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   Evaluation of the Miniature Concrete Prism Test (MCPT) for Use in LADOTD

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13. Abstract

Existing test methods for aggregate's alkali-silica reactivity (ASR) evaluation, such as the concrete prism test (CPT) and the accelerated mortar bar test (AMBT), have been shown to be either unsuitable for the routine evaluation of aggregates due to a testing period of 1 to 2 years or unreliable due to false-positive and false-negative test results. The miniature concrete prism test (MCPT) method, which requires only up to 84 days of length-change measurements, may be beneficial for ASR testing. To evaluate the feasibility of the MCPT method, a preliminary study was conducted to compare the results of the MCPT method (AASHTO T380) with existing ASR test methods. With available results from the CPT method (ASTM C1293) and the AMBT method (ASTM C1260), 12 fine aggregates and 12 coarse aggregates with a wide range of reactivity were selected for the mixture design in this study. One unreactive coarse aggregate and one unreactive fine aggregate were used as controls to ensure there would be only one aggregate (i.e., either coarse or fine aggregate) with unknown ASR reactivity for each mixture design. The results showed that an agreement of 95.8% for the evaluation of ASR reactivity was reached for the MCPT and CPT methods in this study, and a linear correlation with an R^2 value of 0.83 was established between these two sets of testing results. It was observed that the 56-day MCPT method produced a higher expansion than the 1-year CPT method for the majority of the reactive aggregate samples (i.e., expansion value greater than 0.040%). For coarse aggregates, the MCPT and AMBT methods were in agreement on the classification of 10 out of the 12 coarse aggregates, leading to a disagreement rate of 16.7% for the evaluation of ASR reactivity. Of the 33 mixtures with ASR mitigation measures, the MCPT and CPT methods were in agreement on 26 specimens, leading to an agreement rate of 79% for the ASR mitigation effectiveness evaluation.

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Abstract

Existing test methods for aggregate's alkali-silica reactivity (ASR) evaluation, such as the concrete prism test (CPT) and the accelerated mortar bar test (AMBT), have been shown to be either unsuitable for the routine evaluation of aggregates due to a testing period of 1 to 2 years or unreliable due to false-positive and false-negative test results. The miniature concrete prism test (MCPT) method, which requires only up to 84 days of length-change measurements, may be beneficial for ASR testing. To evaluate the feasibility of the MCPT method, a preliminary study was conducted to compare the results from the MCPT method (AASHTO T380) with existing ASR test methods. With the available results from the CPT method (ASTM C1293) and the AMBT method (ASTM C1260), 12 fine aggregates and 12 coarse aggregates with a wide range of reactivity were selected for the mixture design in this study. One unreactive coarse aggregate and one unreactive fine aggregate were used as controls to ensure there would be only one aggregate (i.e., either coarse or fine aggregate) with unknown ASR reactivity for each mixture design. The results showed that an agreement of 95.8% for the evaluation of the ASR reactivity was reached for the MCPT and CPT methods in this study, and a linear correlation with an R^2 value of 0.83 was established between these two sets of testing results. It was observed that the 56-day MCPT method produced a higher expansion than the 1-year CPT method for the majority of the reactive aggregate samples (i.e., expansion value greater than 0.040%). For coarse aggregates, the MCPT and AMBT methods were in agreement on the classification of 10 out of the 12 coarse aggregates, leading to a disagreement rate of 16.7% for the evaluation of ASR reactivity. Of the 33 mixtures with ASR mitigation measures, the MCPT and CPT methods were in agreement on 26 specimens, leading to an agreement rate of 79% for the ASR mitigation effectiveness evaluation.

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The efforts of Norris Rosser, Austin Gueho, and Aaron Brown in the concrete laboratory are greatly appreciated.

Implementation Statement

Based on the data obtained in this study, it is recommended to adopt the miniature concrete prism test (MCPT) method to evaluate the ASR reactivity for all coarse aggregates, as well as for fine aggregates, provided that the expansions do not exceed 0.30% from the AMBT method. The adoption of the MCPT method would save a significant amount of time for the routine assessment of aggregate's ASR reactivity.

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Introduction

The MCPT method was developed to accelerate the time required to conduct ASTM C1293, which may take up to 2 years. Industry stakeholders would like DOTD to explore the suitability and feasibility of implementing the MCPT method.

