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Analysis of Standardized Concrete Mixes

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Abstract

Concrete is one of the most common materials used in construction. It is mass produced throughout the country, with numerous different designs for concrete mixes. A common practice among concrete manufacturers is to use a standardized concrete mix design. These standardized mix designs are pre-tested and are not usually altered frequently. The hypothesis of this research project is that manufacturers do not constantly investigate new ways to save on their mixes, and simply use the same standardized mix designs.

In this research, investigations into what alterations may reduce the cost of standardized mixes began with a baseline mix design provided from a specific project, focusing on two main classes of concrete. Only one alteration to the baseline mix was made at a time. The most expensive ingredients going into a concrete mix are the cements and the admixtures. As these are the most expensive, the alterations focused on these two main factors. Multiple reductions in the Portland cement were made, while adding slag cement to maintain the cementitious material. Also, a simple Portland cement reduction was made. With admixtures, the midrange water reducer was cut in half and eliminated entirely. The high range water reducer was only reduced by half.

Due to the inconsistencies throughout the laboratory testing and lack of time to gather extensive data, the results are inconclusive. However, based on the results that were gathered, the most likely ways to reduce costs for a mix while maintaining the required compressive strengths would be to reduce the amount or Portland cement until the maximum water-cement ratio was reached, or to eliminate the use of a midrange water reducer.

Preface

Information shown within this report has redacted information. This is to protect all parties involved that provided the information. Terms such as “General Contractor,” “Project,” and “Subcontractor” are shown to keep the identities of certain parties protected.

Personal Background

Work Experience

I worked a total of three cooperative education rotations with General Contractor. For one of these rotations, I was working on the Project. This was my first co-op working with General Contractor, and I enjoyed every day of this project. One of the most intriguing aspects to me was the use of all concrete on the job, both cast-in-place and pre-cast concrete. It was this work experience that led me to study concrete more. I gained a desire to learn about different functions concrete has on jobsites, the different strengths that need to be met depending on what portion of a project it is being used on, and the implementations of these mixes.

Project Importance

I became interested in the testing processes, as well as the economic standpoint for different mixes. Subcontractors must provide testing and inspection forms when they pour concrete on a jobsite. I want to challenge myself and know if I am personally able to match a concrete compressive strength test (provided by professionals) using tools provided to me by The University of Akron. I also want to identify different alterations of mixes that I can make that still meet certain compressive strength criteria. Is it possible to alter mixes used by concrete manufacturers in a way that can make it more economical to produce and still maintain a required compressive strength? Are certain mixes used that meet a standard strength? If so, are these standard mixes used rather than creating slight alterations that may be cheaper to produce? Have manufacturers already found the perfect compromise for strength and cost? I intend to find answers for all these questions.

Project Purpose

Concrete is widely used throughout construction due to its numerous capabilities. Concrete is durable and strong in compression. It will not rust, rot, or burn. Its lifespan far outlasts many other common building materials. It retains and absorbs heat. It holds water effectively by keeping it out of areas that must remain dry and transporting the water to drainage locations. Concrete's strength is enhanced through combination with other building materials, such as steel. Concrete is relatively cheap to produce in comparison with other building materials. However, concrete may be produced even more economically through altering standardized mix designs.

Owners of projects requiring large quantities of concrete will want to save money by having the most economical mix possible. For a contractor on a jobsite that will use concrete, the most economic mix should be used to maximize profits and maintain contractual spending. For a subcontractor bidding on a job, having a cheaper concrete mix may be the difference in getting the contracted work or not. Manufacturers may produce concrete for lower costs on their end, allowing greater profit and a more competitive market. By testing if concrete mixes can be altered and still meet the required compressive strength, each of these professional groups may benefit.

The conclusions of this research project will provide benefits to project owners, general contractors, subcontractors and manufacturers. The greatest benefits may come to manufacturers and subcontractors. For a manufacturer, small savings on one particular job may seem infinitesimal, but over an extended time period major savings may be realized. These massive savings may come at only slight alterations to their standardized mixes. Subcontractors that use a manufacturer that can produce economical concrete may see profits themselves. Subcontractors may be able to win bids for the same cost of a standard mix design, then be able to profit off the use of a less expensive mix. There would be no downside to this, as the concrete strength would satisfy requirements and all parties involved benefit.

Expected Outcomes

Prior to exploring any provided information from General Contractor, predictions were made on what may happen during the duration of the project. Concrete manufacturers and the installing subcontractors already want to provide their services to make money for their company. Companies may use simpler steps to complete a project, rather than spend extra time investigating alternative methods for cheaper solutions in the long run. In short, companies use standardized mixes that have been pre-tested to meet certain requirements without being job-specific.

After completing testing, the expected outcome is that initial results from the base mixes completed in the lab will be similar values to those provided by Subcontractor. This would provide an accurate reference to lab testing at The University of Akron to the manufactured testing provided by Subcontractor. The hypothesis is that manufacturers use a general mix to attain certain strengths. For example, if a specification called for a mix to reach 4,000 psi at minimum, then subcontractors would provide a mix that well exceeds that value, a mix that has likely been used in the past. This allows the possibility for alterations of a mix to become more economical while meeting the required strength. It is expected that these slight alterations are achievable, and a more economical mix may be produced to meet specified compressive strengths.

Project Goals

It is important for a general contractor to properly understand the information provided to them by subcontractors. This research will attempt to match the given concrete mixes from Subcontractor and recreate them and their compressive strengths in a lab setting. If the strengths do not exactly match, ratios can be calculated to determine what Subcontractor may achieve based on the Akron laboratory mixes. Understanding the processes subcontractors go through to produce a concrete mix will enhance how general contractors review all information provided on concrete. This may provide insight to the clarity of testing reports and quality of submittals.

Once the mixes from the subcontractor and the mixes from the lab setting match or show consistency in results, the mixes can be altered. Alterations should be made for less cost to the manufacturer while still meeting compressive strength requirements. Finding alternatives to the initial mix provides a way to save money for project owners, general contractors, and subcontractors. Every company in the construction industry seeks to complete work for the least amount of cost with the greatest quality possible. Providing this alternative for concrete mixes will allow for cheaper construction and maintain the required quality in the concrete.

Provided Information from General Contractor

Through the assistance of General Contractor, all specifications, submittals, and testing and inspection reports have been obtained. Each of these items holds information regarding the mixes used for all cast-in place concrete on the Project, totaling 13,000 cubic yards.

The specifications, provided by General Contractor and redacted from the Appendix, identify the different classes of cast-in-place concrete required, the functionality of each class, and the minimum strength (psi) that must be met. Minimum cementitious content, maximum water-cement ratio, and certain admixture types are identified for certain classes. The submittals, provided by General Contractor and redacted from the Appendix, identify the class of concrete called out in the specifications, the materials used for each class, the quantity of the materials, compressive strength data, and the manufacturer's information for admixtures. The testing and inspection reports, provided by General Contractor and redacted from the Appendix, identify the class of concrete being tested, the area of the project the concrete is being tested, and the compressive strengths of each specimen. For the purpose and scope of this project, only Class III and Class VII concretes will be examined.

