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**CONCRETE MASONRY COMPRESSIVE
STRENGTH USING THE UNIT
STRENGTH METHOD FOR
GROUTED MASONRY**

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Concrete Masonry Compressive Strength using the Unit Strength Method for Grouted Masonry

Background

The Canadian Masonry Design Standard CSA S304.1-04 outlines two methods for engineers to determine the compressive strength of concrete masonry used for design. These methods are either testing a series of representative masonry prisms, or the use of tabulated values given in Table 4 of the Standard. These tabulated values are based on a correlation between the unit compressive strength to the prism compressive strength as determined in part based on research performed in the 1970s and 1980s (Maurenbrecher, 1986).

The objective of the analysis summarized in this report is to re-establish the correlation between unit strength and prism strength using more recent test results. These correlations were examined using a large database of available test results of prism testing conducted in North America.

The analysis presented in this report is intended to be complementary to a report based on hollow masonry construction, also prepared in the University of Alberta (Gayed, 2011), and parallels a similar research project performed by the National Concrete Masonry Association in the United States (NCMA, 2012).

Description of the Database

A database for the compressive strength of grouted masonry prisms was constructed and used in this analysis. A total of 205 average and specified compressive strength data points were computed from the results of 730 individual grouted prisms. Prism strength computations were performed according to CSA S304.1-04. A full list of the collected data points and the references used in this analysis are given in Appendix I and list of references.

Appropriate correction factors were applied to the computed masonry strength values to take into account the influence of prism height-to-thickness on the prism strength. The compressive strength values computed from test results were modified by the factors given in Table D.1 of Annex D of CSA S304.1-04 which is reproduced here as Table 1. The majority of the prisms included in the database were three units high, and ranged from a minimum of two units to a maximum of eight units high.

Table 1– Height to Thickness Correction Factors (CSA S304.1-04)

Correction factor			
Height-to-thickness ratio*	Solid units†	Hollow and semi-solid units	
		Concrete‡	Clay
1.4	—	1.00	0.85
2	0.80	1.00	0.85
3	0.90	1.00	0.90
4	0.95	1.00	0.95
5 to 10	1.00	1.00	1.00

*Linear interpolation is permitted.

†Including fully grouted hollow and semi-solid units.

‡For two-unit-high, hollow and semi-solid concrete block prisms, a correction factor of 0.90 shall be applied.

Both average prism strength results and specified prism strength results were computed. The specified strength of a group of prisms was calculated according to Annex C of CSA S304.1-04 as the 5th percentile of the measured values. For investigations where the coefficient of variation of the tested prisms was not reported or was less than 10%, a minimum value of 10% was assumed following Clause C.2.2 of Annex C of the Canadian Standard.

Results and Discussion

The correlations between the average unit strength and the average compressive strength of grouted masonry were constructed independently for type S and type N mortars and are shown graphically in Figures 1 and 2, respectively. A power correlation in the format $y=ax^b$ was found to have the highest coefficient of correlation, and was used throughout the analysis. Following the method used by Maurenbrecher in developing the original Table 4 values, a best-fit line was reduced by a factor of 0.75 and 0.7 for type S and type N mortar, respectively, in order to assure that 90% of test results fall above the adjusted best fit line.

The correlations between the average unit strength and the specified prism strength were also constructed and are shown in Figures 3 and 4 for type S and type N mortars, respectively. A further analysis using specified block strength against specified prism strength was determined to be less conservative than using the average block strength, and is not presented in this report.

Conclusions and Recommendations

A total of 150 data points from 550 individual prism tests for type S mortar and 55 data points from 180 individual prism tests for Type N mortar were computed and used in this analysis. The test results from the ongoing test program at the University of Alberta were not available yet and are not part of the analyzed data.

Based on the analysis of the correlations for the average unit strength versus the average prism strength and versus the specified prism strength, the revised tabulated values for the compressive strength of grouted masonry given in Table 2 are proposed.

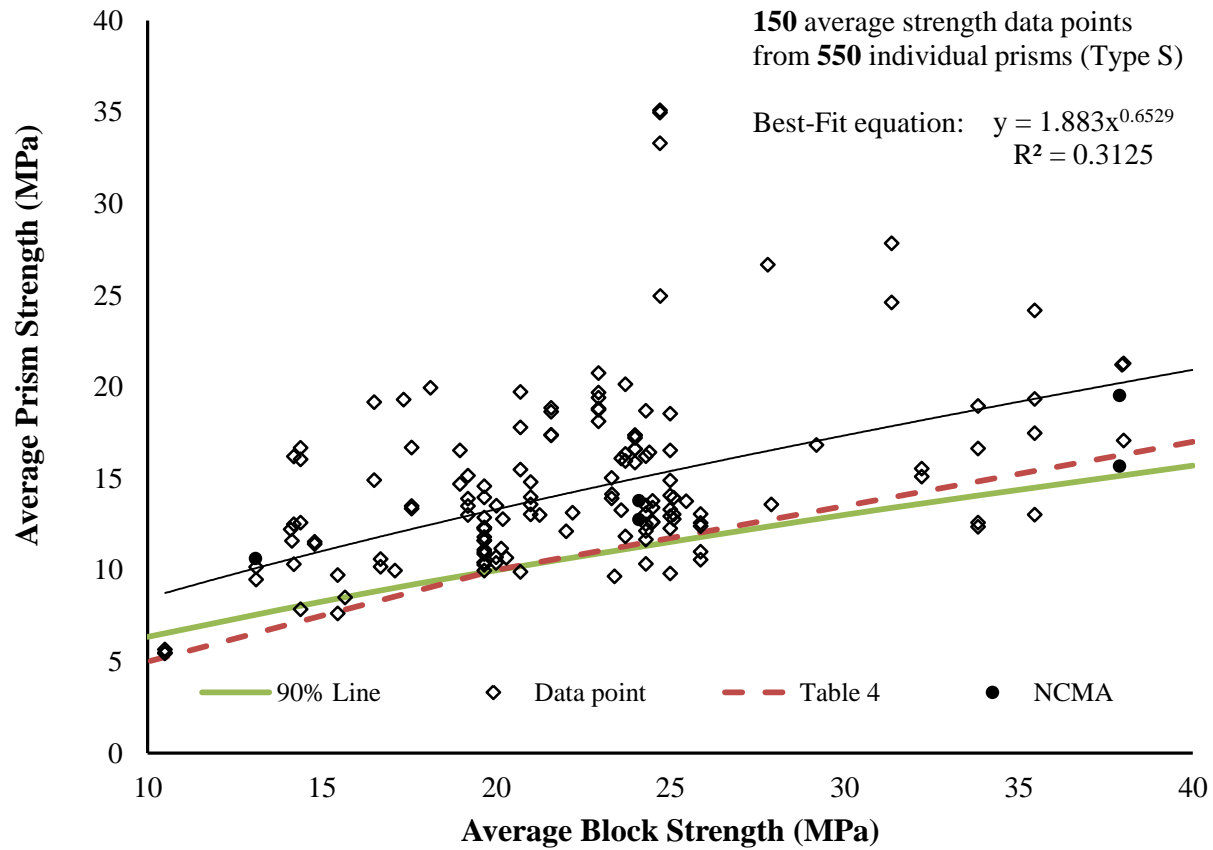


Figure 1– Average Block Strength versus Average Prism Strength for Grouted Masonry Constructed with Type S Morar

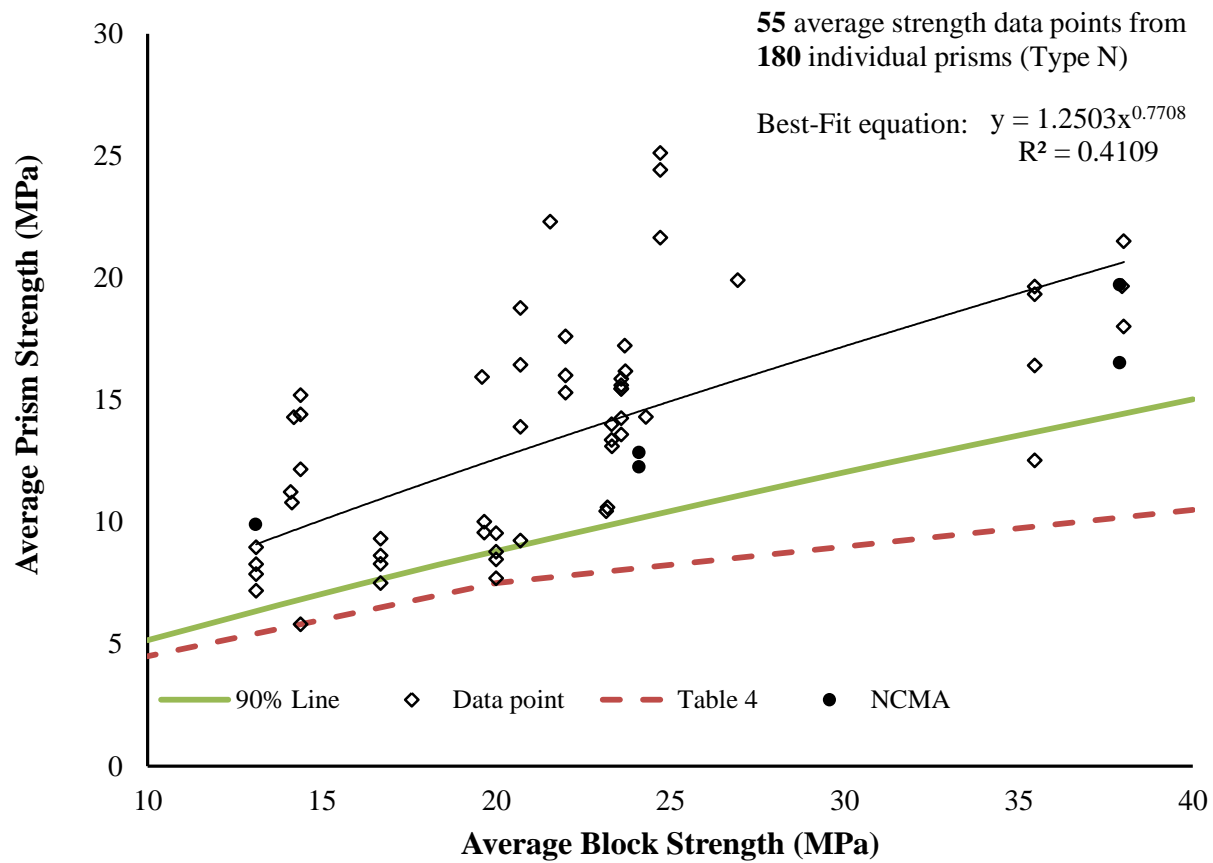


Figure 2– Average Block Strength versus Average Prism Strength for Grouted Masonry Constructed with Type N Morar

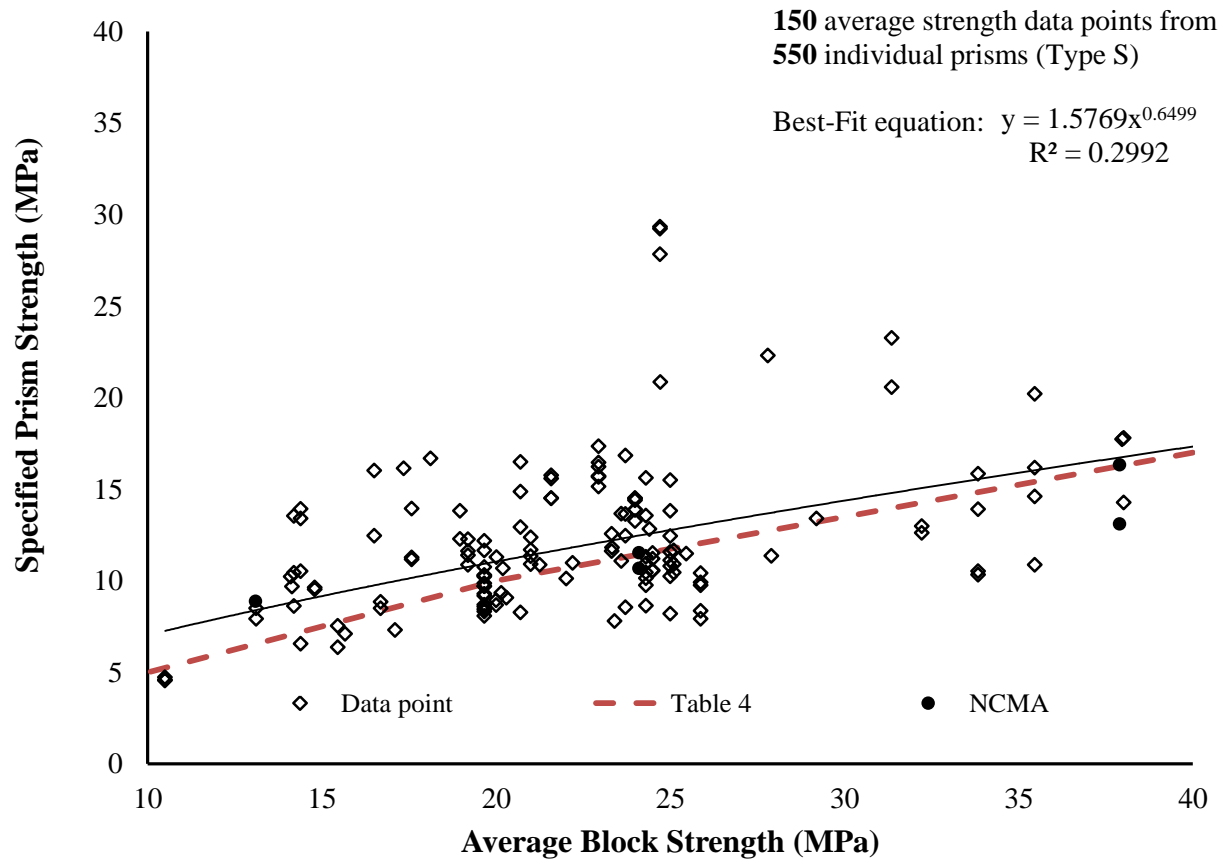


Figure 3– Average Block Strength versus Specified Prism Strength for Grouted Masonry Constructed with Type S Morar

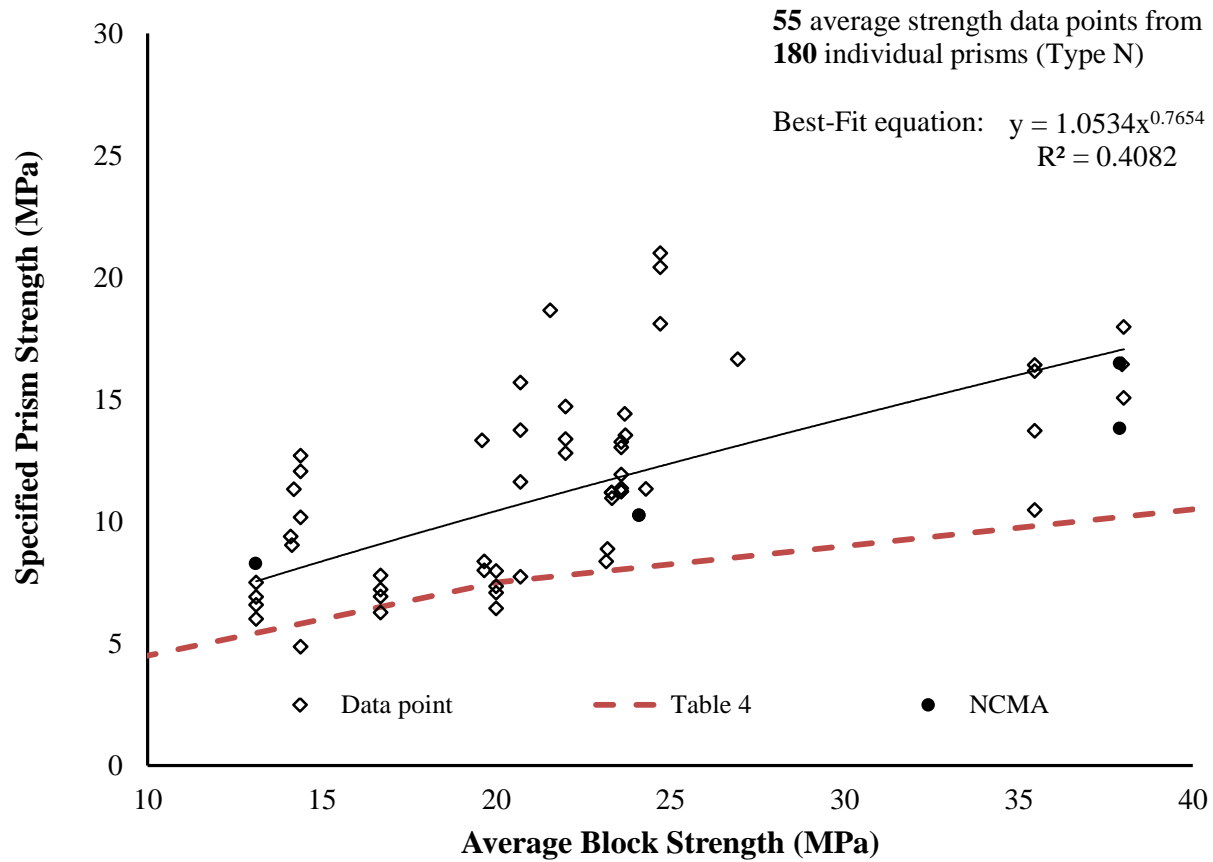


Figure 4– Average Block Strength versus Specified Prism Strength for Grouted Masonry Constructed with Type N Morar

Table 2– Summary of Proposed Updated Compressive Strength Values for Grouted Masonry

Grouted Concrete Masonry Compressive Strength (f_m)												
Block Strength (MPa)	Type S Mortar						Type N Mortar					
	Current Value	90% Line (Average)	Best Fit (Specified)	Proposed Value	% Increase	f_m/f_u	Current Value	90% Line (Average)	Best Fit (Specified)	Proposed Value	% Increase	f_m/f_u
40 or more	17	15.7	17.3	16.5	-3%	0.41	10.5	15.0	17.7	15.0	43%	0.38
30	13.5	13.0	14.4	13.5	-	0.45	9	12.0	14.2	12.0	33%	0.40
20	10	10.0	11.0	10.0	-	0.5	7.5	8.8	10.4	9.0	20%	0.45
15	7.5	8.3	9.2	8.0	6.7%	0.53	6	7.1	8.4	7.0	16.7%	0.47
10	5	6.4	7.0	6.0	20%	0.6	4.5	5.2	6.1	5.0	11.1%	0.50

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Appendix I—Compressive Strength of Grouted Prisms

Reference	Prism Dimensions, mm					Mortar Properties					Grout Properties				Block		Prism Properties									
	Height (h)	Length (L)	Thickness (t)	h/t	Number of Courses	Correction factor	Type Reported	Thickness (mm)	Strength (MPa)	St. Dev. (MPa)	C.O.V. (%)	Comp Str. (MPa)	St. Dev. (MPa)	Coarse or Fine	Mould	Comp Str. (MPa)	St. Dev. (MPa)	Net Strength (MPa)	Corrected Strength (MPa)	Standard Deviation (MPa)	C.O.V. (%)	Number of Prisms	Specified f _m (MPa)	Tabulated (CSA) f _m (MPa)	Specified / Tabulated f _m	C.O.V. (%)
	(mm)																									
1	397	397	194	2.05	2	0.80	S	9.5	12.4	1.5	12	30.0	2.4	Coarse	Porous	25.9	4.8	13.1	10.6	1.6	12	8	7.9	12.1	0.66	12
	397	397	194	2.05	2	0.80	S	9.5	12.1	1.7	14	24.5	4.3	Coarse	Porous	25.9	4.8	13.7	11.0	1.6	12	6	8.4	12.1	0.69	12
	397	397	194	2.05	2	0.80	S	9.5	12.1	1.7	14	24.5	4.3	Coarse	Porous	25.9	4.8	15.6	12.6	1.6	10	5	9.9	12.1	0.82	10
	397	397	194	2.05	2	0.80	S	9.5	12.1	1.7	14	24.5	4.3	Coarse	Porous	25.9	4.8	15.4	12.4	1.6	10	11	9.7	12.1	0.81	10
	397	397	194	2.05	2	0.80	S	9.5	12.1	1.7	14	24.5	4.3	Coarse	Porous	25.9	4.8	16.2	13.1	1.6	10	7	10.4	12.1	0.86	10
2	600	-	178	3.38	3	0.92	S	9.5	15.1	-	-	15.9	-	Fine	Block	19.7	0.8	10.8	10.0	0.6	6	5	9.0	9.8	0.91	6
	600	-	178	3.38	3	0.92	S	9.5	16.7	-	-	15.2	-	Fine	Block	19.7	0.8	11.2	10.3	0.6	6	5	9.2	9.8	0.94	6
	600	-	178	3.38	3	0.92	S	9.5	17.3	-	-	15.2	-	Fine	Block	19.7	0.8	11.3	10.4	0.5	4	5	9.6	9.8	0.98	4
	600	-	178	3.38	3	0.92	N	9.5	5.7	-	-	17.4	-	Fine	Block	19.7	0.8	10.4	9.6	0.3	3	4	9.0	7.4	1.22	3
	600	-	178	3.38	3	0.92	S	9.5	14.2	-	-	15.2	-	Fine	Block	19.7	0.8	11.3	10.4	1.4	12	5	8.1	9.8	0.82	12
	600	-	178	3.38	3	0.92	S	9.5	15.8	-	-	21.3	-	Fine	Block	19.7	0.8	12.8	11.8	0.8	6	5	10.6	9.8	1.07	6
	600	-	178	3.38	3	0.92	S	9.5	13.5	-	-	30.9	-	Fine	Block	19.7	0.8	13.4	12.3	0.9	7	4	10.8	9.8	1.10	7
	600	-	178	3.38	3	0.92	S	9.5	13.5	-	-	17.4	-	Fine	Block	19.7	0.8	12.1	11.1	0.3	3	4	10.5	9.8	1.07	3
	600	-	178	3.38	3	0.92	S	9.5	13.6	-	-	47.2	-	Coarse	Block	19.7	0.8	15.2	13.9	1.0	6	4	12.4	9.8	1.26	6
	600	-	178	3.38	3	0.92	S	19.1	14.2	-	-	19.8	-	Fine	Block	32.2	2.2	16.4	15.1	0.8	5	4	13.8	14.3	0.97	5
	600	-	178	3.38	3	0.92	S	9.5	14.2	-	-	22.0	-	Fine	Block	22.0	0.9	13.2	12.1	0.5	4	4	11.3	10.7	1.06	4
	600	-	178	3.38	3	0.92	S	9.5	14.2	-	-	22.0	-	Fine	Block	21.3	1.3	14.1	13.0	0.6	4	4	12.0	10.4	1.15	4
	600	-	178	3.38	3	0.92	S	9.5	14.2	-	-	19.8	-	Fine	Block	20.1	1.1	12.1	11.2	0.1	1	4	10.9	10.1	1.09	1
	600	-	178	3.38	3	0.92	S	9.5	14.2	-	-	22.0	-	Fine	Block	20.0	1.2	14.7	13.5	1.2	8	4	11.5	10.0	1.15	8
	600	-	178	3.38	3	0.92	S	9.5	14.2	-	-	21.4	-	Fine	Block	15.7	1.3	9.2	8.5	0.3	3	3	8.0	7.8	1.03	3
600	-	178	3.38	3	0.92	S	9.5	12.8	-	-	16.5	-	Fine	Block	19.7	0.8	11.9	11.0	0.6	5	3	10.0	9.8	1.02	5	
600	-	178	3.38	3	0.92	S	9.5	12.8	-	-	16.5	-	Fine	Block	19.7	0.8	13.3	12.2	0.6	5	4	11.2	9.8	1.14	5	
3	590	195	190	3.11	3	0.91	S	10.0	17.0	-	-	21.1	-	Fine	Block	25.1	-	14.4	13.0	0.4	3	5	12.3	11.8	1.05	3
	590	195	190	3.11	3	0.91	S	10.0	17.0	-	-	13.7	-	Fine	Block	25.1	-	14.1	12.8	1.4	10	4	10.4	11.8	0.89	10
	590	195	190	3.11	3	0.91	S	10.0	17.0	-	-	41.0	-	Fine	Block	25.1	-	15.4	13.9	1.0	7	3	12.2	11.8	1.04	7
	590	195	190	3.11	3	0.91	S	10.0	17.0	-	-	21.1	-	Fine	Block	17.1	-	11.0	10.0	1.6	15	3	7.3	8.6	0.86	15

	590	195	190	3.11	3	0.91	S	10.0	17.0	-	-	21.1	-	Fine	Block	27.9	-	15.0	13.6	1.0	7	3	12.0	12.8	0.94	7
	590	195	190	3.11	3	0.91	S	10.0	17.0	-	-	21.1	-	Fine	Block	20.2	-	14.1	12.8	0.3	2	4	12.3	10.1	1.22	2
	590	195	190	3.11	3	0.91	S	10.0	17.0	-	-	21.1	-	Fine	Block	22.2	-	14.5	13.1	0.6	4	3	12.2	10.8	1.13	4
	590	195	140	4.21	3	0.96	S	10.0	17.0	-	-	21.1	-	Fine	Block	23.6	-	13.8	13.3	0.9	6	4	11.8	11.3	1.05	6
	590	195	240	2.46	3	0.85	S	10.0	17.0	-	-	21.1	-	Fine	Block	23.4	-	11.4	9.6	1.1	10	4	7.8	11.2	0.70	10
4	587	390	190	3.09	3	0.90	N	10.0	9.2	-	-	19.4	-	Fine	-	14.2	1.5	15.8	14.3	1.8	11	3	11.3	5.8	1.97	11
	587	390	190	3.09	3	0.90	S	10.0	13.5	-	-	32.0	-	Fine	-	14.2	1.5	17.9	16.2	0.5	3	3	15.3	7.1	2.15	3
	587	390	190	3.09	3	0.90	S	10.0	15.4	-	-	8.6	-	Fine	-	14.2	1.5	13.8	12.5	1.2	9	3	10.6	7.1	1.49	9
	587	390	190	3.09	3	0.90	S	10.0	15.4	-	-	15.7	-	Fine	-	14.2	1.5	11.4	10.3	0.2	2	3	10.0	7.1	1.41	2
5	600	178	143	4.20	3	0.96	S	9.5	14.5	1.1	8	12.3	-	Fine	Block	19.7	0.8	11.3	10.9	1.5	14	5	8.4	9.8	0.86	14
	600	178	143	4.20	3	0.96	S	9.5	18.2	1.1	6	14.1	-	Fine	Block	19.7	0.8	12.1	11.6	0.3	3	4	11.0	9.8	1.12	3
	600	178	143	4.20	3	0.96	N	9.5	5.7	0.3	5	14.1	-	Fine	Block	19.7	0.8	10.4	10.0	0.3	3	4	9.5	7.4	1.28	3
	600	178	143	4.20	3	0.96	S	9.5	14.5	1.1	8	17.2	-	Fine	Block	19.7	0.8	12.8	12.3	0.8	6	5	11.0	9.8	1.12	6
	600	178	143	4.20	3	0.96	S	9.5	14.5	1.1	8	25.0	-	Fine	Block	19.7	0.8	13.4	12.9	0.9	7	4	11.3	9.8	1.15	7
	600	178	143	4.20	3	0.96	S	9.5	14.5	1.1	8	14.1	-	Fine	Block	19.7	0.8	12.1	11.6	0.3	3	4	11.0	9.8	1.12	3
	600	178	143	4.20	3	0.96	S	9.5	14.5	1.1	8	37.9	-	Coarse	Block	19.7	0.8	15.2	14.6	1.0	7	4	12.9	9.8	1.31	7
6	590	390	190	3.11	3	0.91	N	10.0	5.6	-	-	14.8	-	Fine	Block	13.1	-	7.9	7.2	0.0	0	1	7.2	5.4	1.32	0
	590	390	190	3.11	3	0.91	N	10.0	5.6	-	-	20.3	-	Fine	Block	13.1	-	9.1	8.3	0.0	0	1	8.3	5.4	1.52	0
	590	390	190	3.11	3	0.91	N	10.0	8.4	-	-	14.8	-	Fine	Block	13.1	-	8.7	7.9	0.0	0	1	7.9	5.4	1.45	0
	590	390	190	3.11	3	0.91	N	10.0	8.4	-	-	20.3	-	Fine	Block	13.1	-	9.9	9.0	0.0	0	1	9.0	5.4	1.65	0
	590	390	190	3.11	3	0.91	S	10.0	12.4	-	-	14.8	-	Fine	Block	13.1	-	10.5	9.5	0.0	0	1	9.5	6.6	1.45	0
	590	390	190	3.11	3	0.91	S	10.0	12.4	-	-	20.3	-	Fine	Block	13.1	-	11.2	10.2	0.0	0	1	10.2	6.6	1.55	0
	590	390	190	3.11	3	0.91	N	10.0	5.6	-	-	14.8	-	Fine	Block	16.7	-	8.3	7.5	0.0	0	1	7.5	6.5	1.15	0
	590	390	190	3.11	3	0.91	N	10.0	5.6	-	-	20.3	-	Fine	Block	16.7	-	9.5	8.6	0.0	0	1	8.6	6.5	1.32	0
	590	390	190	3.11	3	0.91	N	10.0	8.4	-	-	14.8	-	Fine	Block	16.7	-	9.2	8.3	0.0	0	1	8.3	6.5	1.27	0
	590	390	190	3.11	3	0.91	N	10.0	8.4	-	-	20.3	-	Fine	Block	16.7	-	10.3	9.3	0.0	0	1	9.3	6.5	1.43	0
	590	390	190	3.11	3	0.91	S	10.0	12.4	-	-	14.8	-	Fine	Block	16.7	-	11.2	10.2	0.0	0	1	10.2	8.3	1.22	0
	590	390	190	3.11	3	0.91	S	10.0	12.4	-	-	20.3	-	Fine	Block	16.7	-	11.7	10.6	0.0	0	1	10.6	8.3	1.27	0
	590	390	190	3.11	3	0.91	N	10.0	5.6	-	-	14.8	-	Fine	Block	20.0	-	8.5	7.7	0.0	0	1	7.7	7.5	1.03	0
	590	390	190	3.11	3	0.91	N	10.0	5.6	-	-	20.3	-	Fine	Block	20.0	-	9.7	8.8	0.0	0	1	8.8	7.5	1.17	0
	590	390	190	3.11	3	0.91	N	10.0	8.4	-	-	14.8	-	Fine	Block	20.0	-	9.4	8.5	0.0	0	1	8.5	7.5	1.13	0
590	390	190	3.11	3	0.91	N	10.0	8.4	-	-	20.3	-	Fine	Block	20.0	-	10.5	9.5	0.0	0	1	9.5	7.5	1.27	0	
590	390	190	3.11	3	0.91	S	10.0	12.4	-	-	14.8	-	Fine	Block	20.0	-	11.5	10.4	0.0	0	1	10.4	10.0	1.04	0	

	590	390	190	3.11	3	0.91	S	10.0	12.4	-	-	20.3	-	Fine	Block	20.0	-	11.8	10.7	0.0	0	1	10.7	10.0	1.07	0
7	397	194	194	2.05	2	0.80	S	-	22.0	-	-	15.9	-	Fine	Block	25.0	-	18.5	14.9	0.3	2	5	14.4	11.8	1.22	2
8	600	400	200	3.	3	0.90	N	-	-	-	-	34	-	-	Block	22.0	-	17.0	15.3	1.5	10	8	12.8	7.8	1.64	10
	400	400	200	2.	2	0.80	N	-	-	-	-	34	-	-	Block	22.0	-	22.0	17.6	1.8	10	8	14.7	7.8	1.89	10
	400	400	200	2.	3	0.80	N	-	-	-	-	34	-	-	Block	22.0	-	20.0	16.0	1.6	10	8	13.4	7.8	1.71	10
9	590	390	190	3.11	3	0.91	-	10.0	9.2	-	-	19.4	-	Coarse	Metal	24.3	-	15.8	14.3	2	11	3	11.3	8.1	1.39	11
	590	390	190	3.11	3	0.91	-	10.0	13.5	-	-	32.0	-	Coarse	Metal	24.3	-	17.9	16.2	1	3	3	15.3	11.5	1.33	3
	590	390	190	3.11	3	0.91	-	10.0	15.4	-	-	8.6	-	Coarse	Metal	24.3	-	13.8	12.5	1	9	3	10.6	11.5	0.92	9
	590	390	190	3.11	3	0.91	-	10.0	15.4	-	-	15.7	-	Coarse	Metal	24.3	-	11.4	10.3	0	2	3	10.0	11.5	0.87	2
	590	390	190	3.11	3	0.91	-	10.0	20.2	-	-	23.5	-	Coarse	Metal	24.3	-	13.4	12.1	1	7	3	10.5	11.5	0.91	7
	390	390	190	2.05	2	0.81	-	10.0	21.2	-	-	17.1	-	Coarse	Metal	24.3	-	16.8	13.5	1	5	2	12.2	11.5	1.06	5
	580	390	190	3.05	3	0.90	-	5.0	21.2	-	-	16.5	-	Coarse	Metal	24.3	-	14.5	13.1	1	7	3	11.5	11.5	1.00	7
	610	390	190	3.21	3	0.91	-	20.0	21.2	-	-	17.1	-	Coarse	Metal	24.3	-	12.8	11.7	1	8	3	10.0	11.5	0.87	8
	390	195	190	2.05	2	0.81	-	10.0	21.2	-	-	17.1	-	Coarse	Metal	24.3	-	23.2	18.7	0	1	2	18.2	11.5	1.58	1
10	406	394	152	2.66	4	0.87	N	-	11.9	1.2	10	29.2	2.3	Coarse	Block	24.7	-	28.2	24.4	2.4	10	5	20.4	8.2	2.49	10
	406	394	102	4.	4	0.95	N	-	11.9	1.2	10	29.2	2.3	Coarse	Block	26.9	-	21.0	19.9	2.0	10	5	16.6	8.5	1.95	10
	406	394	203	2.	4	0.80	N	-	11.9	1.2	10	29.2	2.3	Coarse	Block	21.6	-	27.9	22.3	2.2	10	5	18.6	7.7	2.41	10
	406	394	152	2.66	4	0.87	N	-	11.9	1.2	10	29.2	2.3	Coarse	Block	24.7	-	25.0	21.7	2.2	10	5	18.1	8.2	2.21	10
	406	394	152	2.66	4	0.87	S	-	24.3	2.0	8	29.2	2.3	Coarse	Block	24.7	-	28.8	24.9	2.5	10	5	20.9	11.7	1.79	10
	406	394	152	2.66	4	0.87	N	-	11.9	1.2	10	30.6	5.5	Coarse	Block	24.7	-	29.0	25.1	2.5	10	5	21.0	8.2	2.56	10
11	416	406	203	2.05	2	0.80	S	10.0	11.2	-	-	15.5	-	Coarse	Metal	24.5	-	17.1	13.8	0.8	6	3	12.4	11.6	1.07	6
	629	406	203	3.1	3	0.90	S	10.0	11.2	-	-	15.5	-	Coarse	Metal	24.5	-	14.8	13.4	0.8	6	3	12.1	11.6	1.04	6
	842	406	203	4.14	4	0.96	S	10.0	11.2	-	-	15.5	-	Coarse	Metal	24.5	-	13.2	12.6	0.8	6	3	11.4	11.6	0.98	6
	1055	406	203	5.19	5	1.00	S	10.0	11.2	-	-	15.5	-	Coarse	Metal	24.5	-	12.6	12.6	0.8	6	3	11.4	11.6	0.98	6
	416	406	203	2.05	2	0.80	S	10.0	11.2	-	-	15.5	-	Coarse	Metal	21.0	-	16.2	13.0	0.8	6	3	11.8	10.4	1.14	6
	629	406	203	3.1	3	0.90	S	10.0	11.2	-	-	15.5	-	Coarse	Metal	21.0	-	15.0	13.6	0.8	6	3	12.2	10.4	1.18	6
	842	406	203	4.14	4	0.96	S	10.0	11.2	-	-	15.5	-	Coarse	Metal	21.0	-	14.6	14.0	0.8	6	3	12.6	10.4	1.22	6
1055	406	203	5.19	5	1.00	S	10.0	11.2	-	-	15.5	-	Coarse	Metal	21.0	-	14.8	14.8	0.9	6	3	13.3	10.4	1.29	6	
12	842	396	194	4.34	4	0.97	S	10.0	19.5	1.2	6	17.0	2.0	Fine	Metal	33.8	1.3	12.8	12.4	0.6	4	5	11.4	14.8	0.77	4
	842	396	194	4.34	4	0.97	S	10.0	20.2	1.5	7	30.7	2.5	Coarse	Metal	33.8	1.3	17.2	16.6	1.2	7	5	14.7	14.8	0.99	7
	842	396	194	4.34	4	0.97	S	10.0	17.1	2.7	16	27.5	3.1	Coarse	Metal	33.8	1.3	19.6	19.0	1.7	9	5	16.1	14.8	1.08	9
	842	396	194	4.34	4	0.97	S	10.0	19.9	0.4	2	21	3.0	Fine	Metal	33.8	1.3	13.0	12.6	1.0	7	5	11.0	14.8	0.74	7
1	590	390	190	3.11	3	0.91	S	10.0	-	-	-	21.9	-	Coarse	-	25.0	-	10.8	9.8	-	-	1	9.8	11.8	0.83	-

	590	390	190	3.11	3	0.91	N	10.0	-	-	-	34.0	-	Coarse	-	23.7	-	19.0	17.2	-	-	1	17.2	8.1	2.14	-
14	590	390	190	3.11	3	0.91	N	10.0	6.0	1.6	27	25.5	3.3	-	-	19.6	4.1	17.6	15.9	1.6	10	18	13.3	7.4	1.80	10
15	-	-	-	4.	4	0.95	S	-	10.9	-	-	10.2	-	Fine	Metal	25.0	-	12.9	12.3	0.6	5	5	11.2	11.8	0.95	5
	-	-	-	4.	4	0.95	S	-	10.9	-	-	11.6	-	Fine	Metal	25.0	-	14.0	13.3	0.6	5	5	12.3	11.8	1.05	5
	-	-	-	4.	4	0.95	S	-	11.3	-	-	34.9	-	Fine	Metal	25.0	-	14.8	14.1	1.5	11	5	11.6	11.8	0.98	11
	-	-	-	4.	4	0.95	S	-	11.3	-	-	37.4	-	Fine	Metal	25.0	-	13.6	12.9	1.0	8	5	11.2	11.8	0.96	8
	-	-	-	4.	4	0.95	S	-	9.2	-	-	48.9	-	Coarse	Metal	25.0	-	19.5	18.5	0.9	5	5	17.1	11.8	1.45	5
	-	-	-	4.	4	0.95	S	-	12.7	-	-	53.8	-	Coarse	Metal	25.0	-	17.4	16.5	1.2	7	5	14.6	11.8	1.24	7
16	590	390	140	4.21	3	0.96	N	10.0	17.3	1.6	9	15.3	1.4	Fine	Metal	23.2	2.7	10.9	10.4	1.3	12	3	8.4	8.0	1.05	12
	990	390	140	7.07	5	1.00	N	10.0	17.3	1.6	9	15.3	1.4	Fine	Metal	23.2	2.7	10.6	10.6	0.3	2	3	10.2	8.0	1.28	2
17	590	390	140	4.21	3	0.96	-	10.0	4.4	0.3	7	7.2	0.3	Fine		14.4	-	6.1	5.8	0.6	10	3	4.9	5.8	0.84	10
	590	390	140	4.21	3	0.96	-	10.0	4.4	0.3	7	13.9	0.6	Coarse		14.4	-	12.7	12.2	1.2	10	3	10.2	5.8	1.75	10
	590	390	140	4.21	3	0.96	-	10.0	4.4	0.3	7	26.2	1.3	Coarse		14.4	-	15.0	14.4	1.4	10	3	12.0	5.8	2.07	10
	590	390	140	4.21	3	0.96	-	10.0	4.4	0.3	7	35.9	1.6	Coarse		14.4	-	15.8	15.2	1.5	10	3	12.7	5.8	2.18	10
	590	390	140	4.21	3	0.96	-	10.0	4.4	0.3	7	7.2	0.3	Fine		20.7	-	9.6	9.2	0.9	10	3	7.7	7.6	1.02	10
	590	390	140	4.21	3	0.96	-	10.0	4.4	0.3	7	13.9	0.6	Coarse		20.7	-	14.5	13.9	1.4	10	3	11.6	7.6	1.53	10
	590	390	140	4.21	3	0.96	-	10.0	4.4	0.3	7	26.2	1.3	Coarse		20.7	-	17.1	16.4	1.6	10	3	13.7	7.6	1.81	10
	590	390	140	4.21	3	0.96	-	10.0	4.4	0.3	7	35.9	1.6	Coarse		20.7	-	19.5	18.8	1.9	10	3	15.7	7.6	2.06	10
	590	390	140	4.21	3	0.96	-	10.0	4.4	0.3	7	7.2	0.3	Fine		35.5	-	13.0	12.5	1.3	10	3	10.5	9.8	1.07	10
	590	390	140	4.21	3	0.96	-	10.0	4.4	0.3	7	13.9	0.6	Coarse		35.5	-	17.1	16.4	1.6	10	3	13.7	9.8	1.40	10
	590	390	140	4.21	3	0.96	-	10.0	4.4	0.3	7	26.2	1.3	Coarse		35.5	-	20.1	19.3	1.9	10	3	16.2	9.8	1.65	10
	590	390	140	4.21	3	0.96	-	10.0	4.4	0.3	7	35.9	1.6	Coarse		35.5	-	20.4	19.6	2.0	10	3	16.4	9.8	1.67	10
	590	390	140	4.21	3	0.96	-	10.0	7.97	0.4	5	7.2	0.3	Fine		14.4	-	8.2	7.8	0.8	10	3	6.6	7.2	0.91	10
	590	390	140	4.21	3	0.96	-	10.0	7.97	0.4	5	13.9	0.6	Coarse		14.4	-	13.1	12.6	1.3	10	3	10.5	7.2	1.46	10
	590	390	140	4.21	3	0.96	-	10.0	7.97	0.4	5	26.2	1.3	Coarse		14.4	-	16.7	16.0	1.6	10	3	13.4	7.2	1.86	10
	590	390	140	4.21	3	0.96	-	10.0	7.97	0.4	5	35.9	1.6	Coarse		14.4	-	17.3	16.7	1.7	10	3	13.9	7.2	1.94	10
	590	390	140	4.21	3	0.96	-	10.0	7.97	0.4	5	7.2	0.3	Fine		20.7	-	10.3	9.9	1.0	10	3	8.3	10.2	0.81	10
	590	390	140	4.21	3	0.96	-	10.0	7.97	0.4	5	13.9	0.6	Coarse		20.7	-	16.1	15.5	1.5	10	3	12.9	10.2	1.26	10
	590	390	140	4.21	3	0.96	-	10.0	7.97	0.4	5	26.2	1.3	Coarse		20.7	-	18.5	17.8	1.8	10	3	14.9	10.2	1.45	10
	590	390	140	4.21	3	0.96	-	10.0	7.97	0.4	5	35.9	1.6	Coarse		20.7	-	20.5	19.7	2.0	10	3	16.5	10.2	1.61	10
590	390	140	4.21	3	0.96	-	10.0	7.97	0.4	5	7.2	0.3	Fine		35.5	-	13.5	13.0	1.3	10	3	10.9	15.4	0.71	10	
590	390	140	4.21	3	0.96	-	10.0	7.97	0.4	5	13.9	0.6	Coarse		35.5	-	18.2	17.5	1.7	10	3	14.6	15.4	0.95	10	
590	390	140	4.21	3	0.96	-	10.0	7.97	0.4	5	26.2	1.3	Coarse		35.5	-	20.1	19.3	1.9	10	3	16.2	15.4	1.05	10	

	590	390	140	4.21	3	0.96	-	10.0	7.97	0.4	5	35.9	1.6	Coarse		35.5	-	25.2	24.2	2.4	10	3	20.2	15.4	1.31	10
18	590	390	190	3.11	3	0.91	S	10.0	10.5	1.4	13	11.4	1.8	Coarse	Metal	15.5	3.0	10.7	9.7	1.3	12	4	7.5	7.7	0.97	12
	590	590	190	3.11	3	0.91	S	10.0	10.5	1.4	13	11.4	1.8	Coarse	Metal	15.5	3.0	8.4	7.6	0.7	8	4	6.5	7.7	0.84	8
19	-	-	250	2.11	4	0.81	S	9.5	22.9	1.6	7	28.2	5	Coarse	Block	25.5	3.9	16.9	13.7	-	4	5	13.7	11.9	1.15	4
20	990	390	190	5.21	5	1.00	S	10.0	10.9	0.5	5	29.4	1.0	Coarse	Block	17.4	0.1	19.3	19.3	0.1	0	5	19.2	8.7	2.21	0
21	590	390	190	3.11	3	0.91	S	10.0						Coarse	Metal			10.8	9.8	1.3	14	8	7.6	N/A	N/A	14
22	790	390	190	4.16	4	0.96	S	10.0	9.8	2.6	26	30.3	-	Coarse	Block	20.3	0.8	11.1	10.7	0.3	2	3	10.2	10.1	1.01	2
23	590	390	190	3.11	3	0.91	N	10.0	10.8	1.0	9	42.1	2.1	Coarse	Block	23.6	1.9	17.1	15.5	2.6	17	2	11.2	8.0	1.40	17
	590	390	190	3.11	3	0.91	S	10.0	27.8	1.3	5	42.1	2.1	Coarse	Block	23.6	1.9	17.8	16.1	1.3	8	3	14.0	11.3	1.24	8
	590	390	190	3.11	3	0.91	N	20.0	10.8	1.0	9	42.1	2.1	Coarse	Block	23.6	1.9	17.5	15.9	0.7	5	3	14.7	8.0	1.83	5
	590	390	190	3.11	3	0.91	N	10.0	10.8	1.0	9	42.1	2.1	Coarse	Block	23.6	1.9	15.0	13.6	0.4	3	3	12.9	8.0	1.61	3
	590	390	190	3.11	3	0.91	N	10.0	10.8	1.0	9	38.5	6.0	Coarse	Block	23.6	1.9	17.2	15.6	1.4	9	3	13.3	8.0	1.66	9
	590	390	190	3.11	3	0.91	N	10.0	10.8	1.0	9	42.1	2.1	Coarse	Block	23.6	1.9	17.1	15.5	2.6	17	2	11.2	8.0	1.40	17
24	590	390	190	3.11	3	0.91	N	10.0	10.8	1.0	9	30.2	1.5	Fine	Block	23.6	1.9	15.7	14.3	1.1	8	3	12.5	8.0	1.55	8
	390	390	190	2.05	2	0.81	S	10.0	18.8	2.7	14	30.4	-	Fine	Block	19.2	-	18.8	15.1	1.8	12	3	12.3	9.6	1.28	12
	590	390	190	3.11	3	0.91	S	10.0	18.8	2.7	14	30.4	-	Fine	Block	19.2	-	14.9	13.5	1.3	10	3	11.4	9.6	1.19	10
	790	390	190	4.16	4	0.96	S	10.0	18.8	2.7	14	30.4	-	Fine	Block	19.2	-	14.5	13.9	0.1	1	3	13.8	9.6	1.43	1
25	990	390	190	5.21	5	1.00	S	10.0	18.8	2.7	14	30.4	-	Fine	Block	19.2	-	13.0	13.0	0.5	4	3	12.3	9.6	1.28	4
	790	390	190	4.16	4	0.96	S	10.0	-	-	-	64.9	-	Fine	Block	24.4	2.8	17.1	16.4	2.2	13	3	12.8	11.5	1.11	13
	386	185	90	4.29	4	0.96	S	10.0	-	-	-	67.1	-	Fine	Block	29.2	1.6	17.4	16.8	2.1	12	3	13.4	13.2	1.01	12
26	154	51	51	3.03	3	0.90	S	2.5	13.9	-	-	22.8	-	Fine	Block	23.7	1.4	17.7	15.9	2.1	12	5	12.4	11.3	1.10	12
	154	51	51	3.03	3	0.90	S	2.5	11.9	-	-	22.8	-	Fine	Block	23.7	1.4	18.1	16.3	0.7	4	3	15.3	11.3	1.35	4
	154	51	51	3.03	3	0.90	N	2.5	7.7	-	-	22.8	-	Fine	Block	23.7	1.4	17.9	16.2	0.7	4	3	15.0	8.1	1.86	4
	154	51	51	3.03	3	0.90	S	2.5	13.9	-	-	33.6	-	Fine	Block	23.7	1.4	22.3	20.1	1.8	8	3	17.1	11.3	1.51	8
	154	51	51	3.03	3	0.90	S	2.5	13.9	-	-	10.2	-	Fine	Block	23.7	1.4	13.1	11.8	2.0	15	3	8.5	11.3	0.76	15
	152	102	51	3.	3	0.90	S	2.5	16.9	-	-	23.3	-	Fine	Block	24.0	2.0	18.5	16.6	1.1	6	3	14.9	11.4	1.31	6
	203	102	51	4.	4	0.95	S	2.5	16.9	-	-	23.3	-	Fine	Block	24.0	2.0	18.3	17.4	0.2	1	3	17.0	11.4	1.49	1
	254	102	51	5.	5	1.00	S	2.5	16.9	-	-	23.3	-	Fine	Block	24.0	2.0	17.3	17.3	1.6	9	3	14.7	11.4	1.29	9
	152	102	51	3.	3	0.90	S	2.5	16.9	-	-	23.3	-	Fine	Block	24.0	2.0	19.1	17.2	0.8	4	3	15.8	11.4	1.39	4
254	102	51	5.	5	1.00	S	2.5	16.9	-	-	23.3	-	Fine	Block	24.0	2.0	16.6	16.6	0.2	1	3	16.2	11.4	1.42	1	
27	390	390	190	2.05	2	0.81	S	9.5	21.5	-	-	20.1	-	Coarse	Block	21.6	-	21.6	17.4	-	-	2	17.4	10.6	1.65	-
	590	390	190	3.11	3	0.91	S	9.5	21.5	-	-	20.1	-	Coarse	Block	21.6	-	19.2	17.3	-	-	2	17.3	10.6	1.64	-
	790	390	190	4.16	4	0.96	S	9.5	21.5	-	-	20.1	-	Coarse	Block	21.6	-	19.7	18.8	-	-	2	18.8	10.6	1.79	-

	990	390	190	5.21	5	1.00	S	9.5	21.5	-	-	20.1	-	Coarse	Block	21.6	-	18.6	18.6	-	-	1	18.6	10.6	1.77	-
	390	390	140	2.79	4	0.88	S	9.5	21.5	-	-	20.1	-	Coarse	Block	24.7	-	39.9	35.1	-	-	2	35.1	11.6	3.01	-
	590	390	140	4.21	6	0.96	S	9.5	21.5	-	-	20.1	-	Coarse	Block	24.7	-	36.4	35.0	-	-	2	35.0	11.6	3.00	-
	790	390	140	5.64	8	1.00	S	9.5	21.5	-	-	20.1	-	Coarse	Block	24.7	-	33.3	33.3	-	-	1	33.3	11.6	2.86	-
28	406	216	203	2.	2	0.80	S	9.5	14.0	0.3	2	24.3	1.9	Coarse	Block	14.1	0.9	15.3	12.2	0.3	2	3	11.7	7.1	1.66	2
	406	216	203	2.	2	0.80	S	9.5	14.0	0.3	2	25.4	0.4	Coarse	Block	23.3	1.1	17.7	14.1	0.7	4	3	13.0	11.2	1.16	4
	406	216	203	2.	2	0.80	S	9.5	14.0	0.3	2	42.9	0.7	Coarse	Block	38.0	0.8	26.5	21.2	1.1	4	3	19.5	16.3	1.20	4
	406	216	203	2.	2	0.80	N	9.5	6.7	0.4	5	24.3	1.9	Coarse	Block	14.1	0.9	14.0	11.2	0.6	5	3	10.2	5.7	1.77	5
	406	216	203	2.	2	0.80	N	9.5	6.7	0.4	5	25.4	0.4	Coarse	Block	23.3	1.1	16.4	13.1	0.6	3	3	12.2	8.0	1.52	3
	406	216	203	2.	2	0.80	N	9.5	6.7	0.4	5	42.9	0.7	Coarse	Block	38.0	0.8	24.6	19.7	0.4	2	3	19.0	10.2	1.86	2
29	980	390	190	5.16	5	1.00	S	10.0	11.4	-	-	27.8	-	Coarse	-	27.8	-	26.7	26.7	0.6	2	3	25.7	12.7	2.02	2
30	390	390	190	2.05	2	0.81	S	10.0	16.5	-	-	15.4	-	Coarse	-	10.5	-	6.8	5.5	-	-	3	5.5	5.3	1.04	-
	590	390	190	3.11	3	0.91	S	10.0	16.5	-	-	15.4	-	Coarse	-	10.5	-	6.0	5.4	-	-	3	5.4	5.3	1.03	-
	790	390	190	4.16	4	0.96	S	10.0	16.5	-	-	15.4	-	Coarse	-	10.5	-	5.9	5.7	-	-	3	5.7	5.3	1.08	-
31	590	390	190	3.11	3	0.91	S	10.0	31.9	-	-	35.1	-	Coarse	Cubes	18.1	-	22.0	19.9	0.7	3	3	18.9	9.1	2.08	3
32	590	390	190	3.11	3	0.91	S	10.0	25.7	-	-	24.5	-	Coarse	Metal	17.6	-	18.4	16.7	-	-	6	16.7	8.8	1.90	-
	590	390	190	3.11	3	0.91	S	10.0	29.0	-	-	23.0	-	Coarse	Metal	17.6	-	14.8	13.4	-	-	6	13.4	8.8	1.52	-
	590	390	190	3.11	3	0.91	S	10.0	39.4	-	-	29.6	-	Coarse	Metal	17.6	-	14.9	13.5	-	-	6	13.5	8.8	1.53	-
	590	390	190	3.11	3	0.91	S	10.0	25.7	-	-	24.5	-	Coarse	Metal	22.9	-	20.8	18.8	-	-	6	18.8	11.0	1.71	-
	590	390	190	3.11	3	0.91	S	10.0	25.7	-	-	23.0	-	Coarse	Metal	22.9	-	22.9	20.7	-	-	6	20.7	11.0	1.88	-
	590	390	190	3.11	3	0.91	S	10.0	29.0	-	-	23.0	-	Coarse	Metal	22.9	-	20.7	18.7	-	-	6	18.7	11.0	1.70	-
	590	390	190	3.11	3	0.91	S	10.0	29.0	-	-	29.6	-	Coarse	Metal	22.9	-	21.4	19.4	-	-	6	19.4	11.0	1.76	-
	590	390	190	3.11	3	0.91	S	10.0	39.4	-	-	29.6	-	Coarse	Metal	22.9	-	21.7	19.7	-	-	6	19.7	11.0	1.78	-
	590	390	190	3.11	3	0.91	S	10.0	39.4	-	-	23.0	-	Coarse	Metal	22.9	-	20.0	18.1	-	-	6	18.1	11.0	1.64	-
	590	590	190	3.11	3	0.91	S	10.0	25.7	-	-	24.5	-	Coarse	Metal	19.0	-	16.2	14.7	-	-	6	14.7	9.5	1.55	-
	590	590	190	3.11	3	0.91	S	10.0	29.0	-	-	23.0	-	Coarse	Metal	19.0	-	18.3	16.5	-	-	6	16.5	9.5	1.74	-
33	590	390	190	3.11	3	0.91	S	10.0	-	-	-	29.2	-	Coarse	-	14.8	-	12.7	11.5	-	-	1	11.5	7.4	1.56	-
	590	390	190	3.11	3	0.91	S	10.0	-	-	-	39.8	-	Coarse	-	14.8	-	12.6	11.4	-	-	1	11.4	7.4	1.54	-
	590	390	190	3.11	3	0.91	S	10.0	-	-	-	29.2	-	Coarse	-	41.6	-	25.3	22.9	-	-	1	22.9	17.0	1.35	-
	590	390	190	3.11	3	0.91	S	10.0	-	-	-	39.8	-	Coarse	-	41.6	-	24.5	22.2	-	-	1	22.2	17.0	1.30	-
	590	390	190	3.11	3	0.91	S	10.0	-	-	-	29.2	-	Coarse	-	31.4	-	27.2	24.6	-	-	1	24.6	14.0	1.76	-
	590	390	190	3.11	3	0.91	S	10.0	-	-	-	39.8	-	Coarse	-	31.4	-	30.7	27.8	-	-	1	27.8	14.0	1.99	-
34	390	390	190	2.05	2	0.81	S	10.0	-	-	-	28	-	Coarse	-	16.5	-	18.5	14.9	-	-	4	14.9	8.3	1.81	-
	390	390	190	2.05	2	0.81	S	10.0	-	-	-	28	-	Coarse	-	16.5	-	23.8	19.2	-	-	17	19.2	8.3	2.32	-