Survey of the physical properties of hollow concrete blocks produced in Canada
Galbreath, M.

Publisher's version / Version de l'éditeur:
https://doi.org/10.4224/20358876
Technical Note (National Research Council of Canada. Division of Building Research); no. TN-404, 1963-09-01

NATIONAL RESEARCH COUNCIL OF CANADA

DIVISION OF BUILDING RESEARCH

No. 404

TECHNICAL NOTE

PREPARED BY M. Galbreath CHECKED BY NBH APPROVED BY NBH

DATE September 1963

PREPARED FOR National Concrete Products Association

SUBJECT SURVEY OF THE PHYSICAL PROPERTIES OF HOLLOW CONCRETE BLOCKS PRODUCED IN CANADA

A survey of concrete block production was undertaken because of a need for information on the composition, shape and size of hollow concrete blocks produced in Canada. The National Concrete Products Association whose members assisted in the survey wished to know more of the range of production of their members. The Building Structures Section of the Division of Building Research, which is studying the stability of hollow masonry walls, was interested in the strength and weight of the units. The Fire Section, Division of Building Research, wished to learn more about the size, shape and nature of aggregates used in the concrete blocks.

Full co-operation was provided by the Technical Committee of the NCPA who advised on the contents of the questionnaire, distributed the questionnaire to members, collected the replies and operated a coding system to preserve the anonymity of the contributors.

The questionnaire (Appendix A) was designed to obtain information on over-all dimensions of blocks, percentage of solid material in each block, face shell thickness, type of aggregate, and proportion of production devoted to each type of block. Some compromise was necessarily involved in order to keep the questionnaire to workable proportions.

Extent of Survey

The questionnaire was sent to all producer members of NCPA (about 85), and 20 replies were received. Each company reported production in equivalent 8-in. units. Total annual production reported by the 20 companies covered 54,665,000 units (8 companies produced 39,095,000 units or 72 per cent of the total).

Total production reported represents 37 per cent of Canadian production for the same period as reported by Dominion Bureau of Statistics (146,363,000 units). The DBS figure, however, represents only about 90 per cent of the total Canadian production because the DBS survey did not include the smaller producers. If this figure is correct, then this survey may be assumed to cover about 33 per cent of all Canadian production. Another report covering 1,000,000 units was received subsequent to the preparation of this note. It was, however, presented in insufficient detail to add to this study.

Use of Modular Sizes

Each company reported over-all size of blocks produced whether modular, i.e. 15-5/8 by 7-5/8 by 7-5/8, or non-modular. All 20 companies produced modular blocks and 7 companies produced non-modular in addition to modular blocks.

Nature of Coarse Aggregate Used in Blocks

Thirteen companies reported production in a manner that enabled the type of coarse aggregate used to be related to number of blocks produced. Table I shows the nature of the coarse aggregate used in the blocks and the annual production and compares these figures with the DBS figures for the same period. In the survey natural stone aggregates are included in 75 per cent of the blocks and lightweight aggregates in 25 per cent. The DBS figures for the same period are 70 and 30 per cent respectively.

Description of Coarse Aggregates

The descriptions of the coarse aggregates included in the survey returns are set out in Table IX. In general they fall into one or other of the following categories.

1.	Siliceous	Granite
2.	Calcareous	Limestone, dolomite limestone, calcareous gravel
3.	Natural stone (not fully identified)	Crushed stone, gravel, pit run
4.	Lightweight	(a) Expanded blast furnace slag, rotary kiln expanded clay, pumice, (b) Blast furnace slag cinders
5.	Mixed aggregates	Gravel and light aggregate pit run and lightweight (rotary kiln)

Shape of Blocks

The number of cores in the block, the size of the cores, and the face shell thickness are significant factors in the fire endurance of a concrete block wall. In Tables II and III the shapes of 8-in. modular 2-core and 3-core blocks are analyzed in relation to annual production.

It can be seen that:

(a) In 2-core blocks 52 to 53 per cent solid represents 83 per cent of annual production.