Means and Methods of Research

This project will look into the mix design from Class III and Class VII as outlined in the information provided by General Contractor. The specifications, submittal from Subcontractor, and testing and inspection reports (redacted from the Appendix) provide mix designs for both classes. The maximum water-cement ratio for both classes is 0.45. The slump is designed to initially be between 2-4 inches, with a maximum slump of 8 inches when a superplasticizer is used. A superplasticizer was implemented in both classes. Class III concrete must include an air entrainment admixture, and Class VII concrete must include a water reducer.

With the use of The University of Akron's Civil Engineering Lab, concrete mixes can be tested. A baseline mix must be established for both of the classes of concrete being researched. Once baseline mixes and their strengths are obtained, alterations to the base mixes can be made.

Every mix that was tested was prepared through the use of plastic cylindrical molds. These molds were 4"x8" to match what was used by Subcontractor. Each mix was prepared using enough material to create three concrete cylinders to test. Once all ingredients were collected and added to the concrete mixer, the concrete was mixed for three minutes, rested for three minutes, and was mixed again for a final two minutes. Once mixing was complete, the concrete was placed into the cylinder molds. Each mold was filled by 1/3 of its volume at a time. Each time 1/3 was added, the concrete was rodded 25 times. Once all cylinders were filled, they sat for 24 hours to prepare for curing. After 24 hours, the concrete cylinders were removed from their molds. The concrete cylinders were then placed into the curing room until their strength was tested (a total cure time of either 7 days or 28 days). The concrete cylinders were compressed to their breaking point, with each failure stress and load being recorded.

Concrete Mix Designs

This section outlines the mix design and the proportions for each mix. The compressive strengths are shown in the Results section, which follows this section.

Class III mixes have a specified strength of 4,500 psi at 28 days, with an overdesign strength of 5,700 psi to meet ASTM requirements. The fine and coarse aggregates used are in a saturated surface dry (SSD) condition. The admixtures used for this class of concrete were Midrange Water Reducer and Retarder (identified as Admixture 1), and Air Entrainment (identified as Admixture 2). The data sheet for the Midrange Water Reduces is shown in the Appendix. However, the Air Entrainment data sheet is not provided as the sheet was not able to be obtained. Subcontractor provided a mix as shown in Table 1. This mix is identified as Mix 1. This was the final mix used on the jobsite where Class III concrete was called out.

Table 1: Class III Mix 1, Field Use, per cubic yard

Material	Quantity	Units
Portland Cement	428	lb.
Slag Cement	183	lb.
Fine Aggregate	1339	lb.
#57 Limestone	1629	lb.
Air Entrainment	4 to 7	%
Admixture 1	18.3	fl. oz.
Admixture 2	36.6	fl. oz.
Total Water	270	lb.
Max. Slump	7	in.
Water-Cement Ratio	0.442	

Prior to providing the base mix used in the field, Subcontractor had lab tested three slight alterations. The alterations are modifications of the water-cement ratio, and quantities of the cementitious materials, fine and coarse aggregates, and admixtures. These can each be seen in Tables 2, 3, and 4. These are labeled as Mix 1.a, 1.b, and 1.c respectively. This nomenclature designates they are derived from the base mix, Mix 1.

Table 2: Class III Mix 1.a, Contractor Test Mix, per cubic yard

Material	Quantity	Units
Portland Cement	497	lb.
Slag Cement	213	lb.
Fine Aggregate	1245	lb.
#57 Limestone	1594	lb.
Admixture 1	21.1	fl. oz.
Admixture 2	20	fl. oz.
Air Content	5.5	%
Water	286	lb.
Max. Slump	4.5	in.
Water-Cement Ratio	0.403	

Table 3: Class III Mix 1.b, Contractor Test Mix, per cubic yard

Material	Quantity	Units
Portland Cement	385	lb.
Slag Cement	165	lb.
Fine Aggregate	1375	lb.
#57 Limestone	1625	lb.
Admixture 1	16.7	oz.
Admixture 2	19.4	oz.
Air Content	5.1	%
Water	263	lb.
Max. Slump	4.5	in.
Water-Cement Ratio	0.478	

Table 4: Class III Mix 1.c, Contractor Test Mix, per cubic yard

Material	Quantity	Units
Portland Cement	280	lb.
Slag Cement	120	lb.
Fine Aggregate	1485	lb.
#57 Limestone	1655	lb.
Admixture 1	12.2	oz.
Admixture 2	10	oz.
Air Content	6.5	%
Water	262	lb.
Max. Slump	4.5	inch
Water-Cement Ratio	0.655	

The base mix, Mix 1, that was used on the job, along with the contractor test mixes, were all recreated as closely as possible based upon the material availability in the Civil Lab. The base laboratory mix is denoted as Mix 1.0 and is shown in Table 5. The values shown are required to create one concrete cylinder and one cubic yard.

Table 5: Class III Mix 1.0, Laboratory Field Use Mix, per cylinder and cubic yard

Material	Quantity (cylinder)	Units	Quantity (cubic yard)	Units
Portland Cement	0.922	lb.	428	lb.
Slag Cement	0.394	lb.	183	lb.
Fine Aggregate	2.885	lb.	1339	lb.
#57 Limestone	3.510	lb.	1629	lb.
Admixture 1	0.039	fl. oz.	18	fl. oz.
Admixture 2	0.079	fl. oz.	37	fl. oz.
Water	0.582	lb.	270	lb.
Water-Cement Ratio	0.442		0.442	

Tables 6, 7, and 8 show the recreations of the contractor test mixes. These are identified as Mix 1.0.a, 1.0.b, and 1.0.c respectively. These denote the slight changes from what was created in Mix 1.0. The values shown are required to create one concrete cylinder and one cubic yard.