Literature Review

It is known that there is a chemical reaction between the alkali hydroxides in the concrete pore solution and the reactive silica from some types of aggregates. This alkali-silica reaction (ASR) produces a hydrous alkali-silica gel (ASR gel), which has a high swelling potential and causes the concrete to expand after absorbing water. When the expanding pressure exceeds the concrete strength, the concrete starts to crack [1, 2]. In order to avoid the cracks caused by ASR, it is critical to evaluate aggregates' potential of alkali-silica reactivity before using them in concrete production. Currently, there are two widely used testing methods, namely the concrete prism test (CPT) per ASTM C1293, and the accelerated mortar bar test (AMBT) per ASTM C1260 [1].

For the AMBT method, mortar bars with a dimension of 1 x 1 x 11.25 in. are cast and immersed in a 1N NaOH solution at 80°C for 14 days. By measuring the expansion of these mortar bars, it can be determined if the aggregate is prone to have ASR. It takes a total of 16 days to produce the results [3]. However, researchers have noticed that the AMBT method could produce false-positive and false-negative results, raising concerns about its reliability in measuring ASR [1, 4, 5, 6]. For instance, there are cases in which the AMBT method identified aggregates as reactive despite their satisfactory performance in the field and in concrete prism expansion tests [4, 6]. It should also be noted that the AMBT method requires a high storage temperature of 80°C, which is much greater than the typical situation in the field. This significantly high storage temperature could change the nature of the reactive aggregate and the reaction rate, thereby leading to false-positive results [1].

The CPT method, on the other hand, is a more reliable test method to assess ASR in concrete. The specimens are prepared with a dimension of 3 x 3 x 11.25 in. and stored in sealed containers at 38°C and high relative humidity conditions [7]. However, this test method's major limitation is that it takes one year to produce results for reactivity and two years to evaluate the effectiveness of the mitigation measures. This renders the test impractical for the routine assessment of aggregates' reactivity. Moreover, alkali leaching can also occur in the CPT method, which has led to cases in which the CPT prisms exhibit less expansion than concrete specimens tested in the field with the same level of alkalis [5].

In an effort to address the limitations of the AMBT and CPT test methods, researchers from Clemson University proposed a miniature concrete prism test (MCPT) method to assess the alkali-silica reactivity of aggregates. This test method is similar to CPT, but with several modifications. The storage temperature was raised from 38°C to 60°C to accelerate the kinetics of an ASR reaction while not dramatically changing the nature of the ASR reaction itself. Additionally, the alkali leaching observed in the CPT method was addressed by immersing the specimens in a 1N NaOH solution at 60°C. Other modifications included changing the aggregate gradation, maximum coarse aggregate size (from 0.75 in. to 0.50 in.), coarse aggregate volume fraction (from 0.7 to 0.65), and concrete prism size (2 x 2 x 11.25 in.). This study included a total of 19 coarse aggregates and 14 fine aggregates with different lithologies. The result showed that the MCPT method could produce reliable test results for the tested aggregates in 56 days when compared to the field performance [1]. In 2018, the MCPT method was developed as a standard test and published by AASHTO [8].

In order to further investigate the advantages and shortcomings of the MCPT method, Fanijo et al. performed a study to compare ASR testing results from the MCPT, AMBT, CPT, and accelerated concrete prism test (ACPT) methods for a total of 11 different aggregates [9]. They found that the fine aggregate (FA) fractions produced higher expansion values than the coarse aggregate fractions during the MCPT method testing due to the larger surface area for fine fractions. A comparison between the MCPT and CPT results shows that a linear correlation with an R^2 value of 0.69 could be established between the test results, and the 56-day MCPT method tends to produce a higher percentage expansion than the 1-year CPT method. It was noted that the observed expansion trends are different from those reported by Latifee and Rangaraju [1].

To evaluate the efficiency of the MCPT method for aggregates with low or marginal ASR potential, Rangaraju et al. tested 42 aggregates with different mineralogy using the MCPT, CPT, and AMBT methods. It was noted that there were several aggregates characterized as moderately reactive in the MCPT method, but characterized as non-reactive in the CPT method [10].

Because moderately reactive aggregates are more prone to being classified as either false-positive or false-negative through the AMBT method, Konduru et al. investigated the reliability of the MCPT method in assessing ASR for these aggregates [11]. 26 coarse aggregates and 16 fine aggregates with varying reactivity levels were used in their study. It was found that the MCPT and CPT methods produced the same passing or failing results for 23 coarse aggregates and 8 fine aggregates. Their results also showed that the AMBT method identified two fine aggregates as very highly reactive (i.e., 0.460% expansion at 14 days), but only one of the two fine aggregates was classified as very highly reactive by the MCPT and CPT methods. Though the MCPT and CPT methods did not agree with the AMBT method for the classification of the other fine aggregate, the MCPT and CPT methods produced a much smaller difference between the expansion results for this aggregate.

