AGGREGATE INSPECTION

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The Hanshin Expressway Public Corporation was established about 30 years ago. Since then, more than 150 km of expressway has been constructed in the metropolitan area of Osaka. Most of the substructures are concrete pier. In 1982, a large horizontal crack was found in a beam of the bridge pier and its cause was concluded to be AAR. Systematic surveying of the whole concrete structures of the Hanshin expressway detected considerable number of AAR cracked piers. Therefore, the Corporation decided to inspect all the aggregate to be used for the coming construction of the new highway. ASTM C289 and C227 methods were employed for the inspection.

No AAR cracking has been found in the concrete structures constructed after this inspection started. This paper reports the details of the aggregate inspection and effect of the inspection.

INSPECTION OF AGGREGATE

Hanshin Expressway Public Corporation (HEPC) consumes about 200,000~300,000m^3 of concrete per year for highway construction in the metropolitan area of Osaka. Inspection of aggregate started in 1984 to avoid AAR in the future concrete structures. ASTM C289 and C227 have been employed for AAR test. Contractor must submit detail of aggregate to HEPC as shown in Table 1. HEPC makes a judgement whether it is required to test the proposed aggregate or not by referring to the data previously tested. If AAR test is required, the test is done under the supervision of Hanshin Expressway Administration and Technology Center. The mortar bar test of ASTM C227 is carried out by the equivalent Na_2O to be 1.2% of cement weight. The value of 1.2% is adopted as the maximum value of Alkali supplied from cement and sea dredged sand. The AAR test is compulsive to perform any HEPC project.

TABLE 1- Aggregate detail

Project	Contractor	Ready-mixed concrete	Date of sampling
Rokko Bridge	Konoike Construction Co., Ltd.	Rokko Concrete Co.	2, April, 1989

Cement maker	Type of cement	Alkali content of cement
Osaka Cement	Normal portland	0.68%

Aggregate	Aggregate quarry	Type of rock	Blending of aggregate
Coarse aggregate	Ako	sandstone	100%

RESULT OF INSPECTION

Table 2 shows number of samples of aggregate inspected from 1984 to 1990. Almost all the coarse aggregate inspected are freshly crashed stone. These aggregate are mainly andesite, rhyolite and sandstone. Most of sand inspected are mix of sea dredged sand with mountain sand or sand from crashed stone. Blending of sand was done to adjust the grain size distribution. Number of aggregate to be inspected is decreasing with year due to increase of pooled data.

TABLE 2 - Number of samples inspected

year	Coarse-aggregate	sand
1984	135	52
1985	68	27
1986	54	7
1987	63	24
1988	43	20
1989	16	13
1990	20	5
Total	399	148

Table 3 shows the result of inspection in terms of sample and Table 4 shows the inspection result in terms of aggregate quarry. During the last 7 years, 399 samples of coarse aggregate and 148 samples of sand have been inspected. About 13% of aggregate and 3 samples of sand were judged to be deleterious by ASTM C289 and only 1 sample of aggregate and sand were judged to be deleterious by ASTM C227. According to these results, almost all of aggregate being used in HEPC since 1984 are innocuous if judged by the mortar bar test of ASTM C227. However, it should be noticed that more than half of quarries produce deleterious or potentially deleterious aggregate.

TABLE 3 - Result of inspection

	Number of samples	ASTM C289 innocuous	ASTM C289 deleterious*	ASTM C227 innocuous	ASTM C227 deleterious
Coarse aggregate	399	348	51	398	1
sand	148	145	3	147	1

* includes potentially deleterious as well

TABLE 4 - Inspection of quarry

	ASTM C289	ASTM C227	Number of quarries
Group 1	all innocuous	all innocuous	4
Group 2	includes deleterious*	all innocuous	10
Group 3	includes deleterious*	deleterious	1

* includes potentially deleterious as well

EFFECT OF INSPECTION

HEPC had constructed about 4600 concrete piers up to 1983. Among these piers, 68 piers have been suspected to be AAR and 17 piers out of 68 have been detected as ASR pier. Most of aggregate in these piers are bronzite andesite, which is very reactive. Since the aggregate inspection started in 1984, about 850 additional concrete piers and other concrete structures have been constructed by HEPC. No AAR deterioration has been observed in these structures. Major reason why AAR decreased so abruptly is inferred to be followings:
(i) bronzite andesite has been completely eliminated for the use of HEPC concrete structures, and
(ii) the contractor and factory of ready-mixed concrete check their aggregate by their own will before submitting aggregate detail of Table 1. Therefore, most of aggregate appeared in Table 1 is already proved to be innocuous in these days. As the result, the aggregate inspection has been very successful to avoid AAR of new concrete structures.

CONCLUDING REMARKS

The aggregate inspection has been successful in Hanshin Expressway Public Corporation. HEPC already pooled the data of almost all aggregates to be used for HEPC concrete structures. However, most of the aggregate are freshly crashed stone. Therefore, HEPC will continue the aggregate inspection to avoid unexpected reactive aggregate like bronzite andesite which produced many AAR damaged concrete structures in Japan.