CELLEX CELLULAR CONCRETE FOR PRECAST NOISE BARRIERS

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CELLEX CELLULAR CONCRETE FOR PRECAST NOISE BARRIERS

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At an October 1973 meeting between members of the Divisions of Testing and Research and Design, a cellular concrete noise barrier, designated "Cellex," was presented for consideration by Roy Sutherland of Detroit. It is manufactured by Cellex Building Products Corp., Ltd, of Hamilton, Ontario. The Research Laboratory was requested to test the noise barrier material for strength and durability. Several samples of noise barrier paneling, 4 in. thick, and one sample of ornamental paneling, 2 in. thick, were obtained, as well as a descriptive brochure which included unit prices.

The Cellex cellular concrete is made by combining sand, cement, water, and chemical additives. They are cast into a 3 by 10 ft by 4-in. mold where a reaction takes place causing the slurry to foam and to expand, and form independent spherical cells much like foamed polystyrene in appearance. The panels are cast in a horizontal position, the top side of which is open. After the expansion has ceased, and while the concrete is still plastic, a wire is drawn across the form, finishing the panel to the 4-in. thickness. Curing is accomplished in steam chambers.

The panels are nominally 3 ft high by 9 ft-11 in. long by 4 in. thick. They are stacked to form a wall by sliding the ends down between the flanges of adjacent galvanized steel 6-WF beams that are spaced 10 ft apart and set vertically in concrete in the ground. The upper panel rests on the panel below it, the upper portion of the lower panel being tapered to fit into a keyway in the upper panel. Two layers of 2-in., 14-gage wire mesh reinforce the panels. A 12-ft high noise barrier of 4-in. thickness costs $35 per lineal foot installed (Canadian rates) which includes footings designed for soil of 3,000 psf bearing pressure.

A noise barrier of 2-in. thickness is also available. The 2-in. thick noise barrier panels are nominally 4 ft-10 in. by 5 ft, mounted vertically in fabricated 12-gage channels to form a 5-ft wall on top of a standard 1-ft earth fill. A single layer of 2-in., 14-gage wire mesh is used to reinforce the panel. A 6-ft high noise barrier of 2-in. thickness costs $7.50 per lineal foot installed (Canadian).

Materials Tested

Three samples of standard 4-in. thick Cellex noise barrier were tested. Each sample came from a different panel. No reinforcing wire was found in any of the three samples.

Sample A was from the top of a panel, sample B was from the bottom of a panel, and sample C was from the center of a panel.

The location of each sample within the panel from which it was taken was not expected to influence the test results.

One sample of a 2-in. thick Cellex noise barrier was tested and designated sample D; it contained cells of a larger size than did the samples from the 4-in. thick panels. No reinforcing wire was found in sample D.

One sample of a 2-in. thick "ornamental" Cellex panel was tested and designated sample E. Ornamental Cellex panels are used primarily for screen walls near buildings. The panels have a hard cementitious coating on one side, called 'Domfar Crystalite Stucco," which could possibly be applied to the standard noise barrier panels to increase their resistance to brine and water absorption and freeze-thaw scaling. These panels are mounted in a channel-iron frame on all four sides; a single layer of 2-in., 14-gage wire mesh is used to reinforce the panel. Reinforcing wire fitting this description was found in sample E.

Testing Program

A testing program was designed to obtain information on the performance of the Cellex samples in the following areas:

1) Moisture absorption
2) Compressive strength
3) Internal freeze-thaw durability
4) Resistance to freeze-thaw scaling.

The samples subjected to each test, the sample size, and the procedures used in each test are as follows:

1) Moisture absorption was measured in samples A, B, C, and D, only. Samples A, B, and C were 3 by 4 by 4-in., while sample D was approximately 4 by 2-1/2 by 2-in.; one block per sample.

Samples A, B, C, and D were immersed in water about seven days and the absorption and air dry bulk densities determined.

2) Compressive strength was determined for samples A, B, and C only. Two 4-in. cubes of each sample were capped on the exterior panel surface and tested in an air dry condition.

3) Internal freeze-thaw durability was determined for samples A and C only.

