COMPARATIVE STUDY OF THE CONCRETE PRISM TEST (CPT 60°C, 100% RH) AND OTHER ACCELERATED TESTS

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Abstract

Recent Australian studies have shown that some quartz gravels, and gneissic/deformed granitic aggregates are difficult to detect by either RTA T363 (ASTM C-1260) or RTA T364 (ASTM C-1293). The AMBT storage conditions are 80°C in 1M NaOH, and the CPT uses 38°C, 100% RH (CPT38). Another CPT test conducted at 60°C, known as Rilem AAR-4 (CPT60), has shown promise in this respect.

Forty nine aggregates were tested by these methods, to compare the performance of CPT60 with those of RTA T363 and RTA T364. The CPT38 and CPT60 classed fewer aggregates than the AMBT as reactive. The CPT60 eliminated the dormant period of 3 – 4 months, seen in CPT38, i.e., expansion under CPT60 occurred more rapidly than in CPT38. The CPT60 showed a higher confirmation rate than CPT38, for slowly reactive aggregates of gneissic origin. An expansion limit of 0.03% at 4 months detected most of the reactive aggregates.

Keywords: AAR, AMBT, CPT, RILEM, Expansion

1 INTRODUCTION

Testing aggregates for detection of their susceptibility to alkali-aggregate reaction (AAR) has a long history and goes back to 1940 or even earlier. As a result of many attempts to find appropriate tests to enable identification of reactive aggregates, to avoid damage to concrete structures due to AAR, several countries have developed a number of test methods to suit their conditions. Examples of earlier test methods developed in North America are the mortar bar test (ASTMC-227) and the quick chemical test (ASTMC-289), which were the main tests in many countries prior to 1994.

More recently, ASTMC-1260 (accelerated mortar bar test, AMBT) and ASTMC-1293 (concrete prism test, CPT) have been introduced as more reliable tests. The AMBT uses storage conditions of 80°C in 1M NaOH, and the CPT 38°C, 100% RH.

In Australia, test methods such as the Australian Standard mortar bar test (AS 1411-38) and the quick chemical test (AS1141-39), which were the same as the corresponding ASTM C 227 and ASTM C289 tests, respectively, were found in the mid 1980's to be unreliable for the slowly reactive Australian aggregates, and they were abandoned. Although no formal standard test has yet been introduced in Australia to replace those tests, some road authorities have put in place accelerated test methods which better suit the Australian aggregates. These include RTA T363 (AMBT, 80°C in IM NaOH) and RTA T364 (CPT, 38°C, 100% RH) and Vic Roads RC 376.03 (AMBT, same as RTA T363). The AMBT adopted by the road authorities is based on the test method and limits developed for the Australian aggregates [1]. It should be noted that although the corresponding AMBTs in the ASTM and RTA methods are similar, there are important differences between them in both the preparation and conditioning of the specimens and, more importantly, in the expansion limits [2].

Recent Australian studies have pointed out [3] that some quartz gravels, and gneissic or deformed granitic aggregates are difficult to detect by either T363 or T364 (and the corresponding ASTM methods). Work done by the author on non-standard test methods in the past two decades [4, 5], in India [6, 7, 8], in America [9], and in Europe [10, 11, 12] had shown that faster and larger expansion can be achieved in the mortar bar and concrete prism tests if the temperature of storage of the specimens is increased from 38°C to 50°C or 60°C, particularly for the slowly reactive aggregates containing strained quartz. These are desirable attributes for an accelerated test.

The traditional CPT (38°C, 100% RH), designated here as CPT38, takes one year to produce results, which is considered to be too long for contractual situations. Based on the work mentioned above, researchers proposed a faster CPT (60°C, 100% RH), designated here as CPT60, which was considered to produce quicker identification of reactive aggregates in a few months.

Due to the borderline behaviour of the Australian slowly reactive aggregates in the AMBT and CPT38, it was decided to apply the CPT60 to a number of Australian aggregates and compare its performance to those of the former tests. This paper presents the results of testing a large number of

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aggregates using these three methods, and compares their performance in detecting reactive aggregates, particularly the slowly reactive ones.

2 BACKGROUND TO CPT60

Following preliminary work in France in the early 1990s, the French adopted a form of the CPT60 as their standard test NF P18-587. For the storage conditions of 60°C, 100% RH, an expansion limit of 0.02% at two months (56 days) was suggested to discriminate between reactive and non-reactive aggregates. Murdock and Blanchette [13] found that this method was very promising and detected all the reactive and marginal aggregates within two or three months of testing, rather than on year in the traditional CPT38 (e.g. ASTM C-129). They used expansion limits of 0.02% at 2 months or 0.03% at 3 months for detecting reactive aggregates.

DeGrosbois and Fontaine [14] correlated the results of the CPT60 with those of CPT38, and found that different limits apply to different rock types in the CPT60; being 0.04% at 91 days for carbonate and sedimentary rocks, and 0.025% for igneous and metamorphic rocks.