Objective

The objectives of this study were to:

1. Evaluate the suitability of the MCPT method to assess alkali-silica reactivity.
2. Determine the level of implementation and/or continued research required to adopt this test method.

Scope

To fulfill the objectives of this study, aggregates from local sources and DOTD's approved materials list (AML) that have been known to be reactive or potentially reactive were used to produce concrete samples. Length change measurements were taken immediately after the removal of molds based on the required testing schedules for the MCPT method and the existing ASR test method outlined in ASTM C1293. Finally, the testing results from the MCPT method were compared with those from ASTM C1293 to evaluate the feasibility of the MCPT method.

Methodology

During the pre-screening, aggregates from DOTD's approved materials list that have been known to be reactive or potentially reactive were selected to represent a wide range of reactivity. The selected aggregates were tested using both the MCPT (AASHTO T380) and CPT methods (ASTM C1293). After testing, the results were compared to evaluate the feasibility and robustness of the MCPT method for assessing ASR potential.

Experimental Design

Experimental Matrix

Table 1 describes the concrete mixtures based on the requirements set by the AASHTO T380 and ASTM C1293 standards for MCPT and CPT methods, respectively. The grading requirements for both methods are listed in Table 2 and Table 3 [7, 8]. Length change measurements were taken after the removal of molds at 7, 28, and 56 days, as well as at 3, 6, 9, and 12 months, to test each aggregate's susceptibility to ASR, per AASHTO T380 and ASTM C1293.

Table 1. Concrete mixing design

Factor	**Description**	
	AASHTO T380	**ASTM C1293**
Cementitious content	708 lb/yd^3 (420 kg/m^3)	708 lb/yd^3 (420 kg/m^3)
Initial Cement Alkali Content (% Na_2O_{eq})	0.90 ± 0.10	0.90 ± 0.10
Target Cement Alkali Content (% Na_2O_{eq})	1.25	1.25
w/cm	0.45	0.45
Fine aggregate types	12 known reactive or potentially reactive; 1 control	12 known reactive or potentially reactive; 1 control
Coarse aggregate types	12 known reactive or potentially reactive; 1 control	12 known reactive or potentially reactive; 1 control
Coarse Aggregate Volume Fraction (per unit volume)	0.65	0.65
Maximum aggregate size	0.50 in. (12.5 mm)	0.75 in. (19.0 mm)

Factor	Description	
	AASHTO T380	ASTM C1293
Temperature Conditioning	60°C	38°C

Table 2. Grading requirements for the MCPT method

Sieve Size		Mass, %
Passing	Retained	
12.5 mm (½ in.)	9.5 mm (⅜ in.)	57.5
9.5 mm (⅜ in.)	4.75 mm (No. 4)	42.5

Table 3. Grading requirements for the CPT method

Sieve Size		Mass Fraction	
Passing	Retained	Coarse	Intermediate
19.00 mm (¾ in.)	12.5 mm (½ in.)	⅓	-
12.5 mm (½ in.)	9.5 mm (⅜ in.)	⅓	½
9.5 mm (⅜ in.)	4.75 mm (No. 4)	⅓	½

Table 4. Cementitious materials proportion design

Cementitious Materials	Designation
Type I Portland Cement (100%)	100TI
Type I/II Portland Cement (70%) + Class F Fly Ash (30%)	70TI/30F
Type I/II Portland Cement (70%) + Class C Fly Ash (30%)	70TI/30C
Type I/II Portland Cement (50%) + Slag (50%)	50TI/50S

Table 4 describes the four different cementitious systems used in this study, including 100% portland cement and portland cement partially replaced by fly ash or slag. Based on the AMBT testing results (ASTM C1260) from the DOTD materials laboratory, both reactive and non-reactive aggregates were selected to cover a broader range of aggregates during pre-screening. Table 5 presents the types and source locations for all 26 aggregates (including one control fine aggregate and one control coarse aggregate) used in this study. By combining these with the four cementitious systems listed in Table 4, 96 mixtures were prepared for each testing method in this study to evaluate the robustness of the MCPT method for concretes made of various aggregates and cementitious materials.