Table 6: Class III Mix 1.0.a, Laboratory Test Mix Recreated, per cylinder and cubic yard

Material	Quantity (cylinder)	Units	Quantity (cubic yard)	Units
Portland Cement	1.071	lb.	497	lb.
Slag Cement	0.459	lb.	213	lb.
Fine Aggregate	2.683	lb.	1245	lb.
#57 Limestone	3.435	lb.	1594	lb.
Admixture 1	0.045	fl. oz.	21	fl. oz.
Admixture 2	0.043	fl. oz.	20	fl. oz.
Water	0.616	lb.	286	lb.
Water-Cement Ratio	0.403		0.403	

Table 7: Class III Mix 1.0.b, Laboratory Test Mix Recreated, per cylinder and cubic yard

Material	Quantity (cylinder)	Units	Quantity (cubic yard)	Units
Portland Cement	0.830	lb.	385	lb.
Slag Cement	0.356	lb.	165	lb.
Fine Aggregate	2.963	lb.	1375	lb.
#57 Limestone	3.501	lb.	1625	lb.
Admixture 1	0.036	fl. oz.	17	fl. oz.
Admixture 2	0.042	fl. oz.	19	fl. oz.
Water	0.567	lb.	263	lb.
Water-Cement Ratio	0.478		0.478	

Table 8: Class III Mix 1.0.c, Laboratory Test Mix Recreated, per cylinder and cubic yard

Material	Quantity (cylinder)	Units	Quantity (cubic yard)	Units
Portland Cement	0.603	lb.	280	lb.
Slag Cement	0.259	lb.	120	lb.
Fine Aggregate	3.200	lb.	1485	lb.
#57 Limestone	3.566	lb.	1655	lb.
Admixture 1	0.026	fl. oz.	12	fl. oz.
Admixture 2	0.022	fl. oz.	10	fl. oz.
Water	0.565	lb.	262	lb.
Water-Cement Ratio	0.655		0.655	

Once each of these mixes was recreated, alterations in mix design could begin. Each mix alteration was based upon Mix 1.0. The first alteration is designated Mix 1.1, with each suffix identifying the change made. For example, Mix 1.12 will be the second mix design for Mix 1.1.

The first alteration in mix design was a reduction in the amount of Portland cement, to be replaced with an equal weight of slag cement. Portland cement was reduced as it is more expensive to purchase and produce than the slag cement. The Portland cement reductions are shown in Tables 9, 10, and 11. These are denoted as Mix 1.11, 1.12, and 1.13 respectively, and correspond to Portland cement reductions of 5%, 10%, and 20%, respectively. The values shown are required to create one concrete cylinder and one cubic yard.

Table 9: Class III Mix 1.11, 5% Portland Cement Reduction, Maintain Total Cementitious Material, per cylinder and cubic yard

Material	Quantity (cylinder)	Units	Quantity (cubic yard)	Units
Portland Cement	0.876	lb.	407	lb.
Slag Cement	0.440	lb.	204	lb.
Fine Aggregate	2.885	lb.	1339	lb.
#57 Limestone	3.510	lb.	1629	lb.
Admixture 1	0.039	fl. oz.	18	fl. oz.
Admixture 2	0.079	fl. oz.	37	fl. oz.
Water	0.582	lb.	270	lb.
Water-Cement Ratio	0.442		0.442	

Table 10: Class III Mix 1.12, 10% Portland Cement Reduction, Maintain Total Cementitious Material, per cylinder and cubic yard

Material	Quantity (cylinder)	Units	Quantity (cubic yard)	Units
Portland Cement	0.830	lb.	385	lb.
Slag Cement	0.487	lb.	226	lb.
Fine Aggregate	2.885	lb.	1339	lb.
#57 Limestone	3.510	lb.	1629	lb.
Admixture 1	0.039	fl. oz.	18	fl. oz.
Admixture 2	0.079	fl. oz.	37	fl. oz.
Water	0.582	lb.	270	lb.
Water-Cement Ratio	0.442		0.442	

Table 11: Class III Mix 1.13, 20% Portland Cement Reduction, Maintain Total Cementitious Material, per cylinder and cubic yard

Material	Quantity (cylinder)	Units	Quantity (cubic yard)	Units
Portland Cement	0.738	lb.	342	lb.
Slag Cement	0.579	lb.	269	lb.
Fine Aggregate	2.885	lb.	1339	lb.
#57 Limestone	3.510	lb.	1629	lb.
Admixture 1	0.039	fl. oz.	18	fl. oz.
Admixture 2	0.079	fl. oz.	37	fl. oz.
Water	0.582	lb.	270	lb.
Water-Cement Ratio	0.442		0.442	

Extensive testing of the Class III mix was not performed due to the low strength of the concrete, as well as the inconsistencies that were seen in the laboratory test mixes. More thorough testing was performed on the Class VII mix.

Class VII mixes have a specified strength of 6,000 psi at 28 days, with an overdesign strength of 7,300 psi to meet ASTM requirements. Both fine and coarse aggregates used are saturated surface dry (SSD). The admixtures used for this class of concrete were Midrange Water Reducer and Retarder (identified as Admixture 1), and High Range Water Reducer and Superplasticizer (identified as Admixture 3). The Midrange Water Reducer and High Range Water Reducer data sheets are shown in the appendix. Subcontractor provided a mix as shown in Table 12. This mix is identified as Mix 2. This was the final mix used on the jobsite where Class VII concrete was called out.

Table 12: Class VII Mix 2, Field Use, per cubic yard

Material	Quantity	Units
Portland Cement	483	lb.
Slag Cement	207	lb.
Fine Aggregate	1442	lb.
#57 Limestone	1583	lb.
Admixture 3	20.7	fl. oz
Admixture 1	38	fl. oz
Water	289	lb.
Max. Slump	8	in.
Water-Cement Ratio	0.419	

Prior to providing the base mix used in the field, Subcontractor had lab tested three slight alterations. These can each be seen in Tables 13, 14, and 15. These are labeled as Mix 2.a, 2.b, and 2.c, respectively. This nomenclature designates they are derived from the base mix, Mix 2.

Table 13, Class VII Mix 2.a, Contractor Test Mix, per cubic yard

Material	Quantity	Units
Portland Cement	616	lb.
Slag Cement	264	lb.
Fine Aggregate	1310	lb.
#57 Limestone	1530	lb.
Admixture 3	61.7	fl. oz.
Admixture 1	26.7	fl. oz.
Air Content	1.3	%
Water	304	lb.
Slump	8	inch
Water-Cement Ratio	0.346	

Table 14, Class VII Mix 2.b, Contractor Test Mix, per cubic yard

Material	Quantity	Units
Portland Cement	532	lb.
Slag Cement	228	lb.
Fine Aggregate	1391	lb.
#57 Limestone	1559	lb.
Admixture 3	49.2	fl. oz.
Admixture 1	22.5	fl. oz.
Air Content	1.5	%
Water	293	lb.
Slump	8	inch
Water-Cement Ratio	0.385	

Table 15, Class VII Mix 2.c, Contractor Test Mix, per cubic yard

Material	Quantity	Units
Portland Cement	448	lb.
Slag Cement	192	lb.
Fine Aggregate	1474	lb.
#57 Limestone	1596	lb.
Admixture 3	38.3	fl. oz.
Admixture 1	19.2	fl. oz.
Air Content	2	%
Water	285	lb.
Slump	7	inch
Water-Cement Ratio	0.445	

The base mix, Mix 2, that was used on the job, along with the contractor test mixes, were all recreated as closely as possible based upon the availability in the Civil Lab. The base mix is denoted as Mix 2.0 and is shown in Table 16. The values shown are required to create one concrete cylinder and one cubic yard.

