PROPERTIES OF POROUS MORTAR CONTAINING HIGH WATER ABSORBENT RESIN FOR THE USE OF ENVIRONMENTAL CONCRETE INTERLOCKING BLOCKS

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SUMMARY

Properties of mortar which has high water absorption and evaporation characteristic (called cellular mortar) were investigated. The ability of high water absorption and evaporation can control the surface temperature rising because of the cooling effect by moisture evaporation. This type of material will contribute to the reduction of a heat-island phenomenon. In this paper, we experimented with the performance of water absorption, evaporation and temperature controlling of porous mortar including high water absorbent resin for the application use of interlocking block.

Time change of water content, water absorption, evaporation and inner temperature of mortar specimen were measured under the heating and humid condition with various material conditions. Consequently, it was cleared that the effects of water absorption, evaporation, and the temperature controlling ability become high in proportion to the increase of resin content and water cement ratio of specimen.

1. INTRODUCTION

Nowadays, earth environmental problem is serious, and it is important to examine the possibility of concrete to have new function improving human environment and reducing environmental load, not

only maintain concept of conventional concrete. Now, the “urban heat island phenomenon” becomes actual (1992), and one of the reasons for this phenomenon is that concrete or asphalt which is used in walls of structures and roads store heat in the daytime and emit it at night. On the other hand, plants bring cooling effect by water evaporation, and the reduction of green belts by tidying up infrastructures in the city is also one of the reasons of this phenomenon. So, if we could give concrete interlocking block a function of absorbing, keeping and evaporating water, it is considered that relief of urban heat island phenomenon is possible.

In this research, we focus on concrete (mortar) which is equipped with high water absorption and evaporation like plant’s cell, additional to function required to conventional concrete, as Cellular Concrete. If, concrete is equipped with such function, it is hoped the development to temperature rising control function. We performed the basic experiments on the characteristic of absorption, evaporation and heat reduction about mortar which including water absorbent resin.

2. OUTLINE OF EXPERIMENTS

2.1 Properties of materials

Properties of materials used in this study are shown in Table 1. High early strength portland cement (C), river sand as fine aggregate (S), high range water reducer as chemical agent (SP) were used. We selected water absorbent resin which absorb by ionic bonding power, and can constant water absorption if it absorbs alkali water such as water including cement.

2.2 Mix proportion of mortar

Factors and levels are shown in Table 2, and mix proportion of concrete is shown in Table 3. W’/C means assumed water cement ratio in case of accepting absorbed water by water absorbent resin. Quantity of water absorption of resin during the mixing is assumed and settled as 20g/g. W’/C of test specimens are 3 levels, 60 %(L), 45 %(M), 30 %(H). Resin content (volume) is 4 levels (in inner temperature test, 3 levels); weight ratio between cement and fine aggregate is 1:1.

Table 1. Properties of materials

Material	Mark	Type	Characteristic
Cement	C	High early strength Portland cement	Density 3.13g/cm^3
Fine aggregate	S	River sand	Density 2.59 g/cm^3
Water absorbent resin	R	Non-ion, poly alkylen oxide series	Density 0.51g/ml, water absorption 20~30g/g
Chemical agent	SP	High range water reducer	SP8HE

Table 2. Test factors and levels

Factor	Level
Water cement ratio, W'/C	0.60(L), 0.45(M), 0.30(H)
Type of fine aggregate	Uniformity
Type of resin	Uniformity
Resin content (volume)	0%, 4.8%, 6.4% (inner temperature Test)
	0%, 3.3%, 4.8%, 6.4% (other Tests)

Table 3. Mix proportion of mortar

Mark	W'/C	W (kg/m^3)	Absolute volume (l/m^3)			SP C×(%)
			C	S	R	
L00	0.60	439	234	282	0	0
L33	0.60	604	145	174	33	0
L48	0.60	683	101	122	48	0
L64	0.60	761	59	71	64	0
M00	0.45	372	264	319	0	0
M33	0.45	562	164	197	33	0
M48	0.45	654	115	138	48	0
M64	0.45	744	67	80	64	0
H00	0.30	285	304	366	0	0.3
H33	0.30	508	188	226	33	0.3
H48	0.30	616	131	159	48	0.3
H64	0.30	722	77	92	64	0.3

Note: W'/C: water cement ratio in case of accepting absorbed water by water absorbent resin

Table 4. Outline of tests

Test item	Test method
Water content	Test age 28days
Compressive strength	JIS A 1108
Water absorption	One side and plumb
Evaporation	One side, L00 and L64
Inner temperature measurement	40℃-50%RH, 80℃-40%RH

2.3 Method of making test specimens

Mortar mixer was used for mixing. Cement, fine aggregate, and water absorbent resin were mixed in 60 seconds. After added water and high range AE water reducer, they were mixed in 90 seconds. After that, they were left for about 1 minute. 3 specimens of 40×40×160mm rectangular specimen for each mix proportions were made. In case of test specimens of inner temperature measurement, a thermocouple was put in center of test specimen and then specimens were hardened. Specimens were removed from molds 24 hours later the placement, rapped and cured for 4 weeks.

