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Permeability of No-Fines Concrete

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1. Introduction:

Recently, in Japan No-fine Concrete (NFC) is used as an ecological material (Environmentally friendly concrete). Until 1976, no quantitative data on the permeability of NFC was reported. At present, there is no standard laboratory test for permeability of NFC. This paper presents some laboratory experimental results on permeability using constant head and failing head tests. It relates factors such as: aggregate type, aggregate gradation, aggregate shape, void content, paste content and water-cement ratio to permeability.

2. Experimental work

2.1 Preparation of specimens

Several mixes with Aggregate - Cement ratios by volume (A / C=4, 6, 8, and 12) were made. Crushed limestone (CL) with different aggregate gradation, Pumice (P) and Scoria (S) were used as coarse aggregate. Ordinary Portland cement was used as stabilizer. A pan-type forced circulating mixer of 50 liters of capacity was used, and the mixing procedure followed was that specified elsewhere. No effort was required to consolidate or compact the freshly mixed NFC. A light hand tamping, which causes the least particle breakage compared with impact methods of laboratory compaction and ensures uniform distribution was sufficient.

2.2 Testing of specimens

The void content accounts for the total volume through which water can flow inside the sample and was assumed to be a very important factor in the experiments. The void content values were calculated following the procedure described by JCI [1]. The constant head permeability test procedure determines the permeability of NFC by maintaining a constant head (h) on the sample surface and measuring the amount of water collected for a known quantity of time (Δt). However the failing head permeability test determines the permeability of NFC by measuring the time required for the water head to drop from high level (h_0) to a low level (h_1). Herein h_0- h_1=100 mm.

3. Results and discussion

Sets of curves showing the effects of the previous mentioned factors upon permeability of NFC were constructed.

Fig.1 illustrates a relationship between continous void content calculated by volume method (Cv_V) and that by weight metod (Cv_W). Cv_W is bigger than Cv_V. It is clear from this figure that the paste coating the aggregate is not distributed uniformly throughout the mass of NFC or air void was underestimated by volumetric method where the outer surface of the specimen left unsealed during submersion.

Fig.2 depicts a relationship between Cv_V and permeability. The permeability doses not depend on the aggregate type. In case where the permeability is the required property, the use of volcanic aggregate may be successfully for production of NFC.

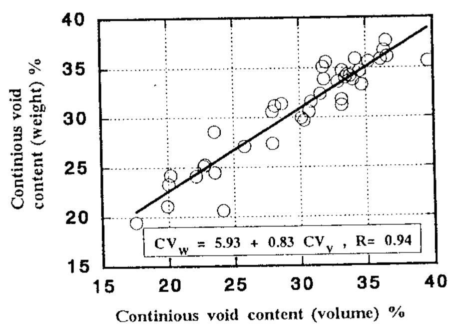

Fig.1 Relationship between Cv_V and Cv_W

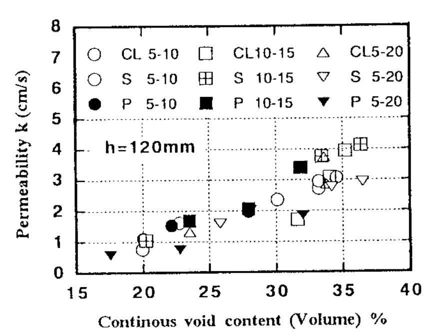

Fig.2 Relationship between Cv_V and k

Fig. 3 shows that: (a) head loss influences significantly the permeability measurement; (b) increasing the binder content reduces the permeability; and (c) reducing the W/C ratio increases the permeability (A/C=8: W/C=25 & 35%).

Fig.4 represents example of results from the two methods used to measure the permeability. Throughout the experiments failing head method was fast and simple but offered higher permeability coefficient than constant one that is time and energy consuming.

Fig.5 shows that the paste content and aggregate's bound limit (Table 1) influence the permeability significantly. The lower the bound-gradation (Scoria: S 5-20 mm) is the higher the permeability is.

