8th ICAAR 1989 KYOTO 8th International Conference on Alkali-Aggregate Reaction

A STUDY ON ACCURACY OF 40MM MORTAR BAR TEST

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1. INTRODUCTION

Immediately after the first discovery of structures deteriorated due to ASR in 1983 in Japan, attempts were made to devise test methods suitable for the situation in Japan for estimating ASR reactivity of aggregates. Conditions for the test methods were that JIS apparatus were to be used and that the reactivity of the various rock-type aggregates of Japan should be properly determined. From the test results made by many researchers, the Ministry of Construction (MOC) devised a tentative mortar bar method, which was modified from the ASTM C 227 mortar bar method. The procedure for modifying and the points of differentiation from ASTM C 227 were reported in the 7th ICAAR.[1]

MOC has been doing the mortar bar test, modified chemical test, which is also modified from ASTM C 289, and concrete specimen exposure tests on more than 500 aggregates from all over Japan, and examines the soundness of the mortar bar test and the chemical method. This paper reports on the criteria and precision of the mortar bar method from the result of tests on 300 aggregates. In addition, the relationship between the mortar bar method and chemical method, and the consideration of the influence of rock types on these test methods is reported on.[2)3)]

2. OUTLINE OF THE TENTATIVE MORTAR BAR METHOD

Major differences between the MOC tentative mortar bar methods and the ASTM C 227 are as follows:

1) The MOC method estimates only the reactivity of aggregates while the ASTM C 227 treats the particular cement-aggregate combination.

2) The mix proportion is fixed: W/C=50%, s/c=2.25, while W/C in ASTM C 227 changes with the flow test.

Table 1 Distribution of Expansion Value of Mortar bar at Each Age

		Volcanic Rock %	Sedimentary Rock	All Types
①	≧ 0.05% at 3 month	46 (35)	21 (21)	75 (25)
②	≧ 0.10% at 6 month	50 (38)	30 (31)	91 (30)
③	≧ 0.10% at 12 month	59 (45)	46 (47)	123 (41)
④	≧ 0.05% at 3 month ≧ 0.10% at 6 month	45 (35)	21 (21)	73 (24)
⑤	≧ 0.05% at 3 month < 0.10% at 6 month	1 (1)	0 (0)	2 (1)
⑥	< 0.05% at 3 month ≧ 0.10% at 6 month	5 (4)	9 (9)	18 (6)
⑦	≧ 0.10% at 6 month ≧ 0.10% at 12 month	50 (38)	30 (31)	91 (30)
⑧	< 0.10% at 6 month ≧ 0.10% at 12 month	9 (7)	16 (16)	32 (11)
⑨	< 0.05% at 3 month ≧ 0.10% at 12 month	14 (11)	25 (26)	50 (17)
⑩	< 0.05% at 3 month < 0.10% at 6 month ≧ 0.10% at 12 month	9 (7)	16 (16)	32 (11)
⑪	< 0.05% at 6 month ≧ 0.10% at 12 month	5 (4)	9 (9)	15 (5)
	Total	130 (100)	98 (100)	300 (100)

3) The alkali content of cement is fixed at 1.2%. To reduce the influence of the difference between Na ions and K ions in the reaction, it is recommended that low alkali cement should be used and the alkali content of the cement should be adjusted to 1.2wt% by the addition of NaOH.

4) The restriction on precision of the measured expansion of the mortar bars is lessened.

3. RESULT OF TEST AND CONSIDERATION OF CRITERIA

Criteria for the mortar bar method are as follows:

1) Aggregates which show expansion greater than 0.05% at 3

months can be considered harmful. But aggregates which show expansion smaller than 0.05% at 3 months should not be considered harmless.

2) Aggregates which show expansion greater than 0.1% at 6 months should be considered harmful.

Table 1 shows the test result. With above criteria 30% of aggregates were estimated harmful. The ratio of harmful aggregates of volcanic rock type (38%) is higher than that of sedimentary rock type (31%).

There is still controversy over whether the above criteria are proper. The other experiments done by the authors showed that when the expansion of mortar bars exceeded 0.1%, pronounced cracks appeared. Hence, this 0.1% criteria seems to indicate a critical point for the start of deterioration. By this criteria, approximately 30% of all aggregates, including 38% of volcanic rock aggregates, and 31% of sedimentary rock aggregates are considered to harmful at 6 months.