In 2003, Rilem introduced a draft concrete prism test method with storage condition of 60°C, 100%RH, designated Rilem AAR-4 Test Method. At that time the present authors tested some Australian aggregates using these storage conditions, and found that the test was very promising for the slowly reactive aggregates tested. Similarly, a limited inter-laboratory testing was conducted by Rilem in 2004 and promising results were obtained. Figure 1, taken from Rilem Committee TC191-ARP communications, presents the results of the Rilem testing, which showed that the reactive and non-reactive aggregates could be identified by an expansion limit of 0.03% at 15 weeks of storage. Note that in Figure 1 all the aggregates with expansion values above 0.03 % are reactive, and all aggregates below 0.03% are non-reactive. Rilem's communication stated that in the AAR-4 test, a maximum expansion of 0.03% at 20 weeks indicates a non-reactive aggregate combination. Sims and Nixon [15] stated that the same outcome is achieved by the expansion limit of 0.03% at 15 weeks, although no definite limit is yet established for this test and it is possible that other values may eventuate. Recent communication from Wigum [16] indicates that the International Partner Project has used a limit of 0.03% at 20 weeks for CPT60.

Considering that the Rilem method (i.e., CPT60) required a much shorter period of testing for the slowly reactive aggregates and, compared to CPT38, produced larger expansion values at earlier ages, the authors started testing a suite of some fifty aggregates early in 2004, using three methods including the CPT60, in order to compare the performance of the latter with those of the RTA T363 and RTA T364 (methods currently used in Australia). The test results are presented and discussed in this paper.

3 SCOPE OF WORK

The present work investigated the performance of 49 aggregates with respect to their susceptibility to alkali-aggregate-reaction (AAR). The potential of the aggregates for AAR expansion was evaluated using three accelerated test methods listed below.

1. The accelerated mortar bar test, RTA T363, (AMBT)
2. The RTA concrete prisms test, RTA T364, (CPT, 38°C), and
3. The Rilem concrete prisms test, Rilem AAR-4, (RILEM CPT@ 60°C).

The results for the various test methods were then compared and evaluated against the service record for each aggregate, when known.

4 MATERIALS AND METHODS

4.1 Test methods

The three methods used are different in mix composition and storage environment of the specimens, as well as in criteria for classification. Table 1 gives the main differences amongst the three test methods. The main aim of this investigation was to find out which test method is most suitable for the evaluation of Australian aggregates, or a sub-group of them, and determine appropriate criteria for the test. Particularly, it is aimed to check whether the RILEM CPT is advantageous compared to RTA T363 and RTA 364, and whether the Rilem AAR-4 (CPT60) test criteria of 0.03% expansion at 15 or 20 weeks, are applicable to the aggregates tested.

4.2 Cement

A general purpose (ordinary) Portland cement of the same origin was used in all the tests. The alkali content of the cement was 0.58% Na_2O equivalent. Some cement batches contained 0.50% Na_2O equivalent, which was taken into account in the calculation of final alkali content of concrete.

4.3 Aggregates studied

Forty-nine aggregates of differing origins, covering a wide range of aggregate types, were obtained from Victoria (VIC), New South Wales (NSW), Queensland (QLD), Tasmania (TAS), Australian Capital Territory (ACT) and Western Australia (WA) for a comparative testing program.

Andesite JAP from Japan was also included for AMBT, but its quantity was insufficient for CPTs. The list of the aggregates used, is presented in Table 2. Some aggregates were used twice, but each time with different sand.

Aggregates No.9 (Basalt KLNR) and No.19 (Basalt DNST) were reference non-reactive coarse aggregates in previous research projects on testing sand reactivity. EXL sand is also non-reactive and produces 0.11% expansion in the AMBT, which is below the 0.15% limit for this test at 21 days. The combination of Basalt DNST and EXL sand gives CPT38 expansion results not exceeding 0.01%.

It should be noted that a number of the CPT and the AMBT results were obtained during 1998 to 2001, whereas almost all the CPT60 tests were done, on the same samples, (which were stored in the laboratory) from 2004 to 2005. A small number of specimens were tested in 2006.

5 RESULTS

The overall results for the AMBT and CPT38 test methods are presented in Figures 2-3, to illustrate the degree of spread of the expansion curves in each test method, which reflect differences in the reactivity of the various aggregates. These Figures are intended to show the trends, not necessarily to identify individual expansion curves. A large number of aggregates are classed as reactive by both methods.

The results presented in Figures 2-3 are to be compared with those of the CPT60 test, which are presented in Figure 4. The latter also shows a wide spread of the expansion curves, reflecting differences in the nature of the various aggregates.

6 DISCUSSION

6.1 Comparison among test methods

For each aggregate, the results of testing by the three methods were plotted as expansion against time. For aggregates rated "reactive" by all three methods, the AMBT produced large expansion values, the CPT60 moderate values, with a continual expansion up to about three to four months, after which the expansion usually levelled off. The CPT38 showed a dormant period of up to 4 months, followed by a period of expansion, if the aggregate was reactive, which often continued up to one year of measurement (Figure 5). The expansion of the prisms at four-month in CPT60 was generally similar to or higher than that of CPT38 at one year. This behaviour was typical of aggregates which have CPT38 expansion values above 0.05% (Figure 5).

Ideker et al. [17] found that the early expansion rate at 60°C is larger than that at 38°C, but that the total long-term expansion (3 months to one year) was smaller at high temperature. Although this behaviour was noted for some of the aggregates tested by us, it was not true for many other aggregates.

For slowly reactive quartz gravels, containing strained quartz, which have caused significant AAR damage to major concrete structures, the CPT60 clearly identified them as reactive, whereas CPT38 failed to detect them and AMBT results were on the borderline (Figure 6).

