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TOLERANCES for Concrete Surfaces

INTRODUCTION

Tolerances are provided to ensure the finished concrete surface is acceptable for the application and the intended function. Setting tolerances also demonstrate that some degree of variation is inherent in all building work.

The position of the concrete element, its function, appearance and the influence of these on the total project would, in many cases, define the appropriate tolerances. On the other hand, tolerances must also be reasonable, i.e. both achievable and able to be checked in the field using the available techniques and at acceptable cost. The importance of specifying appropriate tolerances becomes apparent when the outcome fails to meet the original expectations.

TOLERANCES can be defined as the allowable variations from the specified values or performance levels.

Some Australian Standards specify tolerances for concrete surfaces and it is important to understand their relevance or limitation for particular applications. This Datasheet reviews the tolerance requirements in various codes and standards, provides guidance on appropriate tolerances (particularly for unformed surfaces) and discusses the issues involved in achieving the specified tolerances.

DEFINITIONS

- **Formed Surface:** A Surface requiring formwork to provide shape and texture/finish to the concrete.
- **Unformed Surface:** A surface that does not require formwork to provide either shape or finish to the surface, e.g. the top surface of slabs or pavements.

These surfaces generally have to meet two independent tolerance criteria: the 'flatness' of the surface and variation from the designed elevation (levelness).

- **Flatness:** The deviation of the surface from a straight line joining two points on the surface.
- **Levelness (elevation tolerance):** The permitted vertical variation of the surface from a fixed external reference point or datum.
- **Assessing Tolerances:** It should be noted that measurement for assessment of "as-constructed tolerances must be made within 24 hours to 72 hours of construction.

The reason for this is that factors, outside of the construction process may influence measurements made outside of this time period (e.g. release of propping on suspended slabs and beams, ground movement under slabs cast on ground, shrinkage and curling effects etc.). In the case of columns and walls, measurement should take place as soon as is possible after formwork removal.

MEASURING TOLERANCES

As the specification of tolerances is dependent on the method of measurement, this is usually determined first. While the two common methods used in Australia are the optical and straightedge, methods include:

Optical

Optical survey instruments can be used to measure the levelness, flatness, position or plumb of an element. For pavement or slab levelness and flatness, spot checks on a grid

pattern are often made. If relying entirely on spot measurements, the grid size may be quite small, say 0.5m. Combined with a straightedge, readings may be taken on, say, a 3m grid, with a straightedge used to check the variation between measured points. Instruments can have an accuracy of 0.1mm, and computer topographical maps drawn indicating slab contours to assist with the evaluation. Since small grid sizes may be required, the cost of this method should be evaluated, particularly when used over large areas.

Straightedge

Tolerances can be determined by placing a straightedge anywhere on a concrete surface in any direction and measuring the maximum deviation of the surface from the straightedge (see Figure 1). The use of a 3m straightedge has been found to be a simple and generally satisfactory method of measurement in Australia. A shorter length (0.3m to 15m) straightedge is one of the methods for measuring surface tolerances of formed concrete prescribed by AS 3610.1¹. The variation from the straightedge is typically expressed as a maximum deviation value over the straightedge length but can be assessed by the method provided in ACI 117⁴.

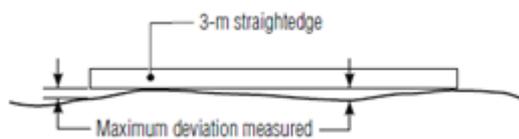


Figure 1: Testing the surface for compliance using a straightedge.

While the 3m straightedge technique is simple, inexpensive and widely used, one of the deficiencies of the method includes the difficulty in testing large pavement areas. Other deficiencies include inability to reproduce test results and failure of the method to assess the acceptability of irregularities such as steps and surface undulations (often referred to as waviness – see Figure 2).

The length of the undulations in an unformed slab surface is an important consideration when choosing the length of a straight edge.

Shorter (300mm and 1500mm) straightedges as specified in AS 2610.1¹ for formed surfaces could be used provided the length of the straightedge exceeds the maximum length of undulations. It is common for the length of undulations in the unformed surface of slabs to

vary from 600mm to 3m, so care should be taken when selecting a straightedge less than 3m for this assessment (see Figure 2).

