FREEZE/THAW TEST OF GLASS FIBER-REINFORCED CONCRETE FOR THE WASHINGTON PEDESTRIAN BRIDGE FASCIA PANELS

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Tables and Figures

PHASE I BACKGROUND: In April 2003, R&TD was asked to perform freeze/thaw and permeability testing on the glass fiber-reinforced concrete (GFRC) planned for use on the section of the Washington Bridge (Number 200) to be converted for use by pedestrians and bicyclists. The test specimens were fabricated at the plant of the potential producer, Symmetry Products of Lincoln, Rhode Island. The specimens are made of Portland cement, sand, water, a latex modifier, a Pozzolan, water-reducing admixture and structural glass fibers (introduced into the matrix during placement of the concrete) and are to be used as thin, decorative (non-structural) fascia panels, held in place vertically by a steel framework. The primary concern was to determine whether it was necessary to use a penetrant sealer and how this would affect the freeze/thaw durability of the GFRC concrete.

Freeze/thaw testing simulates the environmental damage that occurs in the snow belt. Concrete typically contains some moisture and as the temperature drops, the moisture in the concrete matrix freezes. The volume of ice is greater than that of water and unless the void structure in the concrete can accommodate this expansion, the increased stress causes microcracking of the concrete. Over time, these fractures decrease the strength of the concrete and may eventually cause spalling or macrocracking.

Air entrainment additives are generally added to typical RIDOT concrete mixes to create a microscopic void structure in the concrete matrix to relieve the stresses created by the formation of the ice. This is standard practice for Rhode Island concrete mixes, although the GFRC mix is substantially different than those normally used by RIDOT. Air-entrained mixes usually perform very well under freeze/thaw testing.

Freeze/thaw testing consists of placing the specimens in a water bath within a sealed machine and cycling the temperature above and below the freezing point of water. Control specimens with embedded temperature probes are used to monitor the effective values in the center of the concrete. Resonant frequency testing is used to monitor the condition (strength) of the specimens.

Permeability testing was also performed to evaluate the resistance of the GFRC to intrusion of chlorides.

PHASE I PROCEDURE:

Fabrication:

Six 3 × 4 × 16 inch prisms and two 4 × 8 inch cylinders were provided, for use as freeze/thaw specimens and for permeability, respectively. The prisms were cast in rigid steel molds to maintain the close dimensional tolerances necessary. They were pre-coated with a light form oil to facilitate release of the molds after 24 hours curing (standard RIDOT practice). The interior surfaces of the molds were then coated with the GFRC mortar without fibers (called a face mix – about $^{1}/_{32}$" thick) using a pressurized gun, to create a smooth surface and hide the fibers. This is the standard procedure for

Symmetry Products. The molds were then filled with the mortar/fiber mix, with the same apparatus used for the face mix. The process was observed by RIDOT personnel.

The specimens were air-cured for 28 days. They would normally be cured for 14 days, but as the Precast/Prestressed Concrete Institute used the longer period, it was decided to cure it for the same duration. Three of the prisms were treated with a penetrant sealer (an alkyltrialkoxysilane) that is known to perform well in freeze/thaw testing. The remainder were uncoated. The sealer was allowed for to cure for one week prior to freeze/thaw testing.

The permeability disks were sawn from the 4 × 8 inch cylinders and tested per AASHTO T 277 ("Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration").

Testing:

Freeze/Thaw: The prisms were tested in accordance with ASTM C 666 ("Resistance of Concrete to Rapid Freezing and Thawing"). The specimens were cycled between 0°F and 40°F, (averaging 3.75 hours per cycle in RIDOT's machine) and inspected at a maximum of 36 cycles. The total number of cycles per the method is 300.

Resonant Frequency: C 666 specifies ASTM C 215 ("Fundamental Transverse, Longitudinal, and Torsional Frequencies of Concrete Specimens") to monitor the condition of the concrete. An audio frequency signal is transmitted into the concrete at one location and a receiver detects the resultant waveform at another location. A measurement is made of the resonant frequency, which is defined as the frequency having the highest signal strength at the receiver. This is an indicator of the concrete strength (analogous to the tension in a guitar string – the higher the frequency, the greater the tensile load).

The relative dynamic modulus is calculated by dividing the square of the resonant frequency by the square of the frequency value measured initially (prior to freeze/thaw cycling). Monitoring changes in this value allows assessment of strength gain/loss. Concrete typically deteriorates under freeze/thaw and a decrease in modulus is a measure of this loss of strength. A value after 300 freeze/thaw cycles above 60% is acceptable by the ASTM method, although RIDOT uses 80% as the cutoff to increase the factor of safety. When the relative dynamic modulus drops below the minimum value, the strength loss is considered to be detrimental to the acceptable structural capacity of the concrete matrix.

Weight Gain/Loss: The weight of the specimens is also monitored. Aside from the more obvious decreases due to loss of surface material, internal fracturing of the concrete matrix, starting as microcracking, can lead to weight gains as the void structure increases and the concrete can absorb more water.

Visual Inspection: The specimens are examined and distresses are noted. Typically, this is in the form of scaling, spalling and in severe cases, cracking and fracturing of the concrete.

Rapid Permeability: The permeability test is a rapid test (relative to the standard AASHTO T-259 ponding test, which takes 90 days), using a disk specimen sandwiched between two reservoirs. One reservoir holds sodium hydroxide solution against one flat face and the other holds sodium hydroxide against the opposite face. Conduction plates are installed in each cell and sixty volts DC is put across the assembly for six hours. The total charge passed during this period is measured. The more permeable the concrete, the greater the charge passed as more chloride ions pass into the concrete, making it more conductive.

Bulk Specific Gravity: A prism (U1) was cut into three three-inch cubes and each was tested per AASHTO T 24 to determine the specific gravity of the concrete.

Compressive Strength: The cubes were tested per AASHTO T 106. This is done for information only, as the test method is designed for two inch cubes.

Note: There was some concern over the fabrication of the prisms, as they are normally made by hand-placing concrete in two lifts and vibrating the molds (no vibration was used when these specimens were fabricated, as it was not deemed to be necessary for consolidation, given the nature of the process). It was considered that the method of placement for the GFRC mix might not be representative of the concrete to be used in the panels, because of the effects of shooting the concrete into the relatively small mold volume.

