Technical advice from
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Floor Tolerances

measurements from around the world

In keeping with this issue's floor theme, this month's problem clinic outlines some of the different methods of specifying acceptable slab tolerances that exist around the world.

Kicking off with the local condition, in New Zealand we have two standards that specify tolerances. The first, the Concrete Construction Standard NZS 3109, provides floor tolerances to ensure that structural behaviour is not impaired. It does not specify tolerances for the serviceability or usefulness of the floor. However, floors generally have to meet two independent tolerance criteria: elevation and flatness. NZS 3109 requires the elevation to be within ±5mm of that specified.

The more important standard for tolerances is NZS 3114, which specifies flatness tolerances in more detail. The standard specifies 11 different finish types designated U1 to U11. The most common, U3 trowelled finish, requires abrupt changes to be less than 3mm and gradual deviations for exposed interior floors to be less than 5mm (refer Figures 1 & 2 for definitions). These tolerances are regarded as achievable with accurate placement of screed rails and carefully controlled levelling, floating and trowelling operation.

Across the Tasman in Australia, floor flatness is measured by the deviation from a 3m straight edge. This is subtly different from the approach used in NZS 3114, as it implies a ± deviation from a straight line, and it is a little easier to check. Figure 3 shows how a 3mm deviation from a 3m straight edge would be determined on site.

The Australian NATSPEC provides guidance on three classes of surface finish:

- CLASS A , maximum deviation from a 3m straight edge is 3mm
- CLASS B , maximum deviation from a 3m straight edge is 6mm
- CLASS C , maximum deviation from a 600mm straight edge is 6mm

The classes do not really relate to end use but more to the construction method. A screeded floor should be able to achieve Class C, while a machined trowelled surface should achieve Class A. The Class A specification is similar to, but a little less stringent than, the NZS 3114 requirements.

Although simple, one of the drawbacks of using a straight edge is that verification is time consuming. In addition, results are not repeatable.

In the United States, ACI 302 provides another evaluation method. This is normally called the F number system, as the floor is described by two numbers identified as the flatness (FF) and levelness (FL). Figure 4 illustrates the terms level and flatness. The FF number measures the curvature over a 600mm length, and the FL levelness over a 3.05m length. Since slab curling can affect the FL number, the survey should be completed within 72 hours of slab installation.

> The higher the numbers, the flatter and more level the surface. The scheme has an advantage in that the numbers are determined using a small machine that is simply pulled over the surface.

ASTM E 1155 describes how the FF and FL numbers are calculated using the sample readings and the standard deviations of these readings. Table 1 provides typical values that are specified in the USA. Although not directly comparable, an FF value of 25 is approximately similar to the NZS 3114 tolerance requirements.

The UK Concrete Society has recently produced a supplement to its technical report TR34, entitled Concrete Industrial Ground Floors - Specification and Control of Surface Regularity of Free Movement Areas. Free movement areas are areas where multi-direction travel can be expected, for example, the zone at the end of an aisle, or in wide or narrow aisles, where the forklift, or reach truck, front loads. (In very narrow aisle warehouses, the wheel path of the trucks is very well defined and separate tolerances are provided for these defined movement areas).

Table 2 summarises the tolerances recommended by the UK Concrete Society for various floor classifications. Floor Classification FM1 is rarely used, being particularly onerous. FM3 is the most common floor classification.

So there you have it: four different countries, four different floor tolerance measurement schemes. The UK Concrete Society's method is probably the most practical compliance check in most situations. Each scheme has its advantages and disadvantages, however, and which is best for your project will depend on the accuracy required.

Table 1: Typical Specified FF and FL Numbers

Floor profile category	*Random traffic floors*				*Defined traffic*
	Specified overall no's		*Minimum local no's*		*Floors F minimum*
	F_F	F_L	F_F	F_L	
Offices - Carpeted	19	13	13	10	19
Offices - Vinyl	25	17	13	10	25
Warehouse/Factory	38	25	19	13	38
'Flat' Warehouse/Factory	50	33	25	17	50
'Very Flat'	75	50	38	25	75
'Super Flat'	100	66	50	33	100
'Ultra Flat'	150	100	75	50	150

Figure 1 – NZS 3114 Definition of abrupt variation

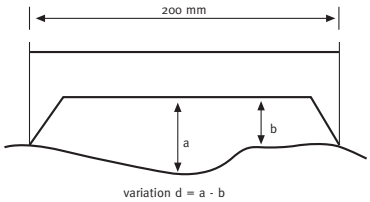


Figure 2 – NZS 3114 Definition of gradual variation

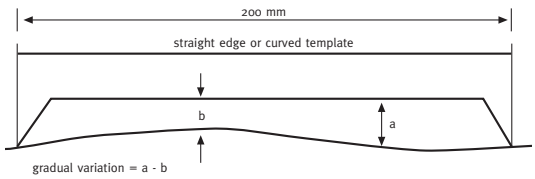


Figure 3 – Australian straight edge testing of surface regularity

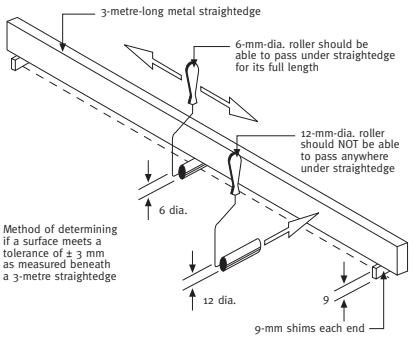


Figure 4 – Illustrates the terms 'level', 'flat' and 'gradient'.

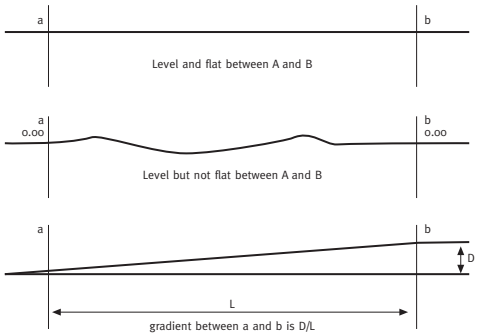
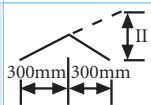
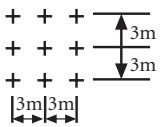


Table 2: Surface Tolerance Recommended by the UK Concrete Society

Floor classification	*Location*	*Maximum permissible limits (mm)*		
		Property II	*Property IV*	
			A	*B*
FM1	Hover transport and areas of special consideration	2.5	3.0	4.5
FM2	Wide aisle warehouses – automatically guided transfer vehicles – transfer aisles	3.5	5.5	8.0
FM3	Wide aisle warehouses using counter balanced trucks. Manufacturing facility – general warehousing for block stacking.	5.0	5.5	8.0



Difference in slope over 600mm



Difference in elevation of points on a 3m grid