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IN

CIVIL ENGINEERING

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VERY EARLY STRENGTH LATEX-MODIFIED CONCRETE USED FOR BRIDGE DECK REPAIRS

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EXECUTIVE SUMMARY

This research investigated the performance of Very Early Strength Latex-Modified Concrete (VESLMC), which was used as concrete repair material on H-1 Airport Viaduct. In the field cracking and spalling/delamination occurred in some locations. This paper reports on the mix design performance is affected by different conditions which can occur during placement operations during a repair.

The first task was to determine how to best replicate the volumetric mixing process in the laboratory using a drum mixer. 30 seconds of mixing was determined to be the optimum mixing time for dispersing glass fiber without causing excessive damage to the fibers. It was found that VESLMC can be produced using a drum mixer instead of a volumetric mixer was possible. However, it took several mixing and consolidation methodologies to obtain a sufficient result. Mixing time was reduced from 8 minutes in ASTM C39 to less than 3 minutes and admixture and fiber addition needed to be controlled for time and mixing duration. The final process developed enabled more time for consolidation and produced better quality VESLMC for the laboratory experiments to test the robustness of the VESLMC mix design.

VESLMC properties, especially compressive strength, were affected by the condition of the Rapid Set cement, the cement itself degraded rather quickly even in the lab conditions –partial hydration evidenced by clumping of the cement occurred in ambient laboratory conditions. Moreover, the splitting tensile and compressive strength response to moisture content, indicates the mix design reached its optimum water/cement ratio.

Latex substitution by water had a minor effect on compressive strength, while reducing its splitting tensile strength significantly. Early modulus of elasticity had highest values of all mixes. Adjustment related to w/c ratio could also alter compressive strength results of VESLMC. Rapid set cement condition, which degraded quickly in lab condition, also lowers the compressive strength of VESLMC products.

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Abbreviation:

VESLMC: Very Early Strength Latex Modified Concrete

SSD: Saturated-surface-dry

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Chapter 1. Background

Recently, the Hawaii Department of Transportation (HDOT) has spent a lot of resources repairing reinforced concrete bridge decks with extensive cracking and delamination. Many of these decks were built in the 1970s and in use for 40 years. The HDOT has used a high early strength concrete for deck repairs to minimize lane closure duration. In most locations, partial depth of the repair deck is specified. In some locations, the full depth of the deck is repaired. Regardless, within a few years after the repairs, cracks reappear.

Evaluation, repair, and rehabilitation of existing reinforced concrete structures can be complex due to many potential sources of degradation. It is important to understand the underlying sources of degradation before an appropriate solution can be found. Symptoms of bridge deck degradation often include extensive cracking and delamination. While cracking on the surface can be visually quantified, it is the delamination beneath the surface that is difficult to quantify and is the source of significant cost uncertainty and overruns.

The proposed project intends to identify the sources of degradation and test new non-destructive methods for quantifying the extent and growth of delamination.

Sources of Degradation

Degradation during normal use is the physical manifestation of a flawed design. Reinforced concrete bridges are susceptible to many degradation mechanisms. The age of these structures and their exposure to atmospheric chloride, present in Hawaii, might lead an engineer to initially assume corrosion as the source of degradation. However, during recent repairs it was discovered that corrosion is not the primary mechanism initiating the deck cracking and delamination. Mechanisms related to the concrete mix design (original and repair), the structural element design, as well as the loading criteria used for design may each significantly contribute to reductions in reliability of these deck structures.

Concrete Mix Design.

It has been the experience of many DOTs that deck cracking and delamination has become more problematic now than in the past—concrete in older structures seem to have performed better than new concrete. This is despite the fact that current knowledge allows concrete mixtures to be designed with a variety of new admixtures designed for specific performance requirements. Some experts think that premature degradation of newer concrete desks is related to: changes over time in cement and cementitious materials; use of higher slump concretes; concrete mix settlement; and inadequate curing (NHI 2007). Effective curing practices can reduce shrinkage related cracking. Recent advances in internal curing have been developed and used with mixed reviews as to its benefits for reducing cracking in bridge deck applications (NHI 2007). The New York State DOT developed a high-performance concrete (HPC) specification specifically to mitigate cracking and delamination of concrete decks. An investigation of bridge decks built with the HPC reports that half of 84 decks inspected exhibited no cracking (NHI 2007). However, the data in the report shows that 57 of the 84 were observed within two years of construction so it is likely that the shrinkage cracking process was not complete for those 57 bridges. The report states that up to 80 percent of the decks that did have transverse cracking had an average crack density comparable to decks cast without using the high-performance concrete (Owens and Alampalli 1999). A review of concrete mixes and placement techniques used by HDOT contractors and how deck repairs have performed may provide information about the remaining causes of degradation.

Chapter 2. Research Need Statement

Recently, concrete deck repair projects on the H1 freeway have incurred significant taxpayer costs. Identifying the scope of repair projects have been problematic. Scope has grown in the period of time between RFP development and contract award—leading to significant changes in cost and duration of repairs. In addition, a major concern to the HDOT is that within a few years after being repaired, deck cracking and delamination reappear.

Much of the viaduct is constructed with precast prestressed concrete T-beams with cast-in-place (CIP) composite concrete topping; there are also areas with precast prestressed concrete I-girders with CIP composite slabs, and concrete box girders. The underlying cause of deck deterioration for these typical systems is complex. This research is needed to help understand the underlying causes of cracking and delamination and to determine the most suitable method for accurately quantifying delamination.

Chapter 3. Objectives

The objective of the research documented in this report is to document the early age performance of concrete repair material and investigate potential problems associated with the mix design and placement techniques. A case study of the Very Early Strength Latex Modified Concrete (VESLMC) mix design used for recent repairs at the Airport Viaduct of the H1 Freeway in Honolulu, Hawaii. The study will investigate the robustness of the mix design used as well as provide early age mechanical properties to support the primary objectives: to determine the cause of early age cracking or delamination in this system, and to improve repair practices and specifications.

Chapter 4. Approach

The VESLMC is produced using a volumetric mixer in the field. At the UH Structures and Construction Materials testing lab, drum mixers are used to produce test batches of concrete. The approach outlined in this chapter describes several challenges that were overcome to ensure we could produce a similar product. The challenges included: preventing glass fiber damage caused by excessive mixing times; air entrapment or foaming of admixtures during excessive mixing times which resulted in low densities; and moisture content control of aggregates which influenced strength.

4.1. Preventing Glass Fiber During Mixing

When using any type of fibers in concrete, if the mixing time is short, the fibers would not be distributed throughout the batch. In the case of glass fibers, overmixing can cause damage. The damage is likely due to rotary action of the mixer causing friction between and impact with aggregates. Knowing the optimum mixing time required after the addition of glass fibers to the VESLMC using a drum mixer was essential if the other concrete properties were to be determined accurately. The type of glass fibers used in the repair mix is specifically designed for dispensing into a volumetric mixer where the mixing time is very short which limits the time for damage to occur. Washing out freshly-mixed concrete to collect fibers for each sample was the most feasible method. This method helped not only approximately measure fibers content but also visually evaluate the fibers after mixing. There was no known certified method for such assessment. Therefore, this chapter describes in detail steps taken in the laboratory, and reports results that were used to decide on the fiber mixing time used for the remainder of the investigation.

Figure 4-1 Slurry Fil Glass Fiber used in the investigation.

Fibers rolls (bobbins) are chopped by a cutting wheel dispenser into a volumetric mixer. In this lab, fibers were pre-chopped by VM fibers feeder into the 1-1/2” specified length. The glass fiber product used is known as Slurry FIL produced by Owens Corning. The company advertised that adding these fibers helps control plastic shrinkage and improve long-term durability. (Owens Corning, 2015). They produce two types of glass fibers; one is used with volumetric mixers the other is used with drum mixers. The primary difference is that the fibers used for volumetric mixers have different material properties which make them less susceptible to breaking during dispensing.

The following sections describe related standard test methods as well as the concrete mixing, paste removal, and fiber collection procedure development used during this investigation.

4.1.1. Standard Test Method the Wash-Out Test (ASTM C1229-15)

ASTM C1229-15 Standard Test Method for Determination of Glass Fiber Content in Glass Fiber Reinforced Concrete (GFRC) (Wash-Out Test) can be performed to obtain fibers from freshly mix concrete. However, the precision of the test was not known at the time of this research—the current ASTM indicates that the precision is not known and is being determined. Also, the ASTM is applicable to shotcrete which does not utilize coarse aggregate. Two procedures were investigated based on this method to filter fibers out of concrete which uses a 3/8 inch max aggregate size. To investigate the fiber collection procedure and prevent rapid setting associated with VESLMC, Type I/II Portland cement was used in the same volumetric proportion as the Rapid Set cement specified in the subject VESLMC mix under investigation. Rapid Set cement sets (hardens) in 20 minutes, fibers can only be recovered during concretes fluid state. The following sections describe the concrete mixing, paste removal, as well as two fiber collection procedures used.

4.1.2. Concrete Mixing Procedure

Items needed: Concrete mixer (STOW CM9), scale, stopwatch, empty sample buckets, and mix constituents.

Figure 4-2 Stow CM9 mixer

- Measure tare weight of each sample bucket (W_b).
- Obtain constituents in accordance with the mix design and adjusted for moisture content of the aggregate.
- Add water (including admixtures in each individual bucket), coarse and fine aggregates and mix using the concrete mixer.
- With the mixer running, add cement, then latex.
- Let the mixer run for 3 minutes.
- Stop the mixer and allow the mix to rest for 3 minutes.
- Turn on the mixer for 2 minutes.

- Add fibers and run the mixer for 15 seconds. Obtain samples of fresh concrete and place into sample buckets (15 second fiber mixing samples).
- Run mixer run for an additional 15 seconds. Obtain samples of fresh concrete and place into sample buckets (30 second fiber mixing samples).
- Run mixer run for an additional 15 seconds. Obtain samples of fresh concrete and place into sample buckets (45 second fiber mixing samples).
- Weigh each bucket containing a sample (W_{b+c}).
- Determine weight of concrete sample (W_C) with the equation below:

$$W_C = W_{b+c} - W_b \qquad \text{(Eq 4.1)}$$

Note: Immediately after finding the mass of the sample, add extra water to the container with the sample to dilute the cement paste and prevent hydration product from binding with fibers. This is especially important if mixing occurs at elevated outdoor temperatures which will accelerate setting of the cement.

4.1.3. Paste Removal Procedure

Items needed: (2)-5 gallon buckets; a 12” diameter No.4 sieve and No. 16 sieve; and a water hose.

Figure 4-3 Paste removal items

- Place the Nos. 4 and 16 sieves on bucket A. Note: the sieve diameter is slightly larger than the bucket diameter and creates a tight fit.
- Pour approximately half of the sample on the middle of the No. 4 sieve.
- Spray water to rinse the cement, sand and fibers from the aggregate through the No. 4 sieve. The fibers will tend to collect on the No. 16 sieve. Rinse until the water runs clear.
- Inspect material retained on the No. 4 sieve to ensure all fibers have been rinse into the No. 16 sieve. Discard coarse aggregate retained on the No. 4 sieve.

- Empty the material retained on the number 16 sieve into bucket B. Rinse all fibers and retained material into bucket B by tilting the sieve over the opening of bucket B with the hose aimed into the bucket.
- Inspect the sieve to ensure all fibers have been transferred into bucket B.
- Place the sieves back onto bucket A and repeat with the remaining concrete sample.
- Check the contents of bucket A to observe if any fibers passed through the No. 16 sieve during rinsing. Using rinsing as necessary to retrieve fibers from bucket A and place them into bucket B.
- Cover and store Bucket B, which contains relatively clear rinse water, fibers, and aggregate until all samples are collected.
- Repeat with all remaining samples before proceeding to the Fiber Collection Procedure.

4.1.4. Fiber Collection Procedure

Here two methods for fiber collection are described; Trial Method A and Trial Method B. A discussion of the results and how these procedures were incorporated into the VESLMC investigation are described at the end of this section.

Trial Method A

Items needed: 2'x2' fabric (cotton cloth), No. 4 sieve, and a motor driven rotary drum mixer equipped with a hose attachment for adding water directly to the bottom of the drum.

- Weigh a fabric filter (W_f), place it on the No. 4 sieve. The sieve acts as a support frame.
- Add sample into the drum mixer. The axis of the drum is tilted at an angle of approximately 60 degrees from vertical. The drum mixer is fitted with a hose attachment which allows addition of water directly at the bottom of the drum. The inside surface of the drum should be smooth to prevent adhering of fibers to the side walls.
- While continuously adding water using the hose attachment, rotate the drum to agitate the mixture slowly such that the water separates the fibers from the aggregate. The drum rotation can be either by hand or by using the motor.

Figure 4-4 Epoxy-coated drum for fibers collection

Figure 4-5 Rotatory engine

- Allow the water containing fibers, fines, and latex to overflow from the drum and to collect in a bucket. Once the bucket is full pour the contents through a No. 4 sieve containing a fabric filter. Repeat in 3 buckets to remove as many fibers as possible.
- Once all the fibers have been collected, fold the fabric filter to prevent fiber loss. Dry the fabric in an oven at 105^0C for over a day. TO PREVENT A FIRE, DO NOT LEAVE THE FABRIC IN THE OVEN OVERNIGHT OR UNATTENDED FOR AN EXTENDED PERIOD.
- Measure the dry weight of the fabric filter with retained fibers and other material (W_2).

Total fiber content by percent weight ρ_{1F} is determined:

$$\rho_{1F} = \frac{\mathrm{W_2} - \mathrm{W_f}}{\mathrm{W_c}} \qquad \text{(Eq 4.2)}$$

Where $\mathrm{W_c}$ is the weight of the freshly-mixed concrete sample (lbs) obtained during the previously described concrete mixing procedure.

The apparent fiber dosage is obtained by multiplying the total fiber content by the total batch weight of concrete per cubic yard.

Trial Method B

Items needed: (1) No.16 sieve, (1) No. 50 sieve, (1) pan, buckets of samples, cheese cloth, oven, hand scraper, scale, scoop.

- Place No.16 sieve on top of No.50 sieve.
- Stir then pour the liquid part through those sieves.
- Pour sample of aggregates and fibers onto the pan. Note: If hardened concrete binds fibers to the bottom of bucket, use scraper to scrape it off. Hand scraping might further damage fibers.
- Mechanically separate each sample into 3 or 4 equivalent portions. Note that each portion should not cover more than 1 inch in depth when spreading out at the bottom of buckets.
- Bring one portion back to the bucket, rinse water around the side of bucket until it is half-full. Gently stir water with hand and agitate aggregates. As water flow slowly reduces, pour it out through the set of sieves. Repeat this process 4 or 5 times for each portion until most of the visible intact fibers end up on the sieves. When each portion of the concrete sample is free from fibers, dispose of the aggregate in the designated aggregate recycling area. Note: Always check hands, palms, side and opening of buckets. It is recommended to visually identify, and hand pick any remaining glass fibers from the sample bucket by the fifth cycle of sieving for each sample.
- Collect fibers into bucket by tilting the sieve over the opening of bucket with the hose aimed into the bucket.
- Stir water inside bucket to facilitate segregation of the aggregate fines from the fibers. As fibers are transported with the water motion, rapidly pour the water onto cheese cloths placed on top of sieve No.16 (sieve number is not important as its purpose was structural support of the cheese cloth). Repeat it twice, hand pick any remaining glass fibers from the sample bucket as needed. Note: Check if fibers stick to the side of the bucket, hands, and palms.

Total fiber content by percent weight can be also calculated by equation 4.2 The apparent fiber dosage is obtained by multiplying the total fiber content by the total batch weight of concrete per cubic yard.

Intact Fiber and Total Fiber Content

Items needed: Paper for sample weighing, latex gloves, scale.

- Determine the mass of a weighing paper (W_P) in lbs.
- Mechanically separate intact fibers from the fabric filter and place onto weighing paper.
- Determine the mass of the intact fiber + weighing paper (W_3) in lbs.
- Intact fiber content by percent weight could be calculated below:

$$\rho_{2_F} = \frac{W_3 - W_P}{W_c} \qquad \text{(Eq 4.3)}$$

Observation and discussion:

Mix 1:

This mix was utilized several times to find the most practical method to retrieve the fibers from a concrete mix. Fibers were badly damaged after mixing more than once.

Mix 1 as shown in Appendix A and an assumption of 4% air content, the theoretical total fiber content is 5.4 lbs/cu.yd.

Mix 1 used Type II Portland cement to replace the Rapid Set Cement, heavy bleeding of water and latex were observed. During subsequent mixes using Type II Portland cement, the hydration control admixture (Delvo) was reduced from a dose of 26 oz/cwt to the manufacturer's recommended dosage rate of 4 oz/cwt. The reduction in the Delvo dosing rate reduced the bleeding to an acceptable level.

After adding fibers, mixer was stopped. Each concrete scoop carried between 6 to 10 lbs of concrete. As water receding from the mix, freshly-mixed concrete was more and more cohesive, and each scoop weight was less as approximately similar bulk volume.

Figure 4-6 Bleeding mix using Type I/II cement in place of Rapid Set cement

Ten samples were obtained from this mix. The average total fiber content was 7.2 lbs/cu.yd compared to 6 lbs/cu.yd as designed. On the other hand, the average intact fiber content was 3.8 lbs/cu.yd, with a coefficient of variation of 0.07. Considering only intact fibers contribute to concrete performance, a second mix (with similar content) was made and the fiber collection process focused on retrieving intact fibers only.

Table 4-1 Fibers data of first mix

Mix	Sample	Weight of Bucket + Concrete Sample W_1 (lb)	Weigh of Concrete Sample W_C (lb)	Weight of Filter Material W_F (g)	Weight of Filter + Retained Fibers W_2 (g)	Weight of Paper W_P (g)	Weight of Paper + Intact Fibers W_3 (g)	Total Fiber Content (lb/cyd)	Intact Fiber Content (lb/cyd)
1	1	8.834	8.834	70.3	78.5	11.96	15.88	7.9	3.8
1	2	8.8395	8.8395	68.3	74.8	12.16	16.37	6.4	4.1
1	3	8.266	8.266	69.6	78.5	11.65	15.28	9.2	3.8
1	4	7.6585	7.6585	68.5	74.6	11.5	14.62	6.9	3.5
1	5	7.699	7.699	71.4	83.5	12.03	15.26	13.4	3.6
1	6	8.794	8.794	75.3	81.2	12.36	16.25	5.8	3.8
1	7	7.85	7.85	72.3	79.8	11.18	14.98	8.2	4.2
1	8	7.3175	7.3175	63.5	66.7	12.2	15.6	3.7	4.0
1	9	8.495	8.495	81.2	86.2	11.43	15.31	5.1	3.9
1	10	6.86	6.86	76.9	81.0	11.61	14.27	5.1	3.3

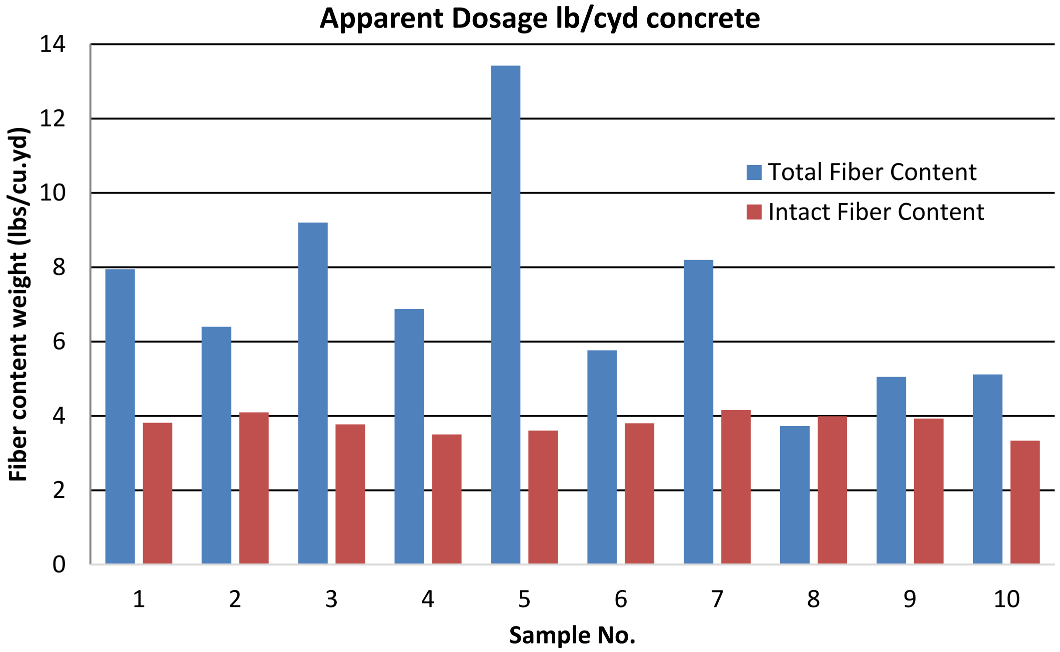


Figure 4-7 Fiber content of the first mix

During washout, water carrying latex, fine, and cement seemed to clog the cotton cloth. An improvised procedure was used for samples 8 and 9 in order to try to speed up the process and maintain effectiveness. Water from the overflow drum was poured into No.16 sieve placed on a bucket. The sieve containing some fibers was then placed on another bucket, and water from original bucket was poured through the sieve again to retain fibers. This step was repeated 3 times before letting water drain. The results of this step showed consistency with the original procedure. The 8th and 9th samples had intact fiber content of 4 lb/cu.yd and 3.9 lbs/cu.yd which was not very different from other samples.

The weight of fiber (W_2) included some fines and small sand particles. Mechanically picking out fibers and placing them onto a paper to weight was crucial to obtain more consistent and accurate results.

Mix 2:

The purpose of this mix was to try to improve the fiber filteration and measurement process. Similar to the previous mix, the theoretical total fiber content was 5.4 lbs/cu.yd. In order to prevent water bleeding during sampling, the samples were drawn from the mix consecutively after 15, 30, and 45 seconds after the addition of fibers into the concrete. In this lab section, there were 4 samples obtained from the mix for each time interval. Freshly-mixed concrete rested about two minutes between each interval. During the paste removal process of the 4th sample, cement paste was hardened. To reduce the effects of cement setting on the fiber collection, water was added to the samples with stirring to separate fibers from the cement paste.

Table 4-2 Fibers data of second mix

Unit Weight (lb/cyd)	Sample (seconds) #	Weight of Bucket + Concrete Sample W1 (lb)	Weigh of Concrete Sample WC (lb)	Weighing Paper #	Weight of Cheese Cloth WP (g)	Weight of Cheese Cloth + Fibers W3 (g)	Intact Fiber Content (lb/cyd)
3900	(15)1	8.5935	8.5935	1	11.22	15.35	4.1
3900	(15)2	7.1395	7.1395	2	10.68	14.53	4.6
3900	(15)3	7.605	7.605	3	10.38	14.34	4.5
3900	(15)4	9.147	9.147	4	10.55	16.28	5.4
3900	(30)1	9.7025	9.7025	5	10.72	16.53	5.1
3900	(30)2	8.6485	8.6485	6	10.79	16.11	5.3
3900	(30)3	8.716	8.716	7	10.68	16.02	5.3
3900	(30)4	9.3825	9.3825	8	10.56	16.09	5.1
3900	(45)1	8.366	8.366	9	10.72	15.92	5.3
3900	(45)2	9.7495	9.7495	10	10.78	16.94	5.4
3900	(45)3	8.8545	8.8545	11	11.07	15.89	4.7
3900	(45)4	8.867	8.867	12	12.05	17	4.8

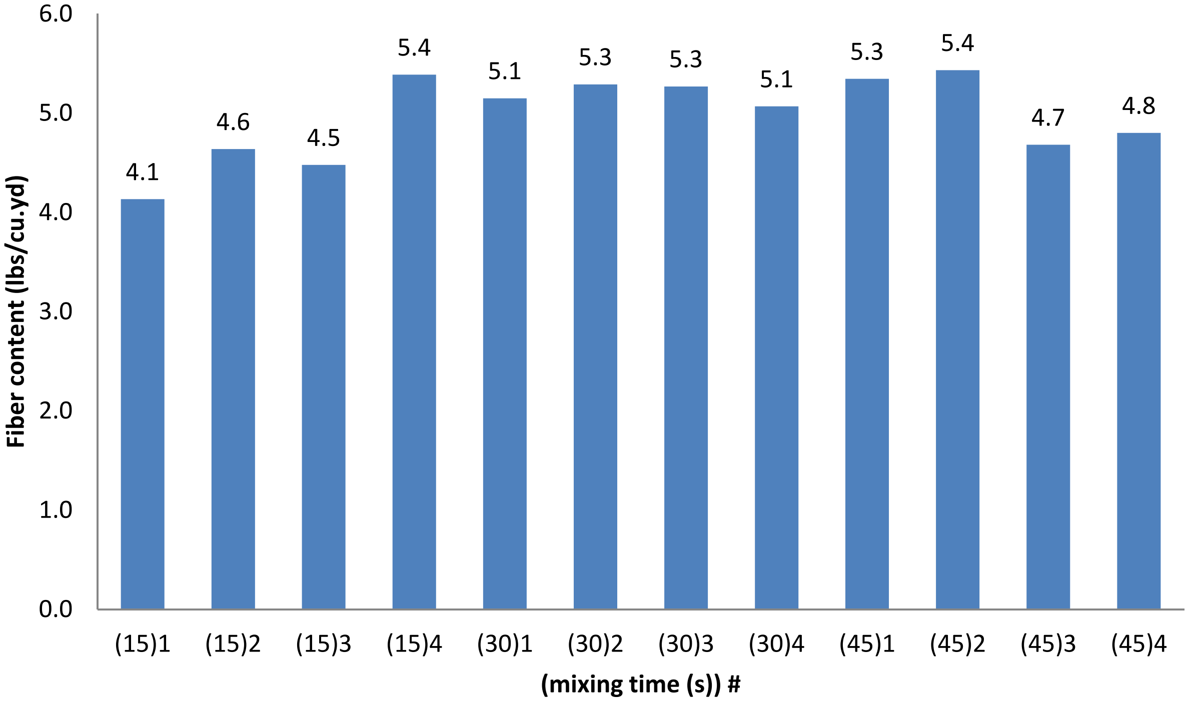


Figure 4-8 Fibers content of the second mix

The result of fiber mixing is summarized in Table 4-2. After mixing fibers for 15 seconds, the average total fibers content was 4.7 lb/cu.yd. The standard deviation was 0.53 lbs/cu.yd. The coefficient of variation is 0.11. It was assumed that 15 seconds was not enough time for fibers to thoroughly disperse in the mixture. These samples had lowest amount of damage fibers, which could be visually distinguished.

For samples in which the fibers were mixed for 30 seconds, the average total fiber content was 5.2 lb/cu.yd, and the standard deviation was 0.1 lb/cu.yd. The coefficient of variation was 0.02, which was the lowest compared to the 15-second and 45-second samples. The fibers sustained minimal damage while uniformly dispersed in the freshly-mixed concrete.

It was visually apparent that 45 seconds of mixing caused excessive damage to the fibers. The average total fiber content was 5.1 lb/cu.yd, and their standard deviation was 0.38 lb/cu.yd. The coefficient of variation was 0.07. The heavily damaged fibers were observed and would not significantly contribute to concrete properties.

4.2. Other materials:

Type I/II Portland cement and Rapid Set cement were utilized in this research. The coarse aggregate used was Kapaa Chips which are 3/8” maximum size aggregate (Project No. IM-H1-1(68), ASTM C136). Fine aggregate was British-Columbia Sand (Project No. IM-H1-1(68), ASTM C136). Admixtures including retarder (Delvo), superplasticizer (Glenium 3400NV), and corrosion inhibitor (MCI). Each of the admixtures were dispensed separately to the concrete mixes. These admixtures enhance not only normal concrete mixtures but also affect the Rapid Set cement-based mixes as well, however, the effects are not exactly the same. Glass fibers were also added.

4.2.1. Cement

Type I/II Portland cement:

Hawaiian Cement was stored in wooden cabinets placed outside. These Type I/II Portland cement bags were restocked each academic semester.

Rapid Set cement:

Rapid Set cement specific gravity was 2.98. The manufacturer indicates that its shelf life is 12 months when stored properly in a dry location, protected from moisture, out of direct sunlight, and in an undamaged package.

Saturated application surface with no standing water is the optimum condition for utilizing Rapid Set cement concrete as overlays. Most materials made with RAPID SET CEMENT must be water cured. Keep exposed surfaces wet for a minimum of 1 hour. Begin curing as soon as the surface starts to lose its moist sheen. When experiencing extended setting time due to cold temperature or the use of retarder, longer curing times may be required. While material temperatures below 70°F (21°C) could delay setting time and reduce the rate of strength gain, material temperatures above 70°F (21°C) may speed setting time and increase the rate of strength gain. (CTS Manufacturing Corp, 2017)

According to the manufacturer, mortars utilizing rapid set cement had average 1-hour, 3-hour, 1-day, and 28-day compressive strength of 2000 psi, 4400 psi, 5500 psi, and 6000 psi, respectively. 5-hour, 1-day, and 28-day flexural strength of extended material (ASTM C78) reached 500 psi, 650 psi, and 750 psi, respectively. 28-day modulus of elasticity is reported to be 4000 ksi. Bond strength of extended material (ASTM C882) reportedly reached 1200 psi in 1 day and 2500 psi in 20 days. (Product specification for Rapid Set Cement, 2006)

Rapid Set cement obtained from the Airport Viaduct repair contractor was stored in a supersack stored inside an agricultural box with bulk box lid. It was placed outside of the lab. Under warm and humid weather of Hawai'i, the Rapid Set cement appeared to be partially hydrated and did not perform as well as reported by the State of Hawaii DOT Testing Lab during the project. This cement was utilized in mix 3 from 8/30/2016 to 2/2/2017.

Recognizing that cement condition in the box may be playing a role in the reduced performance, new cement was ordered for continuing the research program. The new batch of Rapid Set cement was kept in the manufacturer's moisture control bag. However, even when placed in the lab condition (70 degrees with approximately 50% relative humidity), the cement seemed to hydrate in the bag prior to mixing. The first mix using the new cement was mix 3 on 3/2/2017.

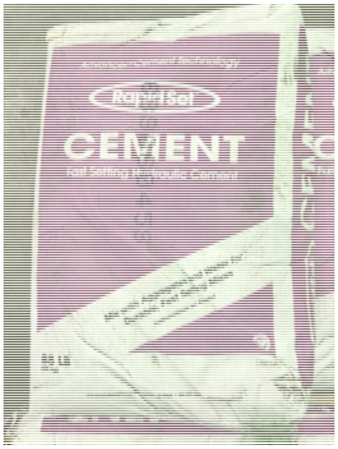


Figure 4-9 Rapid setting cement

4.2.2. Coarse aggregate

Kapaa chips are crushed basalt aggregate manufactured on Oahu Hawaii from the Kapaa Quarry. Aggregate was kept in black plastic bins bin to control moisture. The nominal maximum size of the coarse aggregate was 3/8 in. ASTM C136 (Standard test method for Sieve analysis of Fine and Coarse Aggregate) was conducted to confirm that the gradation used in the laboratory testing was similar to that of the contractor's stock. The aggregates were all obtained from the same supplier. The fineness modulus of the coarse aggregate was 5.69, which varied from contractor's results by 0.16%. ASTM C128-15 (Standard test method for relative density and absorption of coarse aggregate) and ASTM C566 (Standard test method for Total Evaporable Moisture Content of Aggregate by Drying) were used to determine the aggregates absorption and moisture content, respectively. The absorption capacity was 2.59%. ASTM C566 was used to determine moisture condition of aggregates typically one or two days before mixing. Note that sample sizes of coarse aggregates did not reach minimum size requirement in ASTM C566. The test results were used to perform the moisture adjustment for lab mixes. Other properties were also confirmed such as oven-dry specific gravity of 2.67, and saturated-surface-dry (ssd) specific gravity of 2.74.

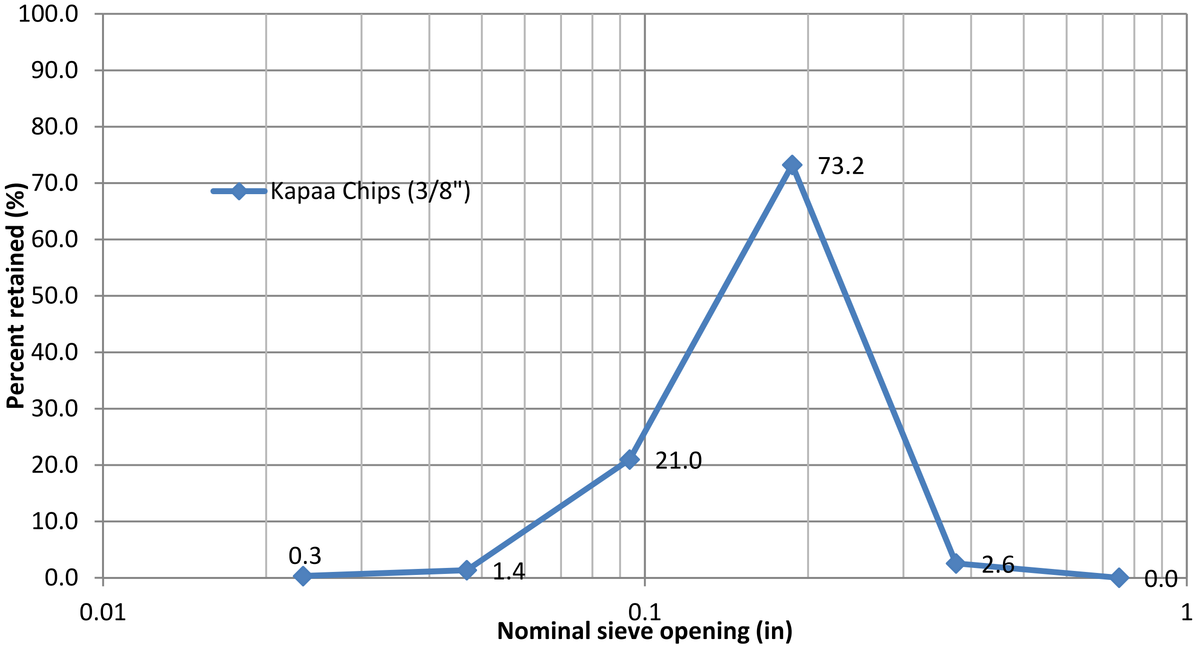


Figure 4-10 Kapaa Chip 3/8" grading

Table 4-3 Sieve analysis result of coarse aggregate

Seive No.	Seive weight (g)	Seive & sand (g)	Seive retained (g)	Seive retained %	Cul. retained %	MFG Report Cuml. % Retained	% difference from mix design
0.75	1218.8	1219	0.2	0.0	0.0	0	0.01
0.375	1171.4	1230.5	59.1	2.6	2.6	4	-1.44
4	1117.6	2814.6	1697	73.2	75.8	86	-10.21
8	1258.4	1744.7	486.3	21.0	96.8	97	-0.22
16	751.2	782.5	31.3	1.4	98.1	98	0.13
30	1049.3	1056.6	7.3	0.3	98.4	100	-1.56
50			0	0.0	98.4	100	-1.56
100			0	0.0	98.4	100	-1.56
200			0	0.0	98.4	100	-1.56
pan	1280.4	1316.5	36.1	1.6	100.0	100	0.00

Total Sample	2317.3	FM =	5.69	5.85	-0.16

4.2.3. Fine aggregate

British Columbia sand is imported from Canada. Aggregate was kept in black plastic bins bin to control moisture. ASTM C127-15 (Standard test method for Relative Density and Absorption of Fine Aggregate) and ASTM C566 were used to determine absorption and moisture content. The acceptable result of absorption capacity was 1.46%. ASTM C566 was used to determine the moisture condition of aggregates typically one or two days before mixing. The results were used to perform the moisture adjustment for lab mixes. Other properties were also confirmed such as specific gravity of 2.66, saturated-surface-dry density. The initial British-Columbia sand stock in the UH structural lab was used up. In early January, a new batch of aggregate was delivered for continuing the research project. The new batch was visually different from the first stock in the structures lab at the beginning of the research program, see Figure 4-11. On 1/20/2017, the new stock of British Columbian sand was tested to determine absorption (1.26%) and moisture content (above 2%). Gradation results are shown in Table 4-4 and Figure 4-12

Figure 4-11 Two samples of British Columbian sand

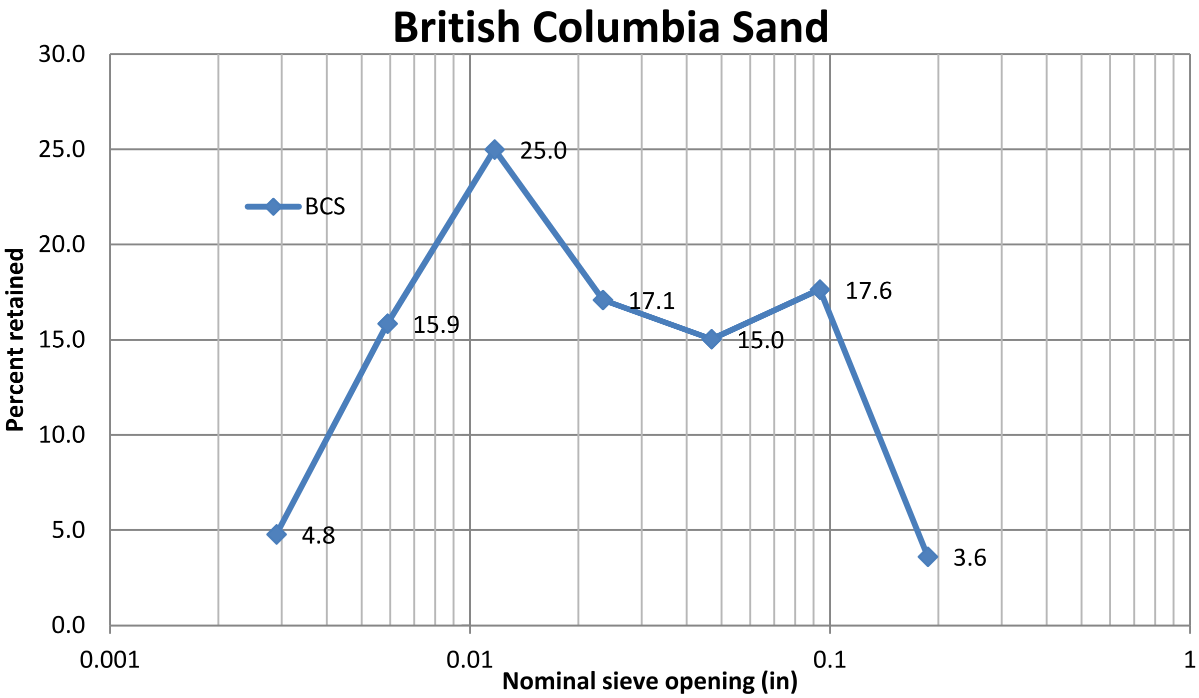


Figure 4-12 British Columbia sand gradation

Table 4-4 Sieve analysis result of fine aggregate

Sieve No.	Sieve weight (g)	Sieve & sand (g)	Sieve retained (g)	Sieve retained %	Cuml. retained %	MFG Report Cuml. % Retained	% difference from mix design
0.75			0	0.0	0.0	0	0.00
0.375			0	0.0	0.0	0	0.00
4	1117	1223.5	106.5	3.6	3.6	3	0.61
8	1257.3	1777.9	520.6	17.6	21.2	16	5.25
16	750.8	1194.4	443.6	15.0	36.3	32	4.28
30	1049	1553.4	504.4	17.1	53.4	50	3.37
50	991.6	1729.3	737.7	25.0	78.4	74	4.37
100	915.4	1383.2	467.8	15.9	94.2	93	1.22
200	896.5	1037.6	141.1	4.8	99.0	99	0.00
pan	1280.3	1309.9	29.6	1.0	100.0	100	0.00

Total Sample	2951.3	FM =	2.87	2.68

4.2.4. Latex

Styrofan® 1186 was the latex used in the concrete. The latex is suspended in a large quantity of water which is comprised of over half of the design water in the mix. According to BASF (chemicals company), it can help to reduce the water/cement ratio and maintain workability. Reduced water to cement ratios tend to result in a higher concrete compressive strength. The manufacturer indicates that its applications include concrete bridge deck and parking garage overlays. The manufacturer claims that this polymer reduces air voids and hairline cracks and flexural strength and abrasion resistance are also increased. In addition, the manufacturer claims that adhesion is improved between new concrete and existing concrete substrates. The manufacturer also claims the product increase the concrete resistance to salt and oil penetration. The optimum temperature to store Styrofan® 1186 was 50^0F - 85^0F. (BASF Corperation, 2010)

For this research, Styrofan bin was placed outside of the UH structural lab and in the shade. However, during mixing procedure, latex tended to foam and caused visual air voids on the surface of concrete cylinders after consolidation. Solid residue formed inside latex liquid. Latex was later drawn from latex bin and store in the lab. It was run through No.4 sieve to filter the residue from latex liquid. As observation, thin no-color liquid layer separated and floated from the whole. For such reason, a new barrel of Styrofan® 1186 was delivered for continuing mixes after 5/21/2017. Pump was installed, and the barrel was placed inside the UH structural lab. Temperature ranged from 20-25^0C.

4.2.5. Delvo

Delvo stabilizer, manufactured by BASF, extends the setting time to provide flexibility in placing and finishing concrete. It also acts as a water reducer. At normal doses, setting time is extended between 1 to 5 hours for Portland cement based concrete mixes. However, Delvo is less effective as a set control admixture for Rapid Set cement based concrete mixes. Recommended dosage for Portland cement concrete mixes is 4 ± 1 fluid oz/cwt (BASF Corporation, 2015).

Delvo was stored in plastic containers in a wood cabinet outside of the lab. For concrete mixes with Type I/II Portland cement, a dosage of 4 oz/cwt as recommended by the manufacturer was utilized. The VESLMC mix design using Rapid Set cement used a dosage of 26 oz/cwt as utilized by the repair contractor. Delvo dosage varied along with mixing temperature as Figure 4-17 shown. On the other hands, Delvo was reduced by half in some mixes for effect on Rapid Set cement concrete strength development. Delayed addition was applied for all mixes. More about dosage utilized in VESLMC were described in Figure 4-17.

4.2.6. Glenium

MasterGlenium® 3400, manufactured by BASF, was the high range water reducing admixture used in each mix. The manufacturer reports that this product controls rheology, improves workability and strength. Typical dosage ranges between 2 oz/cwt and 12 oz/cwt. Minimum shelf life was 6 months. The recommended maximum storage temperature is 40^{o}C. According to the manufacturer, it had no trace of chloride-based chemical and did not enhance corrosion in reinforced concrete. (BASF Corporation, 2015)

In this research, Glenium was stored in plastic containers inside a wood cabinet placed outside of the research lab. The Glenium dose for both Type I/II cement concrete mixes and Rapid Set cement concrete mixes was 6 oz/cwt based on Rapid Set cement weight. Delayed addition was commonly applied for all mixes.

4.2.7. MCI

MCI-2005, manufactured by Cortec Corporation, is an amine carboxylate corrosion inhibitor. The manufacturer claims that the chemical forms a corrosion inhibiting protective layer and prevents corrosion of steel and other metals reinforced concrete. The manufacture reports that one minor effect includes retarding concrete up to 4 hours compared to control. Recommended dosage was 1 pint/cu.yd. The manufacturer indicates that an acceptable storage temperature range is 0 – 100^{o}C. The shelf life of this product is 12 months. (Cortec Corporation, 2003).

MCI was stored in closed-lid plastic containers inside a cabinet placed outside of the lab. Dosage was consistently 3.65 oz/cwt for both of the Type I/II Portland cement concrete and Rapid Set cement concrete mixes. MCI was diluted in water before adding to freshly mix concrete. Some mixes did not include MCI to determine if it contributed to excessive air void formation in the concrete. MCI utilization was described more detail in mix design sheet.

4.3. Mix design

4.3.1. VESLMC

Figure 4-17 shows the mix design for VESLMC used in this research. Coarse and fine aggregates were obtained from the same source as the contractor's source. Aggregate gradation obtained by testing in the laboratory are comparable with the data provided by the contractor of the repair project the laboratory and manufacturer data are compared in Table 4-3 and Table 4-4.

One noticeable error on the mix design was volume of latex. With 210 lbs latex in weight and 468 oz/cwt, latex volume should be equivalent to 3.22 ft^3 rather than 0.22 ft^3as reported in the contractor's mix design. The contractor's mix design actually totals a volume of 30 cubic feet instead of 27 cubic feet (one cubic yard). Also, rapid set cement specific gravity was reported as 2.95, which was slightly lower than 2.98 as reported by the manufacturer's specification (CTS Manufacturing Corp, 2017). The theoretical density of VESLMC was 144.4 lbs/ ft^3 based on an assumed air content of 4%.

Table 4-5 VESLMC mix design

Airport Viaduct Mix Design		SP GR.	ABS Vol.				Weight
	Material		(%)	(mL)	(gal)	(ft^3)	(lb/cu.yd)
CM	Portland Cement (I-II)	3.15					0
CM	Rapid Set Cement	2.95	11.9%	101201	26.74	3.57	658
CA1	Kapaa Chips (3/8")	2.7	29.3%	249144	65.82	8.80	1483
FA1	British-Columbia sand	2.65	37.3%	317092	83.78	11.20	1852
W	Water	1	6.2%	52990	14.0	1.87	117
F	CEM Fibers	2.68	0.1%	1016	0.27	0.04	6
	Air (4%)	0	4.0%	30577	8.08	1.08	0
			Dosage				
	Admixtures		(oz/cwt)	(mL)	(gal)	(ft^3)	(lb/cu.yd)
ADMIX 1	Latex	1.045	468	91767	24.1	3.22	210
ADMIX 2	MCI	1.19	3.65	716	0.2	0.03	2
ADMIX 3	Delvo	1.068	26	5098	1.3	0.18	12
ADMIX 4	Glenium	1.1	6	1177	0.3	0.04	3
					Total	**30.02**	**4336**

4.3.2. LMC

A Latex modified concrete (LMC) mix used in this research. Its design was the result of modifying the VESLMC repair material mix design. The modification included using an equivalent volume of cement content, weight of Type I/II Portland cement to replace the rapid set cement. The Delvo dosage was reduced to the recommended dosage in the product data sheet (BASF Corporation, 2015). Delvo was reduced from 26 oz/cwt (VESLMC mix) to 4 oz/cwt (BASF Corporation, 2015). Other admixture dosages were unchanged from the VESLMC as shown in Table 4-5. Such change allowed concrete set in time for next day stripping from molds. Since the specific gravity of Type I/II Portland cement is higher than that of rapid set cement, slightly higher density of concrete was estimated. The theoretical Density of LMC was 146.57 lb/ft^3. The theoretical volume also slightly changed due to lower Delvo dosage. All other materials and admixtures had similar weight and volume.

Table 4-6 LMC mix design

			ABS Vol.				Weight
	Material	SP GR.	(%)	(mL)	(gal)	(ft^3)	(lb/cu.yd)
CM	Portland Cement (I-II)	3.15	11.97%		26.74	3.57	703
CM	Rapid Set Cement	2.95					
CA1	Kapaa Chips (3/8")	2.7	29.46%		65.82	8.80	1483
FA1	British-Columbia sand	2.65	37.49%		83.78	11.20	1852
W	Water	1	6.27%	52990	14	1.87	117
F	CEM Fibers	2.68	0.12%	1016	0.27	0.04	6
	Air (4%)	0	4.00%	30577	8.08	1.08	0
		SP GR.	Dosage				
	Admixtures		(oz/cwt)	(mL)	(gal)	(ft^3)	
ADMIX 1	Latex	1.045	~~468~~	~~91767~~	~~24.1~~	~~3.22~~	210
ADMIX 2	MCI	1.19	~~3.65~~	~~716~~	~~0.2~~	~~0.03~~	2
ADMIX 3	Delvo	1.068	4	~~784~~	~~0.2~~	~~0.03~~	2
ADMIX 4	Glenium	1.1	~~6~~	~~1177~~	~~0.3~~	~~0.04~~	3
					Total	**29.87**	**4378**

4.3.3. Test results from HDOT

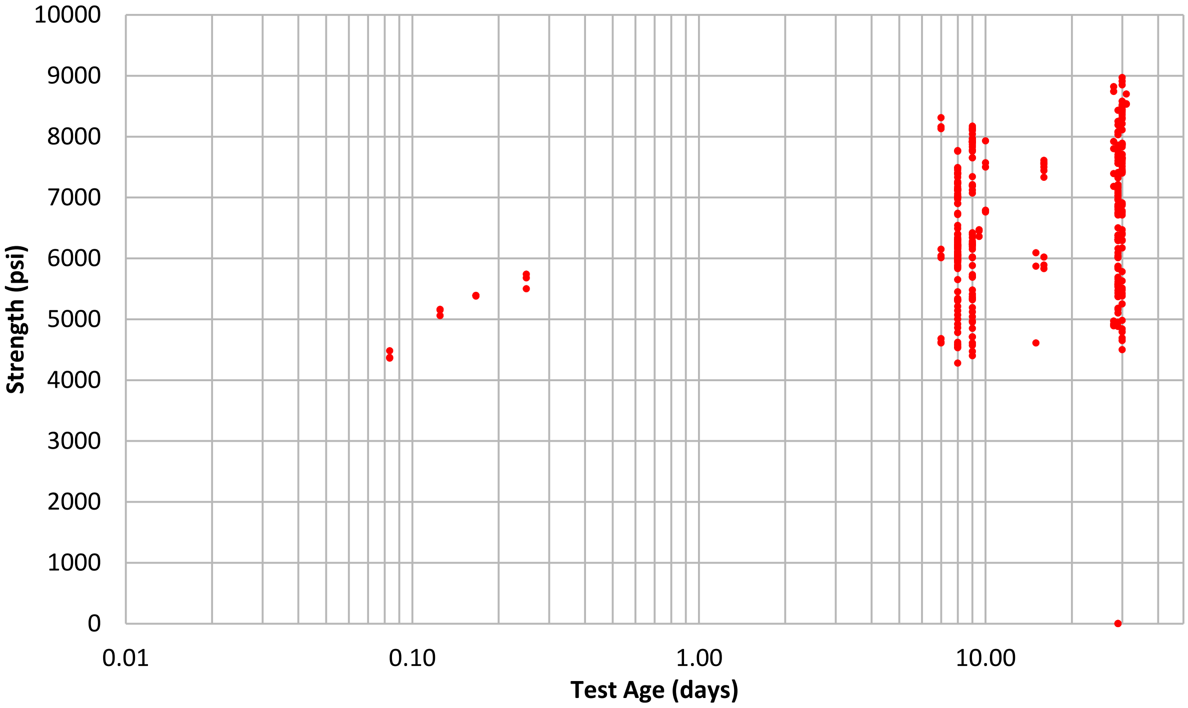


Figure 4-13 Compressive strength of VESLMC (State of Hawaii Department of Transportation Highways Division, 2014)

Figure 4-13 shows results of compressive strength testing performed by the State of Hawaii Department of Transportation Highways Division, (see Appendix B). The 3-hour compressive strength of 5123 psi and the other early age strength data was obtained from a single mix—the first tested to qualify the concrete for use. The 2-hour compressive strength, was 4403 psi well above 3000 psi requirement at 3-hour (Section 676, 2013). The 4-hour results from 3 cylinders of the same mix reached 5387 psi. The 6-hour compressive strength from a different mix reached 5640 psi. The 7-day compressive strength from 3 mixes and 9 cylinders were 6301 psi. The average 28-day compressive strength was 6868 psi and ranged from 4500 psi to 8970 psi. 28-day compressive strength results from 156 cylinders were recorded on 28th, 29th, 30th, and 31st day. Note that mixing temperature ranged from high 70^{0}F to high 80^{0}F.

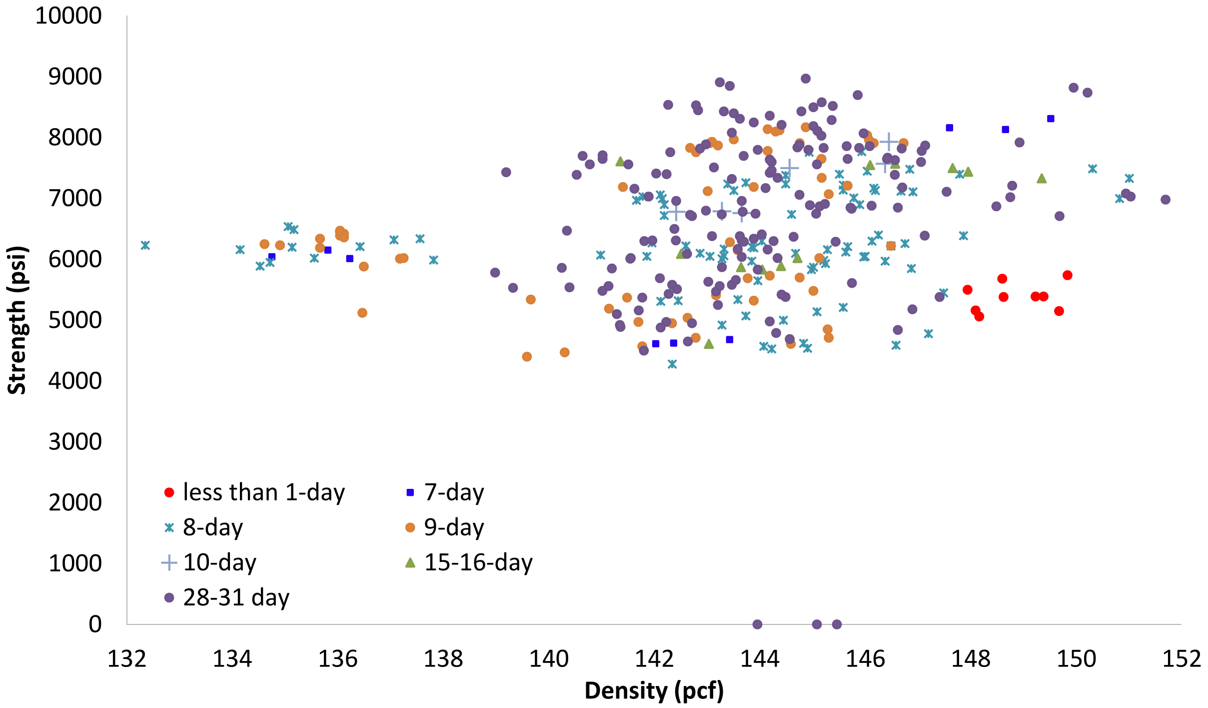


Figure 4-14 Compressive strength vs density (State of Hawaii Department of Transportation Highways Division, 2014)

The modulus of rupture was obtained from ASTM C78 (Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading), 2015) and ASTM C293 (Standard Test Method for Flexural Strength of Concrete (Using Simple Beam With Center-Point Loading), 2016). All specimens were 3”x3”x12” prisms. Dimension were estimated to determine the modulus of rupture. As prisms’ length was 12 in, span length L was estimated to be 9 in for all specimens based on rupture modulus results. Earlier-than-28-day rupture modulus were well exceeding 28-day requirement. Average 7-day modulus of rupture from 3 specimens was 910 psi. The results were quite matching to 3-hour modulus of rupture results at UH structural lab. Average 10-day, 11-day, and 12-day rupture modulus had respectively reached 1807 psi, 1244 psi, and 1490 psi, which all surpassed 28-day rupture modulus requirement (Section 676, 2013). Results shown abnormality that 10-day rupture modulus (ASTM C78) was higher than 11-day (ASTM 293) and 12-day (ASTM C78) results. Figure 4-14 suggested that compressive strength slightly responded to minor change in VESLMC density. Equation 5.3 and below equation were used to calculate modulus of rupture in Table 4-7.

$$R = \frac{3PL}{2bd^2} \qquad \text{(Eq 4.4)}$$

Where R is modulus of rupture (psi),

P is maximum applied load recorded by testing machine (lbs),

L is span length (in),

b is average width of specimen (in), and

d is average depth of specimen (in).

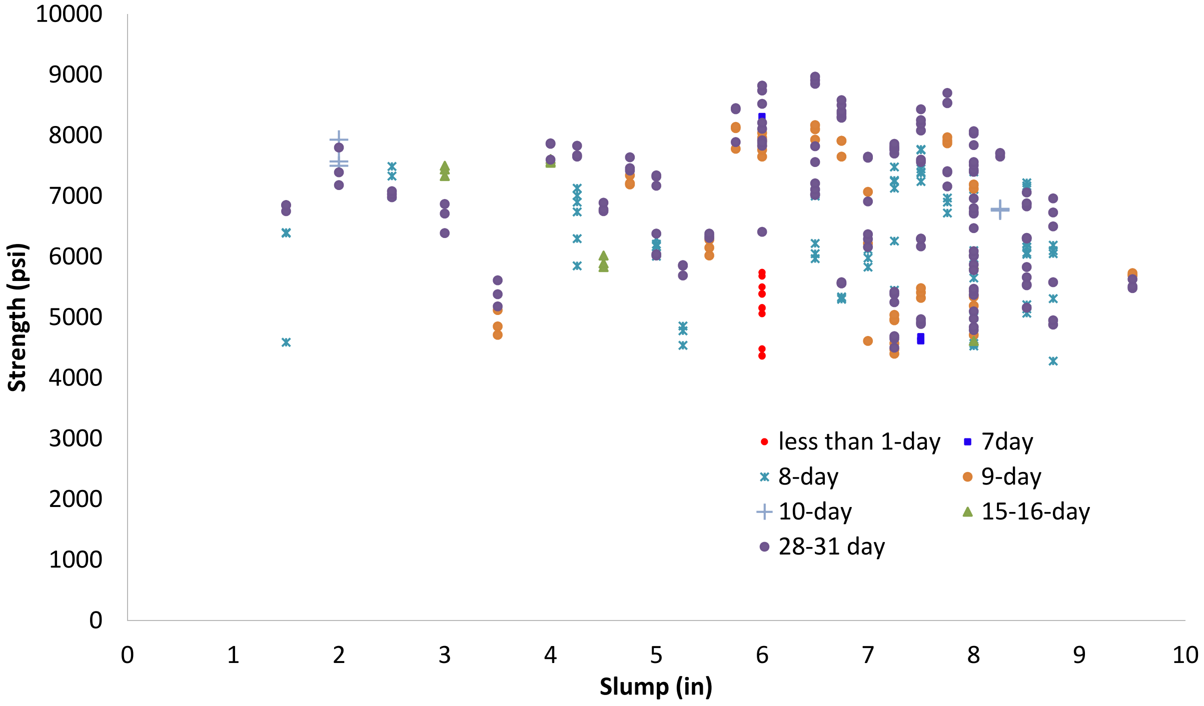


Figure 4-15 Compressive strength vs slump (State of Hawaii Department of Transportation Highways Division, 2014)

Lower slump caused VESLMC compressive strength lower, according to Figure 4-15. No recorded note about field consolidation. Density of concrete was recorded relatively lower than from cylinders in compressive tests. Size of concrete might alter density results of prism. Compressive strength and density both decreased as slump increased.