Table 5. Aggregates used in this study

Type	Source Location	14-day AMBT Result (%)	Designation
Limestone	Salem, KY	0.34	CA#1
Sand	Amite, LA	0.28	FA#1
Sand	Fluker, LA	0.20	FA#2
Limestone	Smithland, KY	0.22	CA#2
Sand	DeRidder, LA	0.25	FA#3
Sand	Independence, LA	0.19	FA#4
Sand	Columbia, MS	0.19	FA#5
Sand	Greenwell Springs, LA	0.13	FA#6
Sand	St. Francisville, LA	0.26	FA#7
Sand	Franklinton, LA	0.16	FA#8
Sand	Pearl River, LA	0.18	FA#9
Sand	Columbia, MS	0.17	FA#10
Sand	Hattiesburg, MS	0.20	FA#11
Limestone	Salem, KY	0.36	CA#3
Limestone	Grand Rivers, KY	0.38	CA#4
Limestone	Smithland, KY	0.25	CA#5
Granite	Malvern, AR	0.02	CA#6
Rhyolite	Cove, AR	0.29	CA#7
Gravel	Franklinton, LA	0.21	CA#8
Sand	Denham Springs, LA	-	FA#12
Limestone	Tuscumbia, AL	0.13	CA#9
Sandstone	Sawyer, OK	0.13	CA#10
Limestone	Fredonia, KY	0.15	CA#11
Sandstone	Cave-in-Rock, IL	0.11	CA#12
Sand	Woodworth, LA	0.04	Control_FA
Gravel	Norwood, LA	0.02	Control_CA

Discussion of Results

Aggregate Testing Results

According to AASHTO T380 and ASTM C1293, an aggregate is classified as reactive if its expansion is more than 0.04% for the 56-day MCPT method and 1-year CPT method [7, 8]. It should also be noted that there are additional categories for the MCPT method if a more specific degree of reactivity is needed (Table 6) [8].

Table 6. Classification of aggregate reactivity based on the MCPT method

Expansion at 56 days	**Average 2-week expansion from 8 to 12 weeks** [a]	**Classification**
Less than 0.03%	N/A [b]	Nonreactive
0.031% ≤ Expansion ≤ 0.040%	≤ 0.010%	Nonreactive
0.031% ≤ Expansion ≤ 0.040%	> 0.010%	Low/slow reactive
0.041% ≤ Expansion ≤ 0.120%	N/A [b]	Moderate reactive
0.121% ≤ Expansion ≤ 0.240%	N/A [b]	Highly reactive
Greater than 0.240%	N/A [b]	Very highly reactive

[a] Average 2-week expansion = (expansion at 12 weeks - expansion at 8 weeks)/2.
[b] Not applicable.

The aggregate testing results from both the MCPT and CPT methods are shown in Table 7. It reveals that both the MCPT and CPT methods produced the same conclusion for 23 aggregates. However, there is one coarse aggregate (CA#10) that is classified as reactive through the MCPT method but as non-reactive through the CPT method. Therefore, an agreement of 95.8% was reached between these two methods during the evaluation of the ASR reactivity of all coarse and fine aggregates. By comparing the MCPT and CPT test results (see Figure 1), it can be observed that a good linear correlation with an R^2 value of 0.83 could be established between these two sets of testing results. Additionally, the 56-day MCPT method produced higher expansion values than the 1-year CPT method for the majority of the reactive aggregate samples (i.e., expansion value greater than 0.040%).

As mentioned in experimental design, all aggregates were selected based on the test results from the AMBT method (see Table 5). It should also be noted that one fine aggregate was tested with a different testing method during its certification in Louisiana, leading to 11

AMBT test data points for the fine aggregates. By comparing the test results from the AMBT and MCPT methods, it can be observed that these two methods have a better agreement for coarse aggregates than for fine aggregates. Specifically, the MCPT method identified all 11 fine aggregates which have been classified as deleterious or potentially deleterious through the AMBT method as non-reactive. In contrast, with an expansion limit of 0.040% for the MCPT method and 0.10% for the AMBT method, both methods classified 10 out of the 12 coarse aggregates as reactive, leading to a disagreement rate of 16.7% for the ASR evaluation of coarse aggregates. It is also noted that the correlation between the MCPT and AMBT test results is poor, with an R^2 value of 0.0333 (see Figure 2). Such a difference was expected since it has been reported in previous studies that there are reliability concerns for the AMBT method due to its tendency to produce false-positive and false-negative results [1, 4, 5, 6]. Additionally, MCPT was designed to correlate with CPT test results.

