Proceedings of the 7th International Conference on Asian and Pacific Coasts
(APAC 2013) Bali, Indonesia, September 24-26, 2013

INFLUENCE OF THE CURING METHOD ON COMPRSSIVE STRENGTH AND POROSITY OF CONCRETE MIXED WITH SEA WATER, MARINE SAND AND FLY ASH

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ABSTRACT: There many archipelagic state such as Japan, Indonesia and other countries. Indonesia consists of thousands of islands where many peoples live in the low land area, the distant and isolated islands that lack of clean water or fresh water and mountain sand or river sand.Transporting the fresh water or clean water and mountain aggregates or river aggregates for concrete production to the low land area, the distant and isolated islands will make the price of concrete work becomes more expensive. In order to overcome the problem of shortage of clean water and fine aggregate in the low land area, the distant island, and saving the fresh water over the world, this research seeks to use sea water and sea sand to produce concrete. In order to overcoming the continuous dumping of waste material, this research also uses semen containing wasted material such as fly ash. This research is a part of ongoing investigation that focuses to study the mix design), mechanical properties (compressive strength-modulus elasticity), porosity, and curing method in order to achieve an optimum correlation between sea water, marine sand, cement, river or mountain coarse aggregate in production of high performance concrete. Furthermore, it is important to conduct research on utilization of sea water, whose percentage is 97% of the total water on the earth, as an effort for improving the technology of saving fresh water.

Keywords: Sea water, marine sand, fly ash, compressive strength, modulus elasticity, porosity.

INTRODUCTION

Now days many countries face the crisis of growing water scarcity, and if current situations continue, in 2015, approximately of 605 million people will continue to use unimproved source to meet their drinking water needs and 2.4 billion people would remain without access to basic level of sanitation (UN Water GLASS, 2012). Globally, concrete industry uses several billion tons of water annually for mixing water, curing water and cleaning water, while the utilization of sea water in concrete industry is inhibited. It is important to conduct researh on utilization of sea water, whose percentage is 97% of the total water on the earth, as an effort for improving the technology of saving fresh water.

Marine aggregates are suitable for ready mixed concrete, fill material and the others construction work, therefore it can be used to secure the aggregate supply for construction works. A number of countries have been using sea sand as construction material for substitution of mountain material and river sand, with taking into account the inevitable impact of marine aggregate mining and extraction on the marine biodiversity environment preservation (David R. Hitchcock and Steve Be, 2004).

There many archipelagic state such as Japan, Indonesia and other countries. Indonesia consists of thousands of islands where many peoples live in the distant and isolated islands that lack of clean water or fresh water and mountain sand or river sand. Transporting the fresh water or clean water and mountain aggregate or river for concrete production to the distant and isolated islands will make the price of concrete work becomes more expensive. In order to overcome the problem of shortage of clean water and fine aggregate in distant island, and saving the fresh water over the world, this research seeks to use sea water and sea sand to produce concrete.

This research is a part of ongoing investigation that focuses to study the mix design, workability (slump, segregation), mechanical properties (compressive strength-modulus elasticity), porosity, and curing method in order to achieve an optimum correlation between sea water, sea sand, cement, coarse aggregate in production of high performance concrete. In order to overcoming the continuous dumping of waste material, this research also uses semen containing wasted material such as fly ash (Secondary Cementitious Materials, **SC**Ms), etc.

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EXPERIMENTAL METHOD AND MATERIAL

Concrete Mixtures and Materials

There were two concrete mixtures. The first mixture used sea water with chloride content of 0.522 mol/liter as mixing water. This mixture was cured in the sea water, and in the air. The second mixture was mixture control that used fresh water (the tap water) as mixing water and cured in the fresh water. All concrete mixtures used sea sand that has been cleaned from the chloride content, a type of ordinary portland cement and fly ash type B. The ordinary portland cement and fly ash type B meet the requirements of JIS R 5210 (Portland Cement) and JIS R 5213 (Fly Ash Cement), respectively. Table 1 and 2 show the physical properties of coarse aggregates and the mixes design of concrete. The specific gravity (saturated surface dry), water absorption, and fine modulus of sea sand were 2.55, 1.82% and 2.77, respectively.

Property		Crushed stone 1 (CS1)	Crusehd stone 2 (CS2)
Diameter		10-20 (mm)	5-10 (mm)
Specific gravity	Oven dry	2.89	2.89
	Saturated surface dry	2.91	2.91
Water absorption		0.62	0.62

Table 1 Physical properties of coarse aggregates

Name	Water (w)	Cement (c)	FA	sand	Crushed stone
Tap Water Normal 1	160	81	29	274	411
Tap Water Normal 2	160.2	81	29	309	376
Sea water	165	84	30	305	372

Table 2.Mixes design of concrete (in 1000 litre)

Curing Methods

There are three curing methods used in this study, curing in the fresh water, curing in the sea water and curing in the air (temperature 20^{0}C, 60 RH). The specimens of compressive strength-elasticity and porosity were cured in the fresh water, cured in the sea water and cured in the air until the testing time.