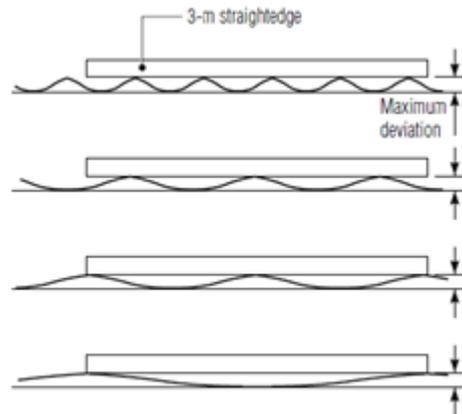


Figure 2: 3m straightedge tolerances fail to assess surface undulations (waviness).

A better method of using a 3m straightedge and assessing its resulting test data is provided in ACI 117⁴. This standard recognises the difficulties in assessing straightedge data and recommends that two limits are applied for flatness tolerance. These are based on a standard approach to measuring the slab surface and the proposed deviation limits that are the limit at which 90% of the test measurements are less than and also the limit which 100% of the test measurements are less than. This approach to assessment is reflected in Table 1 overleaf, and used here to compare straightedge data with that from instruments used to measure flatness numbers and levelness numbers.

String-lines

String-lines are suitable for assessing large elements but should be used only in still air conditions. They are more suited to vertical surfaces, as the deflection or 'sag' over long distances could introduce errors for horizontal surfaces. They are typically held away from the surface on suitable spacers to ensure the string-line is straight and the deviation of the surface from the string-line can be measured.

F-Meter and Dipstick Instruments

The F-Meter and Dipstick instruments were developed by the Face Company in the United States. These instruments are used to assess the flatness and levelness of floors by measuring the Face floor-profile numbers, called F-numbers. The Flatness F-number (F_f) is related to the maximum allowable floor

curvature over 600mm computed on the basis of successive 30mm elevations differentials².

The Levelness F-number (F_L) is related to the relative conformity of the surface to a horizontal plane as measured over a 3m length.

Generally, the two F-numbers are expressed as F_F and F_L . Further information on this measuring system can be found in ACI 302.1³ and ASTM E1155M².

Large areas can be assessed easily for compliance using this method, as the instrument can be quickly moved across the surface (see Figure 3).

It is important that measurements are taken as soon as possible, since subsequent procedures, such as saw cutting joints, will affect results. These instruments are available in Australia but their use is still relatively rare with the Dipstick instrument more commonly used. To allow a contractor to assess the work (and cost) involved in delivering the required finish, a correlation between the F-numbers and an existing familiar method such as the straightedge may initially be required. While there is no direct equivalence between F-numbers and 3m straightedge tolerances, Table 1 gives an approximate correlation between the two systems as used by the method of ACI 117⁴.



Figure 3: F-Meter

Profilograph

This instrument is a variation of the F-Meter and was developed by the Australian Road Research Board – Transport Research (ARRB TR). It is a height-measuring device for checking the longitudinal profile of both new and existing road pavements.

Table 1: Approximate correlation between F-numbers and straightedge tolerances (after ACI 117⁴)

Floor profile quality	FF	FL	3m Straightedge
			Tolerance (90% less than – 100% less than) (mm)
Conventional Surface			
Bull-floated	15	13	16 - 23
Straight-edged*	20	15	13 - 19
Flat	25	20	10 - 16
Very flat	50	30	3 - 7
Super flat	100	50-100	2 - 3
Typical warehouse	25-35		6 - 12

*Refers to a finishing process in which a long straightedge (3m to 4m) is drawn across the surface transverse to the direction of screeding to remove undulations in the transverse direction.

STANDARDS AND SPECIFICATIONS

When specifying tolerances for concrete work, reference is often made to the Australian Standards/Specifications AS 360.1¹, AS 3600⁵ and NATSPEC⁶. The relevant contents of these are outlined below.