Table 7. Expansion test results for aggregate reactivity

Type	Designation	Cement*	MCPT		CPT	
			56-Day (%)	Reactivity	1-year (%)	Reactivity
CA	CA#2	100TI	0.298	Reactive	0.221	Reactive
CA	CA#1	100TI	0.225	Reactive	0.170	Reactive
FA	FA#1	100TI	0.014	Non-reactive	0.012	Non-reactive
FA	FA#2	100TI	0.014	Non-reactive	0.013	Non-reactive
FA	FA#3	100TI	0.025	Non-reactive	0.015	Non-reactive
FA	FA#4	100TI	0.013	Non-reactive	0.016	Non-reactive
FA	FA#5	100TI	0.016	Non-reactive	0.016	Non-reactive
FA	FA#6	100TI	0.018	Non-reactive	0.012	Non-reactive
FA	FA#7	100TI	0.012	Non-reactive	0.012	Non-reactive
FA	FA#8	100TI	0.016	Non-reactive	0.005	Non-reactive
FA	FA#9	100TI	0.025	Non-reactive	0.005	Non-reactive
FA	FA#10	100TI	0.029	Non-reactive	0.008	Non-reactive
FA	FA#11	100TI	0.013	Non-reactive	0.009	Non-reactive
CA	CA#3	100TI	0.223	Reactive	0.170	Reactive
CA	CA#4	100TI	0.294	Reactive	0.301	Reactive
CA	CA#5	100TI	0.115	Reactive	0.051	Reactive
CA	CA#6	100TI	0.178	Reactive	0.117	Reactive
CA	CA#7	100TI	0.178	Reactive	0.081	Reactive
CA	CA#8	100TI	0.021	Non-reactive	0.014	Non-reactive

Type	Designation	Cement*	MCPT		CPT	
			56-Day (%)	Reactivity	1-year (%)	Reactivity
FA	FA#12	100TI	0.019	Non-reactive	0.013	Non-reactive
CA	CA#9	100TI	0.197	Reactive	0.080	Reactive
CA	CA#10	100TI	0.144	Reactive	0.025	Non-reactive
CA	CA#11	100TI	0.233	Reactive	0.108	Reactive
CA	CA#12	100TI	0.241	Reactive	0.126	Reactive

Note:
CA = Coarse Aggregate, FA = Fine Aggregate
* See Table 4 for cementitious materials designation

Figure 1. Correlation between ASR testing results from the MCPT and CPT methods

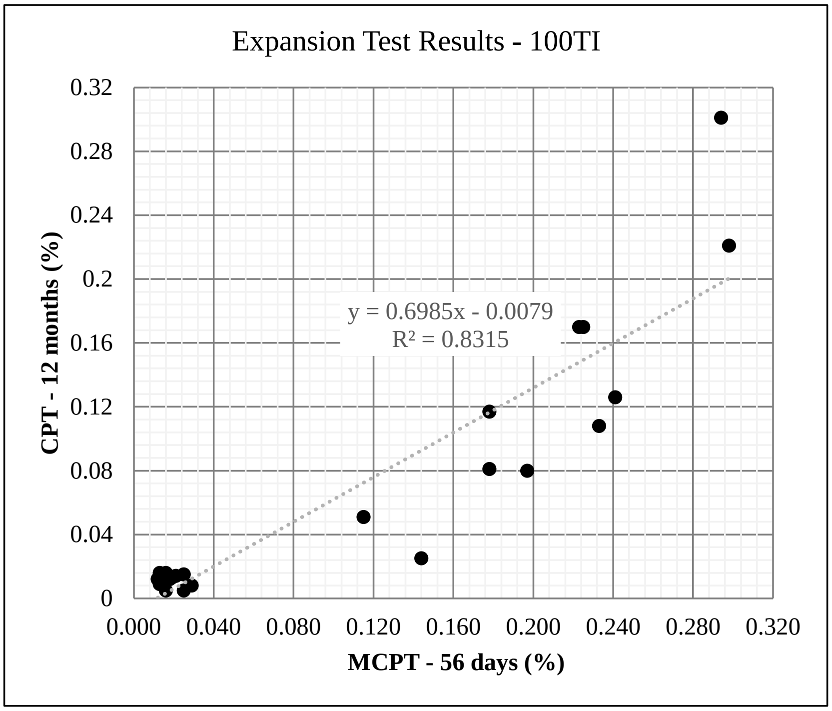
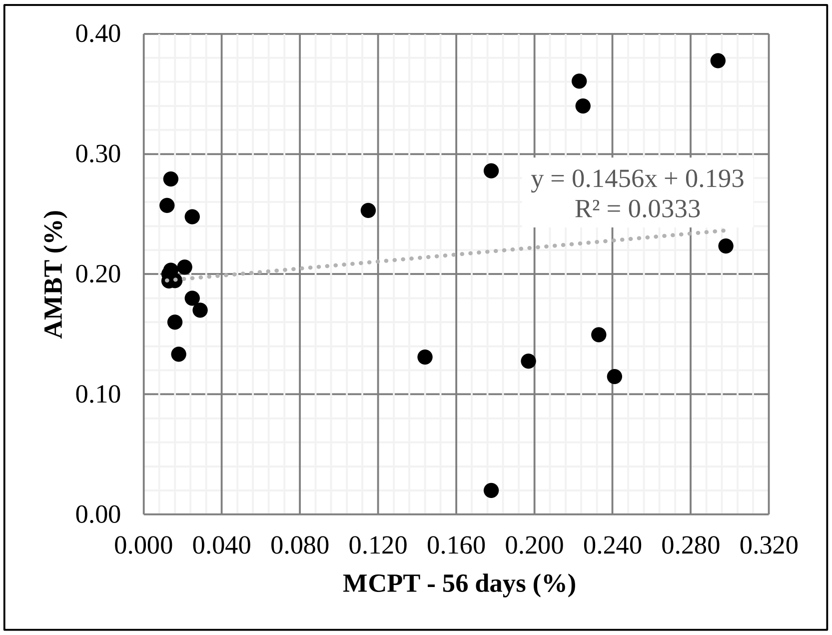


