



FRESH CONCRETE PERFORMANCE GUIDELINES FOR CONSTRUCTION PROJECTS IN NEW ZEALAND

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Fresh properties of concrete are sometimes poorly defined in construction projects with these properties being either ignored or specified in an impractical manner that unnecessarily limits flexibility and/or productivity. Clearer guidance is required for slump, air content, segregation, bleeding and setting time if this situation is to be improved. Important fresh properties of concrete are illustrated in Figure 1.

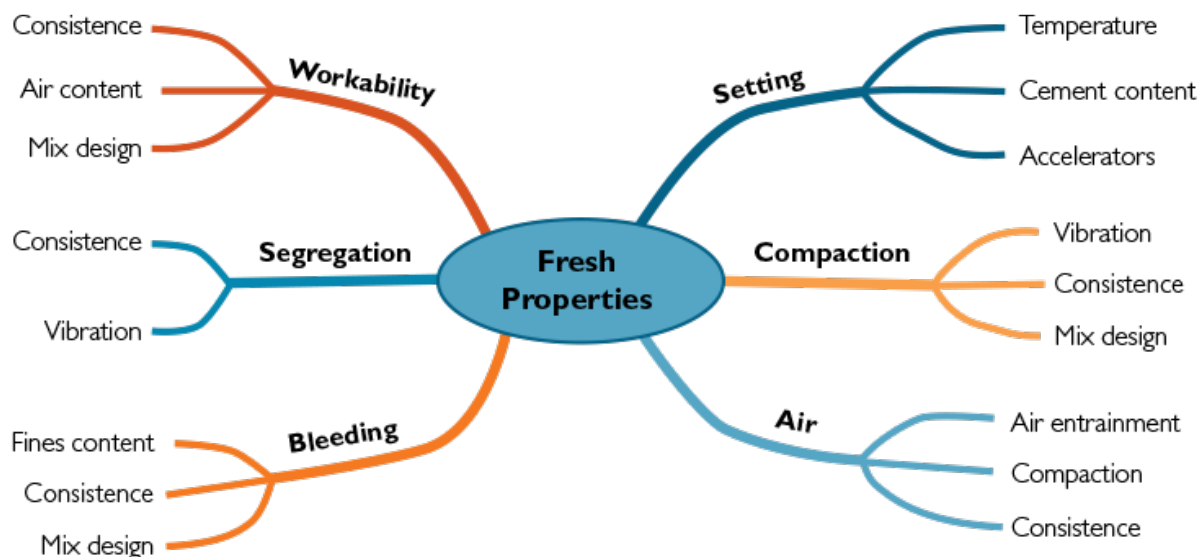


Figure 1: Map showing the main fresh properties of concrete and influences

SLUMP TESTING

Slump testing measures the consistence of concrete from which the workability of a specific mix can be estimated. Slump targets have been increasing over the last few decades as water reducing admixtures have decoupled the relationship between slump and compressive strength. Many specifications have ignored these developments while some have seen slump as the property that designers can use to compensate for a lack of site supervision on projects. This has led to several myths persisting in the structural engineering fraternity, including linking lower slumps with better quality of concrete. Specification should avoid prescriptive slump limits but rather should allow contractors to nominate an appropriate slump, which then becomes the performance target.

AIR CONTENT

The durability requirements for air entrainment of concrete in the New Zealand Standards are poorly understood and need to be clearly stated in order to avoid confusion. See Figure 2.

- Air entrainment does not provide any anti-freeze benefit to fresh or setting concrete since all concretes are extremely vulnerable to frost damage during the first few nights after casting.
- Lower grades of concrete (typically 17.5-25 MPa and 17.5-30 MPa in the south of the South Island) require air entrainment since these concrete have relatively high water/cement ratios and are more vulnerable to freeze-thaw action.

- Lower strength concrete is generally air entrained regardless of exposure since there are other benefits to these mixes such as improved workability and material savings.
- Higher strength concrete may require air entrainment if the surface is exposed to multiple freezing cycles per annum (structures at higher altitudes or freezer rooms entrances).

SEGREGATION

Segregation is the separation of constituents in a mixture leading to an uneven distribution of materials that can affect strength and durability of concrete. Structural concrete at normal slump levels of 100-150 mm is sufficiently cohesive that segregation will only occur through poor placing practice or excessive vibration. Self-compacting concrete is more vulnerable to segregation due to the more fluid nature of the paste and testing