Figure 7 shows that for a known non-reactive aggregate (Basalt 19) all the three tests produced agreeable results, whereas for another one (Basalt 40) the results were not entirely agreeable, as the CPT38 caused expansion close to 0.04%.

However, clear discrepancies were observed when, for example, the AMBT produced large expansion values which were not matched by other tests, or vice-versa, as shown in the examples given in Figure 8.

The discrepancies in relation to the behaviour of basalt aggregates in various tests have been explained earlier [18]. The expansion trends of the rhyodacite aggregate (Figure 8) were similar to those of the basalt, in the sense that much more expansion was seen in the AMBT compared with the CPTs. It appears that, for dense aggregates that contain reactive glassy or cryptocrystalline components, the AMBT test generates higher expansion than the CPTs, because it is very likely that some reactive components are released into the fine fraction of the crushed aggregate and are directly exposed to alkali in the AMBT, causing large expansion. In the CPTs, the reactive components are locked inside the dense coarse aggregate particles and are protected from alkali attack, hence low expansion values.

The gneissose / deformed granites appear to be much more responsive to CPT60 than CPT38 (Figures 5, 8). The latter has been shown to be inadequate for some aggregates of this nature [3].

Overall, using the assessment limits given in Table 1, the classification of the 49 aggregates, excluding the andesite JAP, by the tests can be summarised as follows:

- AMBT- reactive aggregates: 39 (80%)
- CPT38- 0.03% at 1 year: 23 (47%); 0.04% at 1 year: 18 (37%)
- CPT60- 0.02% at 112 days: 33 (67%); 0.03% at 112 days: 28 (57%); 0.03% at 140 days: 31 (63%); 0.04% at 112 days: 26 (53%).

From the above, and by plotting the test results, it is clear that more aggregates were rated reactive by the AMBT, than by the two CPTs (Figures 9-10). Also, CPT60 rated more aggregates than CPT38 as reactive (Figure 11). There were a number of aggregates with borderline behaviour in CPT38, with expansion values around 0.03% at one year, but they showed much larger expansion in CPT 60 at 112 days. These were, in fact, the slowly reactive aggregates (gneissic granite and quartzite) containing strained quartz. The CPT60 seems to overcome the deficiency of CPT38 for detecting these types of aggregate. The behaviour of other gneissic granite aggregates and that of other reactive rock types are presented in Figure 12, further indicating the stronger responses of the gneissic granites to CPT60.

Overall, it is shown that compared with the AMBT, CPT38 and CPT60 class fewer aggregates as reactive. Also, CPT60 showed a higher confirmation rate than CPT38 for slowly reactive aggregates. The CPT60 eliminated the dormant period of about 3 – 4 months, which was usually seen in CPT38, i.e., the expansion of specimens under CPT60 occurred more rapidly than in CPT38.

6.2 Analysis of observed discrepancies

Figures 9-10 show that the results of CPT60 and CPT38 did not always confirm the AMBT classification, and this was the case particularly for some sands. Table 3 lists the proportion of aggregates classed as reactive or non-reactive by the CPT60 test, in comparison with the AMBT classification. Table 4 provides a similar comparison between CPT38 and the AMBT tests

The ID numbers of the aggregates giving the "mismatches" in Tables 3 and 4 are listed in Table 5. Some of these mismatches are not actually real. For example, the non-reactive sand BNYG usually produces expansion values below the test limit of 0.15% for sands, which matches its behaviour in the CPTs. However, in the present work it gave 0.216% expansion (outlier result), which resulted in a mismatch. Among the aggregates that were classed "reactive" by AMBT and non-reactive by both prism tests were three sands (all had 21-day expansion of about 0.2%). Shayan, et al. [19] explained the behaviour of similar sands in accelerated tests, pointing out that some sands which are classed as non-reactive in CPT38, may actually contain reactive components that can be activated at higher alkali content and temperature of AMBT or in CPT38 which has additional alkali. Strictly, they may be potentially reactive in nature, but under normal temperature and alkali contents they behave non-deleteriously in concrete. Therefore, it can be argued that the AMBT correctly evaluates the inherent nature of the aggregate with respect to its resistance against alkali attack, and the CPTs reveal its behaviour under given alkali and temperature conditions. It appears that the AMBT conditions are more severe than those of both CPTs.

In relation to the nature of sands, it has been reported [17] that the type of non-reactive fine aggregate (sand), which is combined with the target coarse aggregate, to be tested by the CPT60, has a significant effect on the expansion results. The reason for this was stated not to be clear. However, although these sands may be considered to be non-reactive in concrete under ambient conditions, they may contain some reactive components that react differently at higher alkalinity and temperature [19].

As another possible reason for the mismatched results for sands, it may be pointed out that the volume percentage of sand in the prism tests, especially in CPT60 is much lower than that in the mortar bar test, i.e. 54%, 20% and 27% for the AMBT, CPT60 and CPT38, respectively.

An aggregate of interest is the NPR River gravel (No. 39 in Table 2), which is shown by Figure 12 to be very slowly reactive with respect to CPT38, although this aggregate is known in the concrete industry as non-reactive. In fact, Fournier et al. [20] correlated the results of AMBT and CPT38 for a number of aggregates, including an Australian aggregate designated RG in their paper, which is the same aggregate as the NPR River gravel in the present paper. In Fournier's work, the aggregate had produced about 0.31% expansion in the AMBT (at 14 days) and about 0.032% in the CPT38 (1 year). They stated that the AMBT (14 days) was too severe for this aggregate, and that the CPT expansion of less that 0.04% (1 year) was in accord with the "non-reactive" nature of the aggregate.