2.4 Test methods

Outline of tests are shown in Table 3. In compressive strength test, specimens rapped and cured for 4 weeks and 40×40×80mm rectangular were used. In water absorption test, 40×40×80mm rectangular specimens cured for 4 weeks were used. Test specimens were placed in the drying chamber set the temperature 80℃ for 3 days, dried completely. Then cooled to air temperature and sealed the side by epoxy resin. Small sides (40×40mm) of specimens were put under overflowed water in a vessel and water absorption of them was measured for 24 hours. Water absorption $q_t(\%)$ is introduced by equation (1). Water absorption test is shown in Figure 1.

$$Qt = (t_m - m_0) \ / \ V \times 100 \qquad (1)$$

m_t: Weight of a specimen after t minutes water absorption (mg)

m_0: Weight of a dried specimen (mg)

V: Volume of a specimen ($40\times40\times80mm^3$)

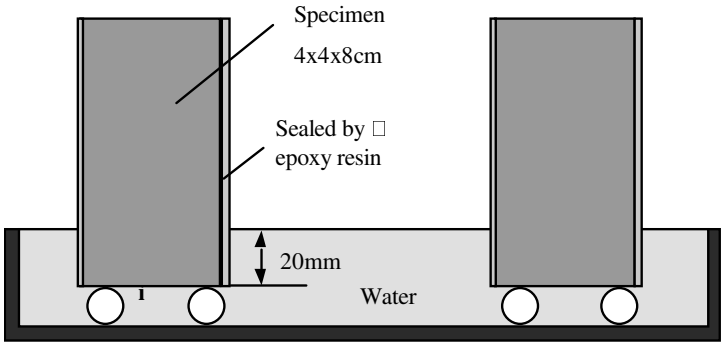


Figure 1. Water absorption test

In the evaporation test, quantity of evaporation of most high water absorbent specimens and normal specimens were compared. Side sealed test specimens of L00 and L64 were absorbed water from two small sides for 2 days. After this, they were put in the environment of 20℃, 45%RH, weighed the quantity of evaporation at each minutes. Evaporation E_t (%) is introduced by equation (2).

$$E_t = (m_0 - m_t) / V \times 100 \quad (2)$$

m_0: Weight of a specimen before evaporation (mg)

m_t: Weight of a specimen after t minutes evaporation (mg)

V: Volume of a specimen ($40\times40\times80 mm^3$)

In the inner temperature test, test specimens put a thermocouple in center of them and hardened were used. Each of test specimens absorbed enough water was placed in a chamber which is kept constant temperature and humidity. Thermocouples put in center of specimens were jointed to the data logger. It is said that the temperature of outdoor concrete slab rises to 80℃, and air temperature rises to 40℃ in mid-summer. So, the temperature and humidity in the chamber were set as each of 40℃, 50 %RH and 80℃, 40%RH.

3. RESULTS AND DISCUSSION

3.1 Relationship between compressive strength and quantity of resin

Relationship between 28 days compressive strength and quantity of resin is shown in Figure 3. The compressive strength was getting smaller in proportion to increase of resin content and was less than the compressive strength of plain mortar as L ($33N/mm^2$), M ($49 N/mm^2$) and H ($72 N/mm^2$).

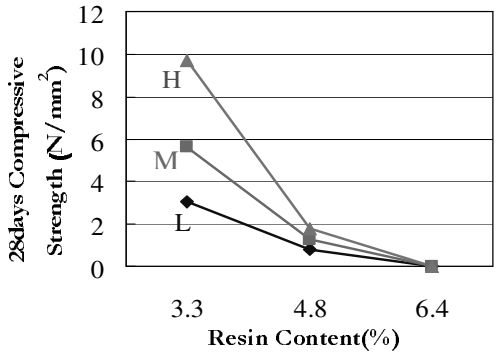


Figure 3. Relationship between compressive strength and resin content

3.2 Water absorption

Result of water absorption test is shown in Figure4 (classified by resin content) and Figure 5 (classified by W'/C). Within plain mortar (including no resin), L is originally apt to absorb water. Classified by resin content, when resin content is 0 to 4.8 %, differences between L and M, H were big. And, when resin content is 6.4 %, differences between L and M, M and H were almost equal.

Classified by W'/C, large amount of absorption is shown in L. Water absorption was reduced in M and H, but compared with normal mortar including no resin, water absorption was larger. The reason of this high water absorption is thought that mortar became porous by expansion of water absorbing resin in mixing procedure and also the resin in mortar was absorbing high amount of water.