Table 4-7 Flexural test results (State of Hawaii Department of Transportation Highways Division, 2014)

Sample No.	ID No.	Test Age (days)	Max load (lbs)	Strength (psi)	Weight (g)	Density (lbs/ft^3)	ASTM Test method
JC-1081-CS-43	A	12.00	4886	1629	1629	134.2	C78/T97
JC-1081-CS-43	B	12.00	4390	1463	1463	132.6	C78/T97
JC-1081-CS-43	C	12.00	4138	1379	1379	133.3	C78/T97
JC-1082-CS-44	A	11.00	2370	1185	1185	137.7	C293/T177
JC-1082-CS-44	B	11.00	2419	1210	1210	137.8	C293/T177
JC-1082-CS-44	C	11.00	2673	1337	1337	138.1	C293/T177
JC-1085-CS-47	A	7.00	1728	864	864	135.3	C293/T177
JC-1085-CS-47	B	7.00	2034	1017	1017	136.5	C293/T177
JC-1085-CS-47	C	7.00	1700	850	850	135.3	C293/T177
JC-1090-CS-52	A	10.00	5483	1828	1828	136.2	C78/T97
JC-1090-CS-52	B	10.00	5660	1887	1887	138.3	C78/T97

JC-1090-CS-52	C	10.00	5121	1707	1707	138.7	C78/T97

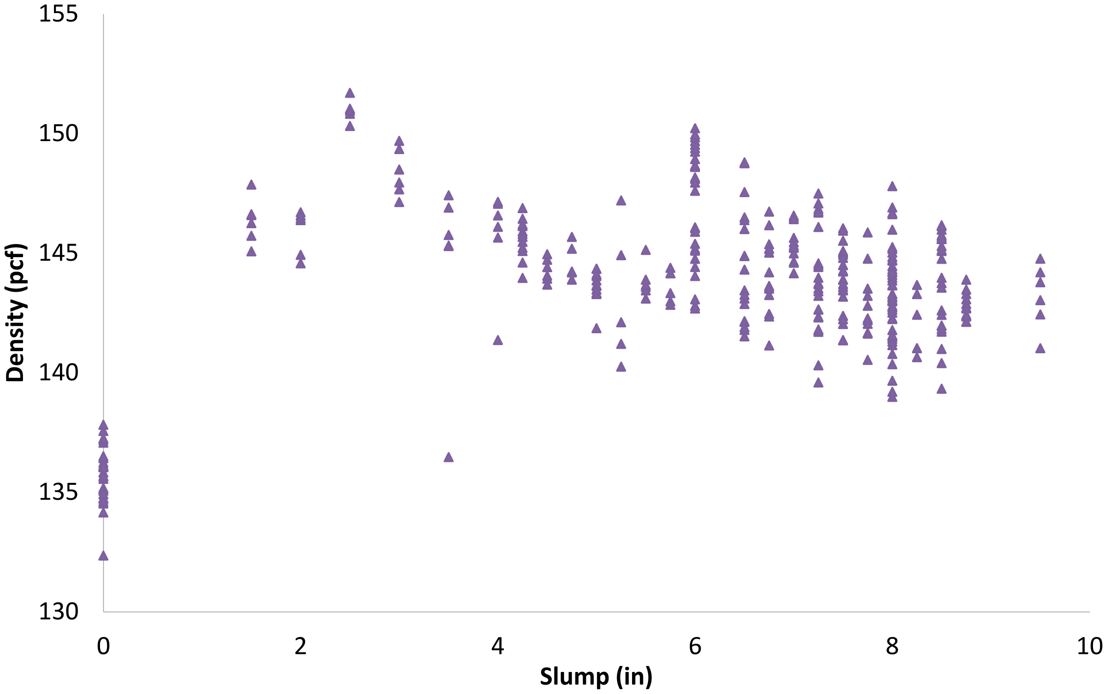
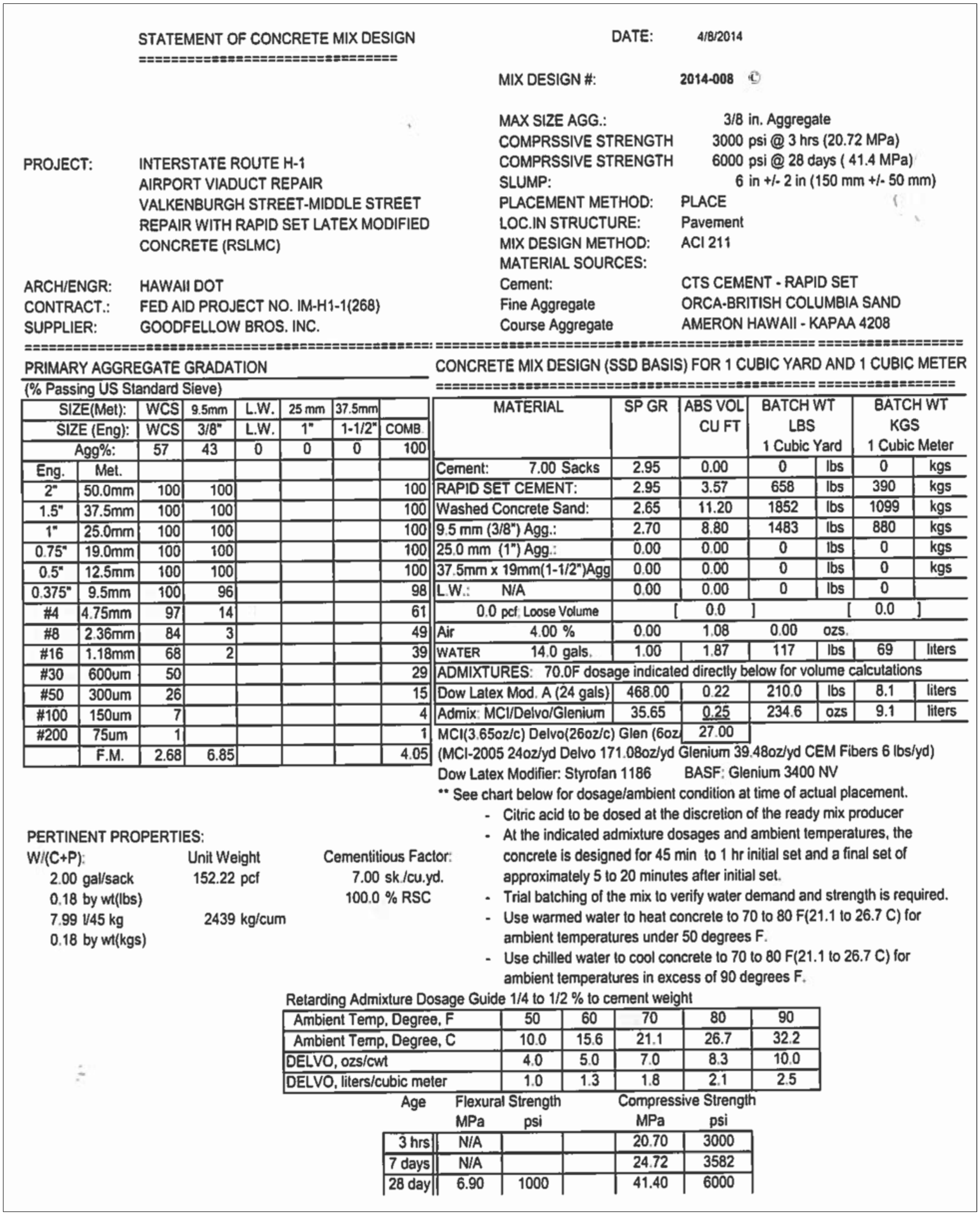


Figure 4-16 Slump vs density (State of Hawaii Department of Transportation Highways Division, 2014)

3-hour compressive strength of VESLMC from was doubtfully higher than this lab results and also other technical reports. VESLMC with similar mix proportion utilizing as overlays constructed for the Virginia Department of Transportation could only reach 3720 psi for SB1 cement and 2130 psi for SB2 cement after 3 hours of curing. These mixes in their report occurred during night time, in which mix temperature ranged 63-80^{0}F. Mixes for apply the overlay in Hawai'i occurred during day time, which probably higher temperature range. Evaporation contributing to shrinkage during first couple hours was possibly more extreme.

However, these conditional differences could affect 3-hour compressive strength from cylinders from the field. 3-hour compressive strength reached 5120 psi in average, while average 2-hour result reached 4400 psi. Higher day-time temperature potentially contributed to abnormal high results.



STATEMENT OF CONCRETE MIX DESIGN

DATE: 4/8/2014

MIX DESIGN #: 2014-008

PROJECT:	INTERSTATE ROUTE H-1 AIRPORT VIADUCT REPAIR VALKENBURGH STREET-MIDDLE STREET REPAIR WITH RAPID SET LATEX MODIFIED CONCRETE (RSLMC)
ARCH/ENGR:	HAWAII DOT
CONTRACT.:	FED AID PROJECT NO. IM-H1-1(268)
SUPPLIER:	GOODFELLOW BROS. INC.

MAX SIZE AGG.:	3/8 in. Aggregate
COMPRSSIVE STRENGTH	3000 psi @ 3 hrs (20.72 MPa)
COMPRSSIVE STRENGTH	6000 psi @ 28 days (41.4 MPa)
SLUMP:	6 in +/- 2 in (150 mm +/- 50 mm)
PLACEMENT METHOD:	PLACE
LOC.IN STRUCTURE:	Pavement
MIX DESIGN METHOD:	ACI 211
MATERIAL SOURCES:	
Cement:	CTS CEMENT - RAPID SET
Fine Aggregate	ORCA-BRITISH COLUMBIA SAND
Course Aggregate	AMERON HAWAII - KAPAA 4208

PRIMARY AGGREGATE GRADATION

(% Passing US Standard Sieve)

SIZE(Met):		WCS	9.5mm	L.W.	25 mm	37.5mm	
SIZE (Eng):		WCS	3/8"	L.W.	1"	1-1/2"	COMB.
Agg%:		57	43	0	0	0	100
Eng.	Met.						
2"	50.0mm	100	100				100
1.5"	37.5mm	100	100				100
1"	25.0mm	100	100				100
0.75"	19.0mm	100	100				100
0.5"	12.5mm	100	100				100
0.375"	9.5mm	100	96				98
#4	4.75mm	97	14				61
#8	2.36mm	84	3				49
#16	1.18mm	68	2				39
#30	600um	50					29
#50	300um	26					15
#100	150um	7					4
#200	75um	1					1
	F.M.	2.68	6.85				4.05

CONCRETE MIX DESIGN (SSD BASIS) FOR 1 CUBIC YARD AND 1 CUBIC METER

MATERIAL	SP GR	ABS VOL CU FT	BATCH WT LBS 1 Cubic Yard		BATCH WT KGS 1 Cubic Meter	
Cement: 7.00 Sacks	2.95	0.00	0	lbs	0	kgs
RAPID SET CEMENT:	2.95	3.57	658	lbs	390	kgs
Washed Concrete Sand:	2.65	11.20	1852	lbs	1099	kgs
9.5 mm (3/8") Agg.:	2.70	8.80	1483	lbs	880	kgs
25.0 mm (1") Agg.:	0.00	0.00	0	lbs	0	kgs
37.5mm x 19mm(1-1/2")Agg	0.00	0.00	0	lbs	0	kgs
L.W.: N/A	0.00	0.00	0	lbs	0	
0.0 pcf Loose Volume		[0.0]			[0.0]	
Air 4.00 %	0.00	1.08	0.00	ozs.		
WATER 14.0 gals.	1.00	1.87	117	lbs	69	liters
ADMIXTURES: 70.0F dosage indicated directly below for volume calculations						
Dow Latex Mod. A (24 gals)	468.00	0.22	210.0	lbs	8.1	liters
Admix: MCI/Delvo/Glenium	35.65	0.25	234.6	ozs	9.1	liters
MCI(3.65oz/c) Delvo(26oz/c) Glen (6oz		27.00				

(MCI-2005 24oz/yd Delvo 171.08oz/yd Glenium 39.48oz/yd CEM Fibers 6 lbs/yd)

Dow Latex Modifier: Styrofan 1186 BASF: Glenium 3400 NV

** See chart below for dosage/ambient condition at time of actual placement.

- Citric acid to be dosed at the discretion of the ready mix producer
- At the indicated admixture dosages and ambient temperatures, the concrete is designed for 45 min to 1 hr initial set and a final set of approximately 5 to 20 minutes after initial set.
- Trial batching of the mix to verify water demand and strength is required.
- Use warmed water to heat concrete to 70 to 80 F(21.1 to 26.7 C) for ambient temperatures under 50 degrees F.
- Use chilled water to cool concrete to 70 to 80 F(21.1 to 26.7 C) for ambient temperatures in excess of 90 degrees F.

PERTINENT PROPERTIES:

W/(C+P):	Unit Weight	Cementitious Factor:
2.00 gal/sack	152.22 pcf	7.00 sk./cu.yd.
0.18 by wt(lbs)		100.0 % RSC
7.99 l/45 kg	2439 kg/cum	
0.18 by wt(kgs)		

Retarding Admixture Dosage Guide 1/4 to 1/2 % to cement weight

Ambient Temp, Degree, F	50	60	70	80	90
Ambient Temp, Degree, C	10.0	15.6	21.1	26.7	32.2
DELVO, ozs/cwt	4.0	5.0	7.0	8.3	10.0
DELVO, liters/cubic meter	1.0	1.3	1.8	2.1	2.5

Age	Flexural Strength MPa	Flexural Strength psi		Compressive Strength MPa	Compressive Strength psi
3 hrs	N/A			20.70	3000
7 days	N/A			24.72	3582
28 day	6.90	1000		41.40	6000

Figure 4-17 Snipping picture of mix design

4.4. Mixing procedure

ASTM C31/C31M-15 was followed strictly for concrete using Type I/II Portland cement. Delayed addition was applied for all admixtures. Over-mortar was considered for ease of mixing further. Type I/II cement was utilized.

4.4.1. Laboratory Mixes

Figure 4-18 Volumetric mixer on the field

Good average density of over 150 pcf was able to deliver throughout almost all mixes utilizing cement type I/II. However, last mix of Type I/II Portland cement could not obtain its estimated density. Half of Glenium was hold off for this mix as previous ones showed sign of bleeding and segregation. Extremely low density of this mix contributed to the cause of low 28-day compressive strength.

Curing cylinders inside curing chamber was applied for all. However, excess latex was soluble and bled out of concrete cylinders. It turned clear water in the curing chamber to milky one. Cylinders gained weight after curing, but they changed insignificant. These changes could be observed in Table A-5 and

Table A-6. The information and data from these mixes laid the groundwork for producing rapid set cement concrete with drum mixer in the lab condition.

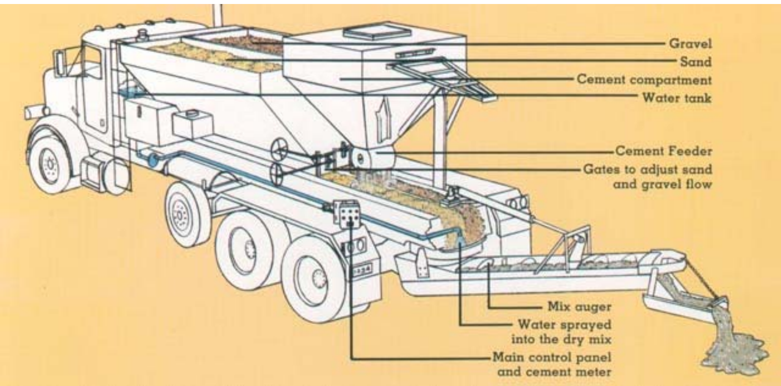
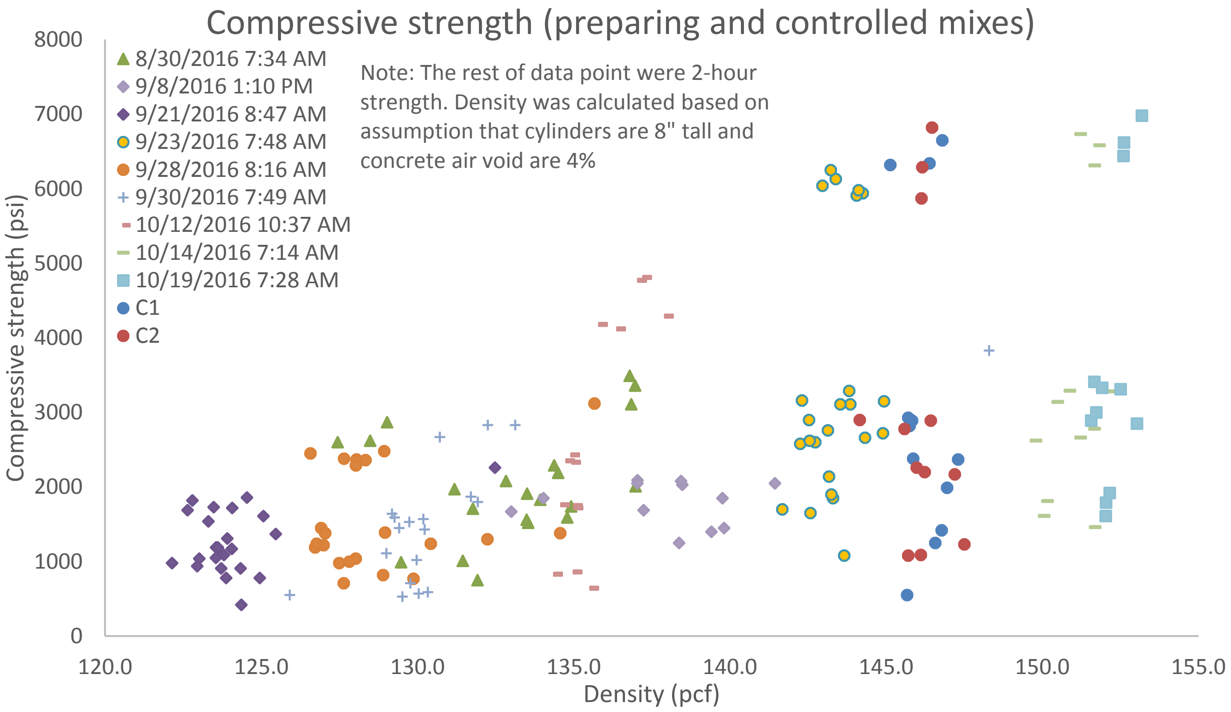


Figure 4-19 Typical volumetric mixer (from Omega Concrete Testing Services Limited website)

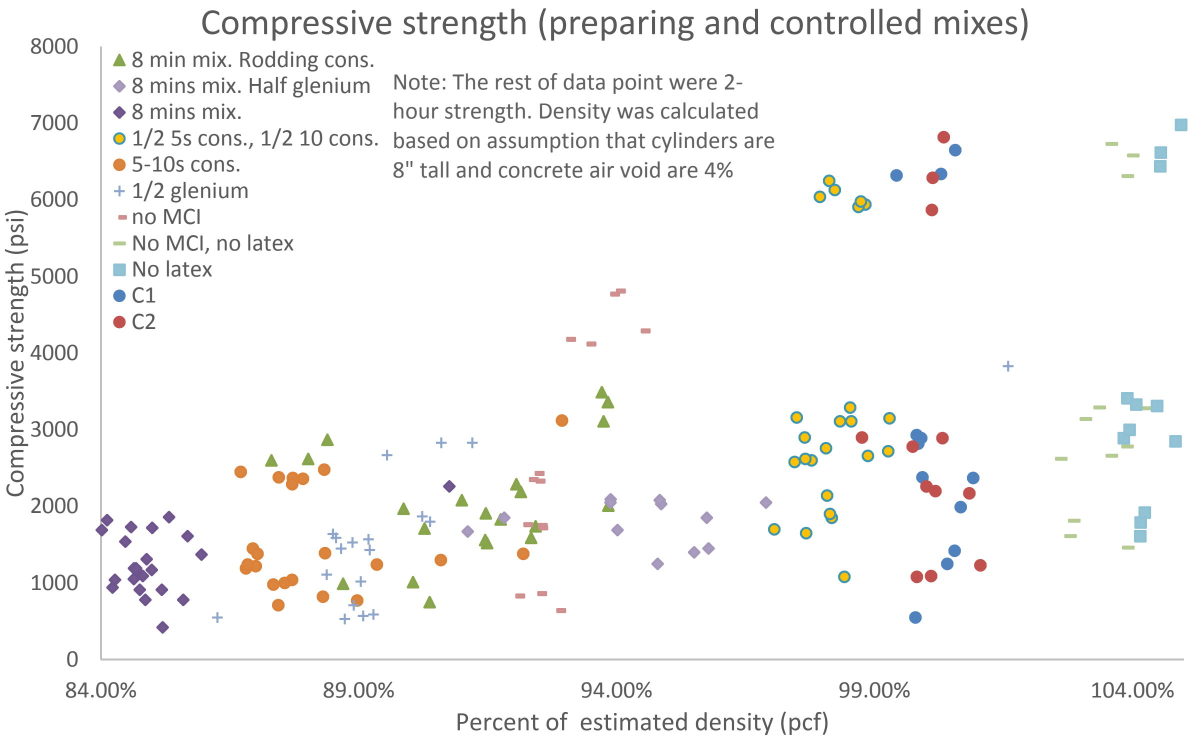
Multiple mixes were performed to figure out the standard mixing method for this research. The standard mixing procedure of 8 minutes described in ASTM C31/C31M-15 caused serious defect for rapid set cement mix. First mix on 8/30/2017 showed problem of water bleeding from the mix. Water kept receding from top layer to bottom one on wheel cart during filling the plastic molds. For this particular mix, its density ranged from 127.4 pcf to 137 pcf. Next mix on 9/8/2017 with half Glenium dosage only produced concrete with average density of 137.8 pcf, which was 95.73% of estimated density. Vibrator insertion was introduced to mix on 9/21/2017 as an attempt to reduce working time with freshly-mixed concrete. However, low density and low compressive strength problem persisted. Concrete products had to meet its estimated density and 3-hour compressive strength of 3000 psi. Moreover, due to observation, foaming created by Styrofan is detected in all mixes compared to water-only mixes. Air void tended to form and to adhere to contact surface of concrete and plastic molds.

Mix on 9/23/2016 had been considered to shorten the mixing time from 8 minutes as ASTM method to less than 3 minutes without resting time as an attempt to reduce foaming effect of latex. This step also enabled more time to work with rapid set cement, and it became major standard for further mixes. Delayed addition was also applied to chemical admixture. Due to low volume of MCI in each mix, the admixture was diluted in water using for mixing before adding to mixes. Density and compressive strength significantly improved. Mix on 9/23/2016 had average density of 143.4 pcf. Average 3-hour compressive strength was 3183 psi, which passed the 3-hour compressive strength requirement. Average 28-day compressive strength of 6 4”x8” cylinders (new and old molds) was 6042 psi. However, low compressive strength and density was as low as previous mixes because of the incompetently new procedure practice and unfamiliar workability loss after mix.


Compressive strength (preparing and controlled mixes)

Note: The rest of data point were 2-hour strength. Density was calculated based on assumption that cylinders are 8" tall and concrete air void are 4%

Figure 4-20 Compressive strength vs density of prepared mixes


Compressive strength (preparing and controlled mixes)

Note: The rest of data point were 2-hour strength. Density was calculated based on assumption that cylinders are 8" tall and concrete air void are 4%

Figure 4-21 Compression strength of prepared mixes (density percent)

4.4.2. General Mixing Procedure

The procedure below was followed for each concrete mix described in this section. The basic mixing equipment included: a 9-cu. ft. volume drum mixer (STOW CM9), a wheel cart, scales for batching the material (including latex) by weight, graduated cylinders for batching other admixtures by volume, and a stopwatch.

General procedure (following ASTM C31/C31M-15):

1) Prepare designated mix.
2) Add coarse and fine aggregates and water (include admixtures in the water; one admixture per bucket) to the mixer.
3) Start the mixer, add cement, then add latex.
4) Let mixer run for 3 minutes, stop the mixer and let stand for 3 minutes.
5) Turn on the mixer for 2 minutes. Then begin to add glass fibers. Let the mixer run for 30 seconds after the addition of fibers is completed.
6) Pour fresh concrete out of mixer into a wheel barrel.
7) Fill molds of required specimens. Rod or vibrate as specified in ASTM C31.
8) Cover the top of the molds to avoid air dry.
9) Strip the molds and place specimens in the curing chamber.

Mixing Procedure for VESLMC mix using laboratory drum mixer:

1) Prepare a full bucket of water to add to the mixer after mixing. (This step helps delay concrete hardening and rinsing mixer)
2) Add coarse and fine aggregates.
3) Start mixer and add water. (include MCI admixture in the water)
4) Add cement, then add the rest of admixtures. (delvo, Glenium)
5) Let mixer run for 2 mins. Then begin to add latex and glass fibers, simultaneously. Let the mixer run for 30 seconds after. (extra seconds added if latex or fibers is not well-mixed with others)
6) Pour fresh concrete out of mixer into a wheel barrel.
7) Fill molds of required specimens. Use commercial vibrator (following ASTM C31) or vibrating table for consolidation. (Two-layer or full-cylinder consolidation was considered depending on freshly-mixed concrete's workability)
8) Cover the top of the molds to avoid air dry.
9) Strip the molds and place specimen in the curing chamber. (air-dry or wet)

Note that all mixes, which were mixed outside of the lab, exposed to air temperatures. Later, they were consolidated inside the lab, in which temperatures remained 73^0F-77^0F. Mixing temperature could vary from high 70^0F to low 80^0F, as mixing time was from 7am to 10am.

4.5. Tests procedures

4.5.1. Compressive tests

Equipment includes: Rhiele compression machine, soil compression machine, diameter snap gage, scale, sulfur capping compound, melting pot, 4”x8” and 6”x12” vertical cappers.

Load rates applying were consistently at 500 lbs/s for 4x8 cylinders and at 1000 lbs/s for 6”x12” cylinders, which were equivalent to 39.79 psi and 35.37 psi for their respective sizes. This satisfied the ASTM C39/C39M load rate of 35 ± 7 psi for all sizes of specimens. Majority of cylinders were not kept wet before loading. Fracture types were recorded according to drawing in ASTM C39/C39M (Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens, 2015).

Preparation and testing procedures:

1) Strip cylinders from molds by applying air compressor to holes which were drilled at bottom.
2) Three measurements of diameters were recorded at 120^0 around each cylinder. Length was assumed to be 8” and 12” for 4”x8” cylinders and 6”x12” ones, respectively.
3) Cap melted sulfur compound on top and bottom of each cylinder following ASTM C617/C617M-15.
4) Position specimen at middle of the bearing plate.
5) Forward bearing plate to touch the top capping of cylinders.
6) Proceed tests at desired loading rates. Adjust the pump to maintain at such loading rate at least 50% testing time as ASTM C39/C39M – 15a requires. For soil compression machine, maximum loads are saved if loads have dropped 2000 lbs as prior configuration.
7) Record max loads and fractural types as describe in Fig.2 of ASTM C39/C39M-15a.

4.5.2. Strain-stress compressive test

Equipment includes: MTS 2-post frame testing machine (no spherical head), strain extensometer (2), circumferential extensometer (1), and bearing plates (2).

Load rate was estimated at 500 lbs/s. The test followed ASTM C469/C469M-14 (Standard Test Method for Static Modulus of Elasticity and Poisson’s Ratio of Concrete in Compression, 2014). Cylinders after test were overload for fracture type distinguishing.

Preparation and testing procedures:

1) Strip cylinders from molds by applying air compressor to holes which were drilled at bottom.
2) Three measurements of diameters were recorded at 120^0 around each cylinder. Length was assumed to be 8” for 4”x8” cylinders.
3) Cap melted sulfur compound on top and bottom of each cylinder.
4) Installed strain and circumferential extensometer on cylinders
5) Position specimen at middle of the top and bottom bearing plates. Forward the top bearing to center specimen with testing machine.
6) Proceed tests as computer record load and deflection along the road.
7) If load passed maximum load capacity (50,000 lbs) of MTS testing machine, disassemble extensometer on cylinders and load them on the soil compression machine. These results were recorded as maximum load.

4.5.3. Split-cylinder test

Equipment includes: a saw with water feeder, a ruler, soil compression testing machine, 4.5” plywood strips

Load rate was lower than 500 lbs/s. Due to logistics of testing Rapid Set concrete on time, all adjustment and centering were eyeballed.

Preparation and testing procedures:

1) Strip cylinders from molds by applying air compressor to holes which were drilled at bottom.
2) Cut cylinders in half.
3) Place first plywood strip at bottom and
4) Place half of cylinder horizontally along and on top of wooden strip.
5) Place another strip on top of and along the half cylinder.
6) Proceed the test. Stop as specimen cracks and maximum load is recorded.

4.5.4. Flexural tests

Equipment includes: rigid support structures, support block, loading block, Rhiele compression machine, a ruler.

Procedures strictly followed ASTM C78/78M – 15a (Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method), 2013). For each prism, three measurements of each depth and width were recorded after test. All prisms in this lab were 6”x6”x24”. Span length was fixed at 18 in by adjusting bottom rigid support structure.

1) Place rigid support structure at testing bed of Rhiele compression machine.

2) Mark on the concrete prism position of support rolls.
3) Place concrete prism on support structure and align with the mark.
4) Place adjusted-sized rigid support structure on top of and align with mark concrete prism.
5) Center the whole setup.
6) Proceed the test until fracture occurs.

4.5.5. Pull-off tests

The purpose of this test was to understand more about bonding capacity of repairing material and substrate. The test followed carefully with ASTM C1583/C1583M-13 (Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method), 2013). Testing steel disk was 2“, on where the coring diameter was 2.2”.

Equipment includes: (1) ground penetration device, (1) jack hammer, (1) needle gun, (1) air hose and extension, 18”x18” wood formwork, (1) core drill rig, (1) commercial vibrator, (10) steel disks, (1) coupling device.

Preparation and testing procedures:

1) Use jack hammer to chip surface concrete to ¾” in depth at certain size (18”x18”).
2) Apply needle gun to corner to disintegrate loose concrete on surface.
3) Apply air compressor to clear surface.
4) Drill and bolt wood form to rectangular chipped concrete.
5) Keep the whole area at saturated-surface-dry condition. Apply moist towels whole area overnight. Dry half of area utilizing air compressor 1 hour before pouring concrete and keep moist towel on another half. Assure no visual bonding water.
6) Pour concrete sample on top.
7) Cover freshly-mixed concrete with plastic sheet for curing for hours
8) Start coring sample within a week before testing (third week after pouring).
9) Attach steel disk on top of circular cut by applying epoxy. Make sure no epoxy dripping and sticking to the side of circular cut. Wait at least 24 hours before test.
10) Install coupling device and follow the manufacture’s manual
11) Slowly turn the crank until reaching maximum load.
12) Record loads and where failures occur.

Figure 4-22 Surface preparation before mixing

4.5.6. Shrinkage tests

Equipment included: 3”x3”x10” prism molds (3), digital indicator and 10” length comparator (1), and pairs of steel inserts (3).

Test procedures followed ASTM C157/C157M - 17 (Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete, 2017).

Preparation and testing procedures:

1) Stripping concrete prism from its molds 3 hours after mixing for VESLMC.
2) Measure the comparator; rotate it couple cycles for stable reading, then tare the digital indicator.
3) Unload the comparator, and load prism on the digital indicator.
4) Rotate prism couple of cycles for stable reading, record difference and time.

Chapter 5. Results

The results for Portland cement based mixes and Rapid Set cement based mixes are summarized in the following sections. The Portland cement based mixes, or Latex modified mixes (LMC), provided results including compressive strength and flexural strength. The Rapid Set cement based mixes (VESLMC), provided results including compressive, flexural, and split cylinder strength; stress-strain results for compressive tests, shrinkage results and pull-off testing results.

5.1. Portland cement mixes (LMC)

5.1.1. LMC Compressive strength results

Table A-1 in the appendix lists the compressive strength test results of LMC Portland cement mixes. Note that the density was calculated based on the assumption that all cylinders were either 8” or 12” long as specified. The theoretical density was calculated assuming the concrete is comprised of 4% air content by volume. Actual testing date and time column were recorded either at mid period of testing cylinders or at estimated testing time.

The density was calculated using below equation:

$$\gamma = \frac{4W}{\pi D^2 h} \qquad \text{(Eq 5.1)}$$

Where,

W = weight of cylinders (lbs),

D = average of 3 measured diameters (in), and

h = estimated length measured. For simplification, h was always assumed to be 12” for 6x12 cylinders and to be 8” for 4x8 cylinders.

Besides that, compressive strength of concrete of each cylinder using the average diameter requirement in ASTM C39/C39M was estimated using this formula:

$$f'_c = \frac{4P_n}{\pi D^2} \qquad \text{(Eq 5.2)}$$

Where f'_c is the compressive strength (psi), P_n is nominal force (lbs).

5.1.2. LMC Flexural test results

This section reports the flexural strength results of Latex-modified concrete utilized Type I/II Portland cement. These results are based on 6”x6”x24” prisms. The 28-day flexural strength of one mix was summarized in Table 5-1 Calculation of the modulus of rupture was performed in accordance with ASTM C78/C78M-15a using the following equation.

$$R = \frac{PL}{bd^2} \tag{Eq 5.3}$$

Where,

R is modulus of rupture (psi),

P is maximum load recorded,

L is span length, which is set at 18 in for all prisms,

b is average width of prism,

d is average depth of prism.

Table 5-1 Flexural test of Portland cement mix

Mix	Spec. #	Nominal Size (DxL)	Mix Date & Time	Actual Testing Date	Actual Age (Days)	Actual Age (hours)	Depth 1 (in)	Depth 2 (in)	Depth 3 (in)	Width 1 (in)	Width 2 (in)	Width 3 (in)	Weight (lbs)	P (lbs)	R (psi)
Mix 2D	9	6x6x24	8/16/2016 10:30 AM	9/13/2016 12:00 PM	28.06	673.50	5.991	6.055	6.207	6.051	6.118	6.046	70.9	9600	769
Mix 2D	10	6x6x24	8/16/2016 10:30 AM	9/13/2016 12:00 PM	28.06	673.50	6.005	6.014	6.046	6.157	6.114	6.117	70	9100	737
Mix 2D	11	6x6x24	8/16/2016 10:30 AM	9/13/2016 12:00 PM	28.06	673.50	6.077	6.034	5.925	6.05	6.148	6.123	69.5	9850	803
Mix 2D	12	6x6x24	8/16/2016 10:30 AM	9/13/2016 12:00 PM	28.06	673.50	5.995	6.013	5.975	6.114	6.098	6.112	69.7	8900	730

Note: All 28-day test dates were correct, but their time.

Table 5-2 Flexural strength results of VESLMC

Mix	Spec. #	Nominal Size (dxhxl)	Mix Date & Time	Target Testing Age (hours)	Actual Testing Date	Depth 1 (in)	Depth 2 (in)	Depth 3 (in)	Weight (lbs)	P (lbs)	R (psi)
C4	9	6x6x24	5/24/2017 9:27 AM	3	5/24/2017 12:33 PM	5.991	6.055	6.207	70.9	8075	654
C4	10	6x6x24	5/24/2017 9:27 AM	3	5/24/2017 12:39 PM	6.005	6.014	6.046	70	8075	668
C4	11	6x6x24	5/24/2017 9:27 AM	3	5/24/2017 12:42 PM	6.077	6.034	5.925	69.5	7250	602
C4	12	6x6x24	5/24/2017 9:27 AM	3.5	5/24/2017 12:46 PM	5.995	6.013	5.975	69.7	7950	664

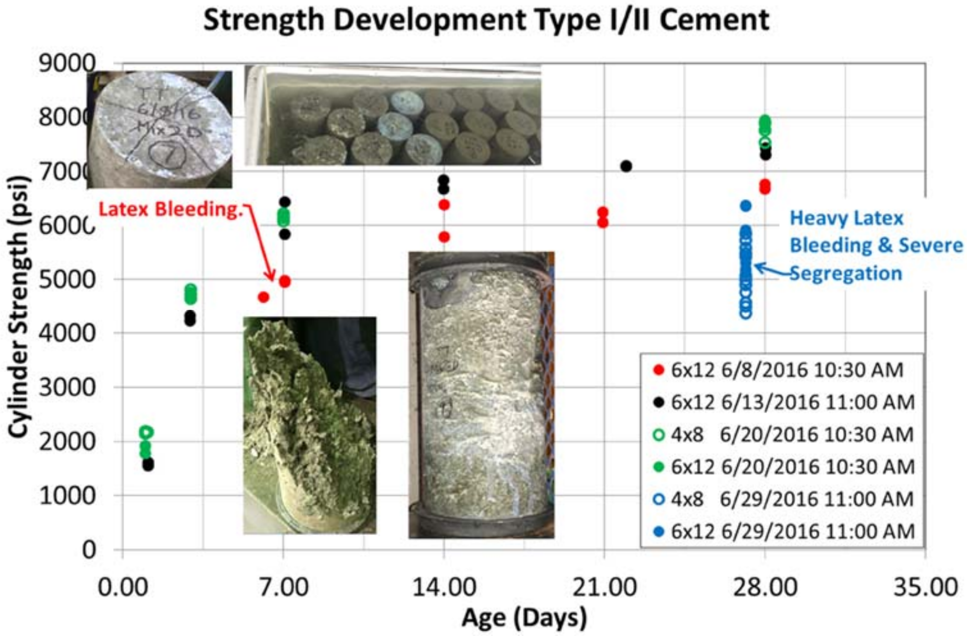


Figure 5-1 Strength development graph of concrete utilizing cement type I/II

Air voids were visible on the surface of these cylinders. Latex bleeding and segregation occurred. The mix on 6/8/2016 experienced latex bleeding to the top surface of cylinders. Heavy latex bleeding at the top and side of the concrete cylinders occurred during the mix on 6/29/2016. Slight segregation also was observed.

5.2. VESLMC mixes

5.2.1. VESLMC Compressive strength results

Table A-1 in the appendix lists the compressive strength test results of VESLMC Rapid Set cement mixes. Note that the density was calculated based on the assumption that all cylinders were either 8” or 12” long as specified. The theoretical density was calculated assuming the concrete is comprised of 4% air content by volume. Actual testing date and time column were recorded either at mid period of testing cylinders or at estimated testing time.

Starting with the mix on 6/14/2017, the compressive strength was obtained from MTS testing machine, with a maximum compression capacity of 50,000 lbs. This machine applied the compression load and has instrumentation to acquire the axial and transverse strain for the test cylinders. Tabulated maximum loads larger than 50,000 lbs were obtained from a separate concrete compression testing machine subsequent to first acquiring the data using the MTS testing machine—these cylinders were loaded twice. See

Table A-6 in Appendix A which lists all the tabulated compression results.

5.2.2. VESLMC Flexural test results

Concrete prisms measuring 6x6x24 inches were cast for determining the modulus of rupture by 4 point loading. The average depth was assumed to be 6 in for all specimens. The weight of each specimen was recorded to check quality of consolidation. Equation 5.3 was used to calculate modulus of rupture. Specimen #11 had diagonal cracks, which was potential torsional effect.

5.2.3. VESLMC Split cylinder tests

Splitting tensile strength results from 13 mixes were reported in Table A-8 Split-cylinder test results of VESLMC. Tests procedures followed strictly with ASTM C496/C496M. Weight of half cylinders, except which were on 3/17/2017 and 4/14/2017, was weighed before test.

$$T = \frac{2P}{\pi l d}$$ (Eq 5.

Where T is splitting tensile strength (psi),

P is maximum load recorded (lbs),

l is length of half cylinders (in),

d is average diameter measured from whole cylinders (in).

Data from Table A-8 was summarized in Figure 5-3

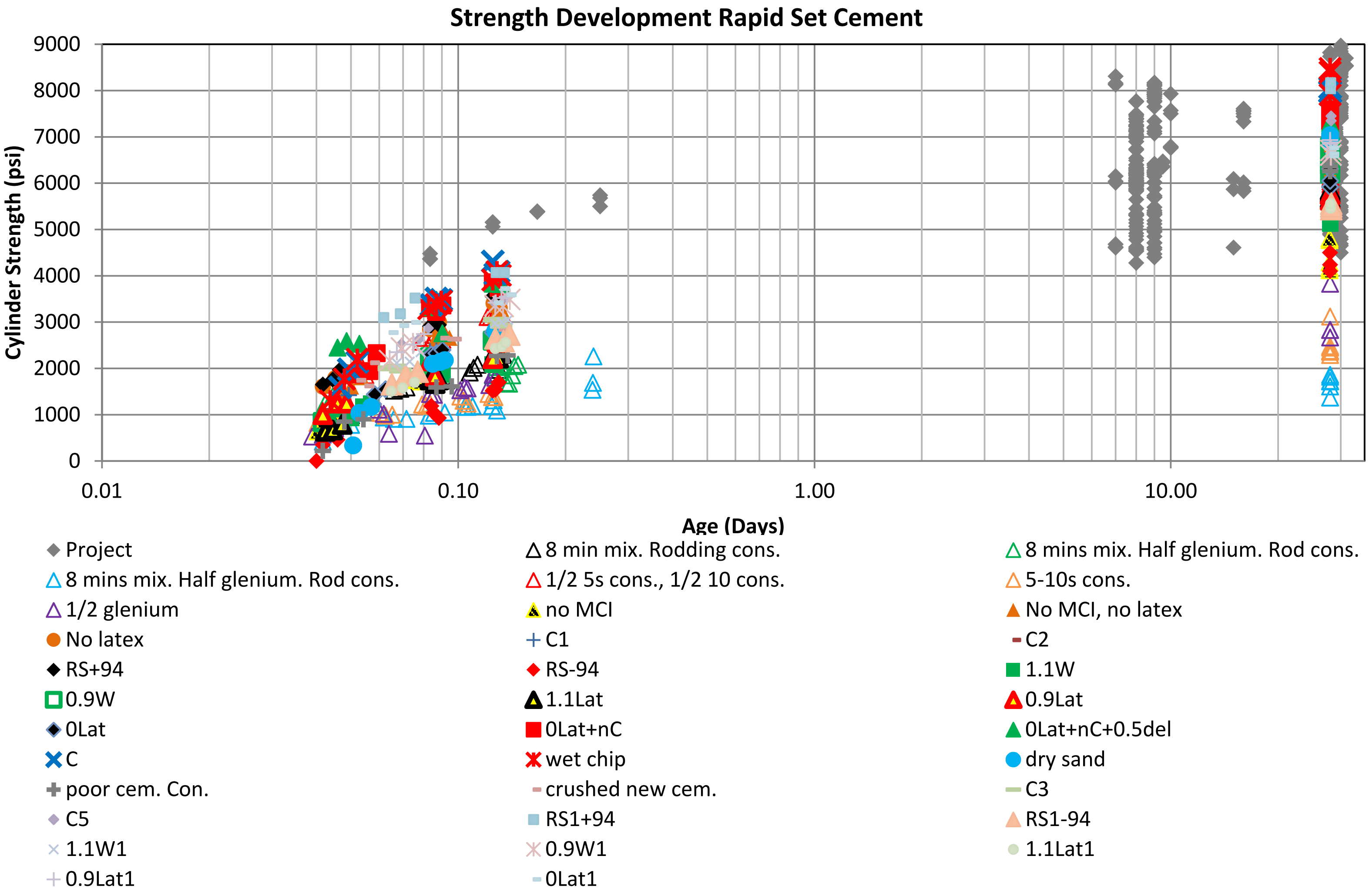


Figure 5-2 Strength development of VESLMC

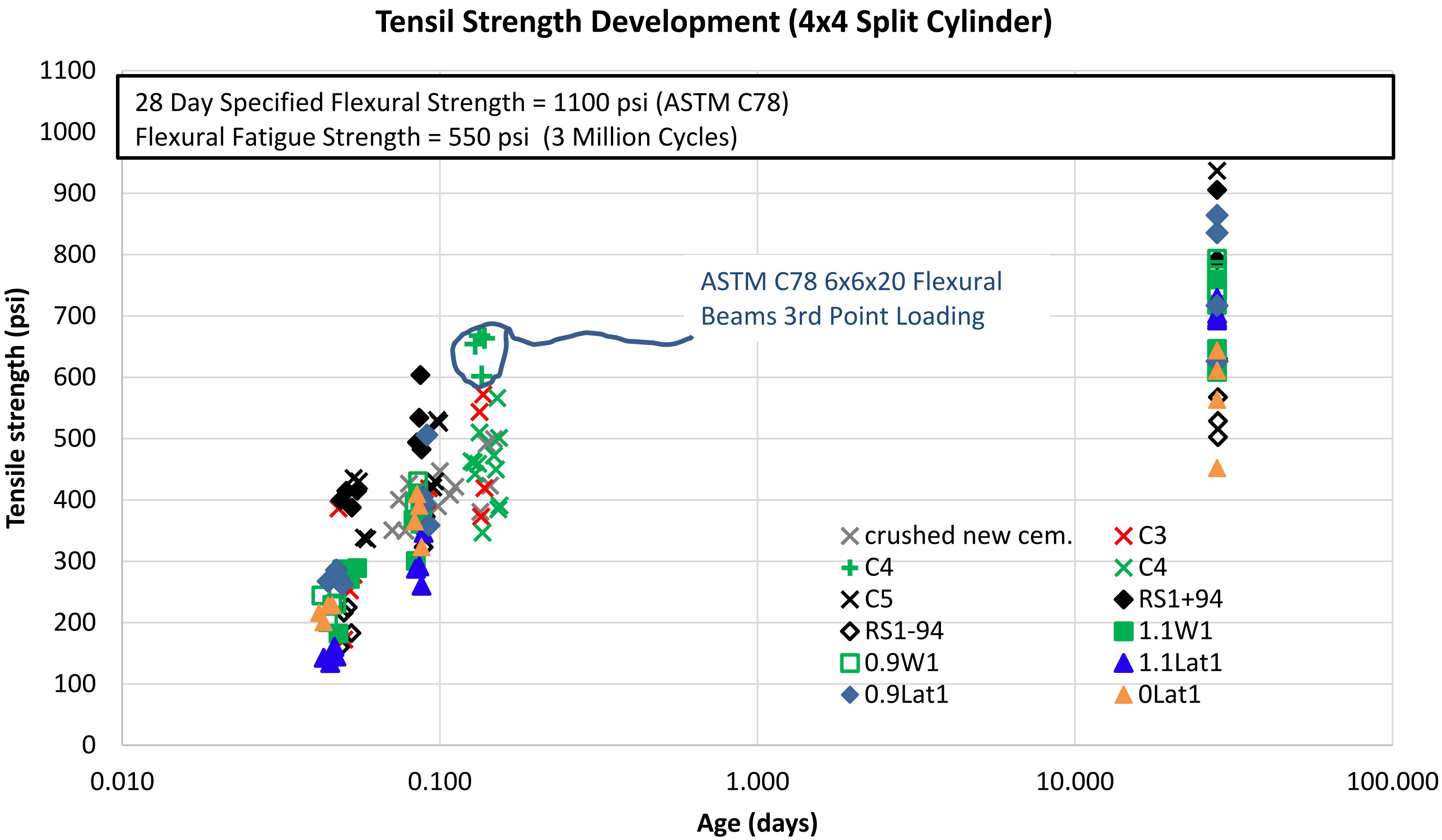


Figure 5-3 Tensile strength development (splitting tensile tests and flexural test)

5.2.4. VESLMC strain-stress results

Three extensometers were used to measure the axial and transverse strain for each compression specimen. Two extensometers were mounted on opposite sides of the specimen to measure the axial strain. The output of these extensometers were electronically averaged before being recorded in the data acquisition system. One extensometer was mounted to a roller chain which wrapped around the circumference of the specimen at mid height. The gage location of this extensometer was such that it directly measured the change in chord dimension between two points on the chain which was parallel to the perimeter of the concrete cylinder. The equations below were used for calculating the axial and transverse strain for the concrete tests compression tests using the MTS testing machine. Equations 5.7 through 5.9 were utilized in tables in Appendix A. Equations 5.5 and 5.6 were used to calculate results in Table 5-3.

To measure the transverse strain, the angle of the initial chord lengthθ_i (rad) was determined as follows:

$$\theta_i = 2\pi - \frac{l_c}{R - r} \qquad \text{(Eq 5.7)}$$

Where r is roller radius (in), l_c is chain length (in), R is specimen radius (in).

The change in specimen circumference, ΔC is then determined by:

$$\Delta C = \frac{\Delta l \pi}{\sin\frac{\theta_i}{2} + \left(\pi - \frac{\theta_i}{2}\right)\cos\frac{\theta_i}{2}} \qquad \text{(Eq 5.8)}$$

Where Δl is difference of cord length and extensometer output (in). Transverse strain ε_t is found by equation 5.9.

$$\varepsilon_t = \frac{\Delta C}{C} \qquad \text{(Eq 5.9)}$$

Modulus of elasticity and Poisson's ratio are calculated by equation 5.10 and 5.11 respectively.

$$E = \frac{f_2 - f_1}{\varepsilon_2 - \varepsilon_1} \qquad \text{(Eq 5.10)}$$

Where f_2 is stress corresponding to 40% of ultimate load, f_1 is stress corresponding to 10% of ultimate load, ε_2 is axial strain corresponding to 40% of ultimate load, ε_1 is axial strain corresponding to 10% of ultimate load.

$$\nu = \frac{\varepsilon_{t2} - \varepsilon_{t1}}{\varepsilon_2 - \varepsilon_1} \qquad \text{(Eq 5.11)}$$

Where ε_{t2} is transverse strain corresponding to 40% of ultimate load, ε_{t1} is transverse strain corresponding to 10% of ultimate load.

Table 5-3 Elastic Modulus and Poisson's ratio results

Mix	Cyl #	Mixing date & time	Test date & Time	Diameter 1 (in)	Diameter 2 (in)	Diameter 3 (in)	ε_{au} (in/in)	P (lbs)	f_c (ksi)	Elastic Modulus (ksi)	Poisson's Ratio
C5	3	6/14/17 8:28 AM	6/14/17 10:07 AM	3.995	4.002	3.992	2.97E-03	31683	2.526	2306	0.0923
C5	4	6/14/17 8:28 AM	6/14/17 10:19 AM	4.003	4	4	3.00E-03	33131	2.635	2765	0.1499
C5	5	6/14/17 8:28 AM	6/14/17 10:26 AM	3.988	3.993	4.01	3.08E-03	36021	2.871	2853	0.1027
C5	8	6/14/17 8:28 AM	6/14/17 11:29 AM	3.995	4.008	3.984	3.31E-03	42874	3.419	2818	0.1632
C5	9	6/14/17 8:28 AM	6/14/17 11:43 AM	4.002	3.999	4.006	3.48E-03	44282	3.520	2757	0.1057
C5	10	6/14/17 8:28 AM	7/12/17 12:46 PM	4.006	3.997	4.008		92510	7.348	4263	0.2001
C5	11	6/14/17 8:28 AM	7/12/17 12:53 PM	4.001	4.003	3.996		93635	7.451	4294	0.1955
RS1+94	3	6/16/17 8:04 AM	6/16/17 9:34 AM	4.006	3.996	3.995	2.81E-03	38885	3.096	2789	0.1974
RS1+94	4	6/16/17 8:04 AM	6/16/17 9:47 AM	4.008	3.999	4.006	3.36E-03	40098	3.184	2552	0.1446
RS1+94	5	6/16/17 8:04 AM	6/16/17 9:55 AM	3.995	4.004	3.992	3.30E-03	44200	3.523	2855	0.1275
RS1+94	8	6/16/17 8:04 AM	6/16/17 11:08 AM	3.988	3.994	4.006		51005	4.067	3115	0.1875
RS1+94	9	6/16/17 8:04 AM	6/16/17 11:18 AM	4	3.994	4		51045	4.066	3287	0.1516
RS1+94	10	6/16/17 8:04 AM	7/14/17 10:12 AM	3.999	4.009	3.991		101025	8.041	4458	0.1970
RS1+94	11	6/16/17 8:04 AM	7/14/17 10:26 AM	3.999	3.996	4.002		102570	8.166	4646	0.2018
RS1-94	3	6/20/17 8:55 AM	6/20/17 10:28 AM	4.007	4.003	4	3.19E-03	20934	1.663	1842	0.1453
RS1-94	4	6/20/17 8:55 AM	6/20/17 10:37 AM	4.019	3.989	4.001	3.14E-03	23315	1.853	1993	0.1504
RS1-94	5	6/20/17 8:55 AM	6/20/17 10:45 AM	4.006	4.01	3.983	2.94E-03	24217	1.927	2155	0.1299
RS1-94	8	6/20/17 8:55 AM	6/20/17 11:57 AM	3.996	3.996	4.005	3.57E-03	33281	2.650	2420	0.1479
RS1-94	9	6/20/17 8:55 AM	6/20/17 12:07 PM	3.995	3.993	4.013	3.51E-03	32547	2.590	2356	0.1175
RS1-94	10	6/20/17 8:55 AM	6/20/17 12:18 PM	3.995	3.991	4.005	3.23E-03	34202	2.726	2522	0.0998
RS1-94	13	6/20/17 8:55 AM	7/18/17 1:31 PM	3.997	3.996	4.007		68325	5.437	3802	0.1270
RS1-94	14	6/20/17 8:55 AM	7/18/17 1:41 PM	4.001	3.989	4.008		69825	5.558	3674	0.1610
RS1-94	15	6/20/17 8:55 AM	7/18/17 1:51 PM	3.998	3.997	4.004		69165	5.505	3643	0.0596*
1.1W1	3	7/5/17 9:19 AM	7/5/17 10:55 AM	3.985	4.005	3.985	3.15E-03	26515	2.119	2352	0.1470
1.1W1	4	7/5/17 9:19 AM	7/5/17 11:04 AM	4.013	4.002	3.999	2.83E-03	27089	2.151	2113	0.1219

Mix	Cyl #	Mixing date & time	Test date & Time	Diameter 1 (in)	Diameter 2 (in)	Diameter 3 (in)	ε_{au} (in/in)	P (lbs)	f_c (ksi)	Elastic Modulus (ksi)	Poisson's Ratio
1.1W1	5	7/5/17 9:19 AM	7/5/17 11:11 AM	4.007	4.012	3.991	3.01E-03	29555	2.348	2287	0.1394
1.1W1	8	7/5/17 9:19 AM	7/5/17 12:21 PM	4.012	3.997	4.001	3.06E-03	37323	2.965	2569	0.1427
1.1W1	9	7/5/17 9:19 AM	7/5/17 12:29 PM	3.997	4.015	3.991	3.45E-03	37676	2.997	2616	0.1643
1.1W1	10	7/5/17 9:19 AM	7/5/17 12:37 PM	4.016	4.003	3.994	3.44E-03	38401	3.049	2610	0.1309
1.1W1	13	7/5/17 9:19 AM	8/2/17 10:29 AM	3.998	3.991	3.993		84465	6.742	3952	0.1403
1.1W1	14	7/5/17 9:19 AM	8/2/17 10:40 AM	3.972	4.02	4		83205	6.630	3881	0.1869
1.1W1	15	7/5/17 9:19 AM	8/2/17 10:49 AM	3.991	4.005	3.993		83510	6.658	3845	0.1884
0.9W1	3	7/7/17 7:50 AM	7/7/17 9:22 AM	3.997	4.004	3.998	3.47E-03	27240	2.168	2171	0.1137
0.9W1	4	7/7/17 7:50 AM	7/7/17 9:29 AM	4.017	3.993	3.99	3.58E-03	30603	2.435	2305	0.1179
0.9W1	5	7/7/17 7:50 AM	7/7/17 9:37 AM	4.005	3.994	4.008	3.41E-03	31905	2.536	2381	0.1592
0.9W1	8	7/7/17 7:50 AM	7/7/17 10:52 AM	4.011	3.99	3.998	3.38E-03	42238	3.362	2794	0.1121
0.9W1	9	7/7/17 7:50 AM	7/7/17 11:02 AM	4.003	3.999	3.993	3.53E-03	41884	3.336	2647	0.1687
0.9W1	10	7/7/17 7:50 AM	7/7/17 11:10 AM	4.019	4.004	3.971	3.73E-03	43774	3.487	2784	0.1611
0.9W1	13	7/7/17 7:50 AM	8/4/17 11:01 AM	3.998	4.001	4.007		83175	6.612	3906	0.1513
0.9W1	14	7/7/17 7:50 AM	8/4/17 11:24 AM	4.023	3.984	3.998		83080	6.606	4120	0.1721
0.9W1	15	7/7/17 7:50 AM	8/4/17 11:36 AM	4.006	4	3.991		84240	6.707	4184	0.2046
1.1Lat1	3	7/11/17 8:44 AM	7/11/17 10:17 AM	4.015	4.001	3.991	3.56E-03	18981	1.509	1487	0.1151
1.1Lat1	4	7/11/17 8:44 AM	7/11/17 10:24 AM	3.979	4.01	4.002	3.54E-03	19838	1.581	1839	0.1251
1.1Lat1	5	7/11/17 8:44 AM	7/11/17 10:32 AM	3.998	3.99	4.01	3.35E-03	21379	1.702	1788	0.1164
1.1Lat1	8	7/11/17 8:44 AM	7/11/17 11:46 AM	4.011	4.009	3.983	3.54E-03	30607	2.434	2159	0.1575
1.1Lat1	9	7/11/17 8:44 AM	7/11/17 11:54 AM	3.993	4.02	3.982	3.51E-03	31051	2.473	2226	0.1383
1.1Lat1	10	7/11/17 8:44 AM	7/11/17 11:59 AM	4.001	4.01	3.991	3.64E-03	32198	2.561	2238	0.1755
1.1Lat1	13	7/11/17 8:44 AM	8/8/17 10:25 AM	4.001	4.008	3.986		68640	5.467	3695	0.1489
1.1Lat1	14	7/11/17 8:44 AM	8/8/17 10:37 AM	3.996	4.004	3.999		68630	5.462	3510	0.1829
1.1Lat1	15	7/11/17 8:44 AM	8/8/17 10:48 AM	4.001	3.986	4.011		69885	5.563	3653	0.1811
0.9Lat1	3	7/13/17 8:52 AM	7/13/17 10:28 AM	4.001	4.009	4.006	3.13E-03	29612	2.350	2289	0.1124
0.9Lat1	4	7/13/17 8:52 AM	7/13/17 10:39 AM	4.003	3.994	4.008	3.18E-03	31729	2.523	2384	0.1582
0.9Lat1	5	7/13/17 8:52 AM	7/13/17 10:47 AM	4	4.002	4.01	2.96E-03	34534	2.743	2528	0.1249
0.9Lat1	8	7/13/17 8:52 AM	7/13/17 11:55 AM	3.997	3.999	3.984	3.27E-03	42788	3.416	2770	0.1104

Mix	Cyl #	Mixing date & time	Test date & Time	Diameter 1 (in)	Diameter 2 (in)	Diameter 3 (in)	ε_{au} (in/in)	P (lbs)	f_c (ksi)	Elastic Modulus (ksi)	Poisson's Ratio
0.9Lat1	9	7/13/17 8:52 AM	7/13/17 12:02 PM	4	3.997	3.998	3.42E-03	44240	3.523	2914	0.1691
0.9Lat1	10	7/13/17 8:52 AM	7/13/17 12:09 PM	3.986	4.005	3.998	3.19E-03	44519	3.549	2861	0.1755
0.9Lat1	13	7/13/17 8:52 AM	8/10/17 9:02 AM	3.995	4.003	4.005		86490	6.879	4265	0.1619
0.9Lat1	14	7/13/17 8:52 AM	8/10/17 9:10 AM	3.983	4.006	4.002		87010	6.934	4289	0.1942
0.9Lat1	15	7/13/17 8:52 AM	8/10/17 9:24 AM	3.98	4.007	4.004		85935	6.849	4464	0.1998
0Lat1	3	7/17/17 9:37 AM	7/17/17 11:09 AM	4.004	3.999	3.904	2.14E-03	34294	2.772	3234	0.1032
0Lat1	4	7/17/17 9:37 AM	7/17/17 11:16 AM	3.986	4.006	3.997	2.28E-03	36668	2.923	3226	0.1060
0Lat1	5	7/17/17 9:37 AM	7/17/17 11:24 AM	4.01	4.002	3.994	2.29E-03	37641	2.992	3350	0.1332
0Lat1	8	7/17/17 9:37 AM	7/17/17 12:39 PM	4.023	3.991	3.993	2.01E-03	42918	3.411	3594	0.0902
0Lat1	9	7/17/17 9:37 AM	7/17/17 12:47 PM	3.988	4.004	3.999	2.23E-03	46679	3.720	3596	0.1421
0Lat1	10	7/17/17 9:37 AM	7/17/17 12:55 PM	3.996	3.995	3.995	2.30E-03	45051	3.593	3590	0.1054
0Lat1	13	7/17/17 9:37 AM	8/14/17 10:12 AM	3.995	4.001	4.005		85005	6.763	4712	0.1379
0Lat1	14	7/17/17 9:37 AM	8/14/17 10:28 AM	4.002	4.001	3.994		82770	6.590	4705	0.1442
0Lat1	15	7/17/17 9:37 AM	8/14/17 10:35 AM	4.003	4.001	3.998		83300	6.627	4745	0.1968

Note: If the compressive load was higher than 50,000 lbs, the concrete cylinder was loaded twice: once in the MTS testing machine for strain-stress relationship and again in the concrete compression machine to determine the maximum load (crushing load). The 28-day and some 3-hour strains ε_{au} corresponding to their respective ultimate compressive stress were not recorded due to the 50,000 lb maximum capacity of MTS testing machine.

* Extensometers slipped on the surface of the concrete. Results should not be considered for further analysis.

5.2.5. VESLMC Shrinkage results

Three 3"x3"x10" specimens were formed from "1/2 Glenium" mix on 9/30/2016. Assuming that the change in Glenium dosage should not affect shrinkage property of VESLMC. Weight was recorded to measure the quality of consolidation. The initial reading was at an age of 3-hours.

Table 5-4 Shrinkage test results

9/30/2016 7:49 AM	spec.1	spec.2	spec.3	Spec.1 shkg.	Spec.2 shkg.	Spec.3 shkg.
Weight (lbs)	7.86	7.82	7.86			
Density (pcf)	150.9	150.1	150.9			
9/30/2016 11:12 AM	0.3318	0.3096	0.3237	0.000%	0.000%	0.000%
9/30/2016 11:39 AM	0.3312	0.3092	0.3233	0.006%	0.004%	0.004%
9/30/2016 12:24 PM	0.3304	0.3088	0.3233	0.014%	0.008%	0.004%
10/3/2016 10:36 AM	0.3284	0.3069	0.3214	0.034%	0.027%	0.023%
10/13/2016 6:30 AM	0.3282	0.3062	0.3203	0.036%	0.034%	0.034%
10/14/2016 9:15 AM	0.3286	0.3065	0.3207	0.032%	0.031%	0.030%
1/17/2017 9:00 AM	0.3274	0.3054	0.3193	0.044%	0.042%	0.044%

5.2.6. VESLMC Pull-off test results

Testing age varied due to difficulties in epoxy application. Most of these were tested more than once, since epoxy tended to de-bond prematurely.

Table 5-5 Pull-off test results

Mix	Mixing date	Test date	Load (lbs)	Failure position	Substrate cond.	Age (days)	Stress (psi)
C5	6/14/2017 8:28 AM	9/24/2017	858	substrate	ssd	102	273
C5	6/14/2017 8:28 AM	9/25/2017	694	substrate	ssd	103	221
C5	6/14/2017 8:28 AM	8/9/2017		substrate	ssd	56	0
C5	6/14/2017 8:28 AM	8/9/2017	350	substrate	dry	56	111
C5	6/14/2017 8:28 AM	8/9/2017	519	substrate	dry	56	165
C5	6/14/2017 8:28 AM	8/9/2017		bonding	dry	56	0
RS1+94	6/16/2017 8:04 AM	8/11/2017	478	substrate	ssd	56	152
RS1+94	6/16/2017 8:04 AM	8/11/2017	963	substrate	ssd	56	307
RS1+94	6/16/2017 8:04 AM	8/11/2017	566	bonding	ssd	56	180
RS1+94	6/16/2017 8:04 AM	8/11/2017	175	repair mat.	dry	56	56
RS1+94	6/16/2017 8:04 AM	9/26/2017	1050	substrate	dry	102	334
RS1+94	6/16/2017 8:04 AM	8/11/2017		repair mat.	dry	56	0
RS1-94	6/20/2017 8:55 AM	8/23/2017	729	substrate	ssd	64	232
RS1-94	6/20/2017 8:55 AM	8/23/2017	525	substrate	ssd	64	167
RS1-94	6/20/2017 8:55 AM	8/23/2017	597	repair mat.	ssd	64	190
RS1-94	6/20/2017 8:55 AM	9/24/2017	618	substrate	dry	96	197
RS1-94	6/20/2017 8:55 AM	8/23/2017	618	substrate	dry	64	197
RS1-94	6/20/2017 8:55 AM	8/23/2017	1003	substrate	dry	64	319
1.1W1	7/5/2017 9:19 AM	8/31/2017	496	substrate	ssd	57	158
1.1W1	7/5/2017 9:19 AM	9/24/2017	898	substrate	ssd	81	286
1.1W1	7/5/2017 9:19 AM	9/24/2017	898	substrate	ssd	81	286

Mix	Mixing date	Test date	Load (lbs)	Failure position	Substrate cond.	Age (days)	Stress (psi)
1.1W1	7/5/2017 9:19 AM	8/31/2017	88	substrate	dry	57	28
1.1W1	7/5/2017 9:19 AM	9/24/2017	776	substrate	dry	81	247
1.1W1	7/5/2017 9:19 AM	9/24/2017	618	bonding	dry	81	197
0.9W1	7/7/2017 7:50 AM	9/11/2017	449	substrate	ssd	66	143
0.9W1	7/7/2017 7:50 AM	9/24/2017	986	bonding	ssd	79	314
0.9W1	7/7/2017 7:50 AM	9/11/2017	846	bonding	ssd	66	269
0.9W1	7/7/2017 7:50 AM	9/11/2017	204	bonding	dry	66	65
0.9W1	7/7/2017 7:50 AM	9/24/2017	823	bonding	dry	79	262
0.9W1	7/7/2017 7:50 AM	9/25/2017	589	substrate	dry	80	187
1.1Lat1	7/11/2017 8:44 AM	9/25/2017	595	substrate	ssd	76	189
1.1Lat1	7/11/2017 8:44 AM	9/26/2017	805	substrate	ssd	77	256
1.1Lat1	7/11/2017 8:44 AM	9/25/2017	193	substrate	ssd	76	61
1.1Lat1	7/11/2017 8:44 AM	9/25/2017	368	bonding	dry	76	117
1.1Lat1	7/11/2017 8:44 AM	9/25/2017	858	bonding	dry	76	273
1.1Lat1	7/11/2017 8:44 AM	9/15/2017	222	rebar	dry	66	71
0.9Lat1	7/13/2017 8:52 AM	9/20/2017	1313	substrate	ssd	69	418
0.9Lat1	7/13/2017 8:52 AM	9/20/2017	208	bonding	ssd	69	66
0.9Lat1	7/13/2017 8:52 AM	9/20/2017	741	repair mat.	ssd	69	236
0.9Lat1	7/13/2017 8:52 AM	9/20/2017	630	bonding	dry	69	201
0.9Lat1	7/13/2017 8:52 AM	9/20/2017	438	bonding	dry	69	139
0.9Lat1	7/13/2017 8:52 AM	9/27/2017	776	repair mat.	dry	76	247
0Lat1	7/17/2017 9:37 AM	9/20/2017	754	repair mat.	ssd	65	240
0Lat1	7/17/2017 9:37 AM	9/20/2017	1190	repair mat.	ssd	65	379
0Lat1	7/17/2017 9:37 AM	9/26/2017	1359	repair mat.*	ssd	71	433
0Lat1	7/17/2017 9:37 AM	9/25/2017	992	repair mat.	dry	70	316
0Lat1	7/17/2017 9:37 AM	9/27/2017	1178	repair mat.*	dry	72	375
0Lat1	7/17/2017 9:37 AM	9/27/2017	980	repair mat.*	dry	72	312

Note: ssd indicates that the substrate condition was saturated-surface dry during placement of the repair mix. See section 4.5.5 for more details.