Figure 2. Correlation between ASR testing results from the MCPT and AMBT methods



Mitigation Testing Results

In order to further investigate how the MCPT method performs in evaluating the effectiveness of ASR mitigation, three parallel sets of studies were conducted by replacing the type I cement with 30% class F fly ash, 30% class C fly ash, and 50% slag respectively, during concrete mixing. As shown in Table 7, there were 11 aggregates classified as reactive through the MCPT method, leading to a total of 33 mixtures for ASR mitigation. Both the 56-day MCPT method and the 2-year CPT method were used for the evaluation of ASR mitigation effectiveness.

According to AASHTO T380, the effectiveness evaluation of ASR mitigation is classified into three categories (Table 8) [8]. However, there are only two categories based on the 2-year CPT method (Table 9) [7]. Since the MCPT and CPT methods have different expansion limits for the classification of mitigation effectiveness, the measured expansions are normalized by 0.02% and 0.04% for the 56-day MCPT method and 2-year CPT method, respectively, to create an easier comparison. In this way, a normalized value of 100% means the expansion reaches the limit in each of the test methods. From Figure 3, it can be observed that there are four specimens classified as effective or not effective through the CPT method but as uncertain through the MCPT method, and three specimens classified as effective through the CPT method but as not effective through the MCPT method. In other words, the MCPT and CPT methods are in agreement on 26 specimens, leading to a value of 79% for the matched classification of ASR mitigation effectiveness evaluation. A further comparison (see Figure 4) shows that a linear correlation with an R^2 value of 0.6697 can be established between these two sets of testing results for the specimens with mitigation measures.

Table 8. Effectiveness evaluation of ASR mitigation based on the MCPT method

Expansion at 56 days	**Classification**
Less than 0.02%	Effective
0.02% ≤ Expansion ≤ 0.025%	Uncertain*
Greater than 0.025%	Not Effective
* It is recommended to apply a higher dosage of mitigation and retest the specimen.	

Table 9. Effectiveness evaluation of ASR mitigation based on the CPT method

Expansion at 2 years	**Classification**
Less than 0.04%	Effective
Greater than 0.04%	Not Effective