PHASE I RESULTS: In Table 1, the relative dynamic moduli is provided and in Table 2, weight changes for the specimens are given. The moduli are given *proportional* to the baseline values and the weight changes are the *differences* from the initial weight. Figures 1 and 2 display the information graphically. The "C" designations are the treated specimens and "U" are the untreated. Note that by definition, all specimens start at 100 percent for the modulus and at zero percent for the weight, referenced to the baseline values. Permeability testing was also performed on six specimens (one equipment channel failed during the test, providing data for only five). The results varied from 2618 to 3631 Coulombs. The average was 3120 Coulombs, with a standard deviation of 430, which would give a range of 1830 to 4410 Coulombs with a 95% confidence level. This would classify the concrete as moderately permeable (2000 to 4000 Coulombs per T 277). The bulk specific gravities ranged from 2.188 to 2.285 and averaged 2.244. Absorptions ranged from 2.33 to 3.17%, averaging 2.80%. The compressive strengths ranged from 4,156 to 7,100 psi and averaged 5,704 psi.

	SPECIMEN					
NUMBER OF CYCLES	C1	C2	C3	U1	U2	U3
0	100.0	100.0	100.0	100.0	100.0	100.0
36	96.6	97.3	98.5	97.3	97.9	98.3
59	98.8	99.9	100.8	100.5	101.3	101.2
89	98.3	98.8	100.4	99.8	99.5	101.8
124	98.3	99.5	97.9	99.8	99.7	101.8
160	101.2	104.2	100.6	102.6	100.7	102.5
196	108.0	107.7	104.7	109.5	109.0	105.8
232	108.4	107.2	108.0	106.1	106.1	110.2
268	103.8	105.6	105.3	106.4	104.5	106.0
300	105.4	106.3	105.5	104.5	106.7	105.7

Table 1 – Relative Dynamic Modulus of Test Specimens, Phase I (%)

	SPECIMEN					
NUMBER OF CYCLES	C1	C2	C3	U1	U2	U3
0	0.00	0.00	0.00	0.00	0.00	0.00
36	2.49	2.11	3.43	3.46	2.85	3.27
59	3.96	2.67	3.78	4.09	3.85	3.96
89	4.70	3.35	4.70	4.86	4.36	4.86
124	5.15	4.53	5.09	5.25	4.99	5.26
160	4.89	4.83	5.46	5.32	4.99	5.51
196	5.71	5.27	6.01	6.08	5.46	6.08
232	5.41	4.48	5.63	5.19	5.07	5.98
268	4.69	4.20	5.31	4.82	4.92	5.72
300	4.65	4.05	5.08	4.61	4.67	5.60

Table 2 – Relative Weight Gain/Loss of Specimens, Phase I (%)

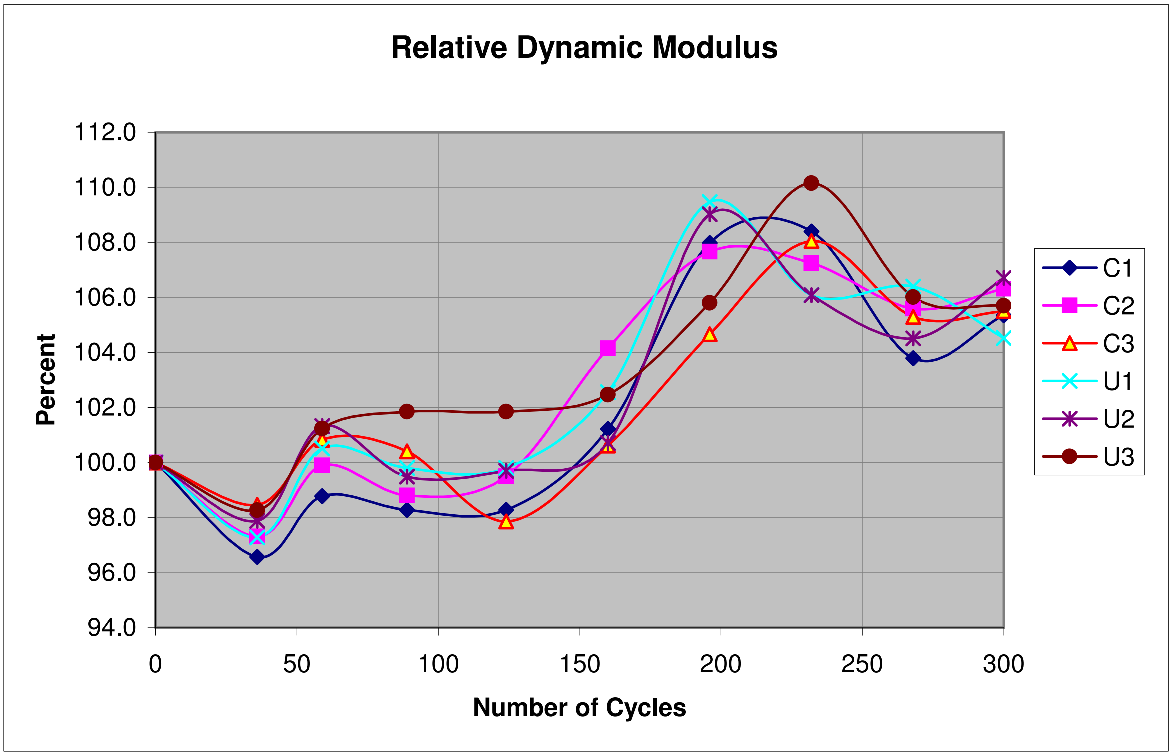

Figure 1 - Relative Dynamic Modulus of Test Specimen, Phase I (%)