AS 3610.1¹ – Formwork for concrete

This Standard deals with the visual quality (appearance) of formed concrete surfaces, for both in-situ and precast concrete elements. The surface finish quality is specified as one of five classes.

Classes 1, 2 and 3 are typical architectural applications where the concrete surface visual quality is important. Tolerances for each class are specified for various aspects of the surface finish (see Table 2). If concrete elements have non-critical faces and/or some of the surface finish tolerances are less important, these can be relaxed and are designated by the suffix 'X' after the class of finish, (e.g. Class 2X). The limits of any less stringent tolerances should be included in the project documentation but should not be less stringent than the tolerances given in AS 3600⁵ for structural adequacy. Classes 4 and 5

are for typical structural applications where the concrete surface is either not visible, or the surface finish quality is not critical (e.g. footings, concrete frames covered by other finishes). While specifications for “Face step” and “Undulations” for Class 4 finishes are included in AS 3610.1¹, the tolerances for Class 4 and 5 finishes are generally governed by the requirements of AS 3600⁵, (i.e. structural design rather than appearance of the surface).

AS 3600⁵ – Concrete Structures

The tolerances specified in AS 3600⁵ relate to the size and position of concrete elements to ensure that the safety factors for the structural design of the elements are maintained. The standard notes that ‘more stringent tolerances may be required for reasons of serviceability, fit of components, or aesthetics of the structure’.

Specifying tolerance in accordance with AS 3600⁵ may not be adequate to satisfy other requirements, (e.g. where precast components are installed into a building frame - see Figure 4 below). Note that AS 3610.1¹ is of little use in this regard as it deals with the surface finish rather than the actual position of the element.

As an example, consider a mezzanine floor in a factory supported by 3m high columns. AS 3600⁵ states that for a point on the top surface of a floor or the soffit of a beam or slab adjacent to a column or wall, the deviation from the specified elevation shall not exceed 40mm vertically i.e. $\pm 40\text{mm}$ from the designed level. The actual variation may be smaller as the deviation from any specified height or 5mm, whichever is greater. For the mezzanine floor, the variation in the column height could thus be $\pm 15\text{mm}$ (height/200). While this is within the $\pm 40\text{mm}$ allowed, in the worst case there could be a 30mm fall across the slab, and the floor levels still comply with tolerances given in AS 3600⁵. This could make the fit of components or construction of walls difficult.

NATSPEC⁶

NATSPEC⁶ nominated a flatness tolerance for each of three classes of unformed surfaces, viz:

- **Class A** Maximum deviation from a 2m straightedge is 4mm.
- **Class B** Maximum deviation from a 3m straightedge is 6mm.

- **Class C** Maximum deviation from a 600mm straightedge is 6mm.

NATSPEC is not clear on the method of assessment and could be interpreted as a maximum deviation for 100% of tests. Class A should not be automatically specified for all floor applications. Achieving a maximum deviation of 4mm under a 3m straightedge may require very special construction techniques at increased cost. Table 1 shows a reasonable tolerance for a conventional finish would be a maximum deviation of 13mm under a 3m straightedge for 90% of tests.

With careful level control and re-screeding where required, it may be possible to achieve a maximum deviation of 10mm under a 3m straightedge for 90% of test results carried out on the majority of a pavement area.

More stringent tolerances should be specified only if required for the application, (e.g. a television studio floor or operating theatre, both of which require sensitive equipment to be moved across the floor). In these cases Class A may be the appropriate flatness to specify but will require specialist finishing to achieve a maximum 4mm on 90% of test let alone 100% of tests suggested here.

Consideration needs to be given to achieving the specified tolerance on site. The specification of a less stringent tolerance and use of a self-levelling topping (after construction) may also be an option to achieve more stringent tolerances, particularly if suspended and/or post tensioned floors are involved. Deflections after formwork removal or stressing can easily exceed the ‘flatness’ tolerance specified. Note that the waviness of the floor may be more critical than having a Class A finish. Fewer ‘waves’ will effectively increase the flatness and allow smoother movement of equipment over the floor surface (see Figure 2).