(b) In 3-core blocks 58 to 60 per cent solid represents 76 per cent of annual production.

The figures for annual production are for the full range of block sizes and are not confined to the 8-in. blocks. This does, however, give some indication of the more common pattern.

In Tables IV and V the range of sizes and shapes of the 4-, 6-, 10- and 12-in. blocks linked to the 8-in. 2-core 52 to 53 per cent solid blocks and the 8-in. 3-core 58 to 60 per cent blocks are set out to illustrate the range of shapes that occur most commonly.

Type of Cement

The questionnaire asked for a description of the type of cement used in the concrete mix and of the use of additives. Of 48 types of concrete block described,

(a) Normal cementitious material was used in	34
(b) Normal cementitious material plus silica flour was used in	4

(c) Block-type cement was used in	10
(d) High early-strength cement was used in	0

Use of Additives

The use of cements and additives is shown in Table VI. The additives were in general described by trade name. So far as these can be identified it appears that they were all air-entraining agents or plasticizers. Additives were used in 30 of the 48 types of concrete blocks described. Nearly all concretes having natural stone aggregates used additives whereas the majority of the lightweight concretes contained no additives.

Method of Curing

The survey returns on the means of curing blocks indicate that:

57 per cent of blocks are cured by low pressure steam,

40 per cent of blocks are cured by autoclave process.

In the remaining 3 per cent the means of curing could not be related to annual production.

Table VII shows the relationship between method of curing, type of aggregate and annual production.

Block-making Machines

The survey returns described 35 block-making machines. These were 2-, $2\frac{1}{2}$- and 3-pallet machines as follows:

	Number of Machines	Type of Machine	Production, units/hour
	6	2-pallet	440 to 900
	3	$2\frac{1}{2}$-pallet	450 to 700
	26	3-pallet	240 to 1000
Total	35		

All blocks were said to be vibrated. One company having 6 machines used both vibrating and tamping.

Sample Blocks

Ten of the companies sent a total of 14 typical 8-in. blocks to the Division of Building Research. These may be used for further detailed study of block shape and dimensions.

Detailed Summary

Table VIII is a summary of the block shapes reported.

Table IX and X present a summary of the aggregates and strength and weight of the blocks.

Table I Nature of Coarse Aggregates used in Blocks

Description of Aggregate.	Annual Production		
	Equivalent 8 in. Units	Percent	D.B.S. figures for same period
Granite	1,700,000		
Limestone	4,000,000	62%	70%
Gravel & Crushed Stone	13,320,000		
Mixed Gravel & Lightweight	4,263,000	13%	
Lightweight other than cinders	7,625,000	24½%	24
Cinders	146,000	½%	6%
Total	30,904,000	100%	100%

Table II Shape of 8 in. Modular 2 Core Blocks

Percent Solid	Face Shell	Annual Production		
		Eight in Equiv. Units	Total	Percent
52%	1 5/16	8,000,000		
52%	1¼	4,800,000	12,800,000	48%
53%	1¼	9,460,000	9,460,000	35%
55%	1¼	2,220,000	2,220,000	8%
58%	1¼	2,350,000	2,350,000	9%
			26,830,000	100%

Table III Shape of 8 in. Modular 3 Core Blocks

Percent Solid	Face Shell	Annual Production		
		Eight in Equiv. Units	Total	Percent
52.1%	$1\frac{1}{4}$ - $1\frac{1}{2}$	600,000	600,000	5%
53%	$1\frac{1}{4}$	1,660,000	1,660,000	14%
55%	$1\frac{1}{2}$	450,000	450,000	4%
58%	1	2,300,000		
58%	$1\frac{1}{4}$ - $1\frac{1}{2}$	900,000	3,200,000	26%
60%	$1\frac{1}{4}$ - $1\frac{1}{2}$	6,250,000	6,250,000	50%
75%	1	150,000	150,000	1%
			12,310,000	100%