There is also controversy over whether the two criteria contradict each other. For instance, one seems to be overly safe and the other seems to be rather dangerous. Table 1 shows the distribution of rates of expansion. Seventy-five out of 300 aggregates show smaller than 0.5% expansion at 3 months. Only two aggregates show smaller than 0.1% expansion at 6 months after showing expansions of greater than 0.5% at 3 months. The ratio of aggregates which are considered dangerous at 3 months but which become safe at 6 months seems very small. Eighteen aggregates show expansions greater than 0.1% at 6 months after showing expansions of 0.5% at 3 months. Thus, it is dangerous to conclude

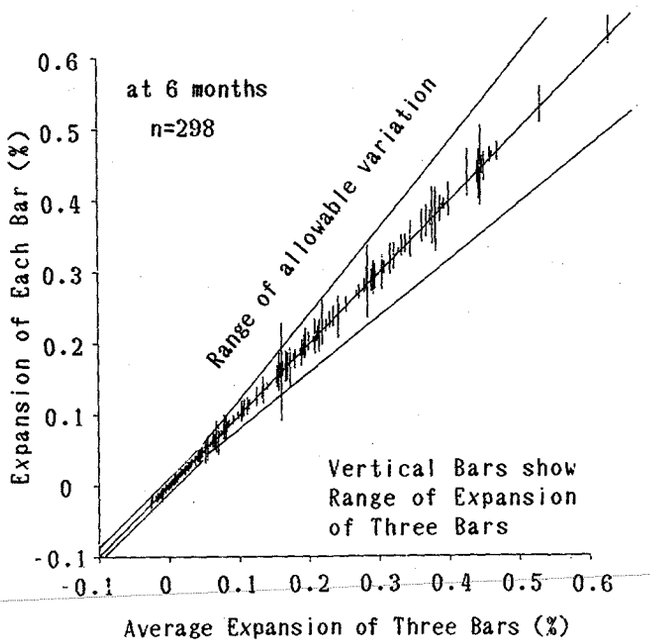

Fig 1 Variation of Expansions of Mortar Bars

that aggregates are not harmful after only a 3 month test. From these results, the current criteria seem to be reasonable.

One more controversy concerns the treatment of aggregates which have very small expansion rates. In Table 1, some aggregates show small expansion at 6 months and keep expanding for a long period of time. For instance, approximately 10% of aggregates show expansions greater than 0.1% at 12 months in spite of being considered harmless at 6 months. In addition, the ratio of these aggregates in sedimentary rock-type aggregates is 16% and it is more than twice that in volcanic rock (7%). The figure of 10% is not negligible. To treat this problem, we have to consider how the condition of 40+2°C 100%RH and 1.2% alkali content of cement accelerates the alkali aggregate reaction compared to normal circumstances. The authors expect that the concrete specimen exposure test will bring some answer to this problem. Also, from the fact that it has taken at least 5 years for real ASR structures to show the first symptoms in Japan[4], and the fact that there are many aggregates which show expansions greater

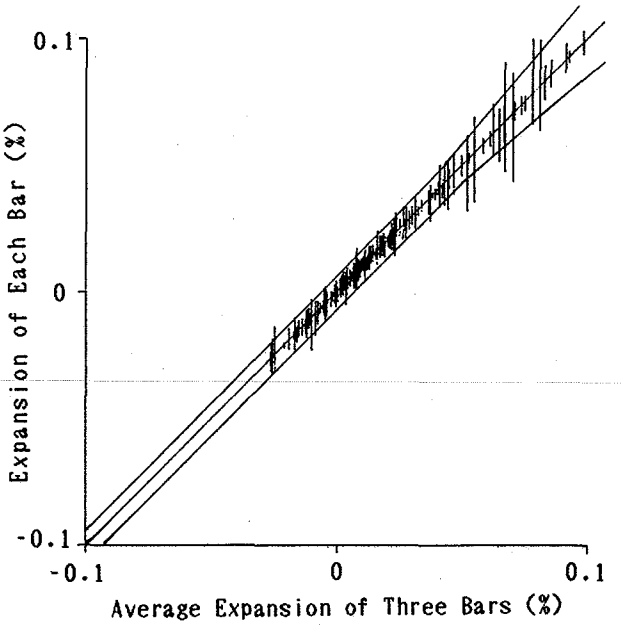

Fig 2 Variation of Expansions of Mortar Bars (from -0.1% to 0.1 %)