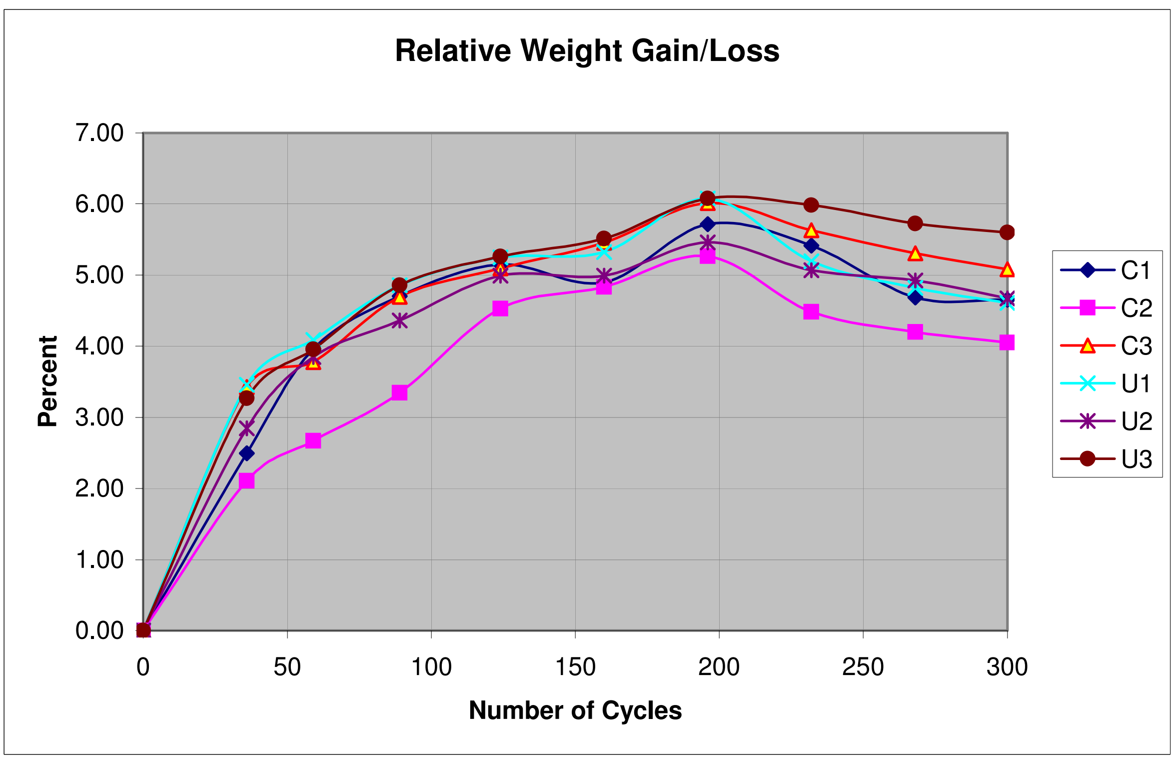

Figure 2 – Relative Weight Gain/Loss of Specimens, Phase I (%)

PHASE I DISCUSSION:

Resonant Frequency: The upward trend of the dynamic modulus is unusual, but not without precedent in RIDOT testing. Some specimens are not fully cured when the initial values are recorded, due to initial curing conditions, characteristics of the mix (such as the presence of certain pozzolans) or a combination of the two factors. Because of this, the concrete may continue to cure during the thawing portion of the cycle, although the average numbers shown here are higher than previously seen. This may be due in part to the air-curing of the prisms, which might have slowed the hydration process, relative to the wet curing method normally used for C 666. While there was some variation in the results from inspection to inspection, this is not that uncommon. Some may be due to deterioration of the surface paste, introducing additional frequencies harmonics during testing. That the specimens followed the same overall up and down pattern, is unexpected and no apparent cause for that has been determined. The final result is well above the RIDOT minimum and these variations are relatively small, however, so there appears to be no cause for concern.

Weight Gain/Loss: The weight gains are higher than normal. The transition from dry to fully saturated normally occurs during the first set of cycles, so there would typically be no significant gain after the first inspection. But as this concrete does not contain coarse aggregate (which is less absorbent), this may not be unusual. Fracturing within the concrete might explain this by creating more voids within the matrix to hold water, except that an attendant decrease in the strength as measured by the dynamic modulus would also be evident. No such loss is seen here. The relative weight loss towards the end of the test is largely due to scaling of the paste.

Visual Inspection: Of concern was the loss of the surface paste (scaling) in the early stages of the test (see Figures 3 and 4 below). The loss of much of the face mix and some of the fine material from the matrix to the degree seen would be unusual for a standard concrete mix. But this isn't a normal mix. Freeze/thaw specimens typically don't have a face mix and consolidating the concrete with fibers into such a small mold (particularly at corners) is more difficult than even a stiff mix with a coarse aggregate. Still, this was potentially a problem, because the concrete is to be used in decorative panels and even if the structural integrity was not affected, aesthetics of the panels is important. The first specimen to experience loss was one of the coated specimens (C1 @ 36 cycles) and as none of the others exhibited this behavior at first, it was thought to be an anomaly. Then the other coated specimens started to scale and finally the uncoated ones showed loss of paste, too. Most of the material was lost in a sheeting type of failure. The scaling was severe by the end of the cycling, particularly around the edges and corners, although even in the worst cases, there was little loss in concrete containing fiber, including the troweled surface. Normally, the troweled face is the first to experience scaling, owing to the mix bleed water creating a higher water/cement ratio. This higher w/c ratio mortar is less resistant to freeze/thaw.

However, the strength was maintained throughout, which is considered the primary indicator of acceptability. This is shown by the relative dynamic modulus never falling below 97.9% for any of the specimens, well in excess of the 80% minimum used by RIDOT for acceptance of concrete mix designs. There was also no significant loss of material from the specimens. Even the face mix showed some structural integrity in that it failed in large sections, rather than by flaking. The loss of the paste was probably caused by the intense stresses created when the water froze in the confined space between the concrete faces and the sides of the specimen compartments.

Permeability: The permeability results, although not typical of what is currently deemed to be desirable for a concrete mix, was determined to be adequate. The GFRC concrete will not have embedded steel reinforcing, so penetration by chlorides and corrosion of the reinforcing is not a factor. The permeability is not considered high enough to contribute to other potential problems and would likely decrease somewhat over time as hydration continues.

Bulk Specific Gravity: Taking into account that the cubes were cut from a single prism, there is high variability in these numbers. Even if it were from the different specimens from the same batch, the range would be large. Standard RIDOT concrete mixes are generally in the 2.25 to 2.40 range (based on the unit weight measurements). The absorptions are not directly comparable for concrete, because of the lack of coarse aggregate.

Compressive Strength: Again, the variability is very high, for the same reasons as the bulk values. For the intended application, however, even the lowest value would probably be adequate. Note, that although the concrete has been through freeze/thaw, since the numbers were maintained above the baseline values, no significant loss of strength is believed to have occurred.

In discussion with Materials, Bridge Engineering and Peter Stone of Symmetry Products, the question was raised whether the fabrication of the prisms was proper, considering the method used for placing the concrete and the small size of the molds. It was decided that much of the issues seen may be due to problems making the specimens rather than flaws in the material. It was also questioned whether it was desirable to use a face mix at all, since that appeared to be the primary cause of the distress and because the public would not be able to see any slight inconsistencies on the surface of the panels from the distance at which the concrete would be visible.

It was agreed that Symmetry Products would cast a slab, using their normal production procedures. One section would have the face mix and the other would not. The slab would be cut into freeze/thaw prisms, half with the face mix and half without. The concrete tested would be what will be used in the structure and the effect of the face mix could be evaluated.