SPECIFYING TOLERANCES

Specified tolerances should realistically reflect the requirements for the appearance and function of the concrete element. The practice of specifying more stringent tolerances than required to cover unforeseen circumstances should be avoided. The more stringent the tolerances, the more sophisticated (and therefore costly) are the

construction and measurement methods needed to achieve and check them. The recommended tolerances for various elements are discussed below and summarised in Table 3.

Footings

If no requirements are specified, footings would be deemed to require only Class 5 finish for which no provisions for the surface appearance are included in the Standards.



Figure 4: Concrete frame may require tolerances appropriate for the fitting of components such as precast units.

Slabs

In addition to the unformed top surface, formed slab edges may also need to be considered – particularly in residential work. For the latter, both are covered by AS 2870⁷.

The formed edges/sides of the concrete slab are generally acceptable if in accordance with the tolerances of AS 3600⁵, as the edge is either below ground level or concealed by the external skin of brickwork and therefore surface appearance is not critical. Note that AS 2870⁷ generally requires concrete work to be in accordance with AS 3600⁵.

Where the edge remains exposed after construction (clad frame construction or as part of the termite barrier system), a Class 3 finish to the formed surface should be specified in accordance with AS 3610.1¹. This will provide satisfactory surface appearance and satisfy the requirement of AS 3600.1⁸ that states 'the exposed face of the perimeter of the slab shall be off-the-form and shall not exhibit areas of rough surface, honeycombing or ripples'.

Table 2: Acceptable quality of formed surfaces (AS 3610¹)

Quality of Surface Finish	Class 1	Class 2	Class 3	Class 4	Class 5				
1. Blowholes	Refer to AS3610.1 for examples			N/A	N/A				
2. Formed Face Deflection	Lesser of 2mm or Span/360	Lesser of 3mm or Span/270	Lesser of 3mm or Span/270	Lesser of 3mm or Span/270	N/A				
3. Face Step	Tolerance for straight elements with smooth surface in mm								
	% of Readings								
	95	100	90	100	80	100	70	100	*
Within the element	1	2	2	3	3	5	5	8	*
At in-situ construction joint	2	3	2	3	3	5	5	8	*
4. Surface Undulations**									
300mm Straightedge (a-b) ≤ 1500mm Straightedge	1	2	2	4	3	4	5	7	*
(a-b) ≤	2	4	3	6	5	7	8	10	*
5. Flatness 1.25m Grid									
At 5m over 10m (N/A to Precast)	4	5	6	7	7	10	*	*	*
	5	7	7	10	10	15	*	*	*
6. Out of plumb. Height less than 3m									
3m < Height < 8m (N/A to Precast)	3	5	4	6	5	7	*	*	*
	6	8	8	10	10	12	*	*	*

*Limited by AS3600⁵

** "a" and "b" are respectively the maximum and minimum distance from the straightedge

A more stringent flatness tolerance than 13mm on 90% of test shown in Table 3 may be required for particular floor finishes such as polished concrete or vinyl, where light reflecting from the surface tends to highlight any undulations.

A maximum variation of 6mm from a 3m straightedge on 90% of tests would be a reasonable tolerance for small areas, and 8mm for larger areas. Reducing the waviness would also assist in achieving a flatter finish.

Tolerances should be measured within 72 hours of placement and not be used to assess the performance over a period of time, as ground movement in excess of the tolerances may occur.

