Suspended Slabs Level Tolerances

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Introduction

There are two issues to consider when specifying floor finish: flatness and levelness. Figure 1 illustrates the differences. This article considers levelness tolerances. Steel Advisor article CMP1004 discusses flatness tolerances

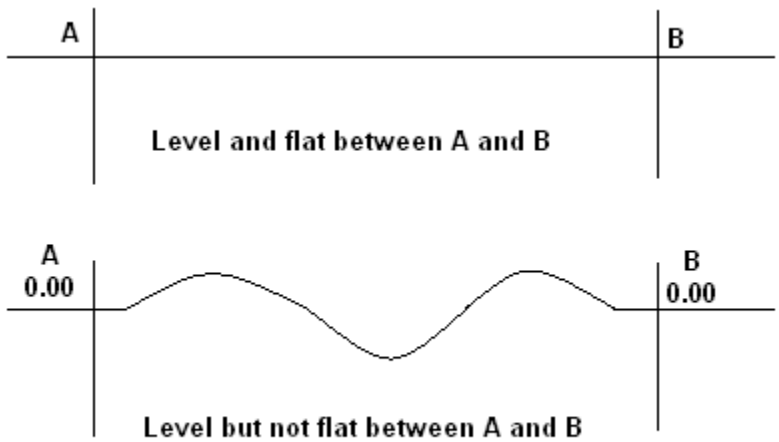

Figure 1: Illustrates the terms 'level', 'flat' (Cook)

Levelness

The achievement of levelness tolerances is problematic. Levelness for suspended floors depends on the location and nature of the supporting structure relative to the point being measured and the deflection of the supporting structure in response to concreting.

There are two options for screeding concrete on suspended slabs: screeding to level; screeding to concrete thickness.

Tolerances of the supporting steel structure are specified in NZS3404 Steel Structures Standard. NZS3404 provides tolerances for individual items/connections and also provides an overall building steel structure tolerances. For example the level tolerance for beams relative to connected elements such as supporting beams and columns at each floor level is given as ±10mm. See figure 2.

The tolerances for the height to the top of steel beams at a particular floor level are given as:

±20mm for heights ≤ 30m

±20mm + 0.25(height – 30)mm for heights greater than 30m

Figure 2: Level tolerance for beams connected to supporting elements

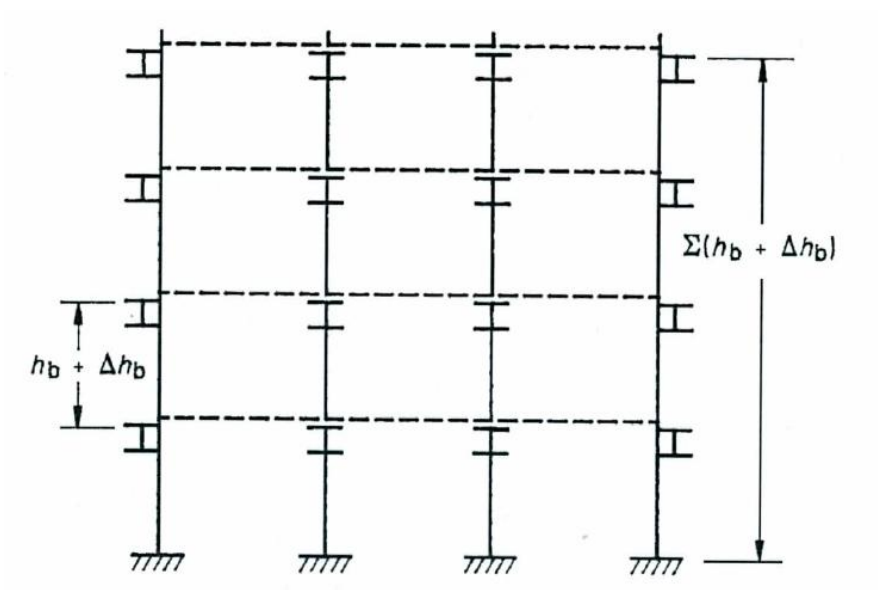

Figure 3: Deviation in heights (Figure 15.3.7.2 NZS3404)

For the concrete slab NZS3109 gives acceptable cross section thickness as:

±5mm for cross sections less than150mm

+10mm, -5mm for cross sections between 150mm and 300mm

British Standard BS 5606:1990 *Guide to accuracy in building* provides a method to combine tolerances. The method considers that the maximum limits on individual tolerances are highly unlikely to occur in combination. Therefore takes a square root of sum of squares approach. I.e.

