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REPORT ON DURABILITY INVESTIGATIONS OF LIMESTONE FROM NEAR ST.CATHERINES FOR USE IN CONCRETE USING FREEZE-THAW METHODS

by

V.A.Haw

Industrial Minerals Division

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A bulk sample of limestone was received from Walker Bros. Quarries Limited of St.Catherines, Ontario for accelerated freeze-thaw investigations. The sample represents stone from the old Savigney Bros. quarry now operated by Walker Bros. which is located on the outskirts of St.Catherines. A new cut has been opened to the south of the quarry and it is from here that the sample was obtained. Previous work has been done on this stone by way of physical tests on the aggregate alone and reported in a letter to Walker Bros. dated August 1, 1957, and in a memorandum of November 5, 1957. Results of this work left some doubt as to its acceptance for general use in concrete. As the stone has a good record of performance it was decided to make further investigations by using accelerated freeze-thaw methods.

Description of Sample

About 400 lb of stone running in size from four to six inches was received for the test. The stone consisted of representative quarry-run material which has been described in detail in previous work. Briefly it consisted of a mixture of mainly fine grained grey dolomite with minor medium grained dark brownish-grey limestone.

Processing of Sample

The sample as received was crushed through 3/4 inch in a 7x12" jaw crusher and the minus four mesh fraction removed by screening.

A portion of the 3/4" -4 mesh was used to make sand in the hammer mill and the balance used as coarse aggregate in the concrete beams. For both coarse and fine aggregate the material was screened and regraded to conform to A.S.T.M. medium gradings. Although it was intended to use the manufactured sand in the tests the final decision was made to use a good durable natural sand for reference purpose to conform to procedures carried out in other laboratories.

Freeze-Thaw Procedure

In conducting the tests concrete beams 3½x4x16 in. were fabricated and exposed to accelerated freeze-thaw cycles between 40 and 0°F at the rate of about eight per day. These consisted of approximately two hours freezing and one hour thawing. Periodically the beams were removed and weighed and tested using our ultrasonic testing equipment to measure the velocity of pulses transmitted through the beams. The velocity of transmission is a measure of the durability of the concrete. It is usual to consider the beam to have failed when the velocity is reduced to 60 per cent of its original value,

measured before being exposed to the freezing and thawing.

Concrete Design

Two basic concrete mix designs were used one with air entrainment the other without any purposefully entrained air. The aggregates used consisted of the stone under investigation as coarse aggregate and a durable local natural sand as fine aggregate.

Table I shows the gradings and other physical properties of the aggregates.

TABLE I

	Fine Agg.		Cse. Agg.
Sieve		Sieve	
# 4	100.0	3/4"	100.0
8	90.0	1/2"	56.0
16	67.5	3/8"	37.5
30	42.5	# 4	0.0
50	20.0		
100	6.0		
Spec.Grav.	2.71		2.71
Absorption	1.22		1.18

The design of the concretes in each case followed usual practice of using about 5½ bags cement per cubic yd. with a slump of about two inches. The aggregates were presoaked for 24 hours before mixing the concrete.