Table 16: Class VII Mix 2.0, Laboratory Field Use Mix, per cylinder and cubic yard

Material	Quantity (cylinder)	Units	Quantity (cubic yard)	Units
Portland Cement	1.041	lb.	483	lb.
Slag Cement	0.446	lb.	207	lb.
Fine Aggregate	3.107	lb.	1442	lb.
#57 Limestone	3.411	lb.	1583	lb.
Admixture 3	0.045	fl. oz.	21	fl. oz.
Admixture 1	0.082	fl. oz.	38	fl. oz.
Water	0.623	lb.	289	lb.
Water-Cement Ratio	0.419		0.419	

Tables 17, 18, and 19 show the recreations of the contractor test mixes. These are identified as Mix 2.0.a, 2.0.b, and 2.0.c respectively. These denote the slight changes from what was created in Mix 2.0. The values shown are required to create one concrete cylinder and one cubic yard.

Table 17: Class VII Mix 2.0.a, Laboratory Test Mix Recreated, per cylinder and cubic yard

Material	Quantity (cylinder)	Units	Quantity (cubic yard)	Units
Portland Cement	1.327	lb.	616	lb.
Slag Cement	0.569	lb.	264	lb.
Fine Aggregate	2.823	lb.	1310	lb.
#57 Limestone	3.297	lb.	1530	lb.
Admixture 3	0.133	fl. oz.	62	fl. oz.
Admixture 1	0.058	fl. oz.	27	fl. oz.
Water	0.655	lb.	304	lb.
Water-Cement Ratio	0.345		0.345	

Table 18: Class VII Mix 2.0.b, Laboratory Test Mix Recreated, per cylinder and cubic yard

Material	Quantity (cylinder)	Units	Quantity (cubic yard)	Units
Portland Cement	1.146	lb.	532	lb.
Slag Cement	0.491	lb.	228	lb.
Fine Aggregate	2.997	lb.	1391	lb.
#57 Limestone	3.359	lb.	1559	lb.
Admixture 3	0.106	fl. oz.	49	fl. oz.
Admixture 1	0.048	fl. oz.	23	fl. oz.
Water	0.631	lb.	293	lb.
Water-Cement Ratio	0.386		0.386	

Table 19: Class VII Mix 2.0.c, Laboratory Test Mix Recreated, per cylinder

Material	Quantity (cylinder)	Units	Quantity (cubic yard)	Units
Portland Cement	0.965	lb.	448	lb.
Slag Cement	0.414	lb.	192	lb.
Fine Aggregate	3.176	lb.	1474	lb.
#57 Limestone	3.439	lb.	1596	lb.
Admixture 3	0.083	fl. oz.	38	fl. oz.
Admixture 1	0.041	fl. oz.	19	fl. oz.
Water	0.614	lb.	285	lb.
Water-Cement Ratio	0.445		0.445	

Once each of these mixes was recreated, alterations in mix design could begin. Each mix alteration was based upon Mix 2.0. The first alteration is designated Mix 2.1, with each suffix identifying the change made. For example, Mix 2.12 will be the second mix design for Mix 2.1.

The first alteration in mix design was a reduction in the amount of Portland cement, but added slag cement. The addition to slag cement was to maintain the same amount of cementitious materials in the mix. Portland cement was reduced as it is more expensive to purchase and produce than the slag cement. Each Portland cement reduction can be seen in Tables 20, 21, and 22. These are denoted as Mix 2.11, 2.12, and 2.13 respectively, and indicate

Portland cement reductions of 5%, 10%, and 20%, respectively. The values shown are required to create one concrete cylinder and one cubic yard.

Table 20: Class VII Mix 2.11, 5% Portland Cement Reduction, Maintain Total Cementitious Material, per cylinder and cubic yard

Material	Quantity (cylinder)	Units	Quantity (cubic yard)	Units
Portland Cement	0.989	lb.	459	lb.
Slag Cement	0.498	lb.	231	lb.
Fine Aggregate	3.107	lb.	1442	lb.
#57 Limestone	3.411	lb.	1583	lb.
Admixture 3	0.045	fl. oz.	21	fl. oz.
Admixture 1	0.082	fl. oz.	38	fl. oz.
Water	0.623	lb.	289	lb.
Water-Cement Ratio	0.419		0.419	

Table 21: Class VII Mix 2.12, 10% Portland Cement Reduction, Maintain Total Cementitious Material, per cylinder and cubic yard

Material	Quantity (cylinder)	Units	Quantity (cubic yard)	Units
Portland Cement	0.937	lb.	435	lb.
Slag Cement	0.550	lb.	255	lb.
Fine Aggregate	3.107	lb.	1442	lb.
#57 Limestone	3.411	lb.	1583	lb.
Admixture 3	0.045	fl. oz.	21	fl. oz.
Admixture 1	0.082	fl. oz.	38	fl. oz.
Water	0.623	lb.	289	lb.
Water-Cement Ratio	0.419		0.419	

Table 22: Class VII Mix 2.13, 20% Portland Cement Reduction, Maintain Total Cementitious Material, per cylinder and cubic yard

Material	Quantity (cylinder)	Units	Quantity (cubic yard)	Units
Portland Cement	0.833	lb.	386	lb.
Slag Cement	0.654	lb.	304	lb.
Fine Aggregate	3.107	lb.	1442	lb.
#57 Limestone	3.411	lb.	1583	lb.
Admixture 3	0.045	fl. oz.	21	fl. oz.
Admixture 1	0.082	fl. oz.	38	fl. oz.
Water	0.623	lb.	289	lb.
Water-Cement Ratio	0.419		0.419	

The next proposed mix design reduced only the amount of Portland cement, thereby reducing the total cementitious material content. The maximum allowable water-cement ratio (0.45) was obtained through this reduction. Table 23 shows this change as Mix 2.21.

Table 23: Class VII Mix 2.21, Portland Cement Reduction, Achieve Maximum Allowable Water-Cement Ratio, per cylinder and cubic yard

Material	Quantity (cylinder)	Units	Quantity (cubic yard)	Units
Portland Cement	0.938	lb.	436	lb.
Slag Cement	0.446	lb.	207	lb.
Fine Aggregate	3.107	lb.	1442	lb.
#57 Limestone	3.411	lb.	1583	lb.
Admixture 3	0.045	fl. oz.	21	fl. oz.
Admixture 1	0.082	fl. oz.	38	fl. oz.
Water	0.623	lb.	289	lb.
Water-Cement Ratio	0.450		0.450	

Alterations in the admixture content were investigated next. Tables 24 and 25 show Mix 2.31 and Mix 2.32, reducing the quantity of midrange water reducer by 50% and 100%, respectively. Table 26 shows Mix 2.41, reducing the high range water reducer by 50%.

