The 2013 World Congress on
Advances in Structural Engineering and Mechanics (ASEM13)
Jeju, Korea, September 8-12, 2013

Investigation of the performance of concrete samples with artificial permeable holes

Sheng Szu Peng[1] Yan Ren Chen [2] Zhang Wei Lai [3]

[1)2)3)] *Department of Civil Engineering and environmental informatics, MUST, No. 1, Hsin-Shing Road, Hsin-Fung, Hsin-Chu 304, Taiwan*
[1)] *Conan@must.edu.tw*

Abstract

The permeability coefficient of traditional concrete is often less than 10^{-8}cm/sec so using concrete pavement base is poor for conservation water. Although the annual rainfall is high in Taiwan but it is not easy for the concrete pavement area to retain the ground water. As a result, there was always lack water for living in Taiwan. This study is forum a permeable concrete with artificial permeable holes by using recycling chopsticks insert to concrete before the concrete is initial setting. The result shows that the artificial area of 0.3 % (single holes), 1.1 % (three holes) is slightly decrease for compressive strength, and the 1.5% (five holes) was reduced less than 10% as well. The flexural strength reduced by 12~54%. The splitting strength reduced by 12%~52%. The average of permeability coefficient is approached 0.01 cm/sec. Therefore, pre-holed permeable concrete can reach the compressive strength requirement of the local code of C-grade of concrete pavement. It also can meet the requirement of water conservation of green building material to reduce the heat island effect.

1. Introduction

The global warming is concerned issue of the world recently, one of reasons is using too much of the impervious of traditional concrete that induced the rain get quickly drained into the sea so the base of urban ground water often cannot be conserved and tends to be get heat island effect. However, (Hwang 2010)the compression strength of traditional concrete is good enough for pavement but permeability coefficient is not good enough as well. On the contrary, pervious concrete can reach the permeability amount, but it is always with lower of compressive strength. Therefore, (Hwang 2011)we need one type of material that can satisfied both of permeability function and compressive strength to reach the local code specification requirements material and to match the function of so called green building materials.

1) Associate professor
2) 3) Graduate student

For permeability reason and more functions purposed, (Chen 2001) JW engineering method using framework-aqueduct and buried it into traditional concrete. Although this design may improve concrete to reach both of permeability and compressive strength but it is expensive device with a higher cost and that is why less disadvantage to the reality of the condition. This study is a model by artificial permeable holes into concrete to create permeable function, and get conserved macro-function of the traditional concrete performance simultaneously.

2. Material and method

Using type I cement, mixed with crushed aggregate, water-cement ratio is 0.6. The specific gravity of aggregate is 2.63, the proportion of concrete is cement: fineness aggregate: coarse aggregate was 1:2:2 respectively. Wherefore, a total amount of per plate mixed is 112 kg shown as Table 1. After the concrete mixed, before pours into molds of diameter 10 cm x 20 cm cylindrical samples for compression test and 15 cm x15 cm x 53 cm prisms for flexural test, using recycling chopsticks inserted into the samples before the concrete initial setting. The chopsticks diameter of is 0.56 cm, each chopsticks area about 0.3% of the section of cylindrical samples, and the average spacing in the prism is about 2 to 4 cm. All chopsticks will be pulled out before the concrete final setting and the artificial holes in the prisms was arranged by single line, three lines, and five lines. Show as Fig. 3~ Fig. 7.

The compressive strength test was performed after 28 days of curing in room temperature water following ASTM C 139/C 39M 05. The flexural strength was performed with third-points loading test following ASTM C 78 02. The permeability test was following ASTM D2434-06 using constant head water test. In addition, the interface layer between sample edge and inner face of mold was sealed by silicone before test to ensure that all of the water was though from the artificial hole. The device of model was shown as Fig. 8, 9. All of the concrete samples are comparison with traditional concrete (no artificial holes sample) and test at the same time and the same conditions.

