Effects of Mixture proportions on the Strength and Permeability of No-Fines Concrete

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1 Introduction :

The primary objective of mix proportioning is to select suitable proportions of the various ingredients of No-Fines Concrete which will yield fresh NFC of desired placeability and consistency, and hardened NFC having the required strength, durability and permeability. In addition, the desired quality of NFC is to be achieved at a reasonable cost. For such as reason an available Pumice (A light-colored vesicular glassy rock having the composition of rhyolite), Scoria (A bomb-size pyroclast that is irregular in form and generally very vesicular. It is heavier, darker, and more crystalline than Pumice) and Crushed limestone (C) are used as coarse aggregates. Pumice (P) and Scoria (S) are of volcanic origin.

2. Experimental work:

Several mixes with various aggregate gradation, different Aggregate - Cement ratio (A/C) by volume were made. Ordinary Portland cement (specific gravity of 3.15 and blaine surface of 3290 cm^2/g) was used. The mixing procedure is that expressed in reference[1]. No effort was required to consolidate or compact the no-fines concrete. A light hand tamping [2], which causes the least particle breakage compared with impact methods of laboratory compaction was sufficient.
To obtain meaningful results the prepared specimens, were brought to the same moisture condition before a strengths and permeability tests can be carried out.

3. Results and discussion:

For the same aggregate gradation, whatever A/C is, NFC's compressive strength made with lightweight coarse aggregates represents only 25% of that made with crushed limestone (Fig.1).
NFC's strength depends on the total void content, while its permeability depends on the continuous void content (Fig2). However, the notion "continuous void content" doesn't describe the texture of NFC in anyway.
For example the NFCs schematized by Figs. 3a and 3b have the same continuous void content (on black) and it is evident that their textures are different.
Therefore the coefficient of water permeability is affected by a number of factors, such as aggregate gradation and cement content (Fig. 4).

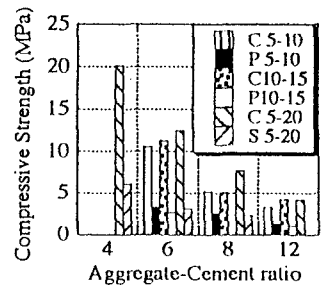


Fig.1: Relationship between Aggregate-Cement ratio and Compressive Strength

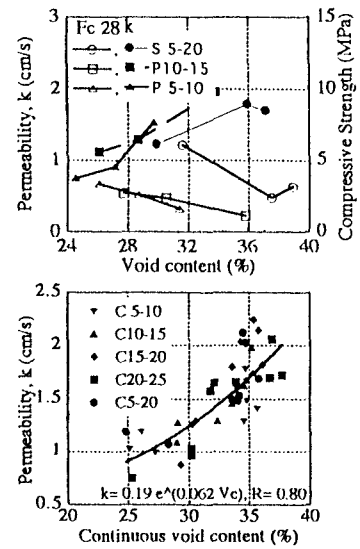
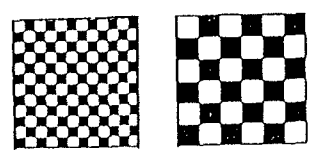


Fig. 2: Relationship between Void content, Compressive Strength and Permeability



(a) (b)

Fig.3

Fig.5 shows that permeability of NFC would be reduced significantly with the decrease of A/C ratio.

It is influenced by the aggregate bound limit [3,4] and it can vary from 0.2 to 5 cm/s, depending on the aggregate gradation [3]. The compressive strength which varies generally among 1.4 to 14 MPa [2] is exponentially function of A/C ratio.

Gradation is the primary factor affecting the permeability and strength of the NFC (Fig. 6). The drop off of permeability for NFC made with crushed limestone of aggregate gradation 20-25 mm could be due to the aggregate shape characterized by its sphericity (Table 1).

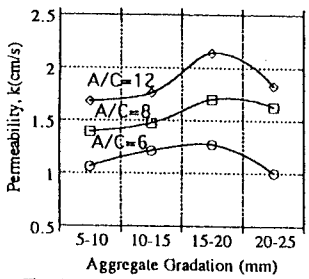


Fig. 4: Effect of Aggregate Gradation on the Permeability coefficient

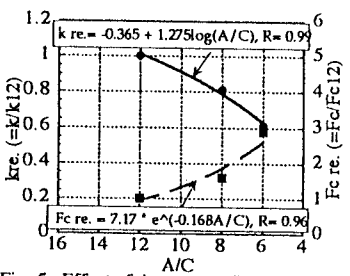


Fig. 5 : Effect of Aggregate-Cement ratio on the Permeability and Compressive Strength

Table 1: Aggregate gradation and Sphericity

Agg.Gradation	Sphericity
C 5-10	0.664
C 10-15	0.703
C 15-20	0.710
C 20-25	0.676

Not only sphericity affects the permeability, also for the same aggregate gradation, the aggregate with 100% fractured faces is more permeable than aggregate with 88% fractured faces [3].

4. Conclusion:

The only way to insure the necessary degree of permeability of the NFC for a particular durability requirement is to specify a range of cement content for the mixture.

References:

[1] Kiyoshi K. et al.: Effect of mixture proportion on zero-slump concrete for artificial fish reef, JCA Proceedings of Cement & Concrete No. 46, pp. 446-451, 1992.

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[3] Tamai, M.: Properties of No-Fines Concrete Containing Silica Fume, Proceedings of CANMET Fly Ash, Silica Fume, Slag, and Natural Pozzolans in Concrete, pp. 799-814, 1989.

[4] Zhou, H., et al.: Determination of Free-Draining Base Materials Properties, Transportation Research Record, No. 1425, pp. 54-63, 1993.

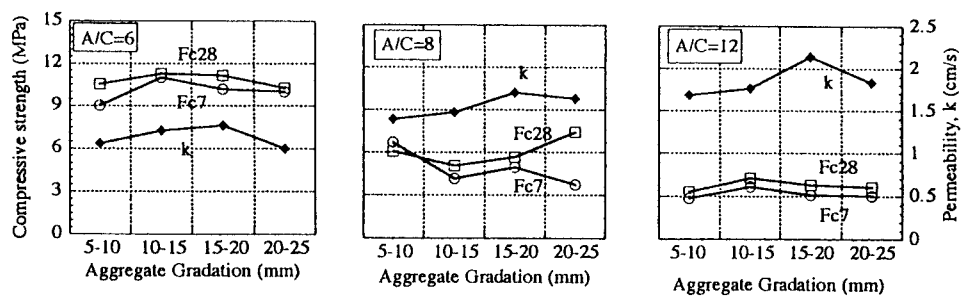

Fig. 6: Effect of Aggregate Gradation on the Strength and Permeability