* Failure occurred in repair material near epoxy interface. 1/8” thick repair material layers, including cement paste, fine and coarse aggregates, attached to the epoxy layers.

Chapter 6. Discussion

6.1. Portland cement mixes

These mixes were primarily used as practice mixes prior to using the rapid set cement mix and to determine the fiber addition methodology. These mixes strictly followed the ASTM 192 methodology for casting concrete. The ASTM recommends that the coarse and fine aggregate stayed in saturated surface-dry condition for batches not exceeding ¼ ft^3. All mix volumes in this research were well over condition. British-Columbian sand and Kapaa chips were relatively dry for these mixes. The condition potentially reduced compressive strength of concrete utilized Type I/II Portland cement. Compressive strength was significantly improved in VESLMC's results as wet sand was introduced into mixes. As soon as water was added, it not only reacted with cement but also absorbed by coarse and fine aggregate.

Figure 6-1 Latex bleeding as concrete hardened

In general, 1-day compressive strength ranged from 1500 to 2100 psi from 2 mixes. Average 3-day, 7-day, 14-day, and 21-day compressive strength increased to 4500 psi, 6000 psi, 6700 psi, and 7100 psi, respectively. Each of these results was collected from 1 to 3 mixes. 28-day compressive strength ranges from 3500 psi to 8300 psi from 85 of both 4"x8" and 6"x12" cylinders. The lowest limit was obtained from heavy-bleeding mix, which also had lowest density. The highest limit was obtained from mix shown no sign of segregation or bleeding and with density of 150 pcf.

Batches following mix design were unstable. Bleeding and segregation problem was detected in mixing fibers as shown in Figure 6-1. The assumption was that excessive dosage of delvo should not be applied to rapid set cement mix. However, mix of water and latex tended to bleed out of concrete mixture. Since these mixes used cement type I/II, compressive strength could only measure at least a day after. According to compressive strength data of mix 2D on 6/20/2016, 6/29/2016, and 7/20/2016, 6"x12" cylinders and 4"x8" cylinders compressive strength data suggested that their compressive strength was not different from each other. However, 2 6"x12" cylinders on 8/16/2016 had higher compressive strength than other 4"x8" cylinders.

These results had enabled more mixes with less volume. This modification was crucial since Rapid Set cement workability stage was shorter than conventional-cement batch.

Compressive strength of harden concrete would have dropped drastically as latex had bled from freshly-mixed concrete. Since it did not harden fast enough, latex combining with excess water tended to bleed on the side and top of cylinders. The Type I/II Portland cement mixes showed how unstable latex was in regular concrete mix. Each mix had different level of bleeding and segregation. Two similar mixes on 6/8/2016 and on 6/13/2016 had different compressive strength development due to heavy latex bleeding. Pictures related to each mix and their strength could be presented in Figure 6-2.

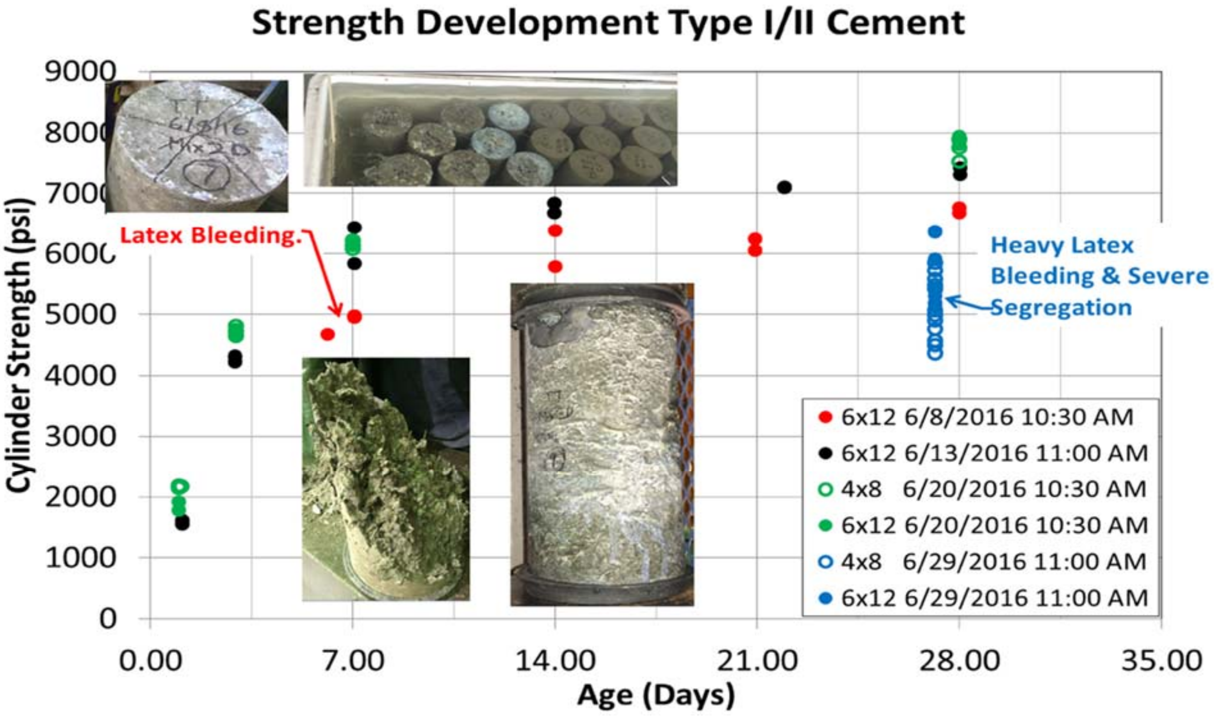


Figure 6-2 Strength development graph of concrete utilizing cement type I/II

Density of concrete definitely showed some effect on compressive strength. Good density of 150 lb/ft^3 was observed for all Type I/II Portland cement concrete. Latex bleeding and segregation had no clear effect on concrete density. Thus, there were no clear relation between concrete density and its compressive strength in LMC as in VESLMC mixes. In fact, even heavy bleeding and segregation did not reflect on density of hardened concrete. However, 3 ft^3 mix on 8/16/2016, which reduced half Glenium dosage for bleeding mitigation, had density of 133 lbs/ ft^3. It was the first mix did not reach its target density. Lower 28-day compressive strength than previous mixes was recorded. Thus, its 28-day modulus of rupture in

Table 5-1 was low.

Although density did not play major role in Type I/II Portland cement concrete property, compressive strength decreased significantly because of latex bleeding from concrete. Regarding slow compressive strength development over curing age in comparison with VESLMC, 28-day compressive strength results were similar to VESLMC's results in section 5.2.1. Heavy latex bleeding and segregation were detected in mixes on 6/29/2016 and on 7/13/2016. Despite of reaching their target density, their 28-day compressive strength results only reached 5300 psi and 4500 psi, respectively. The first mix on 6/8/2016, which showed sign of heavy bleeding and segregation, had slightly low 28-day compressive strength of 6700 psi. However, similar mix on 6/13/2016 perfectly were consolidated, had 28-day compressive strength of 7200 psi. Glenium and water reduction were applied on mix 7/20/2016 as attempt for bleeding and segregation mitigation. New limit of 8300 psi in 28-day compressive strength reached.

Condition of cement utilizing in concrete had very minor effect on strength development. Clump detected in Type I/II Portland cement did not break down during mixing process on 6/20/2017. In fact, Figure 6-2 show that their strength considered slightly higher than the controlled mix on 6/13/2017.

Strength development of Type I/II Portland cement concrete was quite different when utilizing Rapid Set cement. LMC mixes, which experienced no bleeding or segregation or low density, had 28-day compressive strength of 8100 psi (average value from mixes on 6/13/2016 and 7/20/2016). 28-day compressive strength of VESLMC could reached up to 8000 psi in average (based on Mix C5 on 6/14/2017, "Wet chip" Mix on 3/10/2017, and Mix C on 3/9/2017).

While average 28-day LMC compressive strength was rather similar to VESLMC, 28-day LMC rupture modulus was low. 28-day results reached average of 760 psi from four 6"x6"x24" prisms of one mix, which had low density. These results were far below the VESLMC requirement (Section 676, 2013).

6.2. VESLMC mixes

6.2.1. Materials condition and controlled mixes

Some practice mixes with Rapid Set cement were performed to finalize the mixing procedure described in section 4.4.2. These mixes had some major difference in the standard mixing procedure and from each other. However, strength development curves were developed. They categorically helped understand some key characteristics of all materials and admixtures.

Firstly, MCI had minor effect on porosity of concrete. It could be seen through density and compressive strength of concrete. Three mixes without MCI, MCI and latex, and latex on October 12th, 14th, and 19th, respectively were mixed closely following the standard procedure for Rapid Set cement. Mixes with MCI and without MCI had similar compressive strength development curve and density. No difference was experienced during mixing process or test results.

On the other hands, these prepared mixes with latex had considerably lower density and compressive strength. Mixes without latex were able to achieve over 6500 psi in average 28-day compressive strength, while the mix with latex could only reach 4434 psi. Moreover, 3-hour compressive strength of mixes without latex was 3293 psi. The average 3-hour compressive strength of mix with latex could only reach 2370 psi, which was lower than requirement (3000 psi in compressive strength). From 3 concrete mixes mentioned above, average estimated density of latex-modified concrete was 135.6 pcf, which was slightly lower than mixes replaced latex with water by weight. Even C1 and C2 controlled mixes following the standard mixing procedures had lower compressive strength than mixes without latex. The difference could be seen in Figure 4-20 and Figure 4-21.

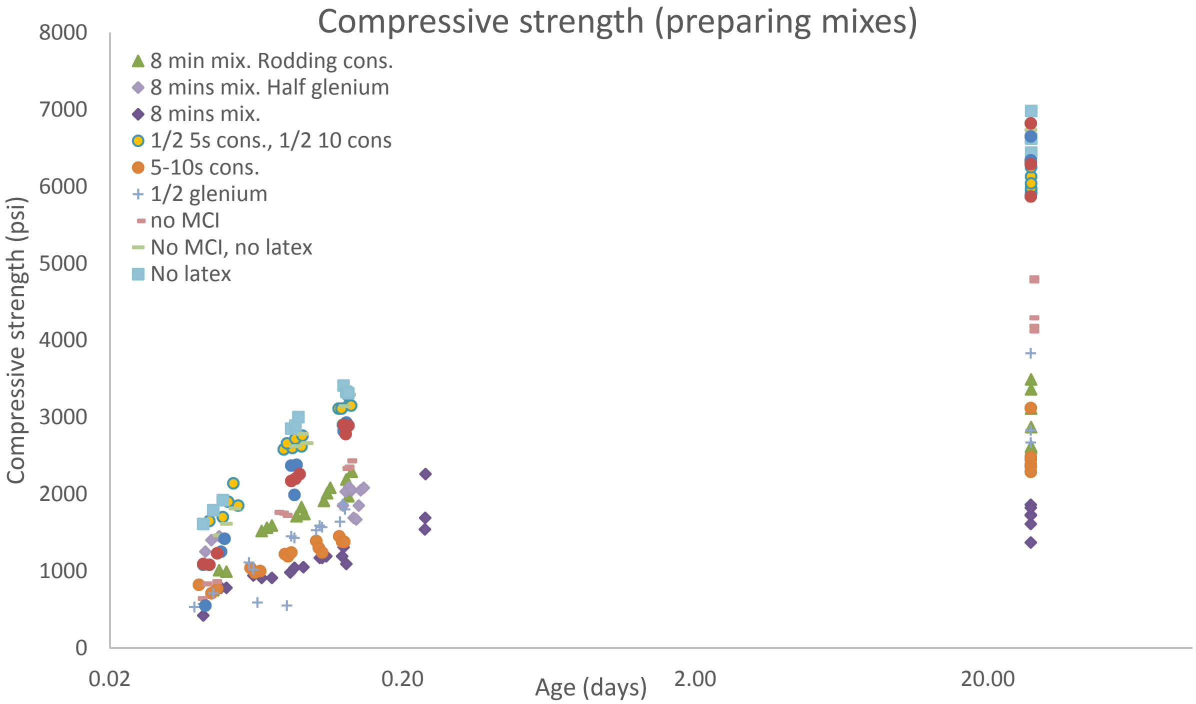


Figure 6-3 Compressive strength vs curing age (preparing mixes)

These mixes also showed that the workability related to compressive strength. Lower water content tended to aid workability decrease. Workability was recorded to drop very quickly in some mixes. They lead to problem of low density concrete, as consolidation was harder over time. The Rapid Set mix on 9/8/2017, in which half of Glenium amount was held off, was recorded rapid drop in workability. Moreover, mixing temperature was high in the afternoon, workability dropped significantly after pouring out of the drum mixer. Thus, only 12 4”x8” cylinders were formed, and their average density was 137.8 pcf. Although mixing time was 8 minutes, 21 to 24 4”x8” cylinders could be obtained from similar-volume mixes on 8/30/2016 and 9/21/2016. When using rodding technique for consolidation, 28-day compressive strength increased to 3320 psi from 2150 psi of 3-hour compressive strength. With 5 seconds vibration each cylinder, average 28-day compressive strength was 1685 psi, and 3-hour one was 1197 psi.

Different method of consolidation did not change the results of low density and compressive strength. However, lower time of mixing help increase tremendous. Density, more important, compressive strength would be able to match the requirement. Other adjustment such as consolidation time with vibrator or new molds improved the compressive strength slightly. Smoother surface and side of concrete was detected. Slightly smaller molds explained the density dropped seen on 9/23/2017 mix. Next mix on 9/28/2017 was to determine consolidation time whether it should be 10 or 5 seconds. 3-hour compressive strength showed minor difference in compressive strength results.

Note that these 28-day cylinders were wet-curing. Due to observation, high porosity in concrete tended to enhance Styrofan bleeding into curing chamber. Weight of concrete cylinders gained inconsistently after 28-day curing period. Thus, long-term compressive strength curve was also affected. Drying curing was applied for mixes on and after 10/19/2017. This limited moisture alteration during curing period. The new modification also helped data consistence and further configuration.

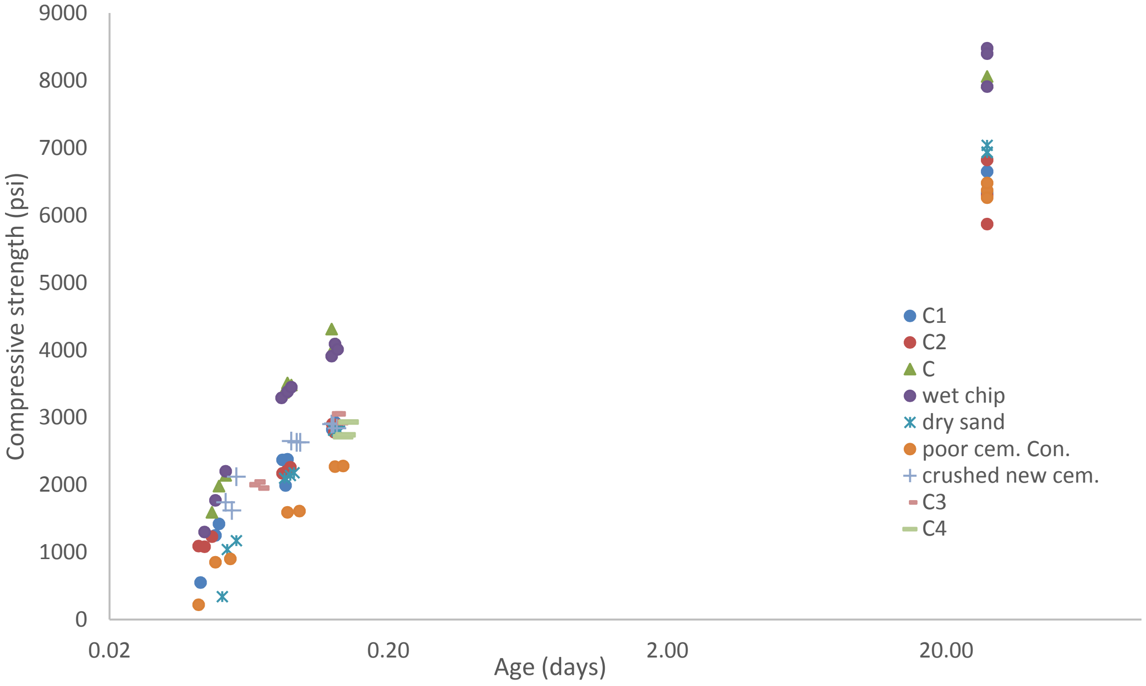


Figure 6-4 Compressive strength of mix design (different material condition)

With preexisting Rapid Set cement, compressive strength was increase significantly in a few hours. Heat of hydration was commonly intense. 3-hour compressive strength was all above 2700 psi, and 28-day strength reached over 6000 psi. These could be observed in Figure 6-4. New cement had significant effect on concrete compressive strength. 3-hour compressive strength of controlled mix C on 3/9/2017, which had similar procedures and material content as controlled mix C1 and C2, could reach slightly over 4000 psi in average. Moreover, average 28-

day compressive strength was over 8000 psi. Although new cement bags were preserved in lab condition, the moisture bags seemed not to work. During mix preparation, partially hydrated cement clumps could be spotted in new intact moisture cement bag after several weeks inside the UH Structural lab. Mix on 3/17/17 obtained lower values in compression due to low quality of cement, so procedure was extended to 8 minutes to hand-crush cement clumps with trowel inside drum mixer. It contained a lot of clumps and did not break up during mixing process. However, its 28-day compressive strength still reached over 6000 psi. Hydration continued as those cylinders were air-dry cured. Further mixes using new cement shown lower compressive strength than these 2 mixes mentioned above. In fact, they had quite similar compressive strength as previous standard C1 and C2 mixes, although some conditions were modified to monitor these related to mixes' performance. Furthermore, 28-day compressive strength was ranges from slightly above 8000 psi to slightly above 7000 psi. These details were also demonstrated in Figure 6-4.

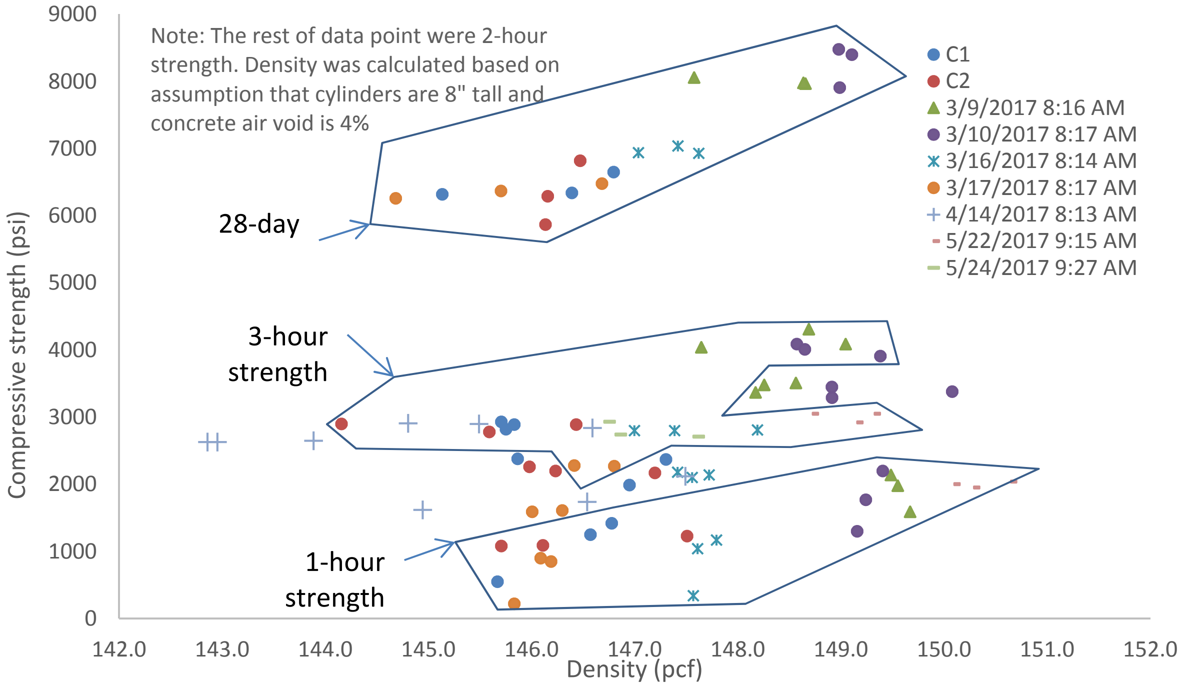


Figure 6-5 Compressive strength and relative density

Furthermore, latex condition had minor effect on concrete compressive strength. Cylinders utilizing new Styrofan had similar appearance as previous mixes as seen in Figure 6-7. Excessive air void covered outside of concrete cylinder. Compressive strength also showed no effect. In May 2017 and further, mixes utilizing new Styrofan had similar compressive strength development as controlled mixes. 3-hour compressive strength was slightly below 3000 psi.

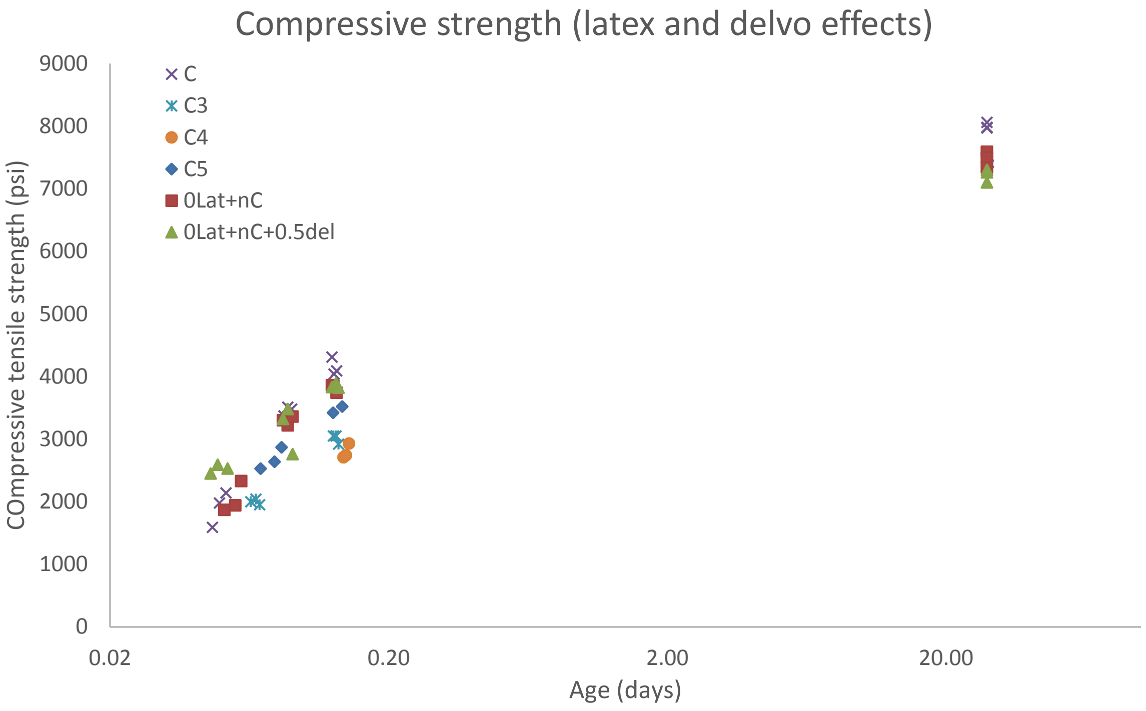


Figure 6-6 Compressive strength vs admixture effects

For these mixes, concrete density was related to compressive strength measured to some extent. Low density leaded to low compressive strength, and opposite. VELSLMC density was generally slightly lower than 150 pcf. For 28-strength, concrete cylinders density increased from 144.5 pcf to 149 pcf as its strength rose from 6000 psi to above 8000 psi. 1-hour and 3-hour showed similar effect of density, but some 1-hour cylinders testing time were 20 minutes offset due to logistics of compressive tests as seen in Figure 6-4.

Figure 6-7 Severe honeycombs of 4”x8” cylinders due to fast drop in workability

Delvo helped slow the initial setting time. During mixing procedure, workability dropped quickly in some mixes. 15-20 minutes, depending on mixing temperature and moisture content, were assumed to be the workability stage of the recommended delvo dosage (26 oz/cwt). Moreover, as explaining before, workability tended to drop quicker at higher mixing temperature. Tougher consolidation progressed as time went by. Decrease in dosage of delvo seemed to have minor effect on compressive strength development. Mix with half of delvo dosage and 100% Styrofan replacement by water on 3/3/2017 had similar 3-hour and 28-day compressive strength as mix with 100% Styrofan replacement on 3/2/2017. However, 1-hour compressive strength was higher than other. In fact, average 1-hour compressive strength increased from 2523 psi to 3187 psi in one hour. 3-hour and 28-day compressive strength reached 3800 psi and 7220, respectively. More mixes with higher Delvo content should be performed to extended VESLMC mixing time without disturbing hardened properties.

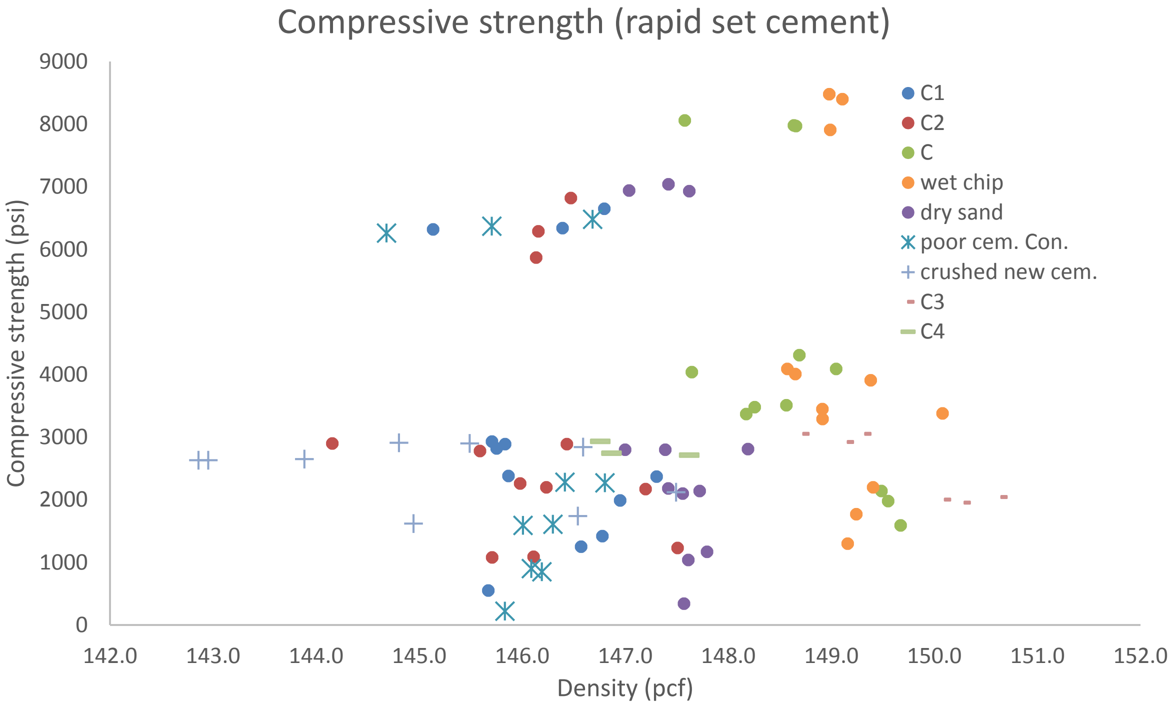


Figure 6-8 Compressive strength vs density (material condition)

Similar to normal concrete, 1.5-hour VESLMC strain corresponding to ultimate stress was about 0.003. However, 3-hour results were 0.0034. Due to testing machine capacity, 28-day results were not able to be recorded. Figure 6-9 suggested strain corresponding to ultimate stress increased over testing age. This assumption was also confirmed in other mixes with variable concrete content. Average 1.5-hour, 3-hour and 28-day elastic modulus were 2641 ksi, 2787 ksi, 4278 ksi, respectively. 3-hour elastic modulus failed requirement (Section 676, 2013) and only slightly increased from 1.5-hour results, even though average 3-hour compressive strength significantly increased from 1.5-hour results. These values were also progressively larger over curing age than calculated elastic modulus of concrete utilizing equation 19.2.2.1.a and

19.2.2.1.b in ACI 318-14 (ACI Committee 318, 2014). Different than the more consistent elastic modulus results with curing age, Poisson's ratio tended to fluctuate considerably. Average within-day result was 0.1228, while average 28-day results increased to 0.1978.

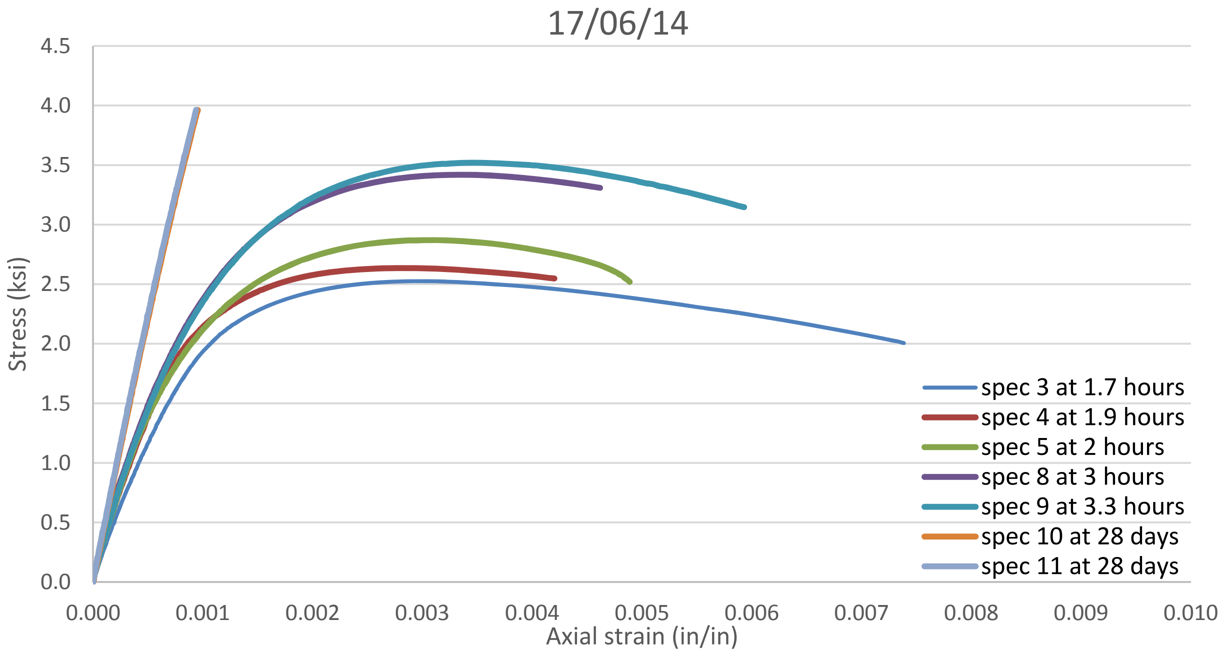


Figure 6-9 Stress-strain of mix C5

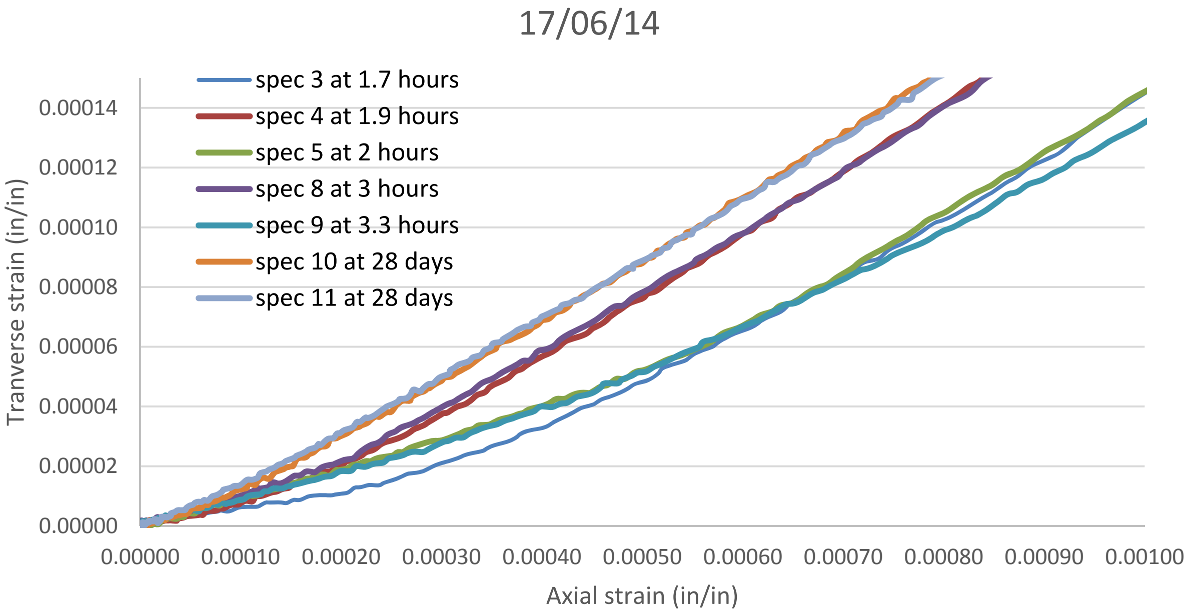


Figure 6-10 Transverse and axial strain of mix C5

Average 1-hour, 1.5-hour, 2-hour, and 3-hour splitting tensile strength were 365 psi, 385 psi, 433 psi, and 816 psi, respectively. These results shown low tensile development within hours, but generated a big leap in 28-day results. Splitting tensile strength was recorded from “Poor cem. Con.” mix on 3/17/2017 and Mix C4 on 5/24/2017. Compressive strength were heavily effected by cement condition, while splitting tensile strength had limited influence by poor cement condition and 8 minutes time extension for mitigation during mixing procedure.

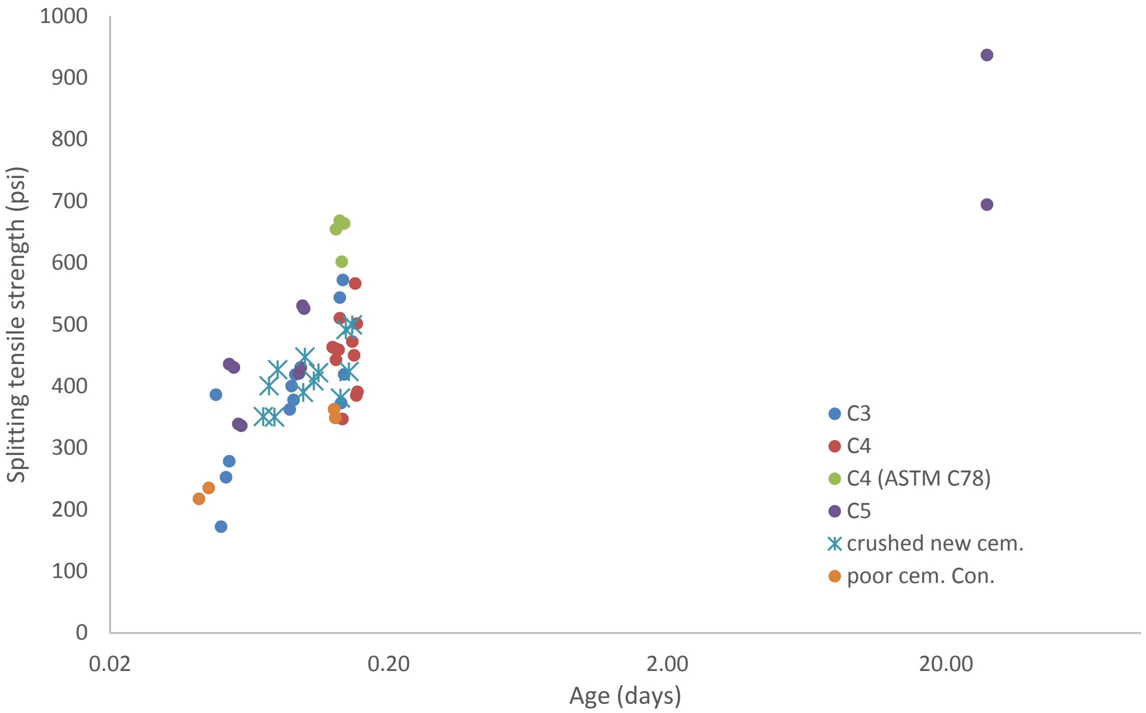


Figure 6-11 Splitting tensile strength of VESLMC with different Rapid Set cement

Average 3-hour rupture modulus of 647 psi was recorded from four 6”x6”x24” prisms in Mix C4 on 5/24/2017. These values were far lower than 28-day rupture modulus requirement, which were 1100 psi at 28-day (Section 676, 2013). Compressive strength and splitting tensile were quite equivalent with other controlled VESLMC mixes. Compressive strength of mentioned mix did not pass its 28-day requirement. Average 3-hour splitting tensile strength of similar mix was still about 70% of corresponding rupture modulus, which were familiar results from regular cement mixes tested in other researches (Olanike, 2014).

Shrinkage results of VESLMC at various curing age were recorded. Plastic shrinkage occurred when water evaporated from the surface of the fresh VESLMC, while autogeneous and drying shrinkage were process of self-dessication and resulting from loss of water. Plastic sheet was placed on top of these forms to reduced plastic shrinkage. Heat sensed from VESLMC cylinders in earlier laboratory mixes suggested that thermal expansion and shrinkage rapidly occurred in the first 3 hour after mixing. Again, these specimens were air cured in lab condition. As the compressive strength development, values were recorded along its curing age after 3 hours.

Average 3.5-hour shrinkage was 47x10^{-6}, and the average 3-month record reached 433x10^{-6}. From other researches, ordinary concrete had shrinkage of 500x10^{-6} (BASF), while high strength concrete 419x10^{-6} (Šahinagić-Isović, Markovski, & Ćećez, 2012).

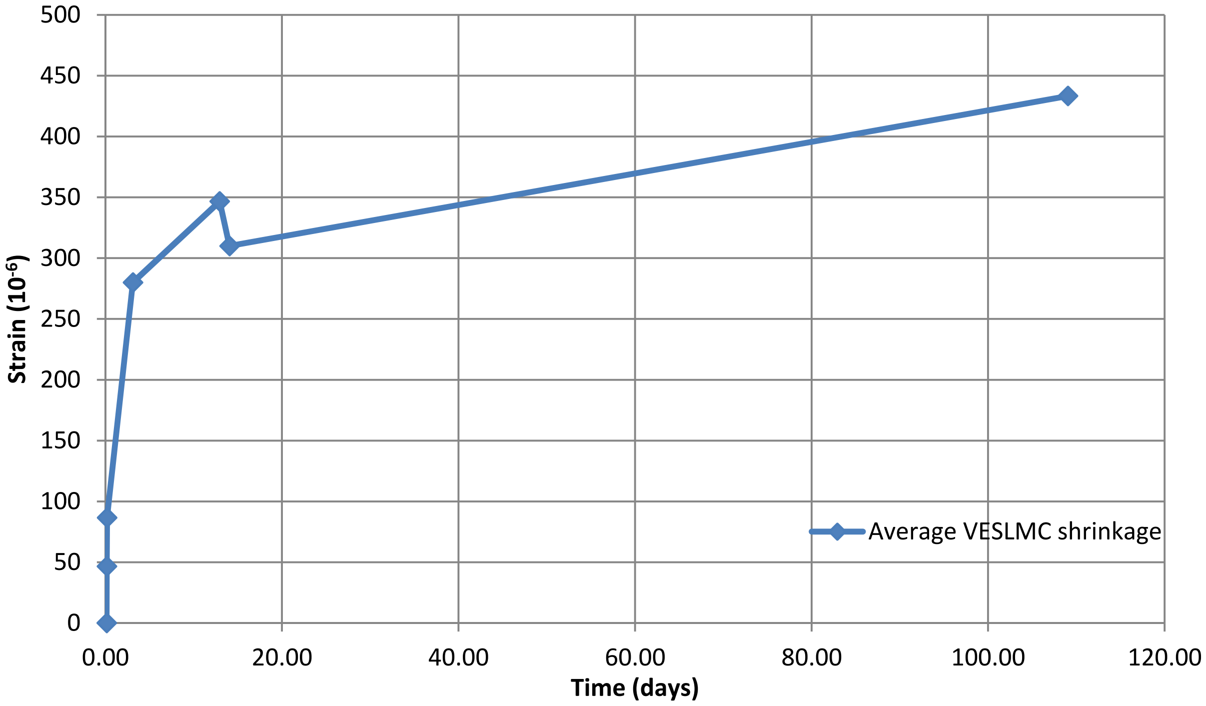


Figure 6-12 VESLMC shrinkage results

Improper practice of core drilling and epoxy application might prevent collecting exact data for analysis. However, certain conclusion could be drawn from results. Substrate condition differentiated pull-off tensile results. Lower results were recorded on air-dry substrate side due to lower curing age. However, this phenomenon also occurred at similar curing age on other mixes. Although there was difference in testing age, majority of failure occurred at substrate layers. 2 coring tests on each side at difference testing age, and these were comparable. Table 5-5 had more details.

6.2.2. Rapid Set-cement mixes with cement content difference

Extra Rapid Set cement adding to mixes would increase its compressive strength. Average 3-hour compressive strength was 3600 psi. On the other hands, lower cement content tended to lower compressive strength. Average 3-hour compressive strength was about 1600 psi, where average of controlled mixes was 2900 psi. Compressive strength dropped severely when more cement added to the mix. The difference was distinctive. Average 28-day compressive strength by deducting 14.28% cement from the mix was 4280 psi, which was about 2/3 average compressive strength of control mixes. Average 3-hour compressive strength of less-cement-content mix was 1586 psi. Their strength development curves were distinctively separated from controlled ones. These could be observed in Figure 6-14. Control mixes 1 and 2 were similar to design mix. RS+94 and RS-94 were mixes with 94 lbs more and 94 lbs less cement for 1 cubic yard batch, respectively. They were equivalent to 14.28% increase or decrease. RS1+94 and RS1-94 were coded similar way.

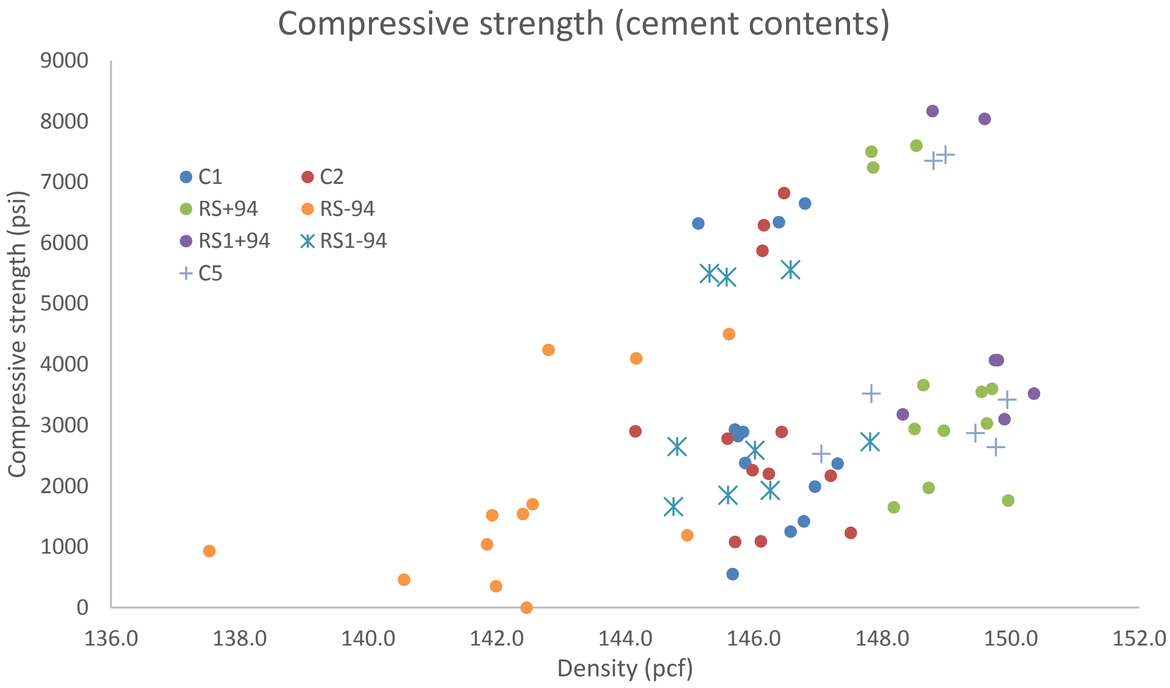


Figure 6-13 Compressive strength vs density (cement content)

However, these two mixes utilized new cement, which were both sieved through No.4 sieve. This helped eliminate partially hydrated cement which occurred during transportation and delivery. High heat of hydration during the first couple hours of hydration coincides with the rapid increase in compressive strength. The average 3-hour compressive strength of control mix C5 was 3470 psi, which exceeded the 3-hour compressive strength requirement in the repair project specification (3000 psi). The average 3-hour compressive strength of the mix with 94 lbs /cyd of cement removed from the mix was 2657 psi. The average 3-hour compressive strength of the mix with 94 lbs /cyd of cement added to the mix was 4070 psi and the average 28-day compressive strength was 8105 psi.

Small changes in density had a more significant impact on long-term compressive strength than on short-term strength. Figure 6-13 suggests that the 28-day compressive strength of higher density concrete cylinder was higher. Higher cement content produced higher density concrete product, while lower cement content had opposite effect. Cement condition also played an important role in these results. However, in order to be comparable, mixes with similar cement condition and consolidation were related. With pre-existing cement in the UH structural lab, concrete density ranged from high 138 pcf of low-cement-content batch to 150 pcf of higher-cement-content one. With better condition cement, concrete density ranged from 145.8 pcf of low-cement-content one to 149 pcf of high-cement-content one.

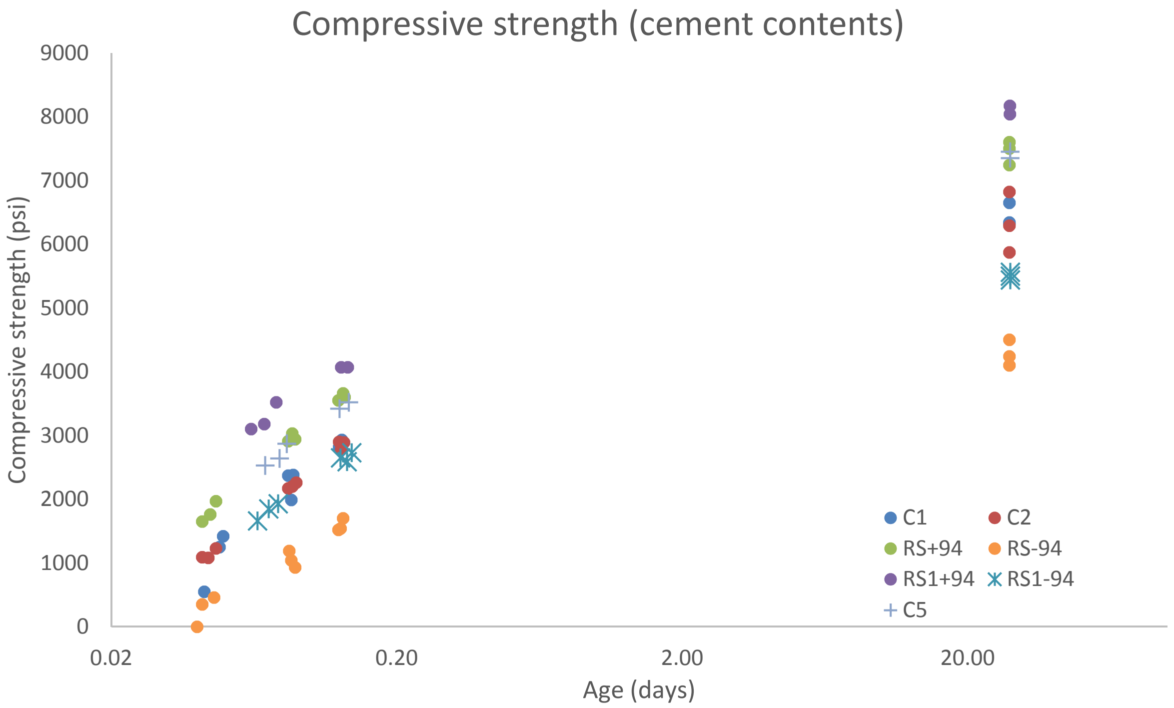


Figure 6-14 Compressive strength due to cement content

In fact, average 28-day compressive strength of all mixes in Figure 6-14 were well above 6000 psi except mixes with 94 lbs cement deducted from 1-cubic-yard mixes. Average 28-day compressive strength of Rapid Set cement condition as delivery was 4280 psi and was much lower compared to 5500 psi of mix with treated Rapid Set cement.

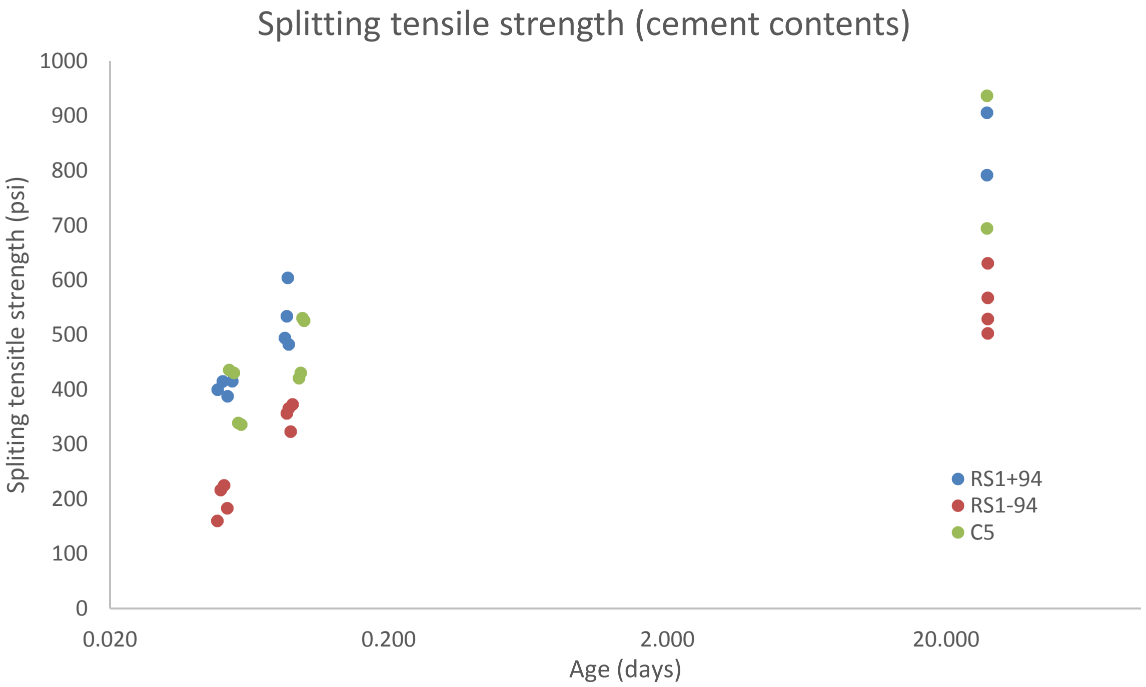


Figure 6-15 Splitting tensile strength due to cement content

Splitting tensile strength of concrete was also affected by cement content. More cement tended to increase splitting tensile strength as well as compressive strength. The effect was not clear between controlled mix and one with more cement due to low number of samples. However, it was more distinctive when results were compared between lower-cement-content and higher one. Average 2.5-hour splitting tensile strength of mix with 94 lbs cement added was 477 psi while controlled mix had similar results of 449 psi. 28-day results Lower-cement-content mix had average 2.5-hour splitting tensile strength of 355 psi. 28-day results only reached 557 psi.

Average 1.5-hour, 3-hour, and 28-day elastic modulus of cement-content-increased mix were 2732 ksi, 3201 ksi, and 4552 ksi, respectively. These values significant improve (ACI Committee 318, 2014) (ACI Committee 318, 2014) (ACI Committee 318, 2014)d from regular VESLMC mix and passed elastic modulus requirement (Section 676, 2013). Similar to the VESLMC controlled Mix C5 on 6/14/2017, these were also progressively larger over curing age than calculated elastic modulus of concrete based on compressive strength in ACI 318-14 (ACI Committee 318, 2014). Poisson's ratio swayed with high coefficient of variance. Average within-day and 28-day Poisson's ratio was 0.1617 and 0.1994, respectively. 28-day results seemed consistent with regular VESLMC mix's, while within-day results distinctively higher. Average strain of 3.16x10^{-3} corresponding to ultimate stress was recorded from 1.5-hour to 2-hour air curing. 3-hour results were not estimated due to MTS compression testing machine's limit.

Average 1.5-hour, 3-hour, and 28-day elastic modulus of cement-content-decreased mix were 1996 ksi, 2433 ksi, and 3707 ksi, respectively. These values were significant decline from regular

VESLMC mix and none of these passed elastic modulus requirement (Section 676, 2013). Similar to the VESLMC controlled Mix C5 on 6/14/2017, these were also progressively larger over curing age than calculated elastic modulus of concrete based on compressive strength in ACI 318-14 (ACI Committee 318, 2014). Average within-day and 28-day Poisson's ratio were 0.1318 and 0.144, respectively. Average 28-day Poisson's ratio of 2 cylinders was as low as within-day result. Strain corresponding to ultimate strength increased from $3.16\text{x}10^{-3}$ at 1.5-hour air curing age to $3.43\text{x}10^{-3}$ at 3-hour age. As their corresponding compressive strength results were lower than higher-cement-content mix's, strain corresponding to ultimate compressive stress increased.

Besides splitting tensile strength, pull-off tests results also were recorded for these mixes. Average results of higher-cement-content mix on the saturated surface dry side performed better than the dry side. On the air-dry side, there was also conspicuous increase in tensile strength of repair material from 56 days to 102 days curing age. Failure occurred in repair material at 56th day while in substrate at 102nd day. However, in the saturated surface dry area, tensile strength of material matured at 56th day enough that all failure happened in substrate and bonding interface.

On the other hands, with the lower-cement-content mix, pull-off tests showed most failure occurrence at substrate. Their values were equivalent considering substrate condition. Most values of the successful pull-off tests, which were obtained on 64th day and 96th day, were comparatively equal with each other. Average of 2 results on the dry side was slightly higher than saturated surface dry side. Higher-cement-content mix still performed better than lower one based on their average results at 56th day and 64th day, respectively.

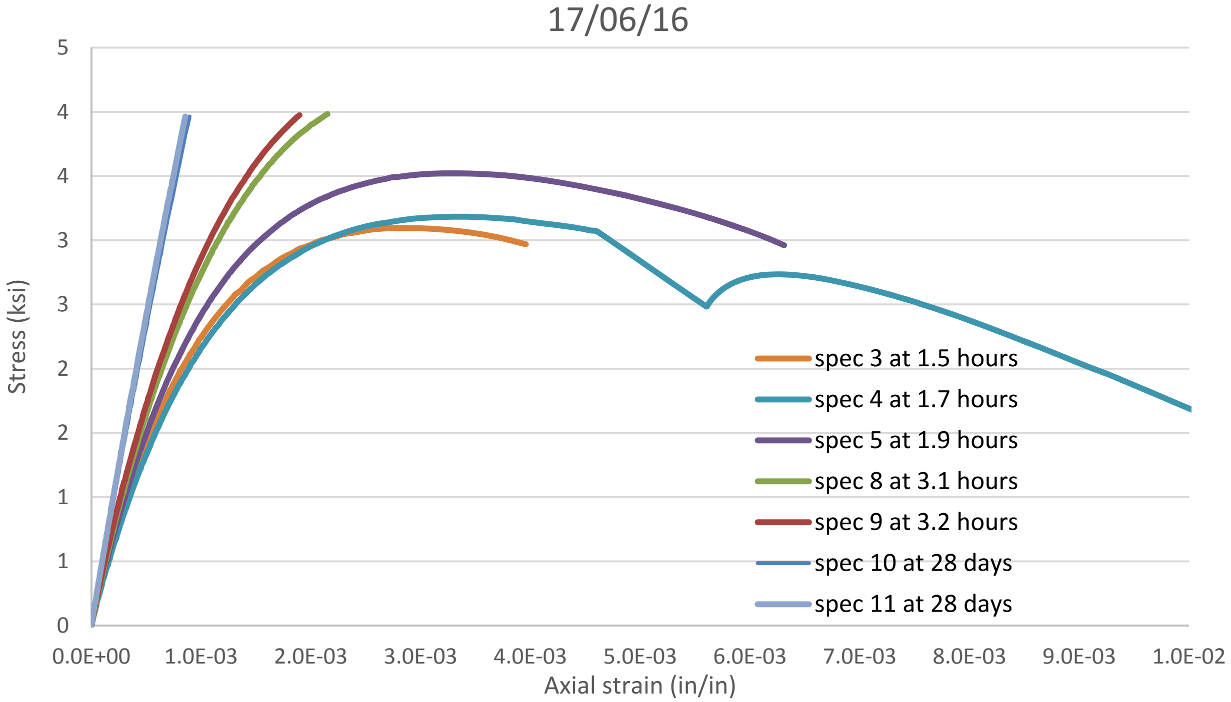


Figure 6-16 Stress-strain development of Mix RS1+94 on 6/16/2017

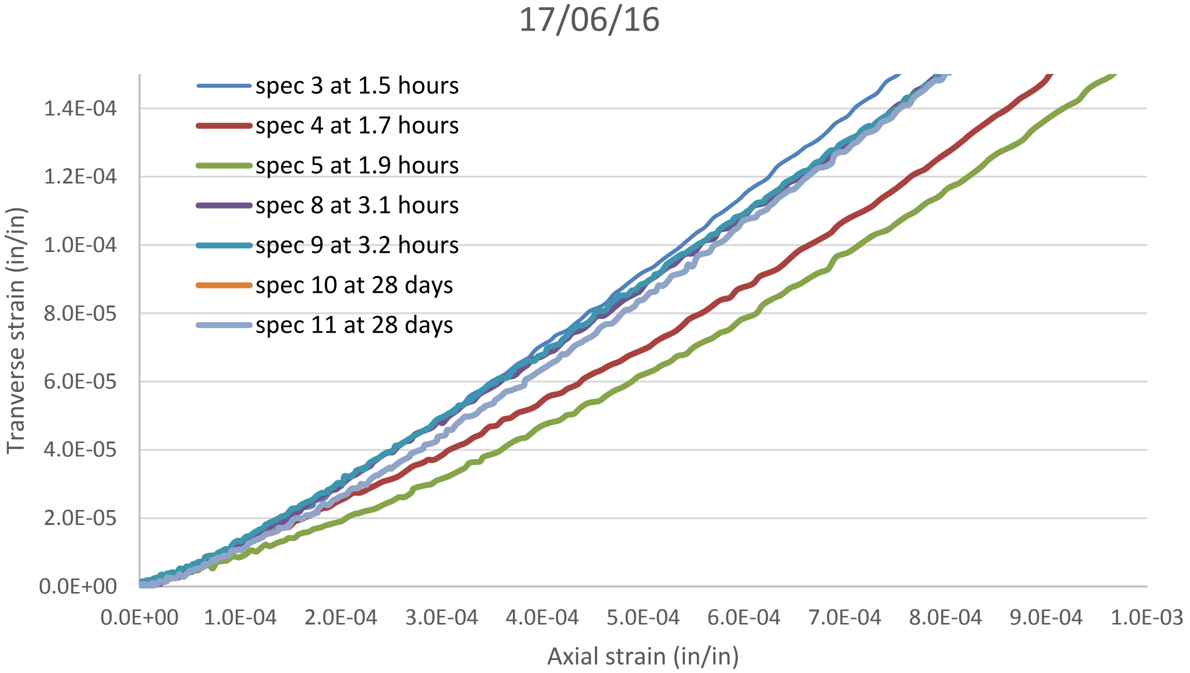


Figure 6-17 Transverse and axial strain of Mix RS1+94 on 6/16/2017

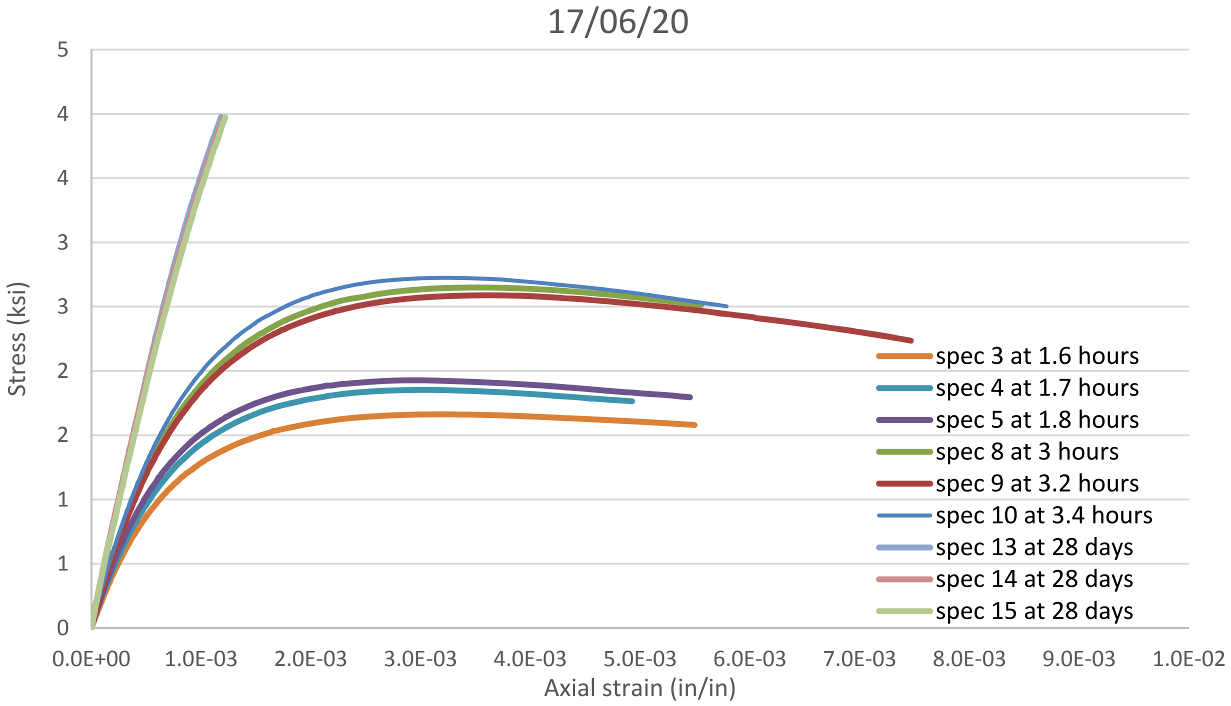


Figure 6-18 Stress-strain development of Mix RS1-94 on 6/20/2017

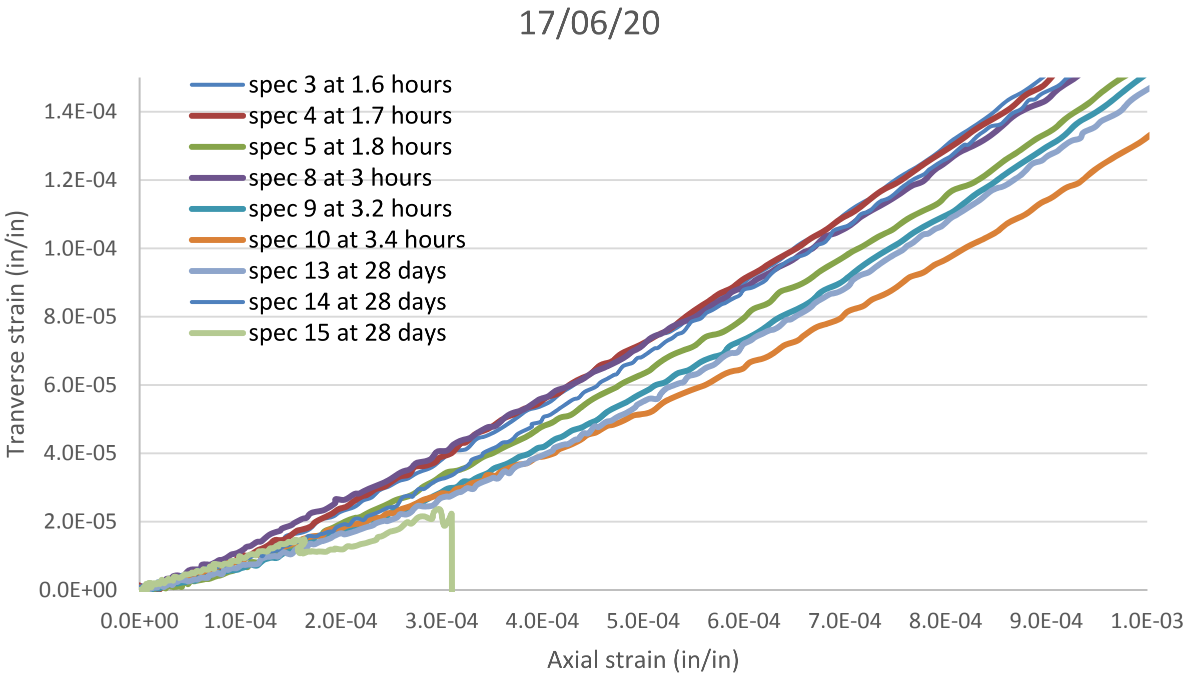


Figure 6-19 Transverse and axial strain of Mix RS1-94 on 6/20/2017

Note: Transverse extensometer failed during specimen 15 testing. This only voided Poisson's ratio value.

