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Synopsis

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PERFORMANCE TEST OF A 3 1/2 CUBIC YARD TURBINE TYPE MIXER AT VARIOUS MIXING TIMES

January, 1964

MATERIALS & RESEARCH DEPARTMENT

64-07

State of California
Department of Public Works
Division of Highways

MATERIALS AND RESEARCH DEPARTMENT

January 15, 1964
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Submitted for your consideration is a report

on:

Performance Test of a 3-1/2 Cubic

Yard Turbine Type Mixer at

Various Mixing Times

Study by . . . . Technical Section
Under general direction of . . . . . D. L. Spellman
Work supervised by . . . . J. H. Woodstrom
Report prepared by . . . . B. F. Neal and
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PERFORMANCE TEST OF A 3-1/2 CUBIC YARD TURBINE TYPE MIXER AT VARIOUS MIXING TIMES

SYNOPSIS

A study was made by the Materials and Research Department of the California Division of Highways to evaluate the uniformity of concrete produced by a revolving blade turbine type mixer operated at various mixing times. The mixing times used were 45, 60, and 90 seconds. Uniformity was evaluated by testing for slump, weight of coarse aggregate per cubic foot of concrete, compressive strength, distribution of cement, and visual observations.

CONCLUSIONS

1. For the mixer and mix design involved in this study (1-1/2" maximum, 6-sack, 4-inch nominal slump), and under the existing conditions of batching, concrete can be satisfactorily mixed at any of the mixing times tested.

2. Test data indicate that while adequate, uniformity is not as good in the 45-second mixes as it is in the 60 and 90-second mixes.

3. The batching procedure for dry materials and the method of adding water are important factors in producing uniformly mixed concrete at shorter mixing times.

4. If additional water is needed to adjust the slump during the mixing cycle, mixing should continue a minimum of 15 seconds after all water is added.

5. Based on visual observations, wetter mixes require more mixing time to produce a uniform appearance than do the drier mixes.

INTRODUCTION

In a letter from Mr. McMahon to Mr. Murphy dated November 13, 1963, authorization was requested for field tests to be performed on a 3-1/2 cubic yard revolving blade type mixer being used by the Contractor, Peter Kiewit Sons Co., to produce concrete for two projects on the Santa Monica Freeway. Information was needed to determine the minimum mixing time necessary to produce uniformly mixed concrete. The laboratory was authorized to proceed with these tests.

The two contracts using concrete from this mixer were 63-7V13C50-IP and 64-7V13C20-I. Mr. Carl Verner, Bridge Department Representative for the former contract, assisted in co-ordinating the laboratory work with the Contractor's operations.

All concrete tested was a nominal 6-sack mix, with 1-1/2-inch maximum size aggregates from the Blue Diamond plant in El Monte. Cement was Riverside, Oro Grande, Type II, low alkali. Tests were made on December 3, 4 and 5, 1963.

EQUIPMENT

The mixer tested was a Smith Turbine, Serial No. 321. The over-all diameter is 10 feet, and the capacity is 3-1/2 cubic yards. There are 12 mixing paddles mounted on a spindle which turn at a constant speed of 24 revolutions per minute. The paddles are shaped and located so as to provide blending of ingredients in all portions of the mixing tub.

The mixer is charged by first starting the aggregate and water, and after about 7 seconds, the cement gate is opened. Water enters from the center of the turbine spraying to all parts of the mixer through a circular ring. When the cement has finished entering, the batch gates are all closed and timing of the mix starts. The total charging time is from 30 to 35 seconds.

The operator normally operates the plant semi-automatically, controlling the water and hence the slump, by means of an ammeter measuring the current used by the blade drive motor. The ammeter indicates the load or drag on the mixer and the operator could control the slump to within approximately 1/2-inch by this means. Because of the relatively constant drag on the blades in this type of mixer, the method appeared to be successful.

The discharge gate is in the bottom of the mixer and on the opposite side from the charging chutes. During operations, this gate was held open for 30 seconds. The bulk of the batch was discharged in the first 15 seconds. After that period, the discharge was in the form of individual rock particles and small amounts of mortars. The additional time was necessary to insure against getting a rock caught between the gate and the bottom of the mixer as the gate was closed. If this happened, the gate would not completely close and the material in the succeeding batch would leak through the partially closed gate. It would appear that the over-all mixing cycle time could be shortened by modifying the discharge gate to allow its closure with small amounts of concrete present in the mixer.

