Department of Transportation

HIGHWAY DIVISION

Materials Section

DOCUMENT NUMBER 00004

Technical Report Documentation Page

Specification No. 504	**ODOT No.**
Report Date February, 1986	**Report No.**

Title

Eugene Sand & Gravel
High-Strength Concrete Report Study
Phase Two Report

Subtitle

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Notes

Key Words

Concrete Cylinder Molds
Compressive Strength
Portland Cement Concrete

Type

Research Report

Location

INTRODUCTION

This report is a supplement to the original EUGENE SAND and GRAVEL HIGH-STRENGTH CONCRETE RESEARCH STUDY. This PHASE TWO report will address what difference, if any, casting cylinders in sealed molds verses unsealed molds and other comparisons has on compressive strengths.

The original report showed a significant difference when comparing; test labs and equipment, and the type of molds used. There was no significant difference when comparing; method of long-term cure, intermediate cure, and method of transport.

The guidelines to follow in selecting the type of mold for forming concrete test cylinders is stated in AASHTO TEST DESIGNATION: M205-83I (ASTM DESIGNATION: C470-81).

PURPOSE

The purpose of this report is to examine through laboratory analysis certain conditions present when casting cylinders at Eugene Sand and Gravel prestressed yard. By laboratory analysis this report will show what effect these different conditions have on compressive strengths.

SCOPE

For laboratory analysis five sets of cylinders were molded. All cylinders were cast from the same high-strength concrete. The subsequent compressive strength testing was performed at OSHD materials laboratory.

The test results were analyzed statistically at a 95% significant level. This was performed by calculating the mean difference and the standard error of the difference between the mean of the sample of two independent populations. Values from the area under the normal probability curve are compared to the accepted convention*. A significant result is a calculated probability less than 0.05, and a highly significant result is a calculated probability less than 0.01. For consistency of a small sample, which is considered a set of less than thirty samples. The standard deviation was calculated with n, the number of samples in the set, as the denominator.

*Probability and Statistics by Alder/Rossler, 1975, 6th. edition.

PROCEDURE

This procedure was developed with the premise that the mix used to mold the specimens was consistent throughout the batch. A single batch was used for the entire procedure.

On Jan. 23, 1986 a class 6000, 3/4 inch, 8 sack mix was batched from OSHD Mix Design ESG-10-85 at Eugene Sand and Gravel prestressed yard. From this batch five sets of ten cylinders each were molded,and placed in the five distinct categories as follows:

A. ES&G sealed steel cylinders, hand rodded, and covered with glass plates.
B. OSHD sealed steel cylinders, hand rodded, and covered with glass plates.
C. ES&G unsealed steel cylinders, hand rodded, and covered with plastic bags.
D. ES&G unsealed steel cylinders, machine vibrated, and covered with plastic bags.
E. OSHD plastic cylinders, hand rodded, and covered with plastic lids.

The cylinders were stored in a regulated environment for 24 hours, and then shipped to OSHD materials laboratory for compressive strength testing. The specimens molded in steel were removed from the molds before shipping.

On Jan 24, 1986 the cylinders arrived at OSHD materials laboratory. At the laboratory the remaining cylinders were demolded. Then all cylinders were capped with sulfur mortar caps, and placed in a 73.4 degree F. + or - 3 degree F. moist cure room until February 20, 1986.

On February 20, 1986 the cylinders were tested for a 28 day break of compressive strength according to AASHTO TEST DESIGNATION: T22-84I (ASTM DESIGNATION: C39-81). The micrometer readings of the cylinder diameter were used to calculate the cross-section area, and applied for accuracy to determine the compressive strength.

TEST RESULTS

The compressive strengths of each cylinder is listed in Table #1 by categories. Each category is represented by the following parameters:

A. Type of mold.
B. Owner of mold.
C. If the mold was sealed.
D. How the cylinder was consolidated.
E. How the cylinder was covered.