6.2.3. Water content effect

Water, however, had minor effect on concrete compressive strength. Early strength of concrete would not be affected as water increase. In fact, 1-hour and 2-hour compressive strength experienced almost no effect from 10%-water-altered mixes. Average 1-hour compressive strength results of 10%-water-increased and 10%-water-decreased mixes were 1113 psi and 890 psi, respectively. The average 2-hour compressive strength progressed to 1860 psi and 2070 psi, respectively. Average 3-hour compressive strength of 10%-water-increased mix was 2107 psi, and equivalent result of 10%-water-decreased mix was 2610 psi. While average 28-day compressive strength of the 10%-water-increased mix was 5167 psi, average 28-day compressive strength of 10%-water-decreased water 6463 psi. Average 1-hour, 2-hour, 3-hour, and 28-day compressive strength of controlled mixes were 1103 psi, 2228 psi, 2868 psi, and 6382 psi, respectively. These values were either higher or equivalent with corresponding ones from water-content-altered mix. This detail revealed that VESLMC potentially reached its optimum water content. With pre-existing Rapid Set cement condition, only 10%-water-decreased mix could reach 28-day compressive strength requirement, and none qualified for 3-hour one.

Density of concrete varied as water content changes. With preexisting Rapid Set cement condition, lower density responded to higher w/c ratio. 10%-water-content-increased mix had average density of 141 pcf, while 10%-water-content-decreased mix had average density of 147.8 pcf. As mentioned above, average density of 24 controlled VESLMC cylinders were 146.2 pcf.

As cement condition improved, controlled and water-altered mixes density slightly improved, and their compressive strength, as mentioned above, significantly improved. 10%-more-water-content mix had average density of 145.6 pcf, while 10-less-water-content mix had average density of 146.7 pcf. They were both lower than 148.6 pcf average density of controlled mix. Other than low density concrete corresponding to higher w/c ratio, average density of controlled mixes had higher record than water-content-altered mixes, though the difference was only distinctive as seen in Figure 6-22.

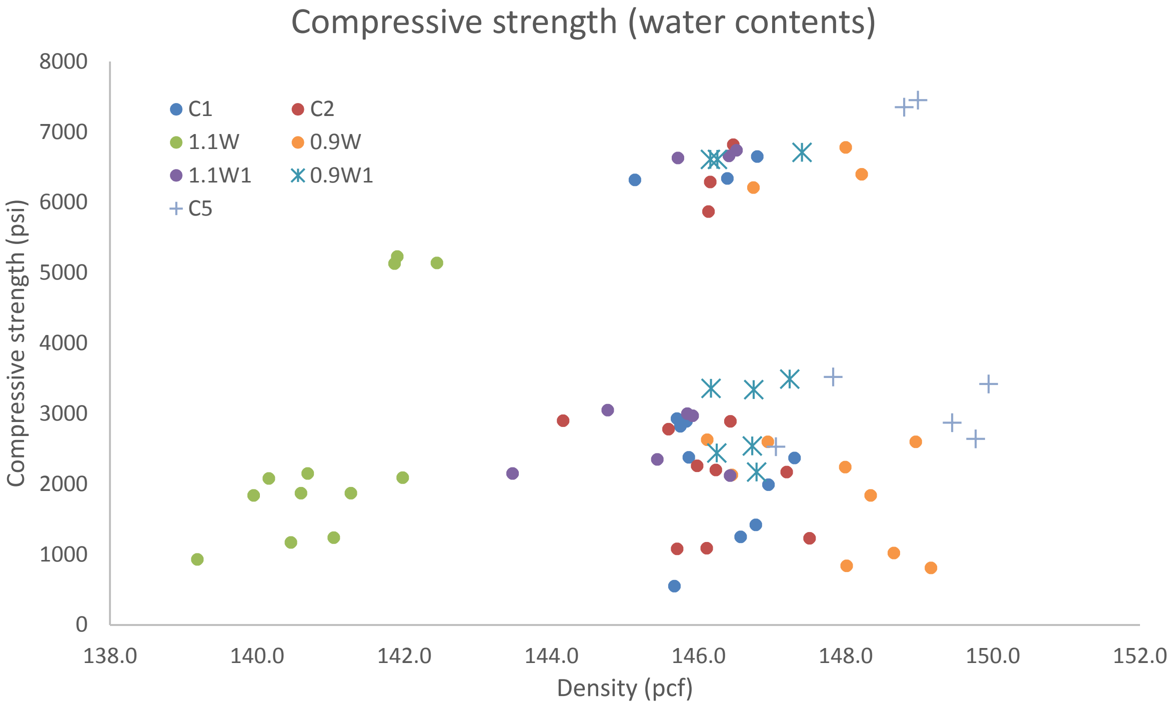


Figure 6-20 Compressive strength vs density (water content)

Note that 10% water did not mean 10% w/c ratio but was only equivalent to 3.58% increase or decrease in w/c ratio.

With better condition cement, these similar mixes were able to reach higher compressive strength. 1.5-hour compressive strength of 10%-water-increased mix was 2207 psi, and 3-hour compressive strength was 3007 psi. Average 28-day compressive strength was 6677 psi and was well above 6000 psi. Meanwhile, 1.5-hour compressive strength of water-decreased mix was 2383 psi, and 3-hour compressive strength was 3397 psi. Average 28-day compressive strength of 10%-water-decreased mix was 6643 psi, which was abnormally lower than the controlled mix. These mixes were air curing, so there was possibly not enough water for further cement hydration during curing period (air curing). Note that 28-day compressive strength utilizing better-conditioned cement was loaded twice due to compressive capacity of lab equipment. Overall, effect of water content decrease and increase were not distinctive on compressive strength, and more mixes should be performed to confirm. These results also showed that cement condition played even more crucial than water content in general.

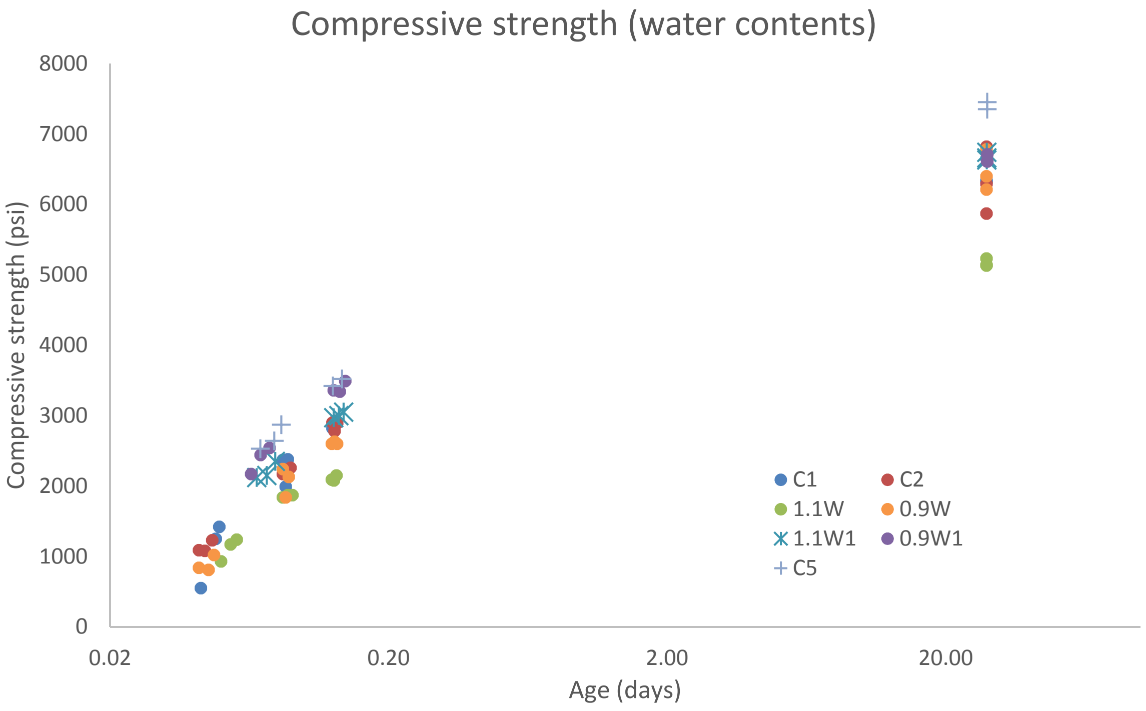


Figure 6-21 Compressive strength and water content

However, 28-day compressive strength revealed more about effect of water. Moisture in mix design reached its optimum level. With pre-existed cement, 28-day compressive strength of 10%-water-increased mix dropped to 5167 psi, and 3-hour compressive strength was only 2107 psi. Similar results of 10%-water-decreased mix reached 6463 psi and 2610 psi, respectively. These values were both equivalent and lower than ones from regular mixes. With new cement condition, 28-day compressive strength of 10%-water-increased mix dropped to 6677 psi, and 3-hour compressive strength was only 3007 psi. Similar results of 10%-water-decreased mix reached 6643 psi and 3397 psi.

These values were also much lower than ones from regular mix with better cement condition. Splitting tensile strength tests were performed with new cement content, the results responded similarly to compressive strength results. Splitting tensile strength also reflected similar results. 2-hour splitting tensile strength of regular mix was 477 psi, which was higher than 360 psi of 10%-water-increased mix and 399 psi of 10%-water-decreased mix. 28-day splitting tensile strength of more-water and less-water mixes could only reached 683 psi and 763 psi, respectively. These values also lower than 816 psi average 28-day splitting tensile strength of controlled mix. While average 1.5-hour results of the controlled mix were 385 psi, the corresponding results of 10%-water-increased and 10%-water-decreased mix were 257 psi and 226 psi, respectively. Notice that it was less distinctive in splitting tensile strength development than one from cement-altered mixes in Figure 6-15. More water tended to cause more severe drop in splitting tensile strength and compressive strength. These results could be seen in Figure 6-23 and again confirmed the optimum moisture content of VESLMC mix design.

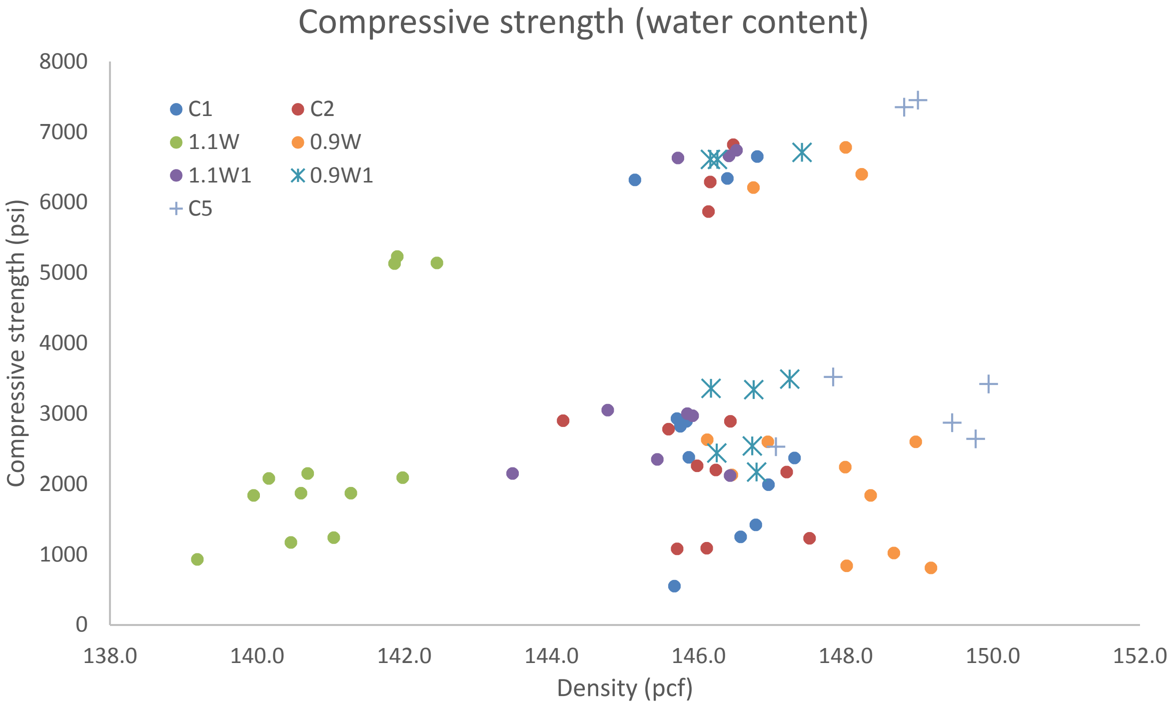


Figure 6-22 Compressive strength vs density (water content)

Average 1.5-hour, 3-hour, and 28-day elastic modulus of water-content-increased mix were 2251 ksi, 2598 ksi, and 3893 ksi, respectively. These values were significant drops from regular VESLMC mix and none of the results passed elastic modulus requirement (Section 676, 2013). Similar to the previous mixes, these were also progressively larger over curing age than calculated elastic modulus of concrete based on compressive strength in ACI 318-14 (ACI Committee 318, 2014). Poisson's ratio swayed with high coefficient of variance. Average 1.5-hour, 3-hour, and 28-day Poisson's ratio was 0.1361, 0.1460, and 0.1719, respectively. 1.5-hour and 3-hour results seemed consistent with each other and with regular VESLMC mix. While 28-day results of slightly lower than corresponding results from VESLMC, it was still significant increase from within-day results. Average strain of 3.0×10^{-3} corresponding to ultimate stress was recorded from 1.5-hour curing age, and 3-hour air curing increase average results to 3.32×10^{-3}. Strain corresponding to ultimate stress development was similar to one from VESLMC.

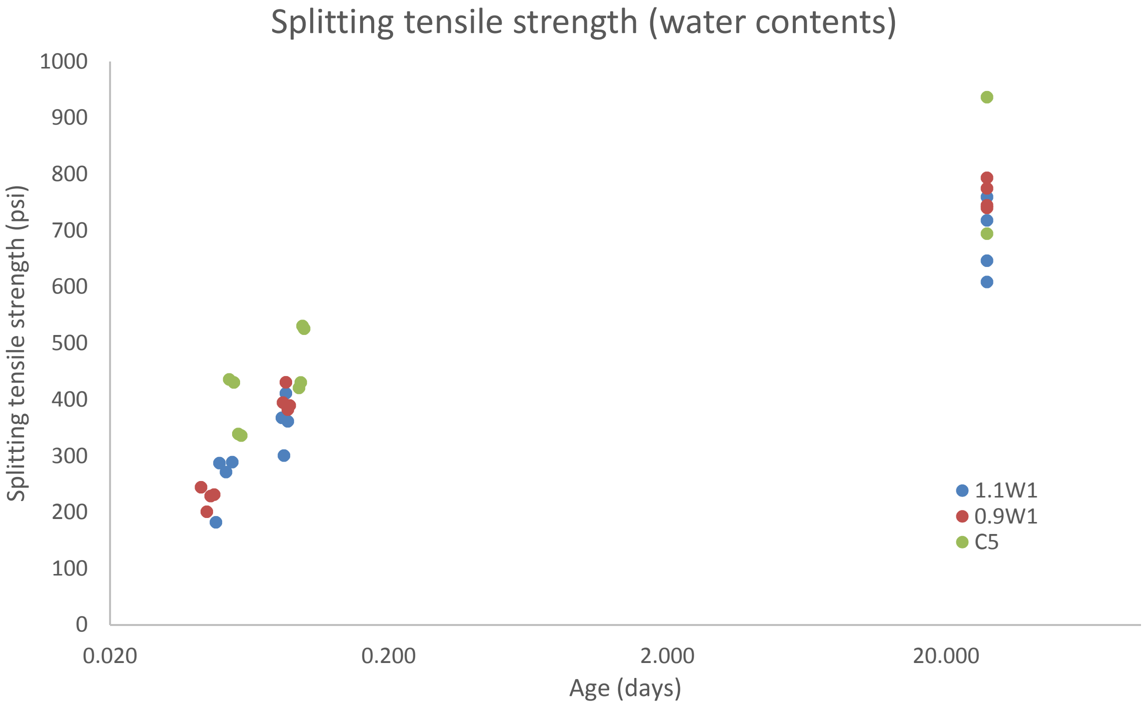


Figure 6-23 Splitting tensile strength due to water content

Average 1.5-hour, 3-hour, and 28-day elastic modulus of water-content-decreased mix were 2286 ksi, 2741 ksi, and 4070 ksi, respectively. These values were significant drops from regular VESLMC mix. 3-hour results did not pass elastic modulus requirement, but 28-day results narrowly did (Section 676, 2013). Similar to the previous mixes, these were also progressively larger over curing age than calculated elastic modulus of concrete based on compressive strength in ACI 318-14 (ACI Committee 318, 2014). These again explained previous assumption that moisture content in mix design had reached its optimum level. Poisson's ratio swayed with high coefficient of variance. Average 1.5-hour, 3-hour, and 28-day Poisson's ratio was 0.13, 0.147, and 0.176, respectively. 1.5-hour and 3-hour results seemed consistent with each other, and regular VESLMC mix. There was almost no difference between these values and 10%-water-content-increased mix's results. While 28-day results of slightly lower than corresponding results from VESLMC, it was still significant increase from within-day results. Average strain corresponding to ultimate stress of 3.49×10^{-3} was recorded from 1.5-hour curing age, and 3-hour air curing increase average results to 3.55×10^{-3}. There was no significant increase between them. While 1.5-hour results were much higher than corresponding results in VESLMC mix, 3-hour results were on slightly higher.

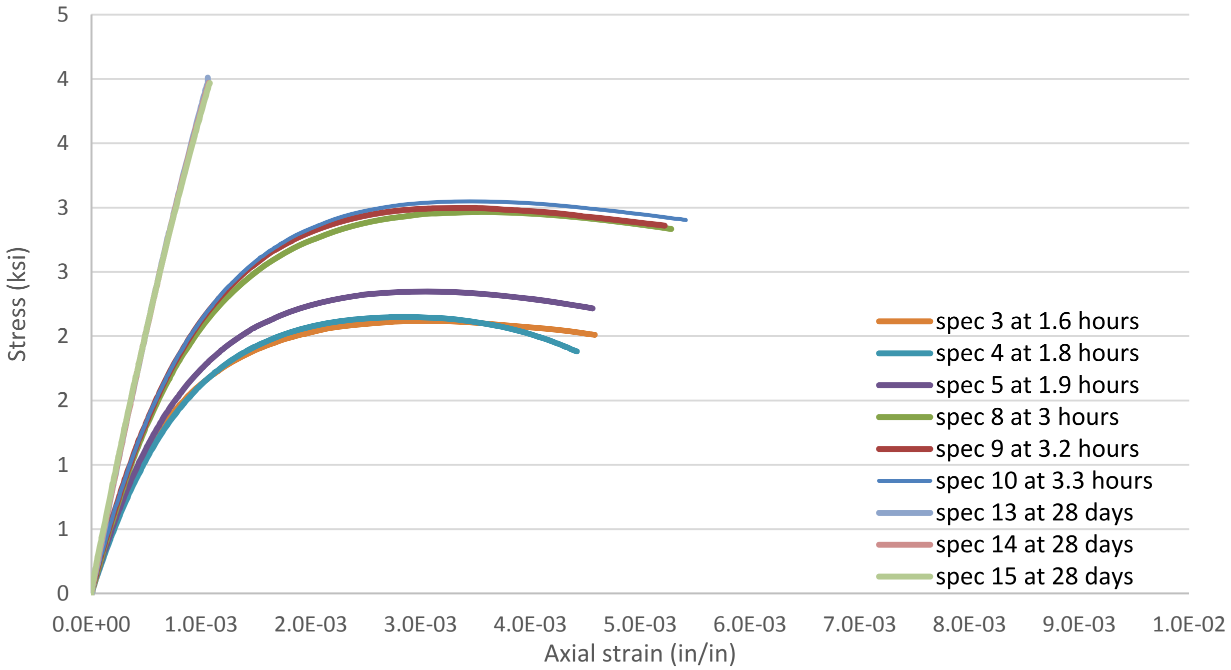


Figure 6-24 Stress-strain development of Mix 1.1W1 on 7/5/2017

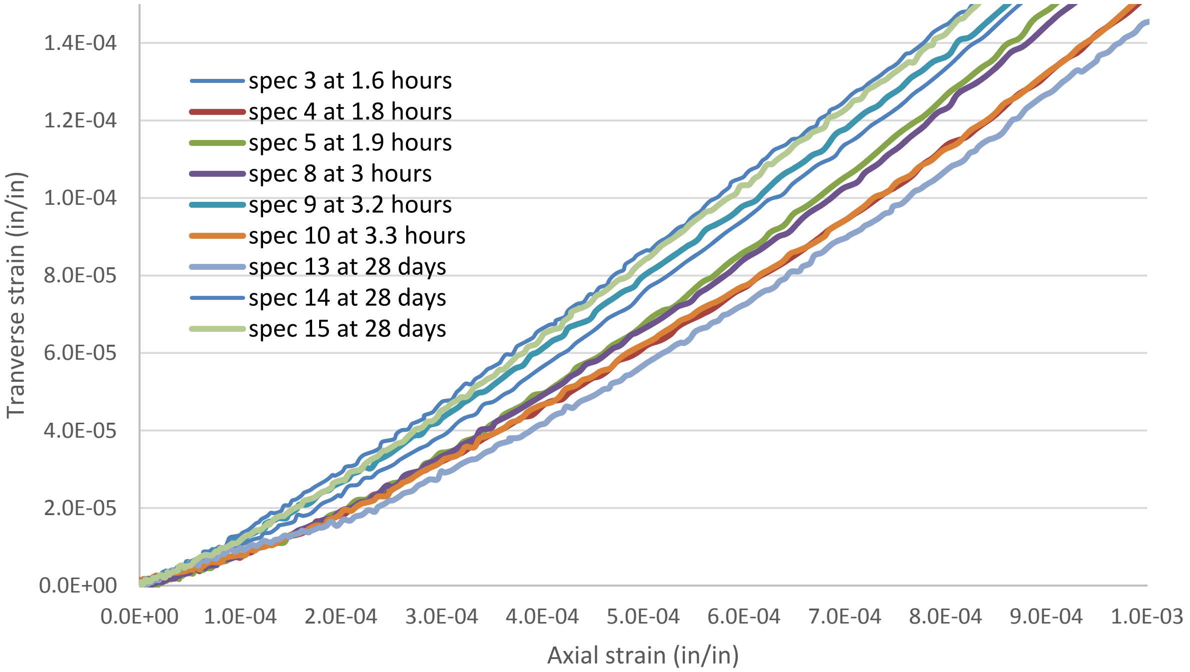


Figure 6-25 Transverse and axial strain of Mix 1.1W1 on 7/5/2017

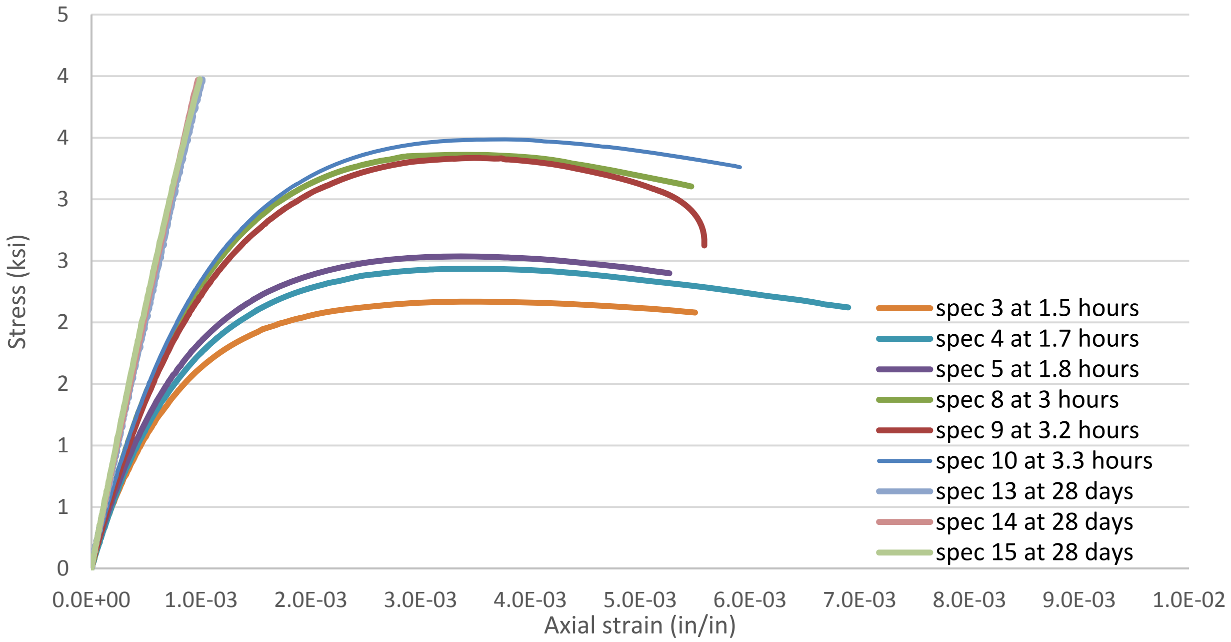


Figure 6-26 Stress-strain development of Mix 0.9W1 on 7/7/2017

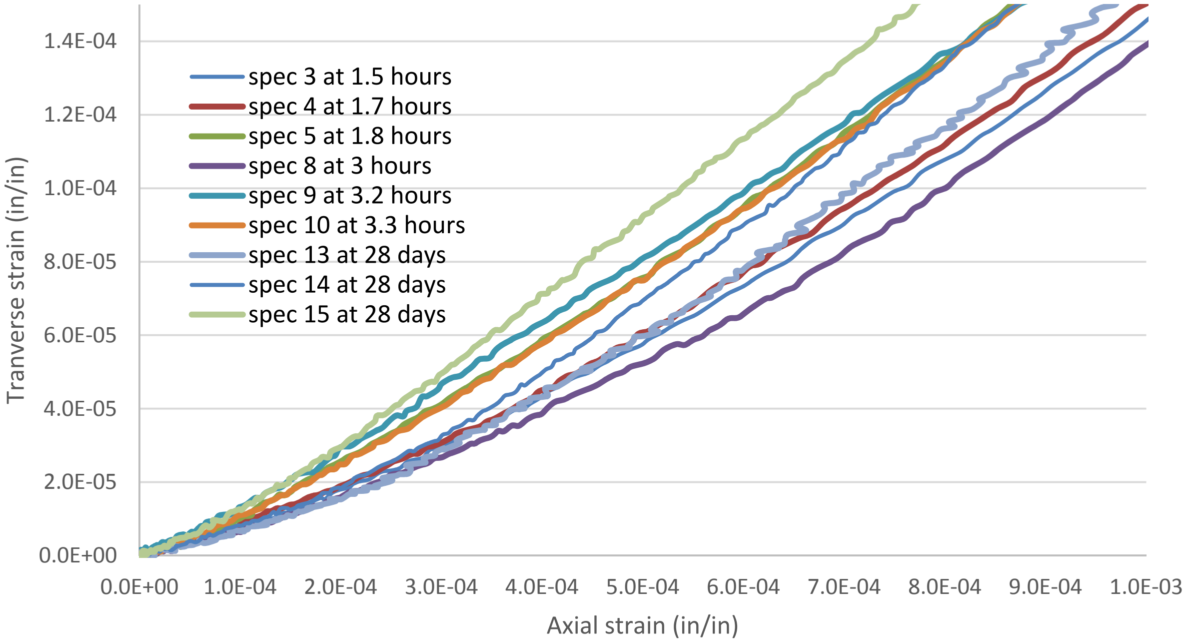


Figure 6-27 Transverse and axial strain of Mix 0.9W1 on 7/7/2017

6.2.4. Latex effect

Latex, however, had major effect on concrete compressive strength. Early strength of concrete would not be affected as moisture increase. In fact, 1-hour compressive strength saw almost no effect from change of 10% increase or decrease in latex. Average 1-hour compressive strength results of 10%-latex-increased and 10%-latex-decreased mixes were 700 psi and 1167 psi, respectively. These results were more considerably severe than water-altered mix. The average 2-hour compressive strength progressed to 1723 psi and 2083 psi, respectively. Average 3-hour compressive strength of 10%-latex-increased mix was 2270 psi, and equivalent result of 10%-latex-decreased mix was 2477 psi. While average 28-day compressive strength of the 10%-latex-increased mix was 5767 psi, average 28-day compressive strength of 10%-latex-decreased water 5713 psi. Average 1-hour, 2-hour, 3-hour, and 28-day compressive strength of controlled mixes were 1103 psi, 2228 psi, 2868 psi, and 6382 psi, respectively. These values were either higher or equivalent with corresponding ones from latex-content-altered mix. This detail revealed that VESLMC potentially reached its optimum water content. With pre-existing Rapid Set cement condition, none of latex-content-altered mix reached 28-day compressive strength requirement, and none qualified for 3-hour one.

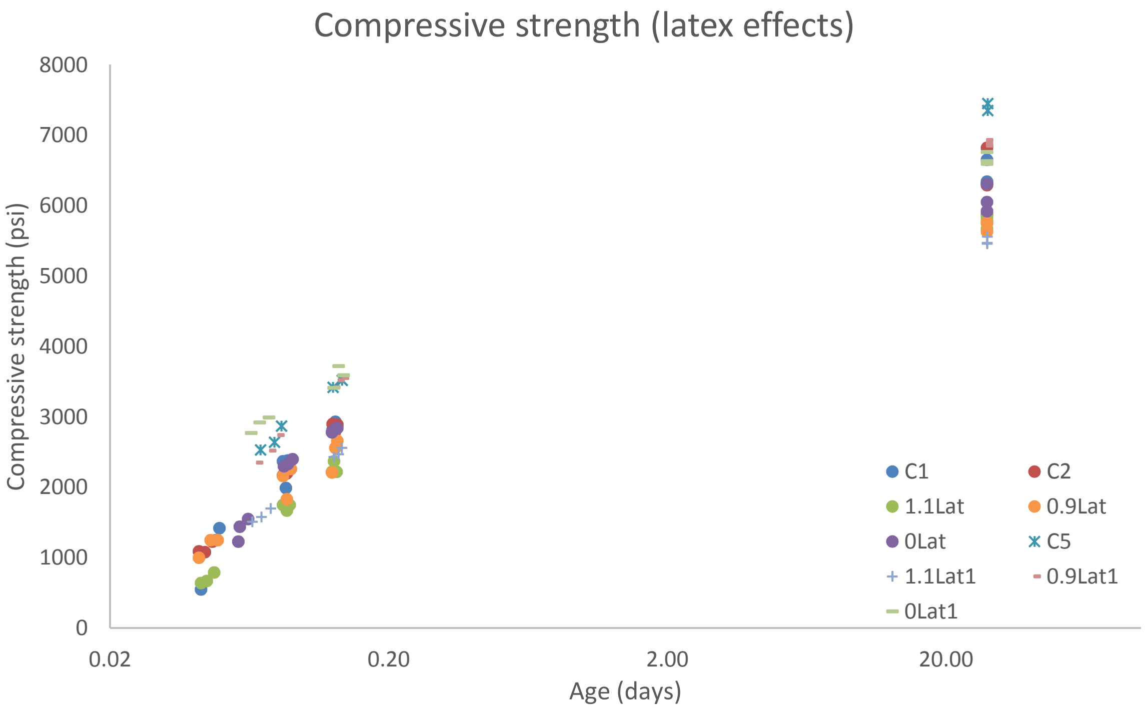


Figure 6-28 Compressive strength and latex content

With previous-conditioned Rapid Set cement, mix with no latex had their early compressive strength equivalent to controlled mixes. The color of cylinders was a bit brighter than VESLMC. Average 1-hour, 2-hour, 3-hour, and 28-day compressive strength were 1407 psi, 2343 psi, 2813 psi, and 6093 psi, respectively. Without latex, compressive strength development was slightly lower to similar to VESLMC. 3-hour compressive strength did not passed requirement, but 28-day results did. (Section 676, 2013)

With better condition cement, these similar mixes were able to reach higher compressive strength. 1.5-hour compressive strength of 10%-latex-increased mix was 1597 psi, and 3-hour compressive strength was 2487 psi. Average 28-day compressive strength was 5497 psi and was well below 6000 psi. Meanwhile, 1.5-hour compressive strength of 10%-latex-decreased mix was 2537 psi, and 3-hour compressive strength was 3497 psi. Average 28-day compressive strength of 10%-latex-decreased mix was 6887 psi, which was abnormally lower than the controlled mix. Therefore, these values surpassed compressive strength requirement (Section 676, 2013). These mixes were air curing, so there was possibly not enough water for further cement hydration during curing period (air curing). Note that 28-day compressive strength utilizing better-conditioned cement was loaded twice due to compressive capacity of lab equipment. Overall, effect of latex content decrease and increase were better distinctive than water-altered VESLMC on compressive strength. These results also showed that cement condition played even more crucial than water content, in general.

With new conditioned Rapid Set cement, water-only mix had better early compressive strength than VESLMC mix. Average 1.5-hour, 3-hour, and 28-day compressive strength were 2893 psi, 3573 psi, 6660 psi. These values passed all compressive strength requirements (Section 676, 2013). Average 3-hour compressive strength was higher than controlled mixes, while 28-day compressive strength was lower. This bolstered the previous assumption that water-only mix performed better than VESLMC in compressive strength.

Density of concrete was ranges from 144 pcf to 154 pcf for all mixes. With low conditioned Rapid Set cement, adjusting latex content tended to increased product density. However, they decreased compressive strength as discussed above. With new-conditioned Rapid Set cement, density of latex-content-altered mix, in opposite, slightly lower than controlled mix. Their average compressive strength at all curing ages, nevertheless, were either equivalent or lower than controlled mix. Different levels of workability affecting consolidation were recorded. 10%-more-latex mixes had better workability condition than controlled and 10%-less-latex mix.

Latex foaming seemed to be norm in VESLMC. It indicated on the appearance of concrete cylinders as seen on Figure 6-7. Tiny air voids could be observed on these. Water-only mix had less severe appearance than VESLMC.

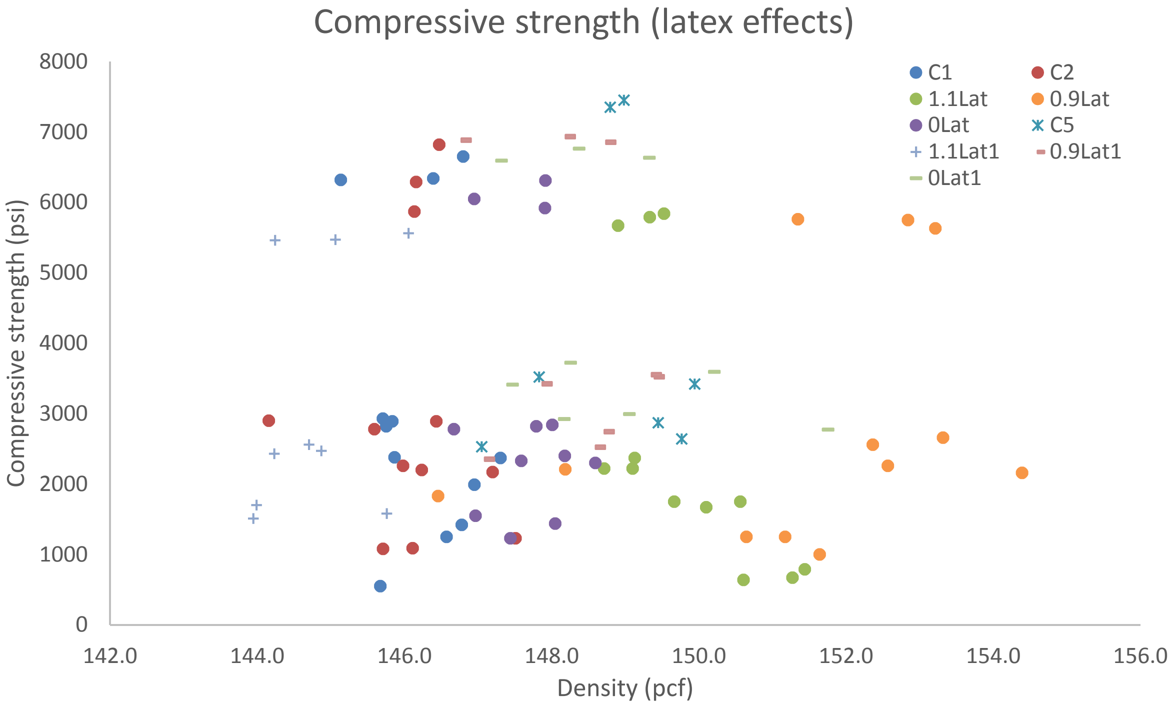


Figure 6-29 Compressive strength vs density (latex content)

Splitting tensile strength experienced significantly drop due to moisture difference. Average 1-hour, 2-hour, and 28-day splitting tensile strength of 10%-latex-content-increased mix were 226 psi, 399 psi, and 763 psi, respectively. These values, when 10% latex was deducted from the mix design, dropped to 145 psi, 296 psi, and 706 psi, respectively. These values, overall, lower than regular mix design results. Moisture content had more important role than latex content when it came to splitting tensile stress.

Splitting tensile strength of VESLMC was greater than water-only mix. Average 1-hour, 2-hour, and 28-day splitting tensile strength of water-only mix were 218 psi, 372 psi, and 568 psi, respectively. 28-day results were lowest of all latex-content-altered mix. These values were relatively lower than controlled mix's. Latex indeed helped tensile strength of concrete. This also explained lower average 28-day compressive strength of water-only mix. Latex took more than couple hours to harden and to develop bonding within concrete matrix.

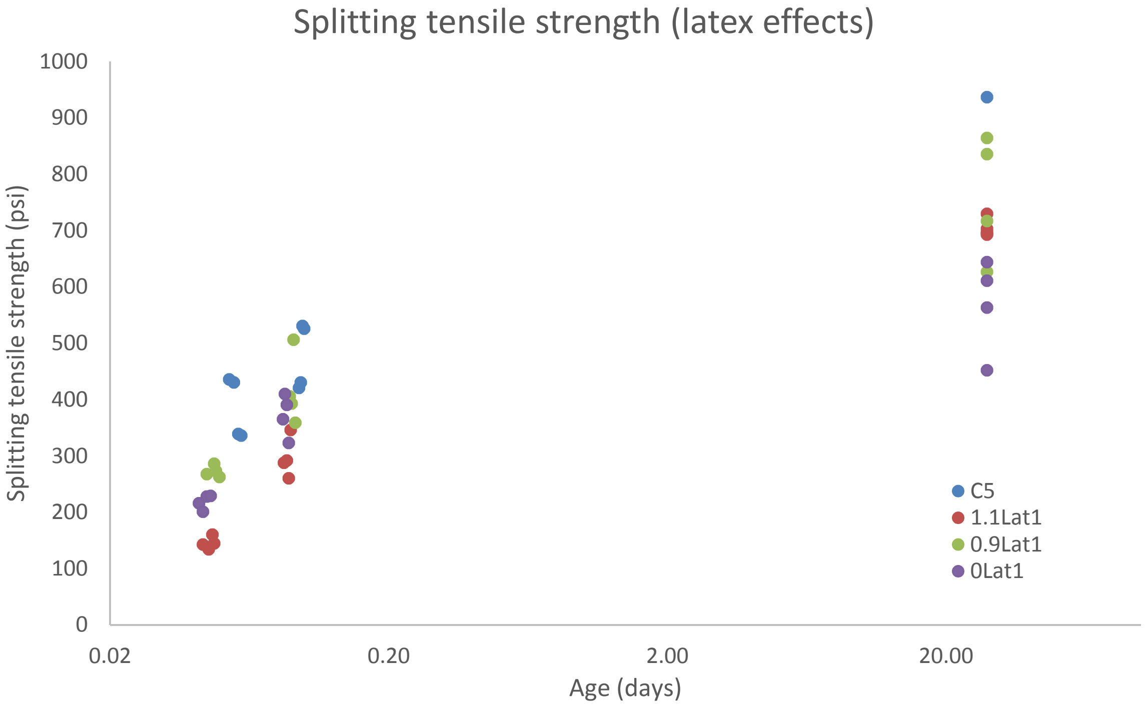


Figure 6-30 Splitting tensile strength due to latex content

Average 1.5-hour, 3-hour, and 28-day elastic modulus of latex-content-increased mix were 1705 ksi, 2208 ksi, and 3619 ksi, respectively. These values were significant drops from regular VESLMC mix and none of the results passed elastic modulus requirement (Section 676, 2013). Similar to the previous mixes, these were also progressively larger over curing age than calculated elastic modulus of concrete based on compressive strength in ACI 318-14 (ACI Committee 318, 2014). Different from the other mixes, Poisson's ratio varies with low coefficient of variance. Average 1.5-hour, 3-hour, and 28-day Poisson's ratio was 0.1188, 0.1571, and 0.171, respectively. 1.5-hour and 3-hour results seemed consistent with each other and with regular VESLMC mix. While 28-day results were expectedly slightly lower than corresponding results from VESLMC, as moisture of the mix increased. Average strain of 3.49×10^{-3} corresponding to ultimate stress was recorded from 1.5-hour curing age, and 3-hour air curing increase average results to 3.56×10^{-3}. These values were both higher than regular type I/II concrete's typical result of 0.003. Strain corresponding to ultimate stress development was similar to one from VESLMC.

Average 1.5-hour, 3-hour, and 28-day elastic modulus of latex-content-decreased mix were 2400 ksi, 2848 ksi, and 4339 ksi, respectively. Similar to the previous mixes, these were also progressively larger over curing age than calculated elastic modulus of concrete based on compressive strength in ACI 318-14 (ACI Committee 318, 2014). These values were significant improvement from regular VESLMC mix. 3-hour results did not pass elastic modulus requirement, but 28-day results narrowly did (Section 676, 2013). These again explained previous assumption that moisture content in mix design had reached its optimum level.

Poisson's ratio swayed with high coefficient of variance as others. Average 1.5-hour, 3-hour, and 28-day Poisson's ratio was 0.1318, 0.1517, and 0.1853, respectively. 1.5-hour and 3-hour results were slightly higher than, when average 28-day results were lower than controlled VESLMC mix. There was slight increase from 10%-latex-content-increased mix's results. This concluded that Poisson's ratio in VESLMC responded to moisture content rather than to compressive strength. While 28-day results of slightly lower than corresponding results from VESLMC, it was still significant increase from within-day results. Average strain corresponding to ultimate stress of 3.09×10^{-3} was recorded from 1.5-hour curing age, and 3-hour air curing increase average results to 3.29×10^{-3}. There was slight increase between them. While 1.5-hour results were similar to corresponding results in controlled VESLMC mix, 3-hour results was on slightly lower.

Average 1.5-hour, 3-hour, and 28-day elastic modulus of water-only mix were 3234 ksi, 3593 ksi, and 4721 ksi, respectively. These values significantly increased from controlled VESLMC mix. These results again emphasized the importance of Styrofan at early ages is that any straining will result in lower induced stresses which will be unlikely to crack. 1.5-hour and 3-hour results both passed 3-hour elastic modulus requirement, and 28-day results well did (Section 676, 2013). Water-only mix performed better in term of modulus of elasticity. Different to the previous mixes, these were slightly lower over curing age than calculated elastic modulus of concrete based on compressive strength in ACI 318-14 (ACI Committee 318, 2014). Poisson's ratio swayed with high coefficient of variance as usual. Average 1.5-hour, 3-hour, and 28-day Poisson's ratio was 0.114, 0.113, and 0.16, respectively. 1.5-hour and 3-hour results were almost no difference, when average 28-day results were lower than regular VESLMC mix. There was slight decrease from 10%-latex-content-increased mix's results. This concluded that Poisson's ratio in VESLMC responded to moisture content rather than to compressive strength. While 28-day results of slightly lower than corresponding results from VESLMC, it was still significant increase from within-day results. Average strain corresponding to ultimate stress of 2.24×10^{-3} was recorded from 1.5-hour curing age, and 3-hour air curing slightly decreased average results to 2.18×10^{-3}. These values were lower than the controlled VESLMC mix's and common known ultimate strain of concrete, as corresponding splitting tensile strength was also lower than VESLMC. These average results could be obtained from Table 5-3.

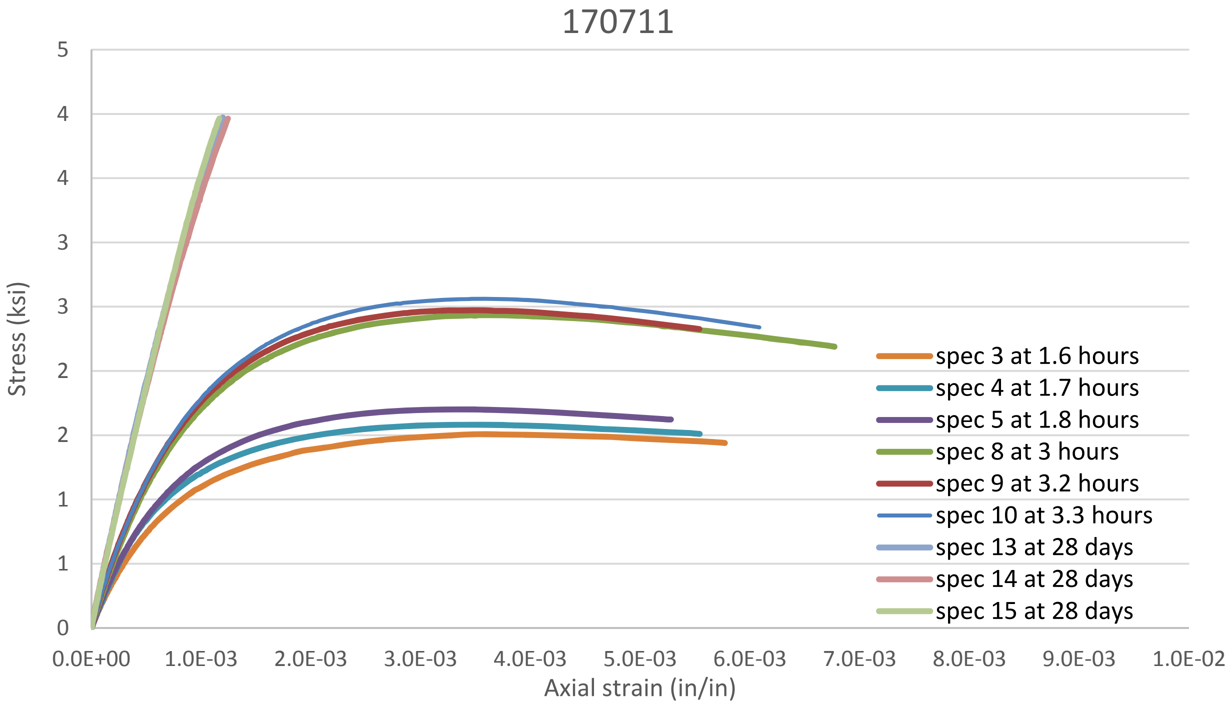


Figure 6-31 Stress-strain development of 10%-latex-content-increased mix

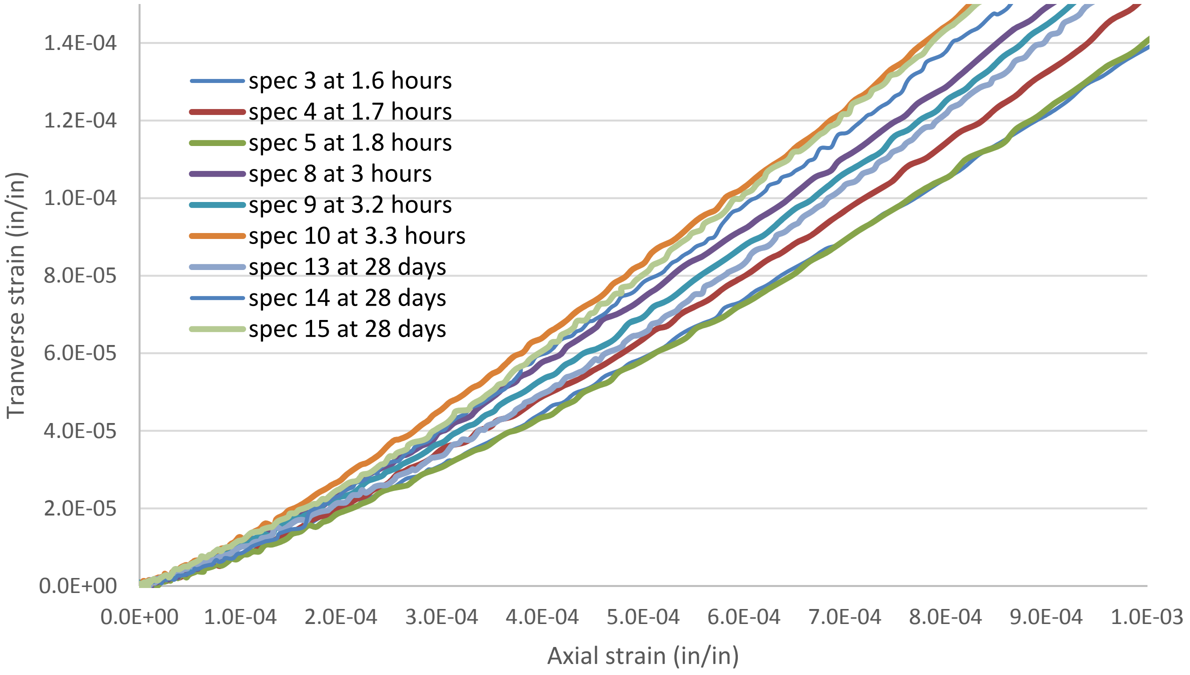


Figure 6-32 Transverse and axial strain of 10%-latex-content-increased mix

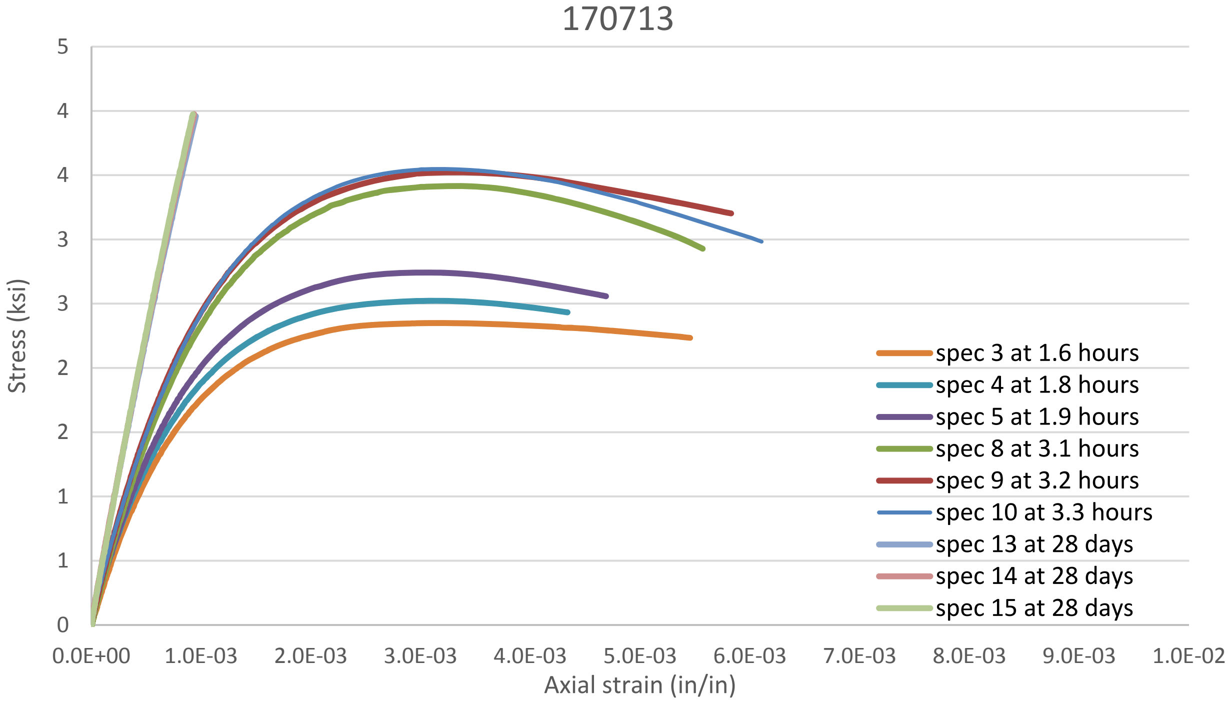


Figure 6-33 Stress-strain development of 10%-latex-content-decreased mix

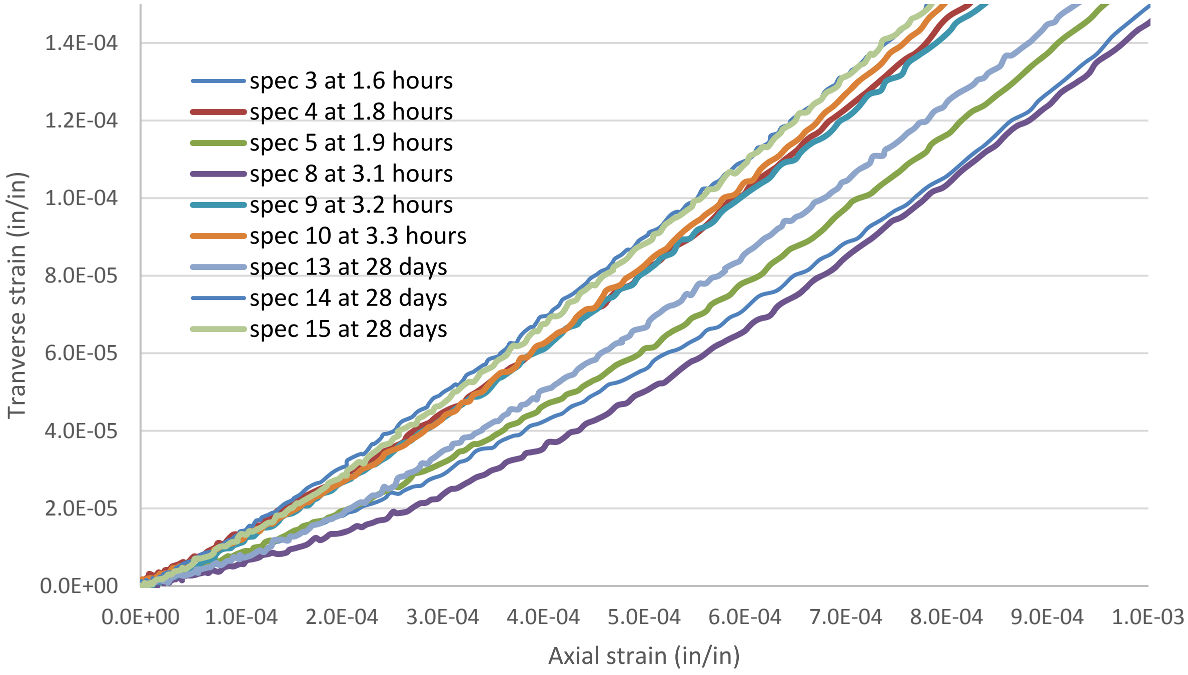


Figure 6-34 Transverse and axial strain of 10%-latex-content-decreased mix

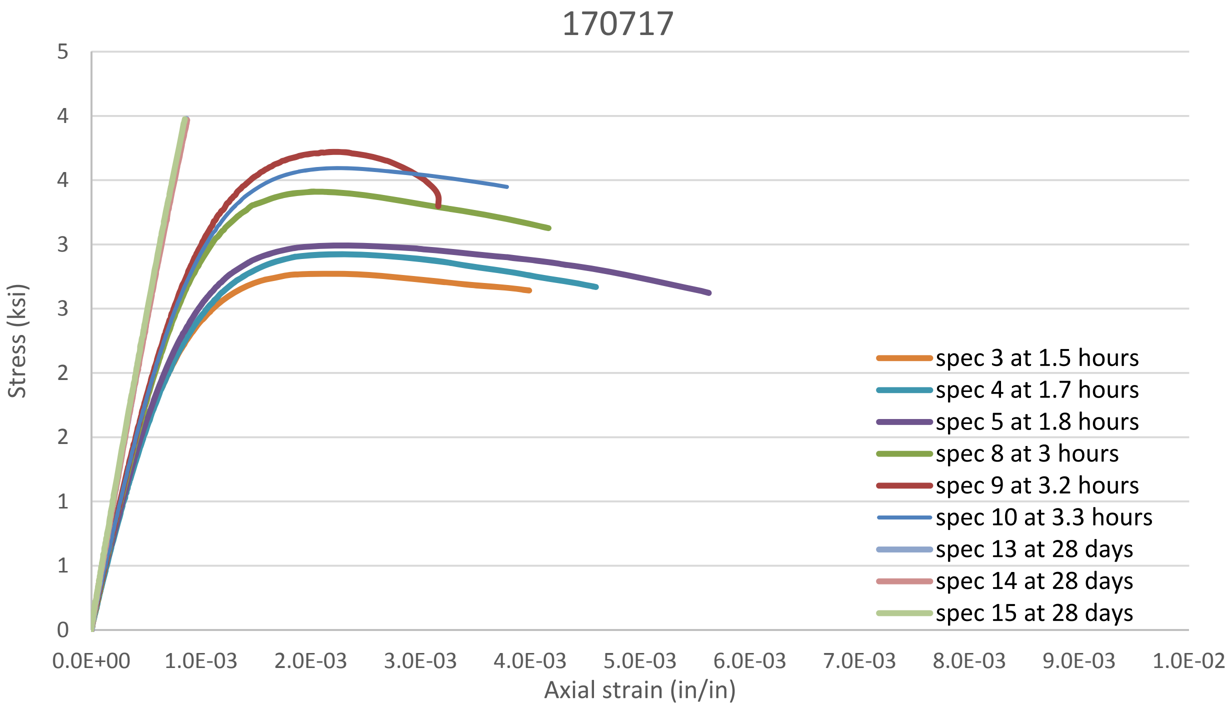


Figure 6-35 Stress-strain development of water-only mix

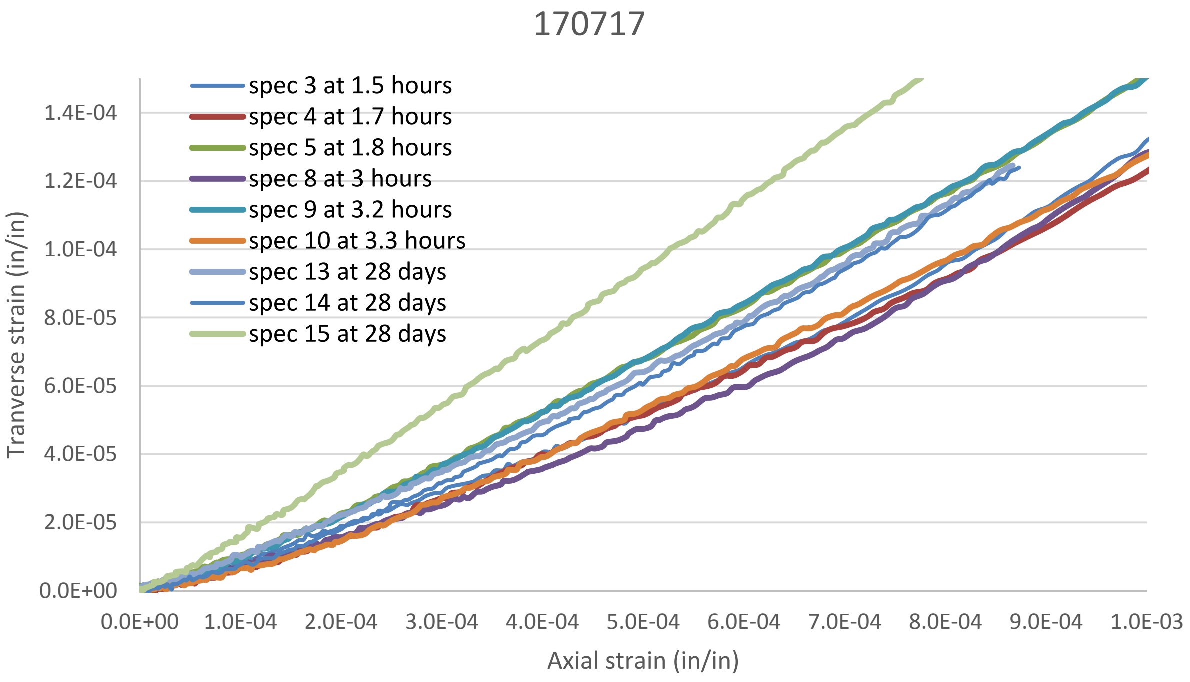


Figure 6-36 Transverse and axial strain of water-only mix

6.3. Comparison of Material Properties with ACI and AASHTO Predictions

The compressive strength of concrete is often used to estimate other material properties such as the elastic modulus, modulus of rupture, tensile strength. ACI and AASHTO provide relationships between these material properties. The data collected for the mixes used in this study are compared to the equations given by ACI and AASHTO.