Table 24: Class VII Mix 2.31, Midrange Water Reducer, 50% Reduction, per cylinder and cubic yard

Material	Quantity (cylinder)	Units	Quantity (cubic yard)	Units
Portland Cement	1.041	lb.	483	lb.
Slag Cement	0.446	lb.	207	lb.
Fine Aggregate	3.107	lb.	1442	lb.
#57 Limestone	3.411	lb.	1583	lb.
Admixture 3	0.045	fl. oz.	21	fl. oz.
Admixture 1	0.041	fl. oz.	19	fl. oz.
Water	0.623	lb.	289	lb.
Water-Cement Ratio	0.419		0.419	

Table 25: Class VII Mix 2.32, Midrange Water Reducer, 100% Reduction, per cylinder and cubic yard

Material	Quantity (cylinder)	Units	Quantity (cubic yard)	Units
Portland Cement	1.041	lb.	483	lb.
Slag Cement	0.446	lb.	207	lb.
Fine Aggregate	3.107	lb.	1442	lb.
#57 Limestone	3.411	lb.	1583	lb.
Admixture 3	0.045	fl. oz.	21	fl. oz.
Admixture 1	0.000	fl. oz.	0	fl. oz.
Water	0.623	lb.	289	lb.
Water-Cement Ratio	0.419		0.419	

Table 26: Class VII Mix 2.41, Midrange Water Reducer, 100% Reduction, per cylinder and cubic yard

Material	Quantity (cylinder)	Units	Quantity (cubic yard)	Units
Portland Cement	1.041	lb.	483	lb.
Slag Cement	0.446	lb.	207	lb.
Fine Aggregate	3.107	lb.	1442	lb.
#57 Limestone	3.411	lb.	1583	lb.
Admixture 3	0.022	fl. oz.	10	fl. oz.
Admixture 1	0.082	fl. oz.	38	fl. oz.
Water	0.623	lb.	289	lb.
Water-Cement Ratio	0.419		0.419	

Laboratory Testing

Results

Mix designs and their proportions are shown in the previous section, Concrete Mix Design. All compressive strengths were gathered in units of pounds per square inch (psi). Once lab tests were completed, their 7-day strengths were gathered. The field tests that were completed gave a ratio of 7-day to 28-day strengths. This field ratio was applied to the 7-day strengths gathered in the lab. This resulted in a theoretical 28-day strength value.

For the Class III mix, the field test ratio was 0.707:1. All 7-day lab strengths use this value to gain a theoretical 28-day strength. Field testing was completed for 7-day and 28-day strengths. The values for the stress (psi) and the load (lb.) are shown in Table 27.

Table 27: Class III Mix 1, Field Test for 7-Day and 28-Day Strengths

Test Age	**7 Day**		**28 Day**	
Test Data	Strength (psi)	Load (lb.)	Strength (psi)	Load (lb.)
	5980	75180	8500	107125
	6350	80055	8530	107450
			8550	107765
			8840	111590
			8820	111350
			9060	114465
Average	6165	77618	8717	109958

Tables 28, 29, and 30 show the contractor test mixes that were created prior to producing the field use mix. These were provided by Subcontractor.

Table 28: Class III Mix 1.a, Contractor Test Mix for 7-Day and 28-Day Strengths in psi

Test Age	7 Day	28 Day
Test Data	4630	6520
	4500	6650
	4610	6330
Average	4580	6500

Table 29: Class III Mix 1.b, Contractor Test Mix 7-Day and 28-Day Strengths in psi

Test Age	7 Day	28 Day
Test Data	3850	5560
	3720	5590
	3640	5640
Average	3737	5597

Table 30: Class III Mix 1.c, Contractor Test Mix 7-Day and 28-Day Strengths in psi

Test Age	7 Day	28 Day
Test Data	1980	3570
	2050	3550
	2050	3540
Average	2027	3553

Table 31 shows the strengths gathered for 7-day and 28-day strengths for the field mix recreation, Mix 1.0. It also shows the theoretical 28-day strength that has the ratio applied to the 7-day lab strength. The actual 28-day strength is shown for comparison to the theoretical.

Table 31: Class III Mix 1.0, 7-Day Actual and 28-Day Theoretical Strengths in psi

Test Age	7 Day Actual	28 Day Theoretical
Test Data	2599	3675
	2951	4172
	2718	3843
Average	2756	3897

Tables 32, 33 and 34 show strengths from the test mix recreations. The 7-day actual and the 28-day theoretical values are provided for comparison to the contractor test mixes.

Table 32: Class III Mix 1.0.a, 7-Day Actual and 28-Day Theoretical Strengths in psi

Test Age	7 Day Actual	28 Day Theoretical
Test Data	4779	6757
	4956	7007
	4828	6826
Average	4854	6864

Table 33: Class III Mix 1.0.b, 7-Day Actual and 28-Day Theoretical Strengths in psi

Test Age	7 Day Actual	28 Day Theoretical
Test Data	2236	3161
	2648	3744
	2292	3241
Average	2392	3382

Table 34: Class III Mix 1.0.c, 7-Day Actual and 28-Day Theoretical Strengths in psi

Test Age	7 Day Actual	28 Day Theoretical
Test Data	670	947
	872	1233
	867	1226
Average	803	1135

Tables 35, 36, and 37 show the alterations in cementitious materials. Portland cement was reduced, and slag cement was added to maintain the same quantity of cementitious materials.

Table 35: Class III Mix 1.11, 7-Day Actual and 28-Day Theoretical Strengths in psi

Test Age	7 Day Actual	28 Day Theoretical
Test Data	2453	3468
	3130	4425
	3106	4392
Average	2896	4095

Table 36: Class III Mix 1.12, 7-Day Actual and 28-Day Theoretical Strengths in psi

Test Age	7 Day Actual	28 Day Theoretical
Test Data	2104	2975
	2054	2904
	1672	2364
Average	1943	2748

Table 37: Class III Mix 1.13, 7-Day Actual and 28-Day Theoretical Strengths in psi

Test Age	7 Day Actual	28 Day Theoretical
Test Data	2967	4195
	2133	3016
	2995	4235
Average	2698	3815

Due to the inconsistencies shown in the Class III mixes, further research into that mix was not completed. A greater focus was placed onto the Class VII mixes.

For the Class VII mix, the field test ratio for 7 days to 28 days was 0.732:1. All 7-day lab strengths obtained use this value to gain a theoretical 28-day strength. Table 38 shows the field testing completed for 7-day and 28-day strengths.

Table 38: Class VII Mix 2, 7 Day and 28 Day Strengths

Test Age	**7 Day**		**28 Day**	
Test Data	Strength (psi)	Load (lbs.)	Strength (psi)	Load (lbs.)
	7580	95280	9490	119530
	5690	71695	10510	132090
	6780	85365	10080	126965
	6890	87010	8660	109145
	6880	86700	8550	107750
	6780	85380	8310	104735
	6810	85535	9900	124700
	6590	82845	9400	118445
	6700	84445	9230	116335
	6590	82755	9480	119100
	7110	89390	9150	115255
	6980	87710	9340	117720
	7080	89030	8960	112535
	7060	89350	9300	116625
	7240	91210	8910	112020
	6570	82605	8840	111120
			9420	118105
			9480	118795
			9510	119250
			10070	126200
			9330	117495
			9480	118865
			9770	122825
			10030	126650
			9220	115870
			8930	112505
			9100	114630
			9000	113440
Average	6833	86019	9338	117454

Tables 39, 40, and 41 show the contractor test mixes that were created prior to producing the field use mix. These were provided by Subcontractor.

