Tentative Guideline of Ministry of Construction for ASR Mortar Bar Method

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ABSTRACT

There are some factors which vary the result of ASR mortar bar test. Experiments were carried out with Japanese domestic aggregate to clarify the influence of the mixing proportion, the difference of alkali metal ion, alkali content of cement, curing condition, etc. With the results of the experiments, The Ministry of Construction Japan made The Tentative Guideline for ASR Mortar Bar Method, which was advanced in precision from ASTM C 227.

1. INTRODUCTION

In Japan in 1983, deterioration of concrete structures due to Alkali Silica Reaction (ASR) was found to arise following salt-attack deterioration in early 1980's. A survey on ASR deteriorated structures showed that ASR might appear extensively. Immediately, the Ministry of Construction began research on countermeasures to ASR including the development of test methods for estimating the reactivity of Japanese domestic aggregate more precisely with JIS (Japanese Industrial standards) testing apparatus.

A study on the influence of various conditions for the expansion of mortar bars using typical Japanese reactive aggregates was carried out. The results of the study led to "The Tentative Guideline of The Mortar Bar Method of The Ministry of Construction" which was established in spring, 1986. This paper shows the outline of the mortar bar method and the background which led to the improvements in it.

2. OUTLINE OF TENTATIVE GUIDELINE OF MORTAR BAR METHOD OF MINISTRY OF CONSTRUCTION

The tentative guideline was based on the ASTM C 227 method, which was also used in Japan immediately after the discovery of ASR. A modified form of the ASTM test was developed and incorporated in the JIS test procedure and apparatus. There are several problems associated with the ASTM C 227 method:

1. The mix proportion, especially the alkali content per unit volume of mortar has a significant influence on expansion of mortar bars.

2. The K-ions produce a different effect from the Na-ions of equal molarity, yet the alkali content is expressed in "Na2Oeq" with changing K to Na on the assumption that equal mole of Na and K make the same influence on the expansion of mortar bar. Therefore, cements with the same total alkali content but different proportion of Na and K produce differences in expansion.

3. A slight difference in the humidity produces a great scattering of the expansion data.

4. It is very difficult to obtain the precision shown in the ASTM 227 even in well controlled tests.

These results led the following improvements in the new test method;

1. This method is only for evaluating the alkali-silica reactivity of an aggregate not for testing the concrete expansion with various cements or mix proportions.

2. The mix proportion is fixed : W/C=50%, S/C=2.25. In ASTM C 227 the flow is specified.

3. The alkali content per unit volume mortar is fixed. To reduce the influence of the difference between Na And K, it is recommended that "low alkali cement" be used and that the alkali content of the cement be adjusted to 1.2% by weight by the addition of NaOH. The "low alkali cement" is regulated by JIS, Feb. 1986.

4. The mortar bars are cured at 100% RH.

5. The restriction on precision of the measured expansion of mortar bars is lightened.

3. DESCRIPTION OF THE BARS

In this Mortar Bar Method the size of the mortar bars is specified as 40*40*160mm, using JIS molds. These mortar bars are thicker and shorter than those specified in ASTM C 227. Stainless steel gauge studs are embedded in the ends of the mortar bars in the same way as in the ASTM methods. The other apparatus used is of JIS design.

4. MIX PROPORTION

The water content in the ASTM C 227 methods is adjusted to give the specified flow. Mortar experiments with some Japanese aggregates using a single cement showed that the expansion varied with the cement content per unit volume of the mix . Bars with NaOH addition showed that the expansion mainly depended on the alkali content per unit volume mortar.(Fig.1) Therefore, in order to reduce the effect of the mix proportion, W/C and S/C are fixed at 50% and 2.25 respectively.

5. PREPARATION OF ALKALI CONTENT

The alkali ions Na and K both cause the reaction, but the effectiveness of each ion is thought to be different. Fig. 2 shows the expansion of mortar bars with added Na and K respectively. Na causes greater expansion than K. Tests with Pyrex glass aggregate showed the same result. Though Japanese cements have more moles of K than of Na, alkali is added as NaOH. The weight ratio of total alkali (Na_2Oeq) to cement for the test is set at 1.2%, on the basis that the highest alkali content of domestic cement on market was approximately 1.2% and mortar bars with some aggregates start to expand rapidly when the alkali content of cement is greater than 1.2%. (Fig. 2)

6. CURING CONDITIONS

Experimental results showed that the influence of humidity conditions on expansion of mortar bars is significant. Slight drying reduces the expansion remarkably. Therefore, curing in sealed containers, in wet paper, in water or in a fog box were tried. The "wet paper wrapping method", in which the bars were wrapped with wet paper and sealed with plastic bag over them, proved to be the best, and is recommended in the guideline. The advantage of this method is that it is not bulky while its disadvantage is the invisibility of specimen surface.

