Superflat floor construction – how easy is it?

Superflat floors are required where very narrow aisle trucks are employed to place and pick goods stacked to heights over 12–13m, where the path of the truck is fixed and the truck is floor supported, i.e. it runs on the floor. Superflat floors are not required where the materials handling system runs on a crane rail – in fact floor tolerances to support these sorts of systems are quite often not very onerous at all.

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Where the trucks lift to over 8m, but less than 13m, a very flat floor is still required, but these are not strictly defined as 'Superflat' in the UK. For instance, Concrete Society Technical Report 34 (TR 34)[1] describes floors where the lift height is in the range of 8–13m as Category 1. There are a number of other worldwide specifications pertaining to very flat, defined movement floors, including DIN 15-185[2], which is widely specified by materials handling equipment manufacturers throughout mainland Europe. The term Superflat will therefore be used generically for the purposes of this article.

Figure 1: Completed Superflat floor.

(Photos: Monofloor Technology Ltd.)

Methods of construction

There are a number of methods used in the construction of these floors. There are three fundamentally different approaches to achieving these tolerances:

- construction in narrow strips with the aim of installing and finishing the concrete floor itself directly to the required tolerances
- construction of a base concrete slab and subsequently applying a finish to achieve the required tolerances
- construction of the concrete slab to 'normal' tolerances and using manual or laser-guided grinding to achieve the desired flatness.

The first of these methods is the most cost-effective and the one that is most widely used. However, the other two options should also be discussed briefly. In a number of countries a base slab is constructed and products such as Magnacite are applied to provide the Superflat wearing course. This product is extremely free-flowing and experienced installers can achieve DIN 15-185 tolerances. However, the product is unsuitable where the floor is likely to be constantly damp and, of course, there are two separate operations involved in the process. Similarly, with other products such as pumpable polymer-modified cementitious overlays, these are normally a minimum of 7mm thick. It is necessary to install levelling points carefully throughout the area to be cast, and while application of the product is straightforward, considerable care and skill is needed to achieve Superflat results (see Figure 1). This method is particularly suited to renovation of existing floors, where there is surface damage or major variations in level exist, or headroom restrictions prevent the use of concrete overlay. In the case of renovation, only the aisles and free movement areas can be 'up-graded'.

The practice of grinding of the aisles to convert large area slabs from the widely used TR 34 'FM2', or (preferably) 'FM2 Special' to 'Category 1' is now widely acknowledged. The extent of grinding varies considerably, depending on the overall standard of the original floor. However, if conversion of a 'normal' floor to Superflat is required, or it is decided to cast the slab deliberately to a lower standard and then use grinding to achieve the Superflat specification, more significant amounts of grinding will almost certainly be necessary. This may result in 'rutting' along the wheel paths of the trucks or, alternatively, full aisle-width grinding. The original finish will be lost, the aggregate will be exposed, and the concrete will normally require sealing. This method may be cost-effective for upgrading existing floors, new (e.g. in speculative units) or old, but it is the author's opinion that it is more cost-effective, and certainly more aesthetically pleasing, to plan and prepare to install new floors to the correct specification at the outset.

It is very likely that most Superflat floors will need some grinding, even when great care is taken to achieve the tolerances directly through the casting process itself. Opinions vary on the amounts to be expected, but a figure in the order of 3–5% of aisle length overall is often quoted. Anything less than this would be considered a success, particularly as Superflat floors are not as common as large area pours, and installation crews have to ascend a learning curve rapidly at the start of each project. However, many floors have been installed to Superflat specifications throughout the world, without the need for any grinding. Some basic procedures that will help to achieve such a successful installation are discussed in the following paragraphs.

Concrete consistency

Much of the success of a Superflat floor installation is determined in advance of the installation. The concrete mix and its consistent delivery are critical. The mix requirements for a Superflat installation may be different to normal. In order to achieve the desired tolerances, particular operations of 'cutting' and filling' need to be undertaken. As a result, bleed rates, finishability, setting characteristics and workability may all need to be modified. But most important is the consistency of concrete within and between loads of concrete. Variations in setting between loads make the achievement of Superflat tolerances very difficult, if not effectively impossible in extreme cases.

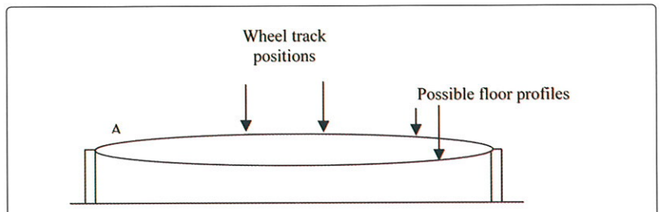
Joint location

The location of the joints is also important. Clearly these need to be located under the racking system, but the preferred location for achievement of the tolerances (midway between the back-to-back racking legs) is not necessarily the preferred location for the slab designer. However, locating the joints here is preferred because the 'strip' will then be symmetrical about the centre line of the aisle (see Figure 2). Therefore, any concave or convex shape that may result from the screeding operations will not show as a difference in elevation across the aisle. The DIN 15-185 specification is particularly onerous in relation to the transverse tolerances. As can be seen from Figure 2, by locating the strip equally about the centre line of the fork-lift truck path, variations that may occur due to 'floating' or 'sinking' of the straight edge, or plastic settlement of the concrete do not affect the transverse tolerances. If the joint was located close to one track of the fork-lift (for example at point A), there would be an 'automatic' slope across the aisle. In addition, plastic settlement of 1mm is not uncommon, thus most of the TR 34 Superflat or DIN 15-185 tolerance is lost immediately.