TESTING

Test samples were taken only from batches which were mixed at the 3-1/2 cubic yard capacity of the mixer and which had no additional water added during mixing. Each batch tested was timed with a stop watch to make sure the proper mixing time was being maintained. Four batches were tested for each mixing time, and samples were taken from two different portions of each batch. The test samples were taken from the first and last portions of the batch while the concrete was being discharged into Dumpcrete trucks.

Concrete mixed for 90 seconds was tested first. Tests were then made on four batches mixed at 60 seconds. Since on-site tests at 90 seconds and 60 seconds of mixing indicated no appreciable variation in weight of coarse aggregate per cubic foot, mixing time was then reduced to 45 seconds for additional tests.

Tests on the fresh concrete consisted of the determination of slump by the cone method, unit weight test, and determination of proportions of coarse aggregate per cubic foot of concrete. A mortar sample for use in determining the distribution of cement was obtained by sieving a quantity of fresh concrete over a No. 4 sieve. For the 90-second mixing time, one 6x12-inch cylinder was molded from each sample for compressive strength tests at 14 days. Except for one batch, two cylinders were made to represent each sample for the 60 and 45-second mixing times. Results of tests on the fresh and hardened concrete are shown in the attached tables, 1, 2 and 3.

DISCUSSION

A difference in the weight of coarse aggregate per cubic foot of concrete of less than 6.0 lbs., is considered satisfactory as far as coarse aggregate distribution is concerned. None of the test batches exceeded this amount. In fact, the average differences in weight of the coarse aggregate per cubic foot were only 2 to 3 lbs. (See Tables 1, 2, and 3.) This indicates that coarse aggregate was uniformly distributed in all the test batches.

Considering strength, there was no significant difference in the average compressive strength between the 90, 60, and 45-second batches; however, the differences between the samples from the individual batches (first and last) were largest for the 45-second mixes. The results were as follows:

	Mixing Time		
	90 Secs.	60 Secs.	45 Secs.
Variation in Strength from the average	85 psi	60 psi	160 psi

The strength tests indicate that there is less uniform distribution of cement in the 45-second batches than in the other batches mixed 90 or 60 seconds. This is not supported by results of tests made on mortar to determine (indirectly) the distribution of cement in the two portions of the batch. This anomaly indicates that a gap exists in conventional tests for uniformity, particularly with respect to the dispersion of the cement.

The difference in compressive strength between the first and last samples however, is not considered excessive for reasonably well mixed concrete. It only indicates that less thorough mixing is occurring in the 45-second mixes.

The difference in slump between the first and last samples did not exceed 1-1/2 inch in any of the mixes tested. In fact, uniformity as measured by difference in slump, was best for the 45-second mixes. The average slump for the 45-second mixes was greater than that for the 60 and 90-second mixes.

If the test sample itself were segregated but contained the proper proportion of rock and mortar, the cone slump test method which requires remixing of the sample, would tend to restore uniformity and thereby indicate uniform slump. Observation of these tests and reports by others show that wetter mixes (high slump) tend to segregate more than drier mixes. Mixes having slumps greater than 4 inches showed greater tendency toward segregation. Additional mixing time of the wetter mixes tended to improve uniformity based on visual observations.

From the results obtained in this testing program, it appears that concrete of satisfactory uniformity can be produced by this particular mixer and under existing batching conditions at any of the mixing times tested. This data should not be the sole criteria in establishing minimum mixing times. For instance, the efficiency of the mixer may be a large variable and is dependent on several factors such as:

1. The condition of the mixer and the blades or paddles. The mixer tested was in very good condition with paddles which had recently be refaced.

2. The location of the charging gates and the timing at which they are operated. The mixer being tested appeared to intermingle all ingredients while batching.

3. Whether or not the mixer is operated automatically. If the operator controls the water manually (adds water late in the mixing cycle), it is doubtful that proper mixing can be completed within 45 seconds.

It is unlikely that all turbine mixers will operate at the same efficiency as the one tested. Until this type of mixer can be controlled by proper specifications relating to mixer condition and method of charging materials, it will probably be necessary to make performance tests or at least consider these factors before a minimum mixing time can be designated.

