Suspended Slabs Flatness Tolerances

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Introduction

The tolerance limits in NZS 3114 have proved to be problematic for flooring contractors. Actual practice has shown that the current New Zealand standards for concrete surface finish tolerances for suspended slabs are not achievable. This article considers what the current New Zealand standards for surface finish are and suggests what tolerances can be reasonably achieved. An alternative method of measuring surface finish tolerance is discussed which may offer a better alternative to the current tolerance provisions.

There are two issues to consider when specifying floor finish: flatness and levelness. Figure 1 illustrates the differences. This article considers only flatness tolerances.

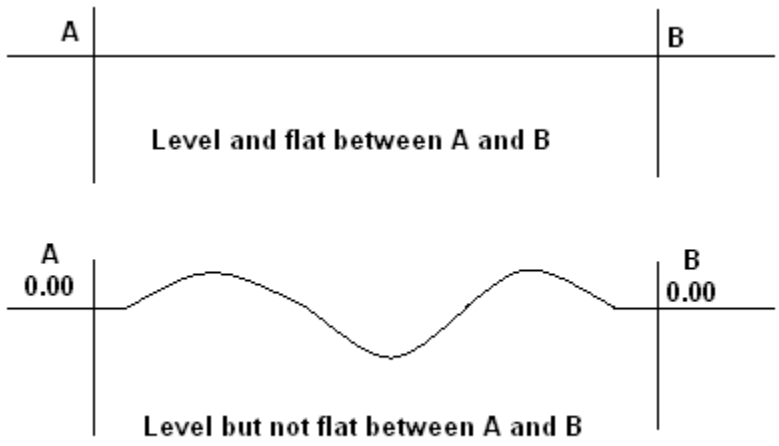

Figure 1: Illustrates the terms 'level', 'flat' (Cook)

Current New Zealand Surface Flatness Tolerances

In New Zealand NZS 3114 specifies the flatness tolerances for concrete placement. 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. For interior floors covered with thin sheet tiles abrupt changes must be 0 and gradual deviations less than 3mm. For interior floors covered with carpet abrupt changes must be 0 and gradual deviations less than 5mm.

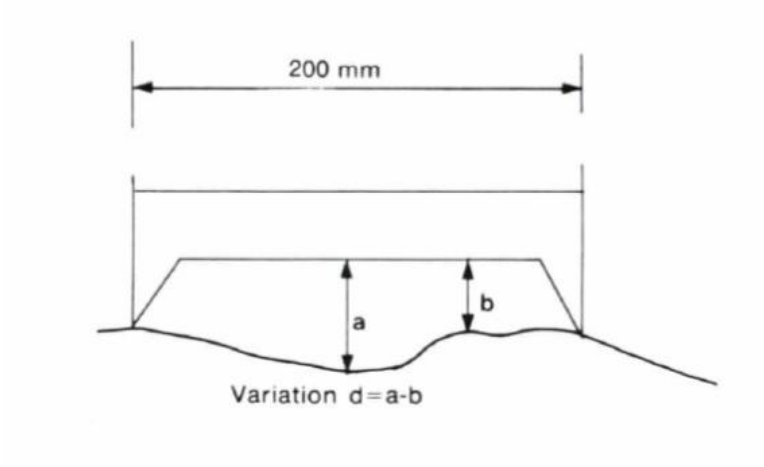

Figure 2: Abrupt Variations or Offsets (NZS 3114:1987)

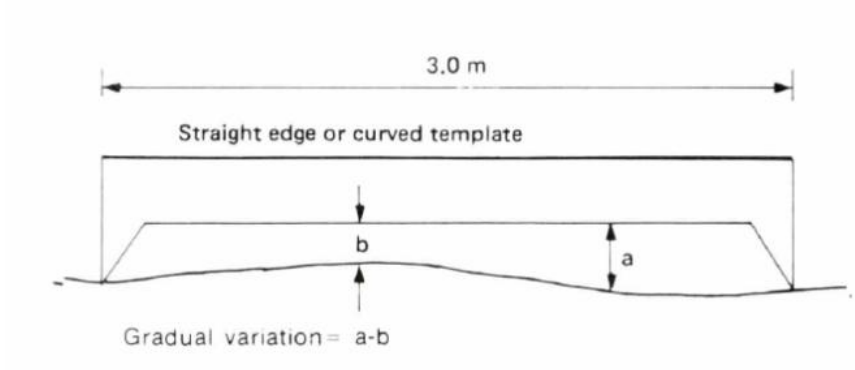

Figure 3: Gradual Variations (NZS 3114:1987)

There are several problems with the approach in NZS 3114. First of all there is no standard procedure to take measurements. Because of this measurements are non-repeatable and this leads to problems in verifying results.

Secondly the tolerances given are totally unrealistic for suspended floors. Measurements on typical concrete floors on grade in the United States found a variation of ±16mm in 3m was typical. (11) The NZS3114 criteria is 3mm over 3m. This shows the NZS3114 criteria to be particularly severe. As greater control can be achieved for slab on grade than for suspended slabs then the NZS 3114 tolerance criteria is obviously extremely hard to achieve for suspended slabs without post concreting levelling or grinding.