Table IV Range of Sizes in Modular 2 Core Blocks
52% to 53% Solid in 8 in. Block

Code Number	4 in nom thick		6 in nom thick		8 in nom thick		10 in nom thick		12 in nom thick	
	% Solid	Face Shell	% Solid	Face Shell	% Solid	Face Shell	% Solid	Face Shell	% Solid	Face Shell
1033	71	1-1½	54	1 - 1-3/16	52	1¼ - 1-11/16	51.5	1½ - 1-11/16	48.5	1½ - 1-11/16
1031	76	1	62	1	52	1-5/16	51	1½	50	1-7/16
1030	72.8	1	60	1	53	1¼	51.8	1½	48.7	1½
1022	-	-	-	-	52.1	1¼	48	1-3/4	-	-
1021	76	1	60	1	53	1-5/16	51	1½	50	1-9/16
1020	-	-	54	1	52	1¼	47	1-3/8	46	1½
1015	72.8	1	54.5	1	53	1¼	51.8	1½	48	1½

Table V Range of Sizes in Modular 3 Core Blocks
58% to 60% Solid in 8 in Block

Code Number	4-in. nom thick		6-in. nom thick		8-in. nom thick		10-in. nom thick		12-in. nom thick	
	% Solid	Face Shell	% Solid	Face Shell	% Solid	Face Shell	% Solid	Face Shell	% Solid	Face Shell
1028	73.5	1	58	1	58	1	54	1 1/8	-	-
1025	74	1	58	1	58	1¼ - 1½	58	1½ - 1 3/4	56	1½ - 1 3/4
1022	76.9	1	58.9	1	58.6	1¼	56.8	1¼	55.1	1½
1019	-	-	-	-	60	1¼ - 1½	58	1 3/4	55.9	1 3/4
1019	73.6	1	58.9	1¼	60	1¼ - 1½	58	1 3/4	55.9	1 3/4

Table VI Use of Cements and Additives

Type of Aggregate	Normal Cement Units	Normal Cement plus Silica Flour Units	Block Type Cement Units	Additives Used Units	No Additives Used Units	Total Units
Siliceous	-	-	1	1	-	1
Calcareous	4	-	1	5	-	5
Natural Store not fully identified	14	2	4	16	4	20
Lightweight	14	2	4	6	14	20
Mixed Gravel & Lightweight	2	-	-	2	-	2
Total	34	4	10	30	18	48

Table VII Manner of Curing Blocks

Curing	Annual Production	Percent of Total
1. Low Pressure Steam		
(a) Gravel Aggregate	17,378,000 (56%)	
(b) Lightweight Aggregate	3,028,000 (10%)	
(c) Mixed Aggregate	1,600,000 (4%)	
(d) Not possible to relate aggregate to production	9,000,000 (30%)	
Total Low Pressure Steam	31,007,000 (100%)	57%
2. Autoclave		
(a) Gravel Aggregate	9,073,000 (43%)	
(b) Lightweight Aggregate	4,822,000 (23%)	
(c) Mixed Aggregate	2,663,000 (12%)	
(d) Not possible to relate aggregate to production	4,600,000 (22%)	
Total Autoclave	21,158,000 (100%)	40%
3. Not possible to relate manner of curing to production	2,500,000	3%
Total	54,665,000	100%