Sample A consisted of two beams which were 11 by 3 by 4 in. Sample C consisted of two beams of 10-1/2 by 3 by 4 in. Both samples were shorter than the 14-in. minimum recommended by ASTM C666-73. The small size of the samples received at the Laboratory precluded beams of greater length.

Procedures outlined in ASTM C666-73, Procedure B, "Rapid Freezing in Air and Thawing in Water," six cycles per day, were used to determine the internal freeze-thaw durability. The sample A beams were soaked three hours, the sample C beams one hour, after which they were weighted and the fundamental transverse frequency measured. The beams were then placed in rapid freeze-thaw cycling.

Sample A beams were weighed and sonic tested after 30, 42, 54, 72, 84, and 114 cycles at the end of the thaw cycle.

Sample C beams were weighed and sonic tested after six cycles of freezing and thawing only after a 15 minute soak in warm water.

The saturated surface dry weight, as well as the fundamental transverse frequency, were used in determining the dynamic modulus of elasticity at each test date.

4) Resistance to freeze-thaw scaling was determined using two different test methods. The first test method employed rapid freeze-thaw cycles as described in ASTM C666-73, Procedure B. The second test procedure involved slow cycling of freezing and thawing by the use of a walk-in freezer.

a) The rapid cycle test for resistance to freeze-thaw scaling was used for sample A only. Three slabs of sample A of 4 by 5 by 3/4 in. and one slab of sample A of 4 by 5 by 1 in. were ponded with a 3 percent salt solution which was retained by the use of a dike of metallic tape and a silicone rubber cement as an edge seal. The ponded slabs were placed in the rapid cycle freeze-thaw machine so that their bottoms were immersed 3/8 in. into the water used in the thawing cycle. The sample A slabs were subjected to 16 cycles of rapid freezing in air and thawing in water with a 1/8-in. deep, 3 percent salt solution ponded on the slabs.

b) The slow cycle test for resistance to freeze-thaw scaling was used for samples C and E only. Two slabs of sample C of 4 by 5 by 2 in. and two slabs of sample E of 6 by 6 by 2 in. were ponded with a 3 percent salt solution which was retained by a dike of metallic tape and a silicone-rubber cement edge seal. The ponded slabs were placed in the walk-in freezer at 0 F for 16 hours, after which they were allowed to thaw in laboratory air for 8 hours, and then were returned to the freezer; this cycle is in accordance with ASTM C672-72T. The slabs of samples C and E were subjected to nine cycles of freezing and thawing with the 3 percent salt solution being replenished prior to each freezing cycle.

Test Results

1) Absorption - The air dry bulk density and absorption are shown in Table 1. The absorption of samples A, B, and C varied inversely with the

air dry bulk density as was expected. A three-hour and one-hour absorption for samples A and C were obtained from the freeze-thaw beams.

TABLE 1
AIR DRY BULK DENSITY AND ABSORPTION

Sample	Density (lb/cu ft)	Absorption (percent)*
A	50.7	30.4 (22.3)
B	51.6	26.6
C	47.6	33.6 (22.7)
D	50.8	35.6
E	64.0	

*Percent by weight, 7-day immersion. Figures in parentheses are for 3 hr and 1 hr immersion on Samples A and C, respectively.

2) Compressive strength - Table 2 shows that sample A had the highest compressive strength even though sample B was the most dense. Each compression cube was loaded on the exterior panel surfaces so any variation in strength in other directions was eliminated.

TABLE 2
COMPRESSIVE STRENGTH
(4-in. Cube, Air Dry)

Sample A	645 psi*
Sample B	500 psi
Sample C	435 psi

*Each value is an average of two cubes.

3) Internal freeze-thaw durability - Table 3 shows the dynamic modulus of elasticity of sample A, expressed as a percent of its initial value. Both beams showed erosion and spalling of the lower one-third to a depth of 1 in., especially at 72 and 114 cycles. The greatest portion of the spalling occurred between the 54 cycle and 72 cycle tests, and as weight was one factor used in the determination of the modulus, this may account for the decrease in the modulus at that point which otherwise showed a continual rise after 42 cycles of freezing and thawing.

