STATISTICAL ANALYSIS OF COMPRESSIVE STRENGTH OF CLAY BRICK MASONRY PRISMS

by

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Dedication

To my late father Dr. M.H. Afghahi who taught me the basics of math, to my mother, Soroush, who always made sure I did my homework in my younger years, and my sister, Sanaz, for her emotional support.

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ABSTRACT

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OF CLAY BRICK MASONRY PRISMS

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The *Specification for Masonry Structures* section of the current governing masonry design document in the U.S., reported by the Masonry Standards Joint Committee (MSJC), contains tables that can be used to determine the compressive strength of masonry, f'_m, as a function of the mortar type and the compressive strength of the unit employed to construct the masonry (option #1). Alternatively, the compressive strength of brick masonry can be established by testing small specimens called prisms according to ASTM standardized procedures for construction and testing (option #2). However, the majority of the data gathered to create the current values for option #1 were generated in studies done prior to 1970. There have been significant changes in materials and procedures since this time frame. Thus, there is a need to

gather and study more recent data that reflect the current type of material typically used at construction sites today, explore various potential influencing factors, and determine how significantly these factors affect the masonry prism compressive strengths. Finally, the results of this study can lead to ways the current design tables can be enhanced, and establish the areas where more research and testing are required.

In this study, clay brick masonry prism test data since 1980 was collected in a database. Several factors that could potentially affect the prism compressive strengths were identified (predictor variables) and their effects were statistically analyzed. These factors consisted of prism height to thickness ratio, brick unit compressive strength, mortar type, hollow versus solid brick units, mortar joint thickness, and the use or absence of grout in prisms. In a factorial design, a number of levels (in this research levels would be combinations of qualitative predictors) are selected by an investigator and experiments are run with all possible combinations. As the dataset in this investigation was observational and not a factorial design certain simplifications had to be made. Also, data for a range of brick unit compressive strength was missing and further testing was performed to fill that gap. Several mathematical models were developed to analyze the data. The models explored the relationship between the prism compressive strength and the predictor variables and the interactions between the predictor variables. Based on this analysis, suggestions were made on how to improve the existing masonry compressive strength design tables to reflect the contemporary material used in construction.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 Background

It is important in masonry design to determine the appropriate ultimate compressive strength of the masonry material. Designers can use an assumed compressive strength (option #1) or have tests (option #2) conducted to establish a more accurate and typically higher value. Option #2 tests are done on masonry prisms, which are small assemblages representing the actual construction, to determine the masonry ultimate compressive strength. The minimum and maximum prism sizes are dictated by the governing code and the capability of the testing apparatus. Once the test results are obtained, they can be used in the design of the masonry.

1.1.1 Current MSJC Design Values

In various design codes one can find tabular values of compressive strength for masonry as a function of the mortar type (M, S, or N as defined in ASTM C 270-03b (29)) and the unit compressive strength. In ACI 530.1-05 (Specification for Masonry Structures)(25), presented in Table 1.1, the compressive strength of masonry is based on the compressive strength of clay masonry units and type of mortar used in construction.

Table 1.1: Compressive Strength of Masonry- ACI 530.1-05

Net area compressive strength of clay masonry units, psi (MPa)		Net area compressive strength of masonry, psi (MPa)
Type M or S mortar	Type N mortar	
1700 (11.72)	2100 (14.48)	1000 (6.90)
3350 (23.10)	4150 (28.61)	1500 (10.34)
4950 (34.13)	6200 (42.75)	2000 (13.79)
6600 (45.51)	8250 (56.88)	2500 (17.24)
8250 (56.88)	10,300 (71.02)	3000 (20.69)
9900 (68.26)	---	3500 (24.13)
13,200 (91.01)	---	4000 (27.58)

It is stated in the Commentary on Specification for Masonry Structures, ACI 530.1-05 (26), that compressive strength of clay masonry values in Table 1.1 were derived using Equation 1.1 from Reference # 24.

$$f'_m = A(400 + Bf_u) \qquad \text{Equation 1.1}$$

where

A = 1 (inspected masonry)

B = 0.2 for Type N Portland cement-lime mortar, 0.25 for Type S or M Portland cement-lime mortar

f_u = average compressive strength of brick, psi

f'_m = specified compressive strength of masonry

(Equation 1.1 is for inch-pound units only)

However, the values in Table 1.1 are based on prisms with height-to-thickness ratios (h/t ratio) of 2 and Equation 1.1 is based on prisms with height-to-thickness ratios of 5. Since smaller h/t ratios yield higher compressive strengths, the values in Table 1.1

represent Equation 1.1 values adjusted by a factor of 1.22 (increase of 22%), see Table 1.2.

The data that is the basis for Equation 1.1 (h/t ratio=5) and Table 1.1 (h/t ratio=2) is from the following sources:

1) "Recommended Practice for Engineered Brick Masonry," Brick Institute of America (formerly Structural Clay Products Association), Reston, VA, 1969.

2) Brown. R.H. and Borchelt, J.G., "Compression Tests of Hollow Brick Units and Prisms," Masonry Components to Assemblages, ASTM STP 1063, J.H. Matthys, editor, American Society for Testing and Materials, Philadelphia, PA, 1990, p.p. 263-278.

The data presented in source No. 1 is itself based on reports and studies performed earlier than 1970. Therefore, there is a need to investigate the relationship between the prism strength and the influencing factors using more recent data to either confirm or improve the current masonry compressive strength design table in the MSJC Specification.

American Society for Testing and Materials (ASTM) standard C 1314-03b is the current standard test method for determining the compressive strength of masonry prisms. Under this standard, masonry prisms are to consist of a minimum of two units with a height-to-thickness ratio (h/t, ratio of prism height to least lateral dimension of prism) between 1.3 and 5.0. ASTM C1314-03b offers correction factors for masonry prism compressive strength based on the height-to-thickness ratio of the prisms, see Table 1.2. This standard uses a height-to-thickness ratio of 2 for the basic prism compressive strength, f'_m.

Table 1.2: Prism Compressive Strength Correction Factors- ASTM C 1314-03b

h/t	1.3	1.5	2.0	2.5	3.0	4.0	5.0
Correction Factor	0.75	0.86	1.0	1.04	1.07	1.15	1.22

Other potential influencing factors should be looked at in conjunction with the h/t ratio to develop the appropriate prism correction factors. In this research the following criteria were attempted to be collected and analyzed for each test:

- Unit properties:
  - Solid versus hollow,
  - Unit compressive strength,
- Mortar properties:
  - Mortar joint thickness,
  - Mortar mix (Portland cement lime, mortar cement, masonry cement),
  - Mortar type (M, S, or N),
  - Bedding (full-bed or face-shell),
  - Mortar cube strength,
- Prism properties:
  - Height-to-thickness ratio,
  - Ultimate compression load,
  - Prism compressive strength,
  - Curing method,
  - Curing time,
- Grout properties:

    - Presence or absence of grout,
    - Grout type (fine, coarse, or self-consolidating),
    - Grout strength.

Due to limited availability of data the most comprehensive mathematical model developed in this research – Model "A" – explores the following predictor variables:

- The compressive strength of the clay masonry units,
- Curing method (moist cured: cured in sealed bags, air cured: cured in room air, and moist/air cured: moist cured for the first seven days and air dried for the remaining of their curing period),
- Curing time (7 or 28 days),
- Mortar type: M, S, or N (compressive strength),
- Presence or lack of grout in the assemblage,
- Units being solid or hollow (solid units have net areas equal to or greater than 75% of their gross areas, and hollow units have net areas less than 75% of their gross areas),
- Mortar joints being face-shell or full-bed (full-bed is when mortar is placed the total face bed of the unit, and face-shell is when mortar is placed on face shells only),
- Height-to-thickness ratio (h/t ratio).

Due to limited information and the current testing standards six other models were developed that either eliminate or ignore certain predictor variables to create less complex mathematical relationships.

CHAPTER 2

LITERATURE SURVEY

2.1 Available Clay Brick Prism Compressive Strength Test Data

There have been numerous studies done on the behavior of masonry prisms under axial compression. The effects of variables such as the height-to-thickness ratio of the prism, mortar type and grout strength, unit geometry, and various capping compounds have been the point of focus of many researchers. Most of the research reports have been presented and published in various conferences around the globe; however, some are unpublished. Some of the data that is the basis of the formula, the graphs, and the design tables presented in various parts of the Masonry Standards Joint Committee (MSJC) specification were the result of research done by the former Brick Institute of America, now the Brick Industry Association (BIA).

The bulk of the available clay brick prism compressive strength data is contained within the public domain. Various publications and sources were used to compile a thorough database of such data. MSJC has assembled a "Unit Strength Task Group" that is in charge of collecting and analyzing the entire concrete masonry prism compressive strength test results available, and updating the concrete masonry compressive strength design table in the MSJC Specification. Through communication with the chairperson of the Task Group and other BIA personnel, the author was given the opportunity to collect the corresponding data for clay brick prisms. Upon analysis and further required testing, modifications to the existing design table are proposed. The complied database used in this research contains the North American prism test data performed after 1980 to better represent the current material available on the market. The collection of the following information for each test (if available) was agreed upon by the MSJC Unit Strength Task Group.

Unit properties: masonry type (clay or concrete), unit geometry, number of units in prism, unit strength

- Mortar properties: mortar mix (Portland cement-lime, masonry cement, mortar cement), mortar type by specifications or by properties as specified in ASTM C 270-03b (M, S, or N), bedding (face shell, or full mortar bedding), and mortar cube strength.
- Prism Properties: prism height-to-thickness ratio, net area, ultimate load, prism strength, modulus of elasticity, curing method and curing duration.
- Grout: presence or lack of grout.

In an effort to collect all the available test data the following sources were reviewed:

1) Proceedings of North American Masonry Conferences,
2) Proceedings of Canadian Masonry Symposiums,
3) Proceedings of International Brick and Block Masonry Conferences,
4) Proceedings of International Masonry Conferences,
5) The Masonry Society (TMS) Journals,
6) The ASTM Special Technical Publications (STP),

7) Unpublished test reports in Research Reports done by BIA formerly known as Structural Clay Products Institute.

8) Published & unpublished reports from Atkinson-Noland & Associates, Inc. library.

9) Papers from the National Concrete Masonry Association library.

10) Specification for Masonry Structures reported by Masonry Standards Joint Committee,

11) Commentary on Specification for Masonry Structures reported by Masonry Standards Joint Committee.

The collected data is presented in Appendix A of this report.

2.1.1. Current Design Values

As described earlier in Chapter 1, the Commentary on Specification for Masonry Structures of ACI 530.1-05 presents an equation (Equation 1.1) that is the basis of the values for compressive strength in Table 1.1. There are also two graphs in the aforementioned Specification that show the data points that are the basis for the developed Equation 1.1. The first step in the analysis was to generate a graph using data from the same references used in the MSJC Specification, see Figure 2.1, and compare it with the graph in the Commentary. The prism compressive strengths in Figure 2.1 are not modified using correction factors based on their height-to-thickness ratios. The graph in Figure 2.1 generated by the author and the one from the MSJC Commentary are in agreement. The next step is to compile a database following the guidelines set for this research and find the areas where further testing might be of needed.

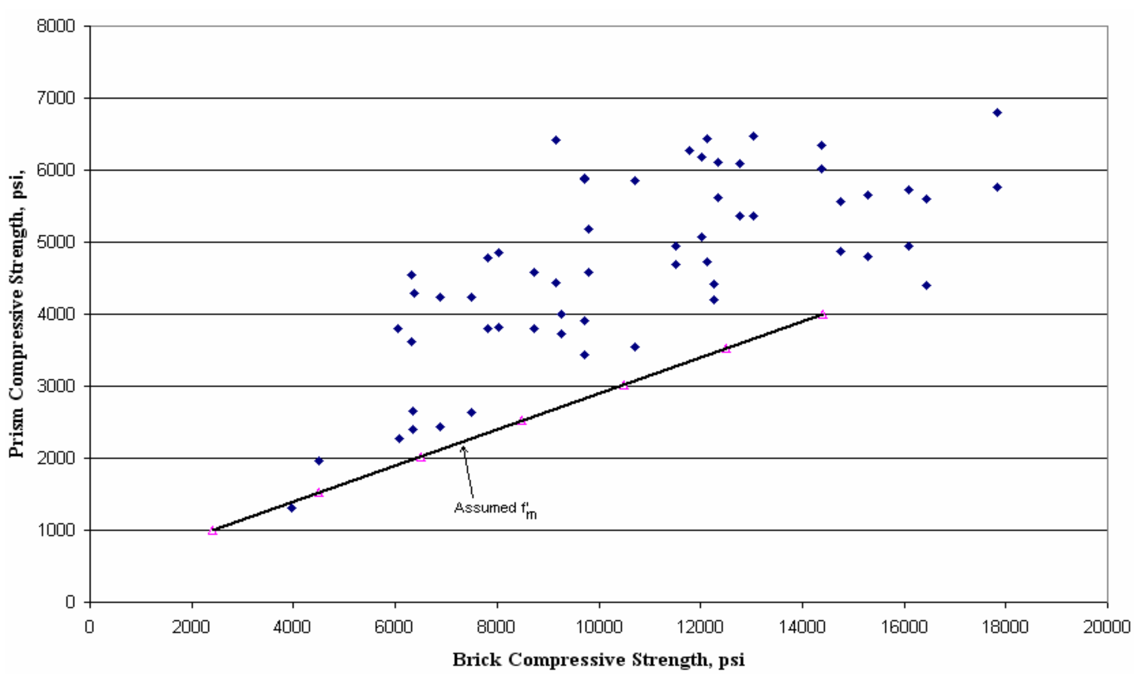

Figure 2.1: Collected Data from MSJC References: Prism Compressive Strength versus Unit Compressive Strength (Type S Mortar, Commercial & SCPI Laboratories).

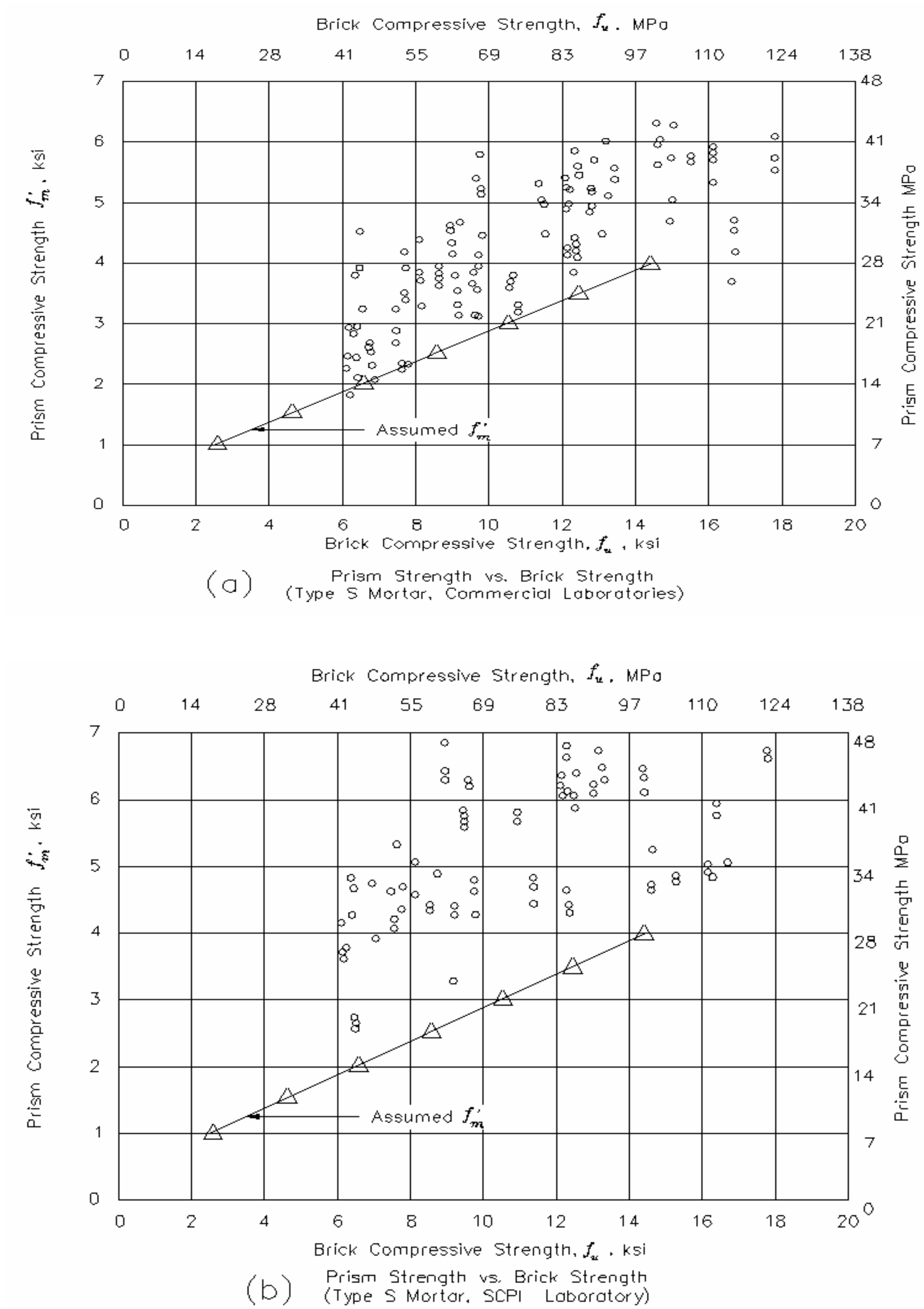

Figure 2.2: Prism Compressive Strength versus Unit Compressive Strength (Type S Mortar, Commercial & SCPI Laboratories)(26).

2.1.2. Is any Additional Testing Required?

Are current values in the MSJC Specification accurate in light of current marketplace materials and test standards? Should they be increased or decreased based on new data? Are there any gaps in the current data that need to be addressed? These are some of the questions that need to be answered to determine whether further testing and analysis are justified.

The clay masonry compressive strength design table in the current MSJC Specification, see Table 1.1, covers a unit compressive strength range of 1,700 psi to 13,200 psi for Types M & S mortars and 2,100 psi to 10,300 psi for Type N mortar, and the associated compressive strengths are based on prisms compressive strengths adjusted to h/t ratio of two. The North American data available after 1980 was used to generate graphs in Figures 2.3, 2.4, and 2.5. As is evident in these graphs, there is a void in prism test data in the lower unit compressive strength ranges. These ranges, described below, are the areas where additional testing should be performed to carry out a more reliable statistical analysis.

1) In Figure 2.2, mortar type M, additional data is needed for unit compressive strengths between 4,000 and 8,000 psi.
2) In Figure 2.3, mortar type S, additional data is needed for unit compressive strengths between 5,000 and 8,000 psi.
3) In Figure 2.4, mortar type N, additional data is needed for unit compressive strengths between 4,000 and 8,000 psi.

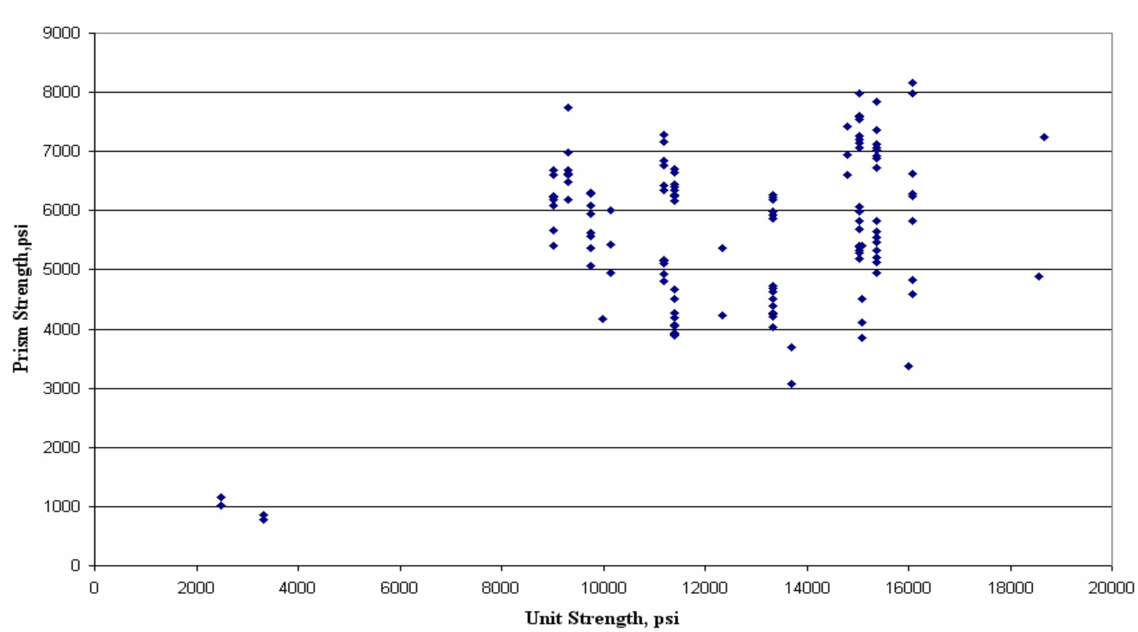

Figure 2.3: Uncorrected Prism Compressive Strength versus Unit Compressive Strength (Type M Mortar, Since 1980).

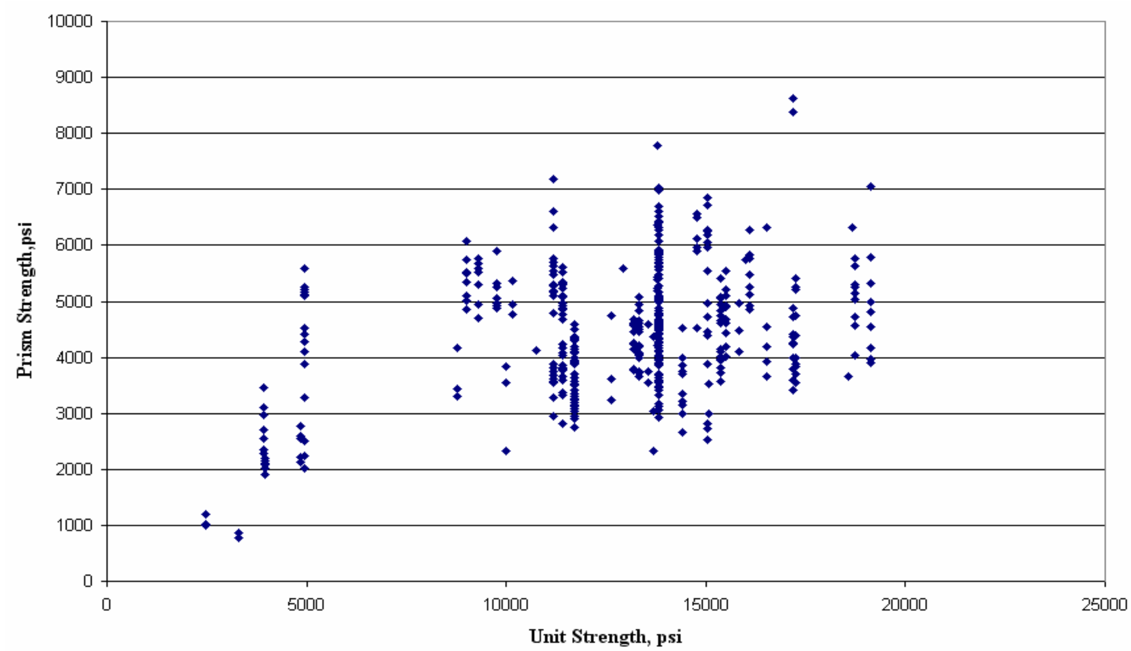

Figure 2.4: Uncorrected Prism Compressive Strength versus Unit Compressive Strength (Type S Mortar, Since 1980).

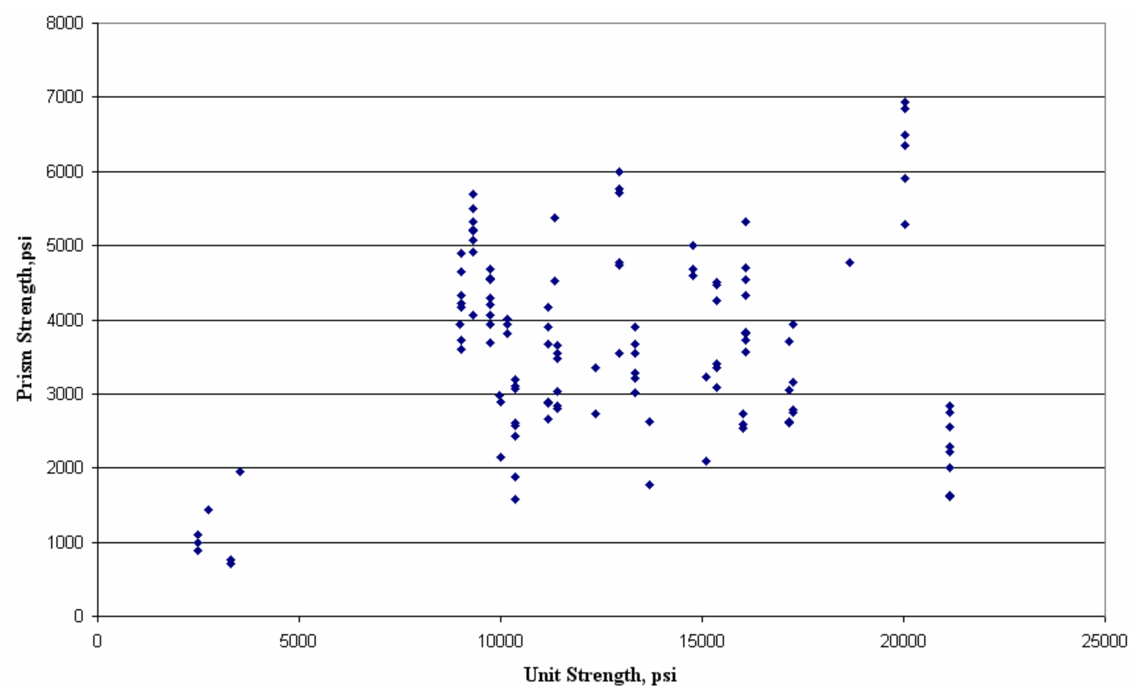

Figure 2.5: Uncorrected Prism Compressive Strength versus Unit Compressive Strength (Type N Mortar, Since 1980).

CHAPTER 3

PRISM TESTS

3.1 Procedures and Standards

As described in Chapter 2, a range of unit compressive strengths for further prism testing was identified for each mortar type. Three types of brick were chosen for additional testing. Approximately sixty prisms were built with each type of brick; ten prisms for each of the six mortar types. For the ten prisms for each mortar type, five had an approximate height-to-thickness (h/t) ratio of five, and five had an approximate h/t ratio of two.

Overall, a total of 179 (one short of 180 due to insufficient number of available type "C" bricks) prisms were built and tested. All the applicable ASTM standards were followed in building, curing, capping, and testing of the prisms and the components, as follows:

ASTM C1552-03a: Standard Practice for Capping Concrete Masonry Units, Related Units and Masonry Prisms for Compression testing.

ASTM C1314-03b: Standard Test Method for Compressive Strength of Masonry Prisms.

ASTM C270-03b: Standard Specification for Mortar for Unit Masonry.

ASTM C216-04b: Standard Specification for Facing Brick (Solid Masonry Units Made from Clay or Shale).

ASTM C67-03a: Standard Test Methods for Sampling and Testing Brick and Structural Clay Tile.

3.2 Material

3.2.1. Brick

The properties of the three types of brick (named A, B, and C) used in prism construction are tabulated in Tables 3.1, 3.2, and 3.3. The units are shown in Figures 3.1, 3.2, and 3.3. All the units used in testing had a net area that exceeded 75% of their gross area. Thus, the compressive strength of the units are calculated based on their gross areas,

Note: The following apply to Tables 3.1, 3.2, and 3.3:
IRA: Initial Rate of Absorption, expressed in grams per minute per 30 in^2.
Cold Water Abs.: Absorption after unit is submerged in cold water for 24 hrs.
Boiling Water Abs.: Absorption after unit is submerged in boiling water for 5 hrs.
Sat. Coef.: Saturation Coefficient (ratio of cold water absorption to boiling water absorption),
Net/Gross Area: The net area of the unit divided by its gross area.
Gross Area: The area of the unit including the openings (cores).
Net Area: The area of the unit excluding the area of the cores.
Ultimate Compressive Strength: Calculated using the gross area of the unit, psi.

Table 3.1: Clay Brick Unit "A" Properties

Unit Brick	IRA	Cold Water Abs., %	Boiling Water Abs., %	Sat. Coef.	Net/Gross Area, %	Ultimate Compressive Strength, psi
A1	29.85	12.2	16.2	0.75	85	7596
A2	30.19	11.3	15.4	0.74	84	9761
A3	20.75	9.1	12.7	0.71	86	10307
A4	30.81	12.0	16.1	0.75	86	7317
A5	30.79	11.9	16.1	0.74	86	8468
AVERAGE	**28.48**	**11.3**	**15.3**	**0.74**	**85**	**8690**
C.O.V.	**-**	**-**	**-**	**-**	**-**	**15.1%**

Table 3.2: Clay Brick Unit "B" Properties

Unit Brick	IRA	Cold Water Abs., %	Boiling Water Abs., %	Sat. Coef.	Net/Gross Area, %	Ultimate Compressive Strength, psi
B1	16.95	5.4	8.7	0.62	81	8906
B2	10.79	5.1	8.7	0.59	81	7403
B3	14.38	5.1	8.7	0.59	81	7786
B4	12.94	5.2	8.6	0.60	80	8788
B5	16.36	5.1	8.5	0.60	81	7934
AVERAGE	**14.28**	**5.2**	**8.6**	**0.60**	**81**	**8163**
C.O.V.	**-**	**-**	**-**	**-**	**-**	**8.0%**

Table 3.3: Clay Brick Unit "C" Properties

Unit Brick	IRA	Cold Water Abs., %	Boiling Water Abs., %	Sat. Coef.	Net/Gross Area, %	Ultimate Compressive Strength, psi
C1	50.98	7.8	11.3	0.69	81	4738
C2	46.43	6.2	9.3	0.67	80	5715
C3	52.77	7.1	10.1	0.70	80	5320
C4	45.39	6.9	9.7	0.71	81	5477
C5	45.73	7.2	10.6	0.68	81	5392
AVERAGE	**48.26**	**7.2**	**8.3**	**0.69**	**81**	**5328**
C.O.V.	**-**	**-**	**-**	**-**	**-**	**6.8%**

The capped half bricks in Figures 3.1 and 3.2 were used for compressive strength testing, and the other halves were used to determine the other physical properties of the units. Bricks were capped and tested for their compressive strengths in accordance with the applicable ASTM standards. A brick unit being tested is shown in Figure 3.4.