Table VIII Summary of Block Shapes Reported

Code Number	Modular	No. of Cores	4-in. nom Block		6-in. nom Block		8-in. nom Block		10-in nom Block		12-in. nom Block	
			% Solid	face shell in.	% Solid	face shell in.	% Solid	face shell in.	% Solid	face shell in.	% Solid	face shell in.
1034	Yes	3	74	1¼	60	1	75	1	65	1½	65	1½
1033	Yes	2	71	1-1½	54	1-1 3/16	52	1¼-1 11/16	51.5	1½-1 11/16	48.5	1½-1 11/16
1032	Yes	3	70	1	56	1	53	1¼	53	1¼	52	1 3/8
1031	Yes	2	76	1	62	1	52	1 5/16	51	1½	50	1 9/16
1030	Yes	3	73.5	1	62	1	57.4	1¼	58	1½	55.9	1½
	Yes	2	72.8	1	60	1	53	1¼	51.8	1½	48.7	1½
1029	Yes	3	68	1-1/8	-	-	-	-	-	-	-	-
	Yes	2	-	-	50	1-1/8	50	1¼	49	1½	46	1-5/8
1028	Yes	3	73.5	1	58	1	58	1	54	1-1/8	-	-
	Yes	2	-	-	-	-	-	-	-	-	52.2	1-1/8
1027	Yes	3	60	1	60	1	60	1¼-1½	60	1¼-1½	60	1¼-1½
	Yes	3	65	-	-	1½-1½	-	1½-1-3/4	-	1½-1-3/4	-	1½-1-3/4
	No	3	60	1	60	1	60	1¼-1½	60	1¼-1½	60	1¼-1½
1026	Yes	3	61.3	1	56.8	1¼	52.1	1¼-1½	59	1½-1-3/4	57.7	1½-1-3/4
1025	Yes	3	74	1	58	1	58	1¼-1½	58	1½-1-3/4	56	1½-1-3/4
1024	Yes	2	73	1	57	1	55	1¼	52	1½	49	1½
1023	Yes	3	73	1	64	1-1/8	-	-	-	-	55	1½
	Yes	2	-	-	-	-	58	1¼	53	1½	-	-
	No	3	-	-	-	-	56	1¼	56	1-3/8	55	1-5/8
	No	3	75	1-1/8	62	1-3/16	60	1½	60	1½	60	2
1022	Yes	3	76.9	1	58.9	1	58.6	1¼	56.8	1¼	55.1	1½
	Yes	2	-	-	-	-	52.1	1¼	48	1-3/4	-	-
	No	2	-	-	-	-	52.4	1¼	47.4	1-3/4	-	-
	No	3	77.2	1	59.9	1	-	-	-	-	55.3	1½
1021	Yes	2	76	1	60	1	53	1-5/16	51	1½	50	1-9/16
1020	Yes	3	70	1	-	-						
	Yes	2	-	-	54	1	52	1¼	47	1-3/8	46	1½
1019	Yes	2	72.8	1	55	1¼	-	-	-	-	-	-
	Yes	3	-	-	-	-	60	1¼-1½	58	1-3/4	55.9	1-3/4
	Yes	3	73.6	1	58.9	1¼	60	1¼-1½	58	1-3/4	55.9	1-3/4
	No	3	69	1	71	1½	62	1½	61.6	1-3/4	59.5	2
1018	Yes	3	60	1½	-	-	-	-	-	-	-	-
1017												
1016	Yes	3	55	1	55	1	55	1½	55	1½	55	1-3/4
	No	3	55	1	55	1	55	1½	55	1½	55	1-3/4
	No	3	60	1	-	-	-	-	-	-	-	-
1015	Yes	2	72.8	1	54.5	1	53	1¼	51.8	1½	48	1½