Note: The freeze/thaw machine experienced a failure of one of the two probes used to determine the specimen temperature. The average of the probes is used to control the cycling of the machine and the failure prevented the machine from switching out of the freezing mode. This occurred at 59 cycles. The machine was out of service for one week while the probe was replaced. At 160 cycles, it was observed that the machine cycle time had extended by about 50%, slightly exceeding the ASTM specification for cycle length. It was determined that the cooling system had a small refrigerant leak, reducing it's efficiency (the freezing portion accounts for 75% of the cycle length). Due to various complications, the machine was out of service for five weeks. Neither problem is considered to have had a significant impact on the test. The scaling began prior to the malfunctions.

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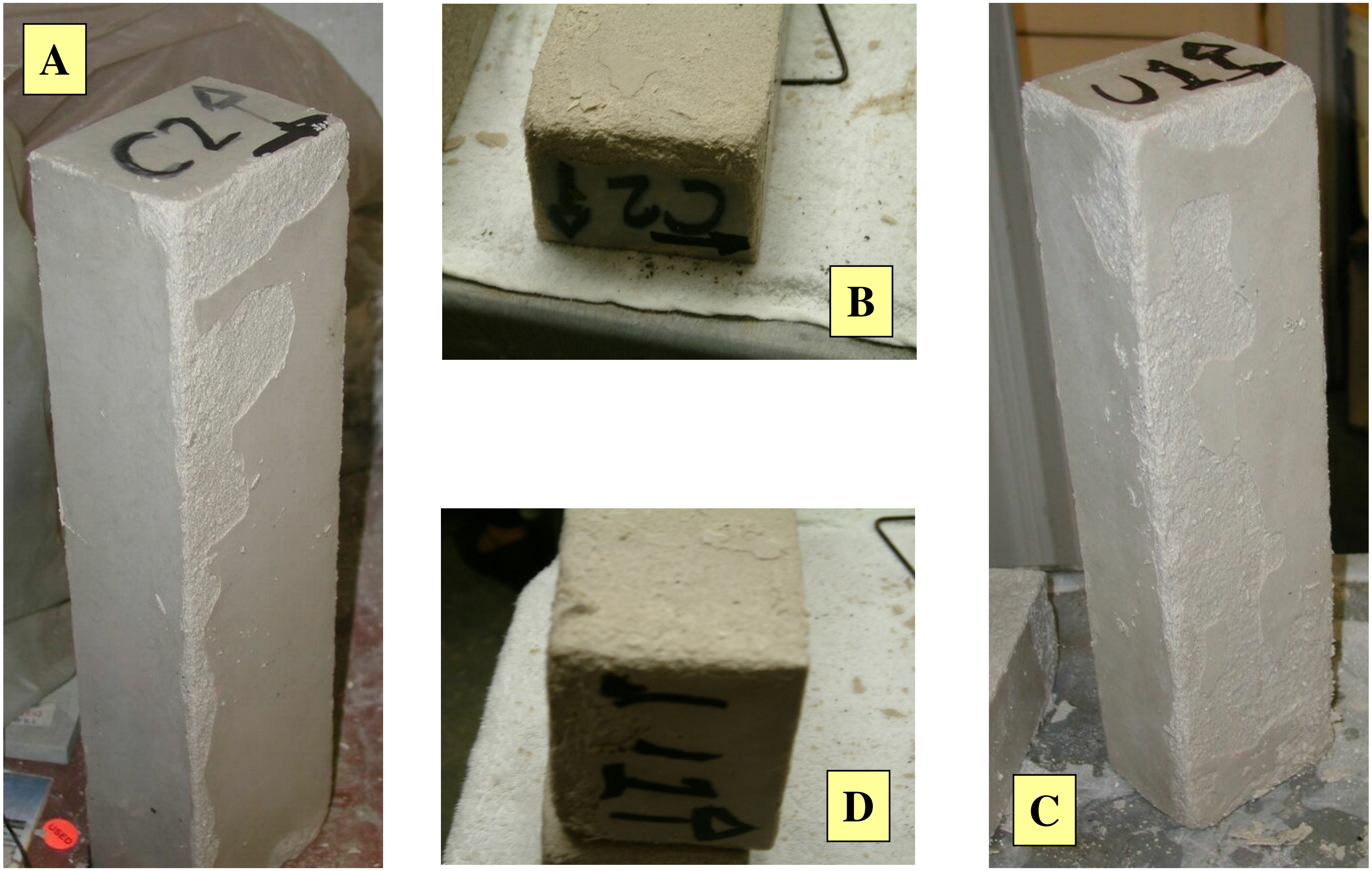

Figure 3 – A: Specimen C2 @ 160 Cycles, B: Specimen C2 @ 300 Cycles, C: Specimen U1 @ 196 Cycles,
D: Specimen U1 @ 300 Cycles

Phase II Background: There was some delay in obtaining the second specimen sets. The necessary physical tolerances for the prisms is very precise, per C 666 and the cutting equipment in-house at Symmetry Products was not adequate to the task. Arrangements were made by Mr. Stone to have them cut at another facility, but the next slab was found to have flaws that would have been likely to accelerate deterioration under freeze/thaw. Separations between layers (probably between passes of the gun) created "fissures" that would be expected to open as water filled them and froze, due to the expansive forces of the ice. Note that these flaws were only exposed due to the cutting operation and would not have been a problem in a normally cast panel. These flaws can be seen to a lesser extent in the specimens tested (see Figure 4). In addition, the panels will not be used in an immersion environment and so would not be exposed to the stresses that would be seen in the freeze/thaw machine. A set was delivered in March 2004 (cast in December 2003) that met the physical tolerances required. Eleven specimens were in the set: Six had fibers visible on the cast surface (no face mix) and five did not. Four were selected from each group. The remaining three were tested for information purposes only, as two had what appeared to be cracks, possibly as a result of handling problems or the cutting process. The mix data for this set is in the Appendix (the data for the set from Phase I would be similar).

PHASE II PROCEDURE: The procedures followed were the same as those in the first phase, except that no permeability testing was performed. N2 was used for the bulk specific gravity and compressive strength testing. Third point loading testing, per AASHTO T 97, was also performed for information. A prism is placed on two supports and loaded from above at two points one third the distance apart (hence third point) of the bottom supports and centered between the bottom supports (see Figure 5). The prism is loaded to failure and the flexural strength (modulus of rupture) is calculated. The deflection at midpoint during loading was also recorded and the values at failure were estimated (the dial indicator needle jumps when the specimen fractures and so an accurate reading cannot be obtained).