Similarly when pouring infill strips, there can easily be 1mm variation at the edge of the concrete already placed. This will then be reflected in the concrete placed against it. If, for example, at the other side of the strip being placed the concrete also has a 1mm variation, the further the truck runs away from the joints the better. Sequencing of placement should be arranged such that the number of infill strips is limited. The most accurate pours are likely to be those constructed with formwork either side. As far as possible, subsequent pours should be arranged such that one edge of the pour comprises adjustable accurate formwork.

Formwork systems

There are a number of different systems used for the formwork: metal, timber and a combination of the two. Whatever type is selected, it should be adjustable to 0.5mm or better. Diamond or similar plate dowels are preferred to round dowels both from a shrinkage crack control point of view but also to make the screeding process easier (no projecting dowels) and to facilitate easy stripping. There is no need to use armoured joints below the racking system, but some contractors use these as a matter of individual choice. All joints in trafficked areas should, of course, be armoured, including those across the end of the aisle strips. Transverse construction joints within aisles should be avoided. Joints are normally levelled using a precise level fitted with a parallel plate.



Joints located under centre of racks result in wheel tracks being symmetrically located

Figure 2: Effect of joint location.

There are many other factors to take into account when planning and designing Superflat floors. These are too numerous to list in this article, but the other most important preparation issues are to ensure that adequate resources, in terms of labour and specialist equipment are available, and that the floor can be constructed within a weather-proofed environment.

Procedures

Once installation is under way, concrete quality control is critical. After conventional placement of the concrete, a sequence of strike-off, rechecking of formwork, transverse sawing, longitudinal straight-edging, application of topping (where specified), repeated sawing, straight-edging and, if necessary, rechecking of formwork, follows at intervals regulated by the workability and setting rate of the concrete. Finishing, initially by 'panning' using a small, non-overlapping, ride-on trowel, takes place much later than usual, to minimise disturbance to the surface. In some cases, it may be necessary to restraighten the floor after the first pass of the power-float, but if the mix design and working of the surface has been done correctly, it is possible to have just one very late pass of the float pans prior to commencing power-trowelling. Curing is done in the normal way, but care needs to be taken with the application of spray-applied membranes to ensure an even coverage so as not to have an effect on the surface tolerances achieved. Prompt surveying of the floor, particularly during the early stages of a project, with informed feedback to the operatives from the supervisors is critical.

Dry-shake toppings

Sometimes, there may be a requirement to install coloured Superflat floors. This can be achieved using dry-shake toppings incorporated into the surface during the sawing or straight-edging process. However, although the better products are helpful in providing 'fat' to aid the cutting and filling operation, which is an integral part of the straight-edging, there is an increased risk of delamination with most of the products available in the UK due to the fineness of their gradation. If inadequate topping is applied, grinding may expose the 'natural' concrete below. In addition, the application of the topping needs to be done very evenly, and most contractors consider it more difficult to achieve Superflat tolerances when a dry-shake is specified.

It is not necessarily the case that dry-shake toppings make the achievement of Superflat tolerances more difficult, but a common method of achieving Superflat floors in Europe and the eastern Mediterranean countries is by the application of a 'fresh-on-fresh' topping. This method comprises laying of the base concrete, readjusting the

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formwork, carrying out an early initial power-floating operation and then applying a 'slurry' of topping material up to 10mm thick. The aggregates used in the topping have a larger maximum size and different grading to dry-shake toppings, but the blend with cement is similar. The water/cement ratio of the topping tends to be in the order of 0.35. This results in a very narrow window in which to carry out the sawing and straight-edging operations. However, the best trained teams can achieve Superflat tolerances without the need for grinding. Not only is this system advantageous in the case of coloured floors, but it also results in a fibre-free surface where steel fibres are used for structural purposes in the base concrete.

Superflat jointless floors

At least one eastern European contractor can install floors to the tightest DIN 15-185 tolerances using a combination of the standard methods and 'wet-screeding' controlled by precise level. This is helpful in order to provide 'jointless' steel-fibre floors, when compared with the normal 'long-strip' method, which normally results in unacceptable aspect ratios for such floor designs. Another method of achieving 'Superflat jointless' floors is by placing an accurate large pour slab and bonding, typically, 70mm-thick 'Superflat strips' to this using a special bonding agent and employing particularly highly skilled labour. Being structurally bonded, the overall depth of the slab is unaltered using this method.

Concluding remarks

In the USA post-tensioning of Superflat floors is common, and the techniques vary slightly compared with European practice. Common in all parts of the world is the need to select the right mix, employ tight concrete quality control and to carry out every operation diligently. Levelling of the formwork is critical, but so is the skill and attention to detail of every operative involved. Hand edging is important for example, even though the joint is located under the racks. This is to ensure that the level of the edge, which becomes the support for the strike-off and sawing beams for the adjacent pour, is tightly controlled. If any one operation is not correctly done, or the job is under-resourced, achieving Superflat tolerances becomes almost impossible. ■

References:

1. THE CONCRETE SOCIETY. Technical Report 34, *Concrete industrial ground floors – a guide to design and construction.* Third Edition, Camberley, 2003.
2. DEUTSCHES INSTITUT FÜR NORMUNG. DIN 15-185: *Warehouse systems with guided industrial tracks: requirements on the ground, the warehouse and other requirements.* Berlin, 1991.