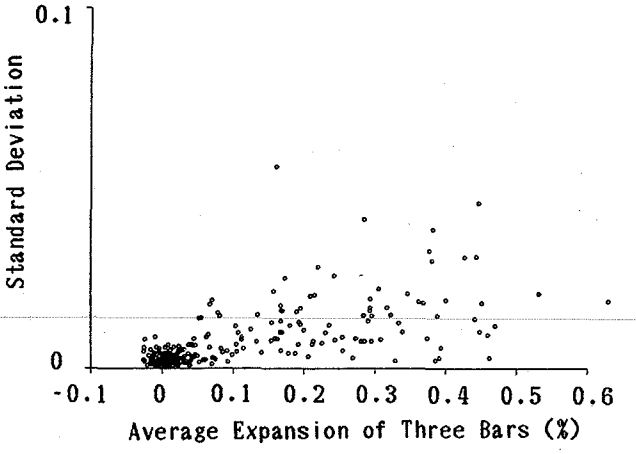

Fig 3 Standard Deviation of Expansions

than 0.1% at only 4 or 8 weeks in the mortar bar test[47], the authors recognize that the conditions of the mortar bar must be fairly severe in accelerating ASR conditions.

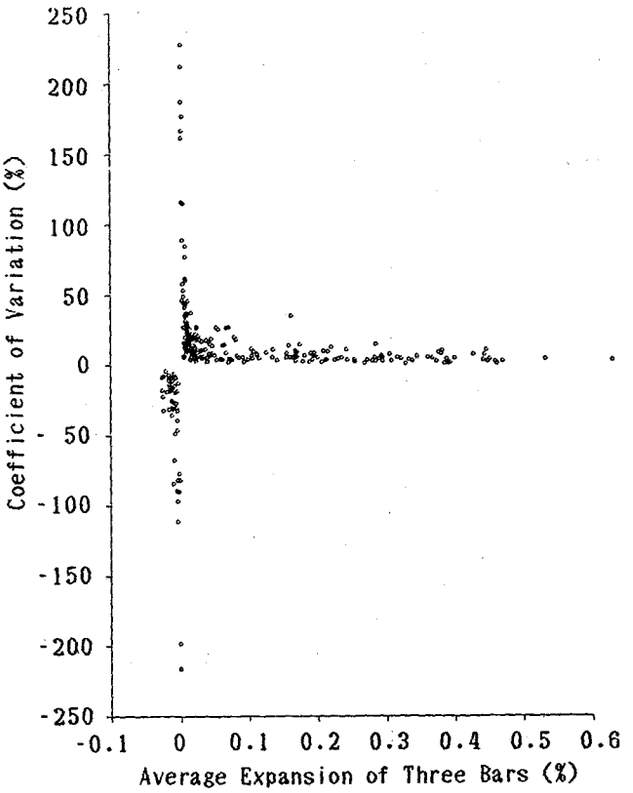

Fig 4 Coefficient of Variation of Expansion

4. PRECISION

Regulation of the precision of the mortar bar method test is less strict than the ASTM C 227 as followings:

ASTM		MOC	
Ave* < 0.02%	Def** < 0.003%	Ave < 0.05%	Def < 0.01%
Ave > 0.02%	RD*** < 15%	Ave > 0.05%	RD < 20%

* average of expansions of three bars
** differece of expansion of any bar from Ave
*** relative difference of expansion of any bar from Ave

Fig 1 shows the results of variations of measured expansions of three sets of bars which were tested under tightly controlled conditions. Figures 2 and 3 show standard deviations and coefficients of the variations of the results. The greater part of the results was within the regulations. In practical use, the mortar bar method contains two clauses stipulating that if the variation is not within the regulations, judgement can be made by averaging two out of the three measurements, excluding the smallest one, or that if all three measured expansions exceed 0.1% the aggregate should be considered harmful, regardless of precision. But Figure 1 shows that when average expansions exceed

0.2%, the variations seem to have a somewhat constant range, and that variations deviated from the regulated range when the averages were less than 0.1%. It is expected that the former clause will be applied in many cases and the latter clause in fewer cases. From many tests the authors recognize that small differences in moisture conditions bring great variations in expansion, and would recommend that the paper-wrapping method be adopted in which a 100%RH factor can be sufficiently maintained.

5. CONCLUSIONS

The following conclusions were derived from the mortar bar tests on 300 aggregates in Japan.

1) Approximately 30% of aggregates, including 38% of volcanic rocks and 31% of sedimentary rocks, were estimated harmful at 6 months test.

2) Few aggregates were estimated harmless at 6 months after being estimated harmful at 3 months.

3) Some aggregates had low expanding rate and expanded more than 0.1% after 12 months.

4) Regulation on precision of the mortar bar test was satisfied in almost test cases.

6. ACKNOWLEDGEMENTS

The authers thank for cooperation of the organizations which collected so many aggregates.

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