7. JUDGMENT CRITERIA AND PRECISION

Results of mortar bar test show a varied expansion and time-expansion relationship according to the type of rock, alkali content, and other conditions. In addition, some rocks have a PESSIMUM property and it makes the evaluation very complicated. Many problems remain to be solved before criteria for establishing the reactivity of an aggregate can be accurately specified. The method follows ASTM C 33, which suggests that aggregates which cause mortar bar expansions of greater than 0.05% at 3 months or 0.10% at 6 months should be considered deleterious. A six month test may be too short for some slowly expanding aggregate. In ASTM Method the "Precision shall be considered satisfactory if the differences in the value for percentage expansion of any given specimen in a group from

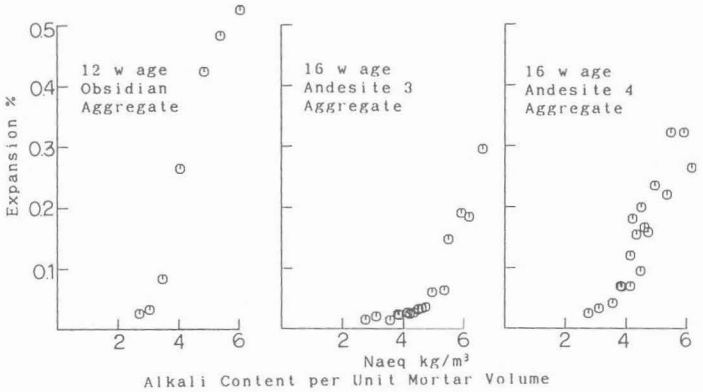

Fig.1 Examples of Relation between Alkali Content per Unit Mortar Volume and Expansion

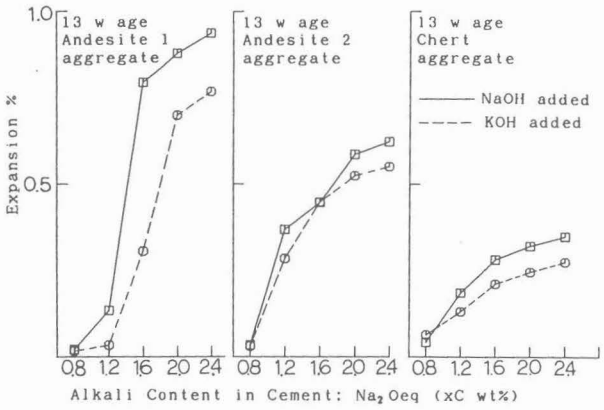

Fig.2 Examples of Difference of Influence to Mortar Bar Expansion between Na and K ion

the average value for percentage expansion of the group does not exceed 0.003, except that, if the average expansion exceeds 0.020%, the repeatability shall be considered satisfactory if the percentage expansion of each specimen molded from the same cement-aggregate combination is within 15% of the average". In this guideline, the number of bars from one batch is three and the precision shall be considered satisfactory if the measured expansion is in the range shown in Fig.3. Furthermore, if all three bars have expansions of more than 0.1% at 6 month age, then the aggregate shall be considered as dangerous without regard to the precision.

8. OTHER CHANGES IN THE GUIDELINE

Grading of the fine aggregate (crushed aggregate) used in mortar bar seems to have a large influence on the results. However, when the fine aggregate is graded corresponding to the standard grading shown in the "Standard of Concrete, the Japan Society of Civil Engineers", the difference of the grading has a small influence to the test result. Therefore, it is permitted to use fine aggregate in standard area of the grading curves.

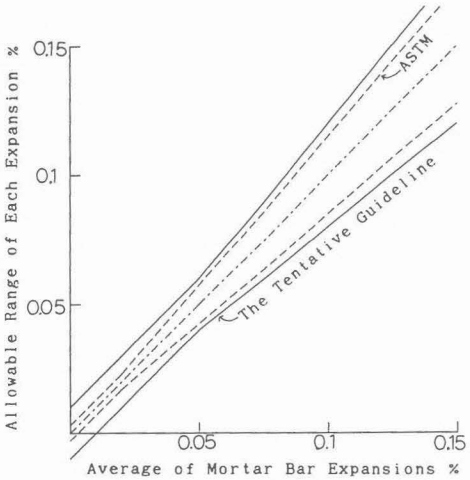

Fig.3 Precision of Measured Expansions

9. OUTSTANDING PROBLEMS

The following items remain to be resolved:

1. To establish expansion criteria for the evaluation of Japanese aggregates.
2. To develop an easy test procedure for taking into account the PESSIMUM.
3. To improve the evaluation probability by considering factors other than the mortar bar expansion, such as the age-expansion relationship or the relation between the alkali content per unit volume mortar and expansion.

10. ACKNOWLEDGMENT

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