$$\Delta_{Total} = \sqrt{\Delta_1^2 + \Delta_2^2 + \Delta_i^2}$$

Illustrations of how this approach can be used are given in tables 1 and 2. Table 1 illustrates the combination of permitted tolerances for a steelwork erector. For the sake of this illustration it has been assumed that the level of the top of the footing is at the correct level. Table 2 illustrates the combination of permitted tolerances for the concrete placer and shows what variance in levels can be expected if the concrete is screeded to thickness. The maximum permitted variation in supporting steelwork levels has been taken. Table 2 assumes that there is no deflection of the supporting structure i.e. the floor and steelwork are propped. If absolute levels are specified for the top surface (i.e. screeded to level) relative to a datum at that level at 4 columns then the expected variation on slab thickness would be equal to the expected variation in levels for concrete screeded to thickness. (i.e. ±15mm)

Table 1: Level Variations for Steelwork Erector

	Variation (mm)	Source
Top of footing	Assumed to be at correct level	
Underside of steel base plate	±10	NZS3404 cl15.3.2.2
Connection of primary beam to column	±10	NZS3404 cl15.3.5(c)
Connection of secondary beam to primary beam	±10	NZS3404 cl15.3.5(c)
Fabricated precamber of secondary beam	+0, -10 i.e. ±5	NZS3404 Table 14.4.5 Note 1
Total expected variation	$=\pm\sqrt{(10^2+10^2+10^2+5^2)}$ $=\pm18.0$	
Maximum permitted variation in overall height to top of steel	±20	NZS3404 cl15.3.7

Table 2: Level Variations for Concrete Placer – Concrete Screeded to Thickness

	Variation (mm)	Source
Connection of primary beam to column	±10	NZS3404 cl15.3.5(c)
Connection of secondary beam to primary beam	±10	NZS3404 cl15.3.5(c)
Concrete slab cross section ≤150mm	±5	NZS3109
Total expected variation	$=\pm\sqrt{(10^2+10^2+5^2)}$ $=\pm15$	

Notes: 1) Floor and steelwork propped, deflection of supporting structure not taken into account

The American Concrete Institute recommends that no levelness tolerance shall apply to slabs placed on a supporting structure that is unshored, cambered, or inclined. This is because the final deflected shape of the slab influences the floor levelness and is not solely a function of the concrete placement.

American Society of Concrete Contractors recommends if the project specifications require a level floor then the level of the top surface shall fall within a ±20mm envelope. This envelope is not related to the absolute design elevation. It simply requires that all elevation measurements on the slab surface vary by not more than 20mm from the average elevation. As levelness varies in time, measurements must be made within 72 hours and before removal of any propping.

If screeded to level the concrete thickness will vary and may exceed the thickness tolerance of NZS3109. Up to 20% extra concrete may be required and the extra weight should be taken into account in Engineers calculations. The extra volume will need to be allowed for and contractors who if they base the required volume of concrete per floor on the specified slab thickness alone will face a cost over-run due to the extra concrete required.

If the floor is screeded to thickness then this requires the concrete placers to place concrete to a constant thickness. To achieve a finished floor levelness within specified acceptance limits when screeding to thickness requires one of the following:

- Either all the supporting secondary and primary beams to be propped or appropriately precambered for self and concrete weight

- Or for these beams to be of sufficient size and support fixity such that wet concrete deflection on both sets of beams is minimal (about 10mm maximum)

Conclusion

Specifying a levelness tolerance criteria is problematic for suspended floors as levelness depends on the location and nature of the supporting structure relative to the point being measured and the deflection of the supporting structure in response to concreting. The recommendation is to follow the American Society of Concrete Contractors recommendation. That is if the project specifications require a level floor then the level of the top surface shall fall within a ±20mm envelope and as levelness varies in time, measurements must be made within 72 hours and before removal of any propping to show compliance with the specification.

To ensure that the design assumptions are met the engineer must specifically state on the drawings the suspended slab construction requirements and these are:

(a) The required extent of propping of the deck and any supporting beams;
(b) The required precamber of beams;
(c) Whether the concrete surface shall be screeded to level or screeded to concrete thickness.

British Standard BS 5606:1990 *Guide to accuracy in building* provides a reasonable method to combine tolerances. The method considers that the maximum limits on individual tolerances are highly unlikely to occur in combination. Therefore takes a square root of sum of squares approach. I.e.

$$\Delta_{\text{Total}} = \sqrt{\Delta_1^2 + \Delta_2^2 + \Delta_i^2}$$

References

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