The statistical comparison between categories is listed in Table #2 and explained below:

1. For statistical analysis between ES&G molds and OSHD molds, category A vs. B, exhibited no significant difference. The value was 0.119.*

2. For statistical analysis between sealed molds and unsealed molds, category A vs. C, exhibited no significant difference. The value was 0.390.*

3. For statistical analysis between vibrated and hand-rodded, category C vs. D, exhibited a highly significant difference. The value was 0.000.**

4. For comparison of steel molds to plastic molds three comparisons were appropriately used.

a) For statistical analysis between ES&G steel and OSHD plastic molds, category A vs E, exhibited a highly significant difference. The value was 0.000.***

b) For statistical analysis between OSHD steel molds and OSHD plastic molds, category B vs E, exhibited a highly significant difference. The value was 0.000.*

c) For statistical analysis between the above two sets of steel molds combined and plastic, category A&B vs E, exhibited a highly significant difference. The value was 0.000*.

*See Illustration#1
**See Illustration #3
***See Illustration #2

For area used in formula on TABLE II by taking the ratio from TABLE II.

CONCLUSIONS

Currently OSHD is using plastic single-use cylinder molds, and it is our intent to use the same single-use molds for all future acceptance testing. These single-use molds have been used at Eugene Sand and Gravel since August, 1985. Prior to that time, reusable steel molds were used.

Vibrating to consolidate samples is covered in AASHTO TEST DESIGNATION; T23-85I, (ASTM DESIGNATION: C31-83). This states that mixes with a slump over three inches shall not be vibrated. Vibrating in this instance was not acceptable, and misrepresented the strengths higher than would have been if rodded to said guidelines. Statistically it was a highly significant value.

In the comparative analysis of ES&G steel molds and OSHD steel molds, there is no significant difference. Both samples followed the guidelines for forming concrete test cylinders as stated in AASHTO TEST DESIGNATION: M205-83I (ASTM DESIGNATION: C470-81). Although unsealed molds do not meet this testing procedure no statistical difference was found between unsealed molds and sealed molds.

In addressing the issue of steel verses plastic molds three comparisons were made. One, ES&G molds verses plastic molds, showed a highly significant difference. The second, OSHD molds verses plastic molds, showed a highly significant difference, therefore the combined showed a highly significant difference. These cylinders were molded within the guidelines set forth in AASHTO (ASTM) as above, and is recognized by The Cement and Concrete Reference Laboratory. OSHD is simply exercising an option of mold type as stated in said guidelines.

COMPRESSIVE STRENGTH OF CYLINDERS

TABLE I

CATEGORY	A	B	C	D	E
TYPE	STEEL	STEEL	STEEL	STEEL	PLASTIC
OWNER	ES&G	OSHD	ES&G	ES&G	OSHD
SEAL	SEALED	SEALED	UNSEALED	UNSEALED	SEALED
CONSOLIDATION	RODDED	RODDED	RODDED	VIBRATED	RODDED
COVER	GLASS	GLASS	BAGGY	BAGGY	PLASTIC
	6170	6850	6075	7015	5605
	6530	6735	6290	7230	5760
	5945	6445	6265	6960	5830
	6460	6600	6260	7190	5900
	6210	6150	6450	6775	5640
	6155	6790	6200	6970	5765
	6210	6630	6195	7145	5810
	6225	6445	6395	6975	5775
	6870	6120	6410	6780	6075
	6820	6675	6225	6965	5725
MEAN	6359.5	6544.0	6276.5	7000.5	5788.5
STD. DEV.	287.08	239.36	108.77	146.16	125.70
STD ERROR	90.78	75.69	34.40	46.22	39.75

STATISTICAL COMPARISON OF CATEGORIES

Molds, Seals, and Consolidation

TABLE II

TYPE	ES&G vs OSHD	SEALED vs UNSEALED	VIBRATED vs RODDED
CATEGORY	A vs B	A vs C	C vs D
MEAN DIFF.	184.5	83.0	724.0
% MEAN DIFF.	2.9 %	1.3 %	11.5 %
STD. ERROR (of mean diff.)	118.19	97.08	57.62
RATIO	1.561	0.855	12.570
(0.5-AREA)2	0.119	0.390	0.000
SIGNIFICANCE	NO	NO	HIGHLY