Table 3: Recommended Tolerances

MEMBER		TOLERANCE ON:																
		Position/Size	Surface quality															
Footings	Concealed	Maximum deviation from any specified height, plan or cross-sectional dimension to be the greater of 1/200 times specified dimensions or 5mm ^a	Maximum deviation of any point of the surface from a straight line joining the two points on the surface to be the greater of 1/250 times the length of the line or 10mm ^a															
	Exposed	As for "Concealed" above plus –Maximum deviation from plumb to be the greater of 1/200 times specified dimensions or 5mm ^{1,b} . Absolute position to be within +15mm horizontally.	Class 4 ^b or higher.															
Slabs		Maximum deviation from any specified height, plan or cross-sectional dimension to be the greater of 1/200 times specified dimensions or 5mm ^a . Surface level – To within +10mm of specified level.	Exposed edges to be Class 3 ^c or 2 maximum. Flatness – Maximum from a 3m straightedge placed anywhere on the surface 13mm for 90% of tests. This tolerance is also consistent with AS3600 section 17 ^g which satisfies structural requirements.															
Columns and Walls		Position - +15mm of specified position. Plumb - +10mm of plumb.	Concealed elements – Class 4 ^c . Elements with applied finishes – Class ^c to be specified to provide appropriate substrate. Elements viewed as a whole – Class 3 ^c . Elements viewed in detail – Class 2 ^c .															
Architectural Elements		As appropriate for type of member.	Class 1, 2 or 3 ^{c,d}															
External Pavements (driveways, footpaths, patio's and other pedestrian pavements)		Surface level – <ul style="list-style-type: none"> • Non-graded pavement: ±10mm of specified level. • Graded pavement: ±10mm of a straight line between control points. • Control points at top and bottom of graded pavement: ±10mm of specified level. Thickness – Maximum deviation to be the greater of 1/200 times the specified thickness or 5mm ^a .	Flatness – Maximum from a 3m straightedge placed anywhere on the surface 16mm for 90% of tests.															
Industrial Pavements		Surface level to be within ±10mm of specified level. Thickness – Maximum deviation to be the greater of 1/200 times the specified thickness or 5mm ^a .	Flatness and levelness – To have the following F-numbers ^e : <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Finishing method/ pavement type</th> <th>F_F</th> <th>F_L</th> </tr> </thead> <tbody> <tr> <td>Bullfloated</td> <td>15</td> <td>13</td> </tr> <tr> <td>Straightedged^f</td> <td>20</td> <td>15</td> </tr> <tr> <td>Flat</td> <td>25</td> <td>20</td> </tr> <tr> <td>Very Flat</td> <td>50</td> <td>30</td> </tr> </tbody> </table>	Finishing method/ pavement type	F _F	F _L	Bullfloated	15	13	Straightedged ^f	20	15	Flat	25	20	Very Flat	50	30
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Straightedged ^f	20	15																
Flat	25	20																
Very Flat	50	30																

Notes (table reference numbers refer to note numbers below):

- A. In accordance with AS 3600⁵.
- B. If class 2 or 3 finish in accordance with AS 3610.1¹ is specified, the associated plumb tolerances apply.
- C. In accordance with AS 3610.1¹.
- D. A tighter tolerance may be required for some floor finishes (e.g. tiled, vinyl, polished) – see page 5 "Slabs".
- E. As measured by the F-Meter – see page 2 for method and Table 1 for 3m straightedge deviation equivalent.
- F. Refers to a finish process using a long straightedge tool (refer to ACI-117⁴).

Columns and Walls

Tolerances for the location and plumb of these members are usually specified in accordance with AS 3600⁵. As surface appearance is generally not critical (i.e. members concealed from view by other finishes) a Class 4 surface finish in accordance with AS 3610.1⁵ should typically be specified. This will ensure good general alignment of the surface.

There are less common cases where columns and walls are constructed to a finish that is to be viewed without any further applied finish. In this case Class 1, 2 or 3 finish may be specified in accordance with AS 3610.1¹.

If the location of these elements is important and they cannot be allowed to 'drift' out of position by the 40mm allowed in AS 3600⁵, then an appropriate, more stringent tolerance, needs to be specified. Again the project documentation may limit the deviation from the specified plan position to say 15mm. While this allows some tolerance for dimension and plumb, it may require each level to be set out to ensure the adequate location of columns and walls.

Regarding the plumb, it is recommended that the 10mm variation allowed in AS 3600⁵ be regarded as a maximum, rather than minimum value. This makes the requirements for plumb, approximately consistent with a Class 3 finish in AS 3610.1¹.