In the interest of correcting the record, it must be stated that aggregate RG in Fournier's paper (NPR River gravel in this work) is, in fact, reactive and has caused damage to a number of submerged bridge piles [21, 22]. In fact the Australian RTA T364 (CPT38) test limit of 0.03% at one year identifies this aggregate as reactive. Considering this aggregate as reactive, would improve the correlation between field performance and various test results. In the case of this aggregate, the AMBT (RTA T363) and CPT38 (2-year expansion value) correctly identify this aggregate.

The behaviour of this aggregate in CPT60 is anomalous. It is possible that loss of moisture during the cooling period prior to expansion measurement caused a low CPT60 reading for this aggregate. Extreme care is required for accurate measurement of expansion under the condition of this test, as the specimens are prone to drying out.

6.3 Discussion on appropriate test limit for CPT60

As already stated in earlier sections, to detect reactive aggregates by CPT60, expansion limits of 0.02% at 2 months or 0.03% at 3 months [13]; 0.03% at 15 weeks [15]; 0.03% at 20 weeks [16] have been proposed.

Fournier et al. [23] found that for two reactive aggregates the limit of 0.04% at 3 months could identify their reactivity. However, DeGrosbois and Fontaine [14] found that reactive aggregates of igneous and metamorphic origin produced expansion values of 0.025% at 3 months rather than 0.04% at 3 months. Therefore, the latter limit may not be appropriate for a wider range of aggregates.

Fournier et al. [20], included results of other researchers, including DeGrosbois and Fontaine [14], in their data analysis and stated that, for the aggregates analysed, the limit of 0.04% at 13 weeks (91 days or 3 months) gave the same aggregate assessment as that of CPT38 at one year.

Obviously, if DeGrosbois and Fontaine [14] required the limit of 0.025% at 3 months for the identification of reactive igneous and metamorphic aggregates, then the expansion limit of 0.04% at 3 months proposed by Fournier et al.[20, 23] would not correctly identify them.

This limit would not correctly identify a number of reactive aggregates tested here. Our results indicate that a limit of 0.03% at 4 months would identify the great majority (80%) of reactive aggregates.

Our experience with the CPT60 test method is that the method of conditioning of the specimens for measurement is critical and needs to be refined and unified. We would support a procedure in which the specimens are transferred to a sealable box, on a mesh located above hot water (60°C or above), and then transferred to the constant temperature room (23°C) for conditioning prior to each measurement.

We would anticipate that, under these conditions, the limit of 0.03% at 4 months would identify all the reactive aggregates, leaving aside occasional exceptions.

7 CONCLUSIONS

Testing some 49 aggregates by the three accelerated test method has shown that:

- The AMBT classed 80% of the aggregates as reactive, including some fine sands for which it may be too severe. This test is considered to be a good screening test.
- The CPT38 confirmed 59% of the AMBT results for reactive aggregate for the expansion limit of 0.03% at 1 year and 46% for 0.04% at 1 year. The CPT38 did not detect some slowly reactive aggregates of gneissic origin containing micro-crystalline quartz.
- The CPT60 confirmed between 67% - 84% of the AMBT results for reactive aggregates, depending on the limit chosen.
- The limit of 0.03% expansion at 4 months is proposed for the CPT60 test which confirmed 80% of the AMBT results.
- Proper conditioning of the specimens prior to measurement is critical for CPT60 and needs to be refined.
- The CPT60 overcomes the deficiencies of CPT38 for slowly reactive aggregates of gneissic origin, which contain microcrystalline quartz as the reactive component.

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TABLE 1: Main attributes of the three test methods

Test	**Mix proportion (kg/m^3)**	**Specimen and moist curing period**	**Storage condition**	**Expansion limit for reactive aggregate**
RTA T363 (AMBT)	Agg/Cem = 2.25; W/C = 0.40 – 0.42	mortar bars 25 x 25 x 280 mm; 3 days	1 M NaOH bath at 80°C	≥ 0.10% @ 21 days for coarse aggregate, or ≥ 0.15% for sand
RTA T364* (CPT38)	Cement: 420 Aggregate: 1080 Sand: 710 w/c= 0.42 Na_2Oeq = 1.38%	concrete prisms 75 x 75 x 280 mm; 7-day	38°C, 100% RH	≥ 0.03% at 1 year (ASTM C1293, ≥0.04%)
RILEM AAR-4 (CPT60)	Cement: 440 Aggregate: 1250 Sand: 525 w/c=0.45 Na_2Oeq = 1.25%	concrete prisms 75 x 75 x 280 mm;1 day	60°C, 100% RH	0.03% at 15-20 weeks-not confirmed yet

TABLE 2: List of coarse and fine aggregates and their combinations in concrete specimens*