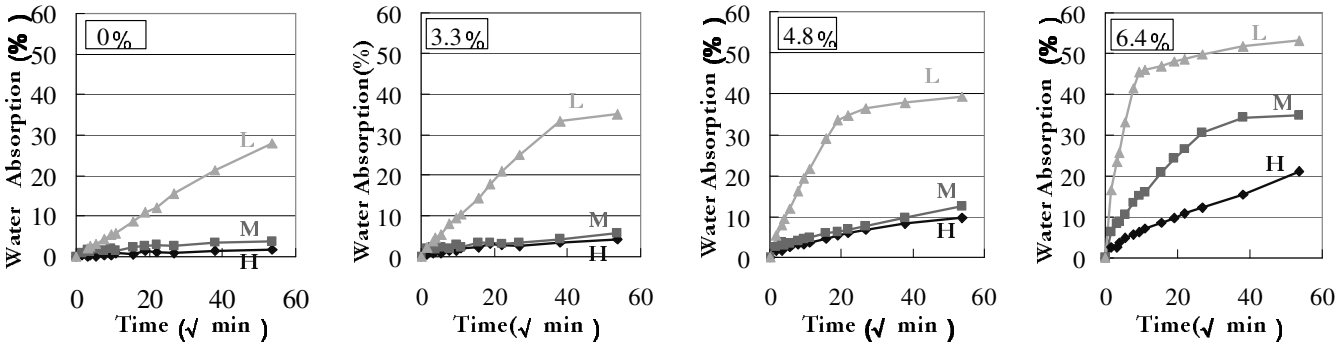


Figure 4. Change of water absorption in time for various resin content

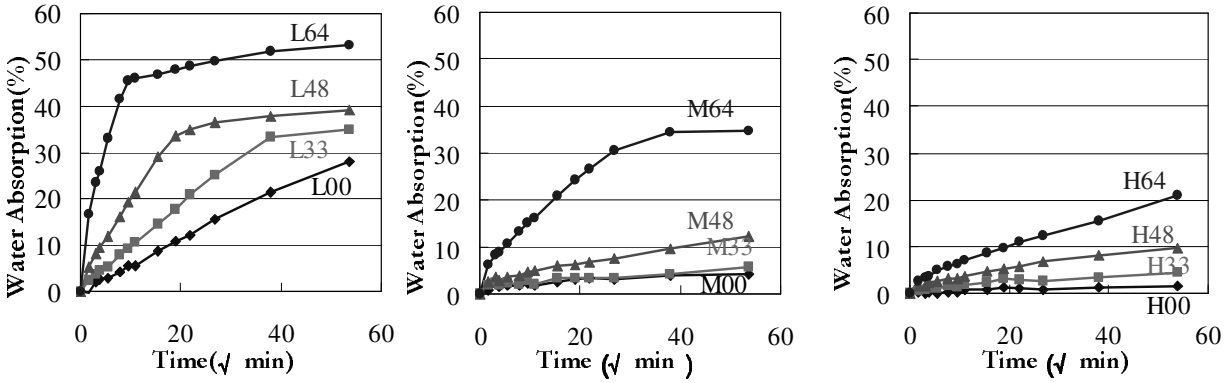


Figure 5. Change of water absorption in time for various W'/C

3.3 Water evaporation

Result of evaporation test is shown in Figure 6. Each test specimens showed constant water evaporation. However, test specimens including 6.4 % of resin content showed evaporation about 4 times the amount of it of test specimens including no resin. Each test specimens needed 22 days to keep balance. Compared to speed of water absorption, that of evaporation is slow. And, compared to Figure 7, evaporation per water absorption of L64 was larger than that of L00.