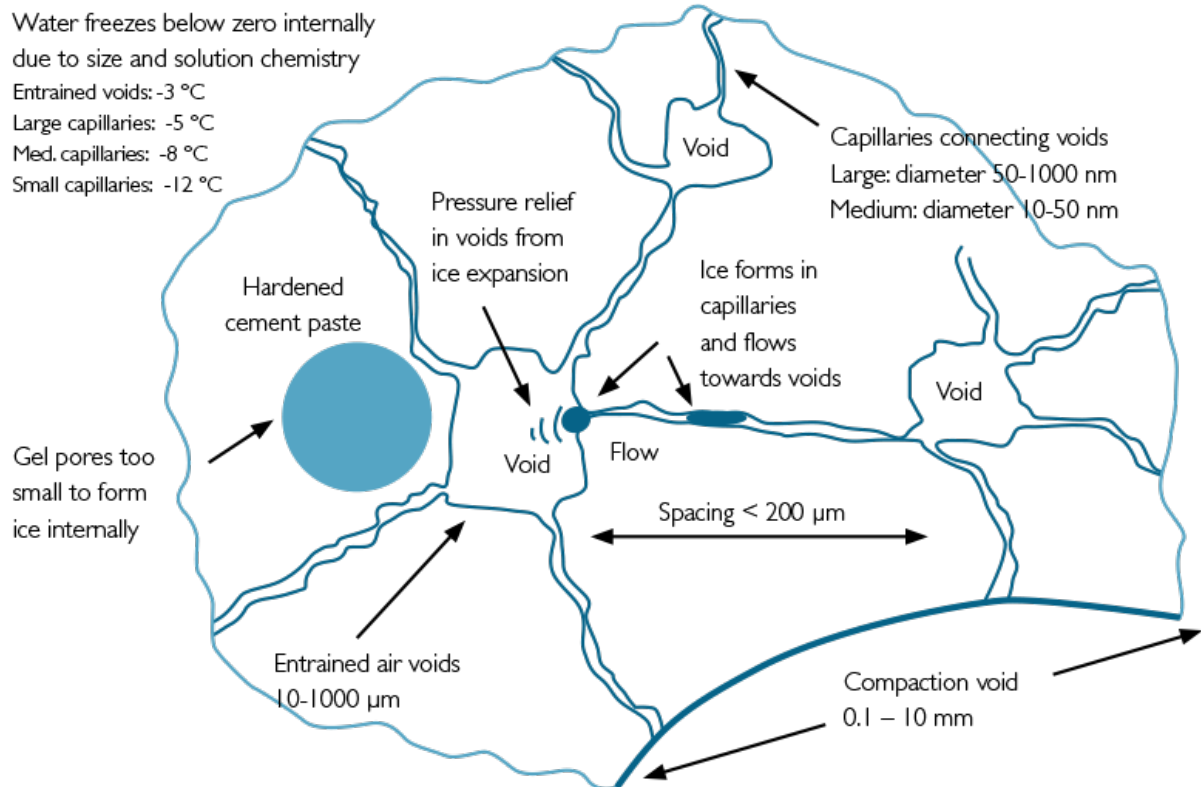


Figure 2: Concrete microstructure response to freezing

BLEEDING AND SETTLEMENT

Bleeding occurs in response to settlement of solid constituents and helps protect the surface from drying since excessive drying can cause plastic shrinkage cracking. The bleed rate of concrete reduces with increasing cement content and decreasing water content and porosity caused by improved particle packing. Evaporation of bleed water off the concrete surface is strongly influenced by wind speed and humidity as well as the air and concrete temperature. Drying will quite often exceed the bleed rate when dealing with commercial or infrastructure concrete (e.g. grade 30 MPa and higher). Protection offered by antieaporative sprays or other measures are essential when concrete is cast outdoors. Local materials will also influence the bleed rate of concrete such that Christchurch concrete made with natural aggregates may have half the bleed rate of that found for Auckland concrete using crushed aggregates.

is routinely undertaken to confirm the segregation resistance of SCC mixes. Segregation testing does however have different levels of complexity. Simple methods, such as the visual stability index are intended for site control, whereas more elaborate methods such as the column segregation test are more appropriate for development trials in the laboratory.

SETTING TIME

Setting of concrete is the onset of rigidity such that final set is the start of strength development of the material. Setting reactions of cementitious materials are complex and involve a series of chemical reactions with calcium silicate and aluminate phases, and also involve sulphate interactions from gypsum used for set control. These chemical reactions are dependent on temperature with reaction rates doubling every 10-20 °C.



Image: PCA

Slump testing measures the consistence of concrete from which the workability of a specific mix can be estimated.

Specifying limits on concrete temperature must be done with caution as lower limits of 15 °C and upper limits of 25 °C are unnecessarily restrictive and not consistent with the recommendations in NZS 3109. Chemical admixtures allow a much wider range of concrete temperatures to be used in practice, with controlled setting still possible between 5 and 30 °C.

SUMMARY

Several fresh properties can be identified as being measurable unambiguously and may be relevant to specific projects. Table 1 gives more details about these fresh

properties in terms of relevance, design limits, tolerances and Standards. While specifications for consistence and air content have some justification for having limits that require relatively strict compliance, other fresh properties such as bleed, segregation and setting time are more rarely specified, and limits are only generally applied in the event of lack of performance in that specific area.

This article is based on the paper "Fresh Concrete Performance Guidelines for Construction Projects in New Zealand" by Dr James Mackechnie, presented at the 2016 New Zealand Concrete Conference in Auckland.

Fresh property	Relevance	Design limits	Tolerances	Relevant standards
Consistence (Slump)	Assesses workability of concrete and consistency of supply	Depends on the application - best nominated by the contractor	± 30mm for a representative ± 40mm for a snatch sample	NZS 3104 NZS 3109
Air content	Freeze-thaw resistance and used for workability	< 2.0 % mild 4-5 % mod. 6% extreme	± 1.5 % for all samples	NZS 3101 NZS 3104
Bleeding	Protects concrete surface from plastic shrinkage cracking	Bleed capacity is sometimes specified at 1-3%	None	ASTM C403 AS 1012.6
Segregation	Provides some robustness for handling of SCC	Column seg. < 5% Penetration <10mm	None	ASTM C1610 ASTM C 1712
Setting time	Predicts setting time of concrete provide conditions are controllable	Typically 6-12 hours depending on strength of concrete and environment	None	NZS 3112 Part 1:10 ASTM C232 IS 8142-1976

Table 1: Fresh concrete guidelines, limits, tolerances and standards

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