Aggregate No.	Aggregate ID.	State	Aggregate Type	Field Reactivity	Companion Aggregate
1	M000221	NSW	Latite DNMR	?	EXL sand
2	M000222	NSW	Basalt PTRG	?	EXL sand
3	M000223	NSW	Rhyodacite tuff HLLQ	?	EXL sand
4	M000224	NSW	Basalt BTST	?	EXL sand
5	M000225	NSW	River gravel PNRT	?	EXL sand
6	M000226	NSW	Meta argillite TVN	?	EXL sand
7	M000227	NSW	Quartzite MRNG	?	EXL sand
8	M000228	ACT	Dacite COMR	?	EXL sand
9	M000230	NSW	Basalt KLNR	NR	NSW sand
10	M000234	NSW	Coarse sand MTGG	?	KLNR basalt
11	M000235	NSW	Rhyodacite tuff SEHM	?	EXL sand
12	M000237	NSW	Rhyodacite SYD2,	PR	EXL sand
13	M000238	NSW	Basalt TVN	?	EXL sand
14	M000245	NSW	Rhyodacite tuff SYD3	PR	EXL sand
15	M000310	VIC	Rhyodacite MTRS	?	BNYG sand
16	M000311	VIC	Sand BMSH	PR	DNST Basalt
17	M000312	VIC	Quartzite MKZC	R	BNYG sand
18	M000313	VIC	Hornfels STWL	?	BNYG sand
19	M000322	VIC	Basalt DNST	NR	BNYG sand
20	M000323	VIC	River Sand BNYG	NR	DNST Basalt
21	M000324	VIC	Greenstone GRHM	?	BNYG sand
22	M000326	VIC	Hornfels DNDG	?	BNYG sand
23	M000328	VIC	River gravel WDNG	PR- R	BNYG sand
24	M000330	VIC	Hornfels/Schist CHRL	R	BNYG sand
25	M000331	VIC	Basalt AXDL	?	BNYG sand
26	M000332	VIC	Granophyre EXTN	?	BNYG sand
27	M000333	NSW	Gneiss BKHL	?	BNYG sand
28	M000334	NSW	Rhyodacite CLCN	R	BNYG sand
29	C04/990	TAS	Quartzite TAS	R	EXL sand
30	C04/963	WA	Granitic Rock GSNL	R	EXL sand
31	M20498	NSW	Unknown COFF	?	EXL sand
32	M030514	ACT	Gneissic granite GTGA	R	EXL sand
33	M970027	VIC	Quartz gravel CC	R	EXL sand
34	M970028	VIC	Quartz gravel PM	R	EXL sand
35	M970029	VIC	Quartz gravel KS	R	EXL sand
36	Andesite JAP- deleted from test program due to insufficient amount of aggregate				
37	M990160	WA	Granitic Rock WARL	PR-R	EXL sand
38	M990204	VIC	Hornfels CHIL	R	EXL sand
39	M980062	NSW	River gravel NPR	R	NSW Sand
40	M980063	NSW	Basalt (non-reactive) S2	NR	NSW Sand
41	M980064	NSW	Rhyodacite S3	PR	NSW Sand
42	M98048	QLD	Greywacke SQLD	R	EXL sand
43	M98050	NSW	River sand NPR	?	DNST basalt
44	M98053	VIC	Hornfels WLRT	PR	EXL sand
45	M98083	VIC	Hornfels LYS	PR	EXL sand
46	M980099	VIC	10 mm aggregate 10AG	?	EXL sand
47	M980100	VIC	20 mm aggregate 20AG	?	EXL sand
48	M990125	VIC	River gravel TOMC	R	EXL sand
49	M990142	VIC	Gneissic granite BRT	R	EXL sand
50	M98069	VIC	Granite OKLJ	?	EXL sand
51	C05/1165	VIC	unknown INVR	?	EXL sand

* One of the 49 aggregates was used twice with different sands, e.g., rhyodacite S3.

TABLE 3: Confirmation of AMBT results by CPT60 at different limits

Outcome	0.02% at 112 days		0.03% at 112 days		0.04% at 112 days		0.03% at 140 days	
	Reactive	Inert	Reactive	Inert	Reactive	Inert	Reactive	Inert
Confirm	29	6	25	6	25	7	27	6
Mismatch	10	4	15†	3†	14	3	12	4
Confirm	74%	60%	63%	67	64%	70%	69%	60%
Mismatch	26%	40%	37%	33	36%	30%	31%	40%

Note 1: Percentages of confirm & mismatch are out of 39 reactive & 10 non-reactive by AMBT

† One non-reactive aggregate by AMBT, was classed reactive by the CPT60 limit of 0.03% at 112 days.

TABLE 4: Confirmation of AMBT results by CPT38 at different limits

Outcome	**0.03% at 1year**		**0.04% at 1year**	
	Reactive	**Inert**	**Reactive**	**Inert**
Confirm	22	9	18	10
Mismatch	17	1	21	0
Confirm	56%	90%	46%	100%
Mismatch	44%	10%	54%	0%

TABLE 5: ID number of the aggregates rated differently by the mortar bar test and prisms tests

	CPT60: 0.04% at 112-day	CPT38: 0.04% at 1 year
Reactive mismatch	3, 4, 5, 11, 14, 16, 20, 25, 26, 39, 41, 43, 44	3, 4, 5, 7, 11, 14, 16, 20, 25, 26, 30, 31, 32, 33, 34, 35, 39, 41, 43, 44, 50
Non-reactive mismatch	37, 45, 46	—