STATISTICAL COMPARISON OF CATEGORIES

STEEL VS PLASTIC

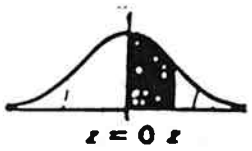
TABLE III

TYPE	ES&G vs PLASTIC	OSHD vs PLASTIC	COMBINED vs PLASTIC
CATEGORY	A vs E	B vs E	A&B vs E
MEAN DIFF.	571.0	755.5	663.3
% MEAN DIFF.	9.9 %	13.1 %	11.5 %
STD. ERROR (of mean diff.)	99.10	85.49	75.53
RATIO	5.762	8.837	8.782
(0.5-AREA)2	0.000	0.000	0.000
SIGNIFICANCE	HIGHLY	HIGHLY	HIGHLY

ILLUSTRATION #1

Table I
Areas Under the Normal Probability Curve

The entries under A denote the area between the line of symmetry (that is, $z = 0$) and the given z-value.



z	A	z	A	z	A	z	A
0.00	0.0000	0.30	0.1179	0.60	0.2258	0.90	0.3159
.01	.0040	.31	.1217	.61	.2291	.91	.3186
.02	.0080	.32	.1255	.62	.2324	.92	.3212
.03	.0120	.33	.1293	.63	.2357	.93	.3238
.04	.0160	.34	.1331	.64	.2389	.94	.3264
.05	.0199	.35	.1368	.65	.2422	.95	.3289
.06	.0239	.36	.1406	.66	.2454	.96	.3315
.07	.0279	.37	.1443	.67	.2486	.97	.3340
.08	.0319	.38	.1480	.68	.2518	.98	.3365
.09	.0359	.39	.1517	.69	.2549	.99	.3389
.10	.0398	.40	.1554	.70	.2580	1.00	.3413
.11	.0438	.41	.1591	.71	.2612	1.01	.3438
.12	.0478	.42	.1628	.72	.2642	1.02	.3461
.13	.0517	.43	.1664	.73	.2673	1.03	.3485
.14	.0557	.44	.1700	.74	.2704	1.04	.3508
.15	.0596	.45	.1736	.75	.2734	1.05	.3531
.16	.0636	.46	.1772	.76	.2764	1.06	.3554
.17	.0675	.47	.1808	.77	.2794	1.07	.3577
.18	.0714	.48	.1844	.78	.2823	1.08	.3599
.19	.0754	.49	.1879	.79	.2852	1.09	.3621
.20	.0793	.50	.1915	.80	.2881	1.10	.3643
.21	.0832	.51	.1950	.81	.2910	1.11	.3665
.22	.0871	.52	.1985	.82	.2939	1.12	.3686
.23	.0910	.53	.2019	.83	.2967	1.13	.3708
.24	.0948	.54	.2054	.84	.2996	1.14	.3729
.25	.0987	.55	.2088	.85	.3023	1.15	.3749
.26	.1026	.56	.2123	.86	.3051	1.16	.3770
.27	.1064	.57	.2157	.87	.3079	1.17	.3790
.28	.1103	.58	.2190	.88	.3106	1.18	.3810
.29	.1141	.59	.2224	.89	.3133	1.19	.3830

ILLUSTRATION #2

Table I. Areas Under the Normal Probability Curve

(continued)