6.3.1. Elastic Modulus

ACI provides the following equations to estimate the elastic modulus given the specified compressive strength or the specified compressive strength and the unit weight of concrete.

$$E_c = 57{,}000\sqrt{f_c'} \text{ or } E_c = 33w^{1.5}\sqrt{f_c'}$$

Where f_c' is compressive strength of concrete (psi),

w is density of normal weight concrete (lbs/ft^3).

AASHTO provides the following equations as estimates of the elastic modulus (ksi) given the specified compressive strength or the specified compressive strength and the unit weight of concrete.

$$E_c = 33{,}000K_1w^{1.5}\sqrt{f_c'}$$

Where f_c' is compressive strength of concrete (ksi),

w is density of normal weight concrete (kcf),

$K_1$is correction factor for source of aggregate to be taken as 1.0 unless determined by physical test, and as approved by the authority of jurisdiction.

With $K_1 = 1$, AASHTO and ACI provide similar formula with different units.

Figure 6-37 shows the relationship bewteen the measured elastic modulus of concrete and the elastic modulus as predicted by the ACI and AASHTO equations. If the ACI and AASHTO predictions were perfect the data would be plotted directly on the line shown which has a slope of 1. In general the data follows the trend with some concrete having higher material stiffness than predicted and other data less stiff than predicted. On average, the results for the VESLMC were 22.5% higher than the ACI and AASHTO prediction. However, average percent difference of Mix 0Lat1 on 7/17/2017 experimental results were -0.59% lower than ACI and AASHTO prediction. Styrofan evidently decreases its products' elastic modulus. Rapid Set cement, on the other hand, appears to not change the ACI predictions which are based on Portland cement at all ages. These can be observed from data summarized in Table A-7 of Appendix A.

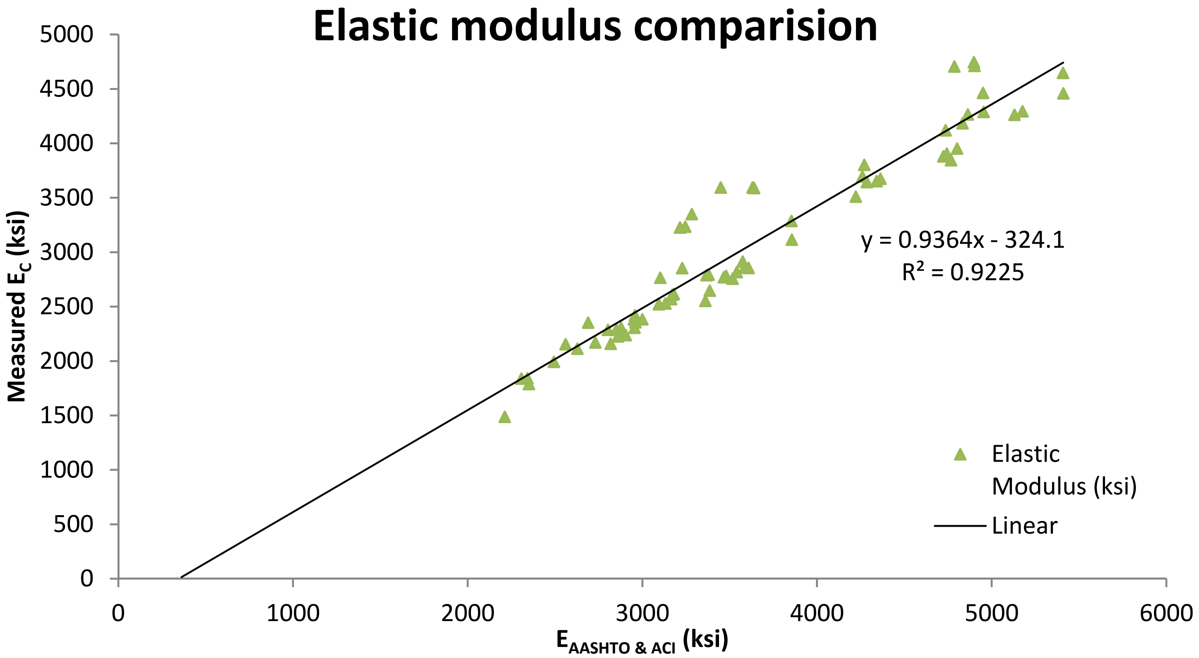


Figure 6-37 Linear regression measured and calculated elastic modulus

6.3.2. Modulus of Rupture

ACI 318 provides the following equations as estimates of the rupture modulus given the specified compressive strength or the specified compressive strength and a reduction factor if the concrete is other than normal weight concrete.

$$f_r = 7.5\lambda\sqrt{f_c'}$$

Where f_c' is compressive strength of concrete (psi)

$\lambda = 1$ for normal weight concrete, and 0.85 for light weight concrete.

AASHTO LRFD Bridge Design Specification provides the following equations as estimates of the rupture modulus given the specified compressive strength or the specified compressive strength and aggregate types. According to the AASHTO document, normal weight concrete has modulus of rupture varying from $0.24\sqrt{f_c'}$ to $0.37\sqrt{f_c'}$. The below formula was recommended for high-strength concrete only.

$$f_r = 0.37\sqrt{f_c'}$$

Where f_c' is compressive strength of concrete (ksi).

Table 6-1 3-hour calculated and experimental rupture modulus

Mix	#	Size (in)	Age (h)	f_c (psi)	P (lbs)	f_r (psi)	f_{rAASTO} (psi)	%diff$_{AASHTO}$	f_{rACI} (psi)	%diff$_{ACI}$
C4	9	6x6x24	3.10	2793	8075	654	618	5.7%	396	49%
C4	10	6x6x24	3.20	2793	8075	668	618	7.7%	396	51%
C4	11	6x6x24	3.25	2793	7250	602	618	-2.7%	396	41%
C4	12	6x6x24	3.32	2793	7950	664	618	7.1%	396	50%

These difference in Table 6-1 confirmed that estimated rupture modulus formulas in AASHTO are still valid for VESLMC. Average percent difference from ACI calculated results is 46.8%, while it is 5.8% with AASHTO formula for high-strength concrete. More samples of each mix should be tested to confirm if the AASHTO formula is adequate to estimate rupture modulus based on compressive strength at targeted ages.

6.3.3. Indirect Tensile Strength

ACI 318 provides the following equations as estimates of the splitting tensile strength given the average compressive strength.

$$f_{ct} = 6.7\sqrt{f_{cm}}$$

Where f_{cm} is average compressive strength of concrete (psi)

AASHTO LRFD Bridge Design Specification provides the following equations as estimates of the splitting tensile strength given the specified compressive strength or the specified compressive strength and the unit weight of concrete.

$$f_{ct} = \frac{\sqrt{f_c'}}{4.7}$$

Where f_c' is average compressive strength of concrete (ksi)

These formulas provide equivalent results; the calculated splitting tensile strength differed by only 2 psi. Note that short-term splitting tensile strength results (1-hour, 2-hour, and 3-hour) are collected but they could not be estimated by corresponding compressive strength due to different testing time. Therefore, only 28-day results were used for comparison. Concrete cylinders were sawed in half 5 minutes (1-hour samples), 30 minutes (3-hour samples), 28 days (28-day samples) before each test, and vibration from such method potentially affected the results. The experimental splitting tensile strength results are summarized in Table 6-2. Linear regression in Figure 6-38 suggested that compressive strength should not be used to estimate splitting tensile strength utilizing ACI and AASHTO formulas. Improved timing of test results in which both compressive and splitting tensile strength tests conducted at the same corresponding time, would be able to confidently simplify different applicable formulas approximating splitting tensile strength.

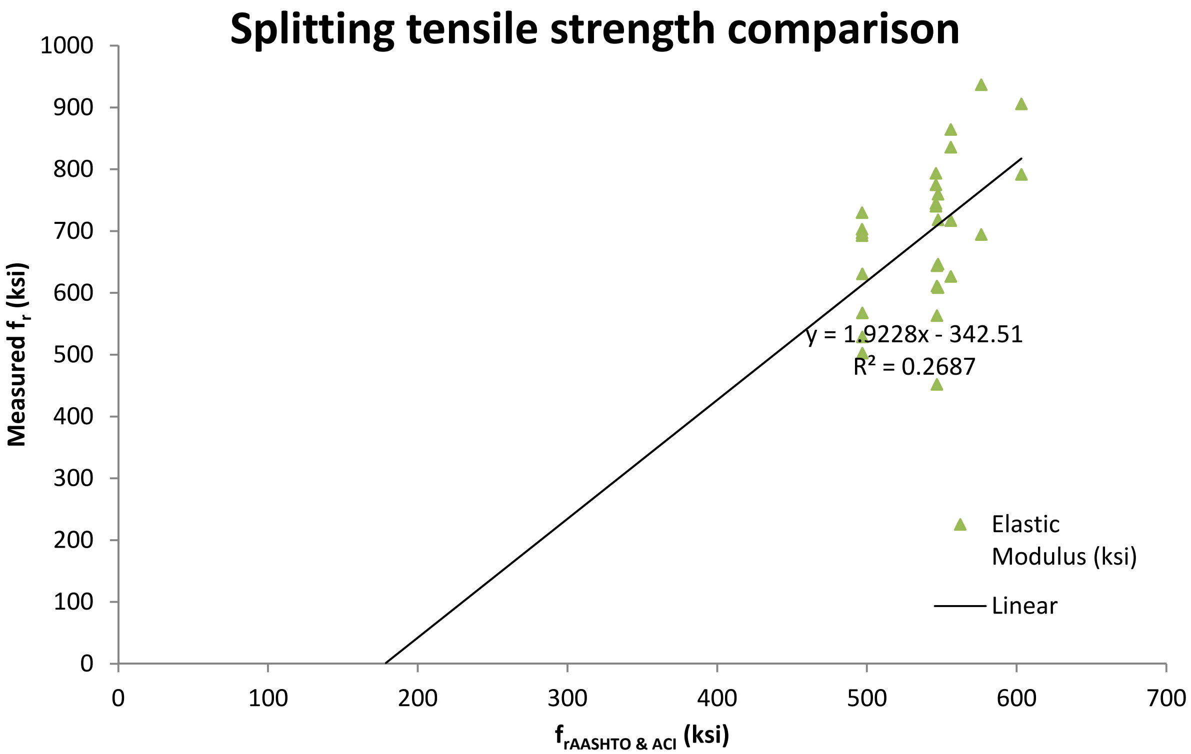


Figure 6-38 Calculated and experimental splitting tensile strength of VESLMC

Table 6-2 28-day calculated and experimental splitting tensile strength

Mix	Cyl #	Actual Age (Days)	Actual Age (hours)	Weight (lbs)	Pn (lbs)	f_{ct} (psi)	f_c (psi)	$f_{ctAASTO}$ (psi)	%diff	f_{ctACI} (psi)	%diff
C5	12a	28	672	4.137	17130	694	7400	579		576	18.2%
C5	12b	28	672	4.255	23820	937	7400	579		576	47.2%
RS1+94	12a	28	672	4.139	20210	792	8105	606		603	26.6%
RS1+94	12b	28	672	4.105	21970	906	8105	606		603	39.7%
RS1-94	11a	28	677	4.115	13995	568	5500	499		497	12.9%
RS1-94	11b	28	677	4.157	15925	631	5500	499		497	23.3%
RS1-94	12a	28	677	4.076	13035	529	5500	499		497	5.8%
RS1-94	12b	28	677	4.214	12700	503	5500	499		497	0.7%
1.1W1	11a	28	672	4.203	18025	718	6677	550		547	26.6%
1.1W1	11b	28	672	4.147	18575	760	6677	550		547	32.1%
1.1W1	12a	28	672	4.266	15320	609	6677	550		547	10.2%
1.1W1	12b	28	672	4.109	15875	647	6677	550		547	16.2%
0.9W1	11a	28	672	4.039	19115	794	6643	548		546	36.5%
0.9W1	11b	28	672	4.327	20040	775	6643	548		546	34.2%
0.9W1	12a	28	672	4.07	19105	740	6643	548		546	29.8%
0.9W1	12b	28	672	4.371	17995	745	6643	548		546	30.4%
1.1Lat1	11a	28	672	4.148	17340	703	5497	499		497	34.0%
1.1Lat1	11b	28	672	4.046	17310	693	5497	499		497	32.5%
1.1Lat1	12a	28	672	4.084	18010	730	5497	499		497	37.6%
1.1Lat1	12b	28	672	4.174	17395	697	5497	499		497	33.1%
0.9Lat1	11a	28	672	4.128	17720	717	6887	558		556	24.9%
0.9Lat1	11b	28	672	4.323	21210	836	6887	558		556	39.8%
0.9Lat1	12a	28	672	4.128	21200	864	6887	558		556	43.0%
0.9Lat1	12b	28	672	4.217	15725	627	6887	558		556	11.5%
0Lat1	11a	28	672	4.225	14025	563	6660	549		547	2.6%
0Lat1	11b	28	672	4.334	11470	452	6660	549		547	-19.4%
0Lat1	12a	28	672	4.227	16060	644	6660	549		547	15.9%
0Lat1	12b	28	672	4.251	15170	611	6660	549		547	10.7%

6.3.4. Pull-off Test Strength

It generally is adequate to assume that the bond between repair material and underlying substrate will resist an interfacial shear equal to the direct tensile pull-off test result. (ACI Committee 562, 2016) Two different substrate surface preparation conditions were tested: saturated surface dry and (SSD) air dry (AD) surfaces both roughened to ¼ inch amplitude with a pneumatic needle gun. The data collected is summarized in Table 5-5. Failures occurred in the substrate in both bonding conditions for Mix C5 on 6/14/2017. The average pull-off pressures were 204 psi with SSD substrate surface prep and 114 psi with air dry (AD) surface prep.

Addition of Styrofan (latex) to the repair material improved the tensile strength of the material. In fact, concrete utilizing Rapid Set cement without Styrofan resulted in tension fracture occurring in the repair material layer and not in the underlying substrate. However, the average pull-off tensile strength was 283 psi. More tests should be conducted to verify this increase in pull-off strength. If this is true, Styrofan could be excluded from the original mix for better performance as a surface repair material. It was observed in Figure 6-6 of section 6.2.1 that similar mixes without Styrofan performance in early compressive strength. However, more tests are needed for validation of moisture on bonding surface effect, moisture content of repair material mixes, concrete constituents, cement contents on substrate strength.

Chapter 7. Conclusion & Recommendations

VESLMC was studied as a repair material for partial deck repairs. The very early strength allows reduction in the time required to shut down lanes on the highway. While the rapid setting nature has benefits, setting time and other material properties tested need to be considered when planning a repair project. The results of this study lead to the following observations and conclusions:

- While not perfect, replication of VESLMC utilizing volumetric mixer is possible with a drum mixer in lab.
- The workable time for VESLMC after Rapid Set cement contact with water is approximately 15 minutes.
- Higher doses of Delvo could be considered for future research if it could extend workability duration.
- Styrofan Latex tends to bleed when Portland Type I/II was used in the same volume as rapid cement for a mix. Segregation also occurred in theses mixes.
- When Styrofan was replaced with water, early compressive strength increased, modulus of elasticity was higher, and ultimate strain reduced to 0.002.
- A change in cement content and cement condition had the most significant effect on VESLMC compressive strength.
- Styrofan Latex content had only a minor effect on compressive strength and significant effect on tensile strength.
- Fine aggregate that is less than saturated surface dry at mixing tends to reduce the compressive strength of VESLMC. Coarse aggregates are not as sensitive to moisture content.
- Moisture content from the mix design was at an optimum level. The VESLMC achieved its peak compressive strength.
- The elastic modulus increased as moisture content decreased.
- Strain corresponding to ultimate compressive stress increased over testing age and ultimate compressive strength itself.
- The potential benefit of a lower latex content in the mix, especially at early ages, is that any strain/deformation at early ages, will result in lower induced stresses which can lower the risk for cracking.

The following items are suggestions for continued work.

- Equipment with higher compressive limits should be used for measuring 28-day ultimate compressive strength, Poisson's ratio, stress-strain curve development.
- More mixes and prisms sample for each mix should be performed for confirming workability stage, concrete density, effect of admixtures, rupture modulus approximation with ACI and AASHTO.

- Replacing Styrofan with water by weight should be studied further. More trial runs on variation of water content for optimum level should be conducted. These could help decide if Styrofan is essential in the repair mix.

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Appendix A. Mixes preparation and results from lab

Over-mortaring quantity and aggregates conditions

Over-mortar quantity:

Buckets (12) with constituents were weighed beforehand. These values were listed in Table A-1. Each empty bucket weighed approximately 1.7 lbs.

After mixing procedure, concrete was poured out from drum mixer to wheel barrel, of which empty weight was measured 52 lbs. Weight of concrete and wheel barrel was measured 335 lbs. Thus, weight of usable concrete sample was 283 lbs.

Table A-1 Weight of buckets before and after mixing

Bucket No.	Before Mixing	After Mixing
1	1.75	60.1
2	1.8	37.65
3	32.05	1.7
4	31.8	1.8
5	38.45	77.05
6	32.15	72.95
7	31.55	35.6
8	34.4	1.767
9	48.5	1.767
10	31.5	1.767
11	12.15	1.775
12	15.55	1.775
Total weight	311.65	295.7

Weight difference $= 311.65 - 295.7 = 15.95\ lbs$

Weight of mixing batch (2 ft^3) $= 292.3\ lbs$

Over-mortaring weight $= 292.3 - 283 \approx 9\frac{lbs}{2cyd} = 4.5\ lbs/ft^3$

Note: Due to observation, coarse aggregates were considered to be excluded from over-mortaring calibration, due to low weight.

Absorption capacity of coarse aggregate

Sample calculation on 8/26/16 results:

$$W_{ssd} = 2839.8 - 912.2 = 1927.6\ g$$

$$V_{aggregate} = \frac{2839.8 - 2025.1 - (912.2 - 801.2)}{1} = 703.7\ cm^3$$

$$W_{Oven\ dry} = 2425.2 - 546.3 = 1878.9\ g$$

$$G_{Oven\ dry} = \frac{W_{Oven\ dry}}{V_{aggregate}} = \frac{1878.9}{703.7} = 2.67$$

$$G_{SDD} = \frac{W_{ssd}}{V_{aggregate}} = \frac{1927.6}{703.7} = 2.74$$

Absorption capacity of Kapaa chips is calculated below.

$$A_{coarse\ aggregates} = \frac{W_{ssd} - W_{Oven\ dry}}{W_{Oven\ dry}} = \frac{1927.6 - 1878.9}{1878.9} * 100\% = 2.59\%$$

Table A-2 Absorption capacity of Kapaa chips (3/8”)

	Kapaa Chips (3/8")	*	*	5/23/16	6/19-22/2016	6/30/16	8/26/16
In air	Weight of basket (g)	909.8	911.8	912.5	912.3	912.3	912.2
	Weight of basket & aggregate (g)	3225.6	3232.5	3144.8	3213.5	3064.7	2839.8
	SSD weight (g)	2315.8	2320.7	2232.3	2301.2	2152.4	1927.6
In water	Weight of wire basket (g)	799.2	799	780	799.4	799.7	801.2
	Weight of basket & aggregate (g)	2275	2269.3	2204	2255.8	2165.9	2025.1
	Volume of Aggregate (cm^3)	840	850.4	808.3	844.8	786.2	703.7
	pan	41.5	41.6	1262.5	837.6	836.9	546.3
	OD sample and pan	2293.5	2297.4	3413	3060.3	2933.4	2425.2
	OD weight	2252	2255.8	2150.5	2222.7	2096.5	1878.9
	SSD density	2.76	2.73	2.76	2.72	2.74	2.74
	OD density	2.68	2.65	2.66	2.63	2.67	2.67
	Absorption cap.	2.83%	2.88%	3.80%	3.53%	2.67%	2.59%

Note that dates of tests were not recorded. These results were used for batch mixing to determine fibers mixing time.

Absorption capacity of fine aggregates

This follows ASTM C128 gravimetric procedure.

British Columbia Sand (Orca BCS)		6/19/16	6/30/16	8/26/16
Pycnometer	434.1	434.1	433.9	434
W & Py	1275.2	1277.3	1266.4	1270
Water weight	841.1	843.2	832.5	836
SSD Sand sample	500	500	500	500
W & Py & Sand	1599.3	1594.7	1591.7	1584.9
Water & sand weight	1165.2	1160.6	1157.8	1150.9
SSD Sand volume	175.9	182.6	174.7	185.1
Pan	49.9	41.6	1228.2	831.7
Dry sand &pan	543.4	535.9	1722.7	1324.5
Dry sand weight	493.5	486	494.5	492.8
SSD Sand density	2.84	2.74	2.86	2.70
OD Sand Density	2.81	2.66	2.83	2.66
Absorption cap. (<2%)	1.32%	2.88%	1.11%	1.46%

Table A-3 Absorption capacity of fine aggregates (British-Columbian sand)

$$G_{Oven\ dry} = \frac{W_{Oven\ dry}}{W_{SSD} + W_{water} - W_{water\ \&\ sand}} = \frac{492.8}{500 + 836 - 1150.9} = 2.66$$

$$G_{SSD} = \frac{W_{SSD}}{W_{SSD} + W_{water} - W_{water\ \&\ sand}} = \frac{500}{500 + 836 - 1150.9} = 2.7$$

Absorption capacity of British-Columbian sand could be obtained using below equation.

$$A_{fine\ aggregates} = \frac{W_{ssd} - W_{Oven\ dry}}{W_{Oven\ dry}} = \frac{500 - 492.8}{492.8} * 100\% = 1.46\%$$

Moisture content of aggregates

Moisture content of aggregates was configured Following ASTM C566.

ASTM C566 was performed on 9/19/2016 to determine moisture content of coarse and fine aggregates. The results are summarized in Table A-4.

Table A-4 Moisture content on 9/19/2016

9/19/2016	Coarse aggregates	Fine aggregates
Pan	546.9	1228
Pan & sample	1646.5	1938.1
Pan & dry sample	1629.1	1933.6

$$p_{coarse\ aggregates} = \frac{(1646.5 - 546.9) - (1629.1 - 546.9)}{1629.1 - 546.9} \times 100\% = 1.61\%$$

$$p_{fine\ aggregates} = \frac{1938.1 - 1228 - (1933.6 - 1228)}{1933.6 - 1228} = 0.64\%$$

Moisture correction of aggregates

$$MC_{coarse\ aggregates} = p_{coarse\ aggregates} - A_{coarse\ aggregates} = 1.61\% - 2.59\% = -0.98\%$$

$$MC_{fine\ aggregates} = p_{fine\ aggregates} - A_{fine\ aggregates} = 0.64\% - 1.46\% = -0.82\%$$

Mix batch quantity calculation

Example batch size on 9/21/2016: 1.5 cu.ft

Quantity was calculated based on Table 4-5.

Original saturated-surface-dry mix batch weight:

$$W_{cement} = \frac{658 * 1.5}{30.02} = 32.9\ lbs$$

$$W_{coarse\ aggregates} = \frac{1483 * 1.5}{30.02} = 74.1\ lbs$$

$$W_{fine\ aggregates} = \frac{1852 * 1.5}{30.02} = 92.5\ lbs$$

$$W_{water} = \frac{117 * 1.5}{30.02} = 5.8\ lbs$$

$$W_{fibers} = \frac{6 * 1.5}{30.02} = 0.3\ lbs$$

$$W_{Styrofan} = \frac{210 * 1.5}{30.02} = 10.48\ lbs$$

$$V_{MCI} = \frac{716 * 1.5}{30.02} = 36\ ml$$

$$V_{Delvo} = \frac{5098 * 1.5}{30.02} = 255\ ml$$

$$V_{Glenium} = \frac{1177 * 1.5}{30.02} = 59\ ml$$

$$\begin{aligned} W_{total} = {} & W_{cement} + W_{coarse\ aggregate} + W_{fine\ aggregate} + W_{water} + W_{fibers} + W_{Styrofan} \\ & + W_{MCI} + W_{Delvo} + W_{Glenium} \\ & = 32.9 + 74.1 + 95.2 + 5.8 + 0.3 + 10.48 + 2.205 \\ & \times 10^{-3}(36 \times 1.19 + 267 \times 1.068 + 59 \times 1.1) = 217\ lbs \end{aligned}$$

Saturated-surface-dry mix batch weight with over-mortaring quantity (4.5 lbs/ft^3), which excludes coarse aggregate amount:

$$W'_{cement} = 32.9 * \frac{(217 + 1.5 \times 4.5 - 74.1)}{(217 - 74.1)} = 34.4\ lbs$$

$$W'_{fine\ aggregates} = 92.5 * \frac{(217 + 1.5 \times 4.5 - 74.1)}{(217 - 74.1)} = 96.9\ lbs$$

$$W'_{water} = 5.8 * \frac{(217 + 1.5 \times 4.5 - 74.1)}{(217 - 74.1)} = 6.1\ lbs$$

$$W'_{fibers} = 0.3 * \frac{(217 + 1.5 \times 4.5 - 74.1)}{(217 - 74.1)} = 0.314\ lbs$$

$$W'_{Styrofan} = 10.48 * \frac{(217 + 1.5 \times 4.5 - 74.1)}{(217 - 74.1)} = 11\ lbs$$

$$V_{MCI} = 36 * \frac{(217 + 1.5 \times 4.5 - 74.1)}{(217 - 74.1)} = 37\ ml$$

$$V_{Delvo} = 255 * \frac{(217 + 1.5 \times 4.5 - 74.1)}{(217 - 74.1)} = 267\ ml$$

$$V_{Glenium} = 59 * \frac{(217 + 1.5 \times 4.5 - 74.1)}{(217 - 74.1)} = 62\ ml$$

Moisture adjustment of mix batch on 9/21/1016 would be determined based on moisture content tests (ASTM C556) conducting on 9/19/2016.

$$w_{coase\ aggregates} = 74.1 * (1 - 0.98\%) = 73.4\ lbs$$

$$w_{fine\ aggregates} = 96.9 * (1 - 0.82\%) = 96.1\ lbs$$

$$w_{water} = 6.1 + 74.1 * 0.98\% + 96.9 * 0.82\% = 7.6\ lbs$$

Mix 1

The absorption capacity of Kapaa chips and British-Columbia sand was 2.83% and 1.32%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.00% and 0.5%, respectively. The mix volume was 2 cu.ft.

The first mix which utilized 26 oz/cwt of Delvo with Type I/II Portland cement. Mix 1 replaces the Rapid Cement with an equal volume of Type I/II Portland cement. By reducing the delvo dosage a normal set time was achieved. The total target volume of the batch was 2 cu.ft. The batch used 1 cu.ft butter batch to account for mortar loss on the mixer. Fibers were not added to butter batch. This mix was used to determine optimum mixing time of fibers in this research.

Mix 2D on 6/8/2016

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.32%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.2% and 0.73%, respectively. Mixing and curing generally followed ASTM C192-15. The mix volume was 2.7 cu.ft, which formed 9 6”x12” cylinders. One cylinder was tested for 6-day strength. The remaining four pairs of cylinders were tested for strength at 7, 14, 21, and 28 days in accordance with ASTM C39-15a.

A prior mix which utilized 26 oz/cwt of Delvo with Type I/II Portland cement did not finish setting after one day in the molds. The dosage rate suggested by the manufacture is 4 oz/cwt for use with Portland cement. The mix used in the freeway repair uses Rapid Cement and it is thought that the delvo is needed at the extreme dosage of 26 oz/cwt for set control. Mix 2D replaces the Rapid Cement with an equal volume of Type I/II Portland cement. By reducing the delvo dosage a normal set time was achieved. The batch used the over-mortaring method to account for mortar loss on the mixer.

Mix 2D on 6/13/2016

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.32%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.2% and 0.73%, respectively. This mix generally followed ASTM C192 -15 curing procedures.

Like the previous mix on 6/8/16, Delvo dosage used was reduced to 4 oz/cwt to avoid over-retarding the mix. Casting and curing the specimens followed ASTM C192/C192M-15. The total volume was 2.7 cu.ft. The over-mortaring method was used. 12 each 6x12 concrete cylinders were cast. Each pair of concrete cylinders was tested for strength at 1, 3, 7, 14, 21, 28 days in accordance with ASTM C39-15a.

Mix 2D on 6/20/2016

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.32%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.2% and 0.73%, respectively. Mixing and curing generally followed ASTM C192-15.

The batch volume was 2.7 cu.ft, which formed 12 4x8 cylinders and 8 6x12 cylinders. Using Type I/II Portland cement, delvo dosage was reduced to 4 oz/cwt for mentioned reasons. 12 4x8 cylinders (each 3 cylinders) and 8 6x8 cylinders (each 2 cylinders) would be tested for 1-day, 3-day, 7-day, and 28-day strength for statistical reason (Detwiler, Thomas, Stangebye, & Urahn, 2009).

Mix 2D on 6/29/2016

Using Type I/II Portland cement, delvo dosage was reduced to 4 oz/cwt as manufacture recommendation. Absorption capacity of Kapaa chips and British-Columbia sand were 2.83% and 1.61%, respectively. Moisture contents of Kapaa chips and British-Columbia sand, which were measured before mixing, were 1.61% and 0.64%, respectively. Mixing and curing generally followed ASTM C192-15.

Aggregates were considered quite dry before utilizing in the mix. This batch volume was 2.7 cu.ft, which formed 12 4x8 cylinders and 8 6x12 cylinders. They all were to test for 28-day strength. The first 6 4x8 cylinders were tested using Rhiele compression machine and the rest were tested using soil compression machine. Same was applied to 8 6x12 cylinders.

Mix 2D on 7/13/2016

Absorption capacity of Kapaa chips and British-Columbia sand were 2.83% and 1.61%, respectively. Moisture contents of Kapaa chips and British-Columbia sand, which were measured before mixing, were 1.6% and 0.51%, respectively. Using Type I/II Portland cement, delvo dosage was reduced to 4 oz/cwt as manufacture recommendation. Using Type I/II Portland cement, delvo dosage was reduced to 4 oz/cwt as manufacture recommendation.

This batch volume was 2.7 cu.ft, which formed 12 4x8 cylinders and 8 6x12 cylinders. They all were to test for 28-day strength. Mixing and curing generally followed ASTM C192-15. The first 6 4x8 cylinders were tested using Rhiele compression machine and the rest were tested using soil compression machine. Same was applied to 8 6x12 cylinders.

Mix 2D on 7/20/2016

Absorption capacity of Kapaa chips and British-Columbia sand were 2.67% and 1.11%, respectively. Moisture contents of Kapaa chips and British-Columbia sand, which were measured before mixing, were 1.92% and 0.62%, respectively. Using Type I/II Portland cement, delvo dosage was reduced to 4 oz/cwt for mentioned reasons. During mixing time, effort was established to reduced serious bleeding and segregation occurring in the previous mixes. Water adding to dilute Glenium dosage before mixing was 3.8 lbs. However, half of it was added to mixer before improvisation was made. Addition of Glenium mixture accorded to the condition of freshly mixed concrete afterward. In the end, there was 0.9 lbs of Glenium mixture in its bucket.

Mixing and curing generally followed ASTM C192-15. This batch volume was 2.7 cu.ft, which formed 12 4x8 cylinders and 8 6x12 cylinders. They all were to test for 28-day strength. Mixing and curing generally followed ASTM C192-15. The first 6 4x8 cylinders were tested using Rhiele compression machine and the rest were tested using soil compression machine. Same was applied to 8 6x12 cylinders.

Mix 2D on 8/16/2016

Absorption capacity of Kapaa chips and British-Columbia sand were 2.67% and 1.11%, respectively. Moisture contents of Kapaa chips and British-Columbia sand, which were measured before mixing, were 1.37% and 0.55%, respectively.

The mix volume was 3 cu.ft, which formed 12 4x8 cylinders, 2 6x12 cylinders and 4 6x6x24 prisms. All cylinders would be tested for 28-day compressive strength, and the prisms were to test for 28-day flexural strength according to customer's specification. Using Type I/II Portland cement, delvo dosage was reduced to 4 oz/cwt. In addition, Glenium dosage was reduced half due to mixing observation for bleeding and segregation occurring in the previous mixes. Mixing and curing generally followed ASTM C192-15.

"8 min mix. Rodding cons." mix on 8/30/2016

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.46%, respectively. On 8/26/2016, the moisture content of Kapaa chips and British-Columbia sand measured 1.27% and 0.6%, respectively.

The mix volume was 1.5 cu.ft, which formed 21 4x8 cylinders. Flash set cement was used in this mix. Those would be tested 1-hour, 1.5-hour, 2-hour, 2.5-hour, 3-hour compressive strength. The first 3 cylinders and the last 3 ones would be tested for its tensile strength. There was no amount water or Glenium holding back during mix. Mixing and curing generally followed ASTM C192-15

"8 mins mix. Half Glenium" mix on 9/8/2016

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.46%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.42% and 0.57%, respectively.

The mix volume was 1.5 cu.ft, which formed 21 4x8 cylinders. Mixing process was occurred 1 hour afternoon. Workability was reduced rapidly over time, and only the first 12 cylinders were decently consolidated and formed. Half amount of Glenium was held off during mixing process. The first 3 cylinders were tested for 1-hour strength, and the rest were tested 3 hours after mixing. Mixing and curing generally followed ASTM C192-15.

"8 mins mix." mix on 9/21/2016

Delayed admixture was applied for all admixtures. MCI amount was small, so it was diluted in water. Mixing and curing generally followed ASTM C192-15. The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.46%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.61% and 0.64%, respectively.

The mix volume was 1.5 cu.ft, which formed 24 4x8 cylinders. The vibrator was first introduced into freshly-mixed concrete, and the interval was 5 seconds. Each 3 cylinders were tested for 1-hour, 1.5-hours, 2-hours, 2.5-hour, 3-hour strength, and 3 cylinders were planned to test 28 days after mixing. The other 3 cylinders were tested 5.5 hours after mixing. Mixing and curing generally followed ASTM C192-15.

"1/2 5s cons., 1/2 10 cons." mix on 9/23/2016

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.46%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.61% and 0.64%, respectively.

Minor modification in procedure utilized to reduce air void causing by Styrofan. Total mixing time reduced to 3 minutes. Delayed addition was applied for all admixtures. The mix volume was 1.5 cu.ft, which formed 24 4x8 cylinders. The vibrator was first introduced into freshly-mixed concrete, and the interval was 5 seconds for the first 9 cylinders and 10 seconds for the second 9 cylinders. Each 3 cylinders were tested for 1-hour, 2-hours, 3-hour strength for the first 9 cylinders and similar testing was applied simultaneously for the second 9. The rest were planned to test 28 days after mixing. Curing generally followed ASTM C192-15.

"5-10s cons." mix on 9/28/2016

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.46%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.23% and 0.39%, respectively.

New procedure was introduced: no more than 3 minutes mixing after cement addition. Vibration period for consolidation was 5 to 10 seconds for each cylinder. The mix volume was 1.5 cu.ft, which formed 24 4x8 cylinders. Each 3 cylinders were tested for 1-hour, 1.5-hours, 2-hours, 2.5-hour, 3-hour strength, and the rest were planned to test 28 days after mixing. Curing generally followed ASTM C192-15.

“1/2 Glenium” mix on 9/30/2016

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.46%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.23% and 0.39%, respectively.

The mix volume was 1.5 cu.ft, which formed 18 4x8 cylinders, one 6x12 cylinder, and 3x3x10 prism. The cylinders were tested for 1-hour, 1.5-hours, 2-hours, 2.5-hour, 3-hour strength, and the rest were planned to test 28 days after mixing. The prisms were used for shrinkage test.

Half of Glenium was deducted from designated mix. Mixing drum was tilted as it was running to reduce foaming in freshly-concrete mix. The interval of consolidation using vibration was 5 seconds to 10 seconds. Vibration table consolidated concrete in wood prism formwork.

“No MCI” mix on 10/12/2016

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.46%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.43% and 0.53%, respectively.

Mixing drum was tilted as it was running to reduce foaming in freshly-concrete mix. Mixing time reduced to 2.5 minutes. Entrapped and entrained air could still be seen forming outside the surface of concrete cylinders. The interval of consolidation using vibration was 5 seconds to 10 seconds. No MCI was added, because it had been suspected as component causing air void. Over-mortar weight was reduced to 2.25 lb/cu.ft. The mix volume was 1 cu.ft, which formed 14 4x8 cylinders. The cylinders were tested for 1-hour, 2-hours, 3-hour strength, and the rest were planned to test 28 days after mixing. Curing generally followed ASTM C192-15.

“No MCI, no latex” mix on 10/14/2016

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.46%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.43% and 0.53%, respectively. The mix volume was 1 cu.ft, which formed 12 4x8 cylinders. The cylinders were tested for 1-hour, 2-hours, 3-hour strength, and the rest were planned to test 28 days after mixing.

No MCI was added, and latex was replaced by extra water weight. Mixing time was still at 2.5 minutes. Entrapped air could still be seen, but entrained air was not. Curing generally followed ASTM C192-15.

“No latex” mix on 10/19/2016

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.46%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.24%

and 0.68%, respectively. The mix volume was 1 cu.ft, which formed 12 4x8 cylinders. The cylinders were tested for 1-hour, 2-hours, 3-hour strength, and the rest were planned to test 28 days after mixing. Air dry curing was applied for 28-day cylinders.

Latex was replaced by extra water weight. Mixing time was still at 2 minutes and 40 seconds. Entrapped air could still be seen, but entrained air were not. It concluded that latex was the air-entrapped factor

Mix C1 on 11/2/2016

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.46%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.22% and 0.68%, respectively. The mix volume was 1 cu.ft, which formed 12 4x8 cylinders. The cylinders were tested for 1-hour, 2-hours, 3-hour strength, and the rest were planned to test 28 days after mixing.

Fibers mixing with latex was added 30 seconds before turning off the mixer. Whole-cylinder consolidation was applied for all concrete mold. Air-dry curing was applied for 28-day cylinders.

Mix C2 on 11/4/2016

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.46%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.22% and 0.68%, respectively. The mix volume was 1 cu.ft, which formed 12 4x8 cylinders. The cylinders were tested for 1-hour, 2-hours, 3-hour strength, and the rest were planned to test 28 days after mixing. Air-dry curing was applied for cylinders which would be tested for 28-day strength.

Half-half consolidation was applied for all concrete mold. Fibers and latex was added to mix at 30 seconds before turning off mixer.

Mix RS+94 on 11/16/2016

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.46%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.29% and 0.63%, respectively. The mix volume was 1 cu.ft, which formed 12 4x8 cylinders. The cylinders were tested for 1-hour, 2-hours, 3-hour strength, and the rest were planned to test 28 days after mixing. Air-dry curing was applied for cylinders which would be tested for 28-day strength.

94 lb/cu.yd was added to mix design. Half-half consolidation was applied for all concrete mold. Fibers and latex was added to mix at 30 seconds before turning off mixer.

Mix RS-94 on 11/18/2016

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.46%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.29% and 0.63%, respectively. The mix volume was 1 cu.ft, which formed 12 4x8 cylinders. The cylinders were tested for 1-hour, 2-hours, 3-hour strength, and the rest were planned to test 28 days after mixing. Air-dry curing was applied for cylinders which would be tested for 28-day strength.

94 lb/cu.yd was deducted from mix design. Full consolidation was applied for all concrete mold. Fibers and latex was added to mix at 30 seconds before turning off mixer.

Mix 1.1W on 12/21/2016:

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.46%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.21% and 0.81%, respectively. The mix volume was 1 cu.ft, which formed 12 4x8 cylinders. The cylinders were tested for 1-hour, 2-hours, 3-hour strength, and the rest were planned to test 28 days after mixing. Air-dry curing was applied for cylinders which would be tested for 28-day strength.

10% of water from original mix was added to mix design. Full consolidation was applied for all concrete mold. Fibers and latex was added to mix at 30 seconds before turning off mixer.

Mix 0.9W on 12/28/2016

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.46%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.27% and 0.73%, respectively. The mix volume was 1 cu.ft, which formed 12 4x8 cylinders. The cylinders were tested for 1-hour, 2-hours, 3-hour strength, and the rest were planned to test 28 days after mixing. Air-dry curing was applied for cylinders which would be tested for 28-day strength.

10% of water from original mix was deducted from mix design. 2-layers consolidation was applied for all concrete mold. Fibers and latex was added to mix at 30 seconds before turning off mixer.

Mix 1.1Lat on 1/12/2017

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.46%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.34% and 0.69%, respectively. The mix volume was 1 cu.ft, which formed 12 4x8 cylinders. The cylinders were tested for 1-hour, 2-hours, 3-hour strength, and the rest were planned to test 28 days after mixing. Air-dry curing was applied for cylinders which would be tested for 28-day strength.

10% of latex from original mix was added to mix design. 2-layers consolidation was applied for all concrete mold. Fibers and latex was added to mix at 30 seconds before turning off mixer.

Mix 0.9Lat on 1/13/2017

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.46%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.34% and 0.69%, respectively. The mix volume was 1 cu.ft, which formed 12 4x8 cylinders. Each 3 cylinders were tested for 1-hour, 2-hours, 3-hour strength, and the rest were planned to test 28 days after mixing. Air-dry curing was applied for cylinders which would be tested for 28-day strength.

10% of latex from original mix was deducted from mix design. Full-cylinder consolidation was applied for all concrete mold to save time due the mix workability was low. Fibers and latex was added to mix at 30 seconds before turning off mixer.

Mix 0Lat on 2/2/2017

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.26%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.16% and 2.67%, respectively. The mix volume was 1 cu.ft, which formed 12 4x8 cylinders. Each 3 cylinders were tested for 1-hour, 2-hours, 3-hour strength, and the rest were planned to test 28 days after mixing. Air-dry curing was applied for cylinders which would be tested for 28-day strength.

All latex weight was substituted by water. 2-layer consolidation was applied for all concrete mold to save time as the mix workability was low. Fibers and latex was added to mix at 30 seconds before turning off mixer.

Mix 0Lat+nC on 3/2/2017

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.26%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.29% and 2.26%, respectively. The mix volume was 1 cu.ft, which formed 12 4x8 cylinders. Each 3 cylinders were tested for 1-hour, 2-hours, 3-hour strength, and the rest were planned to test 28 days after mixing. Air-dry curing was applied for cylinders which would be tested for 28-day strength.

All latex weight was substituted by water, and new cement was utilized. 2-layer consolidation was applied for all concrete mold to save time as the mix workability was low. Fibers and latex was added to mix at 30 seconds before turning off mixer.

Mix 0Lat+nC+0.5del on 3/3/2017

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.26%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.29% and 2.26%, respectively. The mix volume was 1 cu.ft, which formed 12 4x8 cylinders. Each 3 cylinders were tested for 1-hour, 2-hours, 3-hour compressive strength, and the rest were planned to test 28 days after mixing. Air-dry curing was applied for cylinders which would be tested for 28-day compressive strength.

All latex weight was substituted by water, and new cement was utilized. Moreover, half of delvo dosage was utilized. 2-layer consolidation was applied for all concrete mold to save time as the mix workability was low. Fibers and latex was added to mix at 30 seconds before turning off mixer.

Mix C on 3/9/2017

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.26%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.29% and 2.26%, respectively. The mix volume was 1 cu.ft, which formed 12 4x8 cylinders. Each 3 cylinders were tested for 1-hour, 2-hours, 3-hour compressive strength, and the rest were planned to test 28 days after mixing. Air-dry curing was applied for cylinders which would be tested for 28-day strength.

New cement was utilized. 2-layer consolidation was applied for all concrete mold to save time as the mix workability was low. Fibers and latex was added to mix at 30 seconds before turning off mixer.

"Wet chip" Mix on 3/10/2017

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.26%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.29% and 2.26%, respectively. The mix volume was 1 cu.ft, which formed 15 4x8 cylinders. Each 3 cylinders were tested for 1-hour, 2-hours, 3-hour, 28-day compressive strength after mixing. The rest would be subject for chloride test. Air-dry curing was applied for cylinders which would be tested for 28-day strength.

Kapaa chips was saturated before mixing. 2-layer consolidation was applied for all concrete mold to save time as the mix workability was low. Fibers and latex was added to mix at 30 seconds before turning off mixer.

"Dry sand" mix on 3/16/2017

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.26%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.37%

and 0.43 %, respectively. The mix volume was 1 cu.ft, which formed 15 4x8 cylinders. Each 3 cylinders were tested for 1-hour, 2-hours, 3-hour, 28-day compressive strength after mixing. The rest would be subject for chloride test. Air-dry curing was applied for cylinders which would be subject of 28-day compressive strength and chloride test.

British-Columbian sand was sun-dried for 1 days before mixing. 2-layer consolidation was applied for all concrete mold to save time as the mix workability was low. Fibers and latex was added to mix at 30 seconds before turning off mixer.

"Poor cem. Con." mix on 3/17/2017

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.26%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.37% and 2.58 %, respectively. The mix volume was 1 cu.ft, which formed 15 4x8 cylinders. Each 2 cylinders were tested for 1-hour, 2-hours, 3-hour, and 28-day compressive strength after mixing. 2 cylinders were sawed in half and subjects of 1-hour and 3-hour split-cylinder tests. The rest would be subject for chloride test. Air-dry curing was applied for cylinders which would be subject of 28-day compressive strength and chloride test.

Low strength was due to partially hydrated cement. It took 8 minutes to finish mixing. 2-layer consolidation was applied for all concrete molds to save time as the mix workability was low. Fibers and latex was added to mix at 30 seconds before turning off mixer.

"Crushed new cem." mix on 4/14/2017

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.26%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.41% and 2.02%, respectively. The mix volume was 1 cu.ft, which formed 15 4x8 cylinders. Each 3 cylinders were tested for 1-hour, 2-hours, and 3-hour compressive strength after mixing. Each other 2 cylinders were sawed in half and subjects of 1-hour, 2-hour, and 3-hour split-cylinder tests.

The mix had prepared and stored in the UH Structural lab since 3/23/2017. Partially clump cement was grinded for better mixing process. 2-layer consolidation utilizing vibration table was applied for all concrete mold to save time as the mix workability was normal. Fibers and latex was added to mix at 30 seconds before turning off mixer.

Mix C3 on 5/22/2017

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.26%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.24% and 2.82%, respectively. The mix volume was 1 cu.ft, which formed 15 4x8 cylinders. Each 3 cylinders were tested for 1.5-hour and 3-hour compressive strength after mixing. Each other 2 cylinders were sawed in half and subjects of 1-hour, 2-hour, and 3-hour split-cylinder tests.

Cement was run through No.4 sieve. 2-layer consolidation utilizing vibration table was applied for all concrete mold to save time as the mix workability was normal. Fibers and latex was added to mix at 30 seconds before turning off mixer.

Mix C4 on 5/24/2017

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.26%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.25% and 2.15%, respectively.

The mix volume was 2.5 cu.ft, which formed 9 4"x8" cylinders, and 4 6"x6"x12" prisms. 3 cylinders were tested for 3-hour compressive strength, and the rest were sawed in half and subject of split-cylinder tests 3 hours after mixing. New filtered cement was utilized. 2-layer consolidation was applied for all concrete molds. Fibers and latex was added to mix at 30 seconds before turning off mixer.

Mix C5 on 6/14/2017

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.26%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.27% and 2.4%, respectively. The mix volume was 1 cu.ft, which intended to form 15 4"x8" cylinders and 18"x18"x1.5" overlay on existing concrete substrate. Only 12 cylinders were produced. Each 3 cylinders were tested for 1-hour, 2-hours, and 3-hour compressive strength after mixing. 6 cylinders were sawed in half and subjects of 3-hour split-cylinder tests.

Cement was run through No.4 sieve. 2-layer consolidation utilizing vibration table was applied for all concrete mold to save time as the mix workability was normal. Fibers and latex was added to mix at 30 seconds before turning off mixer.

Mix RS1+94 on 6/16/2017

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.26%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.32% and 1.84%, respectively. The mix batch was 1.2 cu.ft, which formed 12 4"x8" cylinders and 18"x18"x1.5" overlay on existing concrete substrate. 3 cylinders were tested for 1.5-hour, and 2 were tested for 3-hour compressive strength after mixing. 5 cylinders were sawed in half. Each 2 were tested for 1.5-hour and 2-hour split-cylinder tests, one were for 28-day.

Cement was run through No.4 sieve. 94 lb/cu.yd of Rapid Set cement was added to mix design. Fibers and latex was added to mix at 30 seconds before turning off mixer. 2-layer consolidation utilizing vibration table was applied for all concrete molds.

Mix RS1-94 on 6/20/2017

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.26%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.38% and 3.63%, respectively. The mix batch was 1.5 cu.ft, which formed 15 4”x8” cylinders and 18”x18”x1.5” overlay on existing concrete substrate. Each 3 cylinders were tested for 1.5-hour and 3-hour compressive strength after mixing. The rest were sawed in half, each 2 were tested for 1-hour, 2-hour, and 28-day split-cylinder tests.

Cement was run through No.4 sieve. 94 lb/cu.yd of Rapid Set cement was deducted from mix design. Fibers and latex was added to mix at 30 seconds before turning off mixer. 2-layer consolidation utilizing vibration table was applied for all concrete molds.

Mix 1.1W1 on 7/5/2017

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.26%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.27% and 2.86%, respectively. The mix batch was 1.5 cu.ft, which formed 15 4”x8” cylinders and 18”x18”x1.5” overlay on existing concrete substrate. Each 3 cylinders were tested for 1.5-hour and 3-hour compressive strength after mixing. The rest were sawed in half, each 2 were tested for 1-hour, 2-hour, and 28-day split-cylinder tests.

Cement was run through No.4 sieve. 10% of water from original mix was added to mix design. Fibers and latex was added to mix at 30 seconds before turning off mixer. 2-layer consolidation utilizing vibration table was applied for all concrete molds.

Mix 0.9W1 on 7/7/2017

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.26%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.23% and 2.13%, respectively. The mix batch was 1.5 cu.ft, which formed 15 4”x8” cylinders and 18”x18”x1.5” overlay on existing concrete substrate. Each 3 cylinders were tested for 1.5-hour and 3-hour compressive strength after mixing. The rest were sawed in half, each 2 were tested for 1-hour, 2-hour, and 28-day split-cylinder tests.

Cement was run through No.4 sieve. 10% of water from original mix was deducted from mix design. Fibers and latex was added to mix at 30 seconds before turning off mixer. 2-layer consolidation utilizing vibration table was applied for all concrete molds.

Mix 1.1Lat1 on 7/11/2017

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.26%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.23% and 2.13%, respectively. The mix batch was 1.5 cu.ft, which formed 15 4”x8” cylinders and

18”x18”x1.5” overlay on existing concrete substrate. Each 3 cylinders were tested for 1.5-hour and 3-hour compressive strength after mixing. The rest were sawed in half, each 2 were tested for 1-hour, 2-hour, and 28-day split-cylinder tests.

Cement was run through No.4 sieve. 10% of Styrofan from original mix was added to the mix design. Fibers and latex was added to mix at 30 seconds before turning off mixer. 2-layer consolidation utilizing vibration table was applied for all concrete molds.

Mix 0.9Lat1 on 7/13/2017

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.26%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.23% and 2.13%, respectively. The mix batch was 1.5 cu.ft, which formed 15 4”x8” cylinders and 18”x18”x1.5” overlay on existing concrete substrate. Each 3 cylinders were tested for 1.5-hour and 3-hour compressive strength after mixing. The rest were sawed in half, each 2 were tested for 1-hour, 2-hour, and 28-day split-cylinder tests.

Cement was run through No.4 sieve. 10% of Styrofan from original mix was deducted from mix design. Fibers and latex was added to mix at 30 seconds before turning off mixer. 2-layer consolidation utilizing vibration table was applied for all concrete molds.

Mix 0Lat1 on 7/17/2017

The absorption capacity of Kapaa chips and British-Columbia sand was 2.59% and 1.26%, respectively. The moisture content of Kapaa chips and British-Columbia sand measured 1.23% and 2.13%, respectively. The mix batch was 1.5 cu.ft, which formed 15 4”x8” cylinders and 18”x18”x1.5” overlay on existing concrete substrate. Each 3 cylinders were tested for 1.5-hour and 3-hour compressive strength after mixing. The rest were sawed in half, each 2 were tested for 1-hour, 2-hour, and 28-day split-cylinder tests.

Cement was run through No.4 sieve. 100% of Styrofan from original mix was replaced by water by weight. Fibers were added to mix at 30 seconds before turning off mixer. 2-layer consolidation utilizing vibration table was applied for all concrete molds.