PHASE II RESULTS: In Table 3, the relative dynamic moduli are provided and in Table 4, weight changes for the specimens are given. Figures 6 and 7 display the information graphically. The "F" series had fibers visible on the surface and the "N" series did not. Figures 8 and 9 show the surface with and without the face mix. Note that both photos have been enhanced to better display detail. Figures 10, 11 and 12 show the defects in the information only specimens. The bulk specific gravities ranged from 2.292 to 2.296 and averaged 2.294. The absorptions ranged from 1.54 to 1.87%, averaging 1.70%. The compressive strengths ranged from 9,000 to 11,000 psi and averaged 10,018 psi. The flexural strengths ranged from 2,175 to 2,390 psi for three specimens, with an average of 2,250 psi. The approximate deflections at failure ranged from 0.0185 to 0.0460 inches, with an average of 0.0335 inches. Even though failed in flexure (increased displacement using the machine head did not increase the measured machine load), the cracked specimens did not separate easily and in fact were able to sustain a sharp blow at the fracture without breaking into two pieces. Figure 13 shows aspects of the tested specimens. The specimens halves shown were from prisms broken in the load frame.

	SPECIMEN							
NUMBER OF CYCLES	**F1**	**F2**	**F3**	**F4**	**N1**	**N2**	**N3**	**N4**
0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
36	98.6	99.3	99.7	97.5	98.0	98.3	100.0	98.3
72	100.5	100.9	100.4	99.7	100.9	100.2	101.0	101.1
108	99.3	99.4	97.2	97.0	99.9	94.4	98.7	97.0
144	98.9	99.1	99.0	96.7	98.0	97.4	97.2	98.2
180	98.8	98.3	99.8	96.1	100.6	98.8	99.0	99.3
216	98.5	97.8	100.0	97.6	100.6	98.1	100.7	99.8
252	98.7	97.5	98.5	98.4	99.8	100.0	100.0	98.1
276	99.1	98.0	98.1	97.3	99.2	97.8	98.5	98.8
300	99.2	99.5	100.1	99.8	100.1	98.9	100.7	100.2

Table 3 – Relative Dynamic Modulus of Specimens, Phase II (%)

	SPECIMEN							
NUMBER OF CYCLES	**F1**	**F2**	**F3**	**F4**	**N1**	**N2**	**N3**	**N4**
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36	2.30	1.91	2.01	2.01	2.06	1.56	1.71	2.32
72	2.95	2.44	2.54	2.52	2.52	2.26	2.35	2.64
108	3.28	2.70	2.94	2.80	2.86	3.03	2.77	3.05
144	3.50	2.87	3.10	3.05	3.06	3.17	3.12	3.25
180	3.67	3.03	3.23	3.15	3.17	3.27	3.26	3.34
216	3.81	3.20	3.36	3.44	3.30	3.39	3.35	3.47
252	3.89	3.28	3.37	3.47	3.34	3.40	3.37	3.47
276	4.00	3.36	3.41	3.54	3.43	3.48	3.44	3.55
300	4.11	3.45	3.47	3.59	3.46	3.50	3.56	3.62

Table 4 – Relative Weight Gain/ Loss of Specimens, Phase II (%)