Figure 3. ASR mitigation testing results from the MCPT and CPT methods

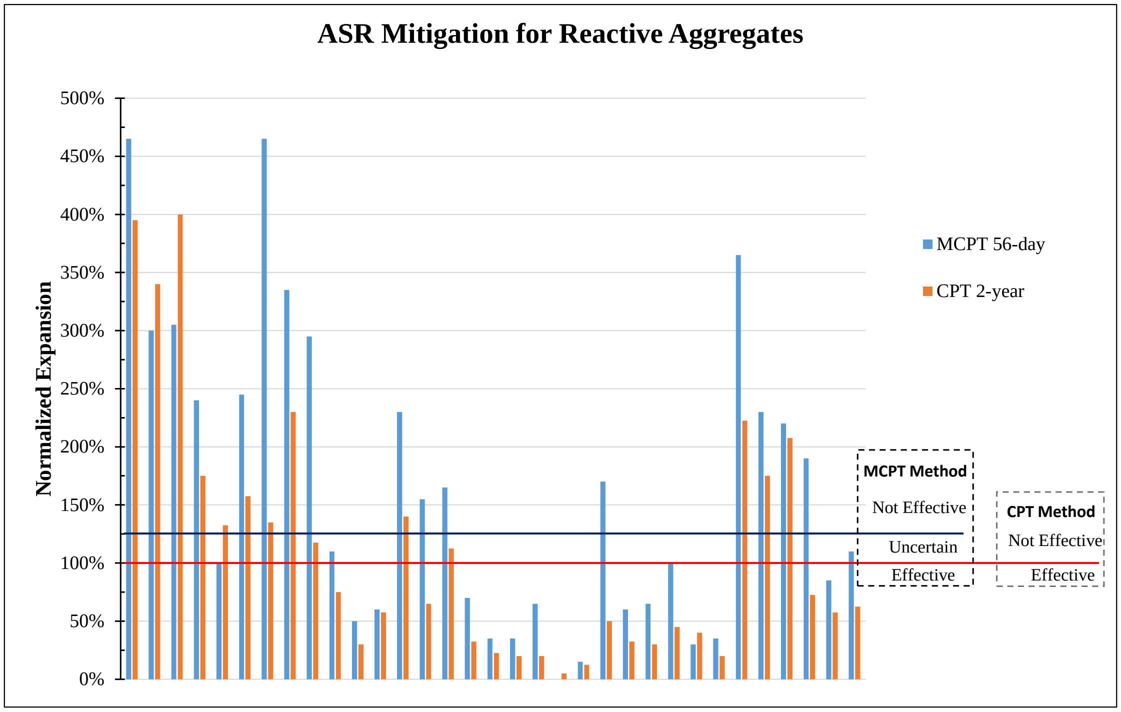
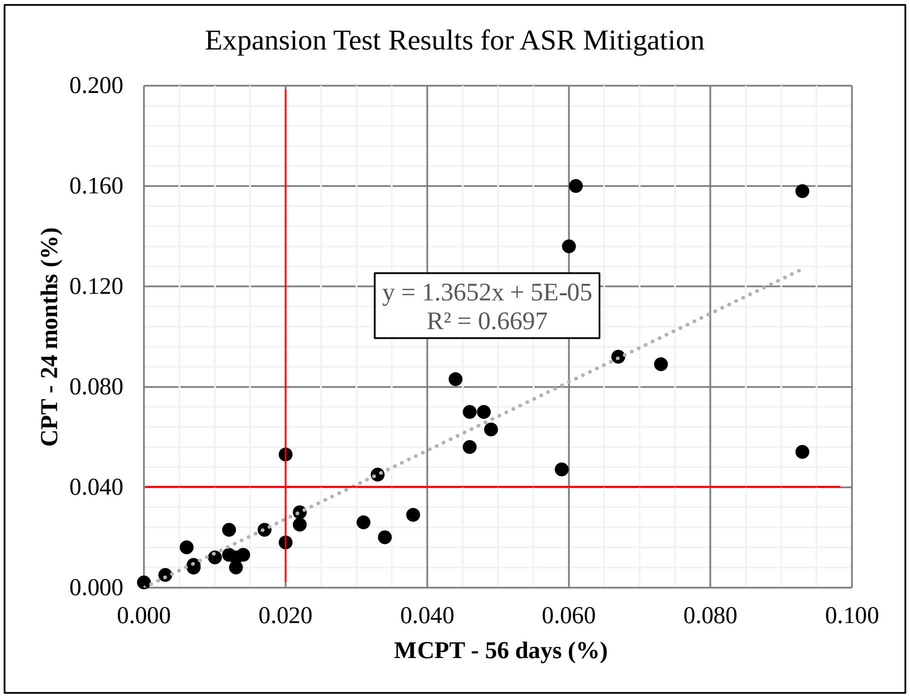


Figure 4. Correlation between MCPT and CPT test results for ASR mitigation



Conclusions

By comparing the test results from the MCPT, CPT and AMBT methods, it was found that:

- The MCPT and CPT methods were in agreement for 23 out of 24 aggregates, rendering an agreement rate of 95.8% for the evaluation of ASR reactivity. A good linear correlation with an R^2 value of 0.83 was established between these two sets of testing results.
- The 56-day MCPT method produced a higher expansion than the 1-year CPT method for the majority of the reactive aggregates (i.e., expansion value greater than 0.040%).
- The MCPT and AMBT methods were in agreement on the classification of 10 out of the 12 coarse aggregates, leading to a disagreement rate of 16.7% for the evaluation of coarse aggregates' ASR reactivity.
- Of the 33 mixtures for ASR mitigation, the MCPT and CPT methods were in agreement on 26 specimens, leading to an agreement rate of 79% for the ASR mitigation effectiveness evaluation.
- The correlation shows that a linear relationship with an R^2 value of 0.6697 can be established between the test results from the MCPT and CPT methods for the ASR mitigation effectiveness evaluation.