Testing Methods for Compressive strength and static modulus of concrete

Compressive strength and modulus of elasticity were tested with according to JIS A 1108 (Method of test for compressive strength of concrete) and JIS A 1149 (Method of test for static modulus of concrete), respectively. The dimension of specimen is 100 mm in diameter and 200 mm in height of cylinder.

Mercury Intrusion Porosimetry (MIP)

The pore size distribution was determined by 5-mm-thick samples cutting from identically produced and cured cylinders specimens . The fragments were dipped into the acetone for 15 min, and then dried in the vacuum desiccator for 2 days. The pressure of MIP ranges from 0 to 35,000 psi (241 MPa). The Hg surface tension of 485 dynes/cm and a contact angle of 130o were used in the Washburn equation to convert applied pressure to pore diameter. The pore width corresponding to the highest rate of mercury intrusion per change in pressure is known as the "threshold" pore width. After achieving this highest rate of intrusion, mercury has been shown to penetrate the interior of the specimen.

RESULTS AND DISCUSSION

Compressive strength results

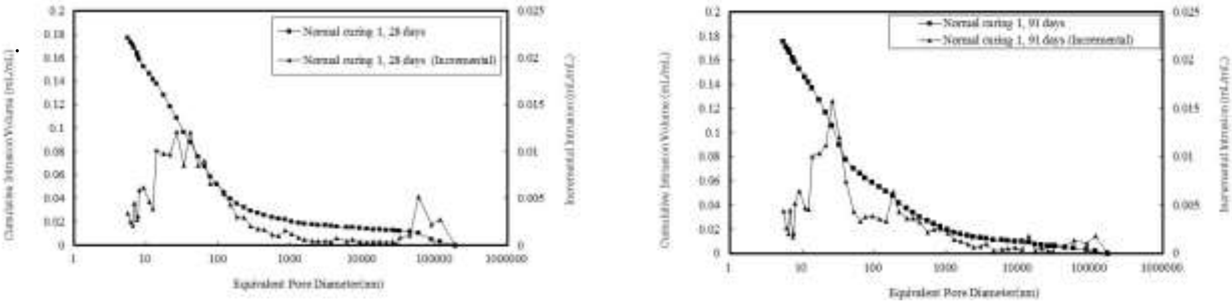
Table 3 shows the compressive strength result. Table 4 shows the elasticity of concrete. All of the mixtures met the requirement of strength of 30 MPa at 28 days. The test results of concrete strength at 28 days and 91 days showed that the concrete compressive strength and elasticity increased in the all curing methods but the rate of increase was different for each curing method. Concrete compressive strength of the air curing method was the lowest. Compressive strength of concrete with cured in the seawater can achieve the same compressive strength of concrete that cured in the fresh water.

Table 3 Compressive strength

Days	Compressive strength (MPa)			
	Normal Curing 1	Normal Curing 2	Sea water curing	Air curing
28	37.93	38.62	38.71	32.24
91	48.91	51.91	51.48	42.12

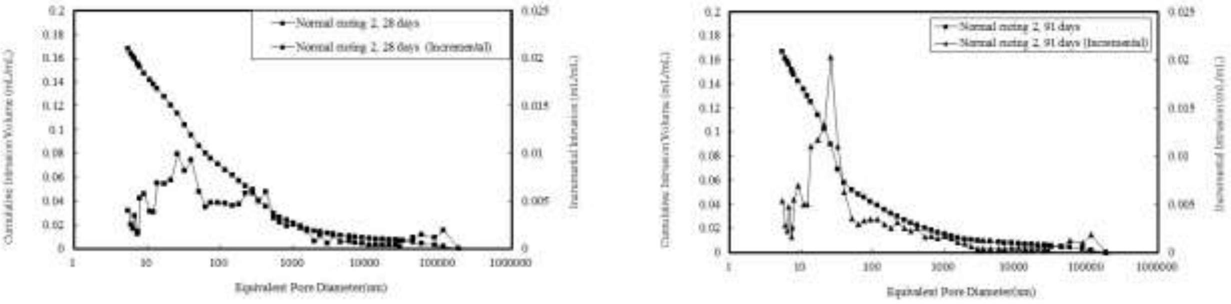
Table 4 Static modulus of concrete

Days	Static modulus of concrete (MPa)			
	Normal Curing 1	Normal Curing 2	Sea water curing	Air curing
28	33,522	33,627	34,054	33,052
91	40,428	43,264	38,708	35,553



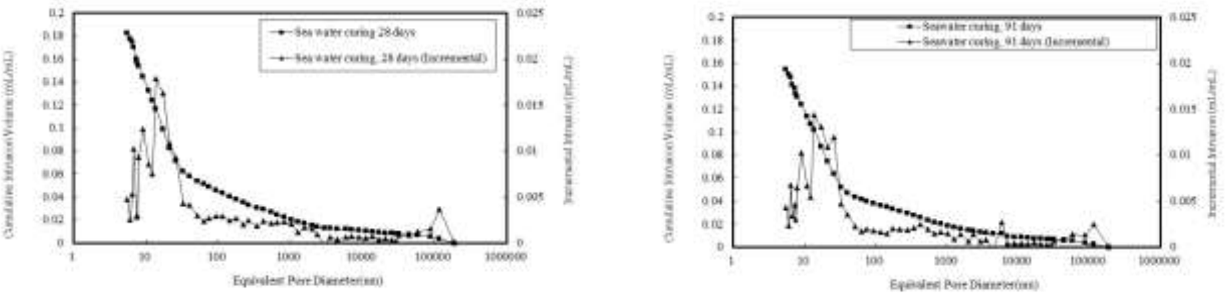
(a) 28 days (b) 91days

Fig.1 Porosity (Normal curing 1)



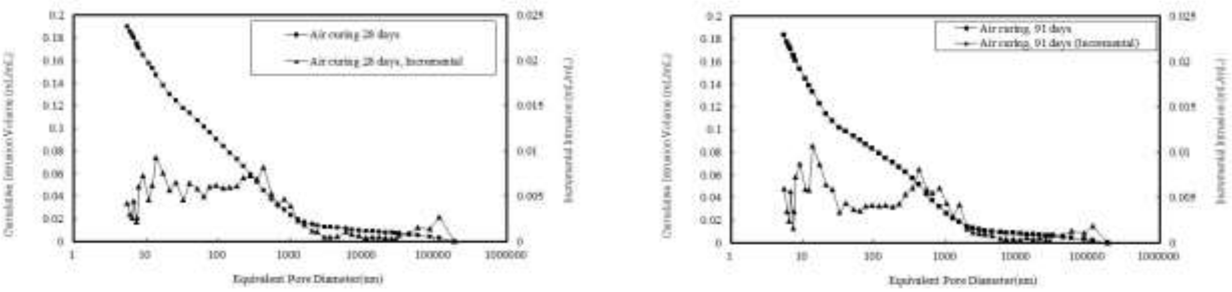
(a) 28 days (b) 91days

Fig.2 Porosity (Normal curing 2)



(a) 28 days (b) 91days

Fig.3 Porosity (Sea water curing)



(a) 28 days (b) 91days

Fig.4 Porosity (Air curing)

Result of Porosity Tests

Figure 1 to Figure 4 show the Mercury Intrusion Porosimetry test results. The number of porosity at 28 and 91 days showed the porosity decreased with the curing period in the all curing methods but the rate of decrease was different for each curing method. Porosity of concrete with cured in the air was the highest. Concrete that cured in sea water had the lowest amount of porosity.

At the air curing, seawater used for mixing quickly evaporates causing the hydration process was not going well that made a lot of pores within the concrete specimen. Seawater and cement particles performed optimally the hydration process when cured in the sea water, same phenomenon with the fresh water curing, an optimum hydration process was performed between fresh water and cement particles.

When sea water is used in concrete mixing, some part of chlorides in seawater becomes bound to the solid matrix. The bounding chloride is called Friedel`s salt, it fill the microvoids and decrease the total numbers of voids, resulting in the lower porosity within the concrete specimens than the concrete specimens that were used fresh water as mixing water and were cured in the fresh water. The interim results showed that the lower porosity within concrete specimens when cured in seawater did not give more effect for the compressive strength and porosity when compared to the concrete specimen that used fresh water for both of mixing and curing.

CONCLUDING REMARKS

The interim result showed that sea water can be used as mixing water of concrete and concrete curing water. After removed from the mold, concrete using sea water as mixing water can be cured in the sea to ensure the hydration process doing well, and to inhibit many pores and cracks occur within the concrete if it is in the air curing.

ACKNOWLEDGEMENTS

The research was carried out by the funding from Hasanuddin University Engineering Faculty Development Project (Short Term Research Scholarship Program). Most of the research work was conducted in the Concrete Laboratory, Civil and Structural Engineering, Kyushu University, Japan.

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