Architectural Elements

In addition to specifying tolerances for the position of concrete elements, where the visual appearance is important, tolerances for the surface finish must also be specified. A group of tolerances which define the surface finish are usually specified as either a Class 1, 2 or 3 finish in accordance with AS 3610.1¹. A specifier should take particular note of the advice regarding visual assessment of concrete surfaces provided by AS 3610.1¹. The Standard advises that surfaces should be viewed from a distance reflecting the viewing distance expected when in service but not less than 3m. For example, this may mean that a visual assessment of a Class 3 surface finish at 2m may satisfy a Class 2 when viewed at 20m.

Class 1 finishes should be specified only for selected small elements contained in a single pour and not for entire building facades. This is due to their cost and difficulty to achieve over

larger areas. Class 1 is often specified for residential and public applications where close scrutiny of the finish is possible.

Class 2 finishes are appropriate for exposed concrete in areas where people have the opportunity to view the finish in detail. Class 2 would usually be the minimum finish for residential applications and other building/structural elements where people can be in close proximity.

Class 3 finishes would suffice for most exposed concrete applications, such as car parks, where the structure is viewed as a whole and people are less alert to the actual finish.

External Pavements

In determining tolerances for external pavements, considerations should be given to:

- Most graded pavements fall to a drain, which itself has an elevation tolerance. If the drain is above the specified elevation, there will be less grade on the pavement, if below, there is more. The tolerance for the pavement should therefore be compatible with that of the drain.
- Care in nominating a minimum grade is required as the levelness tolerance of $\pm 10\text{mm}$ may cause the pavement to fall in the opposite direction for small vertical differences. This is especially critical over short distances. In these situations either more stringent tolerances on the control points are needed, or an appropriate minimum grade.

Industrial Pavements

The surface flatness is often the critical factor for these pavements and the tolerances need to suit the application. Forklift uses range from general circulation areas and wide aisles to specialised turret trucks in narrow aisles for high-bay storage.

Generally, the more restricted the operating space, the flatter the floor surface needs to be to prevent swaying during movement and possible impact with racking.

While the degree of flatness and levelness is dictated by the requirements of the turret truck suppliers, more stringent tolerances are often specified due to particularly narrow aisle widths

or the need to compensate for subsequent movements (e.g. subgrade settlement). For high-bay racking, generally a very flat floor will allow efficient operation of fork lift trucks (manufacturers' specifications need to be checked), with specified tolerance values of $F_F = 50$ and $F_L = 30$. As noted in Table 1, this is roughly equivalent to a maximum deviation of 3mm for 90% of tests under a 3m straightedge.

It can be seen that specifying tolerances using the F-number method is more suitable for industrial pavements. In this case, measuring tolerances over large areas may be difficult using other methods and can lead to dispute over the test results from differing test methods.

The specification of more stringent tolerances (e.g. a 'superflat' floor), involving a considerable increase in cost, is generally not warranted. However, each project must be assessed and the appropriate tolerance determined.

ACHIEVING TOLERANCES

When specifying tolerances, consideration should be given to how they will be achieved on site. Tolerance requirements need to be communicated to the contractor so that appropriate construction techniques and procedures can be planned to deliver the desired result. This is critical where tight tolerances have been specified, as additional time and cost will be involved in achieving them.

Consideration should be given to the following:

- Communication between all parties involved in the project is critical. The contractor must have a clear understanding of the tolerances required and the importance of achieving them so that appropriate construction techniques can be used. As the actual finishing of the surface probably accounts for at least 50% of the success of a project, it is imperative that the concreter also be involved in related discussions and development of procedures for placing/finishing the surface.
 - Compliance should be assessed between 24 hours and 72 hours after placement of concrete (as noted in "Definitions above). This should be completed prior to any activities, such as post-tensioning, formwork stripping/backpropping and loading which may affect the levels.
- Construction costs generally increase as tolerances become more stringent. Specifying tolerances appropriate for the application will control costs for the owner and possibly avoid unnecessary disputes over non-compliance.
 - An understanding of the tolerance limits possible by using various construction techniques will assist in selecting an appropriate method to achieve the specified tolerances. For example, tight tolerances in large floor areas are generally achieved by placing the concrete in narrow strips. If a joint-free surface is required for large open areas, the use of specialised equipment such as laser-guided screeding machines may be required.
- Construction techniques that reduce the waviness of the surface finish will also improve the flatness. An alternative solution for tight tolerances may be to use normal placement and finishing techniques on the base slab combined with a self-levelling topping (see below).
- Construction details can have significant effect on the final surface level and flatness. Examples include:
 - a. Ensuring adequate quality of and preparation of the subgrade under the concrete slab to reduce the potential for ground movement. The use of a designed thickness specified road base material, that is compacted to a specified minimum dry density, is recommended.
 - b. Providing long tapers at edge thickenings to reduce the risk of level changes due to concrete plastic settlement shrinkage.
 - c. Ensuring proper functioning of joints. This should include measures to ensure that the joint accommodates horizontal movement of the slab due to shrinkage and temperature as well as transfer of vertical loads across the joint. This can be achieved by careful design of reinforcement, dowel bars (if required) and joint surface preparation. Correct joint spacing and aspect ratio of pavement

segments between joints is necessary to ensure that joints will work as intended.

- d. Ensuring adequate slab thickness, reinforcement detailing and concrete mix design to control curling of the slab edges. Effective curing of the finished surface of the concrete slab, also combined with plastic (vapour barrier) under the slab where the sub-base is likely to remain moist, will also assist with control of curling of the slab edges.
- While the specified tolerances may be satisfactory when checked for compliance, subsequent movement and/or deflection of the concrete member (e.g. due to ground movement, stripping of formwork, loading, stressing) could result in the final surface not complying. An alternative to specifying more stringent (and perhaps unreasonable and more costly) tolerances to allow for this movement is the specification of less-stringent tolerances combined with an appropriate self-levelling topping.
 - Surfaces requiring tight tolerances (e.g. operating theatres, studios) or ones subject to subsequent movement/deflection may benefit from the use of a topping by which such tolerances are readily achievable. A further benefit is that, since the topping can be placed at the end of the construction period, the need for protection of the floor is minimised. Care should be taken to ensure that toppings are fully bonded to the concrete where using this method.
 - The importance of trial slabs or test panels that incorporate all the features of the critical slabs or elements from preparation, formwork, jointing, placing, compacting, finishing and curing, can't be over emphasized. Trial slabs provide the opportunity to further refine the techniques required to achieve the final result, and to a greater understanding and appreciation of the extent of work involved.

ensure that acceptable results can be achieved. Techniques used in rectification work of unformed surfaces include:

- Belt sanding with an appropriate abrasive paper can be used for areas requiring minor corrections less than say 0.5mm.
- Grinding the surface is an effective way of correcting localized high spots in the finished surface and is the typical method used. Depending on the type of grinding, the appearance will be affected and possibly surface characteristics such as abrasion resistance.
- Localised filling is not recommended as a long-term solution for the correction of tolerances on exposed concrete slabs. It may be used for minor surface defects and as a levelling solution under other floor finishes.
- A proprietary self-levelling topping can be applied to the surface, not only to correct tolerances, but also to provide a uniform appearance to the finished surface.

RECTIFICATION

Depending on the function and appearance of the concrete element, rectification of surfaces outside the specified tolerances may be possible. Parties involved should discuss and agree the procedure to

REFERENCES

1. AS 3610.1 Formwork for Concrete – Specifications, Standards Australia, 2018.
2. ASTM E1155M-14 Standard Test Method for Determining F_F Floor Flatness and F_L Floor Levelness Numbers, 2014.
3. ACI Committee 302.1R Guide for Concrete Floor and Slab Construction, American Concrete Institute, 2015.
4. ACI 117-10 Specifications for Tolerances for Concrete Construction and Materials and Commentary, American Concrete Institute, Reapproved 2015.
5. AS 3600 Concrete Structures, Standards Australia 2009.
6. Concrete Finishes Section of NATSPEC: BUILDING Structure, 2018.
7. AS 2870 Residential Slabs and Footings, Standards Australia 2011.
8. AS 3660.1 Termite Management, Part 1: New Building Work, Standards Australia, 2014.

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