For brick types “A” and “B” half bricks and for type “C” brick full bricks were used to determine the physical properties of the units shown in Tables 3.1, 3.2 and 3.3.

Figure 3.1: Brick Unit “A”.

Figure 3.2: Brick Unit “B”.

Figure 3.3: Brick Unit “C”.

Figure 3.4: Brick Unit Being Tested.

3.2.2. Mortar

Six types of mortar were used in the construction of the prisms. The mortars were prepared using the *Proportion Specification Requirements* of ASTM C270-03b.

The mortar types and the proportions used are as follows:

- Portland Cement-Lime Type S: One part Portland cement, one-half part lime, four and a half part sand,
- Mortar Cement-Type S: One part mortar cement type S, three parts sand,
- Masonry Cement-type S: One part masonry cement type S, three parts sand,
- Portland Cement-Lime Type N: One part Portland cement, one part lime, 6 parts sand,
- Mortar Cement Type N: One part mortar cement type N, three parts sand,
- Masonry Cement Type N: One part masonry cement type N, three parts sand.

The products used are shown in Figures 3.5 thru 3.10.

- Type I/II Portland Cement manufactured by TXI Operations,
- Morta-Lok Type S Masons Hydrated Lime manufactured by Rockwell Lime Company,
- Hill Country Mortar Cement Type S manufactured by Headwaters Construction Materials,
- Best Masonry Cement Type S manufactured by Headwaters Construction Materials,
- Hill Country Mortar cement Type N manufactured by ISG Resources,
- Masonry Cement Type N manufactured by TXI Operations.

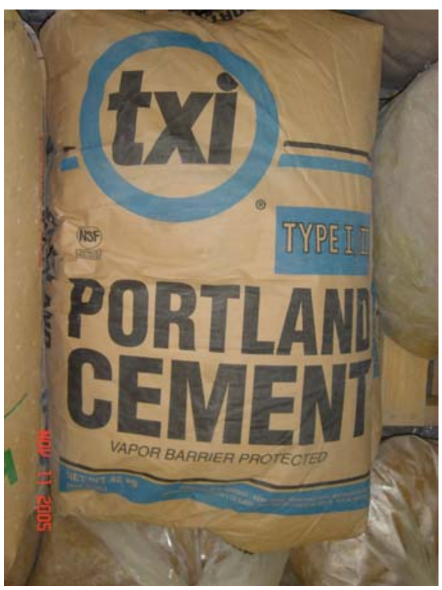

Figure 3.5: Portland Cement Type I/II.

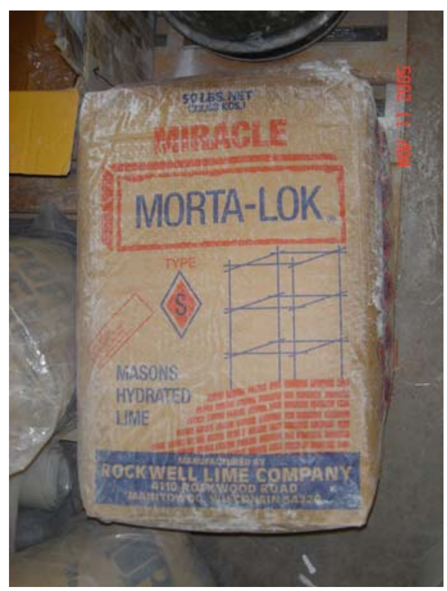

Figure 3.6: Lime.

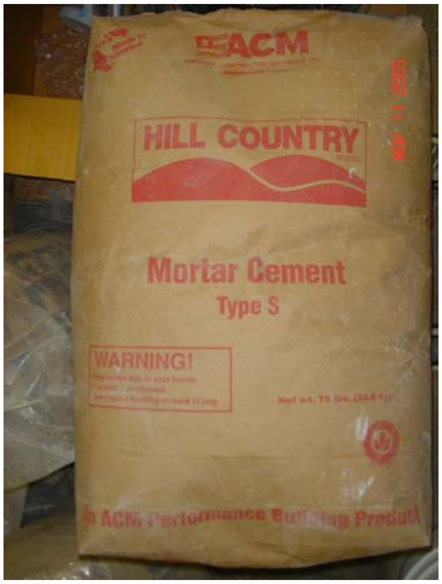

Figure 3.7: Mortar Cement Type S.

Figure 3.8: Masonry Cement Type S.

Figure 3.9: Masonry Cement Type N.

Figure 3.10: Mortar Cement Type N.

Three 2”x2”x2” cubes were prepared for each type of mortar, bag-cured and tested after 28 days along with prisms. The results are shown in Tables 3.4, 3.5, and 3.6 for Bricks “A”, “B”, And “C”, respectively.

Note: The following apply to Tables 3.4, 3.5, and 3.6.

Mortar type S1: Portland cement-lime type S

Mortar type S2: Mortar cement type S

Mortar type S3: Masonry cement type S

Mortar type N1: Portland cement-lime type N

Mortar type N2: Mortar cement type N

Mortar type N3: Masonry cement type N

Mortar cubes being prepared, prior to testing, and after testing are shown in Figures 3.11, 3.12, 3.13, and 3.14.

Table 3.4: Mortar Cube Compressive Strength, Brick “A”

Mortar Type	Cube #1, psi	Cube #2, psi	Cube #3, psi	Average, psi	Standard Deviation, psi	C.O.V., %
S1	2658	2850	2634	2714	118.4	4.4
S2	2150	2434	2277	2287	142.3	6.2
S3	1829	1718	1755	1767	56.5	3.2
N1	1247	1207	-	1227	28.3	2.3
N2	1201	1241	1167	1203	37.0	3.1
N3	1230	1261	1310	1267	40.3	3.2

Table 3.5: Mortar Cube Compressive Strength, Brick "B"

Mortar Type	Cube #1, psi	Cube #2, psi	Cube #3, psi	Average, psi	Standard Deviation, psi	C.O.V., %
S1	2635	2690	2786	2704	76.4	2.8
S2	1943	1730	1910	1861	114.6	6.2
S3	1363	1317	1469	1383	77.9	5.6
N1	1617	1479	1457	1517	86.7	5.7
N2	1262	1212	1236	1237	25.0	2.0
N3	1042	1060	1038	1047	11.7	1.1

Table 3.6: Mortar Cube Compressive Strength, Brick "C"

Mortar Type	Cube #1, psi	Cube #2, psi	Cube #3, psi	Average, psi	Standard Deviation, psi	C.O.V., %
S1	2101	1907	1846	1952	133.2	6.8
S2	2082	1832	2122	2012	157.2	7.8
S3	1218	1260	1331	1270	57.1	4.5
N1	1170	933	1103	1069	122.2	11.4
N2	867	876	812	851	34.6	4.1
N3	838	735	656	743	91.3	12.3

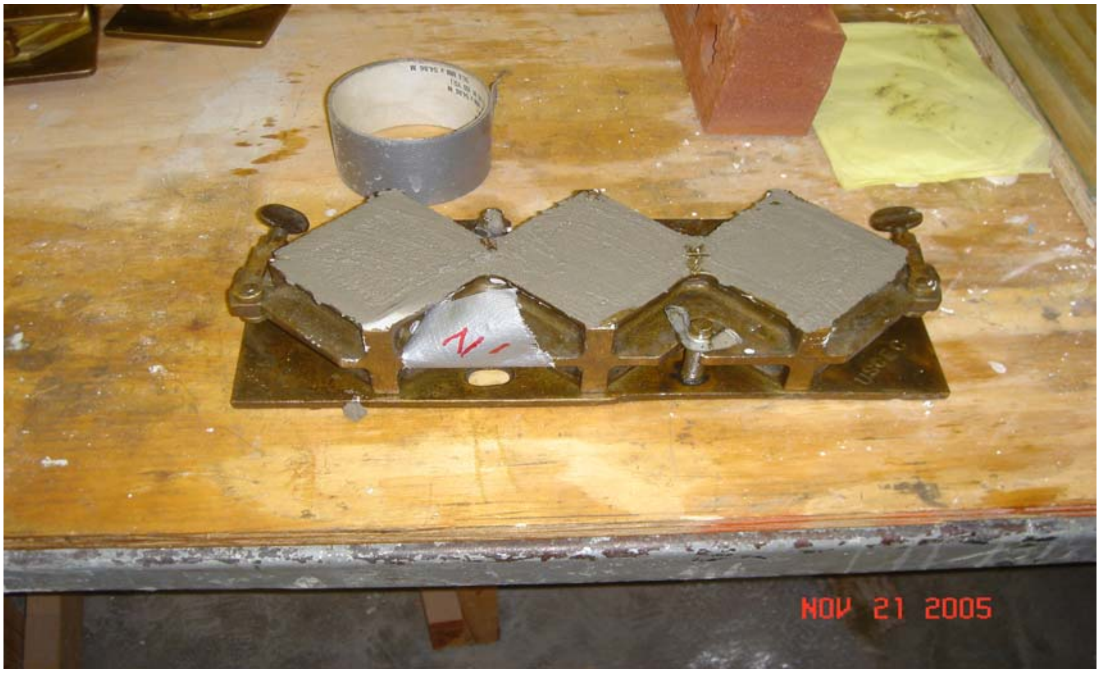

Figure 3.11: Mortar Cubes Being Prepared.

Figure 3.12: Mortar Cubes Prior to Testing.

Figure 3.13: A Mortar Cube after Testing.

Figure 3.14: A Mortar Cube after Testing.

Table 3.7: Properties of Mortar

* Mortar Type	Water, lbs	Flow, %	Cone Pentrometer, mm	**Air, %
S-1-A	32.00	137	66	1.3
S-2-A	28.50	128	58	2.7
S-3-A	27.75	128	65	2.5
N-1-A	35.80	125	67	1.0
N-2-A	30.50	134	69	1.5
N-3-A	26.20	138	70	11.0
S-1-B	31.25	129	66	1.1
S-2-B	27.50	125	66	1.1
S-3-B	26.0	131	67	2.0
N-1-B	33.25	118	61	1.5
N-2-B	28.25	129	65	1.9
N-3-B	23.75	130	66	10.6
S-1-C	31.50	121	63	1.0
S-2-C	27.50	130	60	3.0
S-3-C	26.50	145	74	1.7
N-1-C	31.75	122	62	1.6
N-2-C	27.50	123	61	2.8
N-3-C	24.75	130	66	11.0

* The mortar label consists of three characters; the first character is a letter designating whether it is type S or N, the second character is a number (one for Portland cement-lime, two for mortar cement, and three for masonry cement), and the third character is a letter that corresponds with the type of brick, for which the mortar was used.
** Measured using the pressure-meter method.

3.2.3. Capping

Top and bottom bearing surfaces of specimens were capped using a transparent piece of glass that was secured and leveled horizontally on a flat working surface, as shown in Figure 3.14. The prisms shown in Figure 3.15 are capped and ready to be tested.

Figure 3.15: Working Surface for Capping.

Figure 3.16: Capped Prisms.

3.3 Equipment

The equipments used in this study include but are not limited to the following:

- Heating Unit, Figures 3.17 and 3.18,
- Boiler Unit, Figure 3.19,
- Level, Figure 3.20,
- Electronic Balance, Figure 3.21,
- 60 kip Tension-Compression Testing Machine, Figure 3.22,
- 500 kip Compression Testing Machine, Figure 3.23
- Twelve Cubic Feet Mixer, Figure 3.24.

Figure 3.17: Heating Unit.

3.18: Heating Unit.

Figure 3.19: Boiler Unit.

Figure 3.20: Level.

Figure 3.21: Electronic Balance.

Figure 3.22: 60 kip Tension-Compression Testing Machine.

Figure 3.23: 500 kip Compression Testing Machine.

Figure 3.24: Twelve Cubic Feet Mixer.

3.4 Construction of the Prisms

The prisms were built by a certified mason. The mason was directed to provide full bed mortar and joints with a thickness of approximately 3/8” for all prisms. The prisms were placed in two plastic bags to be cured in accordance with the applicable ASTM standards. Figures 3.25 thru 3.28 show various functions of the construction.

Figure 3.25: Flow Testing of a Mortar Mix.

Figure 3.26: Brick Units Configured for Construction.

Figure 3.27: Certified Mason Building the Prisms.

Figure 3.28: Built Prisms Placed in Bags.

3.5 Testing the Prisms & the Results

Twenty-Six days after construction, the prisms were removed from the bags and capped on both top and bottom bearing surfaces. The prisms were tested using the 500 kip compression testing machine 28 days after they were built. The prisms were loaded as described in ASTM C1314-03b.

The prisms built with type N mortar failed in a less explosive manner than the ones built with type S mortar. The prisms with approximate h/t ratios of 2 failed in conical or semi-conical modes of failure. The prisms with approximate h/t ratios of 5, failed in a combination of vertical splitting and face-shell separation modes of failure. Most of the prisms with approximate h/t ratios of 5 experienced a vertical crack about the middle of the longer face at about three-quarters of their final compressive loading, which caused the force shown by the equipment as being applied to the specimen to drop slightly and then to continue increasing until failure. Examples of tested prisms are shown in Figures 3.29 thru 3.40. Vertical crack is defined as a crack extending vertically on a face of the prism. Conical and face-shell separation modes of failure are based on the sketches provided in ASTM C 1314-03b (FIG. 4 Sketches of Mode of Failure).

Figure 3.29: Prism with Approximate h/t Ratio of Two Built with Brick "A" and Type N Mortar Exhibiting Signs of Conical Mode of Failure.

Figure 3.30: Prism with Approximate h/t Ratio of Two Built with Brick “A” and Type S Mortar Exhibiting Signs of Conical Mode of Failure.

Figure 3.31: Prism with Approximate h/t Ratio of Five Built with Brick “A” and Type N Mortar Exhibiting Signs of Vertical Splitting and Face-Shell Separation Modes of Failure.

Figure 3.32: Prism with Approximate h/t Ratio of Five Built with Brick “A” and Type S Mortar Exhibiting Signs of Vertical Splitting and Face-Shell Separation Modes of Failure.

Figure 3.33: Prism with Approximate h/t Ratio of Two Built with Brick "B" and Type N Mortar Exhibiting Signs of Conical Mode of Failure.

Figure 3.34: Prism with Approximate h/t Ratio of Two Built with Brick "B" and Type S Mortar Exhibiting Signs of Conical Mode of Failure.

Figure 3.35: Prism with Approximate h/t Ratio of Five Built with Brick “B” and Type N Mortar Exhibiting Signs of Vertical Splitting and Face-Shell Separation Modes of Failure.

Figure 3.36: Prism with Approximate h/t Ratio of Five Built with Brick "B" and Type S Mortar Exhibiting Signs of Vertical Splitting and Face-Shell Separation Modes of Failure.

Figure 3.37: Prism with Approximate h/t Ratio of Two Built with Brick “C” and Type N Mortar Exhibiting Signs of Conical Mode of Failure.

Figure 3.38: Prism with Approximate h/t Ratio of Two Built with Brick "C" and Type S Mortar Exhibiting Signs of Conical Mode of Failure.

Figure 3.39: Prism with Approximate h/t Ratio of Five Built with Brick “C” and Type N Mortar Exhibiting Signs of Vertical Splitting and Face-Shell Separation Modes of Failure.

Figure 3.40: Prism with Approximate h/t Ratio of Five Built with Brick “C” and Type S Mortar Exhibiting Signs of Vertical Splitting and Face-Shell Separation Modes of Failure.

The results are reported in Appendix B. All brick units were determined to be solid; therefore, the ultimate compressive strengths of the prisms are calculated using their gross area. The summary of the results are presented in Tables 3.8, 3.9, and 3.10.

Note: The following apply to Tables 3.8, 3.9, and 3.10

N1: Prism built with Portland cement-lime type N,

N2: Prism built with mortar cement type N,

N3: Prism built with masonry cement type N,

S1: Prism built with Portland cement-lime type S,

S2: Prism built with mortar cement type S,

S3: Prism built with masonry cement type S,

AVE.: Average,

STD. DEV.: Standard deviation,

C.O.V.: Coefficient of Variation,

All h/t ratios are approximate. For exact h/t ratio for each tested specimen refer to Appendix B.

Table 3.8: Prism Test Results for Brick "A"

PRISM	H/T RATIO	COMPRESSIVE STRENGTH, psi					AVE., psi	STD. DEV., psi	C.O.V., %
		#1	#2	#3	#4	#5			
S1	2	4950	4780	4806	4824	4712	4814	87	1.81
S1	5	3702	4106	3786	3757	4590	3988	372	9.32
S2	2	4116	4314	4289	4318	3631	4133	293	7.08
S2	5	3294	3239	3684	3088	3384	3338	221	6.63
S3	2	4185	3997	4709	3817	4144	4171	334	8.00
S3	5	3905	3656	3842	3901	3724	3806	111	2.92
N1	2	3759	3971	4042	3413	4191	3875	302	7.79
N1	5	3489	3923	3843	3769	3639	3733	172	4.60
N2	2	3642	3158	3941	3766	3363	3574	314	8.78
N2	5	3239	3161	2979	3178	3210	3153	102	3.24
N3	2	3316	3127	3055	3038	3216	3150	116	3.68
N3	5	2634	2640	2657	2753	3060	2749	181	6.58

Table 3.9: Prism Test Results for Brick "B"

PRISM	H/T RATIO	COMPRESSIVE STRENGTH, psi					AVE., psi	STD. DEV., psi	C.O.V., %
		#1	#2	#3	#4	#5			
S1	2	5284	5010	5422	3378	4889	4796	821	17.11
S1	5	4658	4504	3779	4414	4241	4319	338	7.82
S2	2	3221	3968	3706	3934	4132	3792	354	9.33
S2	5	3310	4494	4174	4065	4090	4027	435	10.81
S3	2	3974	5371	4719	5499	4806	4874	608	12.46
S3	5	4181	3801	3580	4316	3425	3861	381	9.88
N1	2	4034	3504	4450	3754	4103	3969	359	9.04
N1	5	3337	3004	2575	3274	3200	3078	307	9.99
N2	2	4233	3514	3687	3549	3583	3713	298	8.01
N2	5	2344	2877	2691	2683	2761	2671	199	7.44
N3	2	3447	2928	3253	2930	2896	3091	247	7.98
N3	5	2839	2317	2871	2863	2724	2723	234	8.60

Table 3.10: Prism Test Results for Brick "C"

PRISM	H/T RATIO	COMPRESSIVE STRENGTH, psi					AVE., psi	STD. DEV., psi	C.O.V., %
		#1	#2	#3	#4	#5			
S1	2	3614	4782	2251	3491	3592	3546	896	25.28
S1	5	3744	3006	2836	3394	-	3245	352	10.84
S2	2	4097	3511	2409	3775	3656	3490	642	18.38
S2	5	2602	3187	3389	3344	3203	3145	316	10.05
S3	2	2360	3564	3288	3518	3612	3269	523	15.99
S3	5	2753	2916	2700	3026	2955	2870	138	4.80
N1	2	3754	3710	3572	1965	3018	3204	752	23.48
N1	5	2817	3014	2739	2794	3148	2902	172	5.93
N2	2	2803	3054	3186	3068	2857	2994	159	5.31
N2	5	2547	3036	2354	2521	2632	2618	255	9.73
N3	2	2707	3303	3408	3100	3228	3149	271	8.62
N3	5	2951	2814	3025	2943	2934	2933	76	2.59

CHAPTER 4

STATISTICAL ANALYSIS

The first step was to examine the existing data, and then complement the existing with new data generated by prism tests conducted in this research. Various graphs were generated and studied using Microsoft Excel, and multiple statistical models were developed with the assistance of Statistical Analysis Software (SAS) developed by SAS Institute Inc.

4.1 Prism Compressive Strength: Old and New Data

The existing information from the literature survey is shown in Figures 4.1, 4.2, and 4.3. These figures reveal the range of data available for each type of mortar.

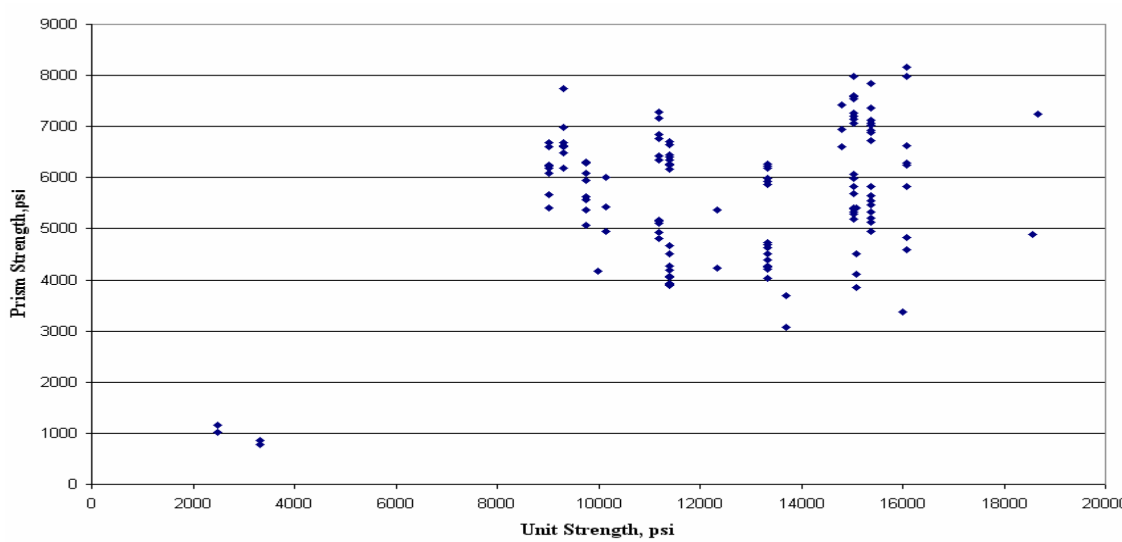

Figure 4.1: Existing Data since 1980 Literature Survey, Type M Mortar.

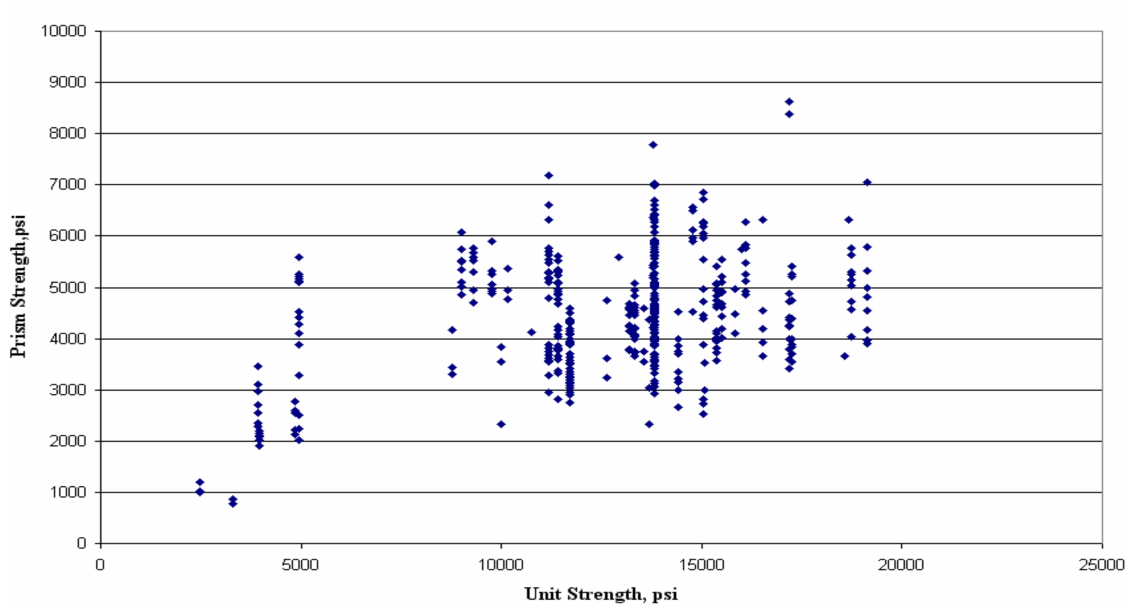

Figure 4.2: Existing Data since 1980 Literature Survey, Type S Mortar.

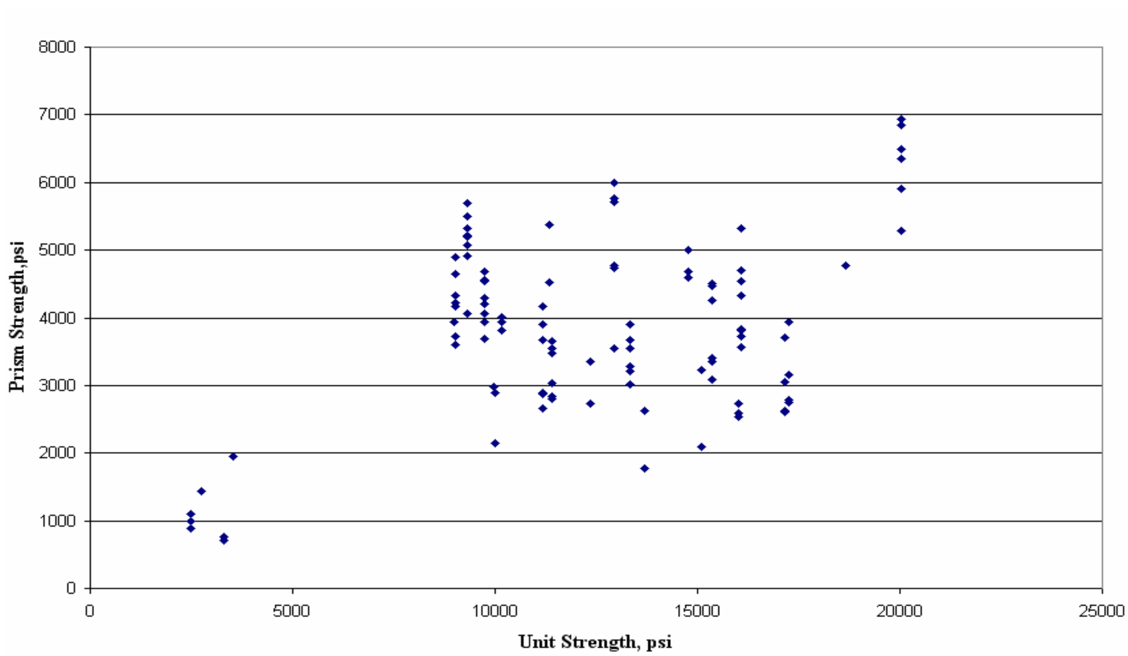

Figure 4.3: Existing Data since 1980 Literature Survey, Type N Mortar.

Figures 4.4 and 4.5 show the information from the literature survey and the results from prism tests done for this research.

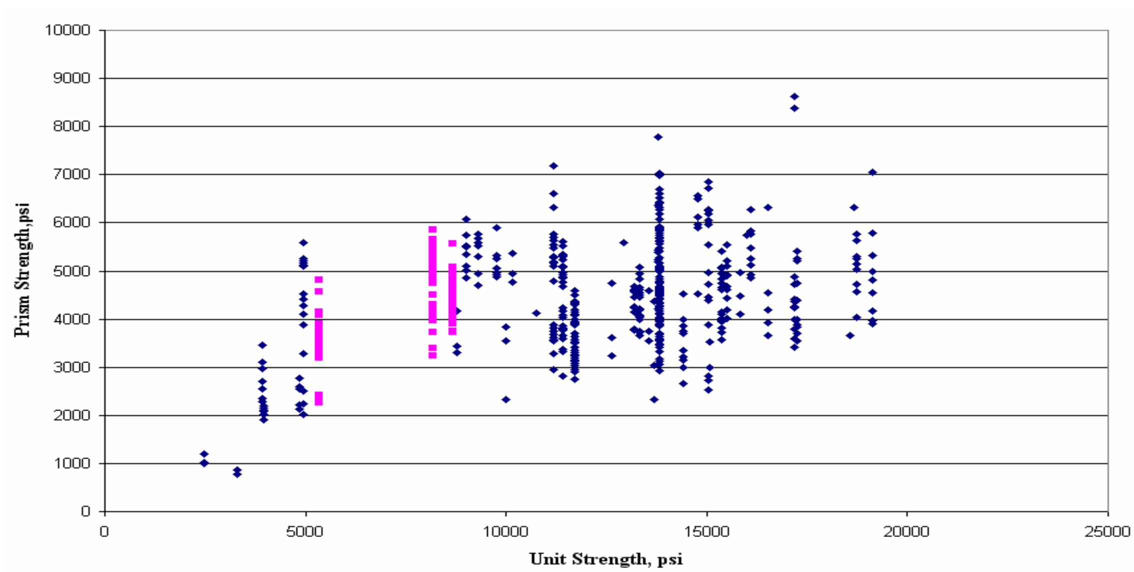

Figure 4.4: Literature Survey and Additional Testing, Type S Mortar.