TABLE II - CONCRETE PROPORTIONS*

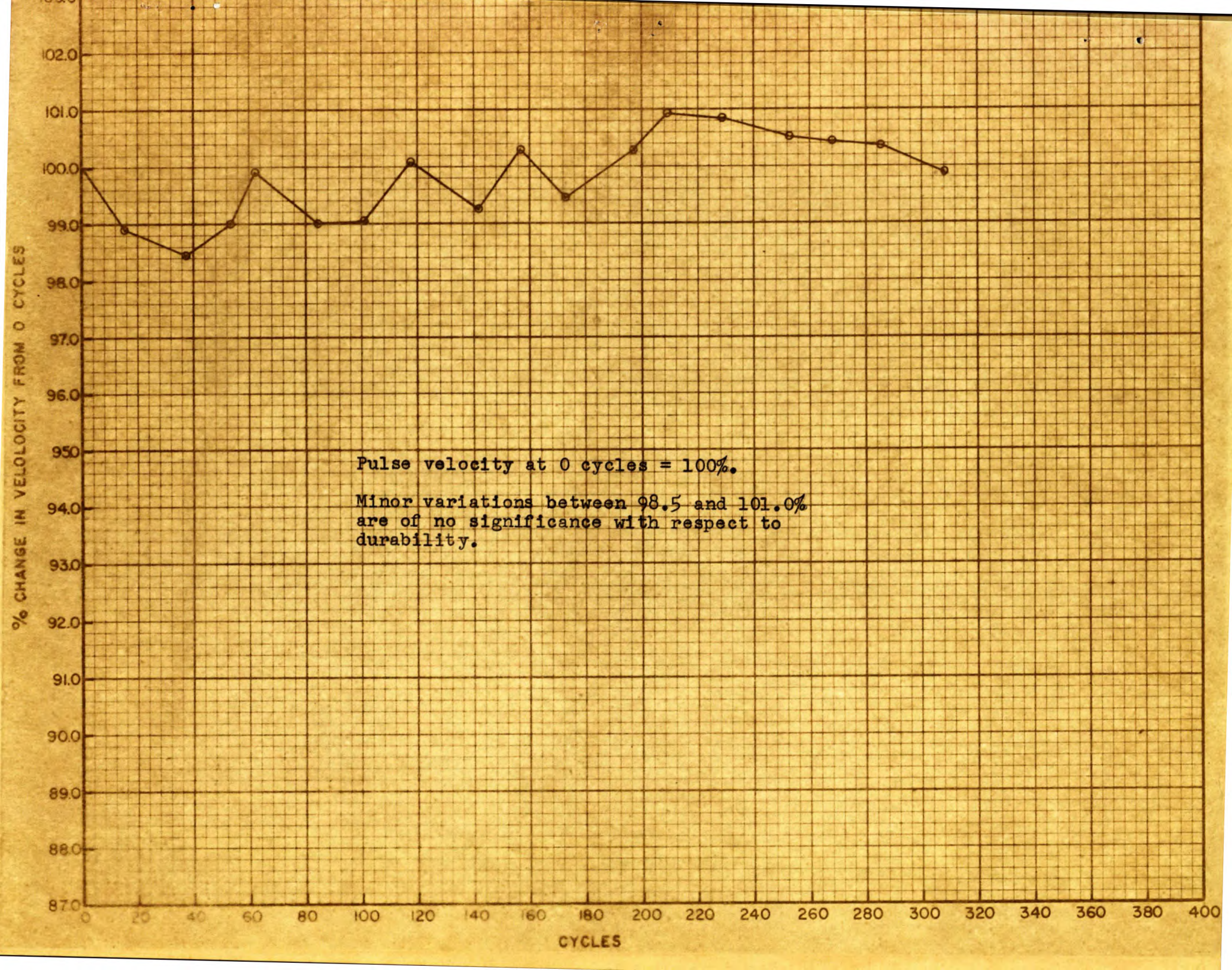
	Cement Bags	W/C Ratio	% Air	Additive	Sand/ Coarse	Slump	7d str. psi	28d str. psi
Non air ent.	5.2	0.75	1.2	-	46:54	2"	3078	3352
Air entrained	5.5	0.60	6.0	5 oz.Darex	41:59	2½"	-	2695

* All proportions in terms of content per cubic yard where applicable.

Three 3½x4x16 in. beams were made from each mix, plus cylinders for compression testing. For the air entrained concrete there was not sufficient concrete to make cylinders for seven day strength tests. The beams were moist cured for 14 days and then subjected to the freezing and thawing.

Results of Tests

The concrete beams with no air entrainment had deteriorated at the end of 24 cycles of the freezing and thawing to a point where it was not possible to obtain a velocity measurement. The appearance of the beams also indicated rapid deterioration although no loss of weight had occurred. The beams with air entrainment were completely sound at the end of 300 cycles - no significant loss in pulse velocity had occurred, and their outward appearance showed no evidence of deterioration. The accompanying graph exhibits some minor variations in pulse velocity during the 300 cycles.


% CHANGE IN VELOLOCITY FROM 0 CYCLES
102.0
101.0
100.0
99.0
98.0
97.0
96.0
95.0
94.0
93.0
92.0
91.0
90.0
89.0
88.0
87.0
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
CYCLES
Pulse velocity at 0 cycles = 100%.
Minor variations between 98.5 and 101.0% are of no significance with respect to durability.

CONCLUSIONS

From the work completed it is apparent that the air entrained concrete containing the stone under investigation as coarse aggregate remained durable after 300 cycles of freeze-thaw exposure. This length of exposure under the conditions outlined is generally accepted as the requirement necessary to establish the durability of an aggregate. On this basis the stone as submitted may be considered to be a durable aggregate for the purpose of making concrete.

The fact that the non air entrained concrete failed early in the test is of no significance as far as the aggregate is concerned. Past research has shown that air entrainment protects the cement paste but not the coarse aggregate.

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V.A.Haw,
Head, Construction Materials Section.