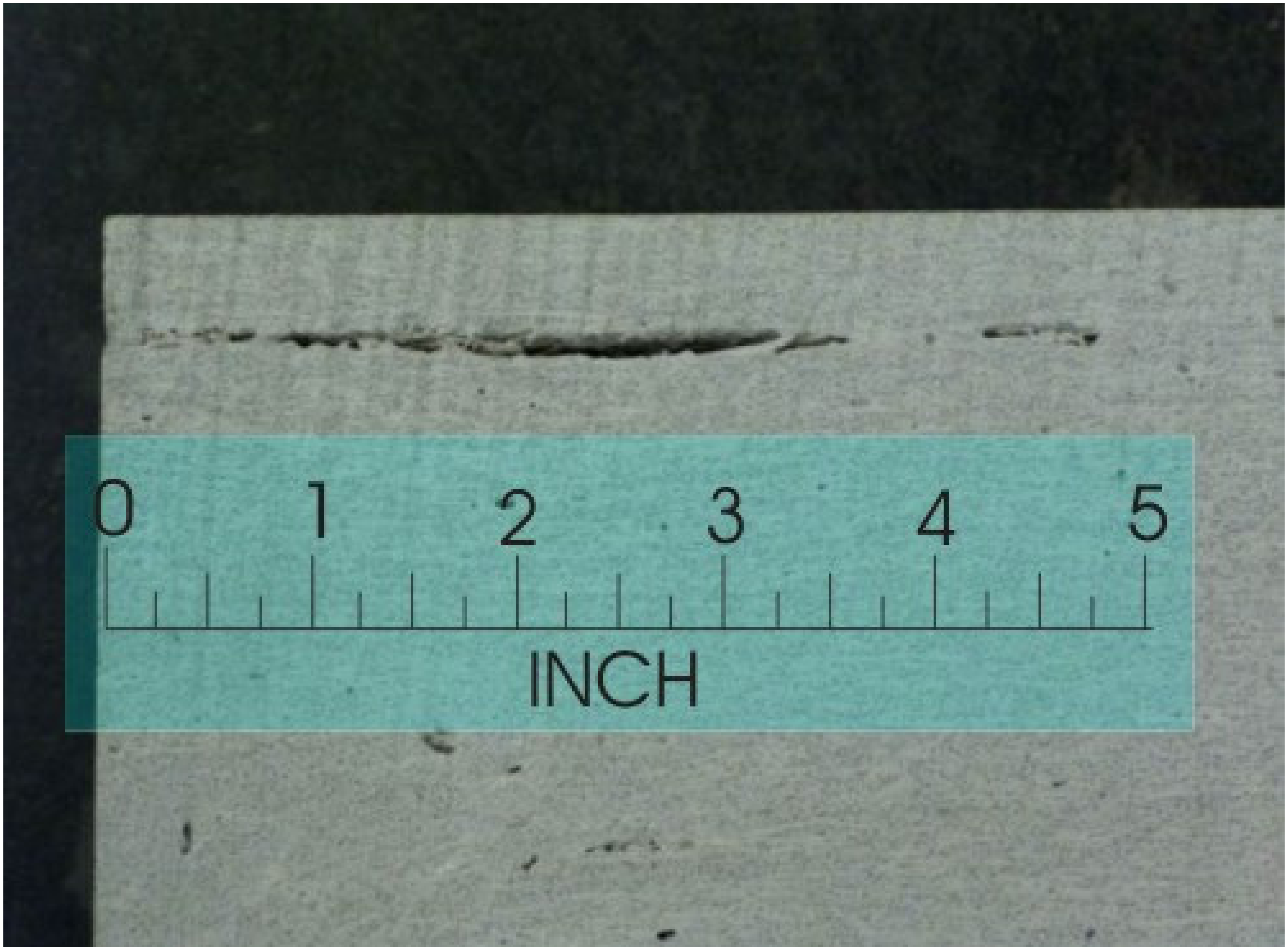

Figure 4 – Closeup of “Fissure” in Glass Fiber Reinforced Concrete Specimen

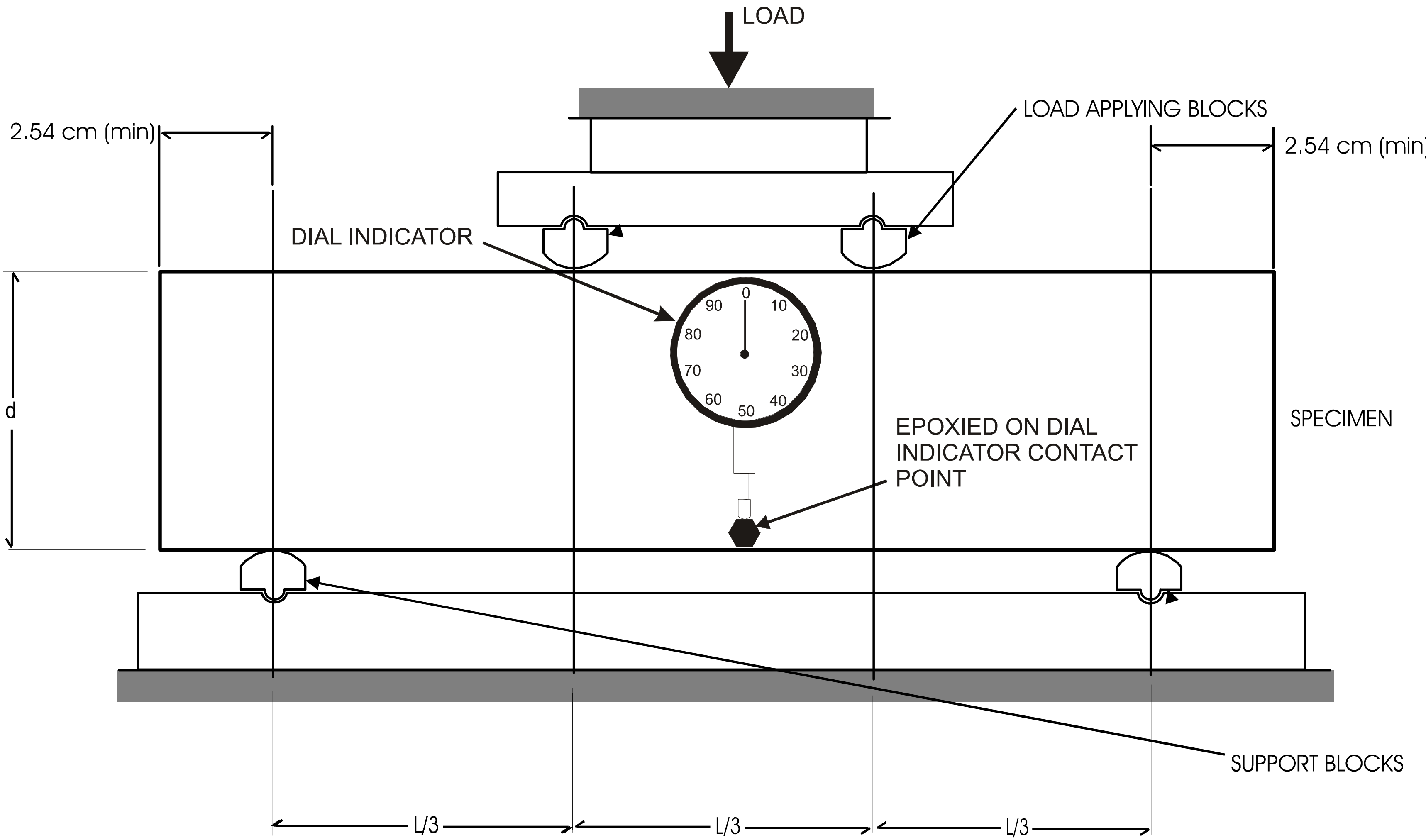

Figure 5 – Third Point Loading Apparatus with Added Dial Indicator

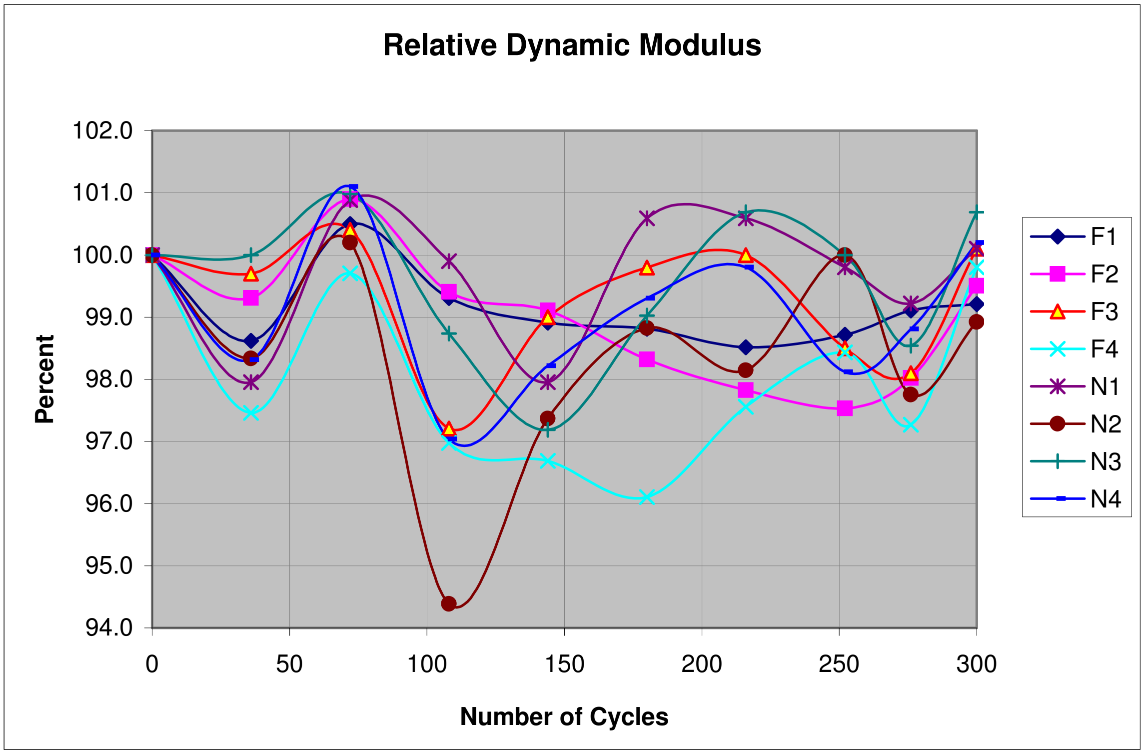

Figure 6 - Relative Dynamic Modulus of Specimens, Phase II (%)