Table1. Mixed proportion of artificial holes of pervious concrete (kg)

	Cement	Fineness aggregate	Coarse aggregate	Water
Per patch	20	40	40	12

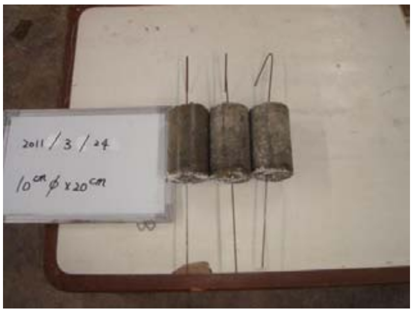

Fig.1 single artificial hole of pervious concrete

Fig.2 three artificial holes of pervious concrete

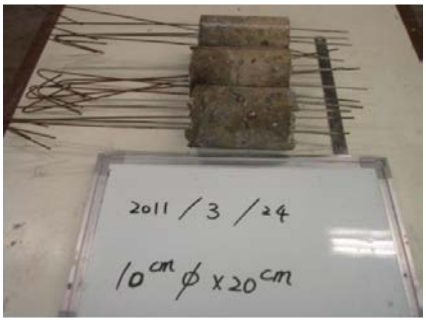

Fig.3 five artificial hole of pervious concrete

Fig.4 single line of artificial hole of pervious concrete

Fig.5 three line of artificial hole of pervious concrete

Fig.6 five line of artificial hole of pervious concrete

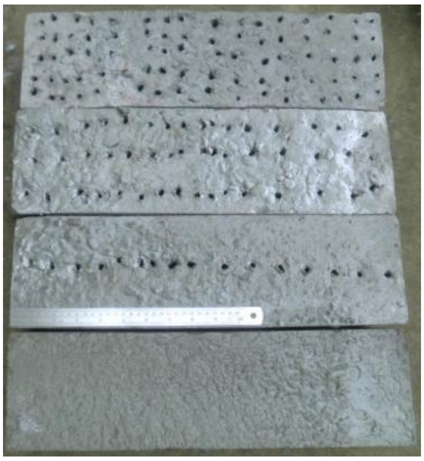

Fig.7 After remold of prism concrete samples

Fig.8 show the edge of sealed single artificial hole of pervious concrete sample before test

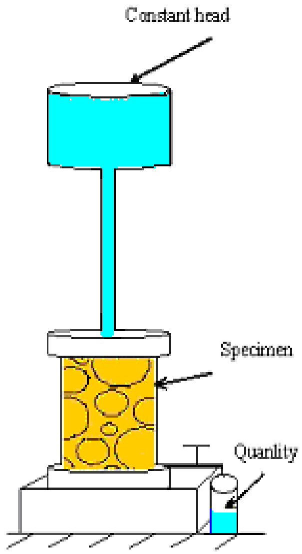

Fig.9 Schematic Lay-out for constant head of permeability test

3. Result

3.1 Compressive strength

The compressive stress Fc was calculated following the equation (1). The result shows as Table 2. Comparison with the traditional concrete, the single-hole, three-hole are almost not affect to the compressive strength and the five-hole sample performance decreased approximately 10%, but still shows that the permeable concrete may reach the C-level pavement material stress of 175 kg/cm2 of local code specification requirements.

$$F_c = P/A \qquad (1)$$

Where P：Compression strength (kgf)

A：Section area of sample (cm^2)

3.2 Split test

The split stress Ft was calculated following the equation (2). Comparison with the traditional concrete, the single-hole, three-holes, and five-holes of permeable concrete shows decreased approximately 12% to 52% as shown in table 2. Figure 8 was shown the samples after split test.

$$F_t = 2P/\pi LD \qquad (2)$$

Where P：Compression strength (kgf)

L：Length of sample (cm)

D：Diameter of sample (cm)

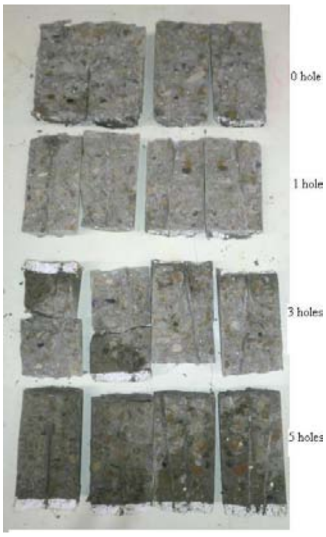

Fig.8 After split test of artificial holes of pervious concrete

3.3 Flexural strength

The flexural stress Fb was calculated following the equation (3). Comparison with the traditional concrete, single-hole, three-hole, five-hole of permeable concrete shows decreased approximately 12% to 54%, was shown as table 2.