Fig.6 represents the effect of aggregate gradation on permeability. Generally the permeability increases with increment of aggregate gradation and the drop of permeability for CL 20-25 mm could be due to its shape. Table 2 shows that CL 20-25 has a disc-shaped whereas that CL 10-15 and CL 15-20 are spherical.

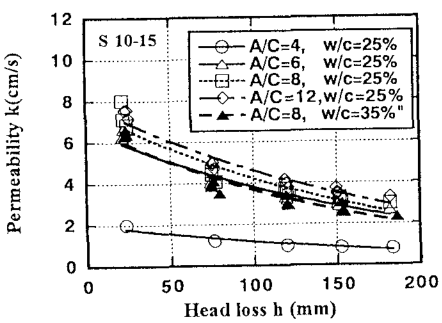

Fig.3 Effect of head loss on permeability

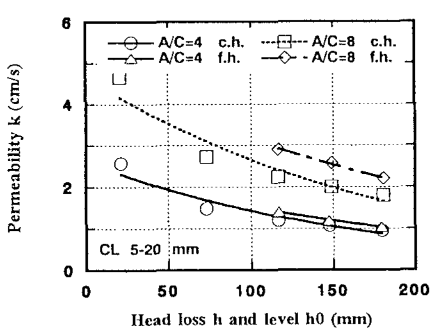

Fig.4 Comparison between constant and failing head test for permeability

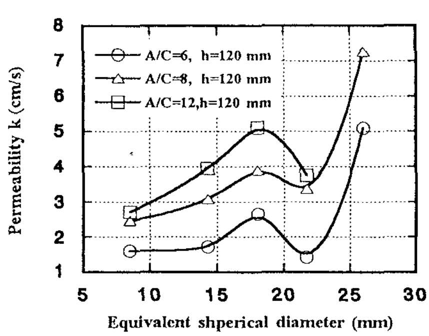

Fig.5 Aggregate gradation Vs permeability

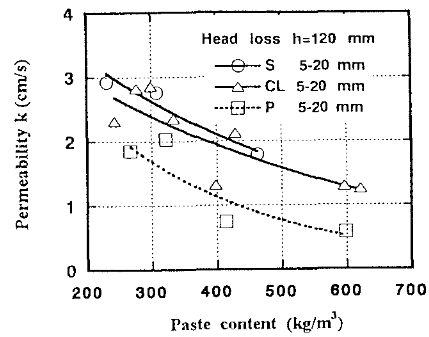

Fig.6 Effect of paste content permeability

Table 1: Aggregate gradation: sieve analysis

Sieve size (mm)	Pumice	Lime stone	Scoria
25	100.0	100.0	100.0
20	99.6	98.5	99.7
15	97.2	69.8	93.7
10	77.0	25.3	26.0
5	2.4	4.6	0.4

Table 2: Results of aggregate shape

Limestone	Eq.d. (mm)	Sphericity	Roundness
CL 5-10	8.49	0.666	0.3 ~ 0.4
CL 10-15	14.30	0.702	0.3 ~ 0.4
CL 15-20	18.01	0.711	0.3 ~ 0.4
CL 20-25	21.70	0.677	0.3 ~ 0.5
CL 20-40	26.00	0.694	0.3 ~ 0.4

4. Conclusion

(1) Since the geometry of the matrix of NFC is concerned void determination should be made using volumetric method.
(2) The permeability is independent of the coarse aggregate origin.
(3) Factors such as aggregate gradation, shape, cement content and water cement ratio influence significantly the texture of NFC and hence its permeability.
(4) Methods used to measure permeability of NFC affect its permeability coefficient. Failing head test is fast, simple a can be used for comparative studies.

References

[1] Molhotra, V. M., Jour. Of ACI, V.73,No. 11, pp.628-644, 1976
[2] Kiyoshi K. et al., JCA. No. 46, pp. 446-451, 1992.
[3] Proceedings of JCI symposium on the present and future views of environmentally-friendly concrete Nov.,1995.