The sample C beams both broke in half upon thawing after 12 cycles of freezing and thawing. The dynamic modulus of elasticity after six cycles of freezing and thawing was 106 percent of its initial value. It is thought the shorter one-hour soak prior to freeze-thaw cycling, and the use of warm water in thawing the beams after 6 and 12 cycles, contributed to the early failure of sample C. It appears that sample C had a higher porosity than sample A which may have led to early saturation and failure.

TABLE 3
FREEZE-THAW DURABILITY OF CELLEX BEAMS DYNAMIC MODULUS OF ELASTICITY
(Percent of Initial Value)

Test Cycles	Sample A
0	100.0
30	99.0
42	94.2
54	109.1
72	106.0(1.2)*
84	119.9
114	139.2(3.0)

*Two figures in parentheses are average weight loss at 72 and 114 cycles for a total loss of 4.2 percent.

4) Resistance to freeze-thaw scaling.

a) The rapid cycle test produced massive failure of the 3/4-in. thick slabs of sample A. The 1-in. thick slab showed full-depth cracks with erosion of the bottom surface to a depth of 3/8 in.

b) Both slabs of sample C were leaking prior to starting slow freeze-thaw cycling. Slight erosion of one side of each slab was noted after two cycles which increased to 3/8 in. after nine cycles of freezing and thawing. The ponded surfaces showed minor deterioration.

c) One slab of sample E was leaking prior to starting slow freeze-thaw cycling. Deterioration of one side and the bottom of the leaking slab was noted after six cycles which increased to 3/8 in. after nine cycles of freezing and thawing. The second slab of sample E began to leak after eight cycles when a few small cracks were noted on the surface; deterioration of one side and bottom was noted after nine cycles of freezing and thawing. The reinforcing wire did not rust.

Discussion of Test Results

The absorption of cellular concrete varies in relation to the air dry bulk density and the size of the cells. The cell size of the 4-in. thick noise barrier was 0.08 in. while the cell size of the 2-in. thick noise barrier (sample D) was 0.14 in., which explains the larger rate of absorption of sample D.

It is apparent the dynamic modulus of elasticity as determined by sonic testing has no exact relation to the actual flexural strength when applied to cellular concrete. Although sample A was tested at the end of the thaw cycle it was thought that ice may still have been present deep within each beam; the sample A beams were placed in warm (75 F) water for 30 minutes following the 114 cycle test and then retested; there was no change in the fundamental transverse frequency between the two tests, indicating that ice was not a factor in the dramatic rise in the modulus.

Spalling may have been a factor in the rise in the fundamental transverse frequency due to a change in beam cross-section but it would have been offset by the decrease in the weight which was also used in calculating the modulus. Deterioration of the surface would cause a compacting at the ram contact point which would increase the efficiency or amplitude of the vibrations but would not have altered the frequency.

The hard surface of the ornamental Cellex (sample E) was more resistant to freeze-thaw scaling than was the standard 4-in. Cellex noise barrier. The primary cause of the deterioration of the ornamental Cellex being the intrusion of salt water into the cellular concrete below.

Standard Cellex noise barrier of 4-in. thickness and 50 lb/cu ft of density proved to be acceptable in all tests except freeze-thaw scaling in the presence of de-icing chemicals. This type of test is very severe when involving the ponding of salt solutions on a highly absorbant surface such as the Cellex.

Recommendations

Standard Cellex noise barrier of 4-in. thickness could be recommended for installation only where it would not come into contact with de-icing chemicals, and especially not be subjected to standing salt solutions. The Cellex barrier panels should not be close enough to the edge of the roadway to be exposed to piled snow containing de-icing salts.

Cellex panels would have a decided weight advantage over conventional concrete from the standpoint of shipping, lifting into place, or replacing broken panels. Cellex panels at 50 lb/cu ft would weigh about 500 lb as compared to 1,500 lb for normal air-entrained concrete.

Standard Cellex noise barrier would have to be treated to reduce its rate of absorption before it could be recommended for installation adjacent to traffic lanes. The hard cementitious coating on the ornamental Cellex did not prove to be durable enough to be used for this purpose. Perhaps a latex-cement brush coat on the traffic face of the panels would eliminate the absorption of destructive salt solutions.

Cellular concrete has possibility for uses other than noise barrier applications. Possible consideration should be given to use it as an attenuator or energy absorbing traffic barrier in ramp gore areas, though in this application it would be in contact with salt.