Recommendations

The results of this study show that an agreement rate of 95.8% for the evaluation of ASR reactivity was reached for the MCPT and CPT methods, and a linear correlation with an R^2 value of 0.83 was established between these two sets of testing results. However, it is also noted that all of the fine aggregates used in this study were identified as non-reactive by the MCPT and CPT methods. Using the data obtained in this study, it is recommended to adopt the MCPT method to evaluate ASR reactivity for aggregates.

Acronyms, Abbreviations, and Symbols

Term	**Description**
AASHTO	American Association of State Highway and Transportation Officials
AMBT	Accelerated Mortar Bar Test
AML	DOTD's Approved Materials List
ASR	Alkali-Silica Reaction
CPT	Concrete Prism Test
DOTD	Louisiana Department of Transportation and Development
FHWA	Federal Highway Administration
in.	inch(es)
kg/m^3	kilograms per cubic meter
lb/yd^3	pound(s) per cubic yard
LTRC	Louisiana Transportation Research Center
MCPT	Miniature Concrete Prism Test
mm	millimeter(s)
w/cm	Water/Cementitious Materials

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Appendix

Table 10. Expansion test results from the MCPT and CPT methods

Aggregate	Designation	Source	Cement *	MCPT 56-Day (%)	CPT 12-Month (%)	CPT 24-Month (%)
Limestone	CA#2	Smithland, KY	100TI	0.298	0.221	
			70TI/30C	0.093		0.158
			50TI/50S	0.060		0.136
			70TI/30F	0.061		0.160
Limestone	CA#1	Salem, KY	100TI	0.225	0.170	
			70TI/30C	0.048		0.070
			50TI/50S	0.020		0.053
			70TI/30F	0.049		0.063
Sand	FA#1	Amite, LA	100TI	0.014	0.012	
Sand	FA#2	Fluker, LA	100TI	0.014	0.013	
Sand	FA#3	DeRidder, LA	100TI	0.025	0.015	
Sand	FA#4	Independence, LA	100TI	0.013	0.016	
Sand	FA#5	Columbia, MS	100TI	0.016	0.016	
Sand	FA#6	Greenwell Springs, LA	100TI	0.018	0.012	
Sand	FA#7	St. Francisville, LA	100TI	0.012	0.012	
Sand	FA#8	Franklinton, LA	100TI	0.016	0.005	
Sand	FA#9	Pearl River, LA	100TI	0.025	0.005	
Sand	FA#10	Columbia, MS	100TI	0.029	0.008	
Sand	FA#11	Hattiesburg, MS	100TI	0.013	0.009	
Limestone	CA#3	Salem, KY	100TI	0.223	0.170	
			70TI/30C	0.093		0.054
			50TI/50S	0.067		0.092
			70TI/30F	0.059		0.047
Limestone	CA#4	Grand Rivers, KY	100TI	0.294	0.301	
			70TI/30C	0.022		0.030
			50TI/50S	0.010		0.012
			70TI/30F	0.012		0.023
Limestone	CA#5	Smithland, KY	100TI	0.115	0.051	
			70TI/30C	0.046		0.056

Aggregate	**Designation**	**Source**	**Cement** *	**MCPT 56-Day (%)**	**CPT 12-Month (%)**	**CPT 24-Month (%)**
			50TI/50S	0.031		0.026
			70TI/30F	0.033		0.045
Granite	CA#6	Malvern, AR	100TI	0.178	0.117	
			70TI/30C	0.014		0.013
			50TI/50S	0.007		0.009
			70TI/30F	0.007		0.008
Rhyolite	CA#7	Cove, AR	100TI	0.178	0.081	
			70TI/30C	0.013		0.008
			50TI/50S	0.000		0.002
			70TI/30F	0.003		0.005
Gravel	CA#8	Franklinton, LA	100TI	0.021	0.014	
Sand	FA#12	Denham Springs, LA	100TI	0.019	0.013	
Limestone	CA#9	Tuscumbia, AL	100TI	0.197	0.080	
			70TI/30C	0.034		0.020
			50TI/50S	0.012		0.013
			70TI/30F	0.013		0.012
Sandstone	CA#10	Sawyer, OK	100TI	0.144	0.025	
			70TI/30C	0.020		0.018
			50TI/50S	0.006		0.016
			70TI/30F	0.007		0.008
Limestone	CA#11	Fredonia, KY	100TI	0.233	0.108	
			70TI/30C	0.073		0.089
			50TI/50S	0.046		0.070
			70TI/30F	0.044		0.083
Sandstone	CA#12	Cave-in-Rock, IL	100TI	0.241	0.126	
			70TI/30C	0.038		0.029
			50TI/50S	0.017		0.023
			70TI/30F	0.022		0.025

CA = Coarse Aggregate, FA = Fine Aggregate

* See Table 4 for cementitious materials designation.