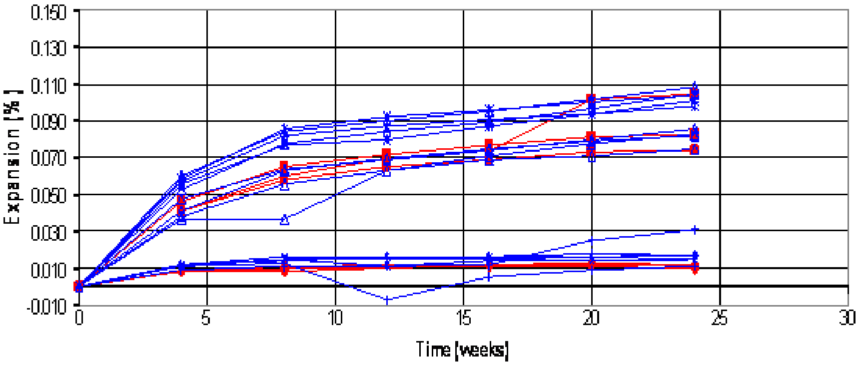

Figure 1: RILEM results for the accelerated concrete prism test

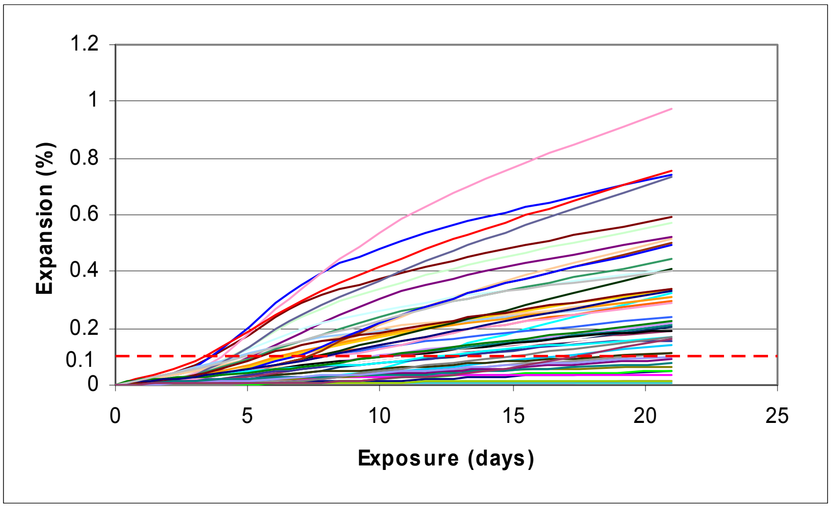

Figure 2: AMBT results, RTA T363 (1M NaOH, 80°C)

