



January 31, 2025

Kim Hansen
 CMT Technical Services
 2688 S. Redwood Road, Suite E
 West Valley, Utah 84119

ASTM C666 Freeze-Thaw Resistance Testing of Concrete Mixes RC971 and RC972

WJE No. 2024.6485

Dear Ms. Kim Hansen:

Per your request, Wiss, Janney, Elstner Associates, Inc. (WJE) has completed freeze-thaw resistance testing of concrete specimens received from CMT Technical Services (CMT). We understand that the specimens represent concrete mix designs RC971 and RC972 and were reportedly cast by CMT on September 7, 2024 and September 3, 2024 respectively. The provided mixture proportions are listed in Table 1. Plastic properties for the concrete used to fabricate the specimens, as reported by CMT, are provided in Table 2. Two specimens for each mix design were received with gauge studs embedded in each end with a nominal specimen length of 11 inches and a cross section of 4-inch by 4-inch.

The curing condition of the specimens prior to receipt at WJE are unknown, and the specimens were shipped to WJE’s laboratories in Northbrook, Illinois. The specimens were received at our laboratory in sealed buckets on October 21, 2024. The specimens were saw-cut to reduce the cross section to be 3-inch by 4-inch before being placed into a tank of lime-saturated water at 73.5 ± 3.5 °F until the start of testing.

Table 1. Concrete Mix Design (per cubic yard)

Material	Description/Source	RC971	RC972
Cement	Holcim IL	399 lb.	519 lb.
Fly Ash	Geofortis N	99 lb.	92 lb.
Water	Not reported	238 lb.	264 lb.
Coarse Aggregate	Stockton #67	1730 lb.	1730 lb.
Fine Aggregate	Bluffdale Sand	1123 lb.	1141 lb.
Calcium Carbonate	Not reported	160 lb.	0 lb.
Air Entraining Admixture	DARAVAIR AT30	6.0 oz./cwt.	4.5 oz./cwt.
Mid-Range Water Reducer	Chryso Quad 842	3.6 oz./cwt.	5.0 oz./cwt.
High-Range Water Reducer	Chryso Plast 950	4.9 oz./cwt.	0.0 oz./cwt.
Set Retarding Admixture	Chryso Recover	1.2 oz./cwt.	1.3 oz./cwt.
W/cm, calculated by WJE	--	0.48 or 0.36 (excluding/including calcium carbonate as cementitious)	0.43

Source: Proportions provided by CMT.

Table 2. Plastic Properties

Property	RC971	RC972
Slump (ASTM C143)	4.00 in.	4.00 in.
Air Content (ASTM C231)	6.0%	5.5%
Unit Weight (ASTM C138)	142.8 lb./ft. ³	138.8 lb./ft. ³

Source: Plastic properties provided by CMT.

Testing

Freeze/thaw resistance testing was performed in general accordance to ASTM C666-15, *Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing*, Procedure A, starting at an age of 62 days for RC971 and 66 days for RC972, which is a modification of the standard curing time required by ASTM C666. Specimens were cycled a minimum of 300 times between 0 and 40 °F. The mass and the fundamental transverse frequency of the specimens were measured after one cycle of freezing and thawing and at intervals generally not exceeding 35 cycles thereafter. At the end of testing, the durability factor was calculated according to the following formula, per ASTM C666:

$$DF = PN/M$$

where:

- DF is the durability factor of the specimen,
- P is the relative dynamic modulus of elasticity at N cycles (calculated as the square of the fundamental transverse frequency at the end of testing divided by the square of the initial fundamental transverse frequency of the sample, expressed as a percent),
- N is the smaller of the number of cycles at which P reaches the specified minimum value for discontinuing the test (considered as 60% during this test) or the specified number of cycles at which the exposure was to be terminated (300 cycles for this test), and
- M is the specified number of cycles at which the exposure is to be terminated (300 cycles for this test).

The durability factor generally assesses the resistance of a concrete specimen to freezing and thawing in a saturated condition, with a durability factor of 100 signifying no alteration or deterioration.

Results

Results from the freeze-thaw testing are presented in the attached test report and are summarized in Table 3 and Table 4. Specimens were cycled for a total of 319 cycles. For mix RC971, the average durability factor upon completion of the 319 cycles was 95, and the average mass change was 0.18 percent (mass gain). For mix RC972, the average durability factor upon completion of the 319 cycles was 94, and the average mass change was 0.11 percent (mass gain).