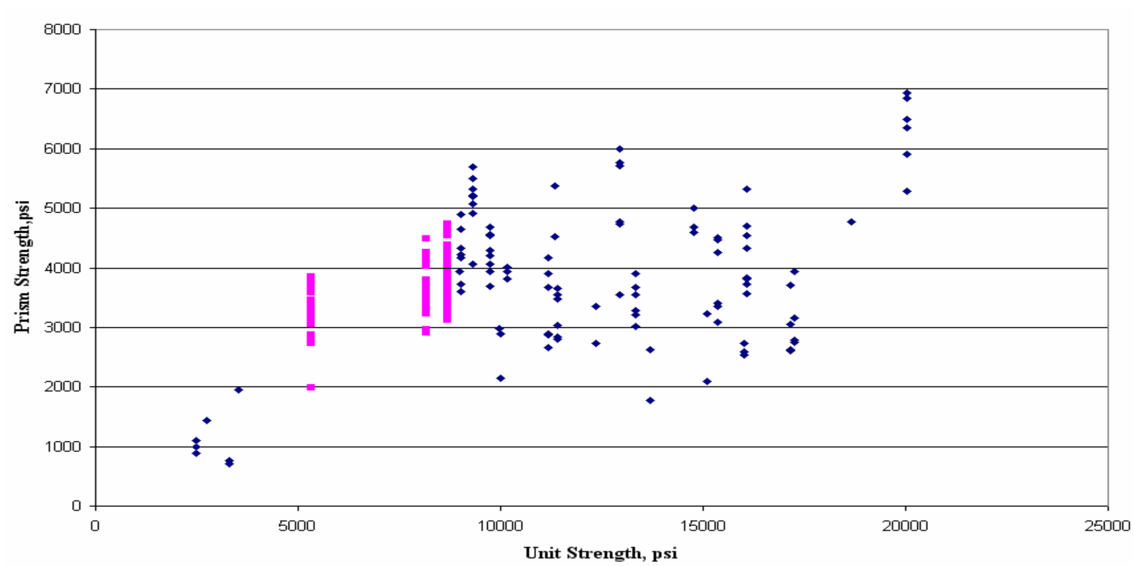

Figure 4.5: Literature Survey and Additional Testing, Type N Mortar.

4.1.1 Influencing Factors

The prism strengths shown in Figures 4.1 through 4.5 are not adjusted for their h/t ratios. Other potentially significant variables amongst these prism strengths that are not distinguished so far include:

- Curing method: air dry, moist dry (air-sealed in bags), moist/dry (kept in air-sealed bags for the first seven days and air dried for the remaining of their curing period,
- Curing time: seven or 28 days,
- Mortar type: M, S, or N,
- Grout: presence or lack thereof,
- Solid versus hollow units,
- Face-shell versus full-bed mortar joints.

Overall, there are three curing methods, two curing periods, three mortar types, two grout conditions, two general types of unit, and two types of mortar joints. All the aforementioned variables are qualitative, whereas the unit strength and prism strengths are quantitative. Thus, there are a total of 144 (the product of the number of levels of the qualitative variable) possible combinations of the qualitative variables and the quantitative variables can be explored within each category. However, the available information provides data in 32 of the 144 possible combinations.

The attempt is to explore the relationship between the prism strength (the response variable) to the other variables to reduce the error in a future estimate. Deriving a relationship between a random variable – prism strength – and measured values of other variables is a process referred to as modeling. The tool for building this model is regression analysis. The regression model enables the researcher to predict values for the response variable in areas where data is not available.

4.1.2 Current Masonry Specification and the Gathered Data

As described in Chapter 1 of this report, the current MSJC Specification provides a prism strength based on mortar type and unit strength. The clay masonry unit compressive strengths covered in the Specification as listed in Table 1.1 are from 1,700 psi to 11,515 for types M & S mortar (it is the author's belief that the number 13,200 for unit strength listed in Table 1.1 should be 11,515 psi, which would yield 4,000 psi for the assemblage compressive strength using Equation 1.1) and 2,100 psi to 10,300 psi for type N mortar. It can be deduced that for mortar types M & S, once the units have compressive strengths of 11,515 psi or higher the compressive strength of the assemblage is 4,000 psi, and for mortar type N, once the units have compressive strengths of 10,300 psi or higher the compressive strength of the assemblage is 3,000 psi. However, the numbers in the Specification are based on prism strengths adjusted to h/t ratio of two. Figures 4.6, 4.7, and 4.8 show the gathered data and the tests results for all data adjusted to h/t ratio of two, in combination with the limits set by the Specification as described above. A linear regression that only explores the average prism strength as a linear function of the unit strength in each mortar type category is also shown in each graph.

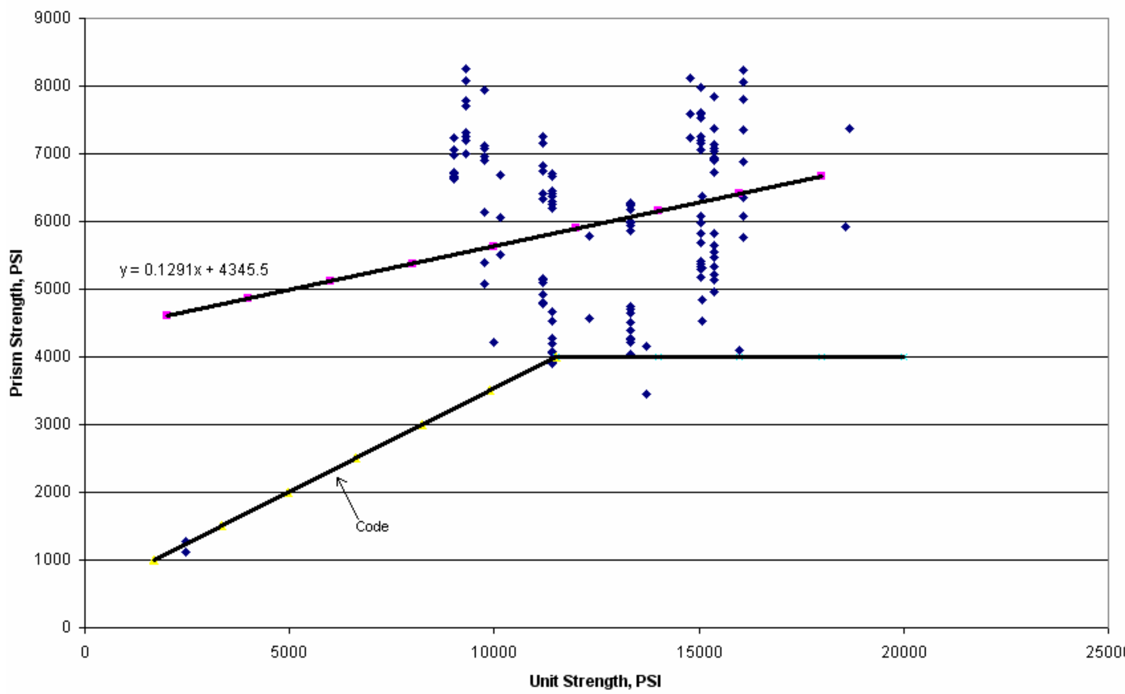

Figure 4.6: Types M Mortar.

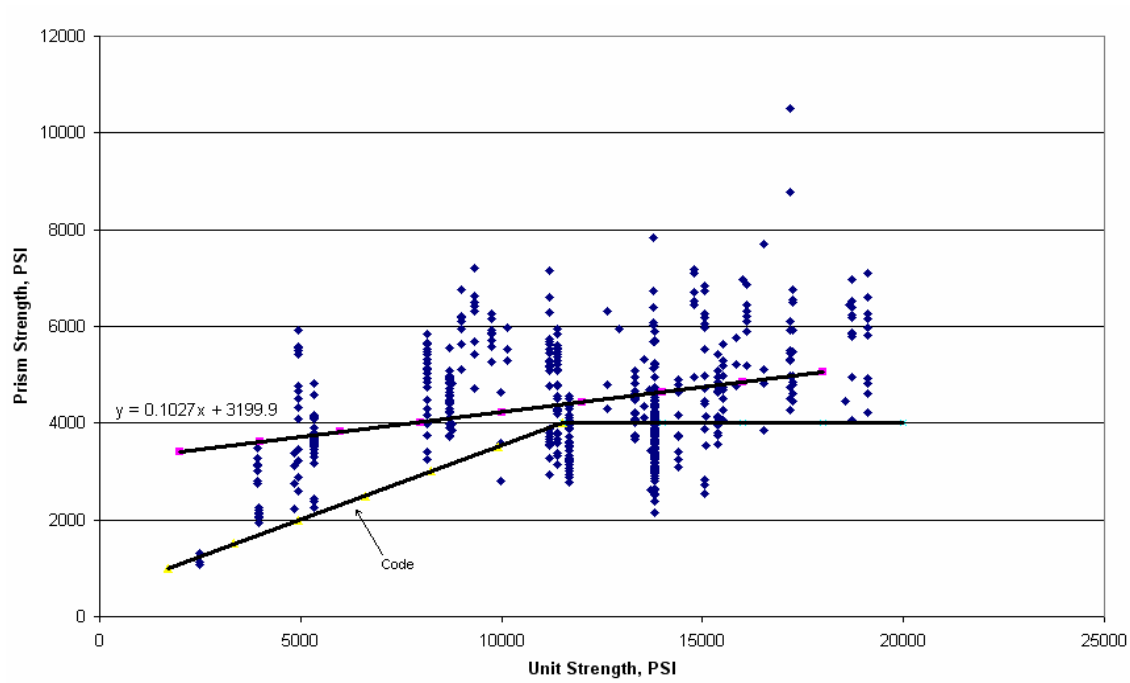

Figure 4.7: Type S Mortar.

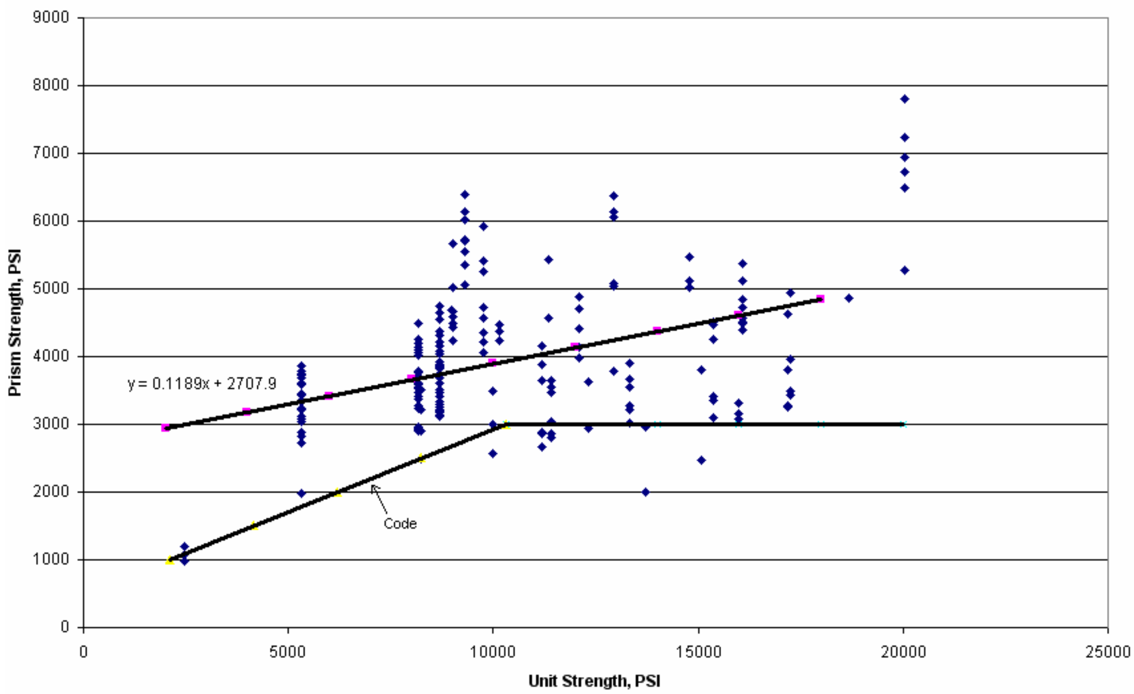

Figure 4.8: Type N Mortar.

The linear regression R^2 (coefficient of determination) for mortar types M, S, and N are 0.072, 0.11, and 0.20, respectively; thus, for type M mortar 7.2%, for type S mortar 11%, and for type N mortar 20% of the total variation in the value of prism strength is explained by variation in unit strength. These regression models predict mean prism strengths as a function of unit strengths. In engineering practice, characteristic (such as fifth quantile) values are typically used to represent statistically reliable values. Also, the data in Figures 4.6, 4.7, and 4.8 are grouped together based on mortar type only and other variables are not accounted for by the regression models. Therefore, a more complicated model needs to be developed to investigate all the variables.

4.2 Mathematical Modeling

The data set consisting of measured values of the criterion variable – prism strength – and the predictor variables – variables whose variation is believed to cause variation in the criterion variable - was compiled. Mathematical models were developed that yielded objective functions, which are explicit functions that are the best fit for the matrix of measured data. Regression was used to minimize the sum of squares of the errors, which are defined as the differences between the predicted and measured values of the criterion variable. The data were analyzed using different models, which are listed below and the variables they explore are tabulated in Table 4.1.

- Model "A" analyzes the entire available data set and explores the largest number of predictor factors and interactions,
- Model "B" examines a modified version of Model "A" data set such that the compressive strengths are based on net area regardless of the size of the openings in the brick unit,
- Model "C" assesses the available data points using only 28 day cured prisms (moist or air-dried),
- Model "D" evaluates the data points for 28-day moist-cured prisms only,
- Model "E" analyzes Model "C" data set, modified such that the compressive strengths are based on net areas regardless of the size of the openings,
- Model "F" analyzes Model "D" data set, modified such that the compressive strengths are based on net areas regardless of the size of the openings,
- Model "G" only examines the data from prism tests conducted at UTA.

Table 4.1: Mathematical Models

Predictor Variables and Their Interactions	Model "A"	Model "B"	Model "C"	Model "D"	Model "E"	Model "F"	Model "G"
Curing Method	X	X					
Curing Time	X	X					
Mortar Type	X	X	X	X	X	X	X
Grout	X	X					
Units: Solid or Hollow	X		X	X			
Bedding: Full-bed or face-shell	X		X	X			
$Ln(f_u)$	X	X	X	X	X	X	X
h/t ratio	X	X	X	X	X	X	X
$Ln(f_u)$ & h/t ratio	X	X	X	X	X	X	X
* XXX & h/t ratio	X	X	X	X	X	X	X
* XXX & $Ln(f_u)$	X	X	X	X	X	X	X
* XXX, $Ln(f_u)$ and h/t ratio	X	X	X	X	X	X	X

* XXX can be curing method, curing time, mortar type, grout (presence or absence of grout), units being solid or hollow, and full-bed or face-shell bedding depending on the model. If any of the aforementioned factors are accounted for by the model in question, their interactions are also taken into account.

4.2.1 Model "A"

As described earlier, out of the 144 possible combinations of the qualitative variables, there exists data in 32 combinations, see Table 4.2. Not all combinations contain a sufficient number of observations. For example, combination #3 contains only two observations and combination #4 contains five observations; however, all five observations are in a small range of unit compressive strength and there is no information available outside that range. Model "A" examines all 32 categories.

The following apply to Tables 4.2 and 4.4.

- Comb.: Counts the number of various combinations for which data is available,
- Cure Method: Curing Method; air dry, moist, moist/dry (cured in an air-sealed bag for the first seven days and air cured thereafter),
- Cure Time: Number of days the specimen was cured prior to testing,
- Mortar Type: M, S, or N.
- Grout: "Yes" signifies presence of grout and "No" lack thereof,
- Solid Hollow: Specifies whether the masonry units used in the assemblage were solid or hollow units,
- Mortar Joint: Specifies whether the joint was reported as face-shell or full-bed.
- Freq.: The number of observations available for the corresponding category,
- Prism Strength: The mean of all prism strengths reported for that combination in psi.

Table 4.2: Available 32 Combinations

Comb.	Cure Method	Cure Time	Mortar Type	Grout	Solid Hollow	Mortar Joint	Freq.	Prism Strength
1	Air dry	28	M	No	Hollow	Faceshell	16	6,275
2	Air dry	28	M	No	Hollow	Fullbed	21	5,872
3	Air dry	28	M	No	Solid	Fullbed	2	5,707
4	Air dry	28	M	Yes	Hollow	Fullbed	5	3,729
5	Air dry	28	N	No	Hollow	Faceshell	25	3,906
6	Air dry	28	N	No	Hollow	Fullbed	21	4,110
7	Air dry	28	N	No	Solid	Fullbed	16	4,386
8	Air dry	28	N	Yes	Hollow	Fullbed	15	3,884
9	Air dry	28	S	No	Hollow	Faceshell	61	4,101
10	Air dry	28	S	No	Hollow	Fullbed	35	4,620
11	Air dry	28	S	No	Solid	Fullbed	26	4,261
12	Air dry	28	S	Yes	Hollow	Faceshell	45	4,080
13	Air dry	28	S	Yes	Hollow	Fullbed	5	3,381
14	Air dry	28	S	Yes	Solid	Fullbed	22	3,878
15	Air dry	7	S	No	Solid	Fullbed	10	4,378
16	Moist	28	M	No	Hollow	Faceshell	42	4,899
17	Moist	28	M	No	Hollow	Fullbed	42	6,760

Table 4.2 – continued

Comb.	Cure Method	Cure Time	Mortar Type	Grout	Solid Hollow	Mortar Joint	Freq.	Prism Strength
18	Moist	28	N	No	Hollow	Faceshell	15	3,087
19	Moist	28	N	No	Hollow	Fullbed	15	3,998
20	Moist	28	N	No	Solid	Fullbed	90	3,182
21	Moist	28	S	No	Hollow	Faceshell	48	3,873
22	Moist	28	S	No	Hollow	Fullbed	78	4,641
23	Moist	28	S	No	Solid	Fullbed	112	3,843
24	Moist	28	S	Yes	Hollow	Fullbed	30	4,150
25	Moist	28	S	Yes	Solid	Fullbed	12	4,662
26	Moist	7	S	No	Solid	Fullbed	20	3,196
27	Moist/dry	28	M	No	Solid	Fullbed	9	4,504
28	Moist/dry	28	N	No	Solid	Fullbed	10	3,359
29	Moist/dry	28	S	No	Solid	Faceshell	8	3,641
30	Moist/dry	28	S	No	Solid	Fullbed	12	4,488
31	Moist/dry	7	S	No	Solid	Faceshell	2	2,887
32	Moist/dry	7	S	No	Solid	Fullbed	12	4,453

The developed mathematical model "A" explores the relationship between prism strength and the following variables:

- The natural logarithm (Ln) of the compressive strength of the clay masonry units ($Ln(f_u)$),
- Curing method,
- Curing time,
- Mortar type,
- Presence or lack of grout in the assemblage,
- Units being solid or hollow,
- Mortar joints being face-shell or full-bed,
- Height-to-thickness ratio (h/t ratio).

There also exist interactions between the variables listed above. The following interactions were included in the model:

- Curing method and h/t ratio,
- Curing method and the natural logarithm of the compressive strength of the clay masonry units,
- Curing method, h/t ratio, and the natural logarithm of the compressive strength of clay masonry units,
- Curing time and h/t ratio,
- Curing time and the natural logarithm of the compressive strength of clay masonry units,
- Curing time, h/t ratio, and the natural logarithm of the compressive strength of clay masonry units,
- Mortar type and h/t ratio,

- Mortar type and the natural logarithm of the compressive strength of clay masonry units,
- Mortar type, h/t ratio, and the natural logarithm of the compressive strength of clay masonry units,
- Presence or absence of grout and h/t ratio,
- Presence or absence of grout and the natural logarithm of the compressive strength of clay masonry units,
- Presence or absence of grout, h/t ratio, and the natural logarithm of the compressive strength of clay masonry units,
- Units being solid or hollow and h/t ratio,
- Units being solid or hollow and the natural logarithm of the compressive strength of clay masonry units,
- Units being solid or hollow, h/t ratio, and the natural logarithm of the compressive strength of clay masonry units,
- Mortar joints being face-shell or full-bed and h/t ratio,
- Mortar joints being face-shell or full-bed and the natural logarithm of the compressive strength of clay masonry units,
- Mortar joints being face-shell or full-bed, h/t ratio, and the natural logarithm of the compressive strength of clay masonry units.

The following relationship between mean prism strength and the predictor variables was established by the model.

$$Mean \quad Prism \quad Strength = -2{,}066.3 + 7{,}782.7B_1 + 30{,}248.8B_2 - 17{,}681.4B_3 - 26{,}058.2B_4 + 1{,}058.3B_5 - 12{,}966.7B_6 + 17{,}849.4B_7 + 6{,}622.4B_8 - 728.6B_9 + 659.5B_{10} + 66.1B_9B_{10} - 6{,}284.2B_1B_9 - 12{,}686.6B_2B_9 - 885.5B_1B_{10} - 3{,}386.8B_2B_{10} + 697B_1B_9B_{10} + 1{,}418.1B_2B_9B_{10} + 7{,}735.6B_3B_9 + 2{,}000.8B_3B_{10} - 881.9B_3B_9B_{10} + 15{,}936.9B_4B_9 + 938.5B_5B_9 + 2{,}882B_4B_{10} - 190.3B_5B_{10} - 1{,}701.8B_4B_9B_{10} - 108.5B_5B_9B_{10} + 3{,}858.8B_6B_9 + 1{,}455.7B_6B_{10} - 410.8B_6B_9B_{10} + 1{,}666.5B_7B_9 - 1{,}813.5B_7B_{10} - 200.7B_7B_9B_{10} - 7{,}149.3B_8B_9 - 816.7B_8B_{10} + 811.3B_8B_9B_{10}$$

$$B1 = \begin{cases} 1 & Air \quad Dry \\ 0 & Otherwise \end{cases} \qquad B2 = \begin{cases} 1 & Moist \quad Cured \\ 0 & Otherwise \end{cases}$$

$$B3 = \begin{cases} 1 & Cured \quad for \quad 28 \quad Days \\ 0 & Cured \quad for \quad 7 \quad Days \end{cases} \qquad B4 = \begin{cases} 1 & Type \quad M \quad Mortar \\ 0 & Otherwise \end{cases}$$

$$B5 = \begin{cases} 1 & Type \quad N \quad Mortar \\ 0 & Otherwise \end{cases} \qquad B6 = \begin{cases} 1 & No \quad Grout \\ 0 & Grouted \end{cases}$$

$$B7 = \begin{cases} 1 & Hollow \quad Units \\ 0 & Solid \quad Units \end{cases} \qquad B8 = \begin{cases} 1 & Face-shell \\ 0 & Full-bed \end{cases}$$

$$B9 = h/t \quad ratio$$

$$B10 = Ln(Unit \quad Compressive \quad Strength)$$

The distribution of the prism strength values at each unit strength value fits a normal distribution. Thus, the following can be used to deduce the fifth quantile values for the response variable.

$$\xi_{0.05}\left(\hat{\mu}, \hat{\sigma}\right) = \hat{\mu} + \hat{\sigma}\,\xi_{0.05}(0,1)$$

$$\xi_{0.05}\left(\hat{\mu}, \hat{\sigma}\right) = Fifth \quad Quantile$$

$$\hat{\mu} = Mean \quad Prism \quad Strength \quad Predicted \quad by \quad the \quad Model.$$

$$\hat{\sigma} = Conditional \quad Standard \quad Deviation = 751.9$$

$$\xi_{0.05}(0,1) = -1.64$$

$$\xi_{0.05}\left(\hat{\mu}, \hat{\sigma}\right) = \hat{\mu} - 751.9 \times 1.64 = \hat{\mu} - 1{,}233.1$$

The coefficient of determination (R^2) for model “A” is 0.68. The relative degree to which the variations of prism strength are explained by the predictor variables and their interactions can be determined by observing the type III sum of squares (type III SS) predicted by the mathematical model. Type III SS for the effect of one variable is the increment in the model when the term in question is the last one fitted in the model. The predictor variables or interactions with relatively larger type III SS values are the terms that explain more of the variation of the prism strengths. The following is generated by model “A”.

Table 4.3: Model “A” Type III SS Values

Source	Type III SS
Curing method: air dry, moist, or moist/dry.	41,047,824
Curing time: 7 or 28 days	5,346,533
Mortar type: M, S, or N	20,245,381
Grout: presence or absence	7,506,783
Units being solid or hollow	9,771,56
Full-bed or face-shell bedding	1,257,931
Height-to-thickness ratio	1,095

Table 4.3 – continued

Source	Type III SS
$Ln(f_u)$	3,530
Interaction between $Ln(f_u)$ & h/t ratio	2,000
Interaction between curing method & h/t ratio	8,827,581
Interaction between $Ln(f_u)$ & curing method	44,734,818
Interaction between $Ln(f_u)$, h/t ratio, & curing method	9,554,435
Interaction between h/t ratio & curing time	2,611,982
Interaction between $Ln(f_u)$ & curing time	5,920,699
Interaction between $Ln(f_u)$, h/t ratio, & curing time	2,928,838
Interaction between h/t ratio & mortar type	16,830,053
Interaction between $Ln(f_u)$ & mortar type	22,692,423
Interaction between $Ln(f_u)$, h/t ratio, & mortar type	17,093,633
Interaction between h/t ratio & grout	765,775
Interaction between $Ln(f_u)$ & grout	8,448,080
Interaction between $Ln(f_u)$, h/t ratio, & grout	782,156
Interaction between h/t ratio & solid or hollow units	227,519
Interaction between $Ln(f_u)$ & solid or hollow units	8,944,113
Interaction between $Ln(f_u)$, h/t ratio, & solid or hollow	300,395
Interaction between h/t ratio & face-shell or full-bed	4,833,110
Interaction between $Ln(f_u)$ & face-shell or full-bed	1,716,633
Interaction between $Ln(f_u)$, h/t ratio, & face-shell or full-bed bedding	5,554,129

The variables and interactions that explain most of the variation in prism strength in the model are listed below in descending order of significance.

1. Interaction between the natural logarithm of the compressive strength of masonry unit and curing method,
2. Curing method,
3. Interaction between the natural logarithm of the compressive strength of masonry unit and mortar type,
4. Mortar type,
5. Interaction between the natural logarithm of the compressive strength of masonry unit, h/t ratio, and mortar type,
6. Interaction between h/t ratio and mortar type,
7. Units being solid or hollow,
8. Interaction between the natural logarithm of the compressive strength of masonry unit and units being solid or hollow.

The average prism strength fifth quantile values across all available categories predicted by model "A" - targeting h/t ratio value of two - and an equation best presenting those values are shown in Figure 4.9, 4.10, and 4.11 for mortar types M, S, N, respectively. The Code values are also shown for each case. Prism strength values cannot be reliably predicted for all ranges of unit compressive strengths due to insufficient test data. There is large gap of type M mortar data for unit strengths of less than approximately 9,000 psi. However, using type S mortar prism strength predictions of the model for type M mortar is conservative. Available data points for mortar types

M and S and the fifth quantile predictions of the model for type S mortar are shown in Figure 4.12. The "x" marks are the available data points associated with the stated mortar type for the applicable model; the "o" marks are used to represent type M mortar data points when shown in conjunction with type S mortar data points on the same graph.; the "▲" symbols represent the fifth percentile prism compressive strength predictions by the model; the curve and the corresponding equation are the best fit regression for the aforementioned fifth percentile predicted values; finally, the line representing the compressive strength design values recommended by the MSJC Specification is labeled as "Code".

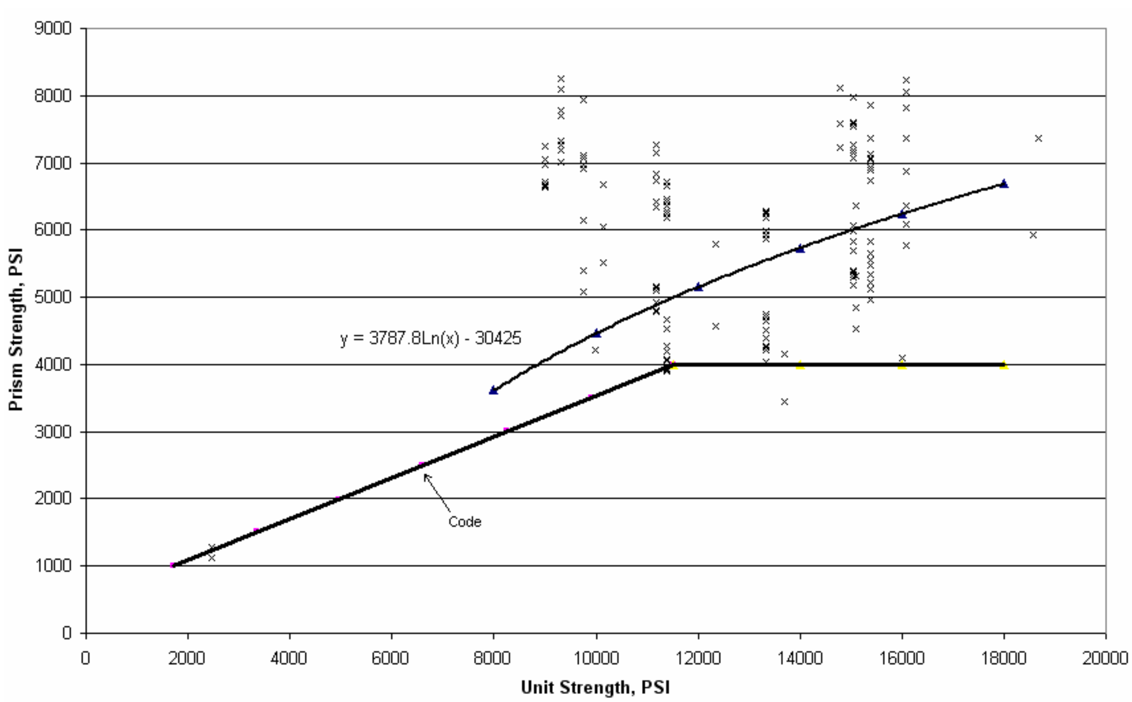

Figure 4.9: Type M Mortar.