Compressive strength test results

Table A-5 Compressive strength of LMC

Mix	Cyl #	Nominal Size (DxL)	Mix Date & Time	Actual Testing Date	Actual Age (Days)	Actual Age (hours)	Diameter 1 (in)	Diameter 2 (in)	Diameter 3 (in)	Weight (lbs)	Density (pcf)	Density percent %	SSD Weight (lb)	P_n (lbs)	f'_c (psi)	ASTM C39 Failure Types
Mix2D	1	6x12	6/8/2016 10:30 AM	6/15/2016 12:00 PM	7.06	169.50	5.987	5.983	5.991	29.441	150.7	103.26%	29.59	140000	4970	4
Mix2D	2	6x12	6/8/2016 10:30 AM	6/15/2016 12:00 PM	7.06	169.50	5.988	5.988	5.988	29.515	151.0	103.48%	29.65	139500	4950	2
Mix2D	3	6x12	6/8/2016 10:30 AM	6/22/2016 11:00 AM	14.02	336.50	5.982	5.987	5.999	29.426	150.5	103.13%	29.58	163000	5790	1
Mix2D	4	6x12	6/8/2016 10:30 AM	6/22/2016 11:00 AM	14.02	336.50	5.995	5.984	5.989	29.66	151.7	103.95%	29.72	180000	6390	1
Mix2D	5	6x12	6/8/2016 10:30 AM	6/29/2016 8:30 AM	20.92	502.00	5.991	5.982	5.989	29.467	150.8	103.34%	29.64	170500	6060	2
Mix2D	6	6x12	6/8/2016 10:30 AM	6/29/2016 8:30 AM	20.92	502.00	5.968	5.968	5.972	29.448	151.6	103.90%	29.6	174500	6240	2
Mix2D	7	6x12	6/8/2016 10:30 AM	6/14/2016 1:30 PM	6.13	147.00	5.992	5.986	5.984	29.49	150.9	103.42%	29.62	131500	4670	4
Mix2D	11	6x12	6/8/2016 10:30 AM	7/6/2016 10:30 AM	28.00	672.00	5.985	5.989	5.986	29.528	151.1	103.58%	29.71	190500	6770	2
Mix2D	12	6x12	6/8/2016 10:30 AM	7/6/2016 10:30 AM	28.00	672.00	5.969	5.972	5.971	29.292	150.7	103.30%	29.46	187000	6680	2
Mix2D	1	6x12	6/13/2016 11:00 AM	6/14/2016 1:30 PM	1.10	26.50	5.99	5.984	5.988	29.311	150.0	102.79%	n/a	43500	1550	4
Mix2D	2	6x12	6/13/2016 11:00 AM	6/14/2016 1:30 PM	1.10	26.50	5.987	5.988	5.987	29.42	150.5	103.17%	n/a	45500	1620	2
Mix2D	3	6x12	6/13/2016 11:00 AM	6/16/2016 9:30 AM	2.94	70.50	5.982	5.988	5.98	29.446	150.9	103.40%	29.57	119000	4230	1
Mix2D	4	6x12	6/13/2016 11:00 AM	6/16/2016 9:30 AM	2.94	70.50	5.997	5.988	5.984	29.457	150.6	103.22%	29.59	121500	4310	4
Mix2D	5	6x12	6/13/2016 11:00 AM	6/20/2016 12:30 PM	7.06	169.50	5.985	5.99	5.99	29.635	151.6	103.89%	29.77	181500	6440	4
Mix2D	6	6x12	6/13/2016 11:00 AM	6/20/2016 12:30 PM	7.06	169.50	5.973	5.968	5.97	29.38	151.2	103.62%	29.51	163500	5840	2
Mix2D	7	6x12	6/13/2016 11:00 AM	6/27/2016 10:30 AM	13.98	335.50	5.99	5.986	5.985	29.508	151.0	103.49%	29.68	192500	6840	2
Mix2D	8	6x12	6/13/2016 11:00 AM	6/27/2016 10:30 AM	13.98	335.50	5.965	5.967	5.969	29.371	151.3	103.71%	29.54	186500	6670	2
Mix2D	9	6x12	6/13/2016 11:00 AM	7/5/2016 9:30 AM	21.94	526.50	5.998	5.991	5.983	29.541	151.0	103.48%	29.73	200,000	7100	2
Mix2D	10	6x12	6/13/2016 11:00 AM	7/5/2016 9:30 AM	21.94	526.50	5.985	5.987	5.985	29.37	150.4	103.06%	29.57	200,000	7110	2
Mix2D	11	6x12	6/13/2016 11:00 AM	7/11/2016 11:30 AM	28.02	672.50	5.984	5.989	5.991	29.448	150.7	103.25%	29.65	206,000	7310	2

Mix	Cyl #	Nominal Size (DxL)	Mix Date & Time	Actual Testing Date	Actual Age (Days)	Actual Age (hours)	Diameter 1 (in)	Diameter 2 (in)	Diameter 3 (in)	Weight (lbs)	Density (pcf)	Density percent %	SSD Weight (lb)	P_n (lbs)	f'_c (psi)	ASTM C39 Failure Types
Mix2D	12	6x12	6/13/2016 11:00 AM	7/11/2016 11:30 AM	28.02	672.50	5.972	5.971	5.972	29.193	150.2	102.92%	29.32	208,000	7430	2
Mix2D	1	4x8	6/20/2016 10:30 AM	6/21/2016 10:00 AM	0.98	23.50	3.998	3.99	4	8.755	150.9	103.39%	n/a	27000	2150	2
Mix2D	2	4x8	6/20/2016 10:30 AM	6/21/2016 10:00 AM	0.98	23.50	3.99	3.994	4.006	8.739	150.5	103.17%	n/a	27500	2190	2
Mix2D	3	4x8	6/20/2016 10:30 AM	6/21/2016 12:00 PM	1.06	25.50	3.997	3.995	3.992	8.738	150.7	103.26%	n/a	27250	2170	1
Mix2D	4	4x8	6/20/2016 10:30 AM	6/23/2016 9:30 AM	2.96	71.00	4.006	3.995	3.998	8.765	150.8	103.32%	8.815	59250	4720	1
Mix2D	5	4x8	6/20/2016 10:30 AM	6/23/2016 9:30 AM	2.96	71.00	4.003	4.004	3.994	8.748	150.4	103.09%	8.798	58500	4650	1
Mix2D	6	4x8	6/20/2016 10:30 AM	6/23/2016 9:30 AM	2.96	71.00	3.996	3.992	3.995	8.725	150.5	103.12%	8.776	60250	4810	4
Mix2D	7	4x8	6/20/2016 10:30 AM	6/27/2016 10:30 AM	7.00	168.00	3.999	3.996	3.992	8.741	150.6	103.24%	8.803	77000	6140	4
Mix2D	8	4x8	6/20/2016 10:30 AM	6/27/2016 10:30 AM	7.00	168.00	3.992	4.006	3.988	8.753	150.9	103.40%	8.816	76250	6080	4
Mix2D	9	4x8	6/20/2016 10:30 AM	6/27/2016 10:30 AM	7.00	168.00	3.997	3.992	3.999	8.769	151.1	103.56%	8.828	78000	6220	2
Mix2D	10	4x8	6/20/2016 10:30 AM	7/18/2016 10:30 AM	28.00	672.00	3.996	4.003	3.999	8.728	150.1	102.90%	8.817	99250	7900	4
Mix2D	11	4x8	6/20/2016 10:30 AM	7/18/2016 10:30 AM	28.00	672.00	3.993	4.004	3.989	8.758	151.0	103.46%	8.844	97250	7760	2
Mix2D	12	4x8	6/20/2016 10:30 AM	7/18/2016 10:30 AM	28.00	672.00	3.999	3.987	4.004	8.733	150.4	103.10%	8.812	94500	7530	4
Mix2D	1	6x12	6/20/2016 10:30 AM	6/21/2016 10:00 AM	0.98	23.50	5.988	5.984	5.987	29.334	150.2	102.91%	n/a	50000	1780	1
Mix2D	2	6x12	6/20/2016 10:30 AM	6/21/2016 10:00 AM	0.98	23.50	5.988	5.989	5.986	29.239	149.6	102.53%	n/a	54000	1920	1
Mix2D	3	6x12	6/20/2016 10:30 AM	6/23/2016 9:30 AM	2.96	71.00	5.987	5.983	5.997	29.284	149.8	102.64%	29.384	130500	4630	2
Mix2D	4	6x12	6/20/2016 10:30 AM	6/23/2016 9:30 AM	2.96	71.00	5.986	5.988	5.988	29.184	149.3	102.35%	29.298	134000	4760	1
Mix2D	5	6x12	6/20/2016 10:30 AM	6/27/2016 10:30 AM	7.00	168.00	5.988	5.982	5.989	29.301	150.0	102.79%	29.45	174000	6180	1
Mix2D	6	6x12	6/20/2016 10:30 AM	6/27/2016 10:30 AM	7.00	168.00	5.971	5.969	5.97	29	149.3	102.29%	29.14	172500	6160	4
Mix2D	7	6x12	6/20/2016 10:30 AM	7/18/2016 10:30 AM	28.00	672.00	5.993	5.986	5.985	29.285	149.8	102.68%	29.468	224000	7950	2
Mix2D	8	6x12	6/20/2016 10:30 AM	7/18/2016 10:30 AM	28.00	672.00	5.967	5.969	5.967	29.077	149.8	102.64%	29.268	218500	7810	2
Mix2D	1	4x8	6/29/2016 11:00 AM	7/26/2016 2:30 PM	27.15	651.50	3.996	4.004	4.002	8.833	151.9	104.07%	8.894	63750	5070	1
Mix2D	2	4x8	6/29/2016 11:00 AM	7/26/2016 2:30 PM	27.15	651.50	4.007	3.997	3.989	8.824	151.9	104.12%	8.888	59750	4760	2

Mix	Cyl #	Nominal Size (DxL)	Mix Date & Time	Actual Testing Date	Actual Age (Days)	Actual Age (hours)	Diameter 1 (in)	Diameter 2 (in)	Diameter 3 (in)	Weight (lbs)	Density (pcf)	Density percent %	SSD Weight (lb)	P_n (lbs)	f'_c (psi)	ASTM C39 Failure Types
Mix2D	3	4x8	6/29/2016 11:00 AM	7/26/2016 2:30 PM	27.15	651.50	3.986	4	3.995	8.761	151.1	103.58%	8.821	56250	4490	1
Mix2D	4	4x8	6/29/2016 11:00 AM	7/26/2016 2:30 PM	27.15	651.50	3.997	3.993	3.995	8.862	152.8	104.71%	8.929	68750	5480	1
Mix2D	5	4x8	6/29/2016 11:00 AM	7/26/2016 2:30 PM	27.15	651.50	4.006	3.993	4	8.846	152.2	104.28%	8.906	62750	4990	1
Mix2D	6	4x8	6/29/2016 11:00 AM	7/26/2016 2:30 PM	27.15	651.50	4.004	3.994	3.989	8.853	152.6	104.57%	8.926	61500	4900	1
Mix2D	7	4x8	6/29/2016 11:00 AM	7/26/2016 2:30 PM	27.15	651.50	3.995	3.992	4.001	8.79	151.5	103.81%	8.852	54835	4370	1
Mix2D	8	4x8	6/29/2016 11:00 AM	7/26/2016 2:30 PM	27.15	651.50	3.992	3.995	4.005	8.901	153.3	105.05%	8.981	70095	5590	4
Mix2D	9	4x8	6/29/2016 11:00 AM	7/26/2016 2:30 PM	27.15	651.50	3.998	3.997	3.995	8.753	150.8	103.33%	8.815	57335	4570	1
Mix2D	10	4x8	6/29/2016 11:00 AM	7/26/2016 2:30 PM	27.15	651.50	3.992	3.989	4.001	8.845	152.6	104.56%	8.92	67930	5420	1
Mix2D	11	4x8	6/29/2016 11:00 AM	7/26/2016 2:30 PM	27.15	651.50	3.99	3.991	4.004	8.798	151.7	103.95%	8.879	73350	5850	1
Mix2D	12	4x8	6/29/2016 11:00 AM	7/26/2016 2:30 PM	27.15	651.50	4.007	3.997	3.991	8.862	152.5	104.53%	8.925	71795	5720	1
Mix2D	1	6x12	6/29/2016 11:00 AM	7/26/2016 2:30 PM	27.15	651.50	5.985	5.982	5.986	29.68	152.0	104.19%	29.814	166500	5920	2
Mix2D	2	6x12	6/29/2016 11:00 AM	7/26/2016 2:30 PM	27.15	651.50	5.99	5.98	5.987	29.665	151.9	104.09%	29.809	179000	6360	2
Mix2D	3	6x12	6/29/2016 11:00 AM	7/26/2016 2:30 PM	27.15	651.50	5.98	5.976	5.967	29.728	152.8	104.71%	29.857	178500	6370	2
Mix2D	4	6x12	6/29/2016 11:00 AM	7/26/2016 2:30 PM	27.15	651.50	5.985	5.981	5.98	29.38	150.6	103.22%	29.521	144000	5120	3
Mix2D	5	6x12	6/29/2016 11:00 AM	7/26/2016 2:30 PM	27.15	651.50	5.979	5.981	5.971	29.814	153.1	104.92%	29.942	145220	5180	2
Mix2D	6	6x12	6/29/2016 11:00 AM	7/26/2016 2:30 PM	27.15	651.50	5.97	5.962	5.969	29.628	152.6	104.61%	29.77	145145	5190	1
Mix2D	7	6x12	6/29/2016 11:00 AM	7/26/2016 2:30 PM	27.15	651.50	5.99	5.983	5.984	29.878	153.0	104.84%	30.06	153425	5450	4
Mix2D	8	6x12	6/29/2016 11:00 AM	7/26/2016 2:30 PM	27.15	651.50	5.98	5.985	5.986	29.514	151.2	103.63%	29.658	149100	5300	2
Mix2D	1	4x8	7/13/2016 10:30 AM	8/10/2016 12:00 PM	28.06	673.50	4.021	4.001	4.018	8.765	149.7	102.62%	8.812	50000	3950	1
Mix2D	2	4x8	7/13/2016 10:30 AM	8/10/2016 12:00 PM	28.06	673.50	4.014	3.992	3.987	8.862	152.6	104.57%	8.913	57250	4560	1
Mix2D	3	4x8	7/13/2016 10:30 AM	8/10/2016 12:00 PM	28.06	673.50	4	4	4.01	8.696	149.3	102.32%	8.743	50750	4030	1
Mix2D	4	4x8	7/13/2016 10:30 AM	8/10/2016 12:00 PM	28.06	673.50	4.01	4.007	4.006	8.827	151.2	103.64%	8.876	50250	3980	1
Mix2D	5	4x8	7/13/2016 10:30 AM	8/10/2016 12:00 PM	28.06	673.50	4.005	3.99	3.989	8.753	150.9	103.44%	8.809	49500	3950	2

Mix	Cyl #	Nominal Size (DxL)	Mix Date & Time	Actual Testing Date	Actual Age (Days)	Actual Age (hours)	Diameter 1 (in)	Diameter 2 (in)	Diameter 3 (in)	Weight (lbs)	Density (pcf)	Density percent %	SSD Weight (lb)	P_n (lbs)	f'_c (psi)	ASTM C39 Failure Types
Mix2D	6	4x8	7/13/2016 10:30 AM	8/10/2016 12:00 PM	28.06	673.50	3.99	4.001	4.007	8.804	151.5	103.80%	8.857	52750	4200	1
Mix2D	7	4x8	7/13/2016 10:30 AM	8/10/2016 12:00 PM	28.06	673.50	4.002	3.993	4.014	8.848	151.9	104.13%	8.898	54960	4370	1
Mix2D	8	4x8	7/13/2016 10:30 AM	8/10/2016 12:00 PM	28.06	673.50	4.01	3.995	3.998	8.878	152.6	104.58%	8.919	59915	4770	1
Mix2D	9	4x8	7/13/2016 10:30 AM	8/10/2016 12:00 PM	28.06	673.50	4.012	4	4.006	8.848	151.7	103.97%	8.901	56240	4460	1
Mix2D	10	4x8	7/13/2016 10:30 AM	8/10/2016 12:00 PM	28.06	673.50	3.996	3.993	4	8.835	152.2	104.32%	8.881	44565	3550	1
Mix2D	11	4x8	7/13/2016 10:30 AM	8/10/2016 12:00 PM	28.06	673.50	3.994	3.995	3.993	8.749	150.9	103.43%	8.788	54220	4330	1
Mix2D	12	4x8	7/13/2016 10:30 AM	8/10/2016 12:00 PM	28.06	673.50	3.999	4.001	3.995	8.958	154.2	105.67%	9.007	66315	5280	2
Mix2D	1	6x12	7/13/2016 10:30 AM	8/10/2016 12:00 PM	28.06	673.50	5.973	5.981	5.978	29.362	150.8	103.32%	29.519	142000	5060	1
Mix2D	2	6x12	7/13/2016 10:30 AM	8/10/2016 12:00 PM	28.06	673.50	5.978	5.981	5.983	29.245	150.0	102.79%	29.395	142500	5070	2
Mix2D	3	6x12	7/13/2016 10:30 AM	8/10/2016 12:00 PM	28.06	673.50	5.981	5.986	5.967	29.612	152.0	104.17%	29.773	134000	4770	2
Mix2D	4	6x12	7/13/2016 10:30 AM	8/10/2016 12:00 PM	28.06	673.50	5.983	5.972	5.98	29.449	151.1	103.59%	29.595	127500	4540	4
Mix2D	5	6x12	7/13/2016 10:30 AM	8/10/2016 12:00 PM	28.06	673.50	5.982	5.978	5.981	29.576	151.7	103.96%	29.709	132750	4730	1
Mix2D	6	6x12	7/13/2016 10:30 AM	8/10/2016 12:00 PM	28.06	673.50	5.972	5.964	5.969	29.34	151.1	103.55%	29.495	122765	4390	2
Mix2D	7	6x12	7/13/2016 10:30 AM	8/10/2016 12:00 PM	28.06	673.50	5.977	5.981	5.984	29.499	151.3	103.68%	29.647	128950	4590	1
Mix2D	8	6x12	7/13/2016 10:30 AM	8/10/2016 12:00 PM	28.06	673.50	5.965	5.966	5.978	29.353	151.1	103.55%	29.504	129855	4640	1
Mix2D	1	4x8	7/20/2016 10:30 AM	8/17/2016 12:00 PM	28.06	673.50	3.983	4	3.993	8.805	152.0	104.19%	8.912	99130	7920	2
Mix2D	2	4x8	7/20/2016 10:30 AM	8/17/2016 12:00 PM	28.06	673.50	4.003	3.988	4.001	8.787	151.3	103.70%	8.852	99540	7930	2
Mix2D	3	4x8	7/20/2016 10:30 AM	8/17/2016 12:00 PM	28.06	673.50	3.992	4.014	4.032	8.841	151.1	103.54%	8.908	98360	7780	2
Mix2D	4	4x8	7/20/2016 10:30 AM	8/17/2016 12:00 PM	28.06	673.50	3.998	3.991	4.003	8.903	153.3	105.07%	8.963	104965	8360	2
Mix2D	5	4x8	7/20/2016 10:30 AM	8/17/2016 12:00 PM	28.06	673.50	3.996	3.987	4.001	8.845	152.5	104.53%	8.908	99450	7940	1
Mix2D	6	4x8	7/20/2016 10:30 AM	8/17/2016 12:00 PM	28.06	673.50	3.992	4.001	3.992	8.88	153.1	104.92%	8.948	100410	8010	1
Mix2D	7	4x8	7/20/2016 10:30 AM	8/17/2016 12:00 PM	28.06	673.50	3.995	3.998	4.001	8.884	152.9	104.81%	8.946	109250	8700	4
Mix2D	8	4x8	7/20/2016 10:30 AM	8/17/2016 12:00 PM	28.06	673.50	3.983	4	4.006	8.91	153.5	105.21%	8.976	110750	8830	4

Mix	Cyl #	Nominal Size (DxL)	Mix Date & Time	Actual Testing Date	Actual Age (Days)	Actual Age (hours)	Diameter 1 (in)	Diameter 2 (in)	Diameter 3 (in)	Weight (lbs)	Density (pcf)	Density percent %	SSD Weight (lb)	P_n (lbs)	f'_c (psi)	ASTM C39 Failure Types
Mix2D	9	4x8	7/20/2016 10:30 AM	8/17/2016 12:00 PM	28.06	673.50	3.988	3.987	4.003	8.95	154.5	105.87%	9.015	105500	8430	2
Mix2D	10	4x8	7/20/2016 10:30 AM	8/17/2016 12:00 PM	28.06	673.50	4.017	3.995	4.012	8.926	152.9	104.78%	8.99	110750	8780	2
Mix2D	11	4x8	7/20/2016 10:30 AM	8/17/2016 12:00 PM	28.06	673.50	4.001	4.002	4.002	8.9	152.9	104.81%	8.964	107500	8550	1
Mix2D	12	4x8	7/20/2016 10:30 AM	8/17/2016 12:00 PM	28.06	673.50	3.98	4.007	4.022	8.915	153.1	104.91%	8.971	109000	8660	2
Mix2D	1	6x12	7/20/2016 10:30 AM	8/17/2016 12:00 PM	28.06	673.50	5.998	5.998	5.999	29.78	151.8	104.05%	29.942	221110	7820	4
Mix2D	2	6x12	7/20/2016 10:30 AM	8/17/2016 12:00 PM	28.06	673.50	5.982	5.986	5.986	29.524	151.2	103.63%	29.684	225865	8030	2
Mix2D	3	6x12	7/20/2016 10:30 AM	8/17/2016 12:00 PM	28.06	673.50	5.979	5.987	5.984	29.52	151.3	103.66%	29.684	215010	7650	2
Mix2D	4	6x12	7/20/2016 10:30 AM	8/17/2016 12:00 PM	28.06	673.50	5.986	5.996	5.98	29.625	151.6	103.89%	29.895	218845	7770	4
Mix2D	5	6x12	7/20/2016 10:30 AM	8/17/2016 12:00 PM	28.06	673.50	5.987	5.989	5.984	29.488	150.9	103.44%	29.646	241000	8560	1
Mix2D	6	6x12	7/20/2016 10:30 AM	8/17/2016 12:00 PM	28.06	673.50	5.971	5.97	5.972	29.359	151.1	103.52%	29.516	235000	8390	2
Mix2D	7	6x12	7/20/2016 10:30 AM	8/17/2016 12:00 PM	28.06	673.50	5.983	5.988	5.979	29.499	151.2	103.59%	29.657	253500	9020	4
Mix2D	8	6x12	7/20/2016 10:30 AM	8/17/2016 12:00 PM	28.06	673.50	5.968	5.965	5.974	29.423	151.5	103.82%	29.59	242500	8670	2
Mix2D	1	4x8	8/16/2016 10:30 AM	9/13/2016 1:30 PM	28.13	675.00	4.004	3.991	4.014	7.703	132.3	90.62%	7.792	46570	3700	4
Mix2D	2	4x8	8/16/2016 10:30 AM	9/13/2016 1:30 PM	28.13	675.00	3.993	4.003	3.997	7.652	131.7	90.26%	7.743	41735	3330	4
Mix2D	3	4x8	8/16/2016 10:30 AM	9/13/2016 1:30 PM	28.13	675.00	3.986	3.999	4.009	7.655	131.8	90.28%	7.749	43710	3480	4
Mix2D	4	4x8	8/16/2016 10:30 AM	9/13/2016 1:30 PM	28.13	675.00	4.004	4.004	3.997	7.686	132.1	90.48%	7.788	45410	3610	2
Mix2D	5	4x8	8/16/2016 10:30 AM	9/13/2016 1:30 PM	28.13	675.00	4.005	3.992	4.006	7.691	132.2	90.56%	7.793	46110	3670	2
Mix2D	6	4x8	8/16/2016 10:30 AM	9/13/2016 1:30 PM	28.13	675.00	3.995	3.999	4	7.676	132.1	90.52%	7.777	43765	3490	2
Mix2D	7	4x8	8/16/2016 10:30 AM	9/13/2016 1:30 PM	28.13	675.00	3.997	3.998	4.003	7.687	132.2	90.59%	7.792	43985	3500	4
Mix2D	8	4x8	8/16/2016 10:30 AM	9/13/2016 1:30 PM	28.13	675.00	4.007	3.999	4	7.702	132.3	90.65%	7.799	44220	3520	2
Mix2D	9	4x8	8/16/2016 10:30 AM	9/13/2016 1:30 PM	28.13	675.00	4.003	4.005	3.999	7.719	132.6	90.83%	7.811	43765	3480	2
Mix2D	10	4x8	8/16/2016 10:30 AM	9/13/2016 1:30 PM	28.13	675.00	4.001	4.009	4.002	7.764	133.3	91.29%	7.862	44915	3570	2
Mix2D	11	4x8	8/16/2016 10:30 AM	9/13/2016 1:30 PM	28.13	675.00	3.995	4.003	4.003	7.725	132.8	91.00%	7.829	39445	3140	4

Mix	Cyl #	Nominal Size (DxL)	Mix Date & Time	Actual Testing Date	Actual Age (Days)	Actual Age (hours)	Diameter 1 (in)	Diameter 2 (in)	Diameter 3 (in)	Weight (lbs)	Density (pcf)	Density percent %	SSD Weight (lb)	P_n (lbs)	f'_c (psi)	ASTM C39 Failure Types
Mix2D	12	4x8	8/16/2016 10:30 AM	9/13/2016 1:30 PM	28.13	675.00	4.002	4.011	3.994	7.654	131.5	90.07%	7.759	42535	3380	4
Mix2D	1	6x12	8/16/2016 10:30 AM	9/13/2016 2:15 PM	28.16	675.75	5.982	5.986	5.984	26.96	138.1	94.61%	27.17	134600	4790	2
Mix2D	2	6x12	8/16/2016 10:30 AM	9/14/2016 2:15 PM	29.16	699.75	5.984	5.985	5.986	27.947	143.1	98.05%	28.15	152250	5410	2

Table A-6 Compressive test results of VESLMC

Mix	Cyl #	Nominal Size (DxL)	Mix Date & Time	Actual Testing Date	Dia. 1 (in)	Dia. 2 (in)	Dia. 3 (in)	Weight (lbs)	SSD Weight (lb)	P_n (lbs)	f'_c (psi)	ASTM C39 Failure Types
8 min mix. Rodding cons.	1	4x8	8/30/2016 7:34 AM	9/27/16 9:30 AM	4.004	3.996	4.006	7.418	7.573	32745	2600	1
8 min mix. Rodding cons.	2	4x8	8/30/2016 7:34 AM	9/27/16 9:30 AM	4.008	4.002	4.002	7.486	7.635	32990	2620	4
8 min mix. Rodding cons.	3	4x8	8/30/2016 7:34 AM	9/27/16 9:30 AM	4.004	3.992	4.009	7.509	7.653	36060	2870	2
8 min mix. Rodding cons.	4	4x8	8/30/2016 7:34 AM	8/30/16 8:39 AM	3.997	4.008	3.999	7.676		9370	750	2
8 min mix. Rodding cons.	5	4x8	8/30/2016 7:34 AM	8/30/16 8:42 AM	4.007	4.009	3.997	7.66		12750	1010	2
8 min mix. Rodding cons.	6	4x8	8/30/2016 7:34 AM	8/30/16 8:46 AM	4.011	3.998	4.005	7.546		12520	990	2
8 min mix. Rodding cons.	7	4x8	8/30/2016 7:34 AM	8/30/16 9:09 AM	3.999	4.005	4.005	7.777		19100	1520	1
8 min mix. Rodding cons.	8	4x8	8/30/2016 7:34 AM	8/30/16 9:13 AM	4	4.001	4.005	7.77		19570	1560	1
8 min mix. Rodding cons.	9	4x8	8/30/2016 7:34 AM	8/30/16 9:17 AM	4	4.002	4.008	7.851		19955	1590	1
8 min mix. Rodding cons.	10	4x8	8/30/2016 7:34 AM	8/30/16 9:39 AM	4.004	3.995	4.007	7.67		21495	1710	1
8 min mix. Rodding cons.	11	4x8	8/30/2016 7:34 AM	8/30/16 9:44 AM	4.005	3.988	4.018	7.802		23020	1830	1
8 min mix. Rodding cons.	12	4x8	8/30/2016 7:34 AM	8/30/16 9:47 AM	4.004	4.002	4	7.853		21915	1740	1
8 min mix. Rodding cons.	13	4x8	8/30/2016 7:34 AM	8/30/16 10:09 AM	3.997	3.997	3.998	7.753		23915	1910	2
8 min mix. Rodding cons.	14	4x8	8/30/2016 7:34 AM	8/30/16 10:13 AM	4.02	3.992	4.009	7.993		25350	2010	2
8 min mix. Rodding cons.	15	4x8	8/30/2016 7:34 AM	8/30/16 10:17 AM	4.019	3.99	3.988	7.72		26140	2080	4
8 min mix. Rodding cons.	16	4x8	8/30/2016 7:34 AM	8/30/16 10:39 AM	4.002	4.005	4.003	7.834		27605	2190	2
8 min mix. Rodding cons.	17	4x8	8/30/2016 7:34 AM	8/30/16 10:42 AM	3.994	4.01	4	7.633		24785	1970	2
8 min mix. Rodding cons.	18	4x8	8/30/2016 7:34 AM	8/30/16 10:47 AM	3.998	4.013	4.017	7.85		28870	2290	4
8 min mix. Rodding cons.	19	4x8	8/30/2016 7:34 AM	9/27/16 9:30 AM	4.008	3.996	4.02	7.989		39185	3110	2
8 min mix. Rodding cons.	20	4x8	8/30/2016 7:34 AM	9/27/16 9:30 AM	3.986	4.028	3.976	7.951		42100	3360	2

Mix	Cyl #	Nominal Size (DxL)	Mix Date & Time	Actual Testing Date	Dia. 1 (in)	Dia. 2 (in)	Dia. 3 (in)	Weight (lbs)	SSD Weight (lb)	P_n (lbs)	f'_c (psi)	ASTM C39 Failure Types
8 min mix. Rodding cons.	21	4x8	8/30/2016 7:34 AM	9/27/16 9:30 AM	3.995	4.017	4.009	7.982		44025	3490	2
8 mins mix. Half Glenium	1	4x8	9/8/2016 1:10 PM	9/8/16 2:11 PM	4.005	4.005	4.007	8.069		15790	1250	2
8 mins mix. Half Glenium	2	4x8	9/8/2016 1:10 PM	9/8/16 2:14 PM	4.004	4.006	4.012	8.136		17715	1400	2
8 mins mix. Half Glenium	3	4x8	9/8/2016 1:10 PM	9/8/16 2:18 PM	4.002	4.003	4.001	8.138		18215	1450	1
8 mins mix. Half Glenium	4	4x8	9/8/2016 1:10 PM	9/8/16 4:10 PM	3.989	4.011	4.006	8.135		23225	1850	2
8 mins mix. Half Glenium	5	4x8	9/8/2016 1:10 PM	9/8/16 4:14 PM	3.994	4.008	4.001	8.056		25485	2030	1
8 mins mix. Half Glenium	6	4x8	9/8/2016 1:10 PM	9/8/16 4:19 PM	4.013	4.007	3.993	7.986		26290	2090	2
8 mins mix. Half Glenium	7	4x8	9/8/2016 1:10 PM	9/8/16 4:23 PM	4.024	4	3.996	7.995		25800	2050	1
8 mins mix. Half Glenium	8	4x8	9/8/2016 1:10 PM	9/8/16 4:26 PM	4	3.985	4.036	8.008		21310	1690	2
8 mins mix. Half Glenium	9	4x8	9/8/2016 1:10 PM	9/8/16 4:30 PM	4.006	3.994	4.015	7.753		21055	1670	1
8 mins mix. Half Glenium	10	4x8	9/8/2016 1:10 PM	9/8/16 4:34 PM	3.992	3.998	4.008	7.791		23210	1850	1
8 mins mix. Half Glenium	11	4x8	9/8/2016 1:10 PM	9/8/16 4:37 PM	4.013	4.015	4.003	8.267		25900	2050	2
8 mins mix. Half Glenium	12	4x8	9/8/2016 1:10 PM	9/8/16 4:42 PM	3.985	4.016	4.009	8.063		26195	2080	2
8 mins mix. Half Glenium	1	4x8	9/21/2016 8:47 AM	9/21/16 9:47 AM	4.009	3.991	3.998	7.229		5320	420	1
8 mins mix. Half Glenium	2	4x8	9/21/2016 8:47 AM	9/21/16 9:56 AM	4.001	4	3.997	7.263		9830	780	1
8 mins mix. Half Glenium	3	4x8	9/21/2016 8:47 AM	9/21/16 9:59 AM	3.998	4.007	4	7.209		9755	780	1
8 mins mix. Half Glenium	4	4x8	9/21/2016 8:47 AM	9/21/16 10:16 AM	4.004	3.98	4.016	7.149		11770	940	1
8 mins mix. Half Glenium	5	4x8	9/21/2016 8:47 AM	9/21/16 10:22 AM	4.001	3.997	4.007	7.236		11465	910	1
8 mins mix. Half Glenium	6	4x8	9/21/2016 8:47 AM	9/21/16 10:30 AM	4.005	4.013	3.993	7.207		11440	910	1
8 mins mix. Half Glenium	7	4x8	9/21/2016 8:47 AM	9/21/16 10:46 AM	4.02	4.01	3.99	7.126		12380	980	1
8 mins mix. Half Glenium	8	4x8	9/21/2016 8:47 AM	9/21/16 10:50 AM	4.007	4.012	3.997	7.172		13155	1040	1
8 mins mix. Half Glenium	9	4x8	9/21/2016 8:47 AM	9/21/16 10:59 AM	3.997	4.008	4	7.19		13160	1050	1

Mix	Cyl #	Nominal Size (DxL)	Mix Date & Time	Actual Testing Date	Dia. 1 (in)	Dia. 2 (in)	Dia. 3 (in)	Weight (lbs)	SSD Weight (lb)	P_n (lbs)	f'_c (psi)	ASTM C39 Failure Types
8 mins mix. Half Glenium	10	4x8	9/21/2016 8:47 AM	9/21/16 11:17 AM	4.009	4.008	4.005	7.24		14755	1170	1
8 mins mix. Half Glenium	11	4x8	9/21/2016 8:47 AM	9/21/16 11:20 AM	4.014	4.003	3.995	7.202		14770	1170	1
8 mins mix. Half Glenium	12	4x8	9/21/2016 8:47 AM	9/21/16 11:25 AM	4.005	4.005	4.004	7.201		14930	1190	1
8 mins mix. Half Glenium	13	4x8	9/21/2016 8:47 AM	9/21/16 11:46 AM	3.995	4.011	4.001	7.196		14975	1190	1
8 mins mix. Half Glenium	14	4x8	9/21/2016 8:47 AM	9/21/16 11:48 AM	4.009	4.003	4.002	7.222		16440	1310	1
8 mins mix. Half Glenium	15	4x8	9/21/2016 8:47 AM	9/21/16 11:52 AM	4.001	3.999	4.016	7.218		13700	1090	1
8 mins mix. Half Glenium	16	4x8	9/21/2016 8:47 AM	9/21/16 2:30 PM	3.986	3.965	3.981	7.089		19160	1540	1
8 mins mix. Half Glenium	17	4x8	9/21/2016 8:47 AM	9/21/16 2:31 PM	3.97	3.986	3.972	7.046		21045	1690	1
8 mins mix. Half Glenium	18	4x8	9/21/2016 8:47 AM	9/21/16 2:32 PM	3.985	3.993	3.982	7.652		28225	2260	NG
8 mins mix. Half Glenium	19	4x8	9/21/2016 8:47 AM	10/19/16 9:00 AM	4.003	4.017	4.011	7.31	7.553	20345	1610	2
8 mins mix. Half Glenium	20	4x8	9/21/2016 8:47 AM	10/19/16 9:00 AM	4.014	4.007	4.009	7.332	7.552	17330	1370	2
8 mins mix. Half Glenium	21	4x8	9/21/2016 8:47 AM	10/19/16 9:00 AM	4.007	4.008	4.007	7.206	7.48	21790	1730	2
8 mins mix. Half Glenium	22	4x8	9/21/2016 8:47 AM	10/19/16 9:00 AM	4.001	4.014	4.013	7.248	7.469	21705	1720	2
8 mins mix. Half Glenium	23	4x8	9/21/2016 8:47 AM	10/19/16 9:00 AM	4.007	4.016	3.997	7.266	7.492	23505	1860	2
8 mins mix. Half Glenium	24	4x8	9/21/2016 8:47 AM	10/19/16 9:00 AM	4.009	4.002	4.004	7.158	7.444	22935	1820	4
1/2 5s cons., 1/2 10 cons.	1	4x8	9/23/2016 7:48 AM	9/23/16 8:48 AM	4.006	3.993	4.01	8.366		13560	1080	1
1/2 5s cons., 1/2 10 cons.	2	4x8	9/23/2016 7:48 AM	9/23/16 8:58 AM	4.009	3.987	4.017	8.256		21445	1700	1
1/2 5s cons., 1/2 10 cons.	3	4x8	9/23/2016 7:48 AM	9/23/16 9:07 AM	4.004	3.988	4.017	8.345		23320	1850	1
1/2 5s cons., 1/2 10 cons.	4	4x8	9/23/2016 7:48 AM	9/23/16 9:41 AM	4.004	4.007	4.001	8.288		32455	2580	1
1/2 5s cons., 1/2 10 cons.	5	4x8	9/23/2016 7:48 AM	9/23/16 9:49 AM	4	3.997	4.012	8.312		32700	2600	1
1/2 5s cons., 1/2 10 cons.	6	4x8	9/23/2016 7:48 AM	9/23/16 9:58 AM	4.014	3.984	4.017	8.31		32950	2620	1
1/2 5s cons., 1/2 10 cons.	7	4x8	9/23/2016 7:48 AM	9/23/16 10:42 AM	3.991	4.011	4.001	8.369		39160	3110	1

Mix	Cyl #	Nominal Size (DxL)	Mix Date & Time	Actual Testing Date	Dia. 1 (in)	Dia. 2 (in)	Dia. 3 (in)	Weight (lbs)	SSD Weight (lb)	P_n (lbs)	f'_c (psi)	ASTM C39 Failure Types
1/2 5s cons., 1/2 10 cons.	8	4x8	9/23/2016 7:48 AM	9/23/16 10:48 AM	3.999	4.009	4.005	8.306		36545	2900	2
1/2 5s cons., 1/2 10 cons.	9	4x8	9/23/2016 7:48 AM	9/23/16 10:57 AM	4.017	4.011	4.001	8.315		39865	3160	1
1/2 5s cons., 1/2 10 cons.	10	4x8	9/23/2016 7:48 AM	9/23/16 8:51 AM	4.015	4.005	4.002	8.321		20755	1650	1
1/2 5s cons., 1/2 10 cons.	11	4x8	9/23/2016 7:48 AM	9/23/16 9:01 AM	4.001	4.007	4.003	8.345		23925	1900	1
1/2 5s cons., 1/2 10 cons.	12	4x8	9/23/2016 7:48 AM	9/23/16 9:04 AM	4.022	3.985	4.016	8.357		26975	2140	1
1/2 5s cons., 1/2 10 cons.	13	4x8	9/23/2016 7:48 AM	9/23/16 9:44 AM	4.005	3.979	3.978	8.339		33245	2660	1
1/2 5s cons., 1/2 10 cons.	14	4x8	9/23/2016 7:48 AM	9/23/16 9:52 AM	4.008	3.975	3.986	8.382		33990	2720	1
1/2 5s cons., 1/2 10 cons.	15	4x8	9/23/2016 7:48 AM	9/23/16 9:59 AM	3.994	3.996	4.01	8.323		34650	2760	1
1/2 5s cons., 1/2 10 cons.	16	4x8	9/23/2016 7:48 AM	9/23/16 10:46 AM	4.006	4.01	3.996	8.363		39210	3110	1
1/2 5s cons., 1/2 10 cons.	17	4x8	9/23/2016 7:48 AM	9/23/16 10:54 AM	4.001	3.999	4.003	8.367		41340	3290	2
1/2 5s cons., 1/2 10 cons.	18	4x8	9/23/2016 7:48 AM	9/23/16 11:00 AM	4.014	4.005	3.972	8.415		39520	3150	1
1/2 5s cons., 1/2 10 cons.	19	4x8	9/23/2016 7:48 AM	10/21/16 9:30 AM	4.012	4.003	4.015	8.43	8.517	74990	5940	2
1/2 5s cons., 1/2 10 cons.	20	4x8	9/23/2016 7:48 AM	10/21/16 9:30 AM	4.02	4.005	4.006	8.42	8.507	74645	5910	4
1/2 5s cons., 1/2 10 cons.	21	4x8	9/23/2016 7:48 AM	10/21/16 9:30 AM	3.998	4.004	4.007	8.393	8.477	75320	5980	4
1/2 5s cons., 1/2 10 cons.	22	4x8	9/23/2016 7:48 AM	10/21/16 9:30 AM	3.974	3.973	3.968	8.22	8.305	75980	6130	2
1/2 5s cons., 1/2 10 cons.	23	4x8	9/23/2016 7:48 AM	10/21/16 9:30 AM	3.961	3.975	3.969	8.182	8.267	74735	6040	4
1/2 5s cons., 1/2 10 cons.	24	4x8	9/23/2016 7:48 AM	10/21/16 9:30 AM	3.963	3.981	3.966	8.204	8.292	77380	6250	4
5-10s cons.	1	4x8	9/28/2016 8:16 AM	9/28/16 9:14 AM	4.007	4.008	3.988	7.499		10260	820	1
5-10s cons.	2	4x8	9/28/2016 8:16 AM	9/28/16 9:20 AM	4.009	4.003	3.997	7.433		8995	710	1
5-10s cons.	3	4x8	9/28/2016 8:16 AM	9/28/16 9:23 AM	4.005	4	4.004	7.563		9730	770	2
5-10s cons.	4	4x8	9/28/2016 8:16 AM	9/28/16 9:43 AM	4.009	3.988	4.018	7.463		13155	1040	2
5-10s cons.	5	4x8	9/28/2016 8:16 AM	9/28/16 9:46 AM	3.998	4	4.012	7.426		12295	980	2

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5-10s cons.	6	4x8	9/28/2016 8:16 AM	9/28/16 9:50 AM	3.995	4.01	3.998	7.436		12590	1000	2
5-10s cons.	7	4x8	9/28/2016 8:16 AM	9/28/16 10:10 AM	4.001	3.981	4.02	7.387		15360	1220	1
5-10s cons.	8	4x8	9/28/2016 8:16 AM	9/28/16 10:13 AM	3.994	3.999	4.009	7.371		14935	1190	1
5-10s cons.	9	4x8	9/28/2016 8:16 AM	9/28/16 10:16 AM	4.007	4	4.004	7.385		15595	1240	1
5-10s cons.	10	4x8	9/28/2016 8:16 AM	9/28/16 10:42 AM	3.999	4.015	3.991	7.505		17515	1390	1
5-10s cons.	11	4x8	9/28/2016 8:16 AM	9/28/16 10:45 AM	3.978	3.994	3.977	7.624		16145	1300	1
5-10s cons.	12	4x8	9/28/2016 8:16 AM	9/28/16 10:49 AM	4.011	4.01	4.002	7.613		15615	1240	1
5-10s cons.	13	4x8	9/28/2016 8:16 AM	9/28/16 11:11 AM	4.003	4.007	3.995	7.386		18275	1450	1
5-10s cons.	14	4x8	9/28/2016 8:16 AM	9/28/16 11:15 AM	4.011	4.008	3.996	7.406		17395	1380	1
5-10s cons.	15	4x8	9/28/2016 8:16 AM	9/28/16 11:18 AM	3.998	3.999	4.003	7.825		17335	1380	1
5-10s cons.	16	4x8	9/28/2016 8:16 AM	10/26/16 8:16 AM	4.005	4.006	4.012	7.451		30055	2380	1
5-10s cons.	17	4x8	9/28/2016 8:16 AM	10/26/16 8:16 AM	4.012	3.999	4.016	7.496		29735	2360	1
5-10s cons.	18	4x8	9/28/2016 8:16 AM	10/26/16 8:16 AM	4.015	4.017	3.998	7.483		29975	2370	1
5-10s cons.	19	4x8	9/28/2016 8:16 AM	10/26/16 8:16 AM	4	4.001	3.999	7.36		30765	2450	1
5-10s cons.	20	4x8	9/28/2016 8:16 AM	10/26/16 8:16 AM	4.015	4.019	4.021	7.513		29045	2290	1
5-10s cons.	21	4x8	9/28/2016 8:16 AM	10/26/16 8:16 AM	4	3.992	4.015	7.506		31140	2480	1
5-10s cons.	22	6x12	9/28/2016 8:16 AM	10/26/16 8:16 AM	5.984	5.983	5.99	26.497		87905	3120	2
1/2 Glenium	1	4x8	9/30/2016 7:49 AM	9/30/16 8:45 AM	4.002	4.005	3.988	7.525		6650	530	1
1/2 Glenium	2	4x8	9/30/2016 7:49 AM	9/30/16 8:49 AM	4.007	4.008	4.002	7.583		7200	570	2
1/2 Glenium	3	4x8	9/30/2016 7:49 AM	9/30/16 8:54 AM	4	3.996	4.015	7.56		8980	710	2
1/2 Glenium	4	4x8	9/30/2016 7:49 AM	9/30/16 9:15 AM	4.008	4.005	4.005	7.524		13985	1110	1
1/2 Glenium	5	4x8	9/30/2016 7:49 AM	9/30/16 9:18 AM	3.999	4.008	3.998	7.564		12820	1020	1

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1/2 Glenium	6	4x8	9/30/2016 7:49 AM	9/30/16 9:21 AM	4.002	3.998	3.998	7.576		7415	590	1
1/2 Glenium	7	4x8	9/30/2016 7:49 AM	9/30/16 9:45 AM	3.998	4.007	4.001	7.329		6965	550	1
1/2 Glenium	8	4x8	9/30/2016 7:49 AM	9/30/16 9:49 AM	4	4.001	4.002	7.529		18260	1450	1
1/2 Glenium	9	4x8	9/30/2016 7:49 AM	9/30/16 9:52 AM	4.003	3.995	4.004	7.575		17960	1430	4
1/2 Glenium	10	4x8	9/30/2016 7:49 AM	9/30/16 10:15 AM	4.003	4.014	3.991	7.554		19275	1530	1
1/2 Glenium	11	4x8	9/30/2016 7:49 AM	9/30/16 10:19 AM	4.002	4.008	3.999	7.528		20055	1590	1
1/2 Glenium	12	4x8	9/30/2016 7:49 AM	9/30/16 10:22 AM	4.005	3.987	4.022	7.588		19755	1570	1
1/2 Glenium	13	4x8	9/30/2016 7:49 AM	9/30/16 10:45 AM	4.006	3.989	4.002	7.508		20640	1640	1
1/2 Glenium	14	4x8	9/30/2016 7:49 AM	9/30/16 10:49 AM	4.005	3.998	4.005	7.669		23531	1870	1
1/2 Glenium	15	4x8	9/30/2016 7:49 AM	9/30/16 10:52 AM	4.006	3.994	4.005	7.678		22640	1800	1
1/2 Glenium	16	4x8	9/30/2016 7:49 AM	10/28/16 7:49 AM	4.004	3.989	4.01	7.745	7.887	35615	2830	2
1/2 Glenium	17	4x8	9/30/2016 7:49 AM	10/28/16 7:49 AM	4.003	4.002	4.003	7.611	7.762	33600	2670	1
1/2 Glenium	18	4x8	9/30/2016 7:49 AM	10/28/16 7:49 AM	3.994	3.999	4.003	7.685	7.828	35595	2830	1
1/2 Glenium	19	6x12	9/30/2016 7:49 AM	10/28/16 7:49 AM	6.002	5.989	6.004	29.087	27.367	108315	3830	1
no MCI	1	4x8	10/12/2016 10:37 AM	10/12/16 11:35 AM	3.996	4.007	3.994	7.877		8100	640	1
no MCI	2	4x8	10/12/2016 10:37 AM	10/12/16 11:37 AM	4.001	4.005	4.005	7.828		10430	830	1
no MCI	3	4x8	10/12/2016 10:37 AM	10/12/16 11:42 AM	3.994	4.007	3.99	7.838		10790	860	1
no MCI	4	4x8	10/12/2016 10:37 AM	10/12/16 12:23 PM	4.008	4.006	4	7.845		22140	1760	1
no MCI	5	4x8	10/12/2016 10:37 AM	10/12/16 12:27 PM	4.004	4.003	4	7.86		21995	1750	1
no MCI	6	4x8	10/12/2016 10:37 AM	10/12/16 12:30 PM	4.005	4	4.006	7.866		21625	1720	4
no MCI	7	4x8	10/12/2016 10:37 AM	10/12/16 1:38 PM	4.001	4.001	4.004	7.855		29285	2330	4
no MCI	8	4x8	10/12/2016 10:37 AM	10/12/16 1:41 PM	3.999	4.005	3.999	7.84		29500	2350	4

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no MCI	9	4x8	10/12/2016 10:37 AM	10/12/16 1:45 PM	4.006	3.992	4.01	7.856		30635	2430	2
no MCI	10	4x8	10/12/2016 10:37 AM	11/9/16 8:30 AM	4.01	4.005	4.007	7.96	8.067	51960	4120	2
no MCI	11	4x8	10/12/2016 10:37 AM	11/9/16 8:30 AM	4.002	4.016	4	7.921	8.036	52625	4180	4
no MCI	12	4x8	10/12/2016 10:37 AM	11/9/16 8:30 AM	3.999	3.998	4.006	8.024	8.133	53960	4290	1
no MCI	13	4x8	10/12/2016 10:37 AM	11/9/16 8:30 AM	4.009	4.005	4.014	8.007	8.004	60245	4770	1
no MCI	14	4x8	10/12/2016 10:37 AM	11/9/16 8:30 AM	4.002	3.998	4.008	7.99	7.988	60520	4810	4
No MCI, no latex	1	4x8	10/14/2016 7:14 AM	10/14/16 8:22 AM	4.016	4.001	3.994	8.837		18390	1460	2
No MCI, no latex	2	4x8	10/14/2016 7:14 AM	10/14/16 8:26 AM	4.005	3.999	4.01	8.746		20340	1610	1
No MCI, no latex	3	4x8	10/14/2016 7:14 AM	10/14/16 8:31 AM	3.996	3.998	4.004	8.729		22785	1810	1
No MCI, no latex	4	4x8	10/14/2016 7:14 AM	10/14/16 9:18 AM	3.996	4.004	3.999	8.709		32980	2620	1
No MCI, no latex	5	4x8	10/14/2016 7:14 AM	10/14/16 9:25 AM	3.992	4.007	4.002	8.821		34945	2780	1
No MCI, no latex	6	4x8	10/14/2016 7:14 AM	10/14/16 9:30 AM	4.009	3.989	4.024	8.826		33530	2660	1
No MCI, no latex	7	4x8	10/14/2016 7:14 AM	10/14/16 10:17 AM	3.997	4.006	3.999	8.754		39475	3140	1
No MCI, no latex	8	4x8	10/14/2016 7:14 AM	10/14/16 10:22 AM	3.986	4.006	3.99	8.825		41150	3280	1
No MCI, no latex	9	4x8	10/14/2016 7:14 AM	10/14/16 10:24 AM	3.996	4.006	4.001	8.778		41340	3290	1
No MCI, no latex	10	4x8	10/14/2016 7:14 AM	11/11/16 7:30 AM	3.997	4.003	4.003	8.798	8.887	84590	6730	4
No MCI, no latex	11	4x8	10/14/2016 7:14 AM	11/11/16 7:30 AM	3.994	3.985	4	8.798	8.9	82390	6580	2
No MCI, no latex	12	4x8	10/14/2016 7:14 AM	11/11/16 7:30 AM	4.004	3.998	3.996	8.817	8.922	79230	6310	4
No latex	1	4x8	10/19/2016 7:28 AM	10/19/16 8:28 AM	3.998	3.996	4.005	8.839		20175	1610	1
No latex	2	4x8	10/19/2016 7:28 AM	10/19/16 8:33 AM	4.001	4.014	3.991	8.85		22515	1790	1
No latex	3	4x8	10/19/2016 7:28 AM	10/19/16 8:38 AM	4.005	3.987	4.004	8.842		24150	1920	1
No latex	4	4x8	10/19/2016 7:28 AM	10/19/16 9:28 AM	3.984	4.01	4.001	8.891		35845	2850	1

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No latex	5	4x8	10/19/2016 7:28 AM	10/19/16 9:32 AM	4.004	3.999	4.009	8.831		36410	2890	1
No latex	6	4x8	10/19/2016 7:28 AM	10/19/16 9:35 AM	4.009	4.004	4	8.842		37750	3000	1
No latex	7	4x8	10/19/2016 7:28 AM	10/19/16 10:29 AM	3.987	4.008	3.996	8.806		42835	3410	1
No latex	8	4x8	10/19/2016 7:28 AM	10/19/16 10:33 AM	4.002	3.988	4.01	8.834		41825	3330	2
No latex	9	4x8	10/19/2016 7:28 AM	10/19/16 10:36 AM	4.002	3.996	4.008	8.877		41645	3310	1
No latex	10	4x8	10/19/2016 7:28 AM	11/16/16 10:00 AM	4.002	4.009	4.007	8.901		83390	6620	1
No latex	11	4x8	10/19/2016 7:28 AM	11/16/16 10:00 AM	4.006	3.996	4.011	8.927		87905	6980	1
No latex	12	4x8	10/19/2016 7:28 AM	11/16/16 10:00 AM	3.991	4.008	3.996	8.866		80885	6440	1
C1	1	4x8	11/2/2016 8:30 AM	11/2/16 9:31 AM	4.008	4.003	3.988	8.469		6965	550	1
C1	2	4x8	11/2/2016 8:30 AM	11/2/16 9:39 AM	4.002	3.999	3.997	8.52		15710	1250	1
C1	3	4x8	11/2/2016 8:30 AM	11/2/16 9:41 AM	3.995	4.002	4.001	8.532		17880	1420	1
C1	4	4x8	11/2/2016 8:30 AM	11/2/16 10:30 AM	4.008	3.996	4.009	8.584		29805	2370	1
C1	5	4x8	11/2/2016 8:30 AM	11/2/16 10:33 AM	3.996	3.993	4.009	8.542		24990	1990	4
C1	6	4x8	11/2/2016 8:30 AM	11/2/16 10:35 AM	3.989	4.006	3.991	8.462		29840	2380	1
C1	7	4x8	11/2/2016 8:30 AM	11/2/16 11:31 AM	4.004	4	3.998	8.478		35510	2820	1
C1	8	4x8	11/2/2016 8:30 AM	11/2/16 11:35 AM	3.995	4.007	3.987	8.457		36710	2930	1
C1	9	4x8	11/2/2016 8:30 AM	11/2/16 11:38 AM	3.997	4.01	3.986	8.47		36320	2890	1
C1	10	4x8	11/2/2016 8:30 AM	11/30/16 8:30 AM	3.997	3.981	4.002	8.484	8.497	79455	6340	4
C1	11	4x8	11/2/2016 8:30 AM	11/30/16 8:30 AM	3.994	3.993	3.999	8.516	8.514	83330	6650	2
C1	12	4x8	11/2/2016 8:30 AM	11/30/16 8:30 AM	4.007	4.005	4.002	8.459	8.449	79620	6320	4
C2	1	4x8	11/4/2016 9:56 AM	11/4/16 10:56 AM	4.015	3.997	4	8.513		13765	1090	1
C2	2	4x8	11/4/2016 9:56 AM	11/4/16 10:59 AM	3.993	4.012	3.996	8.474		13605	1080	1

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C2	3	4x8	11/4/2016 9:56 AM	11/4/16 11:03 AM	3.993	3.997	4.007	8.573		15460	1230	1
C2	4	4x8	11/4/2016 9:56 AM	11/4/16 11:56 AM	4	4.005	4.004	8.572		27295	2170	1
C2	5	4x8	11/4/2016 9:56 AM	11/4/16 12:00 PM	4.003	4.003	3.996	8.506		27610	2200	1
C2	6	4x8	11/4/2016 9:56 AM	11/4/16 12:04 PM	3.996	3.989	4.014	8.487		28365	2260	1
C2	7	4x8	11/4/2016 9:56 AM	11/4/16 12:57 PM	4.006	4.01	3.998	8.402		36520	2900	1
C2	8	4x8	11/4/2016 9:56 AM	11/4/16 1:00 PM	3.988	4	4.015	8.47		34950	2780	1
C2	9	4x8	11/4/2016 9:56 AM	11/4/16 1:04 PM	4.007	4.003	4.012	8.546		36390	2890	1
C2	10	4x8	11/4/2016 9:56 AM	12/2/16 9:56 AM	3.997	3.985	4.018	8.517	8.504	85675	6820	4
C2	11	4x8	11/4/2016 9:56 AM	12/2/16 9:56 AM	4.001	3.982	4.016	8.496	8.484	73755	5870	4
C2	12	4x8	11/4/2016 9:56 AM	12/2/16 9:56 AM	4.01	3.995	4.01	8.52	8.511	79275	6290	4
RS+94	1	4x8	11/16/2016 7:48 AM	11/16/16 8:48 AM	3.995	4.005	3.997	8.612		20740	1650	1
RS+94	2	4x8	11/16/2016 7:48 AM	11/16/16 8:52 AM	3.998	4.008	4.001	8.73		22205	1760	1
RS+94	3	4x8	11/16/2016 7:48 AM	11/16/16 8:55 AM	4.002	4.003	4	8.655		24790	1970	1
RS+94	4	4x8	11/16/2016 7:48 AM	11/16/16 9:48 AM	3.996	3.995	4.01	8.663		36635	2910	1
RS+94	5	4x8	11/16/2016 7:48 AM	11/16/16 9:52 AM	4.002	4.005	3.992	8.699		38110	3030	1
RS+94	6	4x8	11/16/2016 7:48 AM	11/16/16 9:55 AM	4.009	3.995	4.005	8.648		37025	2940	1
RS+94	7	4x8	11/16/2016 7:48 AM	11/16/16 10:48 AM	3.992	4.001	4.001	8.687		44520	3550	1
RS+94	8	4x8	11/16/2016 7:48 AM	11/16/16 10:55 AM	4.005	4.007	3.997	8.656		46120	3660	1
RS+94	9	4x8	11/16/2016 7:48 AM	11/16/16 10:57 AM	3.993	4.005	4.004	8.708		45240	3600	1
RS+94	10	4x8	11/16/2016 7:48 AM	12/14/16 7:48 AM	3.996	4.007	4	8.641	8.688	95585	7600	2
RS+94	11	4x8	11/16/2016 7:48 AM	12/14/16 7:48 AM	4.012	4.003	4.009	8.632	8.658	91390	7240	2
RS+94	12	4x8	11/16/2016 7:48 AM	12/14/16 7:48 AM	4.005	3.999	4.01	8.616	8.713	94525	7500	2

Mix	Cyl #	Nominal Size (DxL)	Mix Date & Time	Actual Testing Date	Dia. 1 (in)	Dia. 2 (in)	Dia. 3 (in)	Weight (lbs)	SSD Weight (lb)	P_n (lbs)	f'_c (psi)	ASTM C39 Failure Types
RS-94	1	4x8	11/18/2016 7:57 AM	11/18/16 8:57 AM	4	4	4	8.284		1	0	1
RS-94	2	4x8	11/18/2016 7:57 AM	11/18/16 8:57 AM	3.995	3.994	4.01	8.255		4450	350	1
RS-94	3	4x8	11/18/2016 7:57 AM	11/18/16 9:03 AM	4.003	3.996	4.009	8.184		5780	460	1
RS-94	4	4x8	11/18/2016 7:57 AM	11/18/16 9:58 AM	3.999	4.005	4	8.435		14965	1190	1
RS-94	5	4x8	11/18/2016 7:57 AM	11/18/16 10:00 AM	4.008	3.99	4.012	8.262		13050	1040	1
RS-94	6	4x8	11/18/2016 7:57 AM	11/18/16 10:04 AM	4.014	4.004	4.006	8.029		11695	930	1
RS-94	7	4x8	11/18/2016 7:57 AM	11/18/16 10:57 AM	4.003	4	4	8.257		19090	1520	1
RS-94	8	4x8	11/18/2016 7:57 AM	11/18/16 11:00 AM	3.99	3.99	4.013	8.271		19330	1540	1
RS-94	9	4x8	11/18/2016 7:57 AM	11/18/16 11:04 AM	3.999	4.021	3.984	8.295		21350	1700	1
RS-94	10	4x8	11/18/2016 7:57 AM	12/16/16 7:57 AM	3.989	4.018	3.98	8.365	8.315	51420	4100	2
RS-94	11	4x8	11/18/2016 7:57 AM	12/16/16 7:57 AM	3.994	4.007	3.997	8.301	8.253	53280	4240	1
RS-94	12	4x8	11/18/2016 7:57 AM	12/16/16 7:57 AM	4	4.006	3.996	8.47	8.417	56505	4500	1
1.1W	1	4x8	12/21/2016 10:07 AM	12/21/16 11:19 AM	4.01	3.998	4.008	8.115		11710	930	1
1.1W	2	4x8	12/21/2016 10:07 AM	12/21/16 11:25 AM	4.006	3.995	4.012	8.185		14675	1170	1
1.1W	3	4x8	12/21/2016 10:07 AM	12/21/16 11:29 AM	3.983	4.014	3.997	8.193		15600	1240	1
1.1W	4	4x8	12/21/2016 10:07 AM	12/21/16 12:07 PM	3.999	4.002	4.002	8.142		23080	1840	1
1.1W	5	4x8	12/21/2016 10:07 AM	12/21/16 12:12 PM	3.986	4.009	4.007	8.178		23560	1870	4
1.1W	6	4x8	12/21/2016 10:07 AM	12/21/16 12:17 PM	4.002	3.978	4.018	8.212		23485	1870	1
1.1W	7	4x8	12/21/2016 10:07 AM	12/21/16 1:07 PM	3.988	4.008	3.994	8.242		26270	2090	1
1.1W	8	4x8	12/21/2016 10:07 AM	12/21/16 1:10 PM	4.005	3.979	4.022	8.158		26220	2080	2
1.1W	9	4x8	12/21/2016 10:07 AM	12/21/16 1:14 PM	3.984	4.007	3.988	8.152		26895	2150	1
1.1W	10	4x8	12/21/2016 10:07 AM	1/18/17 10:07 AM	4.008	4.001	3.993	8.252	8.24	64510	5130	2

Mix	Cyl #	Nominal Size (DxL)	Mix Date & Time	Actual Testing Date	Dia. 1 (in)	Dia. 2 (in)	Dia. 3 (in)	Weight (lbs)	SSD Weight (lb)	P_n (lbs)	f'_c (psi)	ASTM C39 Failure Types
1.1W	11	4x8	12/21/2016 10:07 AM	1/18/17 10:07 AM	4.012	3.993	4.01	8.272	8.259	65840	5230	2
1.1W	12	4x8	12/21/2016 10:07 AM	1/18/17 10:07 AM	3.993	4.012	3.985	8.269	8.255	64510	5140	1
0.9W	1	4x8	12/28/2016 8:37 AM	12/28/16 9:37 AM	3.999	4	4.002	8.608		10560	840	1
0.9W	2	4x8	12/28/2016 8:37 AM	12/28/16 9:42 AM	3.995	3.989	4.002	8.653		10135	810	1
0.9W	3	4x8	12/28/2016 8:37 AM	12/28/16 9:45 AM	3.997	4.02	3.981	8.641		12800	1020	1
0.9W	4	4x8	12/28/2016 8:37 AM	12/28/16 10:37 AM	3.987	4.012	3.986	8.584		28075	2240	1
0.9W	5	4x8	12/28/2016 8:37 AM	12/28/16 10:40 AM	3.994	4.008	3.983	8.604		23010	1840	4
0.9W	6	4x8	12/28/2016 8:37 AM	12/28/16 10:43 AM	4	4.004	3.994	8.513		26740	2130	1
0.9W	7	4x8	12/28/2016 8:37 AM	12/28/16 11:37 AM	4.008	3.996	4.009	8.68		32750	2600	1
0.9W	8	4x8	12/28/2016 8:37 AM	12/28/16 11:41 AM	4.008	3.996	4.007	8.512		33165	2630	1
0.9W	9	4x8	12/28/2016 8:37 AM	12/28/16 11:45 AM	4.001	3.999	3.997	8.54		32650	2600	1
0.9W	10	4x8	12/28/2016 8:37 AM	1/25/17 8:37 AM	3.987	3.99	4.008	8.597	8.598	80240	6400	1
0.9W	11	4x8	12/28/2016 8:37 AM	1/25/17 8:37 AM	3.985	4.001	3.989	8.57	8.571	84845	6780	4
0.9W	12	4x8	12/28/2016 8:37 AM	1/25/17 8:37 AM	3.992	3.996	4.01	8.53	8.529	77960	6210	2
1.1Lat	1	4x8	1/12/2017 8:48 AM	1/12/17 9:49 AM	4.001	3.996	4.002	8.756		8060	640	1
1.1Lat	2	4x8	1/12/2017 8:48 AM	1/12/17 9:52 AM	3.99	4.02	3.979	8.78		8360	670	1
1.1Lat	3	4x8	1/12/2017 8:48 AM	1/12/17 9:56 AM	3.999	3.98	4.015	8.797		9880	790	1
1.1Lat	4	4x8	1/12/2017 8:48 AM	1/12/17 10:48 AM	3.998	3.997	3.999	8.694		22010	1750	1
1.1Lat	5	4x8	1/12/2017 8:48 AM	1/12/17 10:52 AM	4.014	3.999	3.985	8.725		20920	1670	1
1.1Lat	6	4x8	1/12/2017 8:48 AM	1/12/17 10:55 AM	4.002	4.008	3.988	8.752		22010	1750	1
1.1Lat	7	4x8	1/12/2017 8:48 AM	1/12/17 11:48 AM	3.998	4.001	3.997	8.664		27865	2220	1
1.1Lat	8	4x8	1/12/2017 8:48 AM	1/12/17 11:51 AM	4.006	3.992	4.01	8.683		29820	2370	1

Mix	Cyl #	Nominal Size (DxL)	Mix Date & Time	Actual Testing Date	Dia. 1 (in)	Dia. 2 (in)	Dia. 3 (in)	Weight (lbs)	SSD Weight (lb)	P_n (lbs)	f'_c (psi)	ASTM C39 Failure Types
1.1Lat	9	4x8	1/12/2017 8:48 AM	1/12/17 11:55 AM	4	3.999	4.007	8.656		27975	2220	1
1.1Lat	10	4x8	1/12/2017 8:48 AM	2/9/17 8:48 AM	4.002	4.009	3.995	8.667	8.643	71345	5670	1
1.1Lat	11	4x8	1/12/2017 8:48 AM	2/9/17 8:48 AM	3.998	4.01	3.998	8.692	8.675	72865	5790	1
1.1Lat	12	4x8	1/12/2017 8:48 AM	2/9/17 8:48 AM	3.997	3.993	4.011	8.696	8.675	73385	5840	1
0.9Lat	1	4x8	1/13/2017 10:57 AM	1/13/17 11:57 AM	4.011	4.005	4.002	8.844		12595	1000	2
0.9Lat	2	4x8	1/13/2017 10:57 AM	1/13/17 12:03 PM	4.013	3.995	4.01	8.786		15695	1250	1
0.9Lat	3	4x8	1/13/2017 10:57 AM	1/13/17 12:07 PM	3.997	4.007	3.991	8.783		15725	1250	1
0.9Lat	4	4x8	1/13/2017 10:57 AM	1/13/17 12:57 PM	3.997	3.994	4.008	8.976		27200	2160	1
0.9Lat	5	4x8	1/13/2017 10:57 AM	1/13/17 1:01 PM	3.99	3.994	4.011	8.509		23015	1830	1
0.9Lat	6	4x8	1/13/2017 10:57 AM	1/13/17 1:05 PM	3.991	4.004	4	8.864		28335	2260	1
0.9Lat	7	4x8	1/13/2017 10:57 AM	1/13/17 1:57 PM	3.987	4.01	4.004	8.618		27715	2210	1
0.9Lat	8	4x8	1/13/2017 10:57 AM	1/13/17 2:02 PM	3.999	3.995	4.009	8.864		32155	2560	1
0.9Lat	9	4x8	1/13/2017 10:57 AM	1/13/17 2:05 PM	4.003	4.003	3.994	8.915		33390	2660	1
0.9Lat	10	4x8	1/13/2017 10:57 AM	2/10/17 10:57 AM	4.013	3.998	4.016	8.84	8.826	72750	5760	1
0.9Lat	11	4x8	1/13/2017 10:57 AM	2/10/17 10:57 AM	3.996	3.993	4.006	8.88	8.865	72240	5750	4
0.9Lat	12	4x8	1/13/2017 10:57 AM	2/10/17 10:57 AM	3.994	4	4	8.9	8.885	70735	5630	1
0Lat	1	4x8	2/2/2017 8:22 AM	2/2/17 9:45 AM	4.006	4.008	3.997	8.589		15455	1230	1
0Lat	2	4x8	2/2/2017 8:22 AM	2/2/17 9:46 AM	3.985	4.019	3.976	8.58		18075	1440	1
0Lat	3	4x8	2/2/2017 8:22 AM	2/2/17 9:52 AM	4.006	3.994	4.003	8.55		19515	1550	1
0Lat	4	4x8	2/2/2017 8:22 AM	2/2/17 10:23 AM	3.985	3.98	4.009	8.603		28835	2300	1
0Lat	5	4x8	2/2/2017 8:22 AM	2/2/17 10:27 AM	4.004	4.002	3.999	8.589		29270	2330	1
0Lat	6	4x8	2/2/2017 8:22 AM	2/2/17 10:32 AM	4	4.01	3.994	8.622		30190	2400	1