Table 3. Durability Factor and Mass Loss per Procedure A, ASTM C666 for Mix RC971

Sample ID	Completed Cycles	Durability Factor	Mass Change*, %
1	319	95	0.22
2	319	95	0.15
Average	319	95	0.18

* Positive mass change indicates mass gain.

Table 4. Durability Factor and Mass Loss per Procedure A, ASTM C666 for Mix RC972

Sample ID	Completed Cycles	Durability Factor	Mass Change*, %
1	319	94	0.13
2	319	94	0.09
Average	319	94	0.11

* Positive mass change indicates mass gain.

Closing

We appreciate the opportunity to assist you with this evaluation. If you have any questions, please feel free to contact us.

Sincerely,

WISS, JANNEY, ELSTNER ASSOCIATES, INC.



Karthik Pattaje, Ph.D.
Project Associate



Hugh (Xiaoqiang) Hou, Ph.D.
Senior Associate, Petrographer

Attachments:

1. Mix design and plastic testing results reported by CMT
2. RC971 – ASTM C666 – Test report
3. RC972 – ASTM C666 - Test report



Attachments

ASTM C666 Resistance of Concrete to Rapid Freezing and Thawing

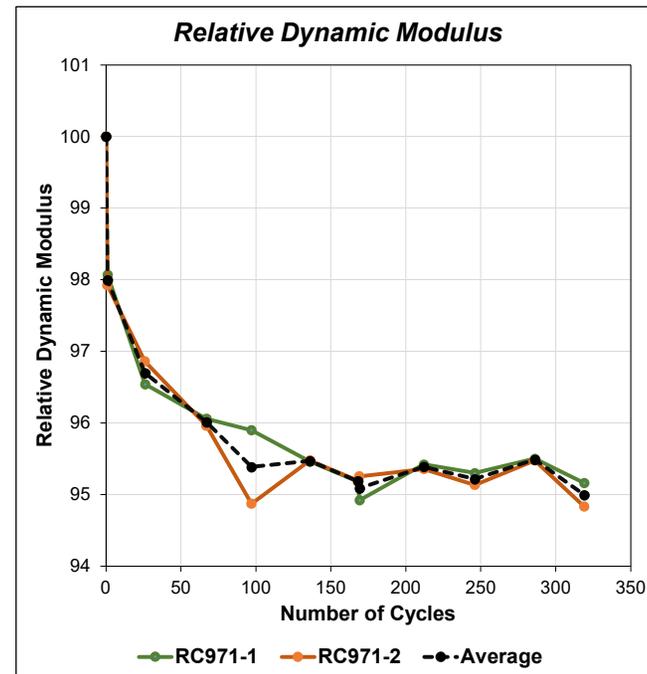
Project Number: 2024.6485 Project Coordinator: H. Hou
 Operator: L. Zegler Date: 11/8/2024
 Checked by: K. Pattaje Date: 1/7/2025

Geometry: Prism Source: Cast Procedure: A-Box #1 Balance: SN B543618517 Caliper: SN B65697
 Cylinder Core Apparatus: A/B Box (Proc. A) SN 1121330641 SN B65703
 Other: _____ Other: _____
 # of Samples: 2
 Cast Date: 9/7/2024

Sample ID	Initial Length (in.)	Initial Depth (in.)	Initial Width (in.)	Initial Weight (g)
RC971-1	11.22	2.98	4.02	4902.7
RC971-2	11.21	2.95	4.02	4866.3

Relative Dynamic Modulus

Date	Number of Cycles	RC971-1	RC971-2	Average
11/8/2024	0	100.0	100.0	100.0
11/8/2024	1	98.1	97.9	98.0
11/11/2024	26	96.5	96.9	96.7
11/15/2024	67	96.1	96.0	96.0
11/18/2024	97	95.9	94.9	95.4
11/22/2024	136	95.5	95.5	95.5
11/25/2024	168	95.2	95.2	95.2
12/2/2024	169	94.9	95.3	95.1
12/6/2024	212	95.4	95.4	95.4
12/9/2024	246	95.3	95.1	95.2
12/13/2024	286	95.5	95.5	95.5
12/16/2024	319	95.2	94.8	95.0



Durability Factor

Max. Cycles:	300		
Min. Relative Dynamic Modulus:	60		
Cycles Completed	RC971-1	RC971-2	Average
Durability Factor	319	319	--
	95	95	95