Table IX Details of 8in. Gravel Aggregate Concrete Blocks

Code No.	Description of Aggregate	Type of Cement	Use of Additives	Modular	No. of Cores	Compressive Strength	Weight of 8in. block lb.
1032	Washed Granite Graded	B	Yes	Yes	3	1400	40
1031	Limestone	N	Yes	Yes	2	1100	40
1021	1/4 to no 4 Crushed Limestone	N	Yes	Yes	3	1200	40
1020	Calcareous Gravel	N	Yes	Yes	2	1600	38.5
1019	Dolomite Limestone	N	Yes	Yes	3	1800	43.5
1019	Dolomite Limestone	N	Yes	Yes	3	1800	45
1034	Crushed Gravel	N	No	Yes	3	2500	46
1033	Buckshot	N	Yes	Yes	2	1200	39
1030	Washed blend of #40 stone	Ns	No	Yes	3	1600	41
1030	Washed blend of #40 stone	N	No	Yes	2	1250	41
1028	Gravel mix 3/8 round particles & down	Ns	No	Yes	3	1200	42
1027	90% crushed 10% rounds	N	Yes	Yes	3	1200-1300	41-42
1027	90% crushed 10% rounds	B	Yes	No	3	1200-1300	42-45
1026	Washed & screened coarse gravel	N	Yes	Yes	3	1400	40
1025	Crushed Stone	N	Yes	Yes	3	1400	42
1024	Natural gravel - crushed	N	Yes	Yes	2	1100	39
1023	3/8 in stone	N	Yes	Yes	2	1200	38
1023	3/8 in stone	N	Yes	No	3	1400	44
1023	3/8 in stone	N	Yes	No	3	1400	47
1022	3/8 in stone	N	Yes	Yes	3	1460	41
1022	3/8 in stone	N	Yes	Yes	2	1423	36.5
1022	3/8 in stone	N	Yes	No	3	1124	38.25
1018	Crushed stone	B	Yes	Yes	3	1230	44
1016	Water washed stone	B	Yes	Yes	3	1400	42
1016	Water washed stone	B	Yes	No	3	1400	47
1015	Pitrun washed & screened	N	Yes	Yes	2	1000	38

* N = Normal cementitious material

Ns = Normal cementitious material plus silica flour

B = Block type cement

Table X Details of 8 in. Lightweight Aggregate Concrete Blocks

Code Number	Description of Aggregate	Type of Cement	Use of Additives	Modular	No. of Cores	Compressive Strength P.S.I.	Weight of 8 in. block lb.
1033	Laylite	N	Yes	Yes	2	1000	26
1032	Haydite AA	B	Yes	Yes	3	1100	25
1031	Pumice	N	No	Yes	2	1200	26
1031	Pumice	N	No	Yes	2	750	18
1030	Haydite FF	Ns	No	Yes	3	1250	24
1028	Expanded Slag	Ns	No	Yes	3	1000	31
1027	Coarse Expanded Slag	B	Yes	Yes	3	1000-1200	30-32
1025	Slag	B	Yes	Yes	3	1200	30
1024	Coated Expanded Slag	N	Yes	Yes	2	1100	26
1023	Slag	N	No	Yes	2	1000	28.5
1023	Slag	N	No	No	3	1100	36
1023	Cinders	N	No	Yes	2	1000	28.5
1023	Cinders	N	No	No	3	1100	34
1023	Cinders	N	No	No	3	1100	36
1021	Italian Pumice	N	No	Yes	2	750	20
1021	Italian Pumice	N	No	Yes	2	1100	29
1020	Rotary kilm expanded clay	N	Yes	Yes	2	1400	24
1019	Blast Furnace Slag	N	No	No	3	1250	31
1019	Haydite FF	N	No	No	3	1250	30
1016	Expanded Slag	B	No	Yes	3	1200	35
1017	Gravel and Light Aggregate	N	Yes	Yes	2	1230	24
1015	Pit run and Lightweight (Rotary kilm)	N	Yes	Yes	2	1000	26

* N=Normal cementitious material Ns = Normal cementitious material plus silica flour
B = Block type cement

APPENDIX A

SURVEY OF THE PROPERTIES OF HOLLOW CONCRETE BLOCKS

To Members of N.C.P.A.

Your co-operation is solicited in the gathering of information on concrete block production in Canada. This information is desired by the Division of Building Research, National Research Council to assist in planning studies and research of concern to this industry. It is believed that it will also be of direct value to the Association, but in any event will be a contribution to the co-operative study programmes which are now being developed between DBR/NRC and NCPA. The questionnaires attached have been reviewed by your Technical Committee and the project has their full approval. Every effort will be made to protect individual interests by suitable coding of the results at the NCPA head office and by careful handling of the results.

The questionnaires, when completed, should be returned to the

(Auditor)
(National Concrete Products Association)

who will be responsible for protecting the anonymity of the information and will assign and retain the code identification in his office. All information obtained from this survey will be treated in the strictest confidence and no publication will be made without the permission of the N.C.P.A.