Table 2 Comparison of the performance of permeable concrete with the artificial holes number (kg/cm^2)

	Contrary sample	Single artificial hole	3 artificial holes	5 artificial holes
F_c	203	229	210	179
F_t	25	22	12	15
F_b	26	22	13	24

$$F_b=PL/bd^2 \tag{3}$$

Where P：Loading (kgf)

L：Length of sample (cm)

b：Width of sample (cm)

d：Height of sample (cm)

3.4 permeability test

The permeability coefficient was calculated following equation (4). In this study, the position of artificial holes was located near by the neutral axis region of the sample. Since the chopstick diameter near the diameter of the permeable mold entrance and exit size, so the water permeability amount is less influence to the artificial holes number. Nevertheless, the average of permeability coefficient is similar and reached 0.01 cm/sec that is the minimum requirements of the local code as shown in Fig. 9.

$$k=Q/iA \quad (4)$$

where Q：quantity of permeability

i：gradient of hydraulic

A：the area of section of sample

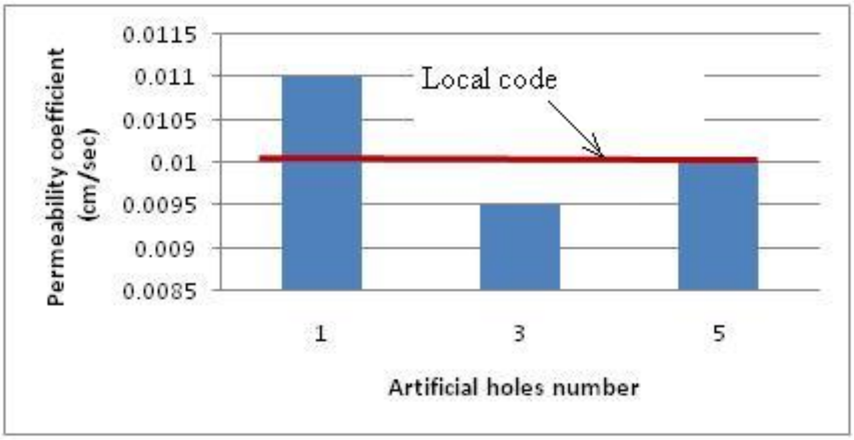

Fig. 9 comparison of the performance of permeable concrete with the artificial holes number and permeability coefficient (cm/sec)

4. Conclusion

(1) The permeable concrete of artificial holes model can reach both of the macro-performance and the permeability coefficient of pavement material of the local code requirements.

(2). Using the artificial hole of permeable concrete for a green building material may success to conserve the base water.

Acknowledgement

The authors are grateful to the graduate students of research team for their assistance in finished the experimental works.

References

ASTM standards C 39-05 “standards test method for compressive strength of cylindrical specimens”.

ASTM standards C 78-02 “standards test method for flexural strength of concrete (using simple beam with third-point loading)”.

ASTM Standards D2434-06, "Standard test for method for permeability of granular soils (constant head)", jurisdiction of ASTM Committee D18 on soil and rock testing, the annual book of ASTM standard.

Hwang, C. L., Peng, S. S., Lin S. H., Wang, E., Haung, S.L. (2010), “The Experimental Investigation of General properties for Pervious Concrete”, Advances in Interaction & Multiscale Mechanics 1st (AIMM10), Jeju, Korea.

Hwang, C.L., Chen, C.T., Huang, H.L., Peng, S.S., Le Anh Tuan Bui and Lee, H.C., (2011), “The Design and Case Study of Pervious Concrete Materials” Advanced Materials Research Vols. 287-290, pp 781-784.

Hwang, C. L., Huang, H.L., Chen, C.T., Peng, S.S., and Yan, Y.Y., (2011), “The Study on the Binders of Pervious Materials”, The 2011 World Congress on Advances in Structural Engineering and Mechanics (ASEM11) Seoul, Korea, 18-22 September.

Chen, R.W., (2001), “Effect of environmental ecological of structural tube pavement”, JW research center of ecological.