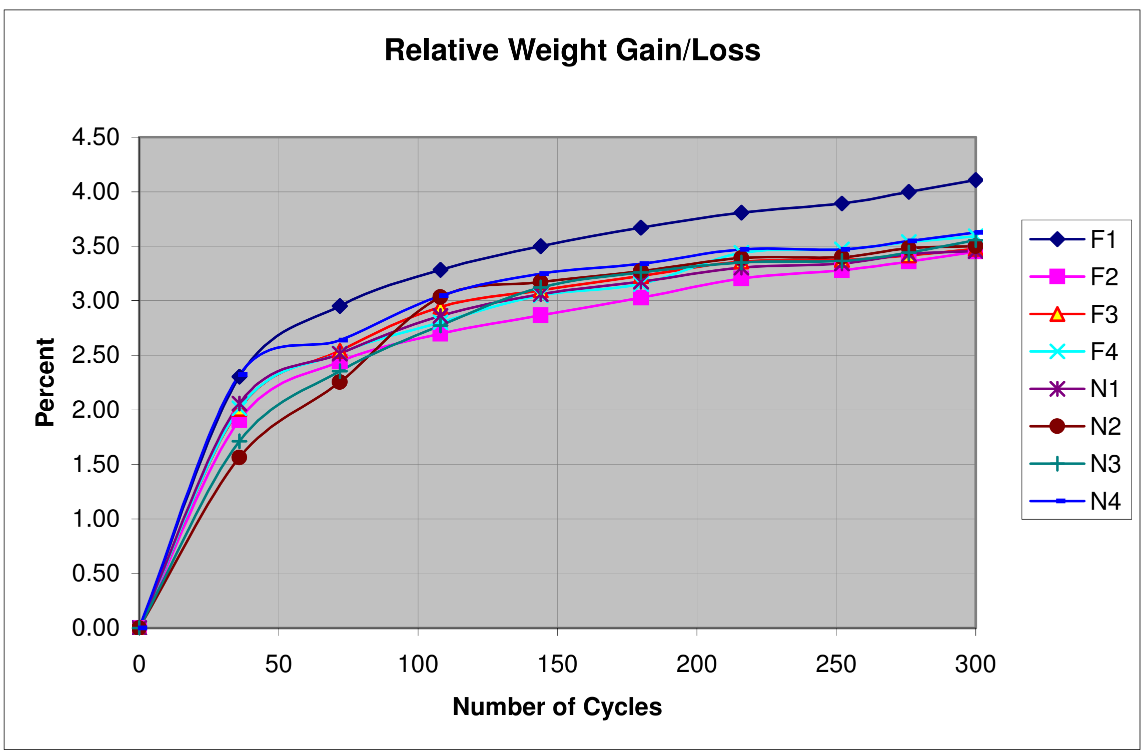

Figure 7 – Relative Weight Gain of Specimens, Phase II (%)