The United Kingdom experience is that a 3mm variation over 3m is not achievable on suspended floors of any construction. Rather they found that a variation of 5mm may be achievable on parts of a composite floor, but will not be achievable over all of a floor. A 10mm variation may be achievable over most of a floor depending on the deflections of the supporting beams. (6)

F-Number System to ASTM E1155M-01

In the United States of America, due to deficiencies of the straight edge approach, a different system of measuring floor flatness has been developed. The system is commonly referred to as the F-Number system. The procedure is covered in ASTM E1155M-01.

The F-number system test method provides two separate F-numbers, one for flatness and one for levelness. The flatness F-number F_F controls local surface bumpiness by limiting the magnitude of successive 300mm slope

changes. The Levelness F-number F_L controls conformance to design grade by limiting differences in departures from the design grade over distances of 3m when measured along sample measurements lines.

Straight lines are marked at various locations on the floor surface. Point elevations are then measured at regular 300 mm intervals along each line. The elevation differences between all adjacent reading points are calculated, and a straight line approximation to the surface profile along each measurement line is produced and evaluated for consistency with visual observations of the floor surface.

The arithmetic differences between all adjacent 300 mm elevation differences and the elevation differences between all points separated 3 m are then calculated. Estimates of each test section's floor F_F Flatness and F_L Levelness F-Numbers are obtained through statistical analyses of these calculated profile values. Finally the F-Numbers of each test section are combined to arrive at a composite set of F-number for each test surface.

Measurements must be made within 72 hrs of the concrete pour, before removal of any shoring, but not over construction joints nor within 600mm of floor penetrations. A time limit is required as flatness varies over time.

Devices, called dipsticks, have been developed to quickly measure and record floor surface profiles. A single operator with a dipstick can collect enough readings in 60 to 90 minutes to measure the typical day's slab on grade placement. Extra care is required for suspended slabs, however 1800 to 2300 square metres can be measured in two to two and a half hours.

The American Concrete Institute has developed recommended F-numbers for suspended slabs. Two values are given for flatness, a specified overall value, and one for the minimum quality level that will be accepted without repair. Minimum local values are generally set at 67 percent of the specified overall values. No recommended values are given for levelness.

The accepted F numbers for suspended floors as follows. (1)

Table 1: Acceptable ACI F numbers

Floor Use Category	$F_{F,typ}$	$F_{F,min}$
Floors with fixed partitions, non critical floors such as mechanical rooms, non public areas, surfaces to have raised computer flooring, surfaces to have thick set tiles and slabs in carparking buildings	20	15
Commercial buildings, lightly trafficked office/industrial buildings	25	17

The older method of using a 3m straight edge may also be used to measure floor flatness, but this is much less satisfactory than the F-number system. When straight edge tolerances are specified, 100% compliance is unrealistic. Compliance with four of five consecutive measurements is more realistic.

F_F numbers may be approximated to tolerances for 3m straight edge as given in table.

Table 2: 3m straight edge equivalent to FF numbers

FF Number	Rough Equivalent to 3m Straightedge
FF20	±8.0mm
FF25	±6.4mm
FF50	±3.2mm
FF100	±1.6mm

Conclusion

The current tolerances for surface finish of concrete slabs from NZS3114 are not reasonably achievable for suspended slabs. There are two issues to consider: flatness; and levelness. The recommendation is to use of the American F-system for measuring flatness. This system has the advantage of a defined procedure for measurements, is repeatable and there is equipment available to measure floor surface profiles quickly and economically.

References

(1) ACI 302.IR-04 Guide for Concrete Floor and Slab Construction; American Concrete Institute, Farmington Hills, MI, 2004

(2) ACI 117-90 Standard Specifications for Tolerances For Concrete Construction and Materials; American Concrete Institute, Detroit, USA; 1990

(3) ASTM E1155M-01, Standard Test Method For Determining F_F Floor Flatness and F_L Floor Levelness Numbers [Metric]; American National Standards, Washington, USA. 2001.

(4) Clifton C., Zaki R., HERA Report R4-107:2005 Composite Floor Construction Handbook, Manukau City, 2005

(5) Cook, D., Floor Tolerance Measurements from Around the World; New Zealand Concrete, March, April 2001, pp 30,31

(6) Couchman G H, Mullet D L, Rackham J W., Composite Slabs and Beams Using Steel Decking: Best Practice for Design and Construction, SCI Publication P300, The Steel Construction Institute, United Kingdom, 2000

(7) Suprenant B., The Concrete Floor Tolerance/ Floor Covering Conundrum; Concrete International, 2003

(8) Standards New Zealand, NZS3404: Part 1: 1997 Incorporating Amendment No. 1 and Amendment No. 2, Steel Structures Standard, Wellington, 2007

(9) Standards New Zealand, NZS3109:1997 Incorporating Amendment No. 1 and Amendment No. 2 Appended, Concrete Construction, Wellington, 2004

(10) Tolerances for Suspended Concrete Slabs Position Statement #24; American Society of Concrete Contractors,

(11) www.faceco.com/40q.html