# A Test Method on Rapid Identification of Alkali Reactivity Aggregate (GBRC Rapid Method)

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## 1. Introduction

Since 1984, the GBRC Rapid Method has been developed in General Building Research Corporation of Japan (GBRC), in order to rapidly identify the alkali reactivity of aggregates. It is also available for the determination of future susceptibility to alkali-aggregate reaction of fresh concrete. We have published the results of studies on GBRC Rapid Method several times in Japan (1-5). In this report, we present an outline of the test method and a description of the investigation to develop the test. We also present test results on 152 aggregate samples using this method, and a correlation of the results of the GBRC Rapid Method with the ASTM Chemical and Mortar-bar Methods, and its application for the identification of future susceptibility to alkali aggregate reaction of fresh concrete.

## 2. GBRC Rapid Method

In this method, the cracking phenomena of mortar due to alkali-aggregate reaction can be observed in mortar after two days. Three mortar bars of 4 × 4 ×16cm are made with 600g of crushed particles of sample aggregate(0.15-0.6mm:0.6-2.5mm:2.5-5mm=2:5:3), 600g of innocuous standard sand (Toyora sand, 0.1-0.3mm) 600g of ordinary portland cement and 300g of NaOH solution. Toyora sand is used so that the mix proportion of aggregate is almost the pessimum. And NaOH solution is used so that the alkali content of the cement used in the mortar is adjusted to 2.5% $Na_2O$ equiv.. After the specimens are cured in the molds for the first day, and in water for the second day, they are then placed in boiling water in a pressure vessel (gauge-pressure: 0.5 kg/cm², total pressure: 1.5 kg/cm², temperature: 111°C) for two hours. Cracking behavior of the mortar specimens is checked just before and after boiling by visual inspection (see Fig. 1) and changes in the value of the ultrasonic pulse velocity, and the dynamic Young's modulus of the specimens.

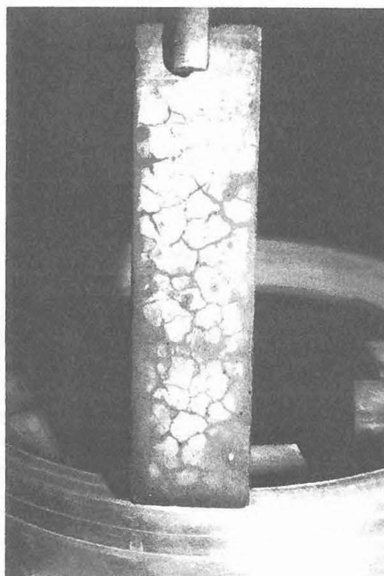

Fig.1 Crack just after boiling

On the basis of our studies mentioned below, we tentatively propose that an aggregate should be evaluated as "Innocuous" by satisfying any of the following three items:

(1) No cracking as observed by visual inspection.
(2) A reduction ratio in the ultrasonic pulse velocity (Ru) of less than 5%.
(3) A reduction ratio in the dynamic Young's modulus (Rd) of less than 15%.

For a more simplified test, where testing must be done frequently, we recommend using mortar pats (about $\phi 10\times 1$ cm) with only thorough visual inspection, instead of bars.

## 3. Fundamental investigations for setting up GBRC Rapid Method

Figs.2 to 6 show the results of investigation on the boiling period (Figs.2 & 3), the total alkali content in mortar (Figs.4 & 5), and the ratio of sample aggregate/total aggregate (Fig.6).

Judging from Figs.2 and 3, we decided for two hours boiling under the pressure of 1.5kg/cm² (temperature: 111℃). The total alkali of 2.5% $Na_2O$ equiv. by weight of cement may seem too high, however, we consider it reasonable to distinguish potentially deleterious aggregates from innocuous ones, according to the test results shown in Figs.4 and 5. As for the ratio of the sample/total aggregate, 50% was considered preferable to 100% from the test results presented in Fig.6.

## 4. Test results by GBRC Rapid Method

### 4.1 On the 152 aggregate samples in Japan

Test results are summarized in Figs.7 and 8. Fig.7 shows that in Japan we can find a lot of innocuous aggregate in spite of the severe conditions of this test method. Fig.8 clearly shows that any of three methods of sample evaluation are satisfactory.

### 4.2 Correlation among the results of GBRC Rapid Method, ASTM Chemical Method & Mortar-bar Method

Fig.9 presents the correlation among the test results of 46 aggregate samples by three kinds of test methods. Judging from this figure, deleterious samples determined by GBRC Rapid Method have the results of $Sc > 250$mmol/l by ASTM Chemical Method, and some of them are also determined as deleterious by ASTM Mortar-bar Method under $R_2O$($Na_2O$ equiv.)$=1.2\%$. In other words, the test criterion of GBRC Rapid Method is between ASTM Chemical Method and Mortar-bar method under $R_2O=1.2\%$. According to petrographic examinations, all deleterious aggregate determined by the GBRC Rapid Method in the studies, contain reactive volcanic minerals such as cristobalite and tridymite concerning classical alkali-aggregate reaction. Among innocuous aggregates, there are a few aggregates containing cryptocrystalline quartz, however, they are evaluated "Innocuous" also by ASTM Mortar-bar Method under $R_2O=1.2\%$.