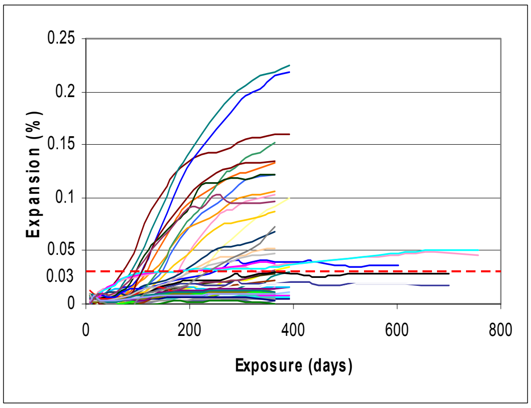

Figure 3: CPT results, RTA T364 (CPT38), 38°C, 100% RH

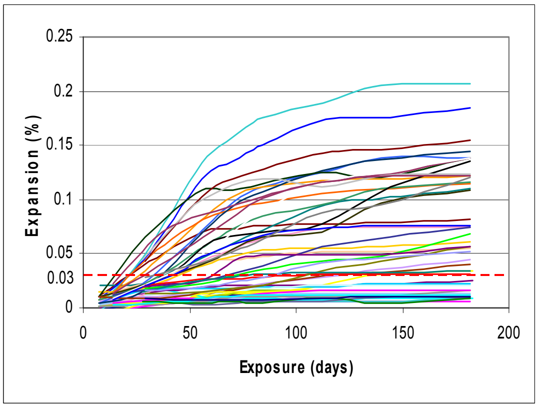

Figure 4: Rilem AAR-4 CPT results (CPT60), 60°C, 100% RH

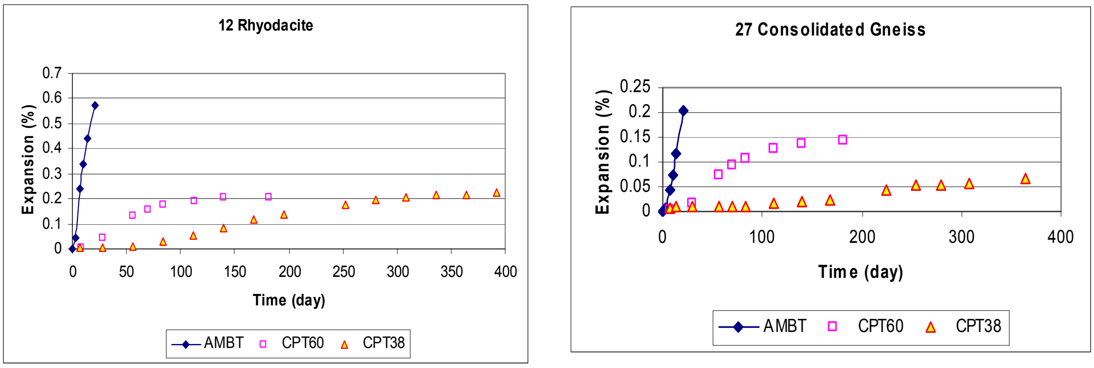

Figure 5: Expansion trends for aggregates rated "reactive" by all three methods

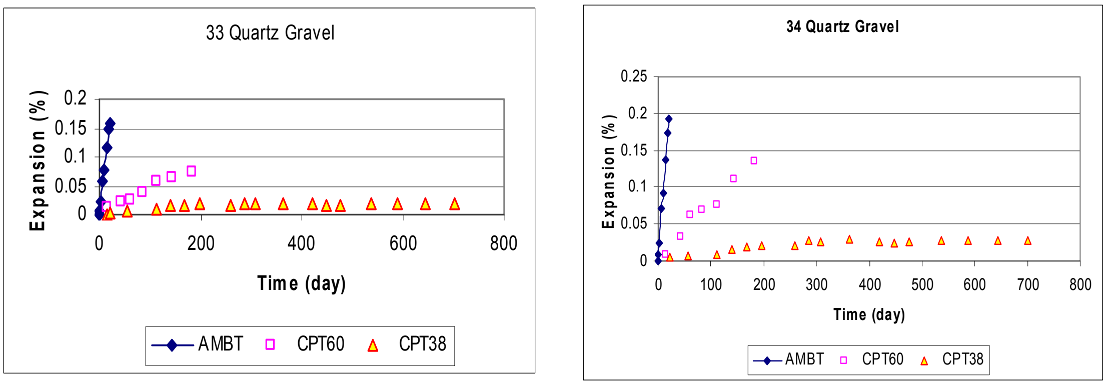

Figure 6: Expansion trends for slowly reactive quartz gravels containing strained quartz

