# Durability of Lightweight Concrete and Mortar Exposed under Some Environment

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**Abstract**

In this experiment, identically composed specimens of lightweight concrete and of a mortar material were exposed to a cold (coastal)* environment (Monbetsu), warm sea environment (Izu) and used in the roof of a building in a warm-climate city (Yokohama) for 3years. The physical and chemical properties of the lightweight concrete specimens and those of the mortar specimens were examined. The results are as follows:

(1) The lightweight concrete specimen contained more salt than the same mortar specimen.

(2) The free calcium content on the surface of lightweight concrete specimens tended to decrease more than that of the mortar specimen.

(3) Ettringite by sulfuric ion and Friedel's salt by chlorine ion were not observed in either the lightweight concrete specimens or the mortar specimens.

## 1. INTRODUCTION

Experiments were carried out in such a way that specimens of lightweight concrete were exposed in cold coastal environment (Monbetsu), warm sea environment (Izu) and warm town area's roof of building (Yokohama) for 3years. The physical and chemical properties of the specimens of lightweight concrete and the same water cement ratio and materials were inspected.

## 2. EXPERIMENTAL PROCEDURES

Mixing condition and material are shown in Table 1 and Table 2. Exposed conditions are shown in Table 3. The method of measurement are shown in Table 4.

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**Table 1** Mix condition and properties of concrete

| Maximum size of coarse aggregate (mm) | W/C (%) | S/a (%) |
|---|---|---|
| 15 | 45 | 45 |

Mixing condition (Kg/m³)

| Water | Cement | Fine aggregate | Coarse aggregate | Chemical admixtures 1 | Chemical admixtures 2 |
|---|---|---|---|---|---|
| 156 | 347 | 802 | 585 | 0.868 | 2.086 |

Properties

| Slump (cm) | | Air content (%) | Temperature of fresh concrete (°C) |
|---|---|---|---|
| Base concrete | After adding HP-20 | | |
| 11.6 | 22.8 | 6.35 | 20.3 |

**Table 2** Material

| Kinds of cement | Fine aggregate | Coarse aggregate | Chemical admixtures 1 | Chemical admixtures 2 |
|---|---|---|---|---|
| Blast-furnace slag cement B(S. G. : 3.06) | S. G. : 2.62<br>A. R. : 1.50% | S.G. : 1.60<br>(Light-weight) | Air entrained | Super-plasticizer |

S. G. : Specific gravity A. R. : Absorption rate (%)

**Table 3** Exposing condition

| Exposing Spot | Distance from sea vater | Temperature (°C) | Relative humidity | Cycles of freeze and thow |
|---|---|---|---|---|
| Monbatsu | 32m | Average minimum of Feb. : −11.3<br>Average maximum of Aug. : 22.3<br>Average of year : 5.9 | Av. of Feb. : 76<br>Av. of Aug. : 85<br>Av. of year : 76 | 80 |
| Izu | 1m | Average minimum of Feb. : 1.8<br>Average maximum of Aug. : 30.5<br>Average of year : 16.0 | Av. of Feb. : 58<br>Av. of Aug. : 78<br>Av. of year : 69 | 20 |
| Yokohama | 10km | Average minimum of Feb. : 1.2<br>Average maximum of Aug. : 30.7<br>Avarage of year : 15.1 | Av. of Feb. : 60<br>Av. of Aug. : 80<br>Av. of year : 71 | 20 |
| Standard curing | | 20 | — | 0 |

*1 : Referring to Tokyo Astronomical Observatory : "Science chronological table"

**Table 4** Items of test and dimension of specimens

| Items of test | Dimension of specimen (cm) | Test mothod |
|---|---|---|
| Weight | Concrete □ 10×10×40 | By balance (sensitivity : lg) measured immedately and measured after soaking for 4 hours |
| | Concrete $\phi$10×20 | |
| | Mortar □ 10×10×20 | |
| Resonance frequency | Concrete □ 10×10×40 | The same as the above condition in accordance with JIS A 1127 |
| | Concrete $\phi$10×20 | |
| Ultra sonic velocity | Concrete □ 10×10×40 | The same as the above condition by using ultrasonic pulse apparatus |
| | Mortar □ 10×10×20 | |
| Compressive strength | Concrete $\phi$10×20 | The same as the above in accordance with JIS A 1107 |

## 3. CONCLUSION

(1) Physical properties

Relation between period of exposing and change in weight are shown in Fig. 1. Relation between period of exposing and change in resonance frequency are shown in Fig. 2. Relation between period of exposing and change in ultrasonic velocity are shown in Fig. 3. Relation between period of exposing and change in compressive strength are shown in Fig.

Example
● : Monbetsu, measured immedately
○ : Mombetsu, measured after soaking for 4 hours
■ : Izu, measured immedately
□ : Izu, measure after soakig for 4 hours
▲ : Yokohama, measured after soaking for 4 hours
△ : Yokohama, measured after soaking for 4 hours
◇ : Standard curing

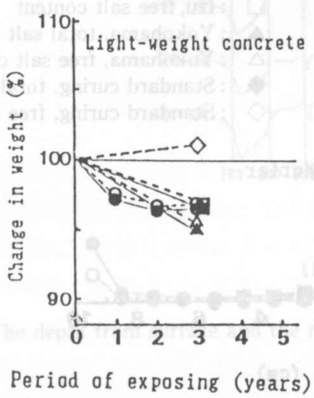


**Fig. 1** Relation between period of exposing and change in weight

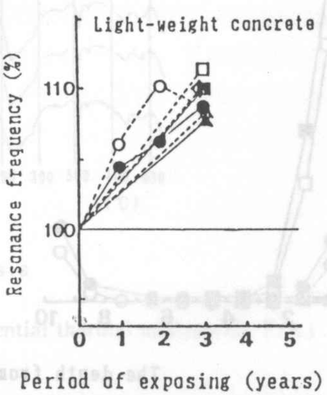


**Fig. 2** Relation between period of exposing and change in resonance frequency

4.

Accordingly physical properties of the specimens after exposing in some environment were nearly the same as that of the specimens after standard curing and there was hardly any deterioration observed in specimens.

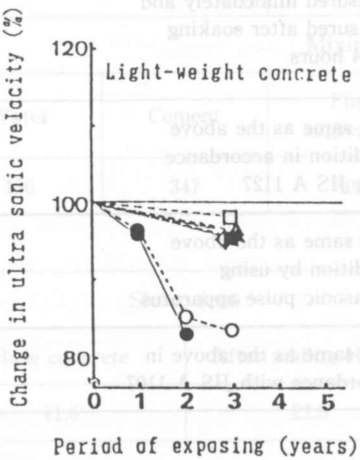


**Fig. 3** Relation between period of exposing and change in ultra sonic velocity

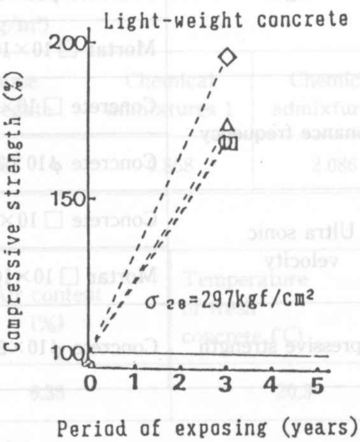


**Fig. 4** Relation between period of exposing and change in compressive strength

(2) Chemical properties

Relation between the depth from the surface and salt content are shown in Fig. 5. The lightweight concrete specimen contained more salt than the same mortar.

Relation between the depth from the surface and free calcium content are shown in Fig. 6.

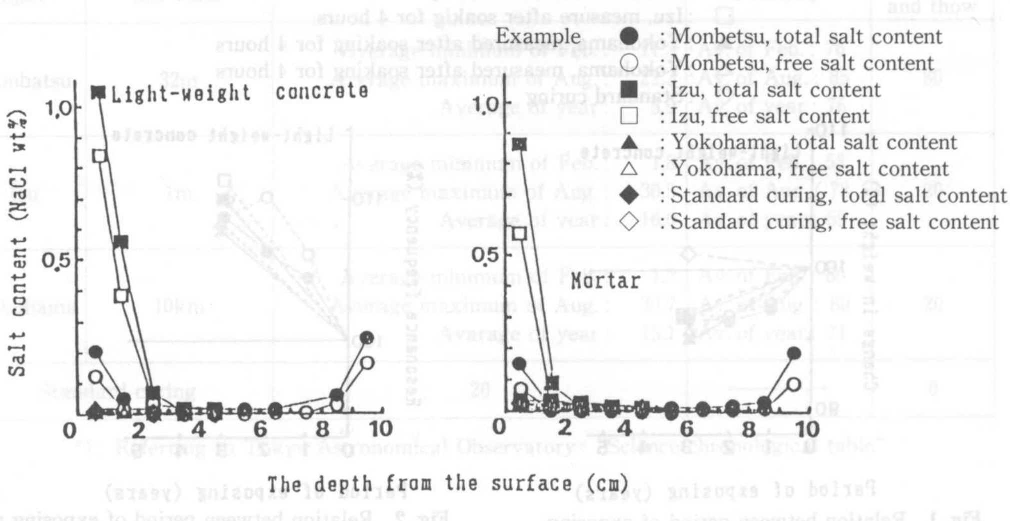


**Fig. 5** Relation between the depth from the surface and salt content exposed in Monbetsu.

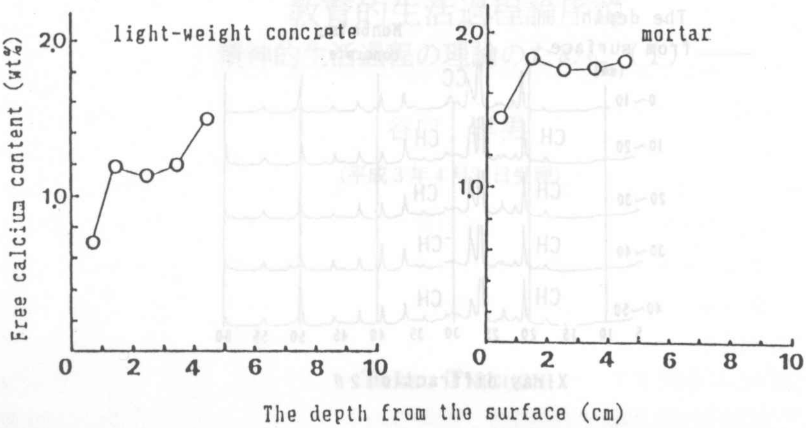


**Fig. 6** Relation between the depth from the surface and free calcium content exposed in Monbetsu.

The depth from surface and the result of differential thermal analysis (D. T. A.) are shown in Fig. 7.

The depth from surface and the result of X-ray diffraction (X. R. D.) test are shown in Fig. 8.

Ettringite by sulfuric ion and Friedel's salt by chloride ion were not observed in both lightweight concrete and the mortar.

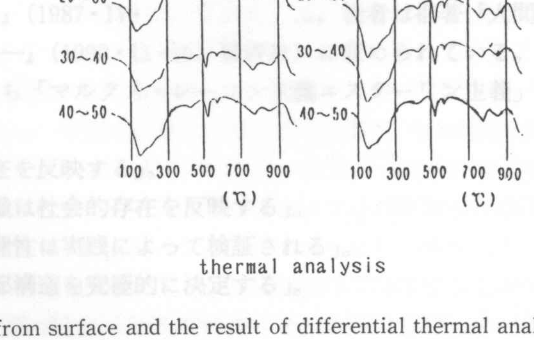


**Fig. 7** The depth from surface and the result of differential thermal analysis (D. T. A.)

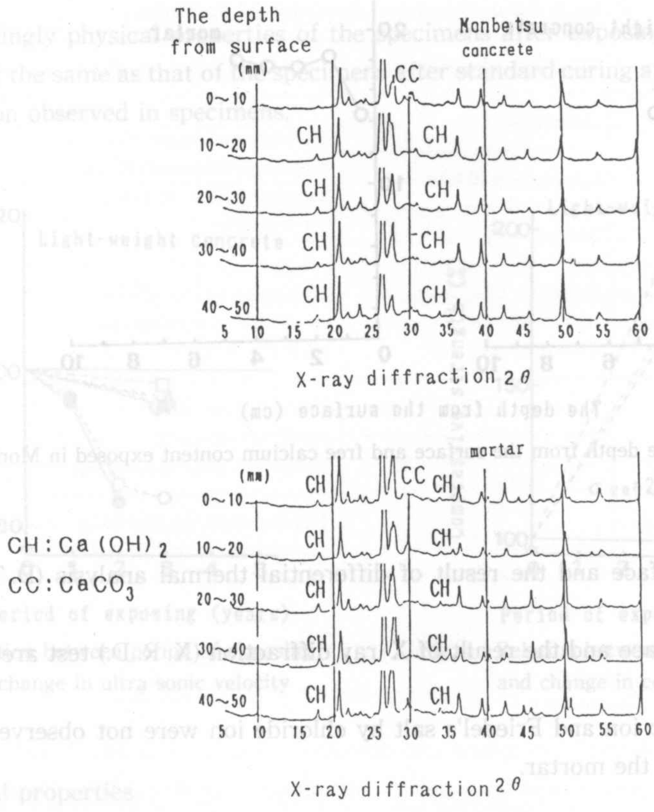


**Fig. 8** The depth from surface and the result of X-ray diffraction (X. R. D.) test

## Reference

1) Sakurai, H., Kaneko, S., Matsuoka, Y. and Naito T. : "Properties of Lightweight Concrete Soaked in Sewage Including Hot Spring Water Containing a Salt", Transaction of JCI vol. 7, 1985