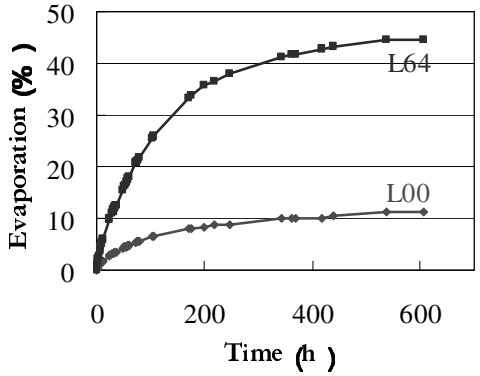


Figure 6. Change of water evaporation over Time

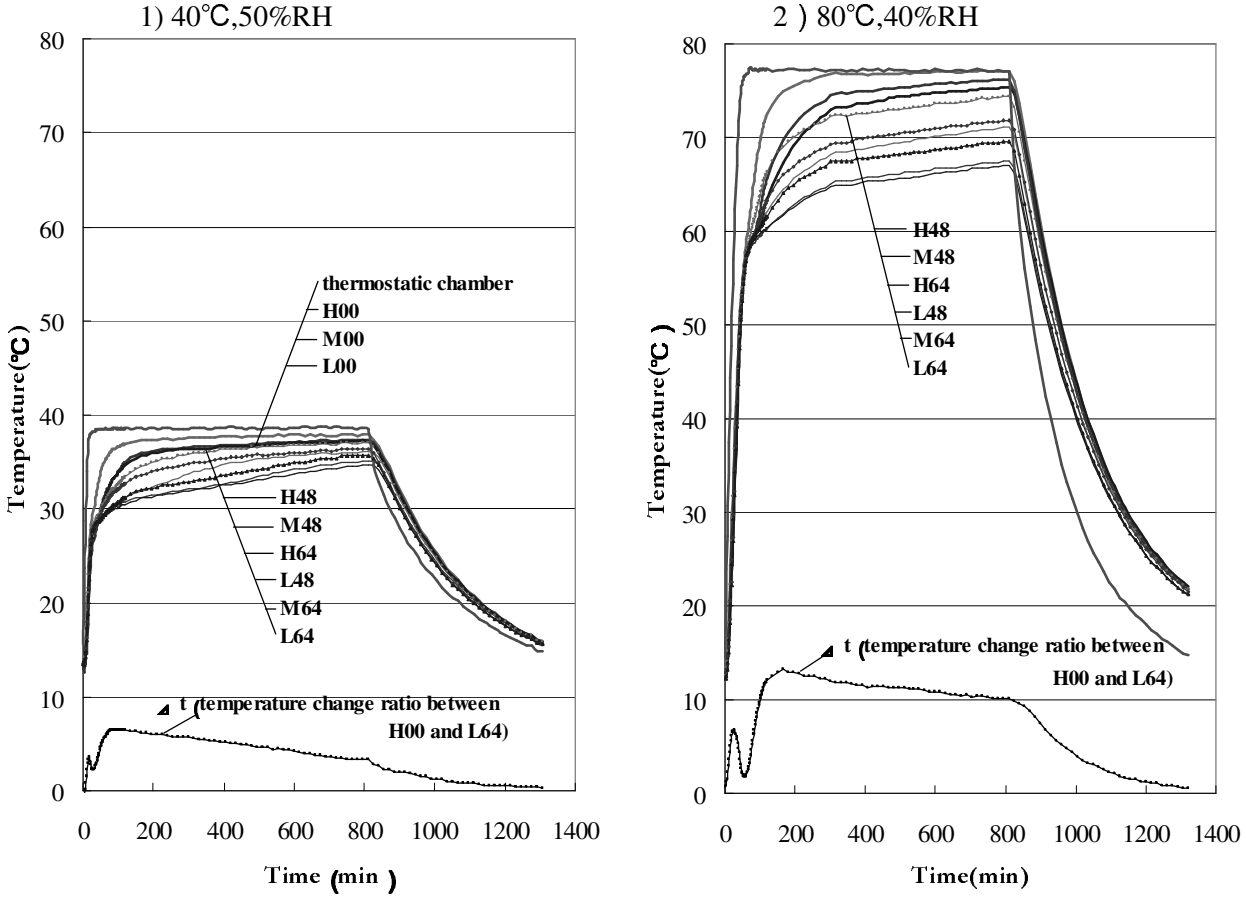


Figure 7. Relationship between inner temperature of specimen and time

3.5 Temperature rise controlling function of mortar

Result of inner temperature test is shown in Figure 7. In each conditions of high and low air temperature, a tendency that the inner temperature rising of mortar became small in proportion to increase of resin content and W'/C was shown.

Difference between inner temperature of H00 and L64 became larger following the temperature rising in the chamber. Directly before temperature rising became slowly, difference between them shrank. Then, difference between them recorded 13.2℃ after 165 minutes in high temperature condition, and 6.5℃ after 102 minutes in low temperature condition. With more heating, differences became smaller. After heating, differences among the rate of temperature falling of each test specimens could not be shown.

4. CONCLUSIONS

(1) Mortar containing water absorbent resin showed high water absorption. The reason of this is thought that mortar became porous by expansion of water absorbing resin in mixing procedure and also the resin in mortar was absorbing high amount of water. These effects were improved with increase of W/C and resin content.
(2) Compressive strength of mortar became extremely low with increase of W/C and resin content.
(3) Mortar containing water absorbent resin showed high water evaporation. This function was improved with increase of quantity of resin.
(4) Mortar containing water absorbent resin possesses ability to control temperature rising. This ability caused evaporation of absorbed water when heated. This ability was improved with increase of W/C and resin content.
(5) Use of the interlocking block made from this mortar could relief urban heat island phenomenon.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

Fukute, T, 1998. Reduction of environmental load by permeability, Concrete Engineering, 36, 16-18.