z	A	z	A	z	A	z	A
1.20	0.3849	1.55	0.4394	1.90	0.4713	2.25	0.4878
1.21	.3869	1.56	.4406	1.91	.4719	2.26	.4881
1.22	.3888	1.57	.4418	1.92	.4726	2.27	.4884
1.23	.3907	1.58	.4430	1.93	.4732	2.28	.4887
1.24	.3925	1.59	.4441	1.94	.4738	2.29	.4890
1.25	.3944	1.60	.4462	1.95	.4744	2.30	.4893
1.26	.3962	1.61	.4463	1.96	.4750	2.31	.4896
1.27	.3980	1.62	.4474	1.97	.4756	2.32	.4898
1.28	.3997	1.63	.4485	1.98	.4762	2.33	.4901
1.29	.4015	1.64	.4495	1.99	.4767	2.34	.4904
1.30	.4032	1.65	.4505	2.00	.4773	2.35	.4906
1.31	.4049	1.66	.4515	2.01	.4778	2.36	.4909
1.32	.4066	1.67	.4525	2.02	.4783	2.37	.4911
1.33	.4082	1.68	.4535	2.03	.4788	2.38	.4913
1.34	.4099	1.69	.4545	2.04	.4793	2.39	.4916
1.35	.4115	1.70	.4554	2.05	.4798	2.40	.4918
1.36	.4131	1.71	.4564	2.06	.4803	2.41	.4920
1.37	.4147	1.72	.4573	2.07	.4808	2.42	.4922
1.38	.4162	1.73	.4582	2.08	.4812	2.43	.4925
1.39	.4177	1.74	.4591	2.09	.4817	2.44	.4927
1.40	.4192	1.75	.4599	2.10	.4821	2.45	.4929
1.41	.4207	1.76	.4608	2.11	.4826	2.46	.4931
1.42	.4222	1.77	.4616	2.12	.4830	2.47	.4932
1.43	.4236	1.78	.4625	2.13	.4834	2.48	.4934
1.44	.4251	1.79	.4633	2.14	.4838	2.49	.4936
1.45	.4265	1.80	.4641	2.15	.4842	2.50	.4938
1.46	.4279	1.81	.4649	2.16	.4846	2.51	.4940
1.47	.4292	1.82	.4656	2.17	.4850	2.52	.4941
1.48	.4306	1.83	.4664	2.18	.4854	2.53	.4943
1.49	.4319	1.84	.4671	2.19	.4857	2.54	.4945
1.50	.4332	1.85	.4678	2.20	.4861	2.55	.4946
1.51	.4345	1.86	.4686	2.21	.4865	2.56	.4948
1.52	.4357	1.87	.4693	2.22	.4868	2.57	.4949
1.53	.4370	1.88	.4700	2.23	.4871	2.58	.4951
1.54	.4382	1.89	.4706	2.24	.4875	2.59	.4952

ILLUSTRATION #3

Table I. Areas Under the Normal Probability Curve
(concluded)

z	A	z	A	z	A	z	A
2.60	0.4953	2.85	0.4964	3.30	0.4995	3.65	0.4999
2.61	.4955	2.96	.4965	3.31	.4995	3.66	.4999
2.62	.4956	2.97	.4965	3.32	.4996	3.67	.4999
2.63	.4957	2.98	.4966	3.33	.4996	3.68	.4999
2.64	.4959	2.99	.4966	3.34	.4996	3.69	.4999
2.65	.4960	3.00	.4967	3.35	.4996	3.70	.4999
2.66	.4961	3.01	.4967	3.36	.4996	3.71	.4999
2.67	.4962	3.02	.4967	3.37	.4996	3.72	.4999
2.68	.4963	3.03	.4968	3.38	.4996	3.73	.4999
2.69	.4964	3.04	.4968	3.39	.4997	3.74	.4999
2.70	.4965	3.05	.4969	3.40	.4997	3.75	.4999
2.71	.4966	3.06	.4969	3.41	.4997	3.76	.4999
2.72	.4967	3.07	.4969	3.42	.4997	3.77	.4999
2.73	.4968	3.08	.4990	3.43	.4997	3.78	.4999
2.74	.4969	3.09	.4990	3.44	.4997	3.79	.4999
2.75	.4970	3.10	.4990	3.45	.4997	3.80	.4999
2.76	.4971	3.11	.4991	3.46	.4997	3.81	.4999
2.77	.4972	3.12	.4991	3.47	.4997	3.82	.4999
2.78	.4973	3.13	.4991	3.48	.4998	3.83	.4999
2.79	.4974	3.14	.4992	3.49	.4998	3.84	.4999
2.80	.4974	3.15	.4992	3.50	.4998	3.85	.4999
2.81	.4975	3.16	.4992	3.51	.4998	3.86	.4999
2.82	.4976	3.17	.4992	3.52	.4998	3.87	.5000
2.83	.4977	3.18	.4993	3.53	.4998	3.88	.5000
2.84	.4977	3.19	.4993	3.54	.4998	3.89	.5000
2.85	.4978	3.20	.4993	3.55	.4998		
2.86	.4979	3.21	.4993	3.56	.4998		
2.87	.4980	3.22	.4994	3.57	.4998		
2.88	.4980	3.23	.4994	3.58	.4998		
2.89	.4981	3.24	.4994	3.59	.4998		
2.90	.4981	3.25	.4994	3.60	.4998		
2.91	.4982	3.26	.4994	3.61	.4999		
2.92	.4983	3.27	.4995	3.62	.4999		
2.93	.4983	3.28	.4995	3.63	.4999		
2.94	.4984	3.29	.4995	3.64	.4999		