MaxFlow

CELLULAR CONCRETE

for GEOTECHNICAL APPLICATIONS

MAXFLOW Environmental Corporation

Technical Bulletin: Rapid Freeze & Thaw Durability

MaxFlow Cellular Concrete fill is a flowable, cementitious material that uses **MaxFlow Foaming Agent** as the means for providing a stable and uniform air cell structure within the fill mixture. Generally, the air content within these mixtures is the primary volume occupying component. Accordingly, MaxFlow Cellular Concrete fill can be designed to have very low in-service unit weights, thus lowering in-place dead loading. Additionally, these low density fill mixtures can be designed to have in-service bearing capacities superior to that of conventional compacted granular backfill.

Upon casting, the strength of the cellular concrete fill develops as a result of hardening of the cementitious materials, which are suspended surrounding the encapsulated, discrete air cells therein. Ultimate bearing capacity of the fill material is reliant on the strength and durability of the aforementioned hardened cementitious matrix.

Strength predictions for MaxFlow Cellular Concrete fill can be reliably made based on cast density. Table (1) contains Density - Strength relationship data for the range of fill mixtures discussed herein.

Table 1. Density / Strength Relationship Data

Cast Density (lbs/ft^3)	**Air Dry Density** (lbs/ft^3)	**Compressive Strength** (min. lbs/in^2)	**Bearing Capacity** ($tons/ft^2$)
27 - 42	**23 - 38**	**60 - 140**	**4.3 - 10.1**

Note: The cementitious material used to contemplate the physical properties as shown in Table 1 is Type I portland cement meeting ASTM C 150. The minimum compressive strength values shown are at 28 days of age and are determined in accordance with ASTM C 495.

In addition to those considerations given to strength, issues of durability, particularly in application environments subjected to cycles of freeze-thaw, may also need to be contemplated. Properties considered to have an influence on freeze-thaw durability are water absorption and permeability. Tables (2) and (3) provide values for these properties within the range of densities of this discussion.

Table 2. 24 Hour Water Absorption Data

Cast Density (lbs/ft^3)	**Air Dry Density** (lbs/ft^3)	**24 Hour Absorption**[1] (% by Vol.)	**Water Penetration** (mm)
27 - 42	**23 - 38**	**0.61 - 2.36**	**3.30 - 4.18**

1. As determined in accordance with ASTM C 796

Table 3. Constant Head Permeability Data

Cast Density (lbs/ft^3)	**Air Dry Density** (lbs/ft^3)	**Constant Head Permeability**[1] (cm/sec)
27 - 42	**23 - 38**	**< 1.00e -7**

1. The samples were prepared by casting plastic cellular concrete in proctor compaction molds. The specimens were thereupon moist cured for 28 days prior to beginning constant head permeameter testing.

The data developed to predict the freeze-thaw durability of MaxFlow Cellular Concrete fill was obtained by use of ASTM C 666, method B. Measurements of fundamental frequency and mass loss were collected at minimal intervals of ten cycles throughout the course of the test. Table (4) quantifies freeze-thaw durability using the expression term "Durability Factor". The equation used to calculate the durability factor is expressed as follows:

$$DF = (E \times N) / M$$

Where:

DF = Durability factor of the specimen.

E= Relative dynamic modulus of elasticity at *N* of cycles (by %).

N= The number of cycles at which *E* reaches 60% of E_O or the number of cycles at which the test is to be terminated, whichever is less.

M= The specified number of cycles at which exposure is terminated.

E_O= Original dynamic modulus

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(Continued)

Table 4. Rapid Freeze Thaw Durability

Cast Density Range (lbs/ft³)	Relative Durability Factor (% of E_O)	Relative Mass (% of M_O)[1]	Number of Cycles at Termination (Max. 150)
27 - 42	**103.4 - 105.9**	**96.3 - 98.7**	**150**

1. Where: (M_O) = Original mass of the specimen.

In addition to the aforementioned data collected from the subjected specimens, companion specimens, also subjected to identical cycles of rapid freeze-thaw were produced for the purpose of destructive testing. Pairs of cubes were cut from the companion beam specimens thru-out the duration of the testing for the purpose of determining whether strength deterioration was occurring. The cubes were loaded in compression to make these determinations. The data shown in Table (5) expresses the strength condition of the cubes by use of the term "Relative Strength". The equation used to determine the relative strength is expressed as follows:

$$S_C = (s_C^2 / s_O^2) \times 100$$

Where:

S_C= Relative compressive strength after *c* cycles of freezing and thawing.

s_C= Compressive strength after *c* cycles of freezing and thawing.

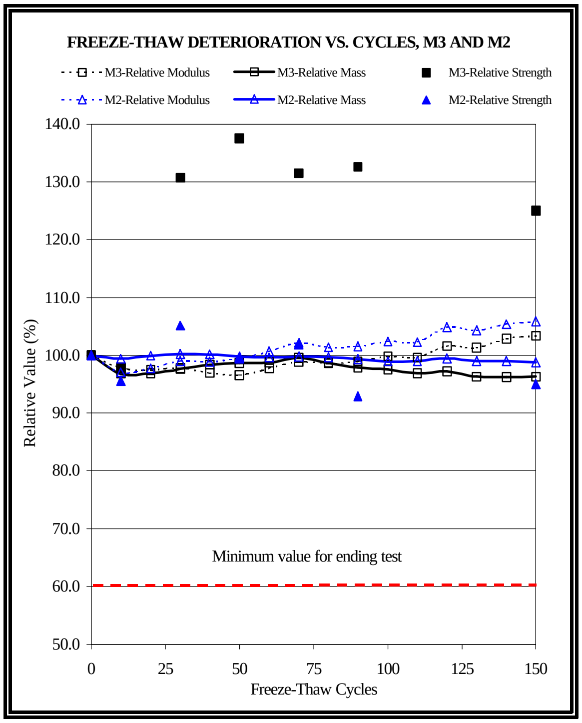
s_O= Original compressive strength at 0 cycles.

Table 5. Relative Strength Data Summary

Cast Density Range (lbs/ft³	Air Dry Density (lbs/ft³)	Range of Relative Strength (%)	Number of Freeze-Thaw Cycles
27 - 42	**23 - 38**	**90.3 - 156.2**	**150**

Finally, Figure (1) is presented to graphically show the performance trends of the test specimens as measured at 10 cycle intervals. Mixtures M2 and M3 respectively represent the maximum and minimum densities of the cast density range tested. The relative value

Figure 1. Specimen Performance Trends



of 100% as shown in the vertical axis of the graph is used to represent the pre-cycled performance characteristics of the specimens.

The data collected herein is assembled to represent the excellent resistance to rapid freeze-thaw deterioration, low water absorption and low permeability characteristics exhibited by MaxFlow Cellular Concrete fill. The data is offered to design professionals considering the use of the MaxFlow fill material in engineered applications. Additional information may be obtained by contacting a MaxFlow representative.

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