TABLE 1

90-SECOND MIXING TIME

Batch No.	Sampled From	FRESH CONCRETE TESTS: Slump* Ins.	FRESH CONCRETE TESTS: Unit Weight Lbs./Cu.Ft.	FRESH CONCRETE TESTS: Diff. in Wt. of CA Lbs./Cu. Ft.	HARDENED CONCRETE TESTS: 14-day Compr. Str., psi	HARDENED CONCRETE TESTS: Calculated Cement Factor** (Sacks per Cubic Yard)	HARDENED CONCRETE TESTS: Diff. in Calculated Cement Factor (Sacks per Cubic Yard)
1	First Portion	5	150.1	3.2	4150	5.93	0.10
	Last Portion	3-1/2	150.9		3900	5.83	
2	First	4	150.8	2.0	4120	5.77	0.36
	Last	3-1/2	150.8		4300	6.13	
3	First	3-1/2	150.6	5.2***	3970	5.93	0.27
	Last	5	149.8		3870	6.20	
4	First	4	151.3	1.9	3840	6.20	0.20
	Last	3-1/2	150.8		3970	6.00	
Average				3.1	4020	6.00	0.23

* By Cone

** $\frac{\text{Nominal Job Cement Factor (6 sks.)}}{\text{Average CaO of all samples}} \times$ CaO of individual sample

This calculation is adequate for making comparisons in cement distribution in terms of cement factor.

*** Last sample was taken near end of discharge where segregation normally occurs.

TABLE 2

60-SECOND MIXING TIME

Batch No.	Sampled From	FRESH CONCRETE TESTS			HARDENED CONCRETE TESTS		
		Slump* Ins.	Unit Weight Lbs./Cu. Ft.	Diff. in Wt. of CA Lbs./Cu. Ft.	14-day Compr. Str., psi	Calculated Cement Factor** (Sacks per Cubic Yard)	Diff. in Calculated Cement Factor (Sacks per Cubic Yard)
1	First Portion	3	150.5	0.5	3840	5.60	0.53
	Last Portion	4	150.7		4080	6.13	
2	First	4	150.8	5.4***	4000 3970	5.70	0.57
	Last	3-1/2	151.7		4180 3850	6.27	
3	First	3-1/2	151.1	2.3	4000 3950	5.97	0.00
	Last	3-1/2	151.2		3720 4080	5.97	
4	First	3-3/4	151.0	1.7	3650 3290	6.23	0.06
	Last	4-1/2	150.9		3680 3590	6.17	
Average				2.5	3850	6.00	0.29

* By Cone

** $\frac{\text{Nominal Job Cement Factor (6 sks.)}}{\text{Average CaO of all samples}}$ x CaO of individual sample

This calculation is adequate for making comparisons in cement distribution in terms of cement factor.

*** Last sample was taken near end of discharge where segregation normally occurs.

TABLE 3

45-SECOND MIXING TIME

Batch No.	Sampled From	FRESH CONCRETE TESTS: Slump* Ins.	Unit Weight Lbs./Cu.Ft.	Diff. in Wt. of CA Lbs./Cu. Ft.	HARDENED CONCRETE TESTS: 14-day Compr. Str., psi	Calculated Cement Factor** (Sacks per Cubic Yard)	Diff. in Calculated Cement Factor (Sacks per Cubic Yard)
1	First Portion	4-1/4	151.9	3.2	3860	5.80	0.27
	Last Portion	4-1/2	150.7		3920 3920 4120	6.07	
2	First	4	150.8	2.5	3940 4100	6.10	0.03
	Last	4	150.8		3710 3610	6.07	
3	First	5-1/2	151.8	0.1	3790 4090	6.00	0.07
	Last	5-1/2	151.3		4280 4360	6.07	
4	First	5	151.8	2.2	3670 3890	5.97	0.10
	Last	5	151.1		4020 4330	5.87	
Average				2.0	3980	6.00	0.12

* By Cone

** $\frac{\text{Nominal Job Cement Factor (6 sks.)}}{\text{Average CaO of all samples}}$ x CaO of individual sample.

This calculation is adequate for making comparisons in cement distribution in terms of cement factor.