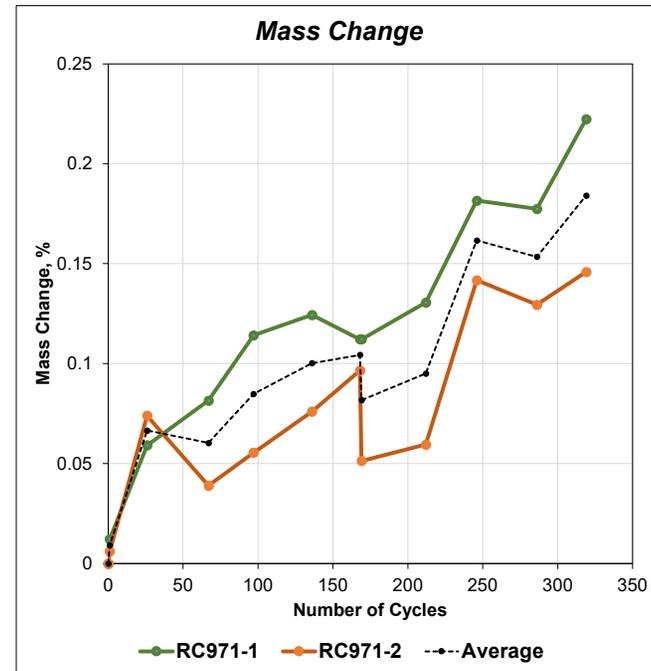
ASTM C666 Resistance of Concrete to Rapid Freezing and Thawing

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Mass Change, percent

Date	Number of Cycles	RC971-1	RC971-2	Average
11/8/2024	0	0.00	0.00	0.00
11/8/2024	1	0.01	0.01	0.01
11/11/2024	26	0.06	0.07	0.07
11/15/2024	67	0.08	0.04	0.06
11/18/2024	97	0.11	0.06	0.08
11/22/2024	136	0.12	0.08	0.10
11/25/2024	168	0.11	0.10	0.10
12/2/2024	169	0.11	0.05	0.08
12/6/2024	212	0.13	0.06	0.10
12/9/2024	246	0.18	0.14	0.16
12/13/2024	286	0.18	0.13	0.15
12/16/2024	319	0.22	0.15	0.18



ASTM C666 Resistance of Concrete to Rapid Freezing and Thawing

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Comments

Date	Number of Cycles	RC971-1	RC971-2
11/8/2024	0		
11/8/2024	1		
11/11/2024	26		
11/15/2024	67		
11/18/2024	97		
11/22/2024	136		
11/25/2024	168	MOVED TO FREEZER	MOVED TO FREEZER
12/2/2024	169	RESTART IN A BOX	RESTART A BOX
12/6/2024	212		
12/9/2024	246		
12/13/2024	286		
12/16/2024	319		

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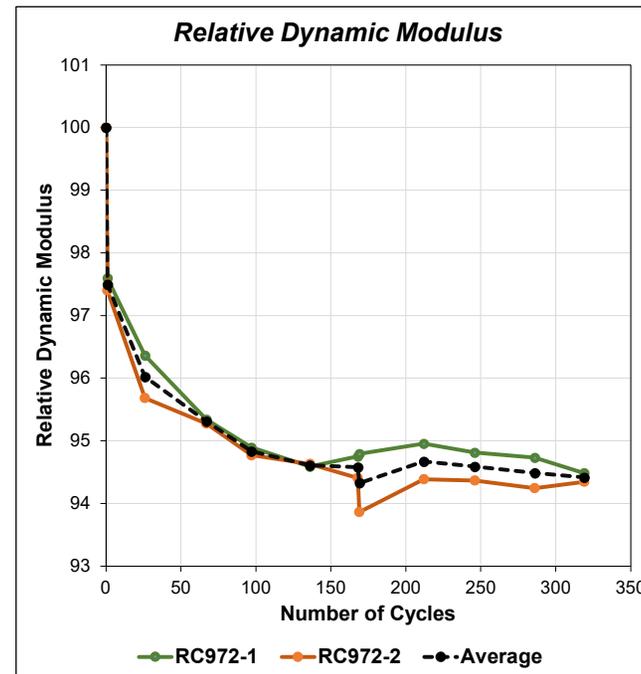
Project Coordinator: H. Hou
Date: 11/8/2024
Date: 1/7/2025