The amount of detail called for on the questionnaire has been kept to a minimum. Additional information, particularly about block shape may be required. To assist in providing this it is suggested that each manufacturer send to the Division of Building Research one 8-in. block which is most typical of his production. These samples should be identified as to Company and forwarded to

Division of Building Research,
Attention of Mr. G.W. Shorter,
Montreal Road Laboratories,
National Research Council,
Ottawa, Ontario.

Attached to this letter are one copy of Sheet One, "Block Size", five copies of Sheet Two "Concrete Mix" and one copy of Sheet Three "Annual Production".

SHEET ONE

BLOCK SHAPE

Identify your submission in a covering letter only. Do not otherwise identify these sheets. All sheets in one submission must be securely fastened together.

(1) For each block shape employed by your company enter the appropriate details in (a),(b) or (c) below. If your production covers more than three block shapes additional sheets may be obtained from N.C.P.A.

	Block Thickness. in.		Percent Solid in Block.	Face Shell Thickness. in.	No. of Cores.
	Nom.	Exact			
(a) Shape 1.	4				
(i) Height of block ...... in.	6				
(ii) Length of block .... in	8				
	10				
	12				
	other				
(b) Shape 2.	4				
(i) Height of block .... in	6				
(ii) Length of block .... in	8				
	10				
	12				
	other				
(c) Shape 3.	4				
(i) Height of block .... in	6				
(ii) Length of block ..... in	8				
	10				
	12				
	other				

(2) Block Making Machine. Describe block making machine used for each of:

(a) Shape 1.......(Modify as proposed by Technical Committee)

(b) Shape 2..

(c) Shape 3..

SHEET TWO

CONCRETE MIX

Identify your submission in a covering letter only. Do not otherwise identify these sheets. All sheets in one submission must be securely fastened together.

(3) For each concrete mix used insert details in (a) and (b) below. If more than five concrete mixes are used additional sheets may be obtained from N.C.P.A. Check A, B, C, D or E to correspond to entries relating to production on Sheet Three.

Concrete Mix. A ☐ B ☐ C ☐ D ☐ E ☐

(a) Material -

(i) Cement. Normal ☐ Block Type ☐ High Early Strength ☐

Other ....

(ii) Coarse Aggregate. Describe..............................

....

Size max...............in. min...................in.

(iii) Fine Aggregate. Describe..............................

....

Size max.........sieve no. Fineness Modulus......if known

(iv) Additives..............................if any.

(b) Mix. Show quantities per batch.

(i) Cementitious Material..............................lb.

(ii) Coarse Aggregate..............................lb.

(iii) Fine Aggregate..............................lb.

(iv) Additives..............................

SHEET THREE

ANNUAL PRODUCTION

Identify your submission in a covering letter only. Do not otherwise identify these sheets. All sheets in one submission must be securely fastened together.

(4) For each combination of block shape, concrete mix and method of curing used insert in the Table below the approximate percentage of your total production, (8 in. equivalent) between 1st January 1961 and 1st January 1962. Shapes 1, 2 and 3 should correspond to details in Sheet One. Concrete Mix A, B, C, D or E should correspond to the description on Sheet Two. If your production covers more than three block shapes or five concrete mixes additional sheets may be obtained from N.C.P.A.

	CONCRETE MIX	COMP. STRENGTH for 8in. block p.s.i.	WEIGHT of 8in BLOCK lb.	ANNUAL PRODUCTION. approx % of total annual production for each means of curing used.		
				LOW.PR.STEAM	AUTOCLAVE	OTHER.
(a) SHAPE 1.	A.					
	B.					
	C.					
	D.					
	E.					
(b) SHAPE 2.	A.					
	B.					
	C.					
	D.					
	E.					
(c) SHAPE 3.	A.					
	B.					
	C.					
	D.					
	E.					

(5) Show approximate total Annual Production in number of units (8 in. equivalent) between 1st January 1961 and 1st January 1962.

...............................units.