## 5. Application of GBRC Rapid Method for the identification of future susceptibility to alkali-aggregate reaction of fresh concrete

We propose another new method for rapid identification of future susceptibility to alkali-aggregate reaction of fresh concrete. The preventive effect of mineral additives on alkali-aggregate reaction can be also easily evaluated by this method.

In this method, NaOH solution is added in mixing water so that the concrete should contain the additional alkali of 9kg/m³ $Na_2O$ equiv. and concrete cylinders of $\phi 10\times 20$cm are used. The other procedures are the same as the GBRC Rapid Method.

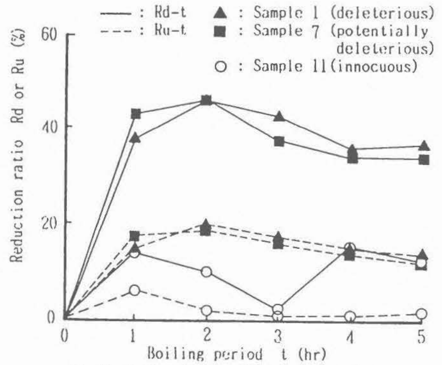


Fig.2 Both relationships between the reduction ratio of dynamic Young's modulus (Rd) and boiling period (t), and the reduction ratio of ultrasonic pulse velocity (Ru) and boiling period (t)

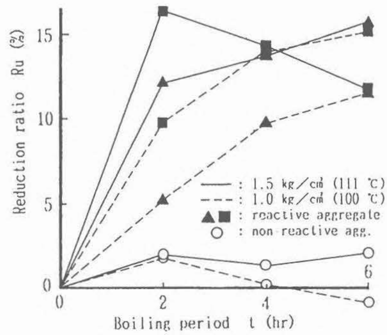


Fig.3 Effects of the pressure (or temperature) at boiling on the reduction ratio Ru

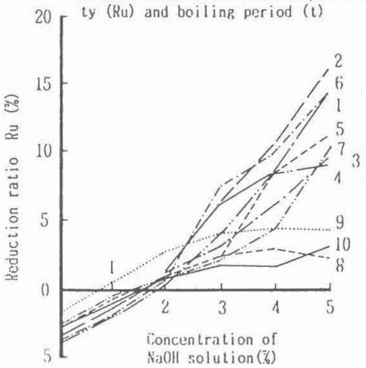


Fig.4 Relationship between the reduction ratio Ru and concentration of NaOH solutin

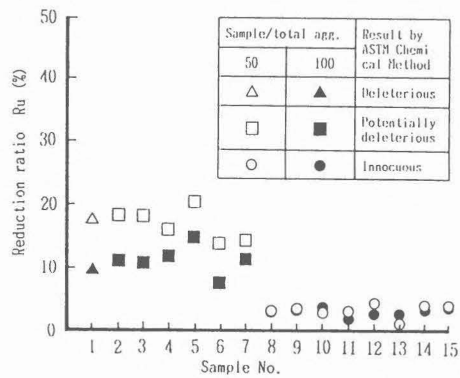


Fig.6 Reduction ratio of ultrasonic pulse velocity (Ru) of a specimen with sample/total aggregate of 50% or 100%

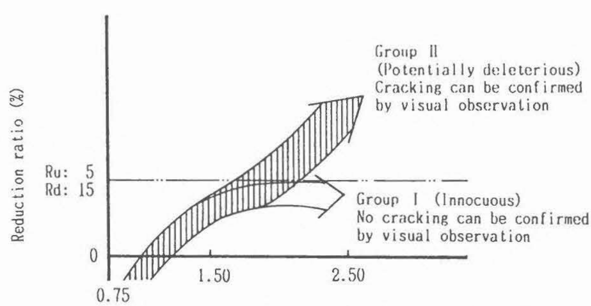


Fig.5 Relationship between the reduction ratio of ultrasonic pulse velocity (Ru) or dynamic Young's modulus (Rd) and concentration of alkali