Geometry: <input type="checkbox"/> Prism <input type="checkbox"/> Cylinder	Source: <input type="checkbox"/> Cast <input type="checkbox"/> Core	Procedure/ Apparatus: <input type="checkbox"/> A-Box #1 <input type="checkbox"/> A/B Box (Proc. A) <input type="checkbox"/> B-Box <input type="checkbox"/> Other: _____	Balance: <input type="checkbox"/> SN B543618517 <input type="checkbox"/> SN 1121330641 <input type="checkbox"/> Other: _____	Caliper: <input type="checkbox"/> SN B65697 <input type="checkbox"/> SN B65703 <input type="checkbox"/> Other: _____
# of Samples: <u>2</u>				
Cast Date: <u>9/3/2024</u>				

Sample ID	Initial Length (in.)	Initial Depth (in.)	Initial Width (in.)	Initial Weight (g)
RC972-1	11.23	2.96	4.01	4853.0
RC972-2	11.23	2.98	4.02	4885.8

Relative Dynamic Modulus

Date	Number of Cycles	RC972-1	RC972-2	Average
11/8/2024	0	100.0	100.0	100.0
11/8/2024	1	97.6	97.4	97.5
11/11/2024	26	96.4	95.7	96.0
11/15/2024	67	95.3	95.3	95.3
11/18/2024	97	94.9	94.8	94.8
11/22/2024	136	94.6	94.6	94.6
11/25/2024	168	94.7	94.4	94.6
12/2/2024	169	94.8	93.9	94.3
12/6/2024	212	95.0	94.4	94.7
12/9/2024	246	94.8	94.4	94.6
12/13/2024	286	94.7	94.2	94.5
12/16/2024	319	94.5	94.3	94.4



Durability Factor

Max. Cycles:	300	
Min. Relative Dynamic Modulus:	60	
	RC972-1	RC972-2
Cycles Completed	319	319
Durability Factor	94	94

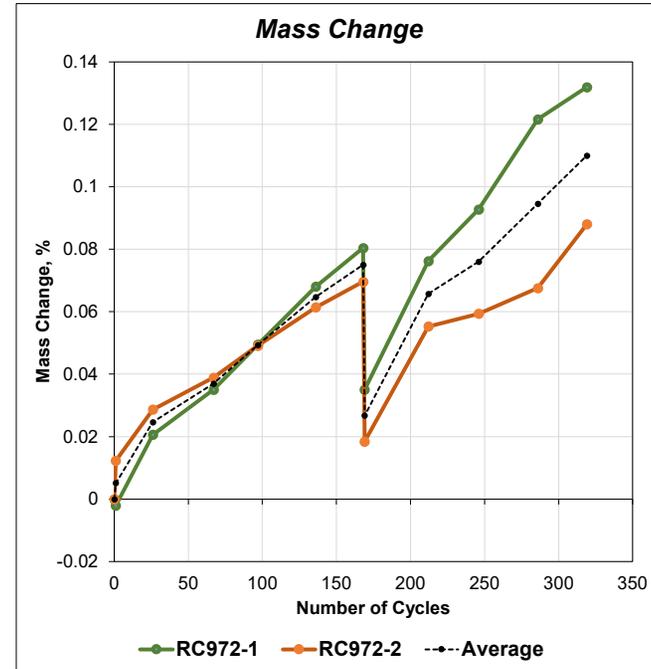
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Mass Change, percent

Date	Number of Cycles	RC972-1	RC972-2	Average
11/8/2024	0	0.00	0.00	0.00
11/8/2024	1	0.00	0.01	0.01
11/11/2024	26	0.02	0.03	0.02
11/15/2024	67	0.04	0.04	0.04
11/18/2024	97	0.05	0.05	0.05
11/22/2024	136	0.07	0.06	0.06
11/25/2024	168	0.08	0.07	0.07
12/2/2024	169	0.04	0.02	0.03
12/6/2024	212	0.08	0.06	0.07
12/9/2024	246	0.09	0.06	0.08
12/13/2024	286	0.12	0.07	0.09
12/16/2024	319	0.13	0.09	0.11



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Date	Number of Cycles	RC972-1	RC972-2
11/8/2024	0		
11/8/2024	1		
11/11/2024	26		
11/15/2024	67		
11/18/2024	97		
11/22/2024	136		
11/25/2024	168	MOVED TO FREEZER	MOVED TO FREEZER
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12/6/2024	212		
12/9/2024	246		
12/13/2024	286		
12/16/2024	319		