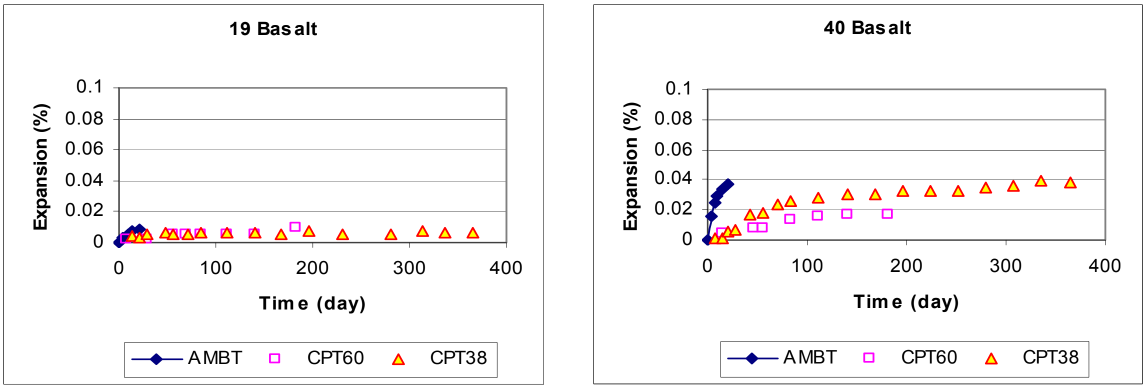

Figure 7: Expansion trends for non-reactive aggregates by all three methods

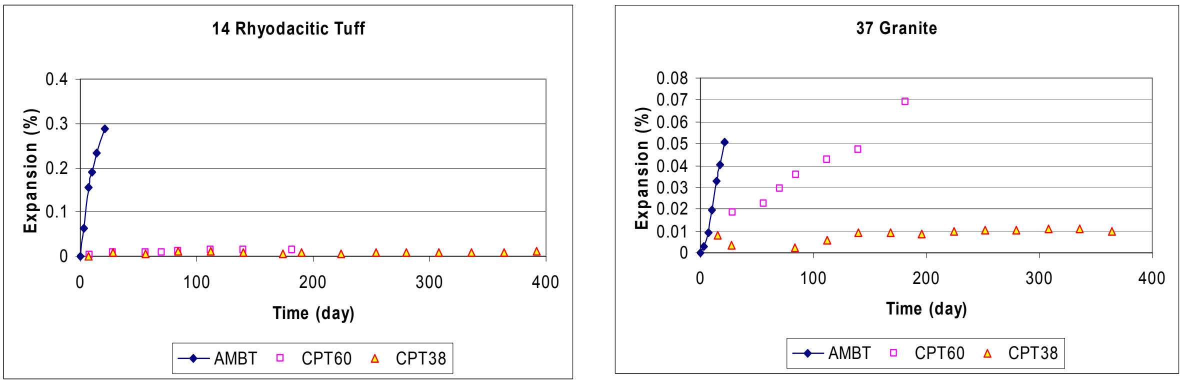

Figure 8: Examples of discrepancy among the results of the three tests

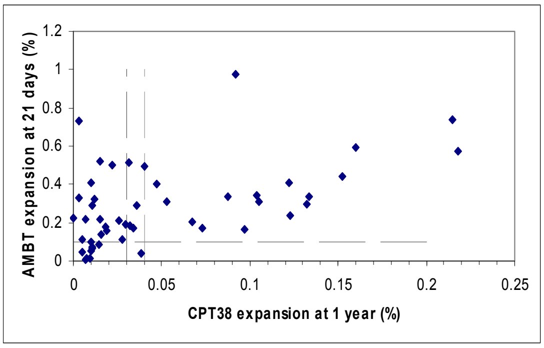

Figure 9: Comparison of CPT38 results and the AMBT results

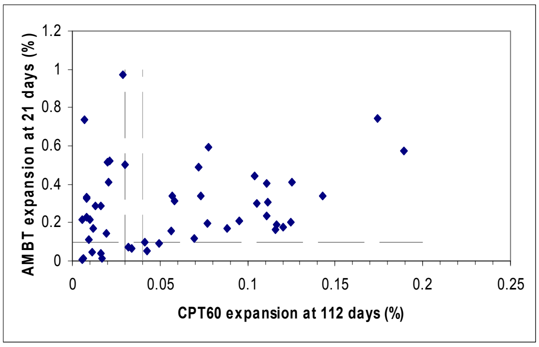

Figure 10: Comparison of CPT60 test results and the AMBT results.

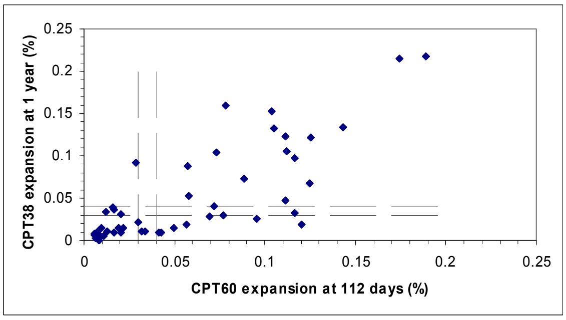

Figure 11: Comparison of expansion of CPT38 at 1-year with that of CPT60 at 112 days.

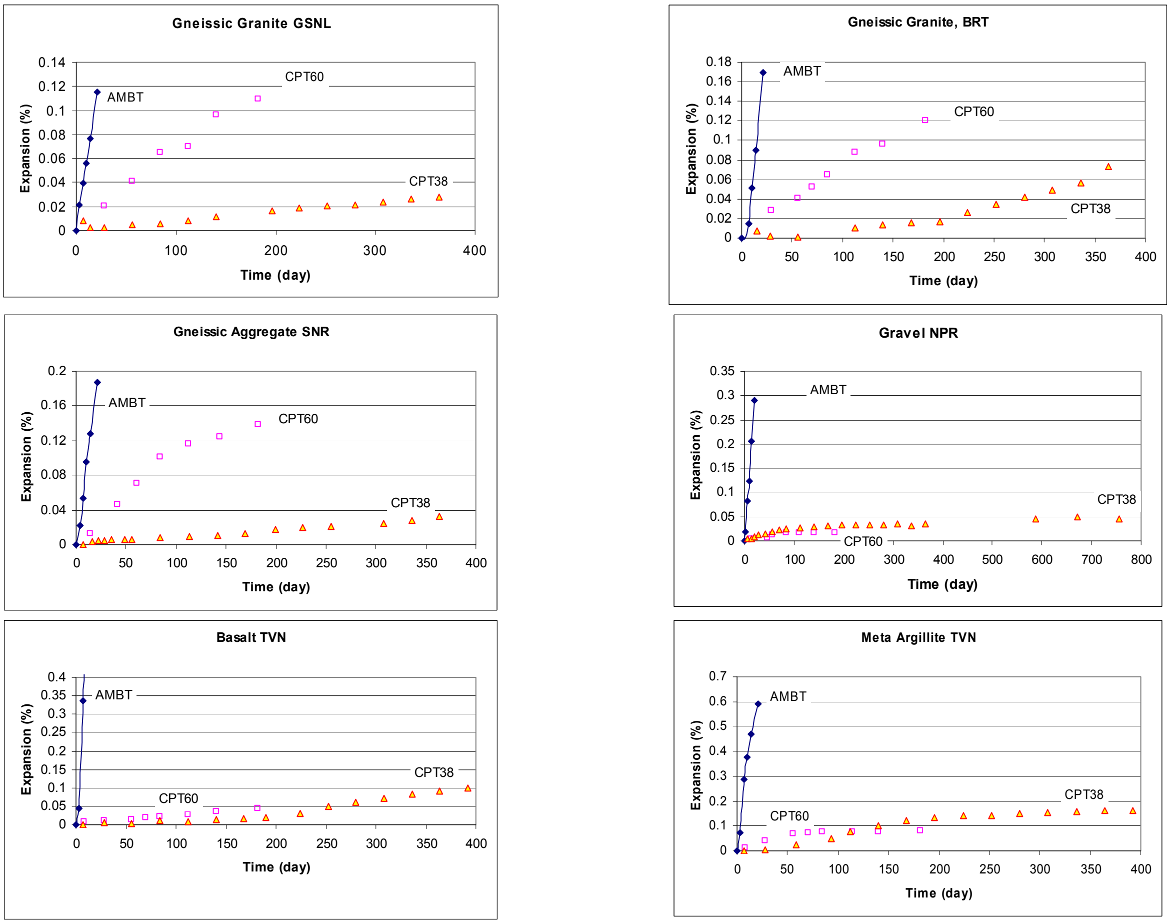

Figure 12: Behaviour of various reactive rock types in the three tests