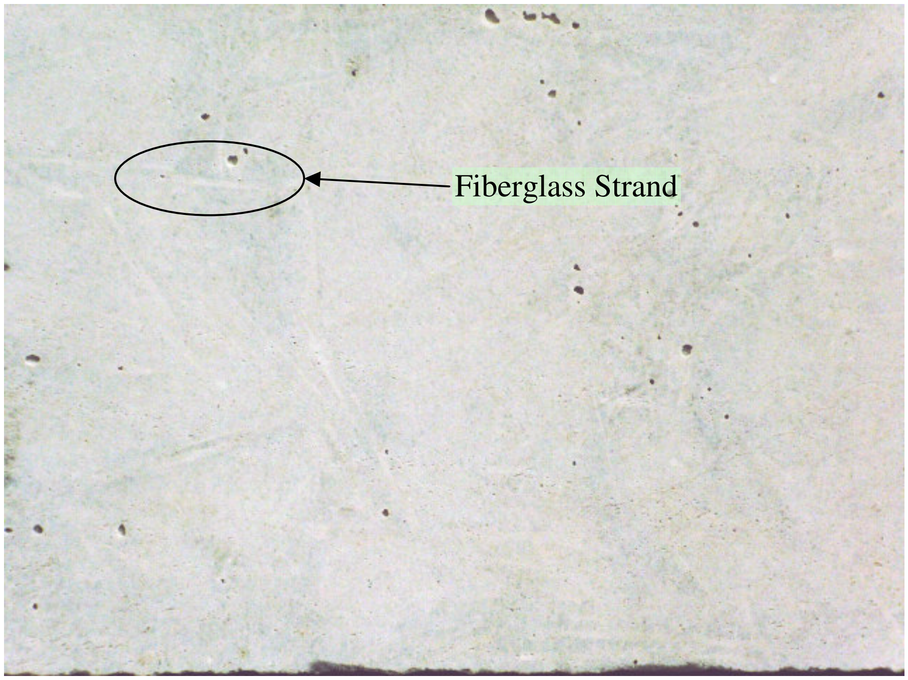

Figure 8 – Specimen Appearance without Face Mix

Figure 9 – Specimen Appearance with Face Mix

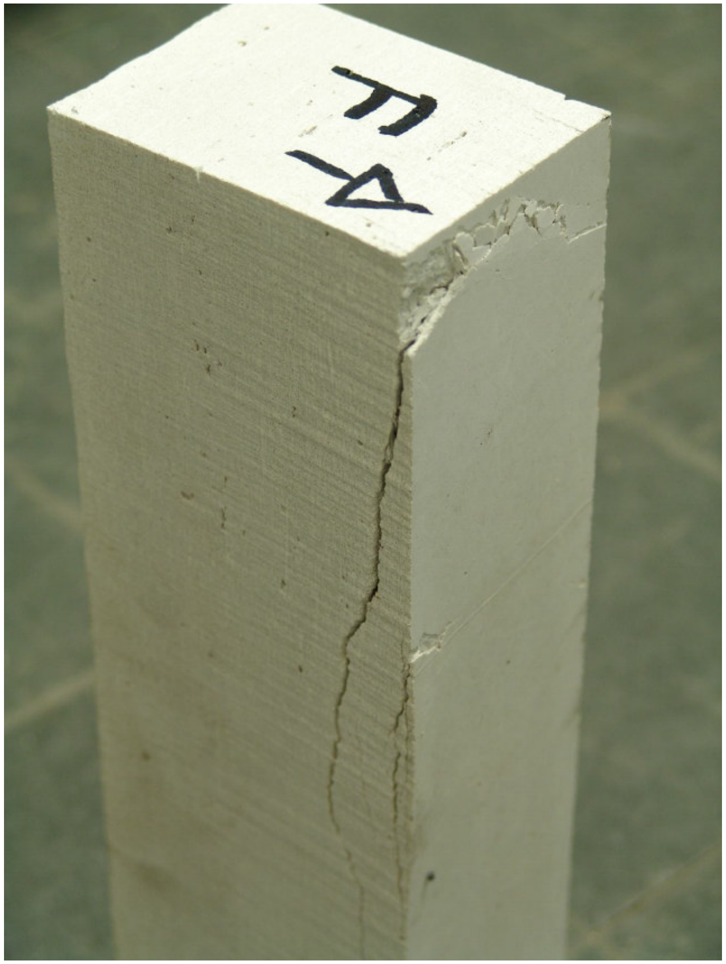

Figure 10 – Fracture in Information Only Specimen without Face Mix

Figure 11 – Fracture in Information Only Specimen with Face Mix

Figure 12 – Fracture in Information Only Specimen without Face Mix @ 108 Cycles (Slight Bulging Evident)

Figure 13 – A: Fractured But Intact, Even While Upright; B: Fibers at Fracture Interface; C: Fractured, But Not Separated; D: Fibers Stretched Across Fracture

PHASE II DISCUSSION:

Visual Inspection: Little deterioration was evident on both of the specimens sets (with the face mix or without), with some slight loss on the edges in a few cases. That isn't unusual in concrete subjected to freeze/thaw. In fact, these specimens have performed better visually than ones from standard silica fume-modified mixes, which generally do quite well.

Resonant Frequency: The up and down variations in the relative dynamic modulus are unusual and more pronounced than that seen in the first Phase, but overall are small and do not appear to be significant. The final values are still comfortably above the acceptable minimum and are in fact at the baseline levels.

Weight Gain/Loss: The weight gain is still higher than normally seen in typical concrete mixes, but lower than the Phase I results. This indicates lower voids in the mix and this is probably a more accurate representation the material composition in the panels, since the specimens were fabricated as the panels would be. The non-standard fabrication method for the first phase (as opposed to normal hand placement) may have contributed to the voids and therefore the weight gains. It is unusual that the weight gain did not show indications of tapering off by the end of the test, although the gain did decrease substantially after the first 50 cycles. This may be normal for this type of mix and the Phase I specimens might have shown the same behavior, if not for the paste loss.

Bulk Specific Gravity: The spread of the numbers was much less than for the first phase values and far more in keeping with what would be expected. The absorptions were not as closely spaced as the bulks, but still much better than seen in Phase I.

Compressive Strength: The numbers are very good for a mortar mix and it may be that the fibers account for much of the high strengths. The specimens tended to hold together even after fracture (like the flexural specimens, as noted below). Since the compressive failures are ultimately a function of tensile strength (in relation to the shear), the fibers would increase the load bearing capabilities of the mix.

Flexural Strength: The flexural results were higher than typical values for other mixes tested previously. The fiberglass appears to have greatly enhanced the tensile strength of the concrete, compared to concrete specimens seen before that had no structural fibers. After the specimens failed under load, the fibers still held the broken halves together. Even after the center of the prisms were deflected by nearly ½", the halves remained solidly connected by the fibers.

The performance of the compressive specimens and the bulk specific gravities and absorptions bear out the concern that the fabrication of the Phase I prisms did not properly represent the characteristics of the typical product. The variability relative to the Phase II specimens indicates that difficulties in placing this type of mix in the standard molds resulted in an inconsistent matrix.

Of particular interest is the behavior of the information only specimens. Normally, it would be expected that the cracks would be enlarged during freezing and eventually lead to fracturing of the prisms. That was why the second set of specimens intended for Phase II (after the ones that didn't meet the dimensional tolerances) were not tested, as stated previously. However, these did quite well, with only a small amount of loss at the very thinnest section on one specimen and a slight bulging at the fissures on another one. This indicates that the fiberglass-reinforced concrete matrix has good resistance to propagation of fractures.

Note: The Phase II specimens were cured for a substantially longer period of time, compared to the Phase I specimens. Some mixes modified with pozzolans take longer to fully cure and approach their optimum characteristics. This may have contributed to the improved performance of the Phase II set.

CONCLUSIONS AND RECOMMENDATIONS: Based on the results of the Phase II testing, it has been determined that the loss of paste on the Phase I specimens is probably an effect of the way those specimens were fabricated. Although the penetrant sealer may have contributed to the scaling (this has been seen to a lesser degree in prior freeze/thaw tests), it does not seem to be the primary cause, since it occurred in the uncoated specimens. Given that the concrete performed well in both runs and that the concrete should have little substantial direct exposure to chlorides, it is less important in this case because there are no internal steel elements, the use of penetrant sealers is deemed unnecessary. The performance of the surface mortar in Phase II, both with and without the face mix, is very good and so it appears that the face mix should be usable without concern for visible signs of deterioration. However, since the presence of the fibers is only visible on close inspection, the face mix would not be required for aesthetics. The public will not have the access to see the panels from a perspective that would allow them to differentiate the fibers.

The ASTM C 666 freeze/thaw test is very harsh and considering the panels will be on the side of the bridge and normally out of the splash zone, they should not see exposure comparable to that in the test procedure. Therefore the mix as presented to RIDOT should be acceptable for this application. Since the concrete did exceptionally well in the test, it would probably also do well in most others.

APPENDIX

Specimen Slab Cast Date: 12/17/03

Slab Size: 4’ × 4’ × 4”

Mix Data:

Component	Product	Quantity
Cement	Lehigh Type 1 White	84.0 lbs.[1]
Water	n/a	25.0 lbs.
Glass Fibers	Cem Fill 61/1	6.4 lbs.
Polymer	Fortron VF 774	12 lbs,
Water Reducer	Daracem 19	4 oz.
Pozzolan	Metakaolin	10 lbs

Combination of Type 1 and Metakaolin

Slurry Weight: 127.45 lbs/ft^3
Shop Temp: 50°F
Slurry Temp: 65.1°F