Table 39: Class VII Mix 2.a, Contractor Test Mix for 7-Day and 28-Day Strengths in psi

Test Age	7 Day	28 Day
Test Data	8850	10310
	8550	11360
	9110	10520
Average	8837	10730

Table 40: Class VII Mix 2.b, Contractor Test Mix for 7-Day and 28-Day Strengths in psi

Test Age	7 Day	28 Day
Test Data	8170	9540
	8130	10110
	8260	9230
Average	8187	9627

Table 41: Class VII Mix 2.c, Contractor Test Mix for 7-Day and 28-Day Strengths in psi

Test Age	7 Day	28 Day
Test Data	6160	8460
	6110	8010
	6370	7770
Average	6213	8080

Table 42 shows the strengths gathered for 7-day and 28-day strengths for the field mix recreation, Mix 2.0. It also shows the theoretical 28-day strength that has the ratio applied to the 7-day lab strength. The actual 28-day strength is shown for comparison to the theoretical.

Table 42: Class VII Mix 2.0, 7-Day Actual, 28-Day Actual, and 28-Day Thepretical Strengths in psi

Test Age	7 Day Actual	28 Day Actual	28 Day Theoretical
Test Data	5515	8066	7536
	5195	8049	7099
	5320	8477	7270
Average	5343	8197	7302

To test for inaccuracies that may have been made early on, Mix 2.0 was recreated. This was done at a later phase in the testing, once the mixing process had improved. The 7-Day actual and 28-day theoretical strengths are shown in Table 43.

Table 43: Class VII Mix 2.0 Retested, 7-Day Actual and 28-Day Theoretical Strengths in psi

Test Age	7 Day Actual	28 Day Theoretical
Test Data	6076	8303
	5751	7859
	6310	8623
Average	6046	8261

Tables 44, 45 and 46 show strengths from the test mix recreations. The 7-day actual and the 28-day theoretical values are provided for comparison to the contractor test mixes.

Table 44: Class VII Mix 2.0.a, 7-Day Actual and 28-Day Theoretical Strengths in psi

Test Age	7 Day Actual	28 Day Theoretical
Test Data	6888	9412
	7475	10215
	7578	10355
Average	7314	9994

Table 45: Class VII Mix 2.0.b, 7-Day Actual and 28-Day Theoretical Strengths in psi

Test Age	7 Day Actual	28 Day Theoretical
Test Data	6727	9192
	6455	8821
	6511	8897
Average	6564	8970

Table 46: Class VII Mix 2.0.c, 7-Day Actual and 28-Day Theoretical Strengths in psi

Test Age	7 Day Actual	28 Day Theoretical
Test Data	5785	7905
	5653	7725
	5401	7380
Average	5613	7670

Tables 47, 48, and 49 show the alterations in cementitious materials. Portland cement was reduced, and slag cement was added to maintain the same quantity of cementitious materials.

Table 47: Class VII Mix 2.11, 7-Day Actual and 28-Day Theoretical Strengths in psi

Test Age	7 Day Actual	28 Day Theoretical
Test Data	7388	10096
	7407	10122
	7554	10323
Average	7450	10180

Table 48: Class VII Mix 2.12, 7-Day Actual and 28-Day Theoretical Strengths in psi

Test Age	7 Day Actual	28 Day Theoretical
Test Data	6904	9434
	7263	9925
	6772	9254
Average	6980	9538

Table 49: Class VII Mix 2.13, 7-Day Actual and 28-Day Theoretical Strengths in psi

Test Age	7 Day Actual	28 Day Theoretical
Test Data	7593	10376
	7547	10313
	7476	10216
Average	7539	10302

Table 50 shows a reduction in Portland cement until the maximum allowable water-cement ratio is reached. The 7-Day actual and 28-Day theoretical values are shown.

Table 50: Class VII Mix 2.21, 7-Day Actual and 28-Day Theoretical Strengths in psi

Test Age	7 Day Actual	28 Day Theoretical
Test Data	7240	9893
	7322	10006
	7081	9676
Average	7214	9858

Tables 51 and 52 show the reductions in the midrange water reducing admixture, a 50% and 100% reduction, respectively. The 7-Day actual and 28-Day theoretical values are shown.

Table 51: Class VII Mix 2.31, 7-Day Actual and 28-Day Theoretical Strengths in psi

Test Age	7 Day Actual	28 Day Theoretical
Test Data	6212	8489
	6386	8727
	6212	8489
Average	6270	8568

Table 52: Class VII Mix 2.32, 7-Day Actual and 28-Day Theoretical Strengths in psi

Test Age	7 Day Actual	28 Day Theoretical
Test Data	6310	8623
	6374	8710
	6186	8453
Average	6290	8595

Table 53 shows the 50% reduction in the high range water reducing admixture. The 7-Day actual and 28-Day theoretical values are shown.

Table 53: Class VII Mix 2.41, 7-Day Actual and 28-Day Theoretical Strengths in psi

Test Age	7 Day Actual	28 Day Theoretical
Test Data	5767	7881
	4177	5708
	6317	8632
Average	5420	7407

Comparison to Expected Outcomes

There was significant variability throughout this entire mix testing process. The slag cement used during the lab process was 15 years old, possibly causing more inconsistencies than a newer batch would. The admixtures used in the lab and in the field were not the same. These were produced by different manufacturers; however, they satisfied the exact same ASTM standards for their designed purpose. The precision of the scale used in the lab was to the nearest tenth of a pound. The accuracy of this scale was not known, which may have skewed results. The materials used (such as the fine and coarse aggregates) may have been inconsistent in their sizes and properties (particularly moisture content). The concrete mixer used may not have always created a truly homogeneous mix. There may have been human error in making the mixes due to a lack of experience in mixing concrete, even though the entire mixing process was improved as lab testing continued.

The Class III mix design proved to be difficult due to its naturally low-strength properties. The addition of air-entrainment mixed into the already low required strength allowed for more inconsistencies to occur in the lab. Extensive testing could not effectively be completed due to the mixed results.

The Class VII mix design was more feasible to test with its more consistent results yielded per cylinder. A higher compressive strength allowed for more room with slight errors to occur and still yield valuable results. However, some results did not match what should have occurred. For example, Mix 2.21 should not have had more strength than any of the mixes from the Mix 2.1 class, as there was less cementitious material in Mix 2.21. Mix 2.32 should have been weaker than Mix 2.31, not the same strength, due to the further reduction of cement.

To gather truly consistent results, further testing would need to be completed. If this research was to be attempted again, there would be further data gathered on the baseline mixes (Mix 1.0 and Mix 2.0). Also, each time a proposed mix design was made, the baseline mix would be made as well. For example, to create Mix 2.21, Mix 2.0 and Mix 2.21 would be created on the same day. This would reduce the amount of potential inconsistencies to occur. Also, a scale with a smaller margin for error would be used. This would ensure there would be no mis-proportioned material quantities.

Impact on the Industry

Although the results gathered are not conclusive, some broad conclusions may still be drawn to enhance standardized mix designs. Two major alterations were investigated: the changes in cementitious material and changes in admixture quantities. Although results may be inconclusive, general cost savings may still be analyzed. Suggestions to change the base mix are only for one variable at a time – altering two different variables at once was not investigated in this study.

Cementitious materials may be altered effectively under the assumption that any change proposed within this report will still meet compressive strength requirements. When reducing Portland cement but increasing slag cement to maintain the same amount of cementitious materials, there was no significant change in strength. By simply reducing the Portland cement to achieve a maximum water-cement ratio, the compressive strength was comparable to maintaining the same cementitious material. Class III and Class VII mixes both showed the weakest strength when a 10% change in cementitious materials was used. For Class VII, the Portland cement reduction still yielded a similar strength to the 10% replacement. Based on these results, the Portland cement reduction is the recommended change to the base mix. Under the assumption that Type 1 Portland Cement costs $110 per ton ($0.06 per pound), a total of $2.61 per cubic yard would be saved from the base mix. If this change was introduced for the entire Project, a total of $33,942.38 would have been saved over all 13,000 cubic yards used. If this proposed changed was used only for the Class VII concrete mix (roughly 1/6 of the total concrete used), a total of $5,657.06 would have been saved. For the reference of a concrete manufacturer, they would save $261,095.24 for every 100,000 cubic yards of concrete produced.

Admixtures added to mixes may be altered effectively under the assumption that any change proposed within this report will still meet compressive strength requirements. The two admixtures that were altered were the midrange and high range water reducers. When altering the amount of midrange water reducer, both reducing the amount by 50% and 100% resulted in a negligible change in strength. This result shows that if midrange water reducer was to be altered, simply removing it altogether would produce the same strength as having half the amount. When altering the high range water reducer, the strengths had a high variance. The severe differences in strength lead to not recommending changing the high range water reducer. Complete removal of the midrange water reducer and using only the high range water reducer is the suggested change to the base mix. Under the assumption that a midrange water reducer costs $5.25 per gallon, a total of $1.56 per cubic yard would be saved. If this change was introduced for the entire Project, a total of $20,261.72 would have been saved over all 13,000 cubic yards used. If this proposed changed was used only for the Class VII concrete mix (roughly 1/6 of the total concrete used), a total of $3,376.95 would have been saved. For the reference of a concrete manufacturer, they would save $155,859.38 for every 100,000 cubic yards of concrete produced.

Personal Gains from Project Completion

The main takeaway from this research project was the best means to complete it effectively. The way it was completed was adequate, but the methods could have been more precise. Due to both time and material constraints for this project, this was not feasible. The research project only lasted one semester, and it was not possible to begin early due to multiple outside factors.

For best and more conclusive results, these experiments should be completed again. The baseline tests should be more thoroughly tested. Three different test mixes of three concrete cylinders each should be made to create each type of baseline mix. For each change in mix design, the baseline mix should also be recreated to ensure consistent results. Then, each change in design should also have three sets of three cylinders created. This level of extensive testing would ensure more accuracy with results, while also providing multiple test results for comparisons to show any outliers.

When working on a job, standardized mix designs may be provided. A greater understanding has now been established about what it entails to produce these mixes. However, it is also known that many times the mixes required for a job may be produced for cheaper than what is being proposed. The vast overdesign does not need to be prevalent in every job.

Appendix

The Project Specifications, Submittals, and Testing and Inspection forms have been redacted from this version of the report.

Shown below are the Midrange Water Reducer and High Range Water Reducer admixture data sheets. The Air Entrainment admixture is not shown as the data sheet was unable to be obtained.

PLASTOL 6400

HIGH RANGE WATER REDUCER - SUPERPLASTICIZER

EUCLID CHEMICAL

DESCRIPTION

PLASTOL 6400 is a polycarboxylate based high range water-reducing admixture which enables concrete to be produced with very low water to cement ratios. Plastol 6400 produces flowable and self-consolidating concrete at low doses and can obtain up to 45% water reduction. Plastol 6400 does not contain added chlorides and will not promote corrosion in steel. Plastol 6400 is compatible with air-entraining agents, microsilica, accelerators and many other admixtures; however, each material should be added to the concrete separately.

PRIMARY APPLICATIONS

- High performance concrete
- Negative slump concrete
- Heavily reinforced concrete
- Flatwork and mass concrete
- High early strength concrete
- Precast/prestressed concrete
- High slump, flowable concrete

FEATURES/BENEFITS

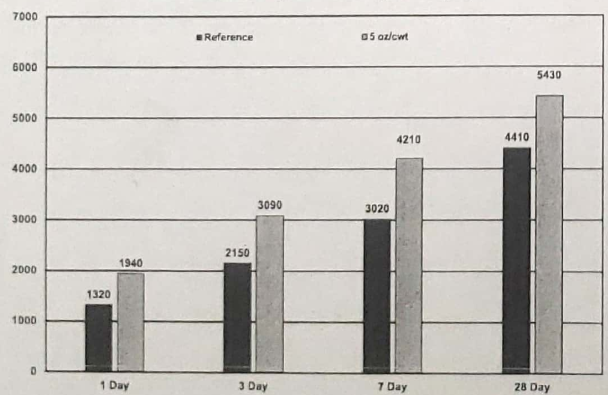
- Produces low water content and low water/cement ratio concrete allowing higher strengths
- Produces flowing concrete with quicker stripping strengths
- Aids in concrete placement and reduces labor cost
- When used in precast work with Type I and Type III cements, Plastol 6400 will produce very high early strengths
- Improved air stability characteristics

TECHNICAL INFORMATION

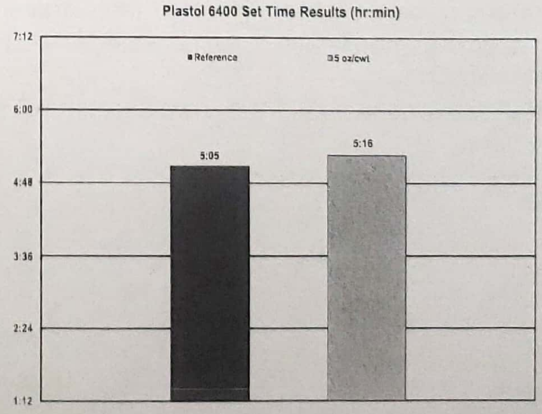
Performance Data:

The following test results were achieved using typical ASTM C 494 mix design requirements, 517 lb/yd^3 (307 kg/m^3) cement content and similar (± 0.5)% air content. These results were obtained under laboratory conditions with materials and mix designs meeting the specifications of ASTM C 494. Changes in materials and mix designs can affect the dosage response of PLASTOL 6400.

Plastol 6400 Compressive Strength Data (psi)



Plastol 6400 Set Time Results (hr:min)



19215 Redwood Road • Cleveland, OH 44110
800-321-7628 t • 216-531-9596 f

PACKAGING

Plastol 6400 is packaged in bulk, 275 gal (1041 L) totes, 55 gal (208 L) drums and 5 gal (18.9 L) pails.

SHELF LIFE

6 months in original, unopened container.

SPECIFICATIONS/COMPLIANCES

- Fully complies with the requirements of ASTM C 494, Types A & F admixtures.
- Complies with the requirements of AASHTO M 194.
- ANSI/NSF STD 61 registered

DIRECTIONS FOR USE

PLASTOL 6400 can be added to the initial batch water or directly on the freshly batched concrete and mixed for approximately 5 minutes or 70 revolutions. However, better results have been observed batching directly on the freshly batched concrete. It should not come into contact with dry cement or other admixtures until mixed thoroughly with the concrete batch.

PLASTOL 6400 is typically used at dosages of 3 to 12 oz per 100 lbs (200 to 780 mL per 100 kg) of cementitious material. Other dosages are acceptable with prior testing and confirmation of the desired performance with specific materials being used.

For any concrete application including Self-Consolidating Concrete (SCC), the dosage of PLASTOL 6400 will vary depending on the mix design, local materials, and individual needs of the concrete producer. Trial mixes should be run to verify plastic and hardened performance with local materials. If the material gradations are not optimum for SCC, a viscosity modifier may be used to improve the quality of the mix. Please consult a local Euclid Chemical Sales Professional for trial mixtures and dosage recommendations.

PLASTOL 6400 is compatible with most admixtures including air-entraining agents, accelerators, most water-reducers, retarders, shrinkage reducers, corrosion inhibitors, viscosity modifiers, and microsilica; however, each material should be added to the concrete separately.

PRECAUTIONS / LIMITATIONS

- Care should be taken to maintain Plastol 6400 above freezing; however, freezing and subsequent thawing will not harm the material if thoroughly agitated. Never agitate with air or an air lance.
- Keep concrete from freezing until a minimum strength of 1000 psi (7 MPa) is reached.
- If re-dosing Plastol 6400 at the jobsite, it is recommended that the air content is checked to conform to job specifications.
- In all cases, consult the Safety Data Sheet before use.

Rev. 11.14

EUCON SE

Water Reducing, Set Retarding Admixture

EUCLID CHEMICAL

Description

EUCON SE is a synthetically produced liquid water-reducing and set retarding admixture. EUCON SE does not contain calcium chloride or other potential corroding materials, and may be used in the presence of aluminum or zinc metals.

It is compatible with air-entraining agents, water reducers and calcium chloride, but they must be added separately to the mix.

Primary Applications

- Flatwork Concrete
- Concrete requiring water reduction and set time control
- Architectural concrete
- Hot weather concrete placement

Features/Benefits

Plastic Concrete

- Improves finishability
- Improves workability
- Reduces water requirements
- Reduces segregation

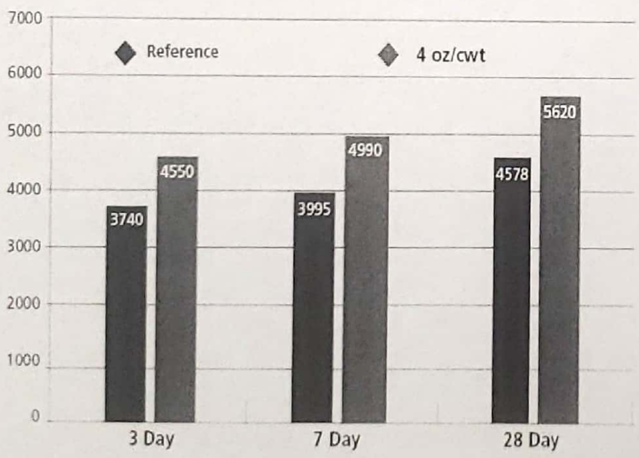
Hardened Concrete

- Increases strengths
- Improves finished appearance
- Reduces cracking
- Reduces permeability
- Non staining

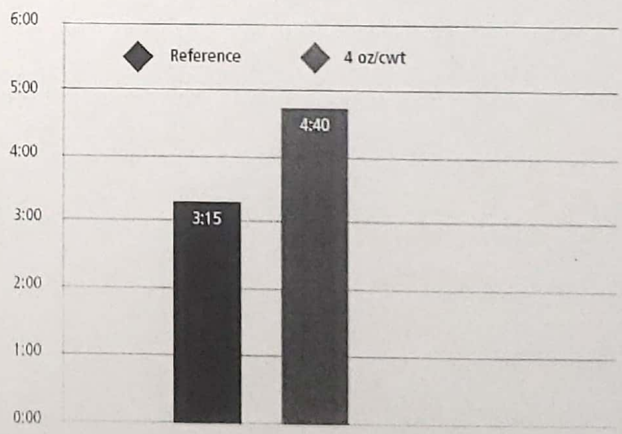
Technical Information

The following test results were achieved using typical mix design requirements of 500 lb/yd3 (297 kg/m3) cement content and similar (± 0.5)% air content. These results were obtained under laboratory conditions with materials meeting ASTM C 494. Changes in materials and mix designs can affect the dosage response of EUCON SE.

EUCON SE Compressive Strength Data (psi)



EUCON SE Set Time Results (hr:min)



WATER REDUCERS

EUCON SE

03 30 00 03 40 00
03 70 00

Packaging

EUCON SE is packaged in bulk, 275 gal (1041 L) totes, 55 gal (208 L) drums and 5 gal (18.9 L) pails.

Shelf Life

1 year in original, unopened container.

Specifications/Compliances

- Fully complies with ASTM C494 Type A and D
- Fully complies with AASHTO M194

Directions for Use

EUCON SE is normally used at dosages of 2 to 5 oz per 100 lb (130 to 330 ml per 100 kg) of cementitious material, depending on the application. Higher dosages are acceptable with prior testing and confirmation of the desired performance with specific materials being used.

EUCON SE should be added to the initial batch water of the concrete mixture. Do not dispense onto dry cement.

Precautions/Limitations

- Care should be taken to maintain EUCON SE above freezing; however, freezing and subsequent thawing will not harm the material if thoroughly agitated.
- Add to mix independent of other admixtures.
- In all cases, consult the Safety Data Sheet before sue.

Rev. 01.18