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0Lat	7	4x8	2/2/2017 8:22 AM	2/2/17 11:22 AM	4.011	4.002	4.002	8.55		34965	2780	1
0Lat	8	4x8	2/2/2017 8:22 AM	2/2/17 11:26 AM	3.99	3.995	3.99	8.558		35230	2820	2
0Lat	9	4x8	2/2/2017 8:22 AM	2/2/17 11:30 AM	3.989	4.01	3.991	8.592		35665	2840	1
0Lat	10	4x8	2/2/2017 8:22 AM	3/2/17 8:22 AM	4.002	3.986	4.006	8.592	8.52	74350	5920	4
0Lat	11	4x8	2/2/2017 8:22 AM	3/2/17 8:22 AM	3.992	4.008	3.984	8.578	8.515	79095	6310	2
0Lat	12	4x8	2/2/2017 8:22 AM	3/2/17 8:22 AM	4.023	3.99	4.016	8.586	8.523	76370	6050	1
0Lat+nC	1	4x8	3/2/2017 8:05 AM	3/2/17 9:19 AM	4.008	3.995	4	8.619		23510	1870	1
0Lat+nC	2	4x8	3/2/2017 8:05 AM	3/2/17 9:26 AM	4.001	3.991	4.003	8.666		24380	1940	1
0Lat+nC	3	4x8	3/2/2017 8:05 AM	3/2/17 9:30 AM	4.013	4.016	3.979	8.635		29325	2330	1
0Lat+nC	4	4x8	3/2/2017 8:05 AM	3/2/17 10:05 AM	3.997	3.999	3.992	8.658		41350	3300	1
0Lat+nC	5	4x8	3/2/2017 8:05 AM	3/2/17 10:10 AM	3.979	3.984	3.997	8.631		40195	3220	1
0Lat+nC	6	4x8	3/2/2017 8:05 AM	3/2/17 10:15 AM	3.994	3.98	4.009	8.691		42120	3360	1
0Lat+nC	7	4x8	3/2/2017 8:05 AM	3/2/17 11:05 AM	4.016	3.994	3.997	8.633		48560	3860	1
0Lat+nC	8	4x8	3/2/2017 8:05 AM	3/2/17 11:07 AM	4.001	4.002	3.989	8.637		48270	3850	1
0Lat+nC	9	4x8	3/2/2017 8:05 AM	3/2/17 11:12 AM	4.001	3.994	4.002	8.657		46930	3740	1
0Lat+nC	10	4x8	3/2/2017 8:05 AM	3/30/17 8:05 AM	3.997	3.999	3.995	8.613		95290	7590	4
0Lat+nC	11	4x8	3/2/2017 8:05 AM	3/30/17 8:05 AM	4.008	4.001	3.989	8.715		94155	7500	1
0Lat+nC	12	4x8	3/2/2017 8:05 AM	3/30/17 8:05 AM	3.998	4.007	3.991	8.628		92235	7340	2
0Lat+nC+0.5del	1	4x8	3/3/2017 7:56 AM	3/3/17 9:02 AM	3.994	3.997	4	8.625		30680	2450	1
0Lat+nC+0.5del	2	4x8	3/3/2017 7:56 AM	3/3/17 9:06 AM	3.988	4.002	3.984	8.66		32390	2590	1
0Lat+nC+0.5del	3	4x8	3/3/2017 7:56 AM	3/3/17 9:12 AM	4.011	3.986	4.006	8.589		31765	2530	1
0Lat+nC+0.5del	4	4x8	3/3/2017 7:56 AM	3/3/17 9:56 AM	3.996	3.995	3.995	8.639		41595	3320	1

Mix	Cyl #	Nominal Size (DxL)	Mix Date & Time	Actual Testing Date	Dia. 1 (in)	Dia. 2 (in)	Dia. 3 (in)	Weight (lbs)	SSD Weight (lb)	P_n (lbs)	f'_c (psi)	ASTM C39 Failure Types
0Lat+nC+0.5del	5	4x8	3/3/2017 7:56 AM	3/3/17 10:01 AM	4.017	3.984	4.008	8.578		43835	3480	1
0Lat+nC+0.5del	6	4x8	3/3/2017 7:56 AM	3/3/17 10:06 AM	4.006	3.999	4.005	8.646		34710	2760	1
0Lat+nC+0.5del	7	4x8	3/3/2017 7:56 AM	3/3/17 10:56 AM	3.982	3.988	3.995	8.577		47840	3830	4
0Lat+nC+0.5del	8	4x8	3/3/2017 7:56 AM	3/3/17 11:02 AM	3.992	3.985	4.004	8.624		48700	3890	1
0Lat+nC+0.5del	9	4x8	3/3/2017 7:56 AM	3/3/17 11:06 AM	4.008	3.996	3.987	8.544		47905	3820	1
0Lat+nC+0.5del	10	4x8	3/3/2017 7:56 AM	3/31/17 7:56 AM	3.999	3.99	4.003	8.564		89100	7100	1
0Lat+nC+0.5del	11	4x8	3/3/2017 7:56 AM	3/31/17 7:56 AM	3.999	4.006	3.983	8.572		91015	7260	2
0Lat+nC+0.5del	12	4x8	3/3/2017 7:56 AM	3/31/17 7:56 AM	3.999	3.995	3.994	8.607		91510	7300	2
C	1	4x8	3/9/2017 8:16 AM	3/9/17 9:23 AM	3.993	3.992	3.997	8.677		19980	1590	1
C	2	4x8	3/9/2017 8:16 AM	3/9/17 9:27 AM	3.978	4.009	3.986	8.657		24710	1980	1
C	3	4x8	3/9/2017 8:16 AM	3/9/17 9:31 AM	3.976	4.006	3.995	8.659		26800	2140	1
C	4	4x8	3/9/2017 8:16 AM	3/9/17 10:17 AM	3.998	3.995	3.991	8.593		42185	3370	1
C	5	4x8	3/9/2017 8:16 AM	3/9/17 10:21 AM	3.999	3.985	3.994	8.607		43905	3510	1
C	6	4x8	3/9/2017 8:16 AM	3/9/17 10:25 AM	3.995	3.981	4.013	8.605		43690	3480	2
C	7	4x8	3/9/2017 8:16 AM	3/9/17 11:16 AM	3.975	4.006	3.985	8.597		53890	4310	2
C	8	4x8	3/9/2017 8:16 AM	3/9/17 11:19 AM	3.998	3.989	4.003	8.571		50630	4040	1
C	9	4x8	3/9/2017 8:16 AM	3/9/17 11:23 AM	3.986	3.992	3.991	8.622		51160	4090	1
C	10	4x8	3/9/2017 8:16 AM	4/6/17 8:16 AM	4.006	3.986	3.992	8.621		99875	7970	4
C	11	4x8	3/9/2017 8:16 AM	4/6/17 8:16 AM	3.997	4.022	3.978	8.577		101215	8060	1
C	12	4x8	3/9/2017 8:16 AM	4/6/17 8:16 AM	3.978	3.982	4.006	8.594		99695	7980	1
C	13	4x8	3/9/2017 8:16 AM		4.001	3.995	4.003	8.449				
C	14	4x8	3/9/2017 8:16 AM		3.999	4.002	3.998	8.555				

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C	15	4x8	3/9/2017 8:16 AM		3.998	3.998	3.995	8.46				
wet chip	1	4x8	3/10/2017 8:17 AM	3/10/17 9:20 AM	3.998	3.995	4.002	8.666		16265	1300	1
wet chip	2	4x8	3/10/2017 8:17 AM	3/10/17 9:26 AM	3.995	3.988	4.001	8.655		22195	1770	1
wet chip	3	4x8	3/10/2017 8:17 AM	3/10/17 9:32 AM	3.997	4.005	3.972	8.65		27490	2200	1
wet chip	4	4x8	3/10/2017 8:17 AM	3/10/17 10:16 AM	3.986	4.001	3.997	8.636		41205	3290	1
wet chip	5	4x8	3/10/2017 8:17 AM	3/10/17 10:22 AM	4	3.988	3.997	8.705		42335	3380	1
wet chip	6	4x8	3/10/2017 8:17 AM	3/10/17 10:26 AM	3.988	4	3.994	8.633		43255	3450	1
wet chip	7	4x8	3/10/2017 8:17 AM	3/10/17 11:17 AM	4.002	3.987	3.997	8.666		49005	3910	1
wet chip	8	4x8	3/10/2017 8:17 AM	3/10/17 11:22 AM	3.99	3.994	3.995	8.609		51215	4090	1
wet chip	9	4x8	3/10/2017 8:17 AM	3/10/17 11:26 AM	3.997	3.981	3.993	8.602		50195	4010	1
wet chip	10	4x8	3/10/2017 8:17 AM	4/7/17 8:17 AM	3.999	3.999	3.982	8.634	8.636	106225	8480	2
wet chip	11	4x8	3/10/2017 8:17 AM	4/7/17 8:17 AM	3.996	3.987	3.998	8.636	8.638	99095	7910	2
wet chip	12	4x8	3/10/2017 8:17 AM	4/7/17 8:17 AM	3.988	3.987	4.002	8.637	8.639	105130	8400	4
wet chip	13	4x8	3/10/2017 8:17 AM		4.001	3.992	3.996	8.68				
wet chip	14	4x8	3/10/2017 8:17 AM		3.997	4.006	3.98	8.641				
wet chip	15	4x8	3/10/2017 8:17 AM		3.988	3.998	3.995	8.665				
dry sand	1	4x8	3/16/2017 8:14 AM	3/16/17 9:27 AM	4.004	3.983	3.997	8.558		4220	340	1
dry sand	2	4x8	3/16/2017 8:14 AM	3/16/17 9:30 AM	4.003	3.97	4.017	8.569		13090	1040	1
dry sand	3	4x8	3/16/2017 8:14 AM	3/16/17 9:36 AM	4.006	3.995	3.997	8.591		14695	1170	1
dry sand	4	4x8	3/16/2017 8:14 AM	3/16/17 10:16 AM	4.008	4.003	3.984	8.573		26430	2100	1
dry sand	5	4x8	3/16/2017 8:14 AM	3/16/17 10:22 AM	3.993	3.997	3.992	8.564		26800	2140	1
dry sand	6	4x8	3/16/2017 8:14 AM	3/16/17 10:26 AM	3.992	4.004	3.997	8.562		27310	2180	1

Mix	Cyl #	Nominal Size (DxL)	Mix Date & Time	Actual Testing Date	Dia. 1 (in)	Dia. 2 (in)	Dia. 3 (in)	Weight (lbs)	SSD Weight (lb)	P_n (lbs)	f'_c (psi)	ASTM C39 Failure Types
dry sand	7	4x8	3/16/2017 8:14 AM	3/16/17 11:17 AM	3.998	4.003	3.983	8.594		35255	2810	1
dry sand	8	4x8	3/16/2017 8:14 AM	3/16/17 11:22 AM	3.986	4.011	3.985	8.522		35030	2800	1
dry sand	9	4x8	3/16/2017 8:14 AM	3/16/17 11:26 AM	3.999	3.981	4.01	8.556		35090	2800	1
dry sand	10	4x8	3/16/2017 8:14 AM	4/13/17 8:14 AM	3.997	4.001	4	8.547	8.538	87155	6940	1
dry sand	11	4x8	3/16/2017 8:14 AM	4/13/17 8:14 AM	3.993	4.006	3.982	8.545	8.535	88170	7040	4
dry sand	12	4x8	3/16/2017 8:14 AM	4/13/17 8:14 AM	3.997	4.011	3.976	8.561	8.554	86850	6930	2
dry sand	13	4x8	3/16/2017 8:14 AM		3.998	3.996	3.992	8.579				
dry sand	14	4x8	3/16/2017 8:14 AM		3.995	4.003	3.992	8.568				
dry sand	15	4x8	3/16/2017 8:14 AM		3.998	4.005	3.995	8.575				
poor cem. Con.	1	4x8	3/17/2017 8:17 AM	3/17/17 9:17 AM	3.979	4.003	4.002	8.478		2710	220	1
poor cem. Con.	2	4x8	3/17/2017 8:17 AM	3/17/17 9:26 AM	4	4	4	8.480		10710	850	1
poor cem. Con.	3	4x8	3/17/2017 8:17 AM	3/17/17 9:35 AM	3.99	3.979	4.022	8.482		11240	900	1
poor cem. Con.	4	4x8	3/17/2017 8:17 AM	3/17/17 10:17 AM	3.998	4.007	3.993	8.522				1
poor cem. Con.	5	4x8	3/17/2017 8:17 AM	3/17/17 10:22 AM	4.007	3.998	3.995	8.49		20035	1590	1
poor cem. Con.	6	4x8	3/17/2017 8:17 AM	3/17/17 10:35 AM	4.002	3.994	3.997	8.497		20250	1610	1
poor cem. Con.	7	4x8	3/17/2017 8:17 AM	3/17/17 11:17 AM	4.002	4.002	3.997	8.517				1
poor cem. Con.	8	4x8	3/17/2017 8:17 AM	3/17/17 11:22 AM	3.987	3.997	4.006	8.522		28485	2270	1
poor cem. Con.	9	4x8	3/17/2017 8:17 AM	3/17/17 11:35 AM	3.98	3.998	4.006	8.491		28635	2280	1
poor cem. Con.	10	4x8	3/17/2017 8:17 AM	4/14/17 8:17 AM	3.972	4.002	4.008	8.447	8.442	79865	6370	4
poor cem. Con.	11	4x8	3/17/2017 8:17 AM	4/14/17 8:17 AM	3.989	3.995	4.001	8.508	8.504	81165	6480	1
poor cem. Con.	12	4x8	3/17/2017 8:17 AM	4/14/17 8:17 AM	4.005	3.995	4	8.413	8.41	78655	6260	4
poor cem. Con.	13	4x8	3/17/2017 8:17 AM		3.991	4.005	3.993	8.407				

Mix	Cyl #	Nominal Size (DxL)	Mix Date & Time	Actual Testing Date	Dia. 1 (in)	Dia. 2 (in)	Dia. 3 (in)	Weight (lbs)	SSD Weight (lb)	P_n (lbs)	f'_c (psi)	ASTM C39 Failure Types
poor cem. Con.	14	4x8	3/17/2017 8:17 AM		3.993	3.999	3.995	8.452				
poor cem. Con.	15	4x8	3/17/2017 8:17 AM		3.998	3.996	3.994	8.492				
crushed new cem.	1	4x8	4/14/2017 8:13 AM	4/14/17 9:28 AM	4	3.996	3.991	8.41		21860	1740	1
crushed new cem.	2	4x8	4/14/2017 8:13 AM	4/14/17 9:32 AM	3.997	3.996	3.995	8.504		20330	1620	1
crushed new cem.	3	4x8	4/14/2017 8:13 AM	4/14/17 9:35 AM	4.007	4.001	3.991	8.575		26575	2120	1
crushed new cem.	4	4x8	4/14/2017 8:13 AM		4.007	3.99	4.003	8.397				
crushed new cem.	5	4x8	4/14/2017 8:13 AM		3.998	4.002	3.992	8.386				
crushed new cem.	6	4x8	4/14/2017 8:13 AM	4/14/17 10:22 AM	3.994	3.995	3.999	8.35		33200	2650	1
crushed new cem.	7	4x8	4/14/2017 8:13 AM	4/14/17 10:28 AM	4	4.006	3.989	8.3		33025	2630	1
crushed new cem.	8	4x8	4/14/2017 8:13 AM	4/14/17 10:32 AM	4	3.997	3.994	8.3		32940	2630	1
crushed new cem.	9	4x8	4/14/2017 8:13 AM		3.995	4.001	3.991	8.3				
crushed new cem.	10	4x8	4/14/2017 8:13 AM		4	3.995	3.994	8.283				
crushed new cem.	11	4x8	4/14/2017 8:13 AM	4/14/17 11:13 AM	3.99	4	4.01	8.46		36500	2900	1
crushed new cem.	12	4x8	4/14/2017 8:13 AM	4/14/17 11:16 AM	3.986	4.004	4.005	8.413		36545	2910	1
crushed new cem.	13	4x8	4/14/2017 8:13 AM	4/14/17 11:21 AM	3.991	3.996	4.006	8.514		35655	2840	1
crushed new cem.	14	4x8	4/14/2017 8:13 AM		3.988	4.004	3.982	8.351				
crushed new cem.	15	4x8	4/14/2017 8:13 AM		4.002	3.998	3.992	8.381				
C3	1	4x8	5/22/2017 9:15 AM		3.994	4.003	3.987	8.713				
C3	2	4x8	5/22/2017 9:15 AM		3.995	4.005	3.996	8.611				
C3	3	4x8	5/22/2017 9:15 AM	5/22/17 10:47 AM	3.998	4	3.993	8.715		25075	2000	1
C3	4	4x8	5/22/2017 9:15 AM	5/22/17 10:51 AM	3.985	4.007	3.984	8.725		25475	2040	1
C3	5	4x8	5/22/2017 9:15 AM	5/22/17 10:54 AM	3.99	4.018	3.974	8.713		24480	1950	1

Mix	Cyl #	Nominal Size (DxL)	Mix Date & Time	Actual Testing Date	Dia. 1 (in)	Dia. 2 (in)	Dia. 3 (in)	Weight (lbs)	SSD Weight (lb)	P_n (lbs)	f'_c (psi)	ASTM C39 Failure Types
C3	6	4x8	5/22/2017 9:15 AM		3.99	3.994	4.001	8.71				
C3	7	4x8	5/22/2017 9:15 AM		4.002	4.011	3.984	8.68				
C3	8	4x8	5/22/2017 9:15 AM		3.99	3.991	3.994	8.708				
C3	9	4x8	5/22/2017 9:15 AM		4.003	3.998	3.993	8.659				
C3	10	4x8	5/22/2017 9:15 AM	5/22/17 12:17 PM	3.998	3.999	3.998	8.641		38355	3050	1
C3	11	4x8	5/22/2017 9:15 AM	5/22/17 12:21 PM	3.984	4.012	3.979	8.647		38210	3050	1
C3	12	4x8	5/22/2017 9:15 AM	5/22/17 12:25 PM	3.996	4.007	3.994	8.669		36725	2920	4
C3	13	4x8	5/22/2017 9:15 AM		3.99	4.008	3.976	8.653				
C4	1	4x8	5/24/2017 9:27 AM	5/24/17 12:45 PM	3.984	4.041	3.98	8.591		34050	2710	1
C4	2	4x8	5/24/2017 9:27 AM	5/24/17 12:49 PM	3.989	3.981	4.016	8.520		34340	2740	1
C4	3	4x8	5/24/2017 9:27 AM	5/24/17 12:54 PM	3.993	4.021	3.975	8.518		36735	2930	1
C4	4	4x8	5/24/2017 9:27 AM		3.998	4.005	3.985	8.616				
C4	5	4x8	5/24/2017 9:27 AM		4.002	3.997	3.997	8.671				
C4	6	4x8	5/24/2017 9:27 AM		4.001	4.001	3.991	8.63				
C4	7	4x8	5/24/2017 9:27 AM		4.009	3.991	4.003	8.559				
C4	8	4x8	5/24/2017 9:27 AM		3.987	3.987	4.008	8.604				
C4	9	4x8	5/24/2017 9:27 AM		4.004	3.981	4.015	8.611				
C5	1	4x8	6/14/2017 8:28 AM		3.995	4.012	3.996	8.614				
C5	2	4x8	6/14/2017 8:28 AM		4.004	3.999	4.005	8.665				
C5	3	4x8	6/14/2017 8:28 AM	6/14/17 10:07 AM	3.995	4.002	3.992	8.535		31680	2530	4
C5	4	4x8	6/14/2017 8:28 AM	6/14/17 10:19 AM	4.003	4	4	8.713		33130	2640	4
C5	5	4x8	6/14/2017 8:28 AM	6/14/17 10:26 AM	3.988	3.993	4.01	8.677		36020	2870	4

Mix	Cyl #	Nominal Size (DxL)	Mix Date & Time	Actual Testing Date	Dia. 1 (in)	Dia. 2 (in)	Dia. 3 (in)	Weight (lbs)	SSD Weight (lb)	P_n (lbs)	f'_c (psi)	ASTM C39 Failure Types
C5	6	4x8	6/14/2017 8:28 AM		3.998	4	4.004	8.61				
C5	7	4x8	6/14/2017 8:28 AM		3.996	3.997	4.011	8.65				
C5	8	4x8	6/14/2017 8:28 AM	6/14/17 11:29 AM	3.995	4.008	3.984	8.7		42870	3420	4
C5	9	4x8	6/14/2017 8:28 AM	6/14/17 11:43 AM	4.002	3.999	4.006	8.606		44300	3520	4
C5	10	4x8	6/14/2017 8:28 AM	7/12/17 12:46 PM	4.006	3.997	4.008	8.668		92510	7350	2
C5	11	4x8	6/14/2017 8:28 AM	7/12/17 12:53 PM	4.001	4.003	3.996	8.663		93635	7450	1
C5	12	4x8	6/14/2017 8:28 AM		4.003	4.005	3.996	8.573				
RS1+94	1	4x8	6/16/2017 8:04 AM		3.994	4.003	4.002	8.621				
RS1+94	2	4x8	6/16/2017 8:04 AM		3.997	4.004	3.997	8.722				
RS1+94	3	4x8	6/16/2017 8:04 AM	6/16/17 9:33 AM	4.006	3.996	3.995	8.712		38880	3100	5
RS1+94	4	4x8	6/16/2017 8:04 AM	6/16/17 9:43 AM	4.008	3.999	4.006	8.643		40097	3180	4
RS1+94	5	4x8	6/16/2017 8:04 AM	6/16/17 9:53 AM	3.995	4.004	3.992	8.73		44190	3520	4
RS1+94	6	4x8	6/16/2017 8:04 AM		3.991	3.999	3.995	8.589				
RS1+94	7	4x8	6/16/2017 8:04 AM		4.007	3.996	4.002	8.689				
RS1+94	8	4x8	6/16/2017 8:04 AM	6/16/17 11:08 AM	3.988	3.994	4.006	8.693		51005	4070	1
RS1+94	9	4x8	6/16/2017 8:04 AM	6/16/17 11:18 AM	4	3.994	4	8.699		51045	4070	4
RS1+94	10	4x8	6/16/2017 8:04 AM	7/14/17 10:12 AM	3.999	4.009	3.991	8.697		101025	8040	4
RS1+94	11	4x8	6/16/2017 8:04 AM	7/14/17 10:26 AM	3.999	3.996	4.002	8.647		102570	8170	4
RS1+94	12	4x8	6/16/2017 8:04 AM		3.99	3.995	3.979					
RS1-94	1	4x8	6/20/2017 8:55 AM		3.993	4.007	3.994	8.473				
RS1-94	2	4x8	6/20/2017 8:55 AM		4.005	4.002	3.997	8.431				
RS1-94	3	4x8	6/20/2017 8:55 AM	6/20/17 10:28 AM	4.007	4.003	4	8.431		20934	1660	1

Mix	Cyl #	Nominal Size (DxL)	Mix Date & Time	Actual Testing Date	Dia. 1 (in)	Dia. 2 (in)	Dia. 3 (in)	Weight (lbs)	SSD Weight (lb)	P_n (lbs)	f'_c (psi)	ASTM C39 Failure Types
RS1-94	4	4x8	6/20/2017 8:55 AM	6/20/17 10:37 AM	4.019	3.989	4.001	8.479		23315	1850	4
RS1-94	5	4x8	6/20/2017 8:55 AM	6/20/17 10:45 AM	4.006	4.01	3.983	8.503		24216	1930	4
RS1-94	6	4x8	6/20/2017 8:55 AM		3.998	3.996	4	8.443				
RS1-94	7	4x8	6/20/2017 8:55 AM		3.999	3.999	3.998	8.512				
RS1-94	8	4x8	6/20/2017 8:55 AM	6/20/17 11:57 AM	3.996	3.996	4.005	8.416		33280	2650	4
RS1-94	9	4x8	6/20/2017 8:55 AM	6/20/17 12:07 PM	3.995	3.993	4.013	8.492		32546	2590	4
RS1-94	10	4x8	6/20/2017 8:55 AM	6/20/17 12:15 PM	3.995	3.991	4.005	8.582		34201	2730	4
RS1-94	11	4x8	6/20/2017 8:55 AM		4.005	4	3.991	8.462				
RS1-94	12	4x8	6/20/2017 8:55 AM		4.005	3.987	3.999	8.482				
RS1-94	13	4x8	6/20/2017 8:55 AM	7/18/17 1:31 PM	3.997	3.996	4.007	8.465		68325	5440	4
RS1-94	14	4x8	6/20/2017 8:55 AM	7/18/17 1:41 PM	4.001	3.989	4.008	8.52		69825	5560	4
RS1-94	15	4x8	6/20/2017 8:55 AM	7/18/17 1:51 PM	3.998	3.997	4.004	8.448		69165	5500	4
1.1W1	1	4x8	7/5/2017 9:19 AM		4.014	4.004	3.992	8.38				
1.1W1	2	4x8	7/5/2017 9:19 AM		4.004	4.012	3.986	8.473				
1.1W1	3	4x8	7/5/2017 9:19 AM	7/5/17 10:55 AM	3.985	4.005	3.985	8.479		26514	2120	4
1.1W1	4	4x8	7/5/2017 9:19 AM	7/5/17 11:04 AM	4.013	4.002	3.999	8.362		27089	2150	4
1.1W1	5	4x8	7/5/2017 9:19 AM	7/5/17 11:11 AM	4.007	4.012	3.991	8.471		29554	2350	4
1.1W1	6	4x8	7/5/2017 9:19 AM		3.995	4.009	4.002	8.383				
1.1W1	7	4x8	7/5/2017 9:19 AM		4.006	3.99	4.007	8.511				
1.1W1	8	4x8	7/5/2017 9:19 AM	7/5/17 12:21 PM	4.012	3.997	4.001	8.499		37323	2970	4
1.1W1	9	4x8	7/5/2017 9:19 AM	7/5/17 12:29 PM	3.997	4.015	3.991	8.485		37676	3000	4
1.1W1	10	4x8	7/5/2017 9:19 AM	7/5/17 12:37 PM	4.016	4.003	3.994	8.436		38401	3050	4

Mix	Cyl #	Nominal Size (DxL)	Mix Date & Time	Actual Testing Date	Dia. 1 (in)	Dia. 2 (in)	Dia. 3 (in)	Weight (lbs)	SSD Weight (lb)	P_n (lbs)	f'_c (psi)	ASTM C39 Failure Types
1.1W1	11	4x8	7/5/2017 9:19 AM		4	3.986	4.013	8.518				
1.1W1	12	4x8	7/5/2017 9:19 AM		3.984	4.004	4.003	8.545				
1.1W1	13	4x8	7/5/2017 9:19 AM	8/2/17 10:29 AM	3.998	3.991	3.993	8.494		84465	6740	4
1.1W1	14	4x8	7/5/2017 9:19 AM	8/2/17 10:40 AM	3.972	4.02	4	8.462		83205	6630	4
1.1W1	15	4x8	7/5/2017 9:19 AM	8/2/17 10:49 AM	3.991	4.005	3.993	8.498		83510	6660	1
0.9W1	1	4x8	7/7/2017 7:50 AM		3.985	4.004	4.005	8.537				
0.9W1	2	4x8	7/7/2017 7:50 AM		3.987	4.003	4.002	8.599				
0.9W1	3	4x8	7/7/2017 7:50 AM	7/7/17 9:22 AM	3.997	4.004	3.998	8.534		27240	2170	4
0.9W1	4	4x8	7/7/2017 7:50 AM	7/7/17 9:29 AM	4.017	3.993	3.99	8.504		30603	2440	4
0.9W1	5	4x8	7/7/2017 7:50 AM	7/7/17 9:37 AM	4.005	3.994	4.008	8.542		31905	2540	4
0.9W1	6	4x8	7/7/2017 7:50 AM		3.99	4	4.008	8.414				
0.9W1	7	4x8	7/7/2017 7:50 AM		3.979	4.005	4.02	8.541				
0.9W1	8	4x8	7/7/2017 7:50 AM	7/7/17 10:52 AM	4.011	3.99	3.998	8.498		42238	3360	1
0.9W1	9	4x8	7/7/2017 7:50 AM	7/7/17 11:02 AM	4.003	3.999	3.993	8.526		41884	3340	4
0.9W1	10	4x8	7/7/2017 7:50 AM	7/7/17 11:10 AM	4.019	4.004	3.971	8.553		43774	3490	4
0.9W1	11	4x8	7/7/2017 7:50 AM		4.006	3.993	3.999	8.535				
0.9W1	12	4x8	7/7/2017 7:50 AM		4.012	3.994	4.002	8.61				
0.9W1	13	4x8	7/7/2017 7:50 AM	8/4/17 11:01 AM	3.998	4.001	4.007	8.513		83175	6610	4
0.9W1	14	4x8	7/7/2017 7:50 AM	8/4/17 11:24 AM	4.023	3.984	3.998	8.506		83080	6610	4
0.9W1	15	4x8	7/7/2017 7:50 AM	8/4/17 11:36 AM	4.006	4	3.991	8.567		84240	6710	4
1.1Lat1	1	4x8	7/11/2017 8:44 AM		4.005	3.995	4.001	8.4				
1.1Lat1	2	4x8	7/11/2017 8:44 AM		4	4.011	3.994	8.446				

Mix	Cyl #	Nominal Size (DxL)	Mix Date & Time	Actual Testing Date	Dia. 1 (in)	Dia. 2 (in)	Dia. 3 (in)	Weight (lbs)	SSD Weight (lb)	P_n (lbs)	f'_c (psi)	ASTM C39 Failure Types
1.1Lat1	3	4x8	7/11/2017 8:44 AM	7/11/17 10:17 AM	4.015	4.001	3.991	8.38		18981	1510	4
1.1Lat1	4	4x8	7/11/2017 8:44 AM	7/11/17 10:24 AM	3.979	4.01	4.002	8.463		19838	1580	1
1.1Lat1	5	4x8	7/11/2017 8:44 AM	7/11/17 10:32 AM	3.998	3.99	4.01	8.37		21379	1700	4
1.1Lat1	6	4x8	7/11/2017 8:44 AM		3.998	3.995	4.001	8.409				
1.1Lat1	7	4x8	7/11/2017 8:44 AM		3.989	4.014	3.991	8.407				
1.1Lat1	8	4x8	7/11/2017 8:44 AM	7/11/17 11:46 AM	4.011	4.009	3.983	8.391		30607	2430	4
1.1Lat1	9	4x8	7/11/2017 8:44 AM	7/11/17 11:54 AM	3.993	4.02	3.982	8.417		31051	2470	4
1.1Lat1	10	4x8	7/11/2017 8:44 AM	7/11/17 11:59 AM	4.001	4.01	3.991	8.417		32198	2560	1
1.1Lat1	11	4x8	7/11/2017 8:44 AM		3.994	4.018	3.989	8.366				
1.1Lat1	12	4x8	7/11/2017 8:44 AM		4.005	4.004	3.987	8.435				
1.1Lat1	13	4x8	7/11/2017 8:44 AM	8/8/17 10:25 AM	4.001	4.008	3.986	8.428		68640	5470	1
1.1Lat1	14	4x8	7/11/2017 8:44 AM	8/8/17 10:37 AM	3.996	4.004	3.999	8.386		68630	5460	4
1.1Lat1	15	4x8	7/11/2017 8:44 AM	8/8/17 10:48 AM	4.001	3.986	4.011	8.49		69885	5560	4
0.9Lat1	1	4x8	7/13/2017 8:52 AM		3.998	3.992	4.015	8.65				
0.9Lat1	2	4x8	7/13/2017 8:52 AM		4.021	3.991	3.992	8.678				
0.9Lat1	3	4x8	7/13/2017 8:52 AM	7/13/17 10:28 AM	4.001	4.009	4.006	8.576		29612	2350	4
0.9Lat1	4	4x8	7/13/2017 8:52 AM	7/13/17 10:39 AM	4.003	3.994	4.008	8.648		31729	2520	4
0.9Lat1	5	4x8	7/13/2017 8:52 AM	7/13/17 10:47 AM	4	4.002	4.01	8.665		34534	2740	4
0.9Lat1	6	4x8	7/13/2017 8:52 AM		3.999	4.01	3.985	8.575				
0.9Lat1	7	4x8	7/13/2017 8:52 AM		3.994	3.994	3.994	8.631				
0.9Lat1	8	4x8	7/13/2017 8:52 AM	7/13/17 11:55 AM	3.997	3.999	3.984	8.57		42788	3420	4
0.9Lat1	9	4x8	7/13/2017 8:52 AM	7/13/17 12:02 PM	4	3.997	3.998	8.68		44240	3520	2

Mix	Cyl #	Nominal Size (DxL)	Mix Date & Time	Actual Testing Date	Dia. 1 (in)	Dia. 2 (in)	Dia. 3 (in)	Weight (lbs)	SSD Weight (lb)	P_n (lbs)	f’$_c$ (psi)	ASTM C39 Failure Types
0.9Lat1	10	4x8	7/13/2017 8:52 AM	7/13/17 12:09 PM	3.986	4.005	3.998	8.669		44519	3550	4
0.9Lat1	11	4x8	7/13/2017 8:52 AM		3.995	3.989	4.02	8.627				
0.9Lat1	12	4x8	7/13/2017 8:52 AM		3.99	4.007	3.999	8.526				
0.9Lat1	13	4x8	7/13/2017 8:52 AM	8/10/17 9:02 AM	3.995	4.003	4.005	8.539		86490	6880	4
0.9Lat1	14	4x8	7/13/2017 8:52 AM	8/10/17 9:10 AM	3.983	4.006	4.002	8.604		87010	6930	4
0.9Lat1	15	4x8	7/13/2017 8:52 AM	8/10/17 9:24 AM	3.98	4.007	4.004	8.636		85935	6850	1
0Lat1	1	4x8	7/17/2017 9:37 AM		3.98	4.008	4.005	8.659				
0Lat1	2	4x8	7/17/2017 9:37 AM		4.01	3.991	3.992	8.648				
0Lat1	3	4x8	7/17/2017 9:37 AM	7/17/17 11:09 AM	4.004	3.999	3.904	8.688		34294	2770	4
0Lat1	4	4x8	7/17/2017 9:37 AM	7/17/17 11:16 AM	3.986	4.006	3.997	8.6		36668	2920	4
0Lat1	5	4x8	7/17/2017 9:37 AM	7/17/17 11:24 AM	4.01	4.002	3.994	8.676		37641	2990	1
0Lat1	6	4x8	7/17/2017 9:37 AM		4.001	3.999	4	8.713				
0Lat1	7	4x8	7/17/2017 9:37 AM		3.977	4.006	3.992	8.62				
0Lat1	8	4x8	7/17/2017 9:37 AM	7/17/17 12:39 PM	4.023	3.991	3.993	8.585		42918	3410	4
0Lat1	9	4x8	7/17/2017 9:37 AM	7/17/17 12:47 PM	3.988	4.004	3.999	8.608		46679	3720	4
0Lat1	10	4x8	7/17/2017 9:37 AM	7/17/17 12:55 PM	3.996	3.995	3.995	8.714		45051	3590	1
0Lat1	11	4x8	7/17/2017 9:37 AM		3.995	4.002	3.999	8.73				
0Lat1	12	4x8	7/17/2017 9:37 AM		4.005	3.993	3.995	8.645				
0Lat1	13	4x8	7/17/2017 9:37 AM	8/14/17 10:12 AM	3.995	4.001	4.005	8.629		85005	6760	2
0Lat1	14	4x8	7/17/2017 9:37 AM	8/14/17 10:28 AM	4.002	4.001	3.994	8.562		82770	6590	4
0Lat1	15	4x8	7/17/2017 9:37 AM	8/14/17 10:35 AM	4.003	4.001	3.998	8.686		83300	6630	2

Elastic modulus VESLMC and LMC

Table A-7 Modulus of elastic comparison

Mix	Cyl #	Density (pcf)	P (lbs)	f'_c(ksi)	Elastic Modulus (ksi)	E_{AASHTO} (ksi)	E_{ACI} (ksi)	Diff (%)
C5	3	147.0	31683	2.5259	2306	2955	2865	28.15%
C5	4	149.7	33131	2.6351	2765	3102	2926	12.21%
C5	5	149.4	36021	2.8708	2853	3228	3054	13.12%
C5	8	149.9	42874	3.4192	2818	3540	3333	25.65%
C5	9	147.8	44282	3.5197	2757	3516	3382	27.54%
C5	10	148.7	92510	7.3482	4263	5130	4886	20.35%
C5	11	148.9	93635	7.4512	4294	5176	4920	20.54%
RS1+94	3	149.8	38885	3.0959	2789	3367	3172	20.71%
RS1+94	4	148.2	40098	3.1840	2552	3361	3216	31.69%
RS1+94	5	150.3	44200	3.5226	2855	3608	3383	26.38%
RS1+94	8	149.7	51005	4.0670	3115	3855	3635	23.77%
RS1+94	9	149.7	51045	4.0661	3287	3853	3635	17.24%
RS1+94	10	149.5	101025	8.0407	4458	5410	5111	21.34%
RS1+94	11	148.7	102570	8.1663	4646	5408	5151	16.38%
RS1-94	3	144.7	20934	1.6631	1842	2342	2325	27.17%
RS1-94	4	145.5	23315	1.8526	1993	2493	2453	25.14%
RS1-94	5	146.2	24217	1.9274	2155	2561	2502	18.83%
RS1-94	8	144.7	33281	2.6497	2420	2958	2934	22.22%
RS1-94	9	145.9	32547	2.5895	2356	2961	2901	25.66%
RS1-94	10	147.7	34202	2.7258	2522	3094	2976	22.66%
RS1-94	13	145.5	68325	5.4371	3802	4271	4203	12.33%
RS1-94	14	146.5	69825	5.5583	3674	4362	4250	18.73%
RS1-94	15	145.2	69165	5.5049	3643	4285	4229	17.62%
1.1W1	3	146.4	26515	2.1188	2352	2689	2624	14.32%
1.1W1	4	143.4	27089	2.1507	2113	2628	2643	24.35%
1.1W1	5	145.4	29555	2.3480	2287	2802	2762	22.53%
1.1W1	8	145.8	37323	2.9652	2569	3165	3104	23.20%
1.1W1	9	145.8	37676	2.9967	2616	3179	3120	21.53%
1.1W1	10	144.7	38401	3.0492	2610	3172	3148	21.53%
1.1W1	13	146.4	84465	6.7417	3952	4802	4680	21.51%
1.1W1	14	145.6	83205	6.6301	3881	4723	4641	21.69%
1.1W1	15	146.3	83510	6.6577	3845	4767	4651	23.96%
0.9W1	3	146.7	27240	2.1681	2171	2731	2654	25.77%
0.9W1	4	146.2	30603	2.4353	2305	2878	2813	24.85%
0.9W1	5	146.7	31905	2.5360	2381	2951	2870	23.94%
0.9W1	8	146.1	42238	3.3618	2794	3379	3305	20.93%
0.9W1	9	146.7	41884	3.3358	2647	3386	3292	27.92%

0.9W1	10	147.2	43774	3.4869	2784	3479	3366	24.97%
0.9W1	13	146.2	83175	6.6122	3906	4743	4635	21.44%
0.9W1	14	146.1	83080	6.6058	4120	4736	4633	14.96%
0.9W1	15	147.3	84240	6.7070	4184	4833	4668	15.51%
1.1Lat1	3	143.9	18981	1.5087	1487	2212	2214	48.77%
1.1Lat1	4	145.7	19838	1.5811	1839	2307	2266	25.49%
1.1Lat1	5	143.9	21379	1.7018	1788	2350	2351	31.42%
1.1Lat1	8	144.2	30607	2.4344	2159	2818	2812	30.52%
1.1Lat1	9	144.8	31051	2.4730	2226	2859	2835	28.45%
1.1Lat1	10	144.6	32198	2.5614	2238	2905	2885	29.79%
1.1Lat1	13	145.0	68640	5.4668	3695	4260	4214	15.30%
1.1Lat1	14	144.2	68630	5.4623	3510	4222	4213	20.28%
1.1Lat1	15	146.0	69885	5.5631	3653	4341	4251	18.85%
0.9Lat1	3	147.0	29612	2.3502	2289	2852	2763	24.57%
0.9Lat1	4	148.5	31729	2.5228	2384	3000	2863	25.86%
0.9Lat1	5	148.6	34534	2.7426	2528	3132	2985	23.87%
0.9Lat1	8	147.8	42788	3.4163	2770	3466	3332	25.14%
0.9Lat1	9	149.3	44240	3.5235	2914	3574	3383	22.67%
0.9Lat1	10	149.3	44519	3.5492	2861	3586	3396	25.34%
0.9Lat1	13	146.7	86490	6.8792	4265	4863	4728	14.04%
0.9Lat1	14	148.1	87010	6.9344	4289	4954	4747	15.51%
0.9Lat1	15	148.7	85935	6.8488	4464	4950	4717	10.90%
0Lat1	3	151.7	34294	2.7718	3234	3245	3001	0.35%
0Lat1	4	148.1	36668	2.9233	3226	3216	3082	0.32%
0Lat1	5	149.0	37641	2.9924	3350	3283	3118	2.02%
0Lat1	8	147.4	42918	3.4113	3594	3449	3329	4.05%
0Lat1	9	148.2	46679	3.7202	3596	3631	3477	0.98%
0Lat1	10	150.1	45051	3.5934	3590	3639	3417	1.37%
0Lat1	13	148.3	85005	6.7634	4712	4901	4688	4.01%
0Lat1	14	147.2	82770	6.5899	4705	4786	4627	1.73%
0Lat1	15	149.3	83300	6.6266	4745	4898	4640	3.23%

Splitting tensile strength tests

Table A-8 Split-cylinder test results of VESLMC

Mix	Cyl #	Mix Date & Time	Actual Testing Date	Actual Age (Days)	Actual Age (hours)	Dia. 1 (in)	Dia. 2 (in)	Dia. 3 (in)	Weight (lbs)	Pn (lbs)	f_t (psi)	Depth (in)
poor cem. Con.	4a	3/17/2017 8:17 AM	3/17/2017 9:17 AM	0.04	1.00	3.998	4.007	3.993		5210	217.53	3.8125
poor cem. Con.	4b	3/17/2017 8:17 AM	3/17/2017 9:22 AM	0.05	1.08	3.998	4.007	3.993		6000	235.10	4.0625
poor cem. Con.	7a	3/17/2017 8:17 AM	3/17/2017 11:20 AM	0.13	3.05	4.002	4.002	3.997		8975	363	3.9375
poor cem. Con.	7b	3/17/2017 8:17 AM	3/17/2017 11:22 AM	0.13	3.08	4.002	4.002	3.997		8625	349	3.9375
crushed new cem.	4a	4/14/2017 8:13 AM	4/14/2017 9:55 AM	0.07	1.70	4.007	3.99	4.003		8265	351	3.75
crushed new cem.	4b	4/14/2017 8:13 AM	4/14/2017 10:00 AM	0.07	1.78	4.007	3.99	4.003		10065	400	4
crushed new cem.	5a	4/14/2017 8:13 AM	4/14/2017 10:05 AM	0.08	1.87	3.998	4.002	3.992		8790	350	4
crushed new cem.	5b	4/14/2017 8:13 AM	4/14/2017 10:08 AM	0.08	1.92	3.998	4.002	3.992		10215	427	3.8125
crushed new cem.	9a	4/14/2017 8:13 AM	4/14/2017 10:35 AM	0.10	2.37	3.995	4.001	3.991		9175	390	3.75
crushed new cem.	9b	4/14/2017 8:13 AM	4/14/2017 10:37 AM	0.10	2.40	3.995	4.001	3.991		11225	447	4
crushed new cem.	10a	4/14/2017 8:13 AM	4/14/2017 10:48 AM	0.11	2.58	4	3.995	3.994		9620	409	3.75
crushed new cem.	10b	4/14/2017 8:13 AM	4/14/2017 10:54 AM	0.11	2.68	4	3.995	3.994		10590	422	4
crushed new cem.	14a	4/14/2017 8:13 AM	4/14/2017 11:26 AM	0.13	3.22	3.988	4.004	3.982		9250	381	3.875
crushed new cem.	14b	4/14/2017 8:13 AM	4/14/2017 11:35 AM	0.14	3.37	3.988	4.004	3.982		12135	492	3.9375
crushed new cem.	15a	4/14/2017 8:13 AM	4/14/2017 11:40 AM	0.14	3.45	4.002	3.998	3.992		10305	424	3.875
crushed new cem.	15b	4/14/2017 8:13 AM	4/14/2017 11:46 AM	0.15	3.55	4.002	3.998	3.992		12150	499	3.875
C3	1a	5/22/2017 9:15 AM	5/22/2017 10:24 AM	0.05	1.15	3.994	4.003	3.987	3.9	9455	386	3.9
C3	1b	5/22/2017 9:15 AM	5/22/2017 10:27 AM	0.05	1.20	3.994	4.003	3.987	4.075	4410	172	4.075
C3	2a	5/22/2017 9:15 AM	5/22/2017 10:30 AM	0.05	1.25	3.995	4.005	3.996	3.9	6185	252	3.9

C3	2b	5/22/2017 9:15 AM	5/22/2017 10:32 AM	0.05	1.28	3.995	4.005	3.996	4.05	7080	278	4.05
C3	6a	5/22/2017 9:15 AM	5/22/2017 11:22 AM	0.09	2.12	3.99	3.994	4.001	4.14	8870	362	3.9
C3	6b	5/22/2017 9:15 AM	5/22/2017 11:24 AM	0.09	2.15	3.99	3.994	4.001	4.36	10235	400	4.075
C3	7a	5/22/2017 9:15 AM	5/22/2017 11:26 AM	0.09	2.18	4.002	4.011	3.984	4.15	9255	378	3.9
C3	7b	5/22/2017 9:15 AM	5/22/2017 11:28 AM	0.09	2.22	4.002	4.011	3.984	4.337	10595	419	4.025
C3	8a	5/22/2017 9:15 AM	5/22/2017 12:27 PM	0.13	3.20	3.99	3.991	3.994	4.14	13295	544	3.9
C3	8b	5/22/2017 9:15 AM	5/22/2017 12:29 PM	0.13	3.23	3.99	3.991	3.994	4.383	9645	373	4.125
C3	9a	5/22/2017 9:15 AM	5/22/2017 12:32 PM	0.14	3.28	4.003	3.998	3.993	4.15	14105	572	3.925
C3	9b	5/22/2017 9:15 AM	5/22/2017 12:34 PM	0.14	3.32	4.003	3.998	3.993	4.32	10665	419	4.05
C4	4a	5/24/2017 9:27 AM	5/24/2017 12:28 PM	0.13	3.02	3.998	4.005	3.985	4.129	11415	463	3.925
C4	4b	5/24/2017 9:27 AM	5/24/2017 12:31 PM	0.13	3.07	3.998	4.005	3.985	4.305	11805	462	4.075
C4	5a	5/24/2017 9:27 AM	5/24/2017 12:33 PM	0.13	3.10	4.002	3.997	3.997	4.109	10775	443	3.875
C4	5b	5/24/2017 9:27 AM	5/24/2017 12:37 PM	0.13	3.17	4.002	3.997	3.997	4.372	11970	459	4.15
C4	6a	5/24/2017 9:27 AM	5/24/2017 12:39 PM	0.13	3.20	4.001	4.001	3.991	4.12	12495	510	3.9
C4	6b	5/24/2017 9:27 AM	5/24/2017 12:43 PM	0.14	3.27	4.001	4.001	3.991	4.328	8930	347	4.1
C4	7a	5/24/2017 9:27 AM	5/24/2017 1:00 PM	0.15	3.55	4.009	3.991	4.003	4.1	11580	472	3.9
C4	7b	5/24/2017 9:27 AM	5/24/2017 1:03 PM	0.15	3.60	4.009	3.991	4.003	4.264	11385	450	4.025
C4	8a	5/24/2017 9:27 AM	5/24/2017 1:05 PM	0.15	3.63	3.987	3.987	4.008	4.113	13860	566	3.9
C4	8b	5/24/2017 9:27 AM	5/24/2017 1:07 PM	0.15	3.67	3.987	3.987	4.008	4.299	9720	385	4.025
C4	9a	5/24/2017 9:27 AM	5/24/2017 1:08 PM	0.15	3.68	4.004	3.981	4.015	4.102	12285	501	3.9
C4	9b	5/24/2017 9:27 AM	5/24/2017 1:09 PM	0.15	3.70	4.004	3.981	4.015	4.321	10195	391	4.15
C5	1a	6/14/2017 8:28 AM	6/14/2017 9:45 AM	0.05	1.28	3.995	4.012	3.996	4.26	10955	436	4
C5	1b	6/14/2017 8:28 AM	6/14/2017 9:48 AM	0.06	1.33	3.995	4.012	3.996	4.173	10685	430	3.95
C5	2a	6/14/2017 8:28 AM	6/14/2017 9:51 AM	0.06	1.38	4.004	3.999	4.005	4.268	8575	339	4.025

C5	2b	6/14/2017 8:28 AM	6/14/2017 9:53 AM	0.06	1.42	4.004	3.999	4.005	4.211	8400	336	3.975
C5	6a	6/14/2017 8:28 AM	6/14/2017 10:45 AM	0.10	2.28	3.998	4	4.004	4.25	10710	421	4.05
C5	6b	6/14/2017 8:28 AM	6/14/2017 10:47 AM	0.10	2.32	3.998	4	4.004	4.185	10630	430	3.93
C5	7a	6/14/2017 8:28 AM	6/14/2017 10:49 AM	0.10	2.35	3.996	3.997	4.011	4.301	13505	531	4.05
C5	7b	6/14/2017 8:28 AM	6/14/2017 10:51 AM	0.10	2.38	3.996	3.997	4.011	4.176	13055	526	3.95
C5	12a	6/14/2017 8:28 AM	7/12/2017 8:28 AM	28	672	4.003	4.005	3.996	4.137	17130	694	3.925
C5	12b	6/14/2017 8:28 AM	7/12/2017 8:28 AM	28	672	4.003	4.005	3.996	4.255	23820	937	4.046
RS1+94	1a	6/16/2017 8:04 AM	6/16/2017 9:14 AM	0.049	1.167	3.994	4.003	4.002	4.287	10095	400	4.02
RS1+94	1b	6/16/2017 8:04 AM	6/16/2017 9:17 AM	0.051	1.217	3.994	4.003	4.002	4.161	10210	415	3.915
RS1+94	2a	6/16/2017 8:04 AM	6/16/2017 9:20 AM	0.053	1.267	3.997	4.004	3.997	4.383	10025	388	4.115
RS1+94	2b	6/16/2017 8:04 AM	6/16/2017 9:23 AM	0.055	1.317	3.997	4.004	3.997	4.161	10215	415	3.915
RS1+94	6a	6/16/2017 8:04 AM	6/16/2017 10:06 AM	0.085	2.033	3.991	3.999	3.995	4.321	12670	494	4.085
RS1+94	6b	6/16/2017 8:04 AM	6/16/2017 10:08 AM	0.086	2.067	3.991	3.999	3.995	4.099	12920	534	3.855
RS1+94	7a	6/16/2017 8:04 AM	6/16/2017 10:09 AM	0.087	2.083	4.007	3.996	4.002	4.357	15565	604	4.1
RS1+94	7b	6/16/2017 8:04 AM	6/16/2017 10:10 AM	0.088	2.100	4.007	3.996	4.002	4.158	11860	483	3.91
RS1+94	12a	6/16/2017 8:04 AM	7/14/2017 8:04 AM	28	672	3.99	3.995	3.979	4.139	20210	792	4.075
RS1+94	12b	6/16/2017 8:04 AM	7/14/2017 8:04 AM	28	672	3.99	3.995	3.979	4.105	21970	906	3.872
RS1-94	1a	6/20/2017 8:55 AM	6/20/2017 10:04 AM	0.048	1.163	3.993	4.007	3.994	4.184	3990	160	3.965
RS1-94	1b	6/20/2017 8:55 AM	6/20/2017 10:06 AM	0.050	1.196	3.993	4.007	3.994	4.116	5335	216	3.925
RS1-94	2a	6/20/2017 8:55 AM	6/20/2017 10:08 AM	0.051	1.230	4.005	4.002	3.997	4.154	5615	225	3.97
RS1-94	2b	6/20/2017 8:55 AM	6/20/2017 10:10 AM	0.053	1.263	4.005	4.002	3.997	4.1	4530	183	3.935
RS1-94	6a	6/20/2017 8:55 AM	6/20/2017 10:58 AM	0.086	2.066	3.998	3.996	4	4.17	9000	356	4.02
RS1-94	6b	6/20/2017 8:55 AM	6/20/2017 11:00 AM	0.087	2.099	3.998	3.996	4	4.079	9045	366	3.94
RS1-94	7a	6/20/2017 8:55 AM	6/20/2017 11:02 AM	0.089	2.133	3.999	3.999	3.998	4.261	8160	323	4.02

RS1-94	7b	6/20/2017 8:55 AM	6/20/2017 11:04 AM	0.090	2.166	3.999	3.999	3.998	4.058	9195	373	3.925
RS1-94	11a	6/20/2017 8:55 AM	7/18/2017 1:31 PM	28	677	4.005	4	3.991	4.115	13995	568	3.925
RS1-94	11b	6/20/2017 8:55 AM	7/18/2017 1:31 PM	28	677	4.005	4	3.991	4.157	15925	631	4.02
RS1-94	12a	6/20/2017 8:55 AM	7/18/2017 1:31 PM	28	677	4.005	3.987	3.999	4.076	13035	529	3.925
RS1-94	12b	6/20/2017 8:55 AM	7/18/2017 1:31 PM	28	677	4.005	3.987	3.999	4.214	12700	503	4.025
1.1W1	1a	7/5/2017 9:19 AM	7/5/2017 10:28 AM	0.048	1.150	4.014	4.004	3.992	4.117	4575	182	3.992
1.1W1	1b	7/5/2017 9:19 AM	7/5/2017 10:30 AM	0.049	1.183	4.014	4.004	3.992	4.097	7115	287	3.94
1.1W1	2a	7/5/2017 9:19 AM	7/5/2017 10:34 AM	0.052	1.250	4.004	4.012	3.986	4.153	6815	271	3.996
1.1W1	2b	7/5/2017 9:19 AM	7/5/2017 10:38 AM	0.055	1.317	4.004	4.012	3.986	4.154	7325	289	4.035
1.1W1	6a	7/5/2017 9:19 AM	7/5/2017 11:18 AM	0.083	1.983	3.995	4.009	4.002	4.123	9200	368	3.982
1.1W1	6b	7/5/2017 9:19 AM	7/5/2017 11:20 AM	0.084	2.017	3.995	4.009	4.002	4.095	7345	301	3.887
1.1W1	7a	7/5/2017 9:19 AM	7/5/2017 11:22 AM	0.085	2.050	4.006	3.99	4.007	4.228	10310	411	3.992
1.1W1	7b	7/5/2017 9:19 AM	7/5/2017 11:24 AM	0.087	2.083	4.006	3.99	4.007	4.117	8850	361	3.896
1.1W1	11a	7/5/2017 9:19 AM	8/2/2017 9:19 AM	28	672	4	3.986	4.013	4.203	18025	718	3.995
1.1W1	11b	7/5/2017 9:19 AM	8/2/2017 9:19 AM	28	672	4	3.986	4.013	4.147	18575	760	3.892
1.1W1	12a	7/5/2017 9:19 AM	8/2/2017 9:19 AM	28	672	3.984	4.004	4.003	4.266	15320	609	4.009
1.1W1	12b	7/5/2017 9:19 AM	8/2/2017 9:19 AM	28	672	3.984	4.004	4.003	4.109	15875	647	3.911
0.9W1	1a	7/7/2017 7:50 AM	7/7/2017 8:51 AM	0.042	1.017	4.014	4.004	3.992	4.239	6200	244	4.035
0.9W1	1b	7/7/2017 7:50 AM	7/7/2017 8:54 AM	0.044	1.067	4.014	4.004	3.992	4.115	5000	201	3.958
0.9W1	2a	7/7/2017 7:50 AM	7/7/2017 8:56 AM	0.046	1.100	4.004	4.012	3.986	4.346	5855	229	4.072
0.9W1	2b	7/7/2017 7:50 AM	7/7/2017 8:58 AM	0.047	1.133	4.004	4.012	3.986	4.068	5560	231	3.825
0.9W1	6a	7/7/2017 7:50 AM	7/7/2017 9:50 AM	0.083	2.000	3.995	4.009	4.002	4.249	10095	395	4.07
0.9W1	6b	7/7/2017 7:50 AM	7/7/2017 9:53 AM	0.085	2.050	3.995	4.009	4.002	3.99	10285	431	3.8
0.9W1	7a	7/7/2017 7:50 AM	7/7/2017 9:55 AM	0.087	2.083	4.006	3.99	4.007	4.303	9825	382	4.092

0.9W1	7b	7/7/2017 7:50 AM	7/7/2017 9:57 AM	0.088	2.117	4.006	3.99	4.007	4.059	9405	390	3.842
0.9W1	11a	7/7/2017 7:50 AM	8/4/2017 7:50 AM	28	672	4	3.986	4.013	4.039	19115	794	3.834
0.9W1	11b	7/7/2017 7:50 AM	8/4/2017 7:50 AM	28	672	4	3.986	4.013	4.327	20040	775	4.116
0.9W1	12a	7/7/2017 7:50 AM	8/4/2017 7:50 AM	28	672	3.984	4.004	4.003	4.07	19105	740	4.111
0.9W1	12b	7/7/2017 7:50 AM	8/4/2017 7:50 AM	28	672	3.984	4.004	4.003	4.371	17995	745	3.849
1.1Lat1	1a	7/11/2017 8:44 AM	7/11/2017 9:46 AM	0.043	1.033	4.005	3.995	4.001	4.236	3685	143	4.109
1.1Lat1	1b	7/11/2017 8:44 AM	7/11/2017 9:49 AM	0.045	1.083	4.005	3.995	4.001	3.965	3185	134	3.782
1.1Lat1	2a	7/11/2017 8:44 AM	7/11/2017 9:51 AM	0.047	1.117	4	4.011	3.994	4.289	4150	160	4.12
1.1Lat1	2b	7/11/2017 8:44 AM	7/11/2017 9:52 AM	0.047	1.133	4	4.011	3.994	3.965	3485	145	3.83
1.1Lat1	6a	7/11/2017 8:44 AM	7/11/2017 10:45 AM	0.084	2.017	3.998	3.995	4.001	4.068	7135	288	3.949
1.1Lat1	6b	7/11/2017 8:44 AM	7/11/2017 10:48 AM	0.086	2.067	3.998	3.995	4.001	4.166	7300	292	3.985
1.1Lat1	7a	7/11/2017 8:44 AM	7/11/2017 10:50 AM	0.088	2.100	3.989	4.014	3.991	4.086	6410	260	3.922
1.1Lat1	7b	7/11/2017 8:44 AM	7/11/2017 10:52 AM	0.089	2.133	3.989	4.014	3.991	4.145	8595	346	3.954
1.1Lat1	11a	7/11/2017 8:44 AM	8/8/2017 8:44 AM	28	672	3.994	4.018	3.989	4.148	17340	703	3.926
1.1Lat1	11b	7/11/2017 8:44 AM	8/8/2017 8:44 AM	28	672	3.994	4.018	3.989	4.046	17310	693	3.977
1.1Lat1	12a	7/11/2017 8:44 AM	8/8/2017 8:44 AM	28	672	4.005	4.004	3.987	4.084	18010	730	3.929
1.1Lat1	12b	7/11/2017 8:44 AM	8/8/2017 8:44 AM	28	672	4.005	4.004	3.987	4.174	17395	697	3.974
0.9Lat1	1a	7/13/2017 8:52 AM	7/13/2017 9:56 AM	0.044	1.067	3.998	3.992	4.015	4.185	6605	268	3.926
0.9Lat1	1b	7/13/2017 8:52 AM	7/13/2017 10:00 AM	0.047	1.133	3.998	3.992	4.015	4.284	7295	286	4.058
0.9Lat1	2a	7/13/2017 8:52 AM	7/13/2017 10:01 AM	0.048	1.150	4.021	3.991	3.992	4.166	6715	273	3.908
0.9Lat1	2b	7/13/2017 8:52 AM	7/13/2017 10:03 AM	0.049	1.183	4.021	3.991	3.992	4.343	6785	263	4.111
0.9Lat1	6a	7/13/2017 8:52 AM	7/13/2017 10:59 AM	0.088	2.117	3.999	4.01	3.985	4.124	10025	406	3.936
0.9Lat1	6b	7/13/2017 8:52 AM	7/13/2017 11:01 AM	0.090	2.150	3.999	4.01	3.985	4.294	9980	393	4.045
0.9Lat1	7a	7/13/2017 8:52 AM	7/13/2017 11:03 AM	0.091	2.183	3.994	3.994	3.994	4.191	12525	506	3.944

0.9Lat1	7b	7/13/2017 8:52 AM	7/13/2017 11:05 AM	0.092	2.217	3.994	3.994	3.994	4.268	9050	359	4.02
0.9Lat1	11a	7/13/2017 8:52 AM	8/10/2017 8:52 AM	28	672	3.995	3.989	4.02	4.128	17720	717	3.932
0.9Lat1	11b	7/13/2017 8:52 AM	8/10/2017 8:52 AM	28	672	3.995	3.989	4.02	4.323	21210	836	4.038
0.9Lat1	12a	7/13/2017 8:52 AM	8/10/2017 8:52 AM	28	672	3.99	4.007	3.999	4.128	21200	864	3.905
0.9Lat1	12b	7/13/2017 8:52 AM	8/10/2017 8:52 AM	28	672	3.99	4.007	3.999	4.217	15725	627	3.996
0Lat1	1a	7/17/2017 9:37 AM	7/17/2017 10:37 AM	0.042	1.000	3.98	4.008	4.005	4.302	5465	216	4.028
0Lat1	1b	7/17/2017 9:37 AM	7/17/2017 10:39 AM	0.043	1.033	3.98	4.008	4.005	4.158	4900	201	3.884
0Lat1	2a	7/17/2017 9:37 AM	7/17/2017 10:41 AM	0.044	1.067	4.01	3.991	3.992	4.104	5530	228	3.863
0Lat1	2b	7/17/2017 9:37 AM	7/17/2017 10:43 AM	0.046	1.100	4.01	3.991	3.992	4.363	5880	229	4.091
0Lat1	6a	7/17/2017 9:37 AM	7/17/2017 11:37 AM	0.083	2.000	4.001	3.999	4	4.256	9005	365	3.925
0Lat1	6b	7/17/2017 9:37 AM	7/17/2017 11:39 AM	0.085	2.033	4.001	3.999	4	4.284	10215	410	3.967
0Lat1	7a	7/17/2017 9:37 AM	7/17/2017 11:41 AM	0.086	2.067	3.977	4.006	3.992	4.234	9720	391	3.968
0Lat1	7b	7/17/2017 9:37 AM	7/17/2017 11:43 AM	0.088	2.100	3.977	4.006	3.992	4.211	8070	323	3.983
0Lat1	11a	7/17/2017 9:37 AM	8/14/2017 9:37 AM	28	672	3.995	4.002	3.999	4.225	14025	563	3.964
0Lat1	11b	7/17/2017 9:37 AM	8/14/2017 9:37 AM	28	672	3.995	4.002	3.999	4.334	11470	452	4.04
0Lat1	12a	7/17/2017 9:37 AM	8/14/2017 9:37 AM	28	672	4.005	3.993	3.995	4.227	16060	644	3.972
0Lat1	12b	7/17/2017 9:37 AM	8/14/2017 9:37 AM	28	672	4.005	3.993	3.995	4.251	15170	611	3.953

Mix composition summary

Table A-9 Overmortar mixes quantities summary

Date	Mix name	Portland Cement (I-II) lb	Rapid Set Cement lb	Kapaa Chips (3/8") lb	British-Columbia lb	Water lb	CEM Fibers lb	Latex lb	MCI ml	Delvo ml	Glenium ml	Total weight lb
	Mix 1	46.8		97.0	122.4	10.6	0.400	14.0	48	340	78	292.2
6/8/2016	m2d	66.5		131.8	174.1	14.3	0.568	19.8	68	74	111	407.7
6/13/2016	m2d	66.5		131.8	174.1	14.3	0.568	19.8	68	74	111	407.7
6/20/2016	m2d	66.5		131.8	174.1	14.3	0.568	19.8	68	74	111	407.7
6/29/2016	m2d	66.5		132.4	174.0	13.9	0.568	19.8	68	74	111	407.7
7/13/2016	m2d	66.5		132.6	174.1	13.5	0.568	19.8	68	74	111	407.7
7/20/2016	m2d	66.5		133.0	174.3	12.9	0.568	19.8	68	74	111	407.7
8/16/2016	m2d	73.8		147.0	193.5	15.3	0.631	22.0	75	82	62	452.9
8/30/2016	8 min mix. Rodding cons.		35.0	73.1	96.0	7.9	0.314	11.1	37	267	62	224.3
9/8/2016	8 mins mix. Half Glenium		34.4	73.2	96.0	7.8	0.314	11.1	37	267	31	223.7
9/21/2016	8 mins mix.		34.4	73.3	96.1	7.6	0.314	11.1	37	267	62	223.8
9/23/2016	1/2 5s cons., 1/2 10 cons.		34.4	73.3	96.1	7.6	0.314	11.1	37	267	62	223.8
9/28/2016	5-10s cons.		34.4	73.1	95.9	8.2	0.314	11.1	37	267	62	223.8
9/30/2016	1/2 Glenium		34.4	73.1	95.9	8.2	0.314	11.1	37	267	31	223.7
10/12/2016	no MCI		22.4	48.8	62.6	5.1	0.205	7.2	0	174	40	146.9

Date	Mix name	Portland Cement (I-II) lb	Rapid Set Cement lb	Kapaa Chips (3/8") lb	British-Columbia lb	Water lb	CEM Fibers lb	Latex lb	MCI ml	Delvo ml	Glenium ml	Total weight lb
10/14/2016	No MCI, no latex		23.0	48.8	64.2	5.3	0.210	0.0	0	178	41	142.1
10/19/2016	No latex		23.0	48.7	64.3	5.3	0.210	0.0	25	178	41	142.1
11/2/2016	C1		23.0	48.7	64.1	5.3	0.209	7.4	25	178	41	149.2
11/4/2016	C2		23.0	48.7	64.1	5.3	0.209	7.4	25	178	41	149.2
11/16/2016	RS+94		26.2	48.7	64.0	5.2	0.209	7.4	25	178	41	152.3
11/18/2016	RS-94		19.7	48.7	64.2	5.3	0.210	7.4	25	178	41	146.0
12/21/2016	1.1W		22.9	48.7	64.2	5.6	0.209	7.4	25	178	41	149.6
12/28/2016	0.9W		23.0	48.7	64.1	4.8	0.209	7.4	25	178	41	148.8
1/12/2017	1.1Lat		22.9	48.8	64.1	5.2	0.209	8.1	25	178	41	149.9
1/13/2017	0.9Lat		23.0	48.8	64.1	5.2	0.209	6.6	25	178	41	148.5
2/2/2017	0Lat		23.0	48.7	65.5	11.2	0.209	0.0	25	178	41	149.2
3/2/2017	0Lat+nC		23.0	48.7	65.3	11.4	0.209	0.0	25	178	41	149.2
3/3/2017	0Lat+nC+0.5del		23.0	48.7	65.3	11.4	0.209	0.0	25	178	41	149.2
3/9/2017	C		23.0	48.8	65.5	3.8	0.209	7.4	25	178	41	149.2
3/10/2017	wet chip		23.0	48.8	65.5	3.8	0.209	7.4	25	178	41	149.2
3/16/2017	dry sand		23.0	48.8	64.1	5.2	0.209	7.4	25	178	41	149.2
3/17/2017	poor cem. Con.		23.0	48.8	65.5	3.8	0.209	7.4	25	178	41	149.2
4/14/2017	crushed new cem.		23.0	48.8	65.1	4.2	0.209	7.4	25	178	41	149.2
5/22/2017	C3		23.0	48.7	65.7	3.7	0.209	7.4	25	178	41	149.2
5/24/2017	C4		57.4	121.8	162.9	10.4	0.523	18.4	62	445	103	372.9
6/14/2017	C5		23.0	48.7	65.3	4.0	0.209	7.4	25	178	41	149.2
6/16/2017	RS1+94		31.4	58.5	77.9	5.2	0.251	8.8	30	213	49	182.8

Date	Mix name	Portland Cement (I-II) lb	Rapid Set Cement lb	Kapaa Chips (3/8") lb	British-Columbia lb	Water lb	CEM Fibers lb	Latex lb	MCI ml	Delvo ml	Glenium ml	Total weight lb
6/20/2017	RS1-94		29.6	73.2	99.4	4.7	0.314	11.1	38	267	62	219.1
7/5/2017	1.1W1		34.4	73.1	98.4	6.1	0.314	11.1	37	267	62	224.3
7/7/2017	0.9W1		34.4	73.1	97.8	5.7	0.314	11.1	37	267	62	223.2
7/11/2017	1.1Lat1		34.4	73.1	97.7	6.3	0.314	12.2	37	267	62	224.8
7/13/2017	0.9Lat1		34.4	73.1	101.0	3.0	0.314	10.0	37	267	62	222.7
7/17/2017	0Lat1		34.4	73.1	100.9	14.1	0.314	0.0	37	267	62	223.8

Table A-10 Batch composition without overmortar quantities

Date	Mix name	Batch target Volume cu.ft	Portland Cement (I-II) lb	Rapid Set Cement lb	Kapaa Chips (3/8") lb	British-Columbia sand lb	Water lb	CEM Fibers lb	Latex lb	MCI ml	Delvo ml	Glenium ml	Total Weight lb
	Mix 1	2	46.8		98.8	123.4	7.8	0.4	14.0	47.7	339.6	78.4	292.2
6/8/16	m2d	2.7	63.5		134.0	167.4	10.6	0.542	19.0	65	71	106	395.6
6/13/16	m2d	2.7	63.5		134.0	167.4	10.6	0.542	19.0	65	71	106	395.6
6/20/16	m2d	2.7	63.5		134.0	167.4	10.6	0.542	19.0	65	71	106	395.6
6/29/16	m2d	2.7	63.5		134.0	167.4	10.6	0.542	19.0	65	71	106	395.6
7/13/16	m2d	2.7	63.5		134.0	167.4	10.6	0.542	19.0	65	71	106	395.6
7/20/16	m2d	2.7	63.5		134.0	167.4	10.6	0.542	19.0	65	71	106	395.6
8/16/16	m2d	3.0	70.6		148.9	186.0	11.7	0.603	21.1	72	79	59	439.4

Date	Mix name	Batch target Volume cu.ft	Portland Cement (I-II) lb	Rapid Set Cement lb	Kapaa Chips (3/8") lb	British-Columbia sand lb	Water lb	CEM Fibers lb	Latex lb	MCI ml	Delvo ml	Glenium ml	Total Weight lb
8/30/16	8 min mix. Rodding cons.	1.5		33.4	74.1	92.5	5.8	0.300	10.6	36	255	59	217.6
9/8/16	8 mins mix. Half Glenium	1.5		32.9	74.1	92.5	5.8	0.300	10.6	36	255	29	216.9
9/21/16	8 mins mix.	1.5		32.9	74.1	92.5	5.8	0.300	10.6	36	255	59	217.0
9/23/16	1/2 5s cons., 1/2 10 cons.	1.5		32.9	74.1	92.5	5.8	0.300	10.6	36	255	59	217.0
9/28/16	5-10s cons.	1.5		32.9	74.1	92.5	5.8	0.300	10.6	36	255	59	217.0
9/30/16	1/2 Glenium	1.5		32.9	74.1	92.5	5.8	0.300	10.6	36	255	29	216.9
10/12/16	no MCI	1.0		21.9	49.4	61.7	3.9	0.200	7.0	0	170	39	144.6
10/14/16	No MCI, no latex	1.0		21.9	49.4	61.7	3.9	0.200	0.0	0	170	39	137.6
10/19/16	No latex	1.0		21.9	49.4	61.7	3.9	0.200	0.0	24	170	39	137.6
11/2/16	C1	1.0		21.9	49.4	61.7	3.9	0.200	7.0	24	170	39	144.7
11/4/16	C2	1.0		21.9	49.4	61.7	3.9	0.200	7.0	24	170	39	144.7
11/16/16	RS+94	1.0		25.0	49.4	61.7	3.9	0.200	7.0	24	170	39	147.8
11/18/16	RS-94	1.0		18.8	49.4	61.7	3.9	0.200	7.0	24	170	39	141.5
12/21/16	1.1W	1.0		21.9	49.4	61.7	4.3	0.200	7.0	24	170	39	145.1
12/28/16	0.9W	1.0		21.9	49.4	61.7	3.5	0.200	7.0	24	170	39	144.3
1/12/17	1.1Lat	1.0		21.9	49.4	61.7	3.9	0.200	7.7	24	170	39	145.4
1/13/17	0.9Lat	1.0		21.9	49.4	61.7	3.9	0.200	6.3	24	170	39	144.0
2/2/17	0Lat	1.0		21.9	49.4	61.7	10.9	0.200	0.0	24	170	39	144.7
3/2/17	0Lat+nC	1.0		21.9	49.4	61.7	10.9	0.200	0.0	24	170	39	144.7
3/3/17	0Lat+nC+0.5del	1.0		21.9	49.4	61.7	10.9	0.200	0.0	24	170	39	144.7

Date	Mix name	Batch target Volume cu.ft	Portland Cement (I-II) lb	Rapid Set Cement lb	Kapaa Chips (3/8") lb	British-Columbia sand lb	Water lb	CEM Fibers lb	Latex lb	MCI ml	Delvo ml	Glenium ml	Total Weight lb
3/9/17	C	1.0		21.9	49.4	61.7	3.9	0.200	7.0	24	170	39	144.7
3/10/17	wet chip	1.0		21.9	49.4	61.7	3.9	0.200	7.0	24	170	39	144.7
3/16/17	dry sand	1.0		21.9	49.4	61.7	3.9	0.200	7.0	24	170	39	144.7
3/17/17	poor cem. Con.	1.0		21.9	49.4	61.7	3.9	0.200	7.0	24	170	39	144.7
4/14/17	crushed new cem.	1.0		21.9	49.4	61.7	3.9	0.200	7.0	24	170	39	144.7
5/22/17	C3	1.0		21.9	49.4	61.7	3.9	0.200	7.0	24	170	39	144.7
5/24/17	C4	2.5		54.8	123.5	154.2	9.7	0.500	17.6	60	425	98	361.7
6/14/17	C5	1.0		21.9	49.4	61.7	3.9	0.200	7.0	24	170	39	144.7
6/16/17	RS1+94	1.2		30.1	59.3	74.0	4.7	0.240	8.5	29	204	47	177.4
6/20/17	RS1-94	1.5		28.2	74.1	92.5	5.8	0.300	10.6	36	255	59	212.3
7/5/17	1.1W1	1.5		32.9	74.1	92.5	6.4	0.300	10.6	36	255	59	217.6
7/7/17	0.9W1	1.5		32.9	74.1	92.5	5.3	0.300	10.6	36	255	59	216.4
7/11/17	1.1Lat1	1.5		32.9	74.1	92.5	5.8	0.300	11.6	36	255	59	218.1
7/13/17	0.9Lat1	1.5		32.9	74.1	92.5	5.8	0.300	9.5	36	255	59	216.0
7/17/17	0Lat1	1.5		32.9	74.1	92.5	16.4	0.300	0.0	36	255	59	217.0

Table A-11 1-cubic-yard mix composition (with no moisture content adjustment)

Date	Mix name	Portland Cement (I-II) lb	Rapid Set Cement lb	Kapaa Chips (3/8") lb	British-Columbia sand lb	Water lb	CEM Fibers lb	Latex lb	MCI ml	Delvo ml	Glenium ml	Total weight lb
	Mix 1	633		1335	1667	105.1	5.401	188.8	644	706	1059	3940
6/8/16	m2d	633		1335	1667	105.1	5.401	188.8	644	706	1059	3940
6/13/16	m2d	633		1335	1667	105.1	5.401	188.8	644	706	1059	3940
6/20/16	m2d	633		1335	1667	105.1	5.401	188.8	644	706	1059	3940
6/29/16	m2d	633		1335	1667	105.1	5.401	188.8	644	706	1059	3940
7/13/16	m2d	633		1335	1667	105.1	5.401	188.8	644	706	1059	3940
7/20/16	m2d	633		1335	1667	105.1	5.401	188.8	644	706	1059	3940
8/16/16	m2d	633		1336	1668	105.2	5.405	188.9	645	707	530	3941
8/30/16	8 min mix. Rodding cons.		597	1324	1654	104.2	5.357	188.8	639	4552	1050	3888.0
9/8/16	8 mins mix. Half Glenium		589	1327	1658	104.5	5.372	189.3	641	4565	527	3887.7
9/21/16	8 mins mix.		589	1326	1657	104.5	5.368	189.2	640	4561	1053	3886.1
9/23/16	1/2 5s cons., 1/2 10 cons.		589	1326	1657	104.5	5.368	189.2	640	4561	1053	3886.1
9/28/16	5-10s cons.		589	1326	1657	104.5	5.368	189.2	640	4561	1053	3886.1
9/30/16	1/2 Glenium		589	1327	1658	104.5	5.372	189.3	641	4565	527	3887.7
10/12/16	no MCI		589	1328	1658	104.6	5.373	189.3	0	4565	1054	3887.9
10/14/16	No MCI, no latex		664	1495	1868	117.7	6.051	0.0	0	5141	1186	4165.1
10/19/16	No latex		663	1494	1866	117.6	6.045	0.0	721	5136	1185	4162.9
11/2/16	C1		589	1326	1657	104.5	5.368	189.2	640	4561	1053	3886.1

Date	Mix name	Portland Cement (I-II) lb	Rapid Set Cement lb	Kapaa Chips (3/8") lb	British-Columbia sand lb	Water lb	CEM Fibers lb	Latex lb	MCI ml	Delvo ml	Glenium ml	Total weight lb
11/4/16	C2		589	1326	1657	104.5	5.368	189.2	640	4561	1053	3886.1
11/16/16	RS+94		661	1304	1628	102.7	5.275	185.9	629	4482	1034	3901.5
11/18/16	RS-94		514	1350	1687	106.3	5.464	192.6	652	4643	1071	3870.3
12/21/16	1.1W		585	1318	1646	114.2	5.334	188.0	636	4532	1046	3871.6
12/28/16	0.9W		593	1335	1668	94.6	5.403	190.4	644	4591	1059	3900.9
1/12/17	1.1Lat		582	1312	1639	103.3	5.309	205.8	633	4511	1041	3861.8
1/13/17	0.9Lat		595	1341	1676	105.6	5.429	172.2	648	4613	1065	3911.0
2/2/17	0Lat		586	1320	1649	292.2	5.341	0.0	637	4538	1047	3866.7
3/2/17	0Lat+nC		586	1320	1649	292.2	5.341	0.0	637	4538	1047	3866.7
3/3/17	0Lat+nC+0.5del		586	1320	1649	292.2	5.341	0.0	637	4538	1047	3866.7
3/9/17	C		589	1326	1657	104.5	5.368	189.2	640	4561	1053	3886.1
3/10/17	wet chip		589	1326	1657	104.5	5.368	189.2	640	4561	1053	3886.1
3/16/17	dry sand		589	1326	1657	104.5	5.368	189.2	640	4561	1053	3886.1
3/17/17	poor cem. Con.		589	1326	1657	104.5	5.368	189.2	640	4561	1053	3886.1
4/14/17	crushed new cem.		589	1326	1657	104.5	5.368	189.2	640	4561	1053	3886.1
5/22/17	C3		589	1326	1657	104.5	5.368	189.2	640	4561	1053	3886.1
5/24/17	C4		589	1326	1657	104.5	5.368	189.2	640	4561	1053	3886.1
6/14/17	C5		589	1326	1657	104.5	5.368	189.2	640	4561	1053	3886.1
6/16/17	RS1+94		661	1304	1628	102.7	5.275	185.9	629	4482	1034	3901.5
6/20/17	RS1-94		514	1350	1687	106.3	5.464	192.6	652	4643	1071	3870.3
7/5/17	1.1W1		585	1318	1646	114.2	5.334	188.0	636	4532	1046	3871.6
7/7/17	0.9W1		593	1335	1668	94.6	5.403	190.4	644	4591	1059	3900.9
7/11/17	1.1Lat1		582	1312	1639	103.3	5.309	205.8	633	4511	1041	3861.8

Date	Mix name	Portland Cement (I-II) lb	Rapid Set Cement lb	Kapaa Chips (3/8") lb	British-Columbia sand lb	Water lb	CEM Fibers lb	Latex lb	MCI ml	Delvo ml	Glenium ml	Total weight lb
7/13/17	0.9Lat1		595	1341	1676	105.6	5.429	172.2	648	4613	1065	3911.0
7/17/17	0Lat1		586	1320	1649	292.2	5.341	0.0	637	4538	1047	3866.7

Appendix B. Results from HDOT

Table B-1 Compressive strength tests results (State of Hawaii Department of Transportation Highways Division, 2014)

Sample No.	ID No.	Test Age (days)	Strength (psi)	Weight (g)	Diameter (in)	Max Load (lbs)	Frac. type	ASTM Test method	Notes
JC-1003-CS-1	A	0.08	4480		4.01	56600	1	C39/T22	The samples were in styrobined boxes and the temp were at 108 +/- 5 F
JC-1003-CS-1	B	0.08	4370		4.01	55240	1	C39/T22	
JC-1003-CS-1	C	0.08	4360		4.02	55390	1	C39/T22	
JC-1003-CS-1	D	0.13	5060	3949	4.02	64160	1	C39/T22	
JC-1003-CS-1	E	0.13	5150	3930	3.99	64440	1	C39/T22	
JC-1003-CS-1	F	0.13	5160	3908	4	64800	2	C39/T22	
JC-1003-CS-1	G	0.17	5390	3938	4	67730	1	C39/T22	
JC-1003-CS-1	H	0.17	5390	3942	4	67730	2	C39/T22	
JC-1003-CS-1	I	0.17	5380	3922	4	67590	1	C39/T22	
JC-1004-CS-2	A	0.25	5680	3941	4.01	71760	1	C39/T22	The samples were in styrobined boxes and the temp were at 108 +/- 5 F
JC-1004-CS-2	B	0.25	5740	3954	4	72090	1	C39/T22	Sample G machine shutdown at appx 6800 psi, restarted and had lower break
JC-1004-CS-2	C	0.25	5500	3904	4	69130	1	C39/T22	
JC-1004-CS-2	D	7.00	8160	3895	4	102480	3	C39/T22	
JC-1004-CS-2	E	7.00	8130	3923	4	102180	3	C39/T22	
JC-1004-CS-2	F	7.00	8310	3926	3.99	103950	3	C39/T22	

Sample No.	ID No.	Test Age (days)	Strength (psi)	Weight (g)	Diameter (in)	Max Load (lbs)	Frac. type	ASTM Test method	Notes
JC-1004-CS-2	G	28.00	7920	3930	4	99480	3	C39/T22	
JC-1004-CS-2	H	28.00	8820	3957	4	110890	3	C39/T22	
JC-1004-CS-2	I	28.00	8740	3964	4	109890	3	C39/T22	
JC-1007-CS-3	A	9.00	5190	3724.6	4	65230	3	C39/T22	
JC-1007-CS-3	B	9.00	5340	3685.5	4	67080	3	C39/T22	
JC-1007-CS-3	C	9.00	5370	3733.6	4	67520	1	C39/T22	
JC-1007-CS-3	D	30.00	4840	3869.1	4	60770	3	C39/T22	
JC-1007-CS-3	E	30.00	4790	3808.2	4	60140	3	C39/T22	
JC-1007-CS-3	F	30.00	4980	3805	4	62590		C39/T22	
JC-1008-CS-4	A	8.00	4780	3884.4	4	60090	3	C39/T22	
JC-1008-CS-4	B	8.00	4540	3823.9	4	57100	1	C39/T22	
JC-1008-CS-4	C	8.00	4860	38930	4	61030	3	C39/T22	
JC-1008-CS-4	D	29.00	5690	3750	4	71500	1	C39/T22	
JC-1008-CS-4	E	29.00	5850	3726	4	73560	1	C39/T22	
JC-1008-CS-4	F	29.00	5860	3701	4	73660	1	C39/T22	
JC-1009-CS-5	A	9.00	5120	3601.2	4	64330	3	C39/T22	
JC-1009-CS-5	B	9.00	4710	3853.7	4.01	59450	3	C39/T22	
JC-1009-CS-5	C	9.00	4850	3853.2	4.01	61310	3	C39/T22	
JC-1009-CS-5	D	29.00	5610	3865.4	4.01	70870	2	C39/T22	
JC-1009-CS-5	E	29.00	5380	3890	4	67610	2	C39/T22	
JC-1009-CS-5	F	29.00	5180	3876.4	4	65070	2	C39/T22	
JC-1019-CS-6	A	8	7330	3984.9	4	92060	3	C39/T22	
JC-1019-CS-6	B	8	7000	3999.9	4.01	88360	1	C39/T22	
JC-1019-CS-6	C	8	7490	3986.3	4.01	94570	3	C39/T22	
JC-1019-CS-6	D	29	7030	3985.6	4	88390	3	C39/T22	
JC-1019-CS-6	E	29	6980	4003	4	87680	3	C39/T22	
JC-1019-CS-6	F	29	7080	3983.2	4	88950	3	C39/T22	
JC-1021-CS-7	A	8	6220	3763	4	78200	1	C39/T22	
JC-1021-CS-7	B	8	6270	3746	4	78820	1	C39/T22	
JC-1021-CS-7	C	8	6070	3739	4.01	76600	1	C39/T22	
JC-1021-CS-7	D	29	6310	3758	4	79300	1	C39/T22	
JC-1021-CS-7	E	29	6310	3765	4.01	79690	1	C39/T22	
JC-1021-CS-7	F	29	6300	3761	4.01	79510	1	C39/T22	

Sample No.	ID No.	Test Age (days)	Strength (psi)	Weight (g)	Diameter (in)	Max Load (lbs)	Frac. type	ASTM Test method	Notes
JC-1022-CS-8	A	8.00	6040	3852	4	75910	1	C39/T22	
JC-1022-CS-8	B	8.00	6210	3844	4	78010	1	C39/T22	
JC-1022-CS-8	C	8.00	6160	3853	4.01	77750	1	C39/T22	
JC-1022-CS-8	D	29.00	6830	3846	4	85860	1	C39/T22	
JC-1022-CS-8	E	29.00	6880	3856	4	86490	1	C39/T22	
JC-1022-CS-8	F	29.00	6870	3830	4	86270	1	C39/T22	
JC-1023-CS-9	A	8.00	4620	3841	4.01	58410	2	C39/T22	
JC-1023-CS-9	B	8.00	4530	3825	4.01	57220	2	C39/T22	
JC-1023-CS-9	C	8.00	4570	3821	4.01	57740	2	C39/T22	
JC-1023-CS-9	D	29.00	5430	3773.2	4.01	68530	3	C39/T22	
JC-1023-CS-9	E	29.00	5100	3747.2	4.01	64400	3	C39/T22	
JC-1023-CS-9	F	29.00	5370	3760	4.01	67800	1	C39/T22	
JC-1026-CS-10	A	8.00	5970	3815	4.01	75380	6	C1231	
JC-1026-CS-10	B	8.00	5870	3846	4.01	74150	6	C1231	
JC-1026-CS-10	C	8.00	5650	3818	4.01	71310	6	C1231	
JC-1026-CS-10	D	29.00	6090	3782.5	4.01	76960	3	C1231	
JC-1026-CS-10	E	29.00	6020	3754.2	4.01	76080	1	C1231	
JC-1026-CS-10	F	29.00	6010	3753.9	4.01	75890	3	C1231	
JC-1027-CS-11	A	9.00	5730	3805	4	72060	2	C39/T22	
JC-1027-CS-11	B	9.00	5690	3794	4	71480	2	C39/T22	
JC-1027-CS-11	C	9.00	5700	3820	4	71600	1	C39/T22	
JC-1027-CS-11	D	30.00	5480	3758.6	4.02	69520	3	C39/T22	
JC-1027-CS-11	E	30.00	5510	3758.6	4	69180	3	C39/T22	
JC-1027-CS-11	F	30.00	5630	3774.3	4	70740	1	C39/T22	
JC-1029-CS-12	A	16.00	6020	3838	4.01	76050	3	C39/T22	
JC-1029-CS-12	B	16.00	5830	3820.3	4.01	73690	3	C39/T22	
JC-1029-CS-12	C	16.00	5890	3829.7	4.01	74370	3	C39/T22	
JC-1029-CS-12	D	30.00	6780	3791.5	4	85210	3	C39/T22	
JC-1029-CS-12	E	30.00	6890	3844.2	4.01	87050	3	C39/T22	
JC-1029-CS-12	F	30.00	6750	3797.9	4	84790	3	C39/T22	
JC-1030-CS-13	A	15.00	4610	3793.4	4.01	58230	3	C39/T22	
JC-1030-CS-13	B	15.00	5870	3809.6	4.01	74110	3	C39/T22	
JC-1030-CS-13	C	15.00	6090	3779.4	4.01	76870	3	C39/T22	

Sample No.	ID No.	Test Age (days)	Strength (psi)	Weight (g)	Diameter (in)	Max Load (lbs)	Frac. type	ASTM Test method	Notes
JC-1030-CS-13	D	29.00	6740	3799.9	4.01	85180	3	C39/T22	
JC-1030-CS-13	E	29.00	6800	3792	4.01	85890	3	C39/T22	
JC-1030-CS-13	F	29.00	6710	3785	4.01	84720	3	C39/T22	
JC-1031-CS-14	A	16.00	7610	3767.7	4.02	96600	3	C39/T22	
JC-1031-CS-14	B	16.00	7550	3893.8	4.02	95890	3	C39/T22	
JC-1031-CS-14	C	16.00	7570	3906.5	4.02	96030	3	C39/T22	
JC-1031-CS-14	D	30.00	7860	3862.7	4.01	99300	3	C39/T22	
JC-1031-CS-14	E	30.00	7870	3921.7	4.02	99860	3	C39/T22	
JC-1031-CS-14	F	30.00	7600	3919.6	4.02	96460	3	C39/T22	
JC-1032-CS-15	A	16.00	7440	3963	4.03	94960	6	C39/T22	Sample A, B, and C had void around top, surface of cylinders more than normal for this mix
JC-1032-CS-15	B	16.00	7500	3916	4.01	94690	6	C39/T22	
JC-1032-CS-15	C	16.00	7330	3941	4	92170	6	C39/T22	
JC-1032-CS-15	D	30.00	6390	3902	4.01	80670	3	C39/T22	
JC-1032-CS-15	E	30.00	6870	3938	4.01	86790	3	C39/T22	
JC-1032-CS-15	F	30.00	6710	3950	4	84360	3	C39/T22	
JC-1035-CS-16	A	10.00	7570	3882	4.01	95550	6	C39/T22	
JC-1035-CS-16	B	10.00	7500	3834	4.01	94660	1	C39/T22	
JC-1035-CS-16	C	10.00	7930	3884	4.01	100120	6	C39/T22	
JC-1035-CS-16	D	28.00	7180	3890.7	4.01	90730	6	C39/T22	
JC-1035-CS-16	E	28.00	7390	3886.9	4.01	93290	3	C39/T22	
JC-1035-CS-16	F	28.00	7800	3843.5	4.01	98450	3	C39/T22	
JC-1037-CS-17	A	8.00	6400	3898	4.02	81240	3	C39/T22	
JC-1037-CS-17	B	8.00	6390	3921.4	4.01	80660	3	C39/T22	
JC-1037-CS-17	C	8.00	4590	3887.5	4.01	57950	6	C39/T22	
JC-1037-CS-17	D	29.00	6750	3847.4	4.01	85260	1	C39/T22	
JC-1037-CS-17	E	29.00	6850	3869.1	4	86110	1	C39/T22	
JC-1037-CS-17	F	29.00	6850	3845.4	4	86140	1	C39/T22	
JC-1038-CS-18	A	9.00	6150	3808	4.01	77620	2	C39/T22	
JC-1038-CS-18	B	9.00	6020	3849	4.01	76020	2	C39/T22	
JC-1038-CS-18	C	9.00	6280	3804	4.01	79280	2	C39/T22	
JC-1038-CS-18	D	29.00	6380	3814	4.02	81020	2	C39/T22	
JC-1038-CS-18	E	29.00	6310	3810	4.01	79640	2	C39/T22	

Sample No.	ID No.	Test Age (days)	Strength (psi)	Weight (g)	Diameter (in)	Max Load (lbs)	Frac. type	ASTM Test method	Notes
JC-1038-CS-18	F	29.00	6340	3816	4.01	80020	2	C39/T22	
JC-1042-CS-19	A	9.00	4400	3702	4.01	55620	3	C39/T22	
JC-1042-CS-19	B	9.00	4570	3760	4.01	57690	1	C39/T22	
JC-1042-CS-19	C	9.00	4470	3721	4.01	56490	3	C39/T22	
JC-1042-CS-19	D	30.00	4500	3742	4	56610	1	C39/T22	
JC-1042-CS-19	E	30.00	4650	3764	4	58490	3	C39/T22	
JC-1042-CS-19	F	30.00	4690	3815	4	58960	3	C39/T22	
JC-1043-CS-20	A	9.00	4950	3793.8	4.02	62830	3	C39/T22	
JC-1043-CS-20	B	9.00	4970	3776.8	4.02	63060	1	C39/T22	
JC-1043-CS-20	C	9.00	5040	3782.7	4.01	63680	1	C39/T22	
JC-1043-CS-20	D	30.00	5420	3830	4.01	68460	3	C39/T22	
JC-1043-CS-20	E	30.00	5380	3832	4.01	67890	3	C39/T22	
JC-1043-CS-20	F	30.00	5250	3817	4.02	66600	1	C39/T22	
JC-1044-CS-21	A	9.00	5480	3846	4.01	69240	3	C39/T22	
JC-1044-CS-21	B	9.00	5320	3816	4.01	67210	1	C39/T22	
JC-1044-CS-21	C	9.00	5410	3816	4.02	68700	3	C39/T22	
JC-1044-CS-21	D	30.00	6170	3827	4.02	78290	1	C39/T22	
JC-1044-CS-21	E	30.00	6290	3811	4.01	79410	3	C39/T22	
JC-1044-CS-21	F	30.00	6300	3826	4.01	79520	3	C39/T22	
JC-1045-CS-22	A	8.00	6170	3820	4.02	78260	3	C39/T22	
JC-1045-CS-22	B	8.00	6050	3781	4.02	76750	1	C39/T22	
JC-1045-CS-22	C	8.00	6060	3801	4.01	76590	3	C39/T22	
JC-1045-CS-22	D	29.00	6020	3828	4.01	76060	3	C39/T22	
JC-1045-CS-22	E	29.00	6040	3829	4.02	76640	1	C39/T22	
JC-1045-CS-22	F	29.00	6380	3828	4.02	80930	3	C39/T22	
JC-1048-CS-23	A	8.00	5070	3831	4.02	64370	3	C39/T22	
JC-1048-CS-23	B	8.00	5140	3867	4.02	65280	1	C39/T22	
JC-1048-CS-23	C	8.00	5210	3861	4.01	65770	3	C39/T22	
JC-1048-CS-23	D	29.00	5530	3695	4.01	69820	3	C39/T22	
JC-1048-CS-23	E	29.00	5160	3777	4.02	65530	3	C39/T22	
JC-1048-CS-23	F	29.00	5540	3742	4.02	70310	1	C39/T22	
JC-1049-CS-24	A	8.00	5980	3832	4	75110	3	C39/T22	
JC-1049-CS-24	B	8.00	5830	3845	4.01	73680	1	C39/T22	

Sample No.	ID No.	Test Age (days)	Strength (psi)	Weight (g)	Diameter (in)	Max Load (lbs)	Frac. type	ASTM Test method	Notes
JC-1049-CS-24	C	8.00	6120	3843	4	76850	1	C39/T22	
JC-1049-CS-24	D	29.00	6370	3836	4.01	80430	3	C39/T22	
JC-1049-CS-24	E	29.00	6290	3838	4	79080	3	C39/T22	
JC-1049-CS-24	F	29.00	6160	3823	4.01	77780	3	C39/T22	
JC-1050-CS-25	A	7.00	4620	3757	4	58050	3	C39/T22	
JC-1050-CS-25	B	7.00	4680	3785	4	58760	3	C39/T22	
JC-1050-CS-25	C	7.00	4610	3748	4	57940	3	C39/T22	
JC-1050-CS-25	D	28.00	4970	3772	4.01	62750	3	C39/T22	
JC-1050-CS-25	E	28.00	4920	3730	4	61840	3	C39/T22	
JC-1050-CS-25	F	28.00	4890	3749	4.01	61700	3	C39/T22	
JC-1051-CS-26	A	9.00	7210	3844	4	90610	3	C39/T22	
JC-1051-CS-26	B	9.00	7190	3816	4.01	90840	3	C39/T22	
JC-1051-CS-26	C	9.00	7340	3831	4	92290	1	C39/T22	
JC-1051-CS-26	D	30.00	7420	3805	4	93290	1	C39/T22	
JC-1051-CS-26	E	30.00	7460	3806	4	93800	3	C39/T22	
JC-1051-CS-26	F	30.00	7640	3805	4	95970	1	C39/T22	
JC-1052-CS-27	A	8.00	5340	3789	4	67130	3	C39/T22	
JC-1052-CS-27	B	8.00	5300	2751	4	66560	1	C39/T22	
JC-1052-CS-27	C	8.00	5320	3778	4.01	67130	1	C39/T22	
JC-1052-CS-27	D	29.00	5560	3780	4	69840	3	C39/T22	
JC-1052-CS-27	E	29.00	5560	3743	4.01	70220	3	C39/T22	
JC-1052-CS-27	F	29.00	5580	3775	4.01	70510	3	C39/T22	
JC-1053-CS-28	A	8.00	7240	3832	4.01	91440	3	C39/T22	
JC-1053-CS-28	B	8.00	7380	3832	4.01	93230	1	C39/T22	
JC-1053-CS-28	C	8.00	7400	3859	4.01	93440	1	C39/T22	
JC-1053-CS-28	D	29.00	8080	3824	4.02	102530	1	C39/T22	
JC-1053-CS-28	E	29.00	7600	3825	4.01	95920	1	C39/T22	
JC-1053-CS-28	F	29.00	8250	3816	4.01	104220	1	C39/T22	
JC-1054-CS-29	A	8.00	7760	3863	4.02	98460	3	C39/T22	
JC-1054-CS-29	B	8.00	7450	3873	4.01	94130	3	C39/T22	
JC-1054-CS-29	C	8.00	7770	3851	4	97610	1	C39/T22	
JC-1054-CS-29	D	29.00	8190	3846	4.01	103480	1	C39/T22	
JC-1054-CS-29	E	29.00	8430	3840	4.01	106520	1	C39/T22	

Sample No.	ID No.	Test Age (days)	Strength (psi)	Weight (g)	Diameter (in)	Max Load (lbs)	Frac. type	ASTM Test method	Notes
JC-1054-CS-29	F	29.00	7560	3867	4.02	95940	1	C39/T22	
JC-1057-CS-30	A	9.00	7650	3850	4.01	96650	3	C39/T22	
JC-1057-CS-30	B	9.00	7910	3872	4	99430	3	C39/T22	
JC-1057-CS-30	C	9.00	7910	3857	4	99390	3	C39/T22	
JC-1057-CS-30	D	30.00	8580	3831	4	107790	3	C39/T22	
JC-1057-CS-30	E	30.00	8400	3806	4.01	106040	3	C39/T22	
JC-1057-CS-30	F	30.00	8360	3805	4	105100	3	C39/T22	
JC-1057-CS-30	G	30.00	8290	3836	4	104120	3	C39/T22	
JC-1057-CS-30	H	30.00	8310	3809	4.01	104950	3	C39/T22	
JC-1057-CS-30	I	30.00	8500	3846	4.01	107370	3	C39/T22	
JC-1058-CS-31	A	9.00	7190	3769	4.02	91210	3	C39/T22	Sample G-H are out of spec, dia/ diff greater than 2% reject (T-23)
JC-1058-CS-31	B	9.00	7120	3774	4	89410	3	C39/T22	
JC-1058-CS-31	C	9.00	4710	3768	4	59240	3	C39/T22	
JC-1058-CS-31	D	30.00	7510	3796	4.01	94840	1	C39/T22	
JC-1058-CS-31	E	30.00	7400	3791	4.02	93930	1	C39/T22	
JC-1058-CS-31	F	30.00	7560	3715	4	94950	1	C39/T22	
JC-1058-CS-31	G	30.00	5780	3686	4.01	73000	2	C39/T22	
JC-1058-CS-31	H	30.00	7430	3747	4.04	95240	1	C39/T22	
JC-1058-CS-31	I	30.00	6470	3778	4.04	82940	1	C39/T22	
JC-1061-CS-32	A	8.00	6900	3771	4.01	87110	3	C39/T22	
JC-1061-CS-32	B	8.00	6720	3771	4.01	84850	3	C39/T22	
JC-1061-CS-32	C	8.00	6970	3757	4.01	88010	3	C39/T22	
JC-1061-CS-32	D	29.00	7160	3756	4.01	90390	1	C39/T22	
JC-1061-CS-32	E	29.00	7390	3727	4.01	93390	3	C39/T22	
JC-1061-CS-32	F	29.00	7410	3767	4.01	93540	3	C39/T22	
JC-1062-CS-33	A	9.00	7930	3795	4.01	100190	0	C39/T22	
JC-1062-CS-33	B	9.00	8170	3823	4	102720	0	C39/T22	
JC-1062-CS-33	C	9.00	8100	3808	4	101750	0	C39/T22	
JC-1062-CS-33	D	30.00	8970	3823	4	112770	0	C39/T22	
JC-1062-CS-33	E	30.00	8910	3799	4.01	112570	0	C39/T22	
JC-1062-CS-33	F	30.00	8850	3785	4	111250	0	C39/T22	
JC-1062-CS-34	A	10.00	6760	3791	4	84930	2	C39/T22	

Sample No.	ID No.	Test Age (days)	Strength (psi)	Weight (g)	Diameter (in)	Max Load (lbs)	Frac. type	ASTM Test method	Notes
JC-1062-CS-34	B	10.00	6790	3800	4.01	85740	3	C39/T22	
JC-1062-CS-34	C	10.00	6780	3777	4.01	85600	2	C39/T22	
JC-1062-CS-34	D	30.00	7700	3730	4.01	97270	4	C39/T22	
JC-1062-CS-34	E	30.00	7650	3740	4.01	96630	3	C39/T22	
JC-1062-CS-34	F	30.00	7710	3740	4.01	97400	4	C39/T22	
JC-1064-CS-35	A	9.00	7910	3820	4	99400	2	C39/T22	
JC-1064-CS-35	B	9.00	7870	3798	4.01	99440	2	C39/T22	
JC-1064-CS-35	C	9.00	7970	3806	4.01	100600	3	C39/T22	
JC-1064-CS-35	D	31.00	8530	3787	4.01	107720	3	C39/T22	
JC-1064-CS-35	E	31.00	8700	3849	4	109360	3	C39/T22	
JC-1064-CS-35	F	31.00	8540	3773	4.01	107860	3	C39/T22	
JC-1073-CS-36	A	9.00	8140	3823	4.01	102840	1	C39/T22	
JC-1073-CS-36	B	9.00	7780	3823	4.01	98220	1	C39/T22	
JC-1073-CS-36	C	9.00	8120	3829	4.01	102560	1	C39/T22	
JC-1073-CS-36	D	30.00	8450	3788	4.01	106700	1	C39/T22	
JC-1073-CS-36	E	30.00	8430	3801	4.01	106490	3	C39/T22	
JC-1073-CS-36	F	30.00	7890	3792	4.01	99660	3	C39/T22	
JC-1075-CS-37	A	7.00	6150	3584	4	77270	1	C39/T22	
JC-1075-CS-37	B	7.00	6010	3595	4	75510	1	C39/T22	
JC-1075-CS-37	C	7.00	6040	3556	4	75850	1	C39/T22	
JC-1076-CS-38	A	9.50	6470	3590	4	81280	-	C39 (Neoprene Cap)	Need to Verify Test Method used
JC-1076-CS-38	B	9.50	6450	3590	4	81010	-	C39 (Neoprene Cap)	
JC-1076-CS-38	C	9.50	6360	3610	4.01	80280	-	C39 (Neoprene Cap)	
JC-1077-CS-39	A	9.00	5880	3620	4.01	74320	-	C39 (Neoprene Cap)	
JC-1077-CS-39	B	9.00	6010	3620	4	75480	-	C39 (Neoprene Cap)	
JC-1077-CS-39	C	9.00	6020	3640	4.01	75970	-	C39 (Neoprene Cap)	
JC-1078-CS-40	A	9.00	6250	3570	4.01	78910	-	C39*	
JC-1078-CS-40	B	9.00	6190	3580	4	77740	-	C39*	
JC-1078-CS-40	C	9.00	6230	3560	4	78310	-	C39*	
JC-1079-CS-41	A	9.00	6390	3590	4	80340	-	C39 (Neoprene Cap)	
JC-1079-CS-41	B	9.00	6340	3580	4	79640	-	C39 (Neoprene Cap)	
JC-1079-CS-41	C	9.00	6420	3610	4.01	81050	-	C39 (Neoprene Cap)	
JC-1080-CS-42	A	8.00	6020	3595	4.01	76010	-	C39*	

Sample No.	ID No.	Test Age (days)	Strength (psi)	Weight (g)	Diameter (in)	Max Load (lbs)	Frac. type	ASTM Test method	Notes
JC-1080-CS-42	B	8.00	5990	3655	4.01	75610	-	C39*	
JC-1080-CS-42	C	8.00	5950	3555	4	74780	-	C39*	
JC-1083-CS-45	A	8.00	6230	3510	4.01	78670	-	C39*	light budge on center of specimen- tested with bulge end on top
JC-1083-CS-45	B	8.00	5890	3550	4	74030	-	C39*	
JC-1083-CS-45	C	8.00	6160	3540	4	77360	-	C39*	
JC-1084-CS-46	A	8.00	6340	3630	4	79610	-	C39*	
JC-1084-CS-46	B	8.00	6320	3617	4	79360	-	C39*	
JC-1084-CS-46	C	8.00	6210	3600	4	78060	-	C39*	
JC-1086-CS-48	A	8.00	6490	3567	4	81590	-	C39*	
JC-1086-CS-48	B	8.00	6540	3564	4	82230	-	C39*	
JC-1086-CS-48	C	8.00	6200	3566	4	77870	-	C39*	
JC-1091-CS-53	A	8.00	7060	3769	4.01	89170	2	C39*	
JC-1091-CS-53	B	8.00	7000	3770	4.01	88400	3	C39*	
JC-1091-CS-53	C	8.00	7030	3779	4.02	89230	2	C39*	
JC-1091-CS-53	D	29.00	7820	3789	4.01	98700	2	C39*	
JC-1091-CS-53	E	29.00	7560	3753	4.01	95480	3	C39*	
JC-1091-CS-53	F	29.00	7030	3782	4.02	89210	3	C39*	
JC-1092-CS-54	A	9.00	7960	3874	4.01	100490	2	C39/T22	
JC-1092-CS-54	B	9.00	7650	3850	4.01	96560	1	C39/T22	
JC-1092-CS-54	C	9.00	8040	3873	4.01	101530	3	C39/T22	
JC-1092-CS-54	D	30.00	8520	3875	4.02	108190	2	C39/T22	
JC-1092-CS-54	E	30.00	7880	3839	4.01	99560	3	C39/T22	
JC-1092-CS-54	F	30.00	7830	3869	4.01	98930	3	C39/T22	
JC-1096-CS-55	A	9.00	7760	3787	4.01	97970	3	C39/T22	
JC-1096-CS-55	B	9.00	7910	3794	4.01	99880	1	C39/T22	
JC-1096-CS-55	C	9.00	7830	3784	4.01	98940	1	C39/T22	
JC-1096-CS-55	D	30.00	8210	3830	4.01	103640	3	C39/T22	
JC-1096-CS-55	E	30.00	8110	3848	4.01	102400	1	C39/T22	
JC-1096-CS-55	F	30.00	6410	3820	4.01	81000	3	C39/T22	
JC-1099-CS-57	A	9.00	4610	3873	4.03	58770	3	C39/T22	
JC-1099-CS-57	B	9.00	7070	3873	4.02	89780	3	C39/T22	
JC-1099-CS-57	C	9.00	6220	3885	4.01	78570	1	C39/T22	

Sample No.	ID No.	Test Age (days)	Strength (psi)	Weight (g)	Diameter (in)	Max Load (lbs)	Frac. type	ASTM Test method	Notes
JC-1099-CS-57	D	30.00	7650	3883	4.01	96630	3	C39/T22	
JC-1099-CS-57	E	30.00	7630	3887	4.01	96360	3	C39/T22	
JC-1099-CS-57	F	30.00	6910	3871	4.02	87660	1	C39/T22	
JC-1100-CS-58	A	8.00	7480	3875	4	94010	3	C39/T22	4x8 cyl
JC-1100-CS-58	B	8.00	5450	3892	4	68530	3	C39/T22	
JC-1100-CS-58	C	8.00	6260	3892	4.01	79100	1	C39/T22	
JC-1100-CS-58	D	29.00	7860	3855	4	98750	4	C39/T22	
JC-1100-CS-58	E	29.00	7820	3871	4	98330	1	C39/T22	
JC-1100-CS-58	F	29.00	7780	3881	4	97730	1	C39/T22	
JC-1103-CS-59	A	8.00	5930	3852	4.01	74950	3	C39*	
JC-1103-CS-59	B	8.00	5000	3850	4.02	63430	3	C39*	
JC-1103-CS-59	C	8.00	6100	3837	4.01	76990	1	C39*	
JC-1103-CS-59	D	29.00	6960	3810	4.01	87900	3	C39*	
JC-1103-CS-59	E	29.00	5470	3816	4.02	69370	1	C39*	
JC-1103-CS-59	F	29.00	5870	3819	4.02	74450	1	C39*	
JC-1107-CS-61	A	8.00	5850	3875.8	4	73490	1	C39/T22	(4x8)
JC-1107-CS-61	B	8.00	6300	3875.4	4.01	79520	3	C39/T22	
JC-1107-CS-61	C	8.00	7130	3857.8	4	89620	3	C39/T22	
JC-1107-CS-61	D	29.00	0	3817.9	4.01			C39/T22	
JC-1107-CS-61	E	29.00	0	3867	4.02			C39/T22	
JC-1107-CS-61	F	29.00	0	3877.1	4.02			C39/T22	
JC-1104-CS-60	A	8.00	7110	3896	4.01	89770	2	C39/T22	
JC-1104-CS-60	B	8.00	7120	3890	4.01	89870	2	C39/T22	
JC-1104-CS-60	C	8.00	7400	3900	4	92930	2	C39/T22	
JC-1104-CS-60	D	29.00	8030	3850	4.01	101440	2	C39/T22	
JC-1104-CS-60	E	29.00	7840	3838	4.01	98990	2	C39/T22	
JC-1104-CS-60	F	29.00	8070	3852	4	101390	2	C39/T22	
JC-1113-CS-63	A	8.00	7220	3861	4.01	91210	1	C39/T22	7.89"
JC-1113-CS-63	B	8.00	7140	3861	4.01	90160	4	C39/T22	7.89"
JC-1113-CS-63	C	8.00	7170	3857	4	90050	3	C39/T22	7.91"
JC-1113-CS-63	D	29.00	5660	3807	4.01	71470	3	C39/T22	7.83"
JC-1113-CS-63	E	29.00	7060	3839	4.01	89100	3	C39/T22	7.90"
JC-1113-CS-63	F	29.00	5830	3818	4.01	73650	2	C39/T22	7.84"

Sample No.	ID No.	Test Age (days)	Strength (psi)	Weight (g)	Diameter (in)	Max Load (lbs)	Frac. type	ASTM Test method	Notes
JC-1116-CS-64	A	8.00	4280	3775	4.01	54100	4	C39/T22	
JC-1116-CS-64	B	8.00	5310	3788	4.02	67380	4	C39/T22	
JC-1116-CS-64	C	8.00	4920	3800	4.01	62130	4	C39/T22	
JC-1116-CS-64	D	29.00	4880	3788	4.02	61880	3	C39/T22	
JC-1116-CS-64	E	29.00	4950	3785	4.01	62570	3	C39/T22	
JC-1116-CS-64	F	29.00	5580	3805	4.01	70510	4	C39/T22	
JC-1123-CS-67	A	8.00	6220	3885	4.01	78530	3	C39/T22	
JC-1123-CS-67	B	8.00	5970	3882	4.01	75340	3	C39/T22	
JC-1123-CS-67	C	8.00	6050	3872	4.01	76440	3	C39/T22	
JC-1123-CS-67	D	29.00	7210	3946	4.01	91010	3	C39/T22	
JC-1123-CS-67	E	29.00	7020	3945	4.01	88660	3	C39/T22	
JC-1123-CS-67	F	29.00	7110	3913	4.01	89790	3	C39/T22	
JC-1120-CS-66	A	8.00	6050	3794	4.01	76430	4	C39/T22	
JC-1120-CS-66	B	8.00	6100	3789	4.01	77010	4	C39/T22	
JC-1120-CS-66	C	8.00	6190	3816	4.01	78120	4	C39/T22	
JC-1120-CS-66	D	29.00	6730	3784	4.01	84970	4	C39/T22	
JC-1120-CS-66	E	29.00	6500	3795	4.02	82440	4	C39/T22	
JC-1120-CS-66	F	29.00	6960	3777	4.01	87890	4	C39/T22	
JC-1124-CS-68	A	8.00	6300	3820	4.01	79510	3	C39/T22	
JC-1124-CS-68	B	8.00	6210	3815	4.01	78480	3	C39/T22	
JC-1124-CS-68	C	8.00	6010	3800	4.01	75920	1	C39/T22	
JC-1124-CS-68	D	29.00	7340	3828	4.01	92730	4	C39/T22	
JC-1124-CS-68	E	29.00	7170	3822	4.01	90610	4	C39/T22	
JC-1124-CS-68	F	29.00	7320	3805	4.01	92390	4	C39/T22	
JC-1128-CS-70	A	8.00	7240	3784	4	90950	1	C39/T22	
JC-1128-CS-70	B	8.00	7260	3793	4	91170	1	C39/T22	
JC-1128-CS-70	C	8.00	7130	3806	4.01	90070	1	C39/T22	
JC-1128-CS-70	D	29.00	7800	3799	4	97960	3	C39/T22	
JC-1128-CS-70	E	29.00	7700	3792	4	96760	3	C39/T22	
JC-1128-CS-70	F	29.00	7760	3774	4.01	97950	3	C39/T22	
JC-1131-CS-71	A	8.00	6740	3835	4.01	85090	2	C39/T22	
JC-1131-CS-71	B	8.00	7010	3847	4	88050	3	C39/T22	
JC-1131-CS-71	C	8.00	6900	3850	4	86690	2	C39/T22	

Sample No.	ID No.	Test Age (days)	Strength (psi)	Weight (g)	Diameter (in)	Max Load (lbs)	Frac. type	ASTM Test method	Notes
JC-1131-CS-71	D	29.00	7830	3832	4	98410	4	C39/T22	
JC-1131-CS-71	E	29.00	7650	3844	4	96120	3	C39/T22	
JC-1131-CS-71	F	29.00	7670	3864	4	96330	4	C39/T22	

Table B-2 Information summary of all mixes

Sample No.	Sample date	Time	Conc mix No.	Slump (in)	Temp (F)	Air Content	Grout sampled (cy)	Quantity represented	Test Method	Acceptance/Notes
JC-1003-CS-1	4/8/2014	10:05 AM	2014-008	6	81	n/a	5	5	C39/T22	Accepted
JC-1004-CS-2	4/18/2014	10:05 AM	2014-008	6	81	n/a	5	5	C39/T22	Accepted
JC-1007-CS-3	5/3/2014	7:37 PM	2014-008	8	82	-	1.8	2	C39/T22	Other low results subject to further review and testing as needed
JC-1008-CS-4	5/11/2014	8:55 AM	2014-008	5.25	88	0	0.2	3.2	C39/T22	
JC-1009-CS-5	5/18/2014	9:40 PM	2014-008	3.5	88	0	0.3	5.2	C39/T22	Fail
JC-1019-CS-6	5/25/2014	6:46 AM	2014-018	2.5	83	0	0.5	6.1	C39/T22	Accepted
JC-1021-CS-7	6/1/2016	9:04 AM	2014-018	8.5	88	0	0.85	6.58	C39/T22	Accepted
JC-1022-CS-8	6/8/2014	9:20 AM	2014-018	8.5	84	0	0.9	11.11	C39/T22	Accepted
JC-1023-CS-9	6/15/2014	11:40 AM	2014-018	8	86	0	2.17	8.83	C39/T22	Fail
JC-1026-CS-10	6/21/2014	7:56 PM	2014-018	8	85	0	0.85	12.14	C1231	Accepted
JC-1027-CS-11	6/28/2014	8:38 PM	2014-018	9.5	84	0	-	15.2	C39/T22	Recommend acceptance based on 9-day test results
JC-1029-CS-12	7/12/2014	11:15 PM	2014-018	4.5	89	6	2.03	6.66	C39/T22	Accepted
JC-1030-CS-13	7/13/2014	6:00 PM	2014-018	8	90	4	1.22	5.56	C39/T22	Accepted
JC-1031-CS-14	7/19/2014	2:52 PM	2014-018	4	88	4	1.47	4.56	C39/T22	Accepted
JC-1032-CS-15	7/26/2014	8:40 PM	2014-018	3	86	4	0.71	5.62	C39/T22	Accepted
JC-1035-CS-16	8/1/2014	8:40 PM	2014-018	2	87	4	0.71	9.59	C39/T22	Accepted
JC-1037-CS-17	8/17/2014	2:59 PM	2014-018	1.5	88	4	0.89	12.12	C39/T22	Accepted
JC-1038-CS-18	8/24/2014	12:35 PM	2014-018	5.5	88	5	1.48	7.67	C39/T22	Accepted
JC-1042-CS-19	9/20/2014	9:33 PM	2014-018	7.25	85	4	2.25	5.22	C39/T22	Failed+Recommend acceptance for this project only. Refer to project memo dated 3/30/15 for basis of acceptance.
JC-1043-CS-20	9/27/2014	8:29 PM	2014-018	7.25	85	4	0.63	3.23	C39/T22	Fail
JC-1044-CS-21	10/4/2014	8:48 PM	2014-018	7.5	84	4	6.08	7.18	C39/T22	Accepted

Sample No.	Sample date	Time	Conc mix No.	Slump (in)	Temp (F)	Air Content	Grout sampled (cy)	Quantity represented	Test Method	Acceptance/Notes
JC-1045-CS-22	10/26/2014	2:35 PM	2014-018	5	87	0	4.98	7.49	C39/T22	Accepted
JC-1048-CS-23	11/2/2014	2:23 PM	2014-018	8.5	86	0	5.82	8.5	C39/T22	Fail
JC-1049-CS-24	11/9/2014	1:56 PM	2014-018	7	84	0	9.51	9.51	C39/T22	Accepted
JC-1050-CS-25	11/14/2014	1:40 PM	2014-018	7.5	86	0	1	1	C39/T22	Fail
JC-1051-CS-26	11/15/2014	8:27 PM	2014-018	4.75	86	0	0.65	6.52	C39/T22	Accepted
JC-1052-CS-27	11/16/2014	2:18 PM	2014-018	6.75	82	0	2.01	12.4	C39/T22	Fail
JC-1053-CS-28	11/23/2014	1:51 PM	2014-018	7.5	84	0	2.75	6.07	C39/T22	Accepted
JC-1054-CS-29	11/23/2014	4:58 PM	2014-018	7.5	85	0	1.21	4.25	C39/T22	Accepted
JC-1057-CS-30	11/29/2014	7:46 PM	2014-018	6.75	80	0	1.24	5.45	C39/T22	Accepted
JC-1058-CS-31	12/6/2014	7:47 PM	2014-018	8	80	0	4.17	6.5	C39/T22	Accepted
JC-1061-CS-32	12/28/2014	1:46 PM	2014-018	7.75	80	0	5.21	10.45	C39/T22	Accepted
JC-1062-CS-33	1/3/2015	7:43 PM	2014-018	6.5	74	0	4.31	6.63	C39/T22	Accepted
JC-1062-CS-34	1/10/2015	7:54 PM	2014-018	8.25	76	0	3.4	6.79	C39/T22	Accepted
JC-1064-CS-35	1/17/2015	8:37 PM	2014-018	7.75	76	0	1.35	8.29	C39/T22	Accepted
JC-1073-CS-36	1/24/2015	8:54 PM	2014-018	5.75	81	0	7.06	8.56	C39/T22	Accepted
JC-1075-CS-37	1/29/2015	11:30 PM	PPC1121	-	-	0	0.5	0.5	C39/T22	Accepted
JC-1076-CS-38	1/30/2015	11:20 PM	PPC1121	-	-	0	9	9	C39 (Neoprene Cap)	Accepted Test Age is 9.5 days
JC-1077-CS-39	1/31/2015	7:18 AM	PPC1121	-	-	0	9	9	C39 (Neoprene Cap)	Accepted
JC-1078-CS-40	1/31/2015	2:17 PM	PPC1121	-	-	0	9	9	C39*	Accepted
JC-1079-CS-41	1/31/2015	10:00 PM	PPC1121	-	-	0	9	9	C39 (Neoprene Cap)	Accepted
JC-1080-CS-42	2/1/2015	7:32 AM	PPC1121	-	-	0	9	9	C39*	Accepted
JC-1081-CS-43	1/31/2015	7:18 AM	PPC1121	-	-	0	9	9	C78/T97	response to RFI-017 exempts flexural testing

Sample No.	Sample date	Time	Conc mix No.	Slump (in)	Temp (F)	Air Content	Grout sampled (cy)	Quantity represented	Test Method	Acceptance/Notes
JC-1082-CS-44	2/1/2015	7:45 PM	PPC1121	-	-	0	9	9	C293/T177	response to RFI-017 exempts flexural testing
JC-1083-CS-45	2/1/2015	6:01 PM	PPC1121	-	-	0	0.2	9	C39*	Accepted
JC-1084-CS-46	2/3/2015	9:40 PM	PPC1121	-	-	0	9	9	C39*	Accepted
JC-1085-CS-47	2/3/2015	10:30 PM	PPC1121	-	-	0	9	9	C293/T177	For information, response to RFI-017 exempts flexural testing
JC-1086-CS-48	2/5/2015	9:15 PM	PPC1121	-	-	0	9	9	C39*	Accepted
JC-1090-CS-52	2/7/2015	10:15 PM	-	-	-	0	9	9	C78/T97	For information, response to RFI-017 exempts flexural testing
JC-1091-CS-53	2/14/2015	9:21 PM	2014-018	6.5	79	0	3.45	4.82	C39*	Accepted
JC-1092-CS-54	2/21/2015	8:09 PM	2014-018	6	79	0	6.13	6.84	C39/T22	Accepted
JC-1095-CS-55	2/26/2015	-	-	-	-	-	-	-	C805	Low break JC sample cards (having rebar hammer reading of 38 or higher) : JC-1007-CS3, JC-1009-CS5, JC-1023-CS9, JC-1043-CS20, JC-1048-CS23, JC-1052-CS27
JC-1096-CS-55	2/28/2015	7:31 PM	2014-018	6	81	0	8.98	8.98	C39/T22	Accepted
JC-1099-CS-57	3/14/2015	7:37 PM	2014-018	7	76	0	5.41	9.21	C39/T22	Accepted
JC-1100-CS-58	3/29/2015	12:43 PM	2014-018	7.25	83	0	7.99	19.5	C39/T22	Accepted
JC-1103-CS-59	4/12/2015	12:46 PM	2014-018	8	84	0	8.3	8.3	C39*	Accepted
JC-1107-CS-61	5/3/2015	11:40 PM	2014-018	4.25	83	0	10.05	20.96	C39/T22	
JC-1104-CS-60	4/19/2015	4:16 PM	2014-018	6.5	83	0	1.19	1.19	C39/T22	Accepted
JC-1113-CS-63	5/31/2015		2014-018	8.5	84	0	5.01	10.21	C39/T22	Accepted
JC-1116-CS-64	6/14/2015	12:54 PM	2014-018	8.75	84	0	4.95	10	C39/T22	Failed Specified Strength
JC-1123-CS-67	8/2/2015	11:49 AM	2014-018	6.5	85	0	5.25	9.62	C39/T22	Accepted
JC-1120-CS-66	7/19/2015	12:14 PM	2014-018	6.5	86	0	5.15	10.18	C39/T22	Accepted
JC-1124-CS-68	8/16/2015	11:52 AM	2014-018	5	91	0	5.22	10.14	C39/T22	Accepted
JC-1128-CS-70	10/18/2015	12:10 PM	2014-018	7.25	83	0	5.2	18.77	C39/T22	Accepted
JC-1131-CS-71	11/8/2015	11:28 AM	2014-018	4.25	87	0	5.23	9.47	C39/T22	Accepted