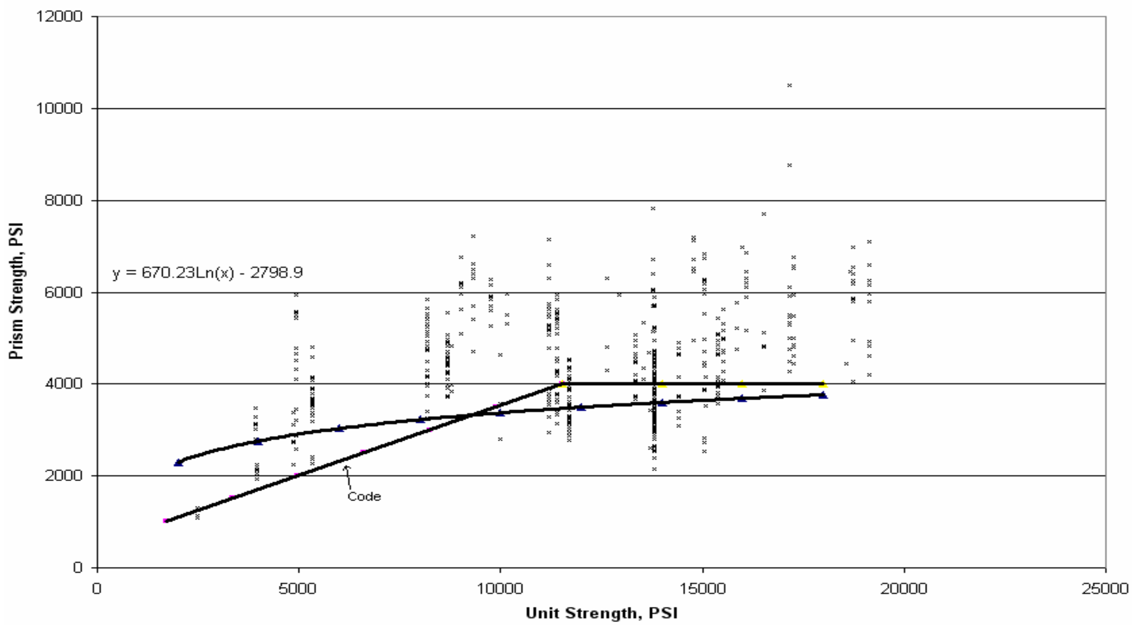

Figure 4.10: Type S Mortar.

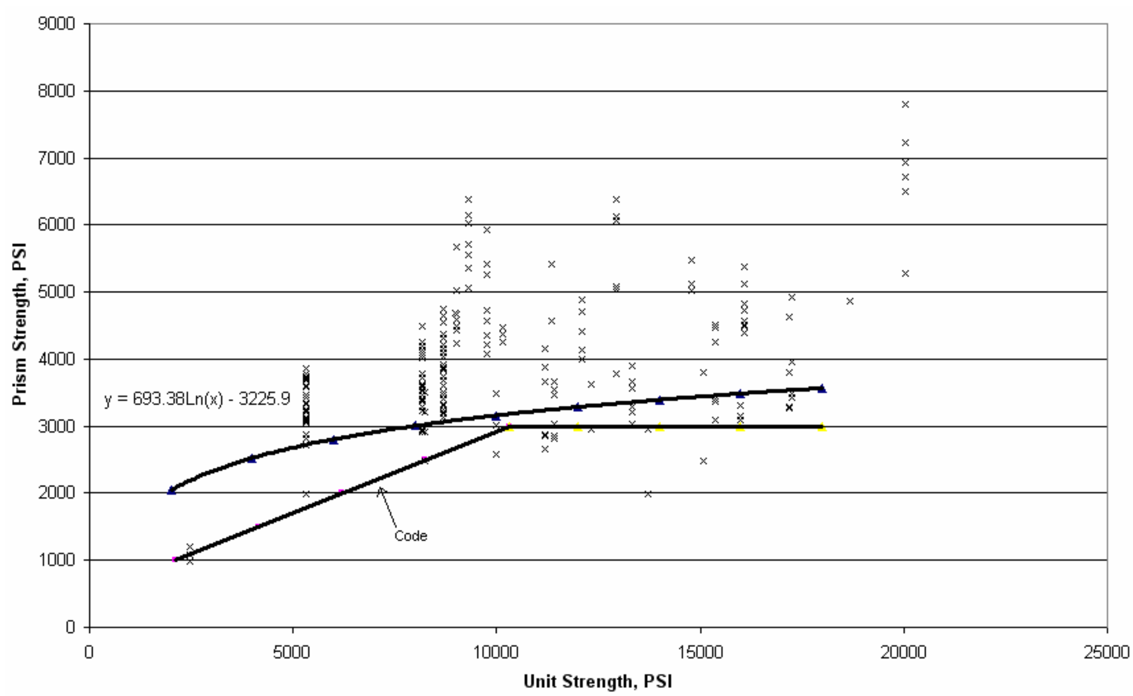

Figure 4.11: Type N Mortar.

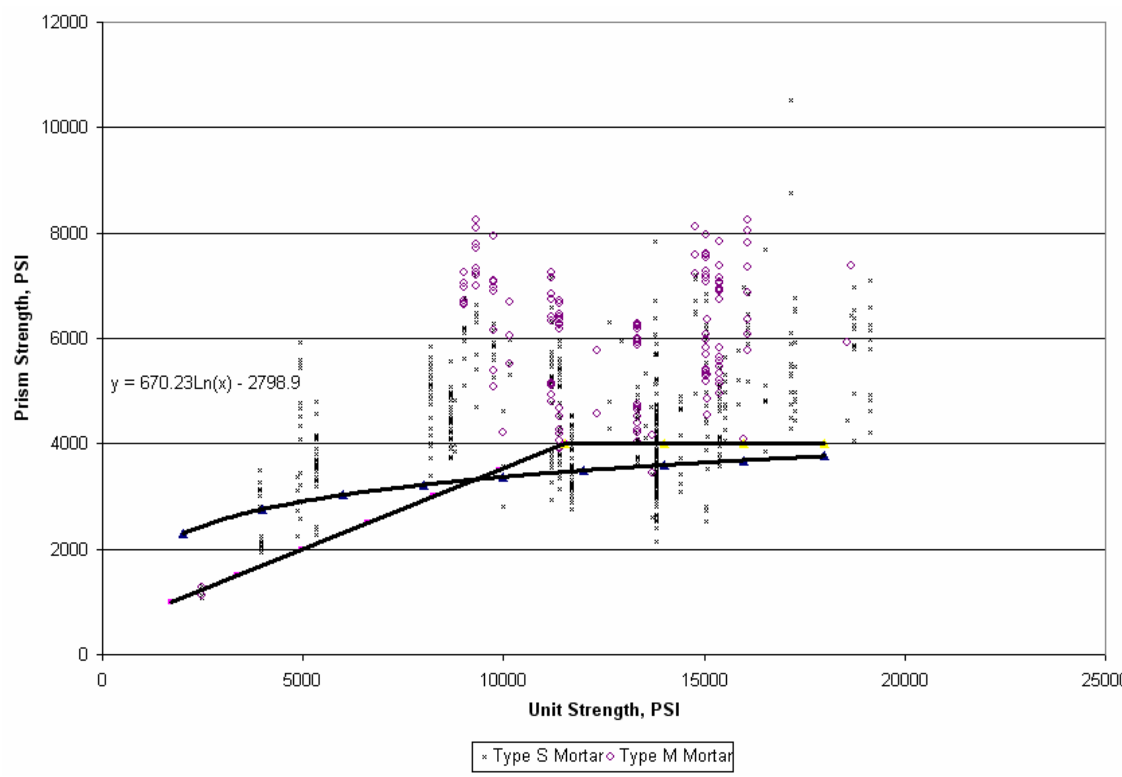

Figure 4.12: Types M and S Mortar.

Equations 4.1 and 4.2 represent the best fit equations for the average prism strength fifth quantile values across all available categories predicted by model "A" - targeting h/t ratio value of two – for mortar type S and N, respectively.

Equation 4.1 (Type S Mortar) $$f'_m = 670.2 \times Ln(f_u) - 2{,}799$$

Equation 4.2 (Type N Mortar) $$f'_m = 693.4 \times Ln(f_u) - 3{,}226$$

f'_m: specified compressive strength of masonry, psi,

f_u: average compressive strength of brick, psi.

4.2.1.1 Comparison of Model "A" Results and Code Values

In a factorial design, a number of levels (in this research levels would be combinations of qualitative predictors) are selected by an investigator and experiments are run with all possible combinations. The test specimens should preferably be built and tested following the current standards with a level of quality control that would minimize the number of cofounders – confounders are variables that are undetected or not recorded and cause unexplained variations in the response variable across different sets of experiments. This research was not a factorial design and there are bound to be confounders due to the nature of the data; the gathered information come from tests performed by various researchers across North America under different conditions, most of which are not recorded; these tests were done during the past 26 years, through which the governing testing standards have changed multiple times and have affected the test conditions; not all details and used testing standards are recorded in the sources; there are not sufficient data available for each level (combination). Workmanship is a very important factor in the strength of any masonry assemblage. In a factorial design the workmanship would be controlled to be as uniform as possible.

The tests performed at UTA in this study consisted of three types of brick with average compressive strength values ranging from approximately 5,000 to 9,000 psi and mortar types S and N. However, type M mortar has a higher compressive strength and including type M mortar with type S is conservative. Compressive strength of masonry as predicted by model "A" for clay masonry units ranging in compressive strength from 5,000 to 9,000 psi are shown in Table 4.4.

Table 4.4: MSJC Design Values and Results from Model "A"

Compressive Strength of Clay Masonry Unit, psi	Compressive Strength of Masonry, psi			
	Types M & S Mortar		Type N Mortar	
	Model "A"	MSJC	Model "A"	MSJC
5,000	3,107	2,013	2,680	1,708
6,000	3,233	2,318	2,806	1,952
7,000	3,340	2,623	2,913	2,196
8,000	3,433	2,928	3,006	2,440
9,000	3,514	3,233	3,087	2,684

4.2.1.2 Linear Regression of Model "A" Data Set

The MSJC Specification is based on linear Equation 1.1, which only distinguishes between mortar types and ignores all other potentially influencing variables. A similar linear regression whose result would be comparable to Equation 1.1 was performed. The data in model "A" data set was corrected for their varying h/t ratio using the h/t correction factors presented in Table 2.1 as suggested by ASTM C 1314-03b for varying h/t ratios. The compressive strength values presented in MSJC Specification are based on h/t ratio of two. Therefore, all the prism strengths in model "A" data set were corrected to an h/t ratio of two. All the other variables were ignored and the data was analyzed based on mortar type using linear regression that related prism compressive strength to the compressive strength of the clay masonry unit for each mortar type. Figures 4.13, 4.14, and 4.15 show the data and the prism compressive strength values (50^{th} and 5^{th} percentiles) along with equations that are best fits for those values for mortar types M, S, and N, respectively.

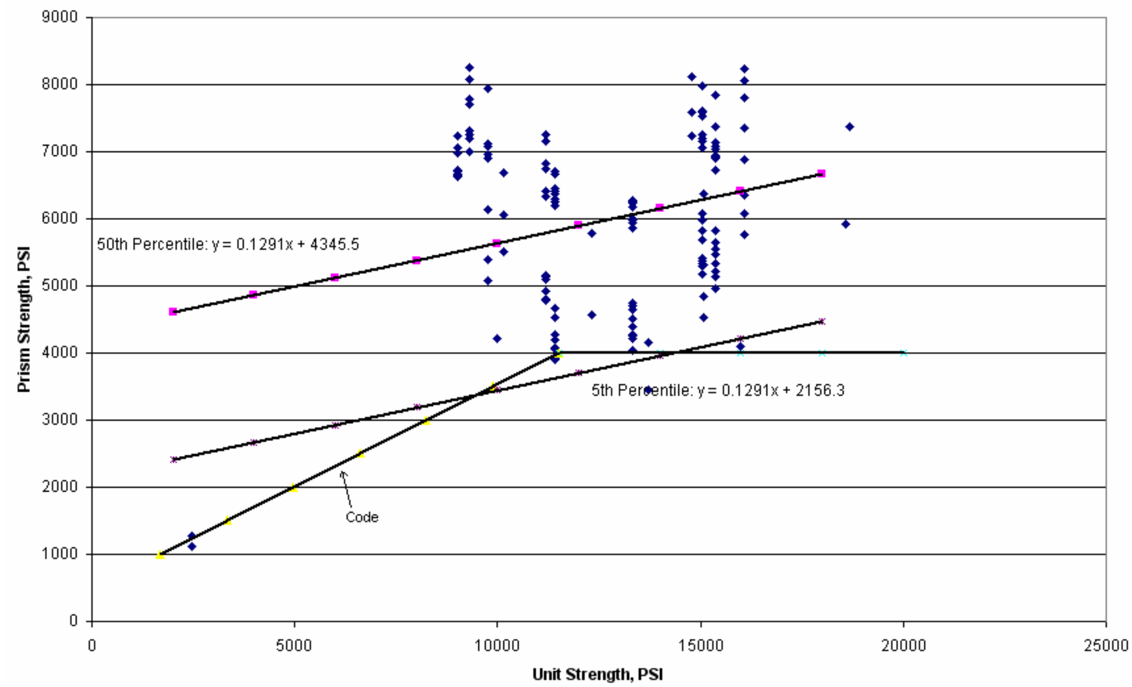

Figure 4.13: Type M Mortar.

Equation 4.3 (Type M Mortar, 50th Percentile) $f'_m = 0.129 \times (f_u) + 4{,}346$

Equation 4.4 (Type M Mortar, 5th Percentile) $f'_m = 0.129 \times (f_u) + 2{,}156$

f'_m: specified compressive strength of masonry, psi,

f_u: average compressive strength of brick, psi.

Coefficient of determination (R^2) = 0.072.

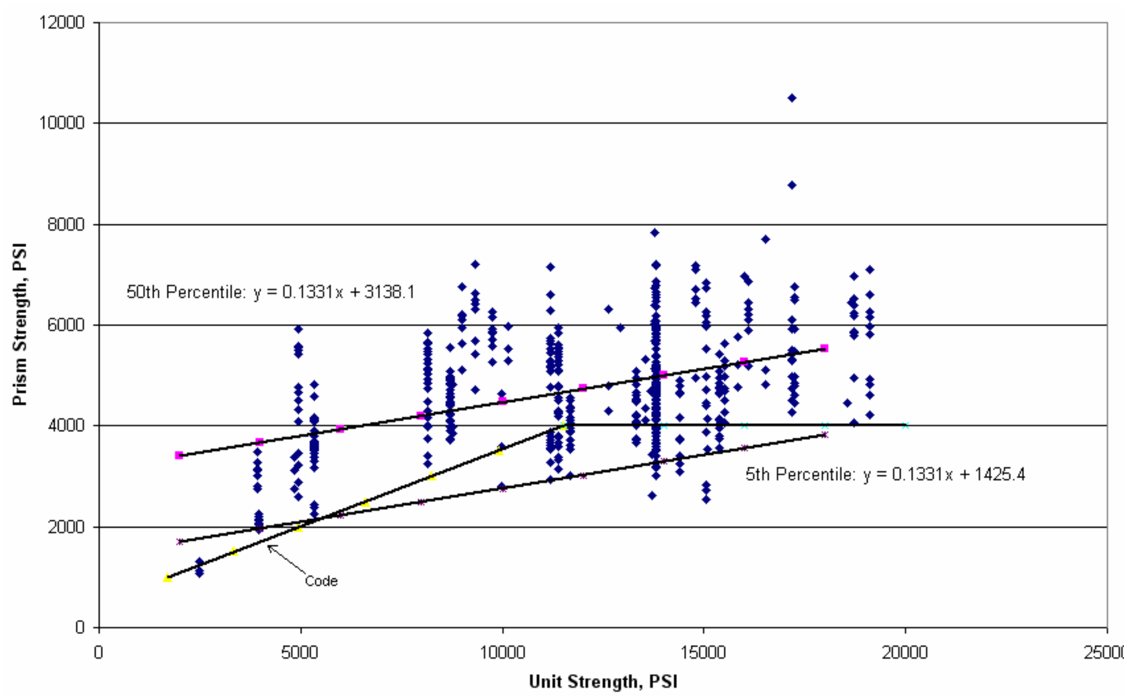

Figure 4.14: Type S Mortar.

Equation 4.5 (Type S Mortar, 50th Percentile) $f'_m = 0.133 \times (f_u) + 3{,}138$

Equation 4.6 (Type S Mortar, 5th Percentile) $f'_m = 0.133 \times (f_u) + 1{,}425$

f'_m: specified compressive strength of masonry, psi,

f_u: average compressive strength of brick, psi.

Coefficient of determination (R^2) = 0.195.

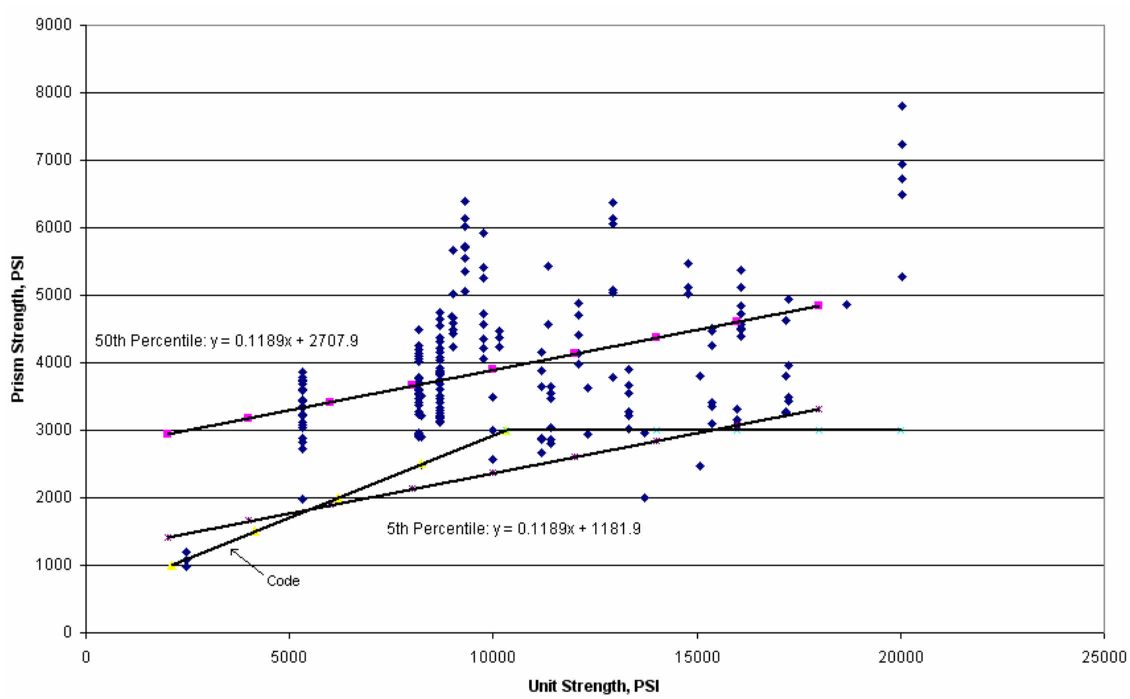

Figure 4.15: Type N Mortar.

Equation 4.7 (Type N Mortar, 50th Percentile) $f'_m = 0.119 \times (f_u) + 2{,}708$

Equation 4.8 (Type N Mortar, 5th Percentile) $f'_m = 0.119 \times (f_u) + 1{,}182$

f'_m: specified compressive strength of masonry, psi,

f_u: average compressive strength of brick, psi.

Coefficient of determination (R^2) = 0.201.

4.2.2 Model "B"

So far once the net area (gross area minus the area of the openings) of a clay masonry unit was in excess of 75% of its gross area, the unit was considered a solid unit and compressive strength was calculated based on the available gross area. However, if the compressive strength of the units are based on net area regardless of the size of the openings and the compressive strength of the assemblage is based on the net bedded area two of the predictor variables and their interaction with other variables will be irrelevant; the units being solid versus hollow and the mortar joint being full-bed or face-shell.

The predictor variables investigated in Model "B" are as follows:

- The natural logarithm (logarithm base e) of the compressive strength of the clay masonry units,
- Curing method,
- Curing time,
- Mortar type,
- Presence or lack of grout in the assemblage,
- Height-to-thickness ratio (h/t ratio).

There also exist interactions between the variables listed above. The following interactions were included in the model:

- Curing method and h/t ratio,
- Curing method and the natural logarithm of the compressive strength of the clay masonry units,
- Curing method, h/t ratio, and the natural logarithm of the compressive strength of clay masonry units,
- Curing time and h/t ratio,
- Curing time and the natural logarithm of the compressive strength of clay masonry units,

- Curing time, h/t ratio, and the natural logarithm of the compressive strength of clay masonry units,
- Mortar type and h/t ratio,
- Mortar type and the natural logarithm of the compressive strength of clay masonry units,
- Mortar type, h/t ratio, and the natural logarithm of the compressive strength of clay masonry units,
- Presence or absence of grout and h/t ratio,
- Presence or absence of grout and the natural logarithm of the compressive strength of clay masonry units,
- Presence or absence of grout, h/t ratio, and the natural logarithm of the compressive strength of clay masonry units.

In Model "B" there are three possible levels for curing method, two for curing time, three for mortar type, and two for grout. Thus, there are a total of 36 possible categories out of which data is available for 15 categories and all are explored by Model "B", as listed in Table 4.5. The following apply to Table 4.5.

- Comb.: Counts the number of various combinations for which data is available,
- Cure Method: Curing Method; air dry, moist, moist/dry (cured in an air-sealed bag for the first seven days and air cured thereafter),
- Cure Time: Number of days the specimen was cured prior to testing,
- Mortar Type: M, S, or N,

- Grout: “Yes” signifies presence of grout and “No” lack thereof,
- Freq.: The number of observations available for the corresponding category,
- Prism Strength: The mean of all prism strengths reported for that combination in psi.

Table 4.5: Available 15 Combinations

Comb.	Cure Method	Cure Time	Mortar Type	Grout	Freq.	Prism Strength
1	Air dry	28	M	No	40	5,974
2	Air dry	28	M	Yes	4	3.698
3	Air dry	28	N	No	64	4,212
4	Air dry	28	N	Yes	13	3,629
5	Air dry	28	S	No	88	4,932
6	Air dry	28	S	Yes	42	3,887
7	Moist/dry	28	M	No	9	4,504
8	Moist/dry	28	N	No	10	3,359
9	Moist/dry	28	S	No	24	5,034
10	Moist/dry	7	S	No	12	5,227
11	Moist	28	M	No	84	5,829
12	Moist	28	N	No	120	3,783
13	Moist	28	S	No	266	4,731
14	Moist	28	S	Yes	60	4,182
15	Moist	7	S	No	32	3,668

The following relationship between mean prism strength and the predictor variables was established by the model.

$$Mean \quad Prism \quad Strength = -19{,}832.7 + 2{,}213.5B_1 - 22{,}263.9B_2 - 3{,}864.1B_3 - 21{,}722.9B_4 - 774B_5 + 26{,}135.2B_6 - 1{,}077.2B_9 + 2{,}371.6B_{10} + 180.5B_9B_{10} + 4{,}304B_1B_9 + 3880.2B_2B_9 - 147.4B_1B_{10} + 2{,}534.7B_2B_{10} - 495.3B_1B_9B_{10} - 457.8B_2B_9B_{10} + 397.5B_3B_9 + 546.9B_3B_{10} - 98.3B_3B_9B_{10} + 14{,}819.7B_4B_9 + 1{,}928.2B_5B_9 + 2{,}405.8B_4B_{10} + 14.1B_5B_{10} - 1{,}592.8B_4B_9B_{10} - 221.3B_5B_9B_{10} - 4{,}705.3B_6B_9 - 2{,}677.7B_6B_{10} + 505.2B_6B_9B_{10}$$

$$B1 = \begin{Bmatrix} 1 \\ 0 \end{Bmatrix} \begin{matrix} Air \quad Dry \\ Otherwise \end{matrix} \qquad B2 = \begin{Bmatrix} 1 \\ 0 \end{Bmatrix} \begin{matrix} Moist/Dry \quad Cured \\ Otherwise \end{matrix}$$

$$B3 = \begin{Bmatrix} 1 \\ 0 \end{Bmatrix} \begin{matrix} Cured \quad for \quad 28 \quad Days \\ Cured \quad for \quad 7 \quad Days \end{matrix} \qquad B4 = \begin{Bmatrix} 1 \\ 0 \end{Bmatrix} \begin{matrix} Type \quad M \quad Mortar \\ Otherwise \end{matrix}$$

$$B5 = \begin{Bmatrix} 1 \\ 0 \end{Bmatrix} \begin{matrix} Type \quad N \quad Mortar \\ Otherwise \end{matrix} \qquad B6 = \begin{Bmatrix} 1 \\ 0 \end{Bmatrix} \begin{matrix} No \quad Grout \\ Grouted \end{matrix}$$

$$B9 = h/t \ ratio$$

$$B10 = Ln(Unit \quad Compressive \quad Strength)$$

The distribution of the prism strength values at each unit strength value fits a normal distribution. Thus, the following can be used to deduce the fifth quantile values for the response variable.

$$\xi_{0.05}\left(\hat{\mu}, \hat{\sigma}\right) = \hat{\mu} + \hat{\sigma}\,\xi_{0.05}(0,1)$$

$$\xi_{0.05}\left(\hat{\mu}, \hat{\sigma}\right) = Fifth \quad Quantile$$

$$\hat{\mu} = Mean \quad Prism \quad Strength \quad Predicted \quad by \quad the \quad Model.$$

$$\hat{\sigma} = Conditional \quad Standard \quad Deviation = 877.7$$

$$\xi_{0.05}(0,1) = -1.64$$

$$\xi_{0.05}\left(\hat{\mu},\hat{\sigma}\right) = \hat{\mu} - 877.7 \times 1.64 = \hat{\mu} - 1{,}439.4$$

The coefficient of determination (R^2) for model "B" is 0.53. The type III sum of squares (Type III SS) generated by model "B" are shown in Table 4.6. The predictor variables or interactions with relatively larger type III SS values are the terms that explain more of the variation of the prism strengths.

Table 4.6: Model "B" Type III SS Values

Source	Type III SS
Curing method: air dry, moist, or moist/dry.	14,702,021
Curing time: 7 or 28 days	167,011
Mortar type: M, S, or N	15,075,803
Grout: presence or absence	20,825,498
Height-to-thickness ratio	2,309,193
$Ln(f_u)$	27,977,027
Interaction between $Ln(f_u)$ & h/t ratio	2,281,147
Interaction between curing method & h/t ratio	3,481,444
Interaction between $Ln(f_u)$ & curing method	15,910,915
Interaction between $Ln(f_u)$, h/t ratio, & curing method	4,011,004
Interaction between h/t ratio & curing time	5,205
Interaction between $Ln(f_u)$ & curing time	292,015
Interaction between $Ln(f_u)$, h/t ratio, & curing time	27,545
Interaction between h/t ratio & mortar type	15,890,507
Interaction between $Ln(f_u)$ & mortar type	16,907,594

Table 4.6 – continued

Source	Type III SS
Interaction between Ln(f_u), h/t ratio, & mortar type	16,377,663
Interaction between h/t ratio & grout	1,165,646
Interaction between Ln(f_u) & grout	19,635,241
Interaction between Ln(f_u), h/t ratio, & grout	1,211,743

The variables and interactions that explain most of the variation in prism strength in the model are listed below in descending order of significance.

1. Natural logarithm of the compressive strength of masonry unit,
2. Presence or absence of grout,
3. Interaction between the natural logarithm of the compressive strength of masonry unit and presence or absence of grout,
4. Interaction between the natural logarithm of the compressive strength of masonry unit and mortar type,
5. Interaction between the natural logarithm of the compressive strength of masonry unit, h/t ratio, and mortar type,
6. Interaction between the natural logarithm of the compressive strength of masonry unit and curing method,
7. Interaction between h/t ratio and mortar type,
8. Mortar type,
9. Curing method.

The average prism strength fifth quantile values across all available categories predicted by model "B" - targeting h/t ratio value of two - and an equation best presenting those values are shown in Figure 4.16, 4.17, and 4.18 for mortar types M, S, N, respectively. The Code values are also shown for each case. Prism strength values cannot be reliably predicted for all ranges of unit compressive strengths due to insufficient test data. There is large gap of type M mortar data for unit strengths of less than approximately 9,000 psi. However, using type S mortar prism strength predictions of the model for type M mortar is conservative. Available data points for mortar types M and S and the fifth quantile predictions of the model for type S mortar are shown in Figure 4.19.

Equations 4.9 and 4.10 represent the best fit equations for the average prism strength fifth quantile values across all available categories predicted by model "B" - targeting h/t ratio value of two - for mortar type S and N, respectively.

Equation 4.9 (Type S Mortar) $f'_m = 1{,}531.7 \times Ln(f_u) - 11{,}097$

Equation 4.10 (Type N Mortar) $f'_m = 1{,}484.3 \times Ln(f_u) - 10{,}772$

f'_m: specified compressive strength of masonry, psi,

f_u: average compressive strength of brick, psi.

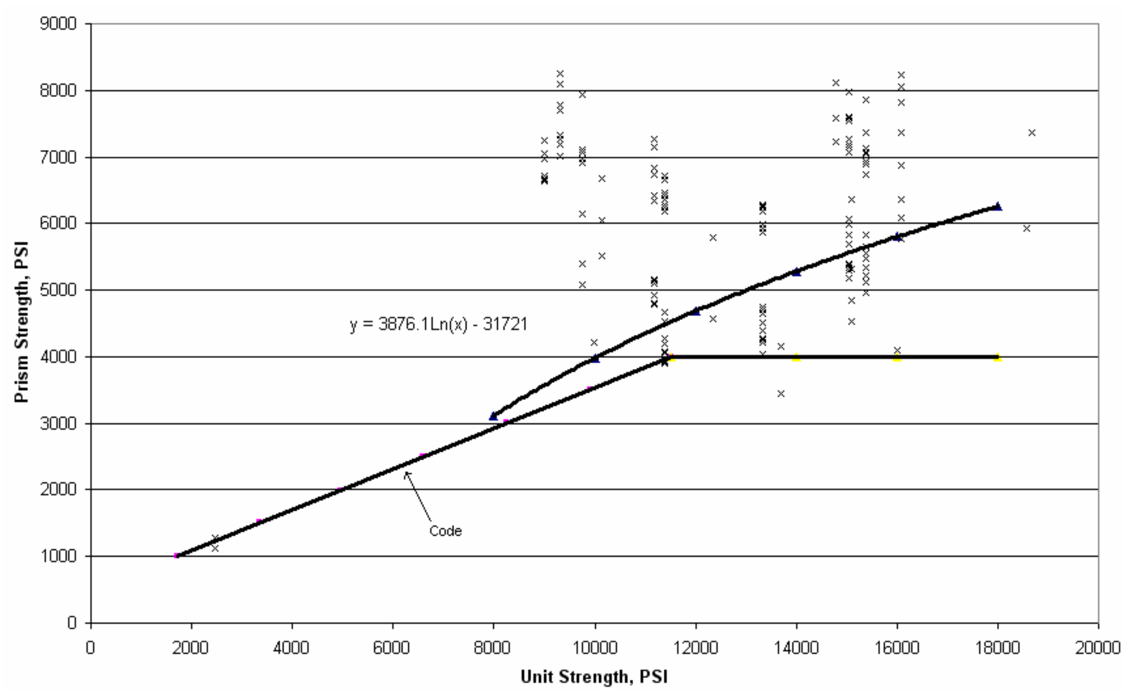

Figure 4.16: Type M Mortar.

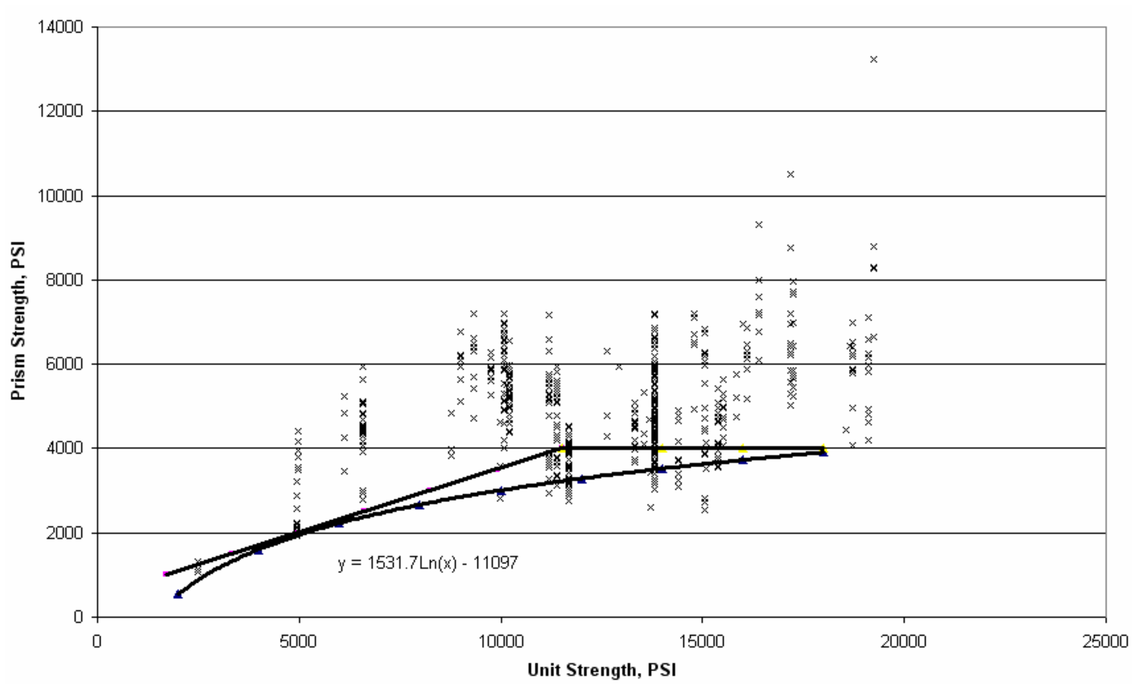

Figure 4.17: Type S Mortar

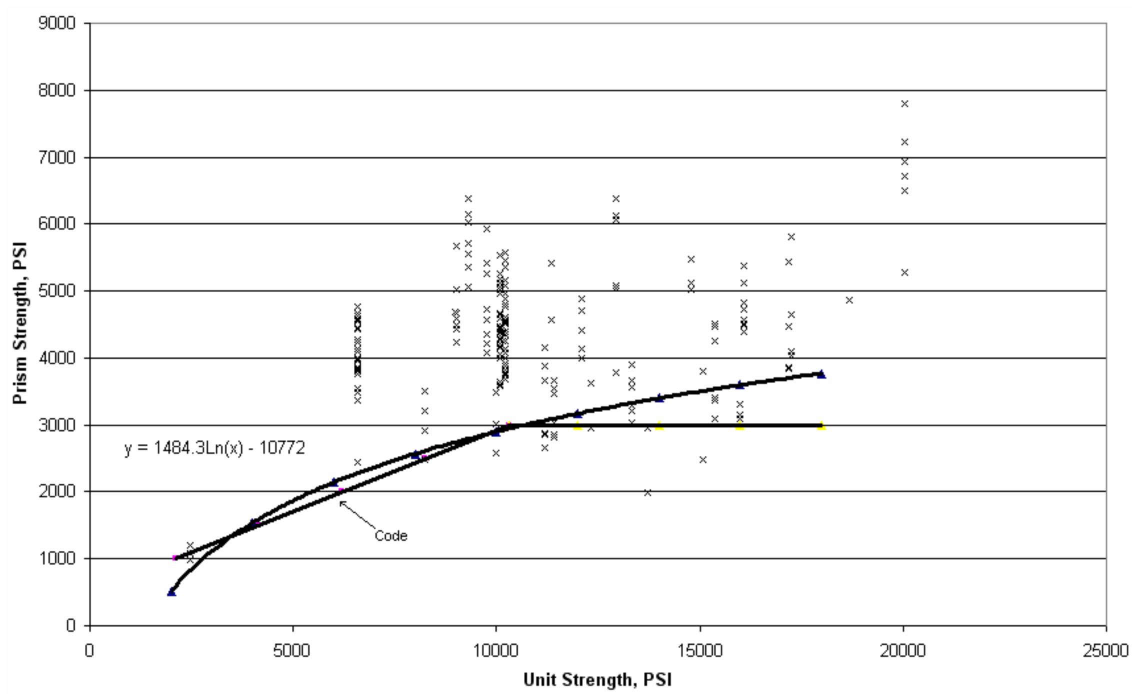

Figure 4.18: Type N Mortar.

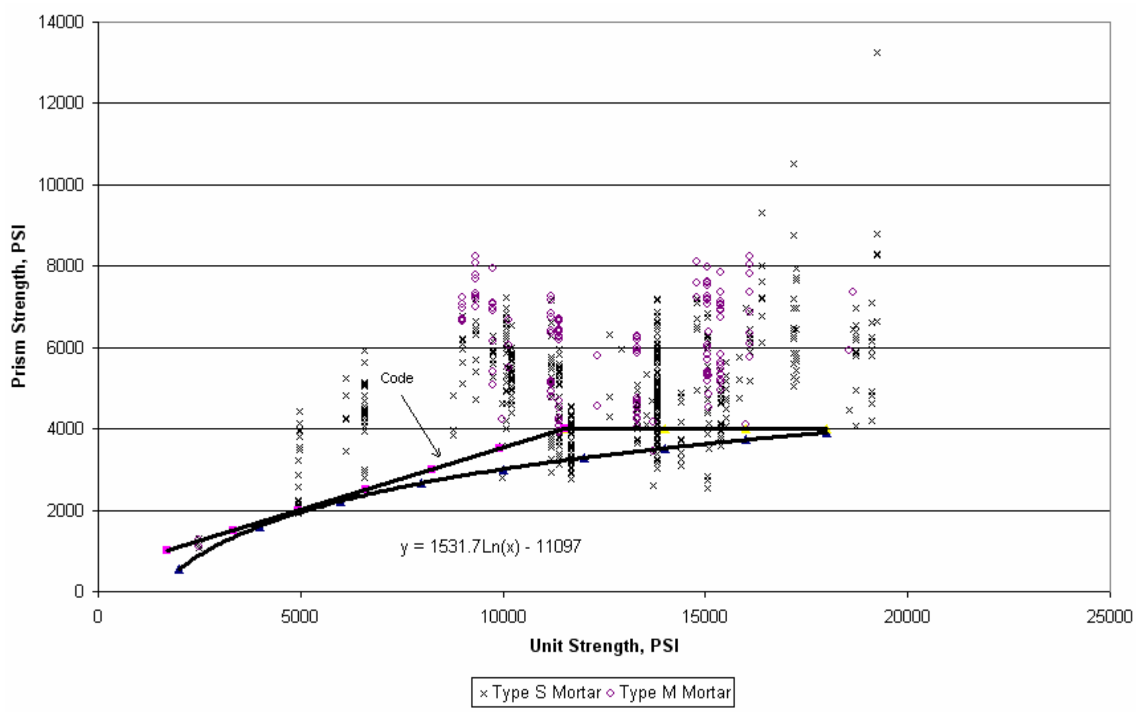

Figure 4.19: Types M & S Mortar.

The prism compressive strength values predicted by Model "B" are generally much closer to the design values from the Code than the data points generated by testing performed for this research. Therefore, this research provides information to update and increase the compressive strength values of masonry in the Code in the range of clay masonry unit compressive strength tested in this study – approximately 5,000 psi to 9,000 psi based on gross area).

4.2.2.1 Linear Regression of Model "B" Data Set

The Model "B" data set were adjusted to h/t value of two based on the correction factors presented in Table 2.1. All the other variables were ignored and the data was analyzed based on mortar type using liner regression that related prism compressive strength to the compressive strength of the clay masonry unit for each mortar type. Figures 4.20, 4.21, and 4.22 show the data and the prism compressive strength values (50^{th} and 5^{th} percentiles) along with equations that are best fits for those values for mortar types M, S, and N, respectively.

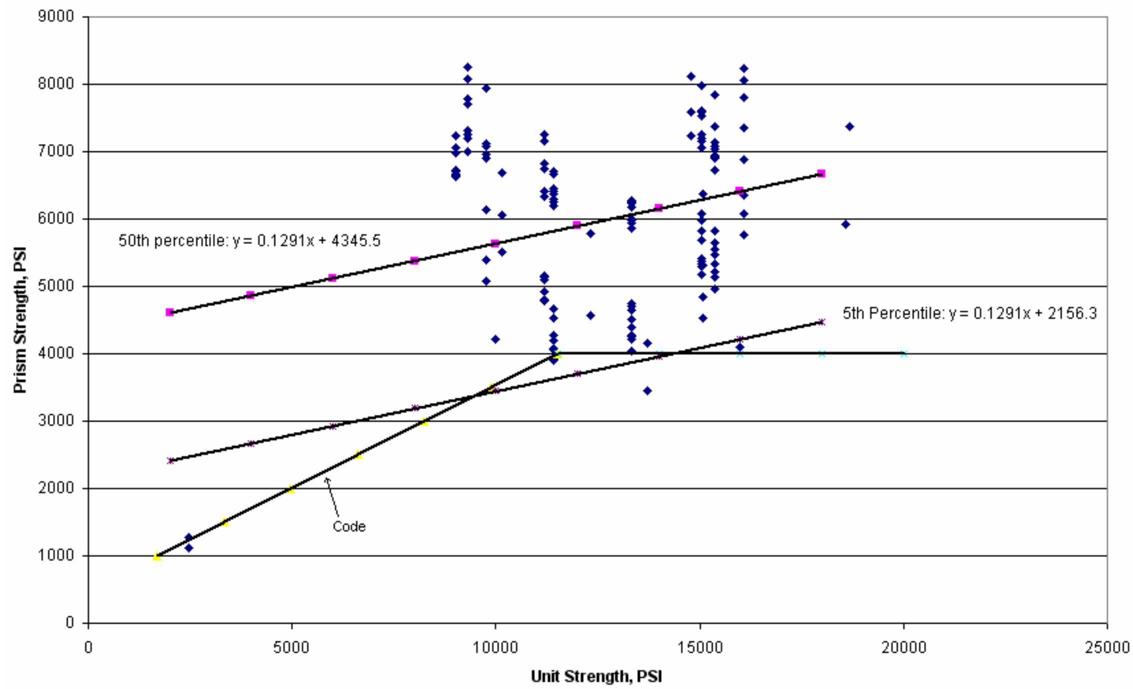

Figure 4.20: Type M Mortar.

Equation 4.11 (Type M Mortar, 50th Percentile) $f'_m = 0.129 \times (f_u) + 4{,}346$

Equation 4.12 (Type M Mortar, 5th Percentile) $f'_m = 0.129 \times (f_u) + 2{,}156$

f'_m: specified compressive strength of masonry, psi,

f_u: average compressive strength of brick, psi.

Coefficient of determination (R^2) = 0.072.

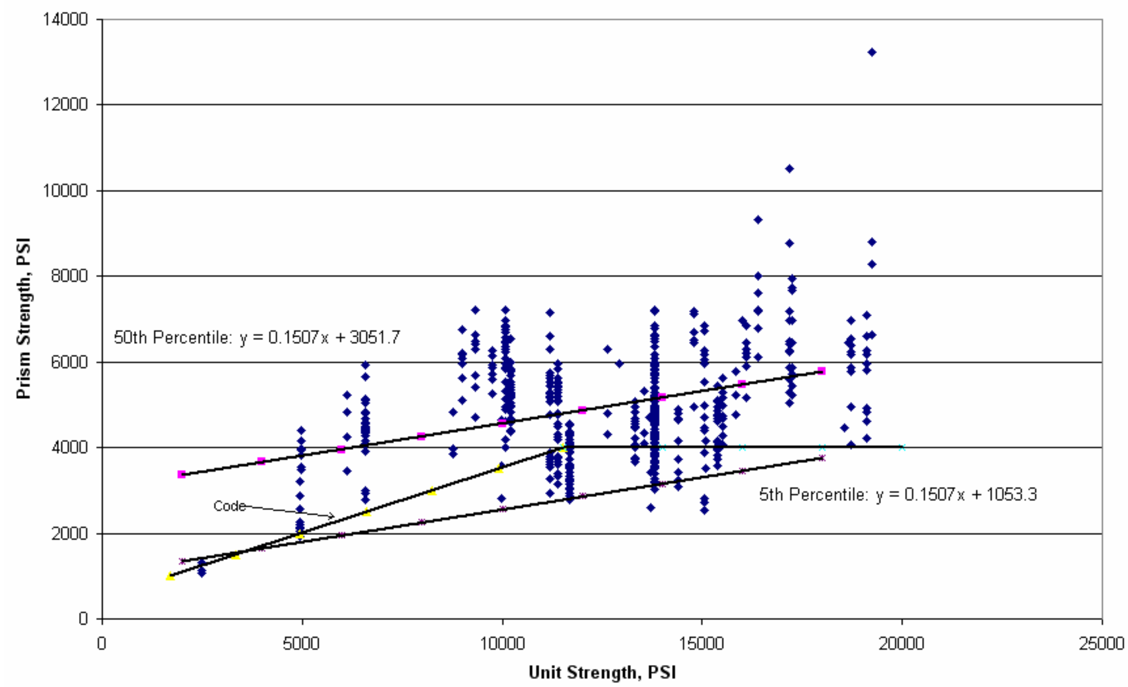

Figure 4.21: Type S Mortar.

Equation 4.13 (Type S Mortar, 50th Percentile) $f'_m = 0.151 \times (f_u) + 3{,}052$

Equation 4.14 (Type S Mortar, 5th Percentile) $f'_m = 0.151 \times (f_u) + 1{,}053$

f'_m: specified compressive strength of masonry, psi,

f_u: average compressive strength of brick, psi.

Coefficient of determination (R^2) = 0.148.

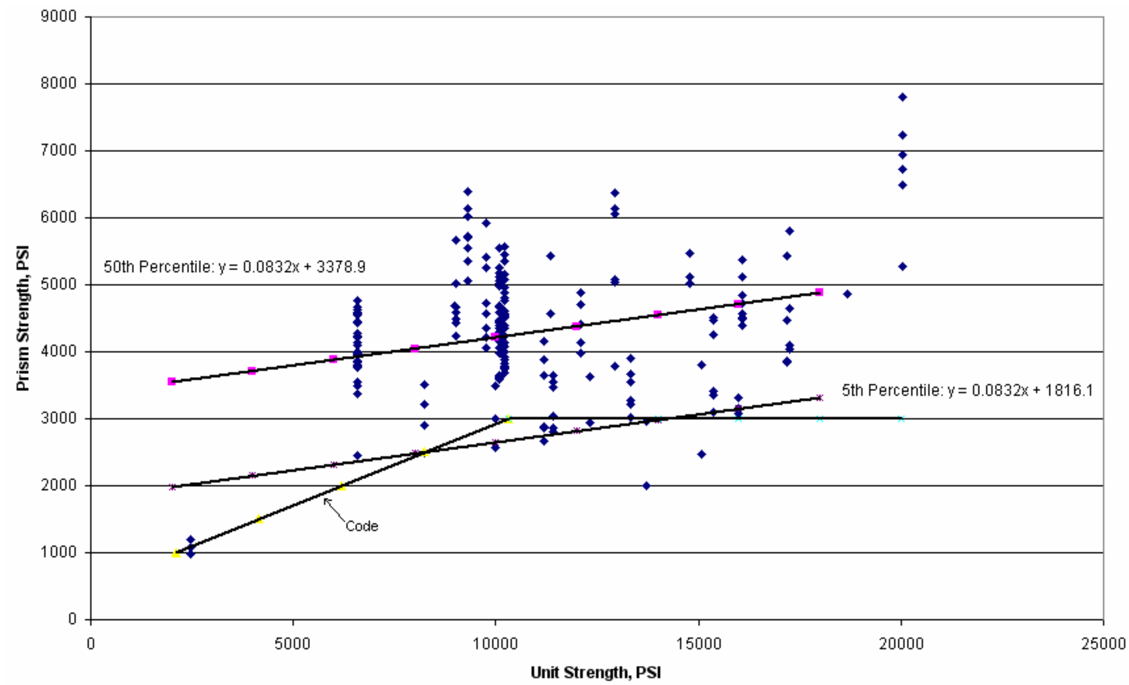

Figure 4.22: Type N Mortar.

Equation 4.15 (Type N Mortar, 50th Percentile) $$f'_m = 0.0832 \times (f_u) + 3{,}379$$

Equation 4.16 (Type N Mortar, 5th Percentile) $$f'_m = 0.0832 \times (f_u) + 1{,}816$$

f'_m: specified compressive strength of masonry, psi,

f_u: average compressive strength of brick, psi.

Coefficient of determination (R^2) = 0.085.

4.2.3 Model "C"

The governing ASTM standards today require prisms to be moist cured and chances are the prisms would be tested at an age of 28 days. Thus, the data points from prisms tested at 7 days and grouted prisms were excluded from Model "C" data set and the curing method was ignored. Therefore, curing time and curing method are not predictor variables in Model “C”. The data points generated from grouted prisms were few and were excluded to produce a more reliable analysis using fewer variables. The compressive strengths are based on gross area for solid units and net area for hollow units. Units being solid or hollow and mortar joint being full-bed or face-shell are variables in Model “C”. The predictor variables investigated are as follows:

- The natural logarithm (logarithm base e) of the compressive strength of the clay masonry units,
- Mortar type,
- Units being solid or hollow,
- Mortar joints being face-shell or full-bed,
- Height-to-thickness ratio (h/t ratio).

There also exist interactions between the variables listed above. The following interactions were included in the model:

- Mortar type and h/t ratio,
- The natural logarithm of the compressive strength of clay masonry units and h/t ratio,
- Mortar type and the natural logarithm of the compressive strength of clay masonry units,
- Mortar type, h/t ratio, and the natural logarithm of the compressive strength of clay masonry units,
- Units being solid or hollow and h/t ratio,

- Units being solid or hollow and the natural logarithm of the compressive strength of clay masonry units,
- Units being solid or hollow, the natural logarithm of the compressive strength of clay masonry units, and h/t ratio,
- Mortar joints being full-bed or face-shell and h/t ratio,
- Mortar joints being full-bed or face-shell and the natural logarithm of the compressive strength of clay masonry units,
- Mortar joints being full-bed or face-shell, the natural logarithm of the compressive strength of clay masonry units, and h/t ratio.

In Model "C" there are three possible levels for mortar type, two for units being hollow or solid, and two for mortar joints being full-bed or face-shell. Thus, there are a total of 12 possible categories out of which there are data available for 10 categories and all are explored by Model "C", as listed in Table 4.7. The following apply to Table 4.7.

- Comb.: Counts the number of various combinations for which data is available,
- Mortar Type: M, S, or N,
- Solid Hollow: Specifies whether the masonry units used in the assemblage were solid or hollow units,
- Mortar Joint: Specifies whether the joint was reported as face-shell or full-bed.
- Freq.: The number of observations available for the corresponding category,

- Prism Strength: The mean of all prism strengths reported for that combination in psi.

Table 4.7: Available 10 Combinations

Comb.	Mortar Type	Solid Hollow	Mortar Joint	Freq.	Prism Strength
1	M	Hollow	Face Shell	58	5,279
2	M	Hollow	Full Bed	58	6,610
3	M	Solid	Full Bed	11	4,723
4	N	Hollow	Face Shell	40	3,599
5	N	Hollow	Full Bed	31	4,241
6	N	Solid	Full Bed	116	3,363
7	S	Hollow	Face Shell	109	4,786
8	S	Hollow	Full Bed	109	4,996
9	S	Solid	Face Shell	8	3,641
10	S	Solid	Full Bed	174	4,076

The following relationship between mean prism strength and the predictor variables was established by the model.

$$Mean \quad Prism \quad Strength = -17{,}314.618{,}696.5B_4 + 3{,}000.9B_5 + 25{,}527.3B_7 + 1{,}535.4B_8 + 2{,}678.2B_9 + 2{,}393.3B_{10} - 314.4B_9B_{10} + 8{,}568.3B_4B_9 + 156.7B_5B_9 + 2{,}086.3B_4B_{10} - 397.3B_5B_{10} - 901.6B_4B_9B_{10} - 26.4B_5B_9B_{10} - 2{,}206.8B_7B_9 - 2{,}703.7B_7B_{10} + 244.8B_7B_9B_{10} - 3{,}833.4B_8B_9 - 248N_8B_{10} + 439.2B_8B_9B_{10}$$

$$B4 = \begin{Bmatrix} 1 \\ 0 \end{Bmatrix} \begin{matrix} Type \quad M \quad Mortar \\ Otherwise \end{matrix} \qquad B5 = \begin{Bmatrix} 1 \\ 0 \end{Bmatrix} \begin{matrix} Type \quad N \quad Mortar \\ Otherwise \end{matrix}$$

$$B7 = \begin{Bmatrix} 1 \\ 0 \end{Bmatrix} \begin{matrix} Hollow \quad Units \\ Solid \quad Units \end{matrix} \qquad B8 = \begin{Bmatrix} 1 \\ 0 \end{Bmatrix} \begin{matrix} Face-shell \\ Full-bed \end{matrix}$$

$$B9 = h/t \; ratio$$

$$B10 = Ln(Unit \quad Compressive \quad Strength)$$

The distribution of the prism strength values at each unit strength value fits a normal distribution. Thus, the following can be used to deduce the fifth quantile values for the response variable.

$$\xi_{0.05}\left(\hat{\mu}, \hat{\sigma}\right) = \hat{\mu} + \hat{\sigma}\,\xi_{0.05}(0,1)$$

$$\xi_{0.05}\left(\hat{\mu}, \hat{\sigma}\right) = Fifth \quad Quantile$$

$$\hat{\mu} = Mean \quad \Pr ism \quad Strength \quad \Pr edicted \quad by \quad the \quad Model.$$

$$\hat{\sigma} = Conditional \quad S\tan dard \quad Deviation = 811.2$$

$$\xi_{0.05}(0,1) = -1.64$$

$$\xi_{0.05}\left(\hat{\mu}, \hat{\sigma}\right) = \hat{\mu} - 811.2 \times 1.64 = \hat{\mu} - 1{,}330.4$$

The coefficient of determination (R^2) for model "C" is 0.63.The type III sum of squares (Type III SS) generated by model "C" are shown in Table 4.8. The predictor variables or interactions with relatively larger type III SS values are the terms that explain more of the variation of the prism strengths.

Table 4.8: Model "C" Type III SS Values

Source	Type III SS
Mortar type: M, S, or N	11,947,814
Units being solid or hollow	24,204,203
Full-bed or face-shell bedding	66,669
Height-to-thickness ratio	2,960,826
$Ln(f_u)$	27,773,119
Interaction between $Ln(f_u)$ & h/t ratio	3,108,046
Interaction between h/t ratio & mortar type	4,136,836
Interaction between $Ln(f_u)$ & mortar type	13,852,285
Interaction between $Ln(f_u)$, h/t ratio, & mortar type	4,032,851
Interaction between h/t ratio & solid or hollow units	770,002
Interaction between $Ln(f_u)$ & solid or hollow units	24,036,705
Interaction between $Ln(f_u)$, h/t ratio, & solid or hollow	838,985
Interaction between h/t ratio & face-shell or full-bed	2,229,237
Interaction between $Ln(f_u)$ & face-shell or full-bed	156,009
Interaction between $Ln(f_u)$, h/t ratio, & face-shell or	2,597,498

The variables and interactions that explain most of the variation in prism strength in the model are listed below in descending order of significance.

1. Natural logarithm of the compressive strength of masonry unit,
2. Units being solid or hollow,

3. Interaction between the natural logarithm of the compressive strength of masonry unit and units being solid or hollow,
4. Interaction between the natural logarithm of the compressive strength of masonry unit and mortar type,
5. Mortar type.

The average prism strength fifth quantile values across all available categories predicted by model "C" - targeting h/t ratio value of two - and an equation best presenting those values are shown in Figure 4.23, 4.24, and 4.25 for mortar types M, S, N, respectively. The Code values are also shown for each case. Prism strength values cannot be reliably predicted for all ranges of unit compressive strengths due to insufficient test data. There is large gap of type M mortar data for unit strengths of less than approximately 9,000 psi. However, using type S mortar prism strength predictions of the model for type M mortar is conservative. Available data points for mortar types M and S and the fifth quantile predictions of the model for type S mortar are shown in Figure 4.26.

Equations 4.17 and 4.18 represent the best fit equations for the average prism strength fifth quantile values across all available categories predicted by model "C" - targeting h/t ratio value of two – for mortar type S and N, respectively.

Equation 4.17 (Type S Mortar) $$f'_m = 1{,}531.7 \times Ln(f_u) - 11{,}097$$

Equation 4.18 (Type N Mortar) $$f'_m = 1{,}484.3 \times Ln(f_u) - 10{,}772$$

f'_m: specified compressive strength of masonry, psi,

f_u: average compressive strength of brick, psi.

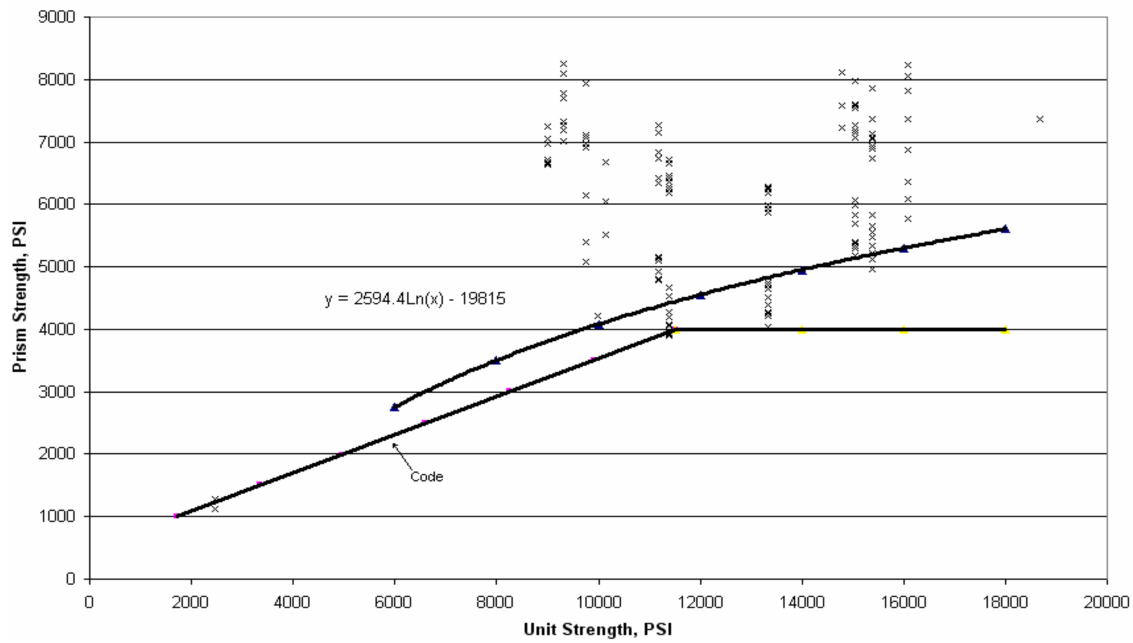

Figure 4.23: Type M Mortar.

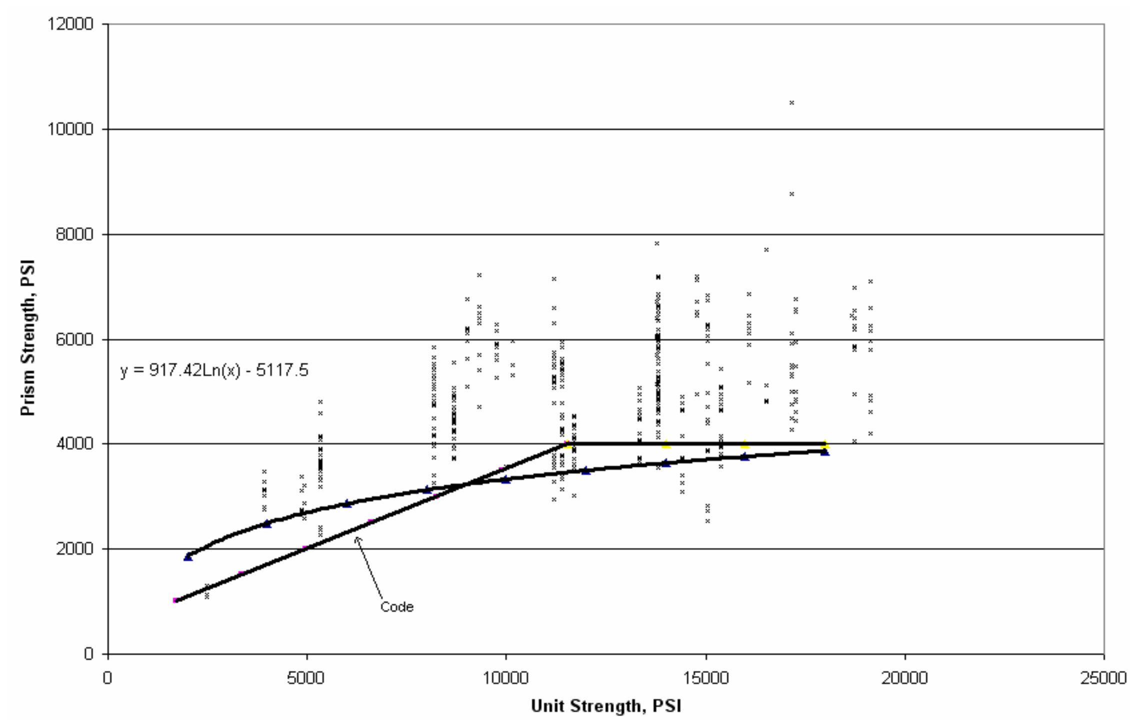

Figure 4.24: Type S Mortar

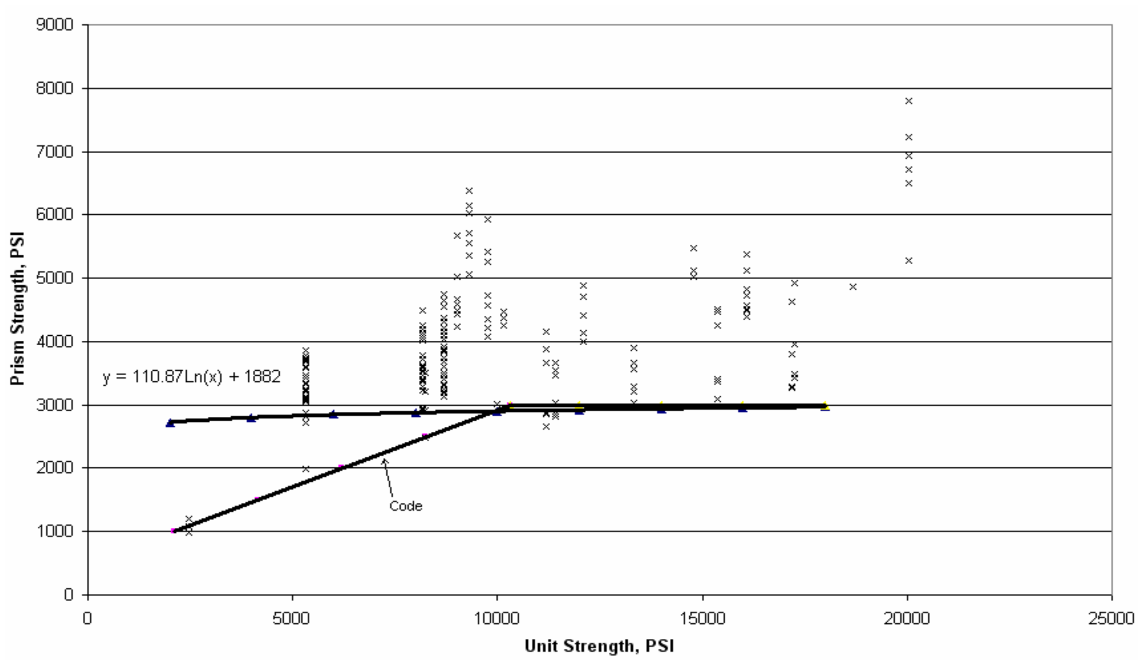

Figure 4.25: Type N Mortar.

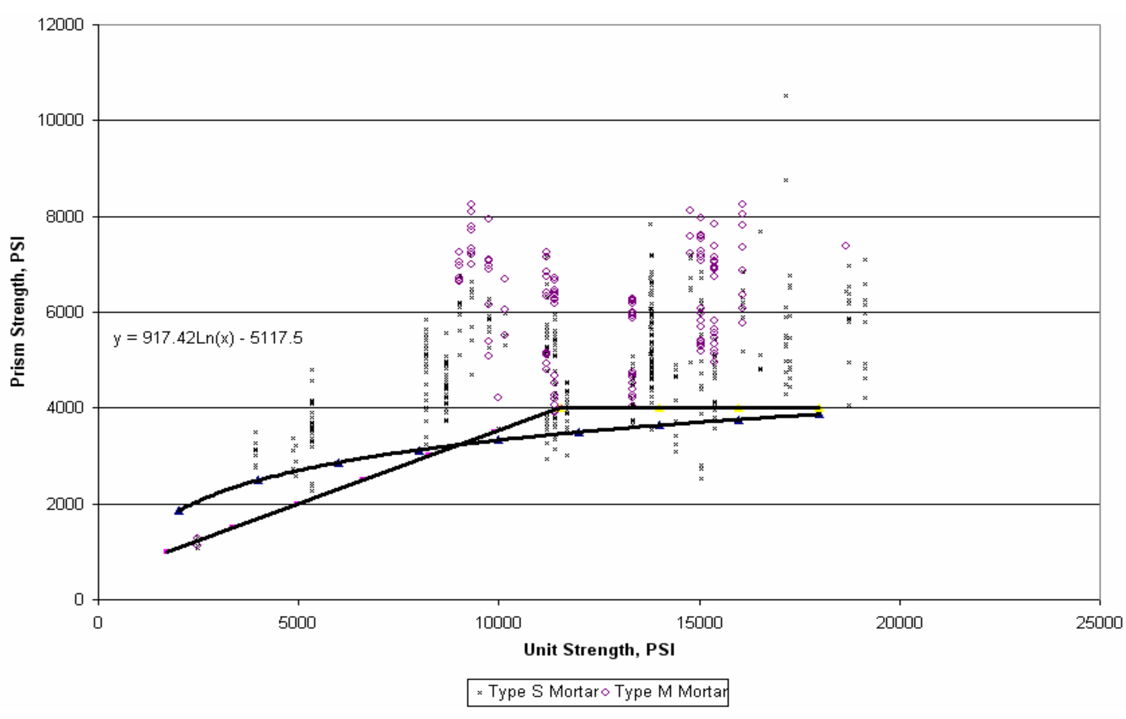

Figure 4.26: Types M & S Mortar.

Model "C" predicts higher prism compressive strengths than the Code values for lower unit compressive strengths. This is true due to the results of the tests performed in this research. A linear regression and 5th percentile prism strength predictions using the test results of this research only could clarify the appropriate prism strengths in the range of unit compressive strengths that were used in testing.

4.2.3.1 Linear Regression of Model "C" Data Set

The Model "C" data set was adjusted to h/t value of two based on the correction factors presented in Table 2.1. All the other variables were ignored and the data was analyzed based on mortar type using liner regression that related prism compressive strength to the compressive strength of the clay masonry unit for each mortar type. Figures 4.27, 4.28, and 4.29 show the data and the prism compressive strength values (50th and 5th percentiles) along with equations that are best fits for those values for mortar types M, S, and N, respectively.

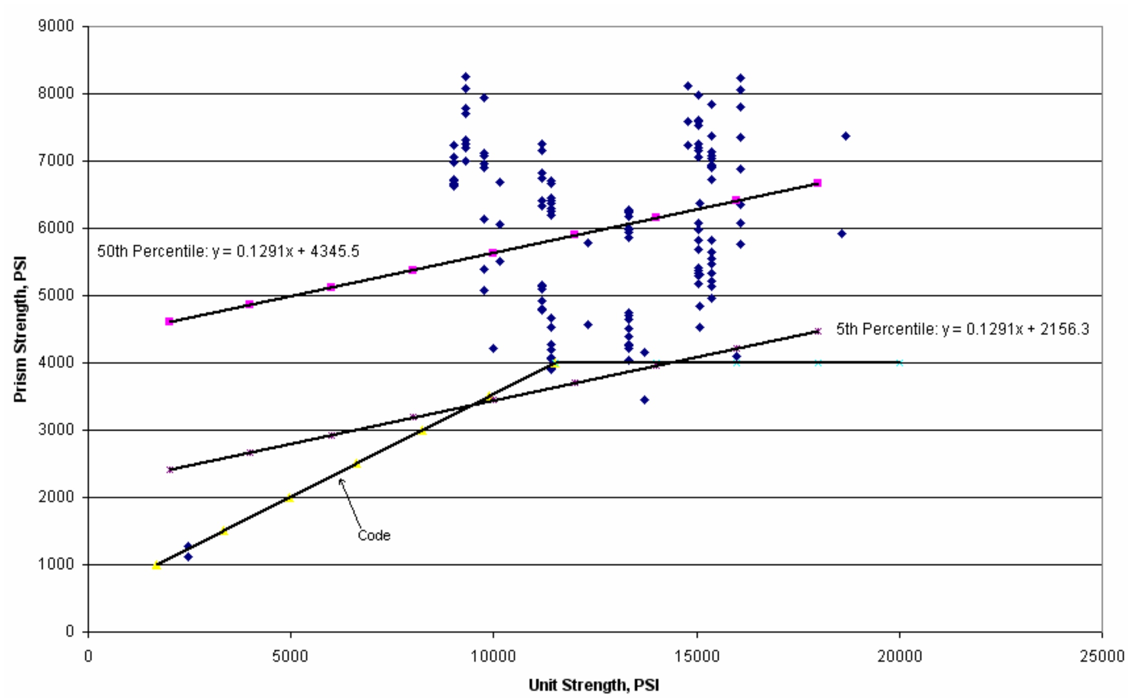

Figure 4.27: Type M Mortar.

Equation 4.17 (Type M Mortar, 50th Percentile) $f'_m = 0.129 \times (f_u) + 4{,}346$

Equation 4.18 (Type M Mortar, 5th Percentile) $f'_m = 0.129 \times (f_u) + 2{,}156$

f'_m: specified compressive strength of masonry, psi,

f_u: average compressive strength of brick, psi.

Coefficient of determination (R^2) = 0.072.

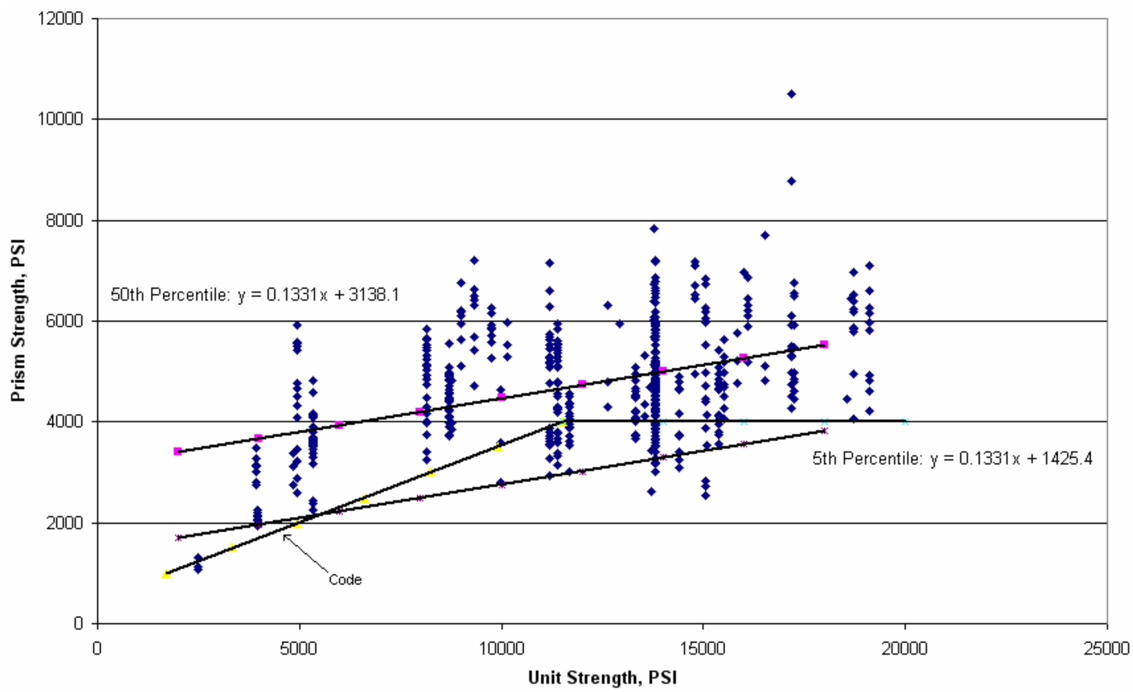

Figure 4.28: Type S Mortar.

Equation 4.19 (Type S Mortar, 50th Percentile) $f'_m = 0.133 \times (f_u) + 3{,}138$

Equation 4.20 (Type S Mortar, 5th Percentile) $f'_m = 0.133 \times (f_u) + 1{,}425$

f'_m: specified compressive strength of masonry, psi,

f_u: average compressive strength of brick, psi.

Coefficient of determination (R^2) = 0.195.

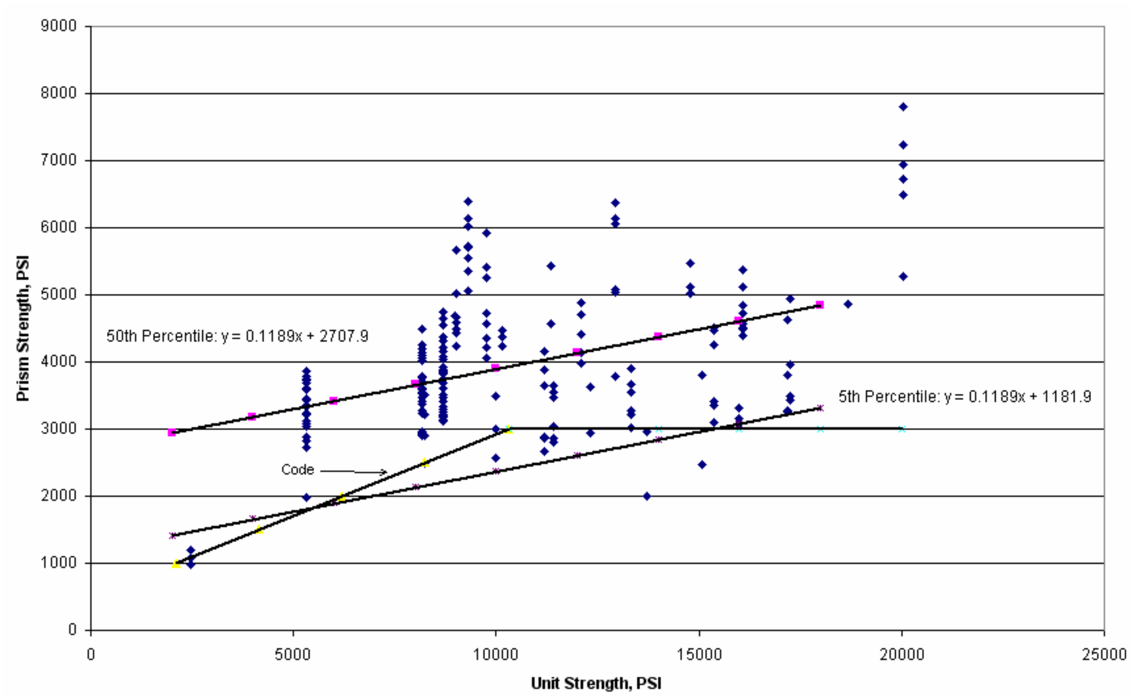

Figure 4.29: Type N Mortar.

Equation 4.21 (Type N Mortar, 50th Percentile) $f'_m = 0.119 \times (f_u) + 2{,}2708$

Equation 4.22 (Type N Mortar, 5th Percentile) $f'_m = 0.119 \times (f_u) + 1{,}182$

f'_m: specified compressive strength of masonry, psi,

f_u: average compressive strength of brick, psi.

Coefficient of determination (R^2) = 0.201.

4.2.4 Model "D"

Model "D" data set consists of data points generated by moist cured prisms that were tested at 28 days. Therefore, curing method is not ignored and is not one of the variables in the analysis. The grouted prisms were excluded from the data set. The compressive strengths are based on gross area for solid units and net area for hollow units. Units being solid or hollow and mortar joint being full-bed or face-shell are variables in Model "D". The predictor variables investigated are as follows:

- The natural logarithm (logarithm base e) of the compressive strength of the clay masonry units,
- Mortar type,
- Units being solid or hollow,
- Mortar joints being face-shell or full-bed,
- Height-to-thickness ratio (h/t ratio).

There also exist interactions between the variables listed above. The following interactions were included in the model:

- Mortar type and h/t ratio,
- The natural logarithm of the compressive strength of clay masonry units and h/t ratio,
- Mortar type and the natural logarithm of the compressive strength of clay masonry units,
- Mortar type, h/t ratio, and the natural logarithm of the compressive strength of clay masonry units,
- Units being solid or hollow and h/t ratio,
- Units being solid or hollow and the natural logarithm of the compressive strength of clay masonry units,
- Units being solid or hollow, the natural logarithm of the compressive strength of clay masonry units, and h/t ratio,

- Mortar joints being full-bed or face-shell and h/t ratio,
- Mortar joints being full-bed or face-shell and the natural logarithm of the compressive strength of clay masonry units,
- Mortar joints being full-bed or face-shell, the natural logarithm of the compressive strength of clay masonry units, and h/t ratio.

In Model "D" there are three possible levels for mortar type, two for units being hollow or solid, and two for mortar joints being full-bed or face-shell. Thus, there are a total of 12 possible categories out of which there are data available for 8 categories and all are explored by Model "D", as listed in Table 4.9.

The following apply to table 4.9.

- Comb.: Counts the number of various combinations for which data is available,
- Mortar Type: M, S, or N,
- Solid Hollow: Specifies whether the masonry units used in the assemblage were solid or hollow units,
- Mortar Joint: Specifies whether the joint was reported as face-shell or full-bed.
- Freq.: The number of observations available for the corresponding category,
- Prism Strength: The mean of all prism strengths reported for that combination in psi.

Table 4.9: Available 8 Combinations

Comb.	Mortar Type	Solid Hollow	Mortar Joint	Freq.	Prism Strength
1	M	Hollow	Face Shell	42	4,899
2	M	Hollow	Full Bed	42	6,760
3	N	Hollow	Face Shell	15	3,087
4	N	Hollow	Full Bed	15	3,998
5	N	Solid	Full Bed	90	3,182
6	S	Hollow	Face Shell	48	3,873
7	S	Hollow	Full Bed	77	5,121
8	S	Solid	Full Bed	112	3,843

The following relationship between mean prism strength and the predictor variables was established by the model.

$$Mean \quad \Pr ism \quad Strength = -3{,}016.1 - 23{,}870.2B_4 + 3{,}539.3B_5 + 2{,}981.5B_7 - 595.5B_8 - 3{,}606.5B_9 + 789.8B_{10} + 391.5B_9B_{10} + 368{,}548.9B_4B_9 + 2{,}802.4B_5B_9 + 2{,}657.4B_4B_{10} - 471.2B_5B_{10} - 40{,}125.4B_4B_9B_{10} - 315.6B_5B_9B_{10} - 126{,}922.1B_7B_9 - 219.9B_7B_{10} + 13{,}041.9B_7B_9B_{10} - 280{,}291.2B_8B_9 - 108.9N_8B_{10} + 30{,}113.5B_8B_9B_{10}$$

$$B4 = \begin{Bmatrix} 1 \\ 0 \end{Bmatrix} \begin{matrix} Type \quad M \quad Mortar \\ Otherwise \end{matrix} \qquad B5 = \begin{Bmatrix} 1 \\ 0 \end{Bmatrix} \begin{matrix} Type \quad N \quad Mortar \\ Otherwise \end{matrix}$$

$$B7 = \begin{Bmatrix} 1 \\ 0 \end{Bmatrix} \begin{matrix} Hollow \quad Units \\ Solid \quad Units \end{matrix} \qquad B8 = \begin{Bmatrix} 1 \\ 0 \end{Bmatrix} \begin{matrix} Face-shell \\ Full-bed \end{matrix}$$

$$B9 = {}^{h}\!/_{t} \; ratio$$

$$B10 = Ln(Unit \quad Compressive \quad Strength)$$

The distribution of the prism strength values at each unit strength value fits a normal distribution. Thus, the following can be used to deduce the fifth quantile values for the response variable.

$$\xi_{0.05}\left(\hat{\mu}, \hat{\sigma}\right) = \hat{\mu} + \hat{\sigma}\, \xi_{0.05}(0,1)$$

$$\xi_{0.05}\left(\hat{\mu}, \hat{\sigma}\right) = Fifth \quad Quantile$$

$$\hat{\mu} = Mean \quad \Pr ism \quad Strength \quad \Pr edicted \quad by \quad the \quad Model.$$

$$\hat{\sigma} = Conditional \quad S\tan dard \quad Deviation = 514.8$$

$$\xi_{0.05}(0,1) = -1.64$$

$$\xi_{0.05}\left(\hat{\mu}, \hat{\sigma}\right) = \hat{\mu} - 514.8 \times 1.64 = \hat{\mu} - 844.3$$

The coefficient of determination (R^2) for model "D" is 0.83. The type III sum of squares (Type III SS) generated by model "D" are shown in Table 4.10. The predictor variables or interactions with relatively larger type III SS values are the terms that explain more of the variation of the prism strengths.

Table 4.10: Model "D" Type III SS Values

Source	Type III SS
Mortar type: M, S, or N	4,959,387
Units being solid or hollow	116,058
Full-bed or face-shell bedding	2,533

Table 4.10 - continued

Source	Type III SS
Height-to-thickness ratio	100,091
$Ln(f_u)$	6,310,397
Interaction between $Ln(f_u)$ & h/t ratio	90,623
Interaction between h/t ratio & mortar type	1,266,405
Interaction between $Ln(f_u)$ & mortar type	5,832,629
Interaction between $Ln(f_u)$, h/t ratio, & mortar type	1,292,385
Interaction between h/t ratio & solid or hollow units	287,076
Interaction between $Ln(f_u)$ & solid or hollow units	55,749
Interaction between $Ln(f_u)$, h/t ratio, & solid or hollow	275,004
Interaction between h/t ratio & face-shell or full-bed	216,948
Interaction between $Ln(f_u)$ & face-shell or full-bed	7,539
Interaction between $Ln(f_u)$, h/t ratio, & face-shell or	219,493

The variables and interactions that explain most of the variation in prism strengths in the model are listed below in descending order of significance.

1. Natural logarithm of the compressive strength of masonry unit,
2. Interaction between the natural logarithm of the compressive strength of masonry unit and mortar type,
3. Mortar type.

The average prism strength fifth quantile values across all available categories predicted by model “D” - targeting h/t ratio value of two - and an equation best presenting those values are shown in Figure 4.30, 4.31, and 4.32 for mortar types M, S, N, respectively. The Code values are also shown for each case. Prism strength values cannot be reliably predicted for all ranges of unit compressive strengths due to insufficient test data. There is large gap of type M mortar data for unit strengths of less than approximately 9,000 psi. However, using type S mortar prism strength predictions of the model for type M mortar is conservative. Available data points for mortar types M and S and the fifth quantile predictions of the model for type S mortar are shown in Figure 4.33.

Equations 4.23 and 4.24 represent the best fit equations for the average prism strength fifth quantile values across all available categories predicted by model "D" - targeting h/t ratio value of two – for mortar type S and N, respectively.

Equation 4.23 (Type S Mortar) $$f'_m = 602.7 \times Ln(f_u) - 2{,}039$$

Equation 4.24 (Type N Mortar) $$f'_m = 135.8 \times Ln(f_u) - 1{,}466$$

f'_m: specified compressive strength of masonry, psi,

f_u: average compressive strength of brick, psi.

Model "D" predicts higher prism compressive strengths than the Code values for lower unit compressive strengths where testing was performed for this study.

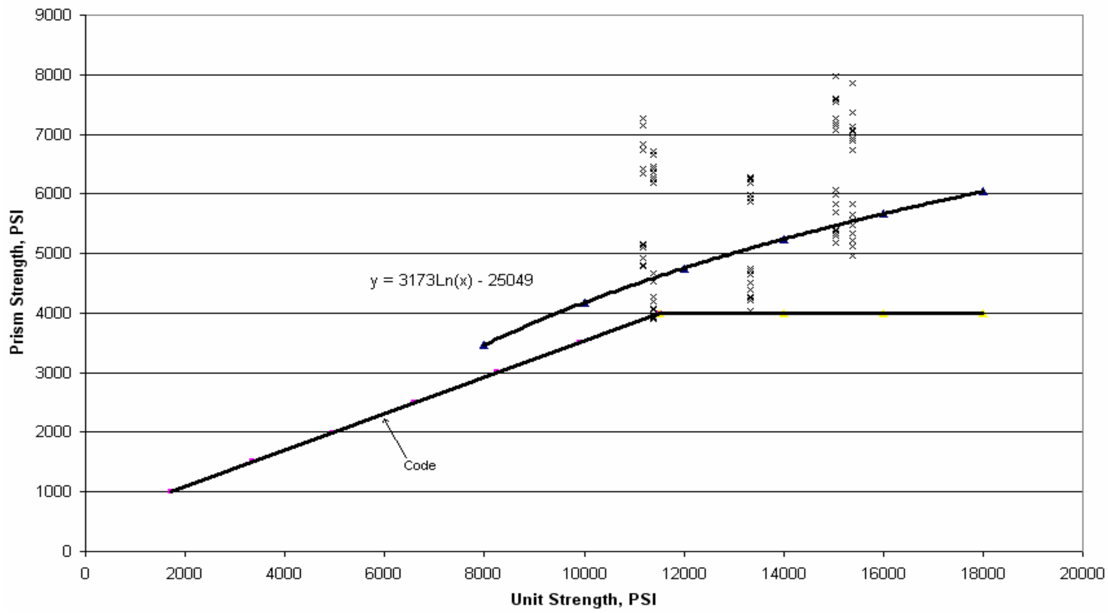

Figure 4.30: Type M Mortar.

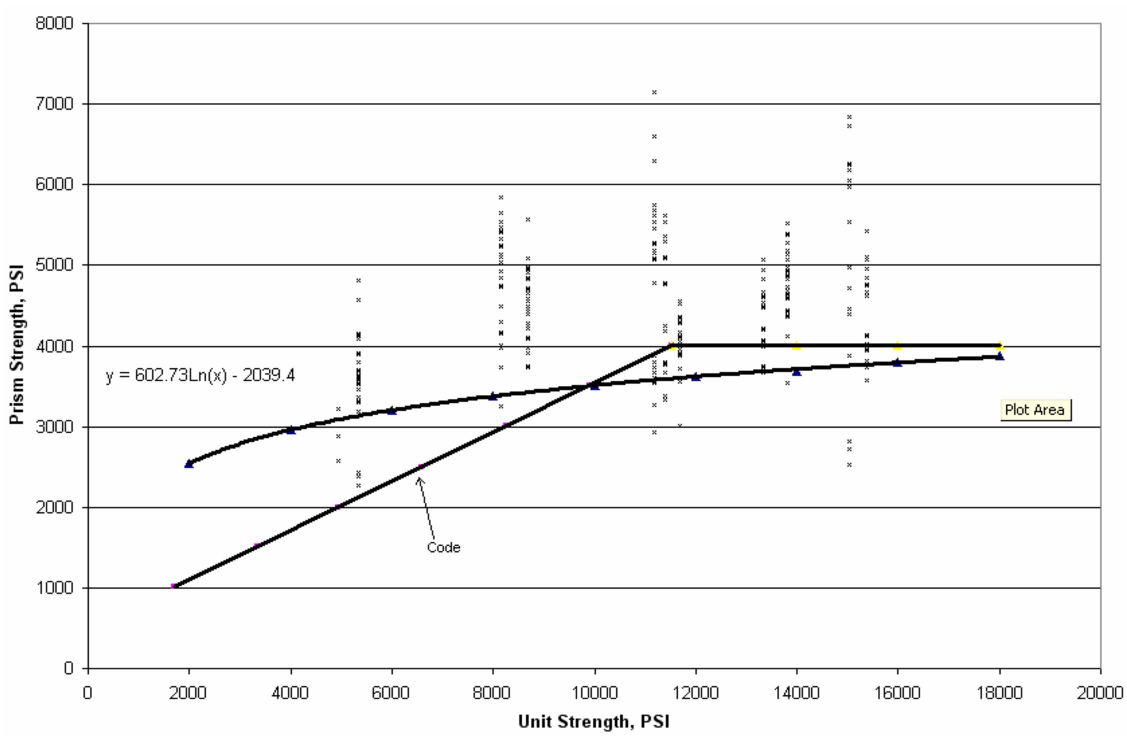

Figure 4.31: Type S Mortar

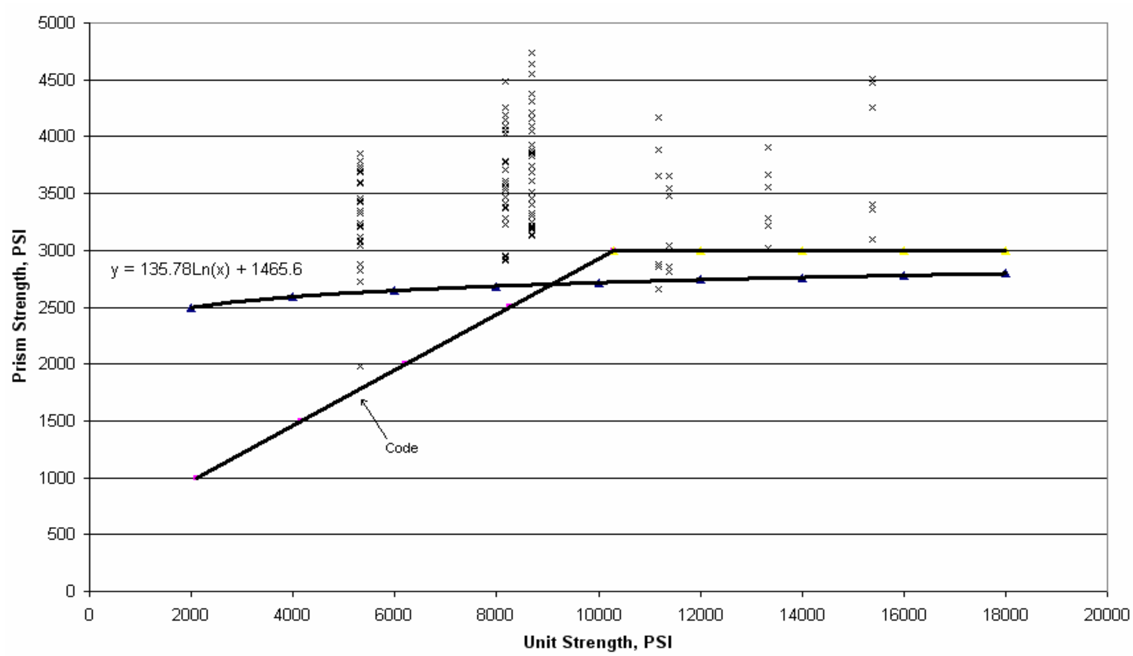

Figure 4.32: Type N Mortar.

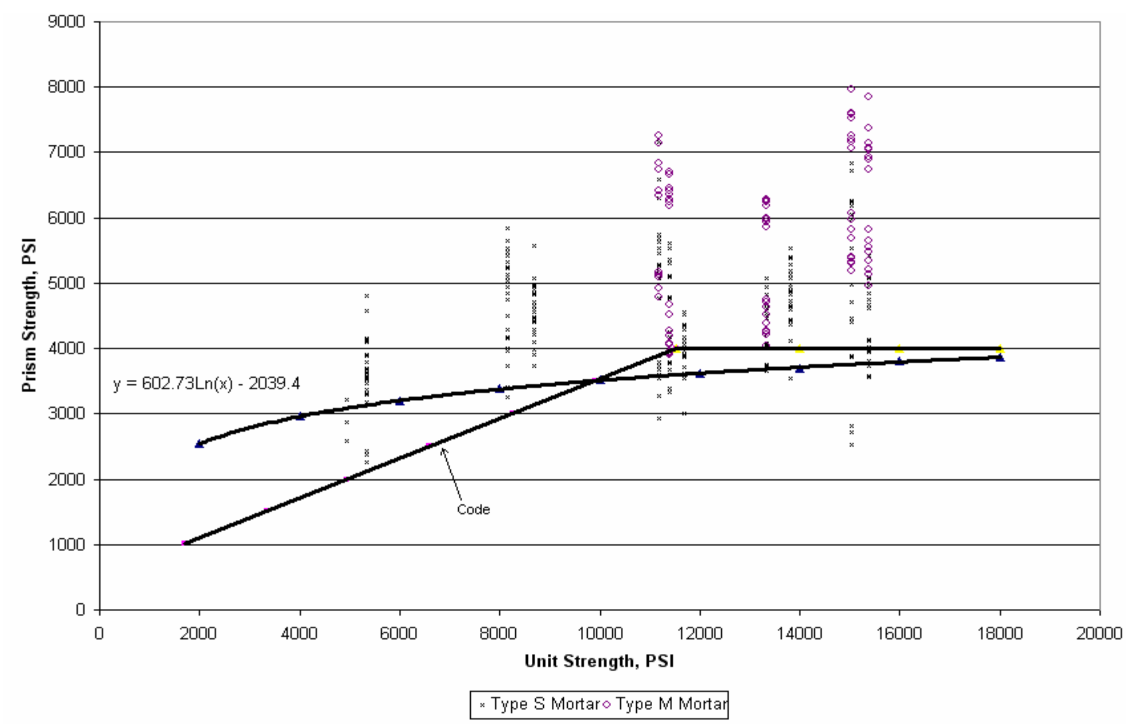

Figure 4.33: Types M & S Mortar.

4.2.4.1 Linear Regression of Model "D" Data Set

The Model "D" data set was adjusted to h/t value of two based on the correction factors presented in Table 2.1. All the other variables were ignored and the data was analyzed based on mortar type using liner regression that related prism compressive strength to the compressive strength of the clay masonry unit for each mortar type. Figures 4.34, 4.35, and 4.36 show the data and the prism compressive strength values (50th and 5th percentiles) along with equations that are best fits for those values for mortar types M, S, and N, respectively.

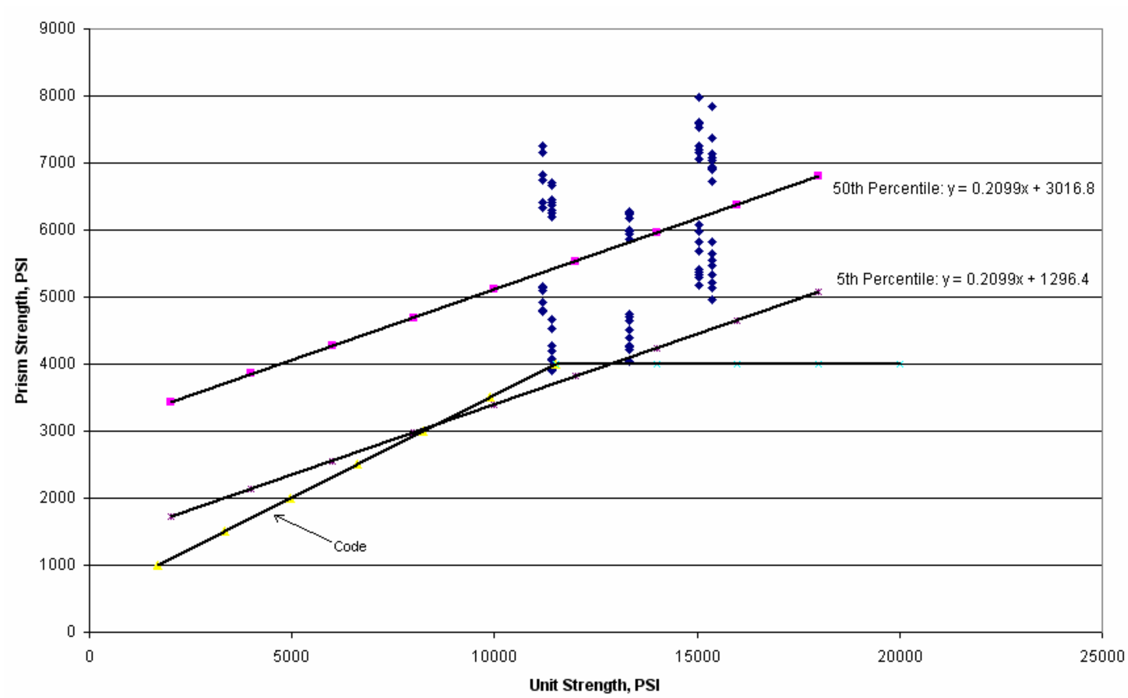

Figure 4.34: Type M Mortar.

Equation 4.23 (Type M Mortar, 50th Percentile) $$f'_m = 0.210 \times (f_u) + 3{,}017$$

Equation 4.24 (Type M Mortar, 5th Percentile) $$f'_m = 0.210 \times (f_u) + 1{,}296$$

f'_m: specified compressive strength of masonry, psi,

f_u: average compressive strength of brick, psi.

Coefficient of determination (R^2) = 0.108.

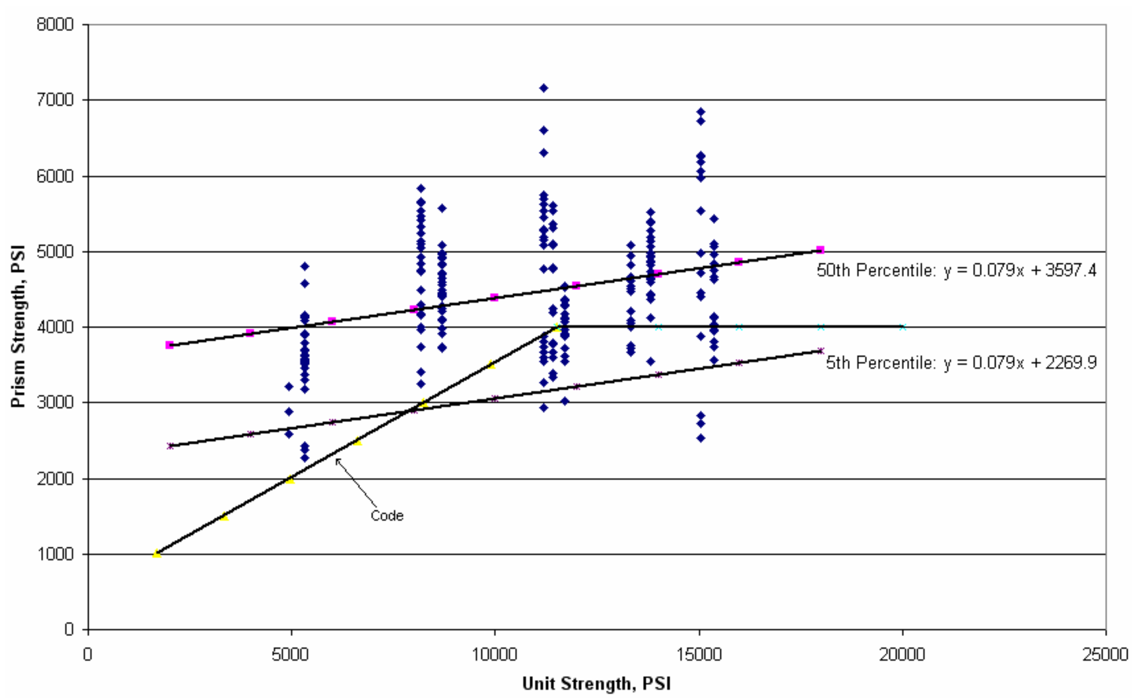

Figure 4.35: Type S Mortar.

Equation 4.25 (Type S Mortar, 50th Percentile) $$f'_m = 0.079 \times (f_u) + 3{,}597$$

Equation 4.26 (Type S Mortar, 5th Percentile) $$f'_m = 0.079 \times (f_u) + 2{,}270$$

f'_m: specified compressive strength of masonry, psi,

f_u: average compressive strength of brick, psi.

Coefficient of determination (R^2) = 0.089.

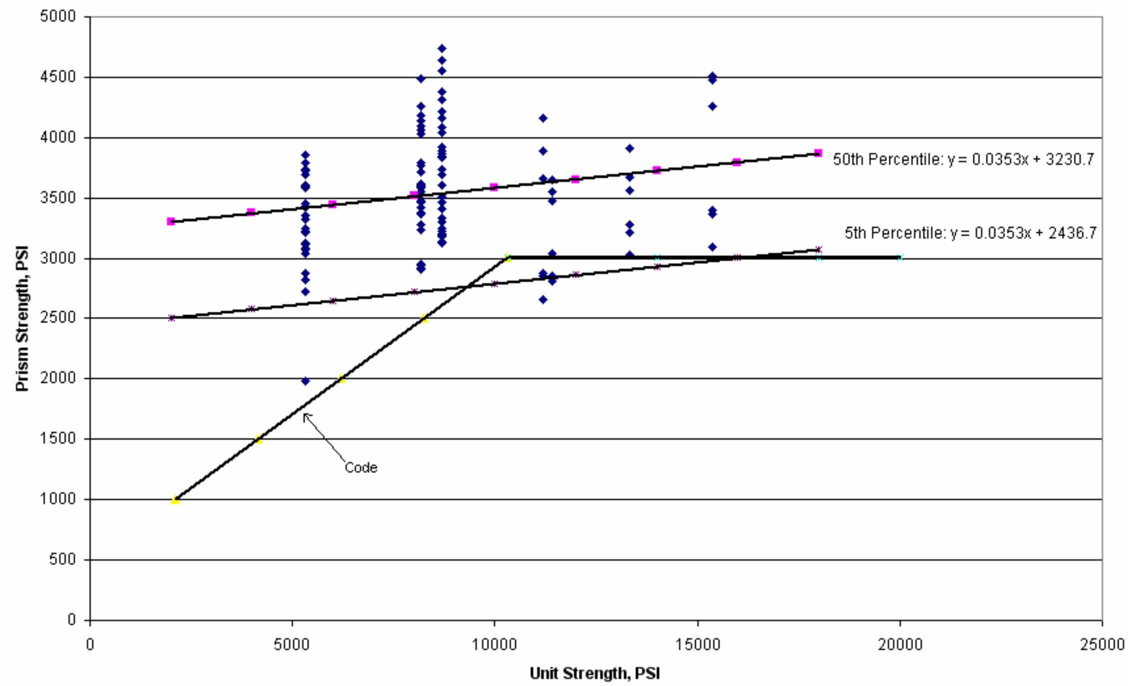

Figure 4.36: Type N Mortar.

Equation 4.27 (Type N Mortar, 50th Percentile) $f'_m = 0.035 \times (f_u) + 3{,}231$

Equation 4.28 (Type N Mortar, 5th Percentile) $f'_m = 0.035 \times (f_u) + 2{,}437$

f'_m: specified compressive strength of masonry, psi,

f_u: average compressive strength of brick, psi.

Coefficient of determination (R^2) = 0.047.

4.2.5 Model "E"

Model "E" data set is data set for Model "C" modified to reflect the compressive strengths of the units based on the net areas and the assemblage based on net bedded areas regardless of the size of the openings. This adjustment excludes two predictor variables – units being solid or hollow, and mortar joints being face-shell or full-bed.

Also, the data points from prisms cured for 7 days only were excluded and the curing method was ignored as a variable. The predictor variables investigated are as follows:

- The natural logarithm (logarithm base e) of the compressive strength of the clay masonry units,
- Mortar type,
- Height-to-thickness ratio (h/t ratio).

There also exist interactions between the variables listed above. The following interactions were included in the model:

- Mortar type and h/t ratio,
- The natural logarithm of the compressive strength of clay masonry units and h/t ratio,
- Mortar type and the natural logarithm of the compressive strength of clay masonry units,
- Mortar type, h/t ratio, and the natural logarithm of the compressive strength of clay masonry units,

In Model "E" there are three possible levels for mortar type. Thus, there are a total of 3 possible categories out of which there are data available for all three, as listed in Table 4.11. The following apply to Table 4.11.

- Comb.: Counts the number of various combinations for which data is available,
- Mortar Type: M, S, or N,
- Freq.: The number of observations available for the corresponding category,

- Prism Strength: The mean of all prism strengths reported for that combination in psi.

Table 4.11: Available 3 Combinations

Comb.	Mortar Type	Freq.	Prism Strength
1	M	127	5,838
2	S	398	4,826
3	N	187	3,910

The following relationship between mean prism strength and the predictor variables was established by the model.

$$Mean \quad Prism \quad Strength = -5{,}558.7 - 15{,}169.1B_4 - 289.8B_5 - 1{,}594.6B_9 + 1{,}108.8B_{10} + 169.3B_9B_{10} + 5{,}875.7B_4B_9 + 1{,}545.4B_5B_9 + 1{,}705.1B_4B_{10} - 29.9B_5B_{10} - 609.7B_4B_9B_{10} - 178.6B_5B_9B_{10}$$

$$B4 = \begin{Bmatrix} 1 \\ 0 \end{Bmatrix} \begin{matrix} Type \quad M \quad Mortar \\ Otherwise \end{matrix} \qquad B5 = \begin{Bmatrix} 1 \\ 0 \end{Bmatrix} \begin{matrix} Type \quad N \quad Mortar \\ Otherwise \end{matrix}$$

$$B9 = {}^{h}\!/_{t} \; ratio$$

$$B10 = Ln(Unit \quad Compressive \quad Strength)$$

The distribution of the prism strength values at each unit strength value fits a normal distribution. Thus, the following can be used to deduce the fifth quantile values for the response variable.

$$\xi_{0.05}\left(\hat{\mu},\hat{\sigma}\right) = \hat{\mu} + \hat{\sigma}\,\xi_{0.05}(0,1)$$

$$\xi_{0.05}\left(\hat{\mu},\hat{\sigma}\right) = Fifth \quad Quantile$$

$$\hat{\mu} = Mean \quad \Pr ism \quad Strength \quad \Pr edicted \quad by \quad the \quad Model.$$

$$\hat{\sigma} = Conditional \quad S\tan dard \quad Deviation = 968.2$$

$$\xi_{0.05}(0,1) = -1.64$$

$$\xi_{0.05}\left(\hat{\mu},\hat{\sigma}\right) = \hat{\mu} - 968.2 \times 1.64 = \hat{\mu} - 1{,}587.8$$

The coefficient of determination (R^2) for model "E" is 0.42. The type III sum of squares (Type III SS) generated by model "E" are shown in Table 4.12. The predictor variables or interactions with relatively larger type III SS values are the terms that explain more of the variation of the prism strengths.

Table 4.12: Model "E" Type III SS Values

Source	Type III SS
Mortar type: M, S, or N	7,333,240
h/t ratio	398,319
$Ln(f_u)$	54,272,081
Interaction between $Ln(f_u)$ & h/t ratio	394,241
Interaction between h/t ratio & mortar type	2,612,810
Interaction between $Ln(f_u)$ & mortar type	8,895,374
Interaction between $Ln(f_u)$, h/t ratio, & mortar type	2,576,917

The variable that explains most of the variation in prism strength in the model is the natural logarithm of the compressive strength of masonry unit. This model ignores the curing method, which causes the curing method to become a potential confounder. The average prism strength fifth quantile values for each mortar type predicted by model "E" - targeting h/t ratio value of two - and an equation best presenting those values are shown in Figure 4.37, 4.38, and 4.39 for mortar types M, S, N, respectively. The Code values are also shown for each case. Prism strength values cannot be reliably predicted for all ranges of unit compressive strengths due to insufficient test data. There is large gap of type M mortar data for unit strengths of less than approximately 9,000 psi. However, using type S mortar prism strength predictions of the model for type M mortar is conservative. Available data points for mortar types M and S and the fifth quantile predictions of the model for type S mortar are shown in Figure 4.40.

Equations 4.29 and 4.30 represent the best fit equations for the average prism strength fifth quantile values across all available categories predicted by model "E" - targeting h/t ratio value of two – for mortar type S and N, respectively.

Equation 4.28 (Type S Mortar) $$f'_m = 602.7 \times Ln(f_u) - 2{,}039$$

Equation 4.30 (Type N Mortar) $$f'_m = 135.8 \times Ln(f_u) - 1{,}466$$

f'_m: specified compressive strength of masonry, psi,

f_u: average compressive strength of brick, psi.

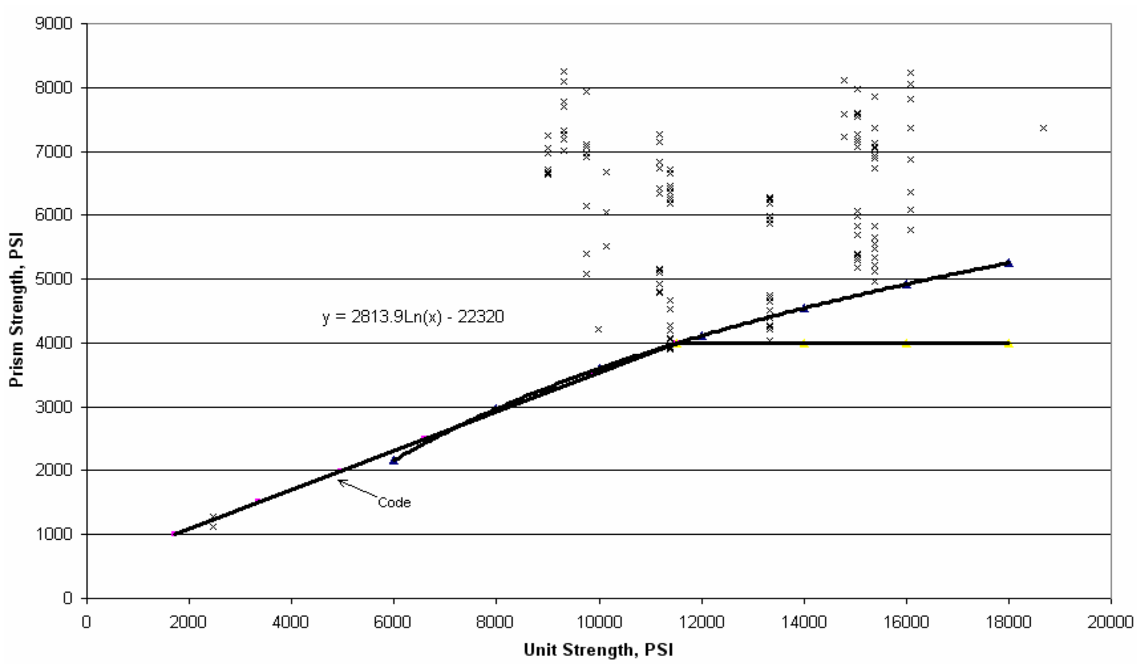

Figure 4.37: Type M Mortar.

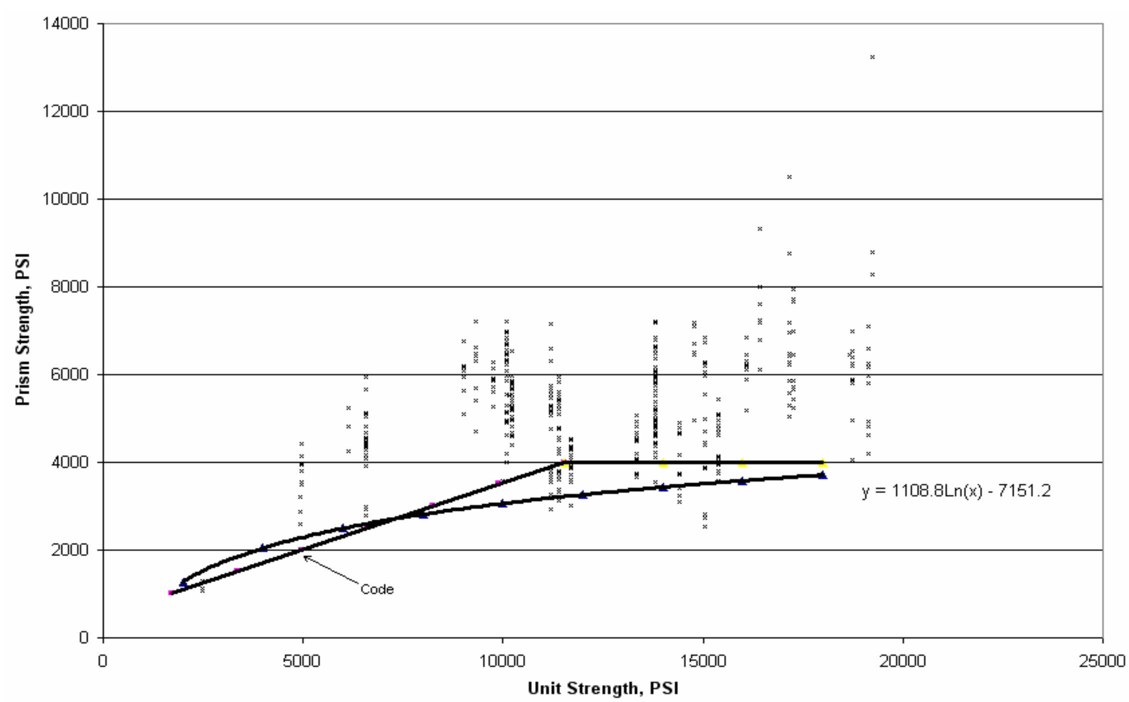

Figure 4.38: Type S Mortar

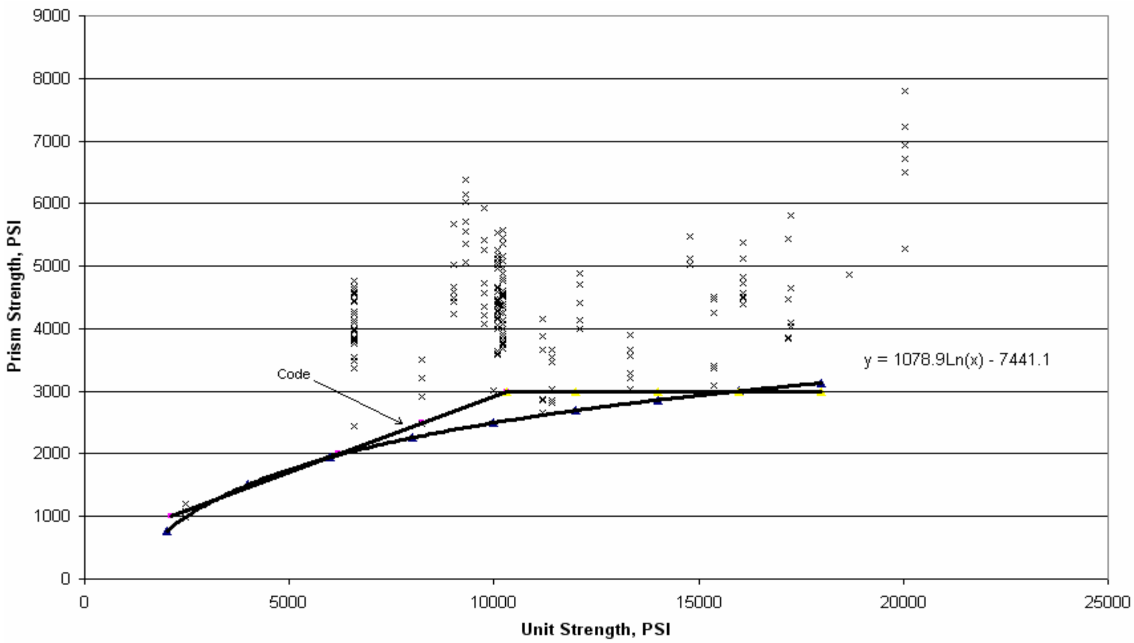

Figure 4.39: Type N Mortar.

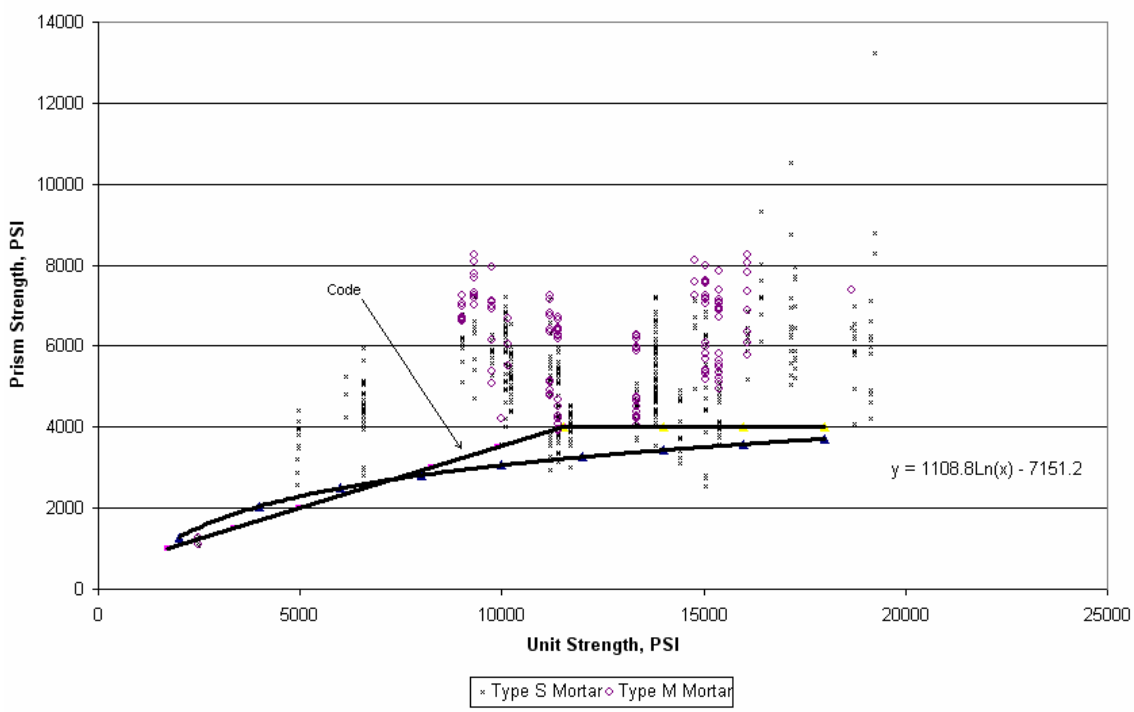

Figure 4.40: Types M & S Mortar.

4.2.5.1 Linear Regression of Model "E" Data Set

The Model "E" data set was adjusted to h/t value of two based on the correction factors presented in Table 2.1. The data was analyzed based on mortar type using liner regression that related prism compressive strength to the compressive strength of the clay masonry unit for each mortar type. Figures 4.41, 4.42, and 4.43 show the data and the prism compressive strength values (50th and 5th percentiles) along with equations that are best fits for those values for mortar types M, S, and N, respectively.

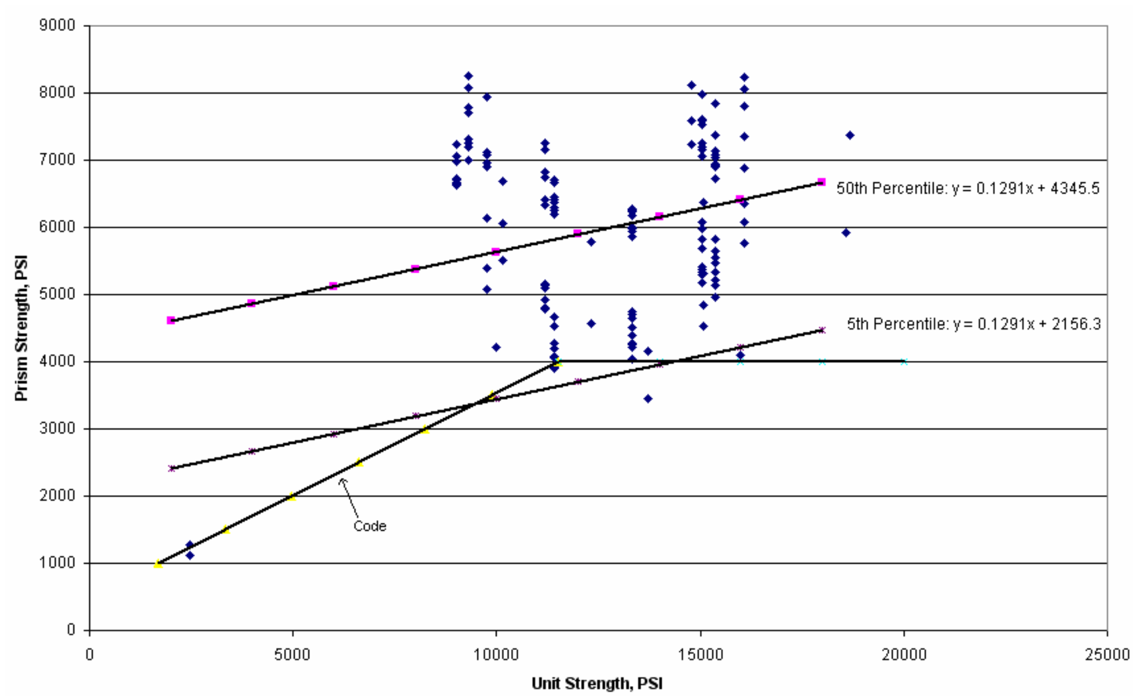

Figure 4.41: Type M Mortar.

Equation 4.29 (Type M Mortar, 50th Percentile) $$f'_m = 0.129 \times (f_u) + 4{,}346$$

Equation 4.30 (Type M Mortar, 5th Percentile) $$f'_m = 0.129 \times (f_u) + 2{,}156$$

f'$_m$: specified compressive strength of masonry, psi,

f_u: average compressive strength of brick, psi.

Coefficient of determination (R^2) = 0.072.

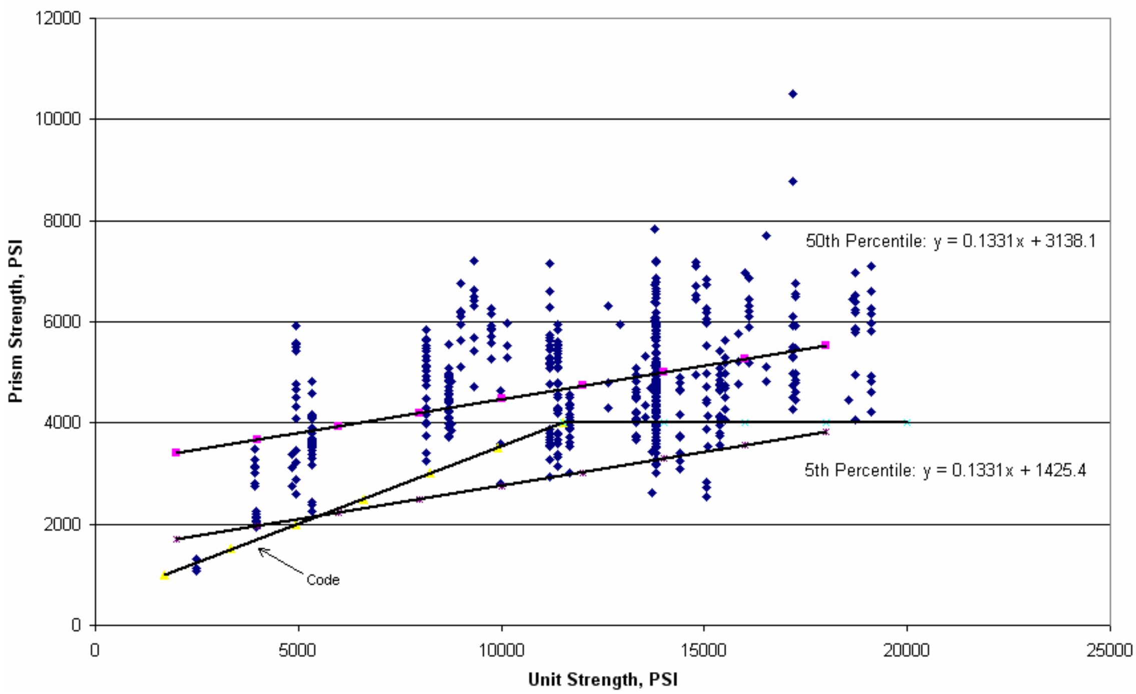

Figure 4.42: Type S Mortar.

Equation 4.31 (Type S Mortar, 50th Percentile) $$f'_m = 0.133 \times (f_u) + 3{,}138$$

Equation 4.32 (Type S Mortar, 5th Percentile) $$f'_m = 0.133 \times (f_u) + 1{,}425$$

f'$_m$: specified compressive strength of masonry, psi,

f_u: average compressive strength of brick, psi.

Coefficient of determination (R^2) = 0.195.

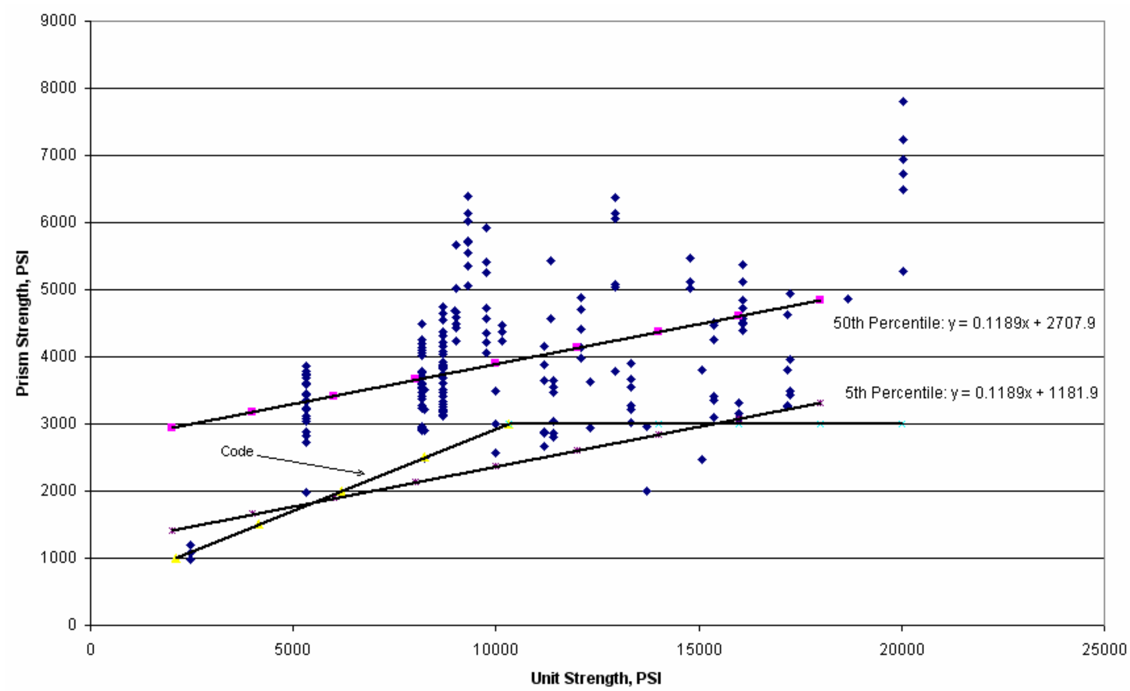

Figure 4.43: Type N Mortar.

Equation 4.33 (Type N Mortar, 50th Percentile) $f'_m = 0.119 \times (f_u) + 2{,}708$

Equation 4.34 (Type N Mortar, 5th Percentile) $f'_m = 0.119 \times (f_u) + 1{,}182$

f'_m: specified compressive strength of masonry, psi,

f_u: average compressive strength of brick, psi.

Coefficient of determination (R^2) = 0.201.

4.2.6 Model "F"

Model "F" data set is data set for Model "D" modified to reflect the compressive strengths of the units based on the net areas and the assemblage based on net bedded areas regardless of the size of the openings. This adjustment excludes two predictor variables – units being solid or hollow, and mortar joints being face-shell or full-bed. Also, the data points from prisms cured for 7 days or cured in other than moist conditions were excluded. The predictor variables investigated are as follows:

- o The natural logarithm (logarithm base e) of the compressive strength of the clay masonry units,
- o Mortar type,
- o Height-to-thickness ratio (h/t ratio).

There also exist interactions between the variables listed above. The following interactions were included in the model:

- Mortar type and h/t ratio,
- The natural logarithm of the compressive strength of clay masonry units and h/t ratio,
- Mortar type and the natural logarithm of the compressive strength of clay masonry units,
- Mortar type, h/t ratio, and the natural logarithm of the compressive strength of clay masonry units,

In Model "F" there are three possible levels for mortar type. Thus, there are a total of 3 possible categories out of which there are data available for all three, as listed in Table 4.13. The following apply to table 4.13.

- Comb.: Counts the number of various combinations for which data is available,
- Mortar Type: M, S, or N,

- Freq.: The number of observations available for the corresponding category,
- Prism Strength: The mean of all prism strengths reported for that combination in psi.

Table 4.13: Available 3 Combinations

Comb.	Mortar Type	Freq.	Prism Strength
1	M	84	5,829
2	S	278	4,719
3	N	120	3,783

The following relationship between mean prism strength and the predictor variables was established by the model.

$$Mean \quad Prism \quad Strength = 775.1 - 24{,}977.6B_4 + 5{,}977.7B_5 - 6{,}161.8B_9 + 423.6B_{10} + 670.7B_9B_{10} + 104{,}036.5B_4B_9 + 3{,}818.8B_5B_9 + 2{,}749.4B_4B_{10} - 730.8B_5B_{10} - 12{,}306B_4B_9B_{10} - 426B_5B_9B_{10}$$

$$B4 = \begin{Bmatrix} 1 \\ 0 \end{Bmatrix} \begin{matrix} Type \quad M \quad Mortar \\ Otherwise \end{matrix} \qquad B5 = \begin{Bmatrix} 1 \\ 0 \end{Bmatrix} \begin{matrix} Type \quad N \quad Mortar \\ Otherwise \end{matrix}$$

$$B9 = {}^{h}\!/_{t} \; ratio$$

$$B10 = Ln(Unit \quad Compressive \quad Strength)$$

The distribution of the prism strength values at each unit strength value fits a normal distribution. Thus, the following can be used to deduce the fifth quantile values for the response variable.

$$\xi_{0.05}\left(\hat{\mu},\hat{\sigma}\right)=\hat{\mu}+\hat{\sigma}\,\xi_{0.05}(0,1)$$

$$\xi_{0.05}\left(\hat{\mu},\hat{\sigma}\right)=Fifth\quad Quantile$$

$$\hat{\mu}=Mean\quad Prism\quad Strength\quad Predicted\quad by\quad the\quad Model.$$

$$\hat{\sigma}=Conditional\quad Standard\quad Deviation=848$$

$$\xi_{0.05}(0,1)=-1.64$$

$$\xi_{0.05}\left(\hat{\mu},\hat{\sigma}\right)=\hat{\mu}-848\times1.64=\hat{\mu}-1{,}390.7$$

The coefficient of determination (R^2) for model "F" is 0.42. The type III sum of squares (Type III SS) generated by model "F" are shown in Table 4.14. The predictor variables or interactions with relatively larger type III SS values are the terms that explain more of the variation of the prism strengths.

Table 4.14: Model "F" Type III SS Values

Source	Type III SS
Mortar type: M, S, or N	8,995,772
h/t ratio	27,321
$Ln(f_u)$	8,195,510
Interaction between $Ln(f_u)$ & h/t ratio	34,405
Interaction between h/t ratio & mortar type	1,359,137
Interaction between $Ln(f_u)$ & mortar type	10,117,805
Interaction between $Ln(f_u)$, h/t ratio, & mortar type	1,420,429

The variables that explain most of the variation in prism strength in the model are the mortar type and the interaction between the natural logarithm of the compressive strength of masonry unit and the mortar type. The average prism strength fifth quantile values for each mortar type predicted by model "F" - targeting h/t ratio value of two - and an equation best presenting those values are shown in Figure 4.44, 4.45, and 4.46 for mortar types M, S, N, respectively. The Code values are also shown for each case. Prism strength values cannot be reliably predicted for all ranges of unit compressive strengths due to insufficient test data. There is large gap of type M mortar data for unit strengths of less than approximately 9,000 psi. However, using type S mortar prism strength predictions of the model for type M mortar is conservative. Available data points for mortar types M and S and the fifth quantile predictions of the model for type S mortar are shown in Figure 4.47.

Equations 4.35 and 4.36 represent the best fit equations for the average prism strength fifth quantile values across all available categories predicted by model "F" - targeting h/t ratio value of two – for mortar type S and N, respectively.

Equation 4.35 (Type S Mortar) $f'_m = 602.7 \times Ln(f_u) - 2{,}039$

Equation 4.36 (Type N Mortar) $f'_m = 135.8 \times Ln(f_u) - 1{,}466$

f'_m: specified compressive strength of masonry, psi,

f_u: average compressive strength of brick, psi.

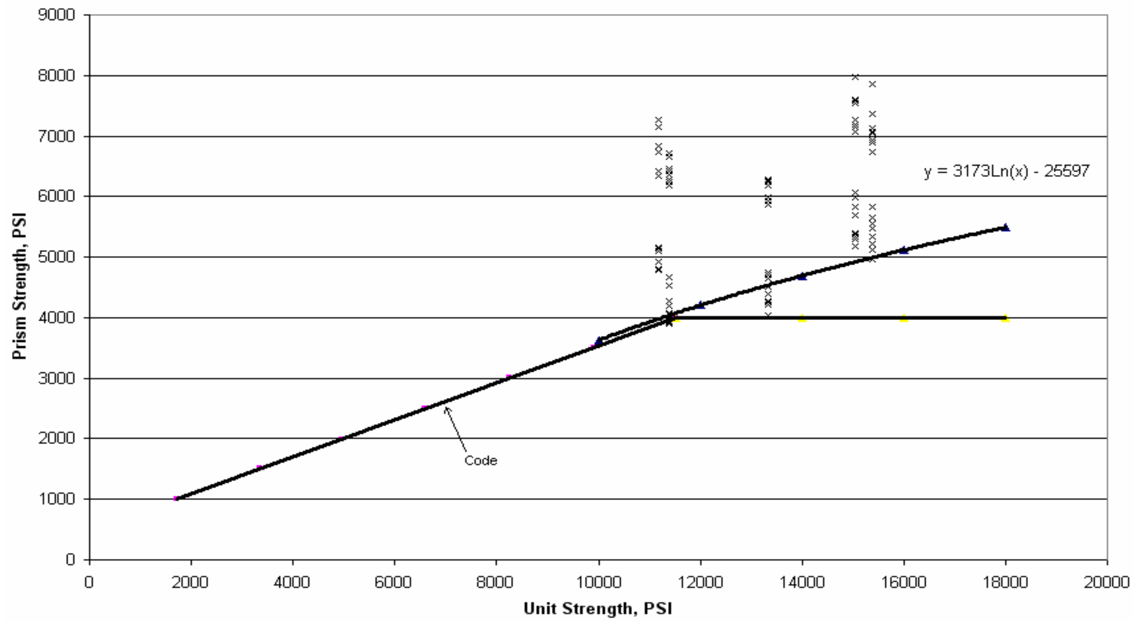

Figure 4.44: Type M Mortar.

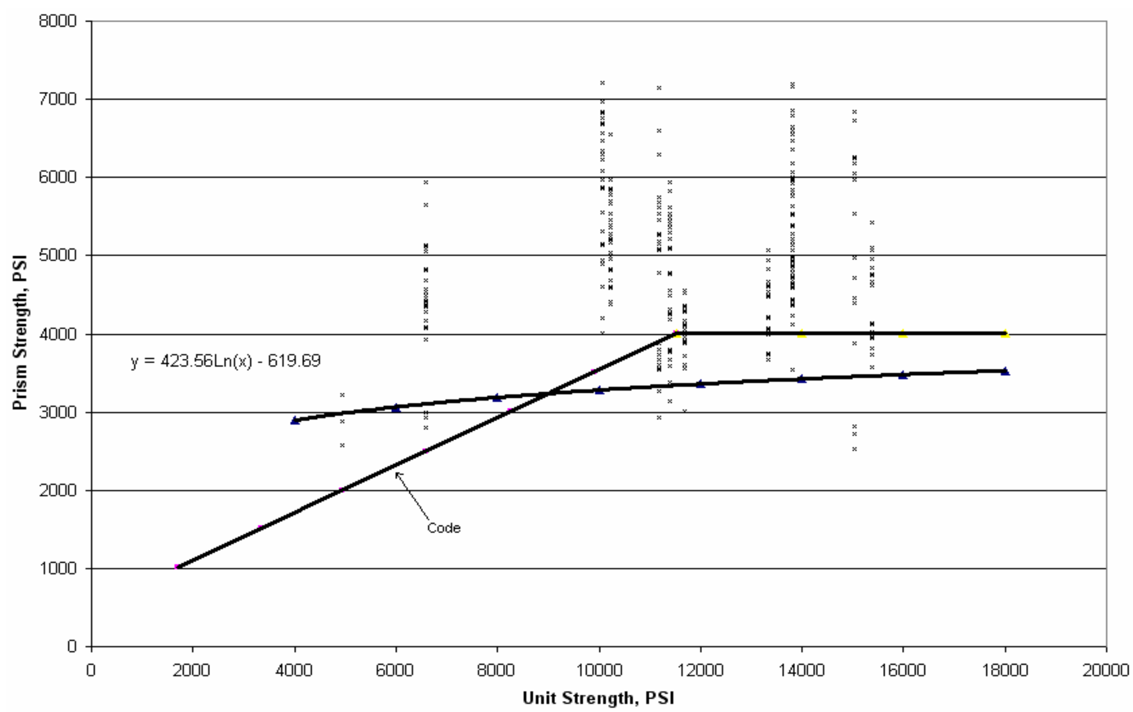

Figure 4.45: Type S Mortar

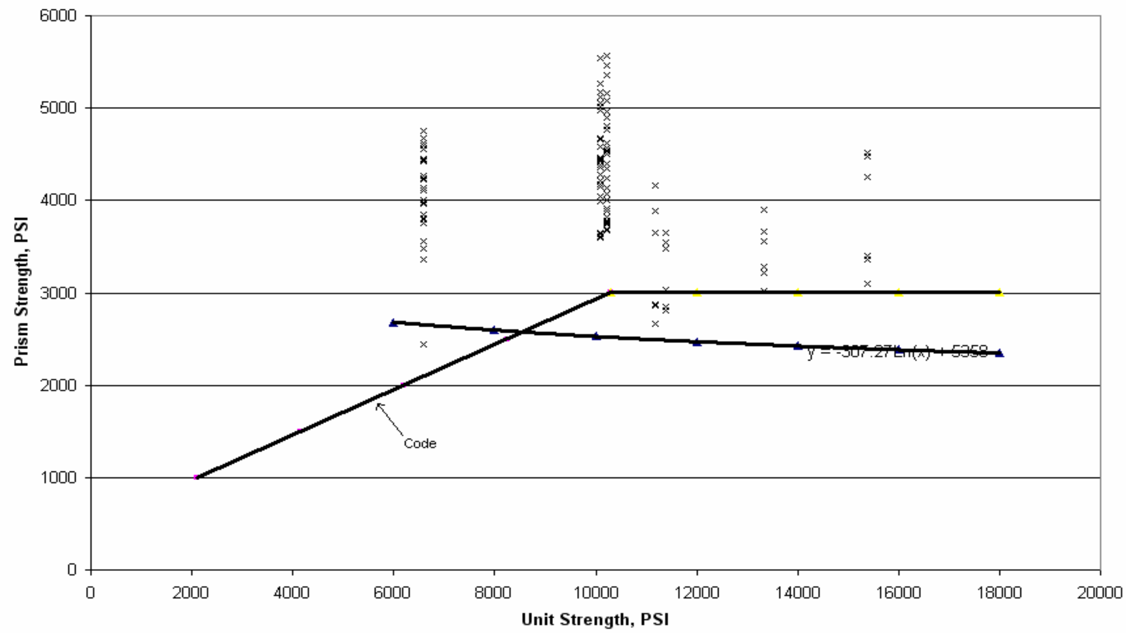

Figure 4.46: Type N Mortar.

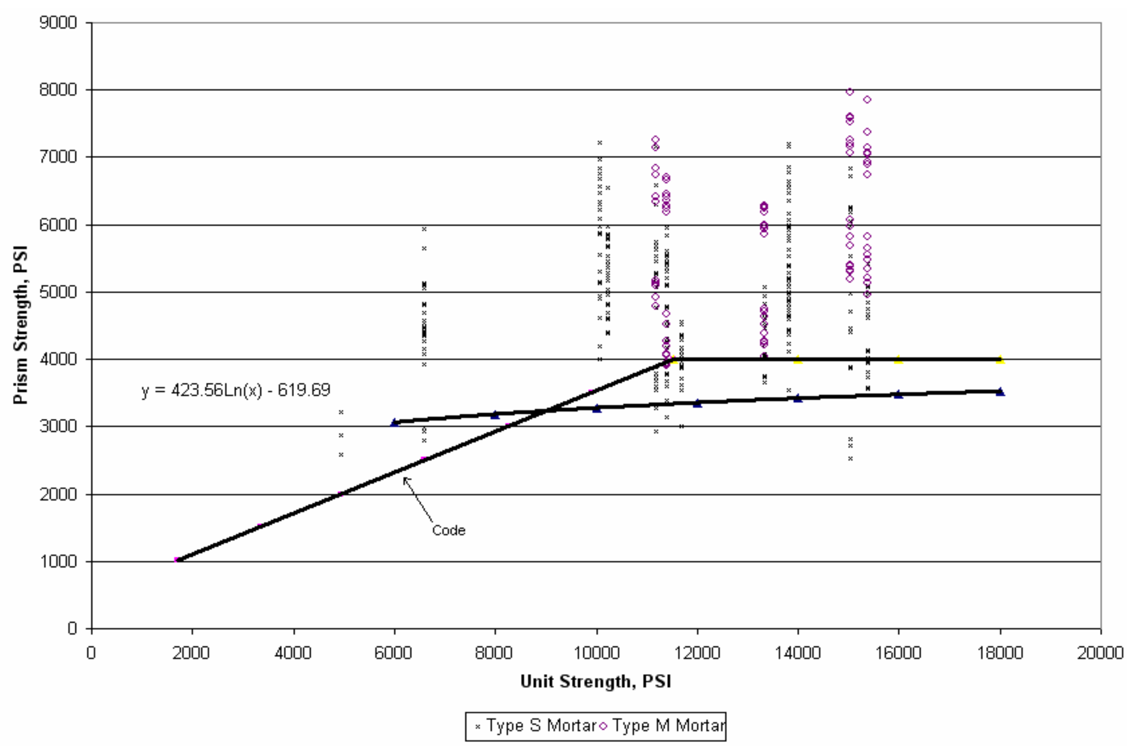

Figure 4.47: Types M & S Mortar.

4.2.6.1 Linear Regression of Model "F" Data Set

The Model "F" data set was adjusted to h/t value of two based on the correction factors presented in Table 2.1. The data was analyzed based on mortar type using liner regression that related prism compressive strength to the compressive strength of the clay masonry unit for each mortar type. Figures 4.48, 4.49, and 4.50 show the data and the prism compressive strength values (50th and 5th percentiles) along with equations that are best fits for those values for mortar types M, S, and N, respectively.

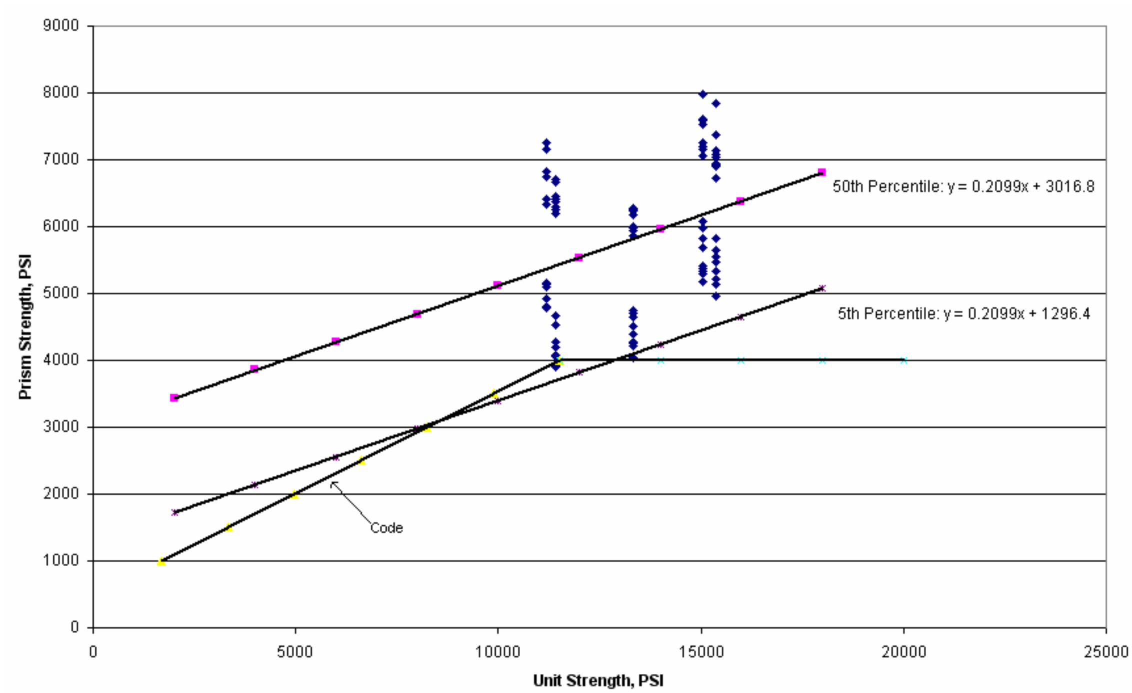

Figure 4.48: Type M Mortar.

Equation 4.35 (Type M Mortar, 50th Percentile) $f'_m = 0.210 \times (f_u) + 3{,}017$

Equation 4.36 (Type M Mortar, 5th Percentile) $f'_m = 0.210 \times (f_u) + 1{,}296$

f'_m: specified compressive strength of masonry, psi,

f_u: average compressive strength of brick, psi.

Coefficient of determination (R^2) = 0.108.