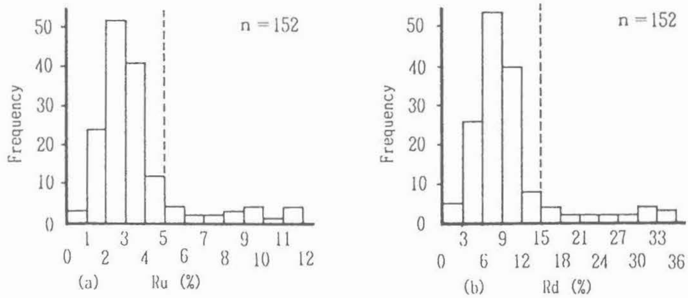


Fig.7 Frequency distribution of 152 test results

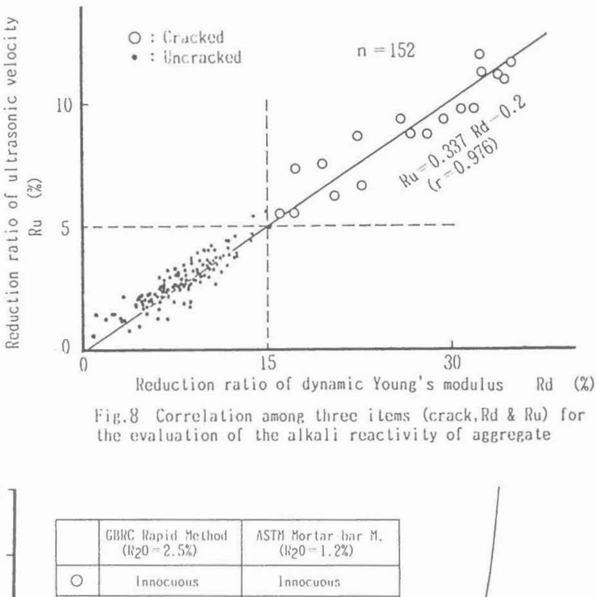


Fig.8 Correlation among three items (crack, Rd & Ru) for the evaluation of the alkali reactivity of aggregate

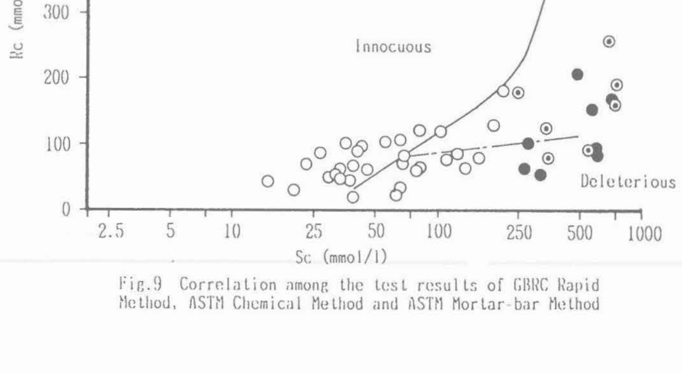


Fig.9 Correlation among the test results of GBRC Rapid Method, ASTM Chemical Method and ASTM Mortar-bar Method

| | Aggregate | Cement | Additive |
|---|---|---|---|
| —●— | Reactive | High-alkali opc. | ———— |
| ---●--- | Reactive | Low-alkali opc. | ———— |
| ✖ | Reactive | High-alkali opc. | Blastfurnace slag |
| ✚ | Reactive | High alkali opc. | Fly ash |
| —○— | Non-reactive | High-alkali opc. | ———— |
| -·-●-·- | Reactive | Type B pbfsc. | ———— |

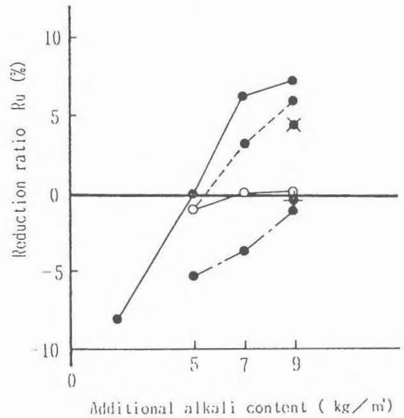


Fig.10 Relationship between the additional alkali content and the reduction ratio Ru

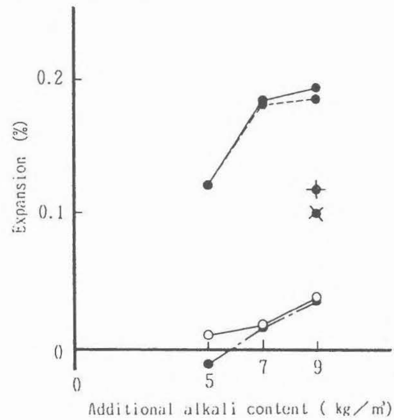


Fig.11 Relationship between the additional alkali content and the expansion at 4 months

Fig.10 & 11 show the results by this rapid method and length expansion test, respectively. Judging from these results, this rapid method is considered to be useful for the evaluation of future susceptibility to alkali-aggregate reaction of fresh concrete.

## 6. Conclusion

We consider the GBRC Rapid Method is suitable not only for the evaluation of reactivity of aggregates, but also for the determination of the future susceptibility to alkali-aggregate reaction of fresh concrete. According to the studies carried out until now, we have found that the GBRC Rapid Method is suitable, at least for the alkali-silica reaction.

In future, we intend to investigate the suitability of the method for other kinds of alkali-aggregate reaction, such as the alkali-carbonate reaction.

## References

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