sometimes provided to facilitate a break in construction at a point other than at a free-movement joint. A joint is formed and provided with the area of reinforcement high enough to prevent the joint opening. If concreting is interrupted long enough for the placed concrete is harden, a tied joint should be used. The reinforcement bars also provide load transfer – see Fig. 8.

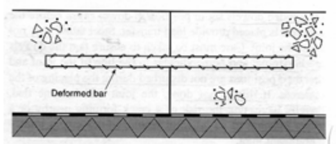


Fig. 8 Tied joint

Isolation joints should be used wherever complete freedom of vertical and horizontal movement is required between the floor and adjoining building elements – see Fig. 9a.

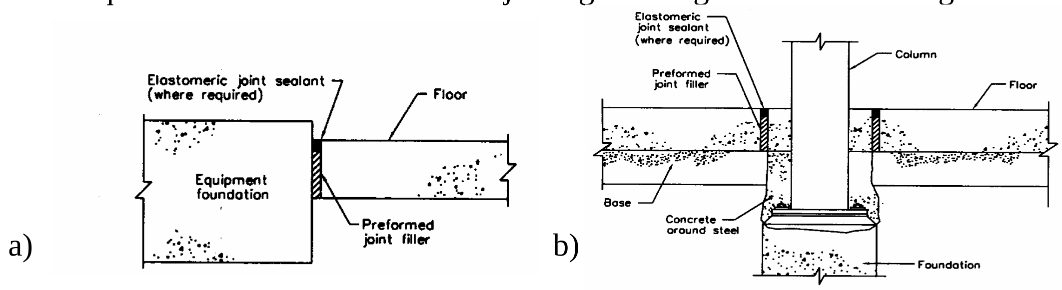


Fig. 9 Dilatation joints

Isolation joints are formed by inserting preformed joint filler between the floor and adjacent element. The joint material should extend the full depth of the slab and not protrude above it. Where the joint filler will be objectionably visible, or where there are the wet condition or hygienic or dust control requirements, the top of the preformed filler can be removed and the joint caulked with an elastomeric sealant – see Fig. 9b. The suitable and unsuitable locations of joints in the combination with isolation joints are demonstrated in the Fig. 10.

3 Reinforcement

Steel fibres are commonly used in concrete to provide load bearing capacity and for control of shrinkage-induced cracking. The composite concrete can have considerable ductility, which depend on fibre type, dosage, tensile strength and anchorage mechanism. In jointless slabs steel fibres on tough ground at doges in the order 35 - 45 kg/m^3 are used to control the width and distribution of shrinkage-induced cracks.

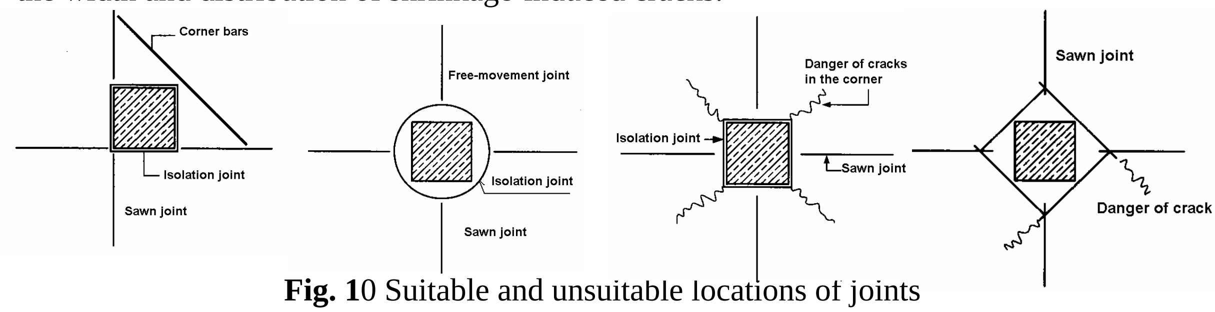


Fig. 10 Suitable and unsuitable locations of joints

In floors with sawn joints, dosages in the range 25 – 30 kg/m^3 are typical. Manufactures should have been asked for data demonstrate that dosages at the lower end of this range are effective (the continuity of fibres in the concrete can be guaranteed) and that there are the minimum ductility required in the ultimate limit state design. Well distributed steel fibres in concrete have no effect on wire guidance systems, but agglomerations of fibres may affect such systems.

Usually the steel fibres do not influence flexural tensile strength of concrete. Therefore very often they are used in the combination with bar reinforcement, or wire fabric. Traditionally, wire fabric was included with the intention of controlling shrinkage-induced cracking. But usually the proportion was in order f 0,1 to 0,15%. However, at these low percentages, there is insufficient steel to affect the crack width and crack distribution significantly. Percentages in the order of 0,4% would be required to achieve the limiting surface cracks widths of about 0,3 mm. When we used the lower percentages of wire fabric with the combination of steel fibres in concrete, it would be possible to achieve the limiting surface crack widths. Combining fibres and traditional or prestressing reinforcement for slabs on piles open new possibilities for slabs on ground applications on soft ground.

Synthetic fibres should be short polypropylene micro fibres and the larger synthetic fibres being developed for structural benefits similar to steel fibres. Polypropylene micro fibres are used in typical dosages 0,9 kg/m^3. These fibres cannot provide any significant post-first crack ductility and therefore they do not fulfil any structural role, as would steel fibres with proven structural performance. Structural synthetic fibres are larger and used at higher dosages than short polypropylene micro fibres. As the tests shown, it is possible used them in practice analogous to steel fibres.

This outcome has been achieved with the financial support of the Ministry of Education, Youth and Sports, project No. 6840770001

References

[1] ACI 302.1R-04 Guide for Concrete Floor and Slab Construction, ACI June 2004

[2] Technical Report No. 34 Third Edition: Concrete industrial ground floors, The Concrete Society, ISBN I 904482015, United Kingdom, 2003,

[3] DBV-Merkblatt: Industrieböden aus Beton für Frei- und Hallenflächen, Deutscher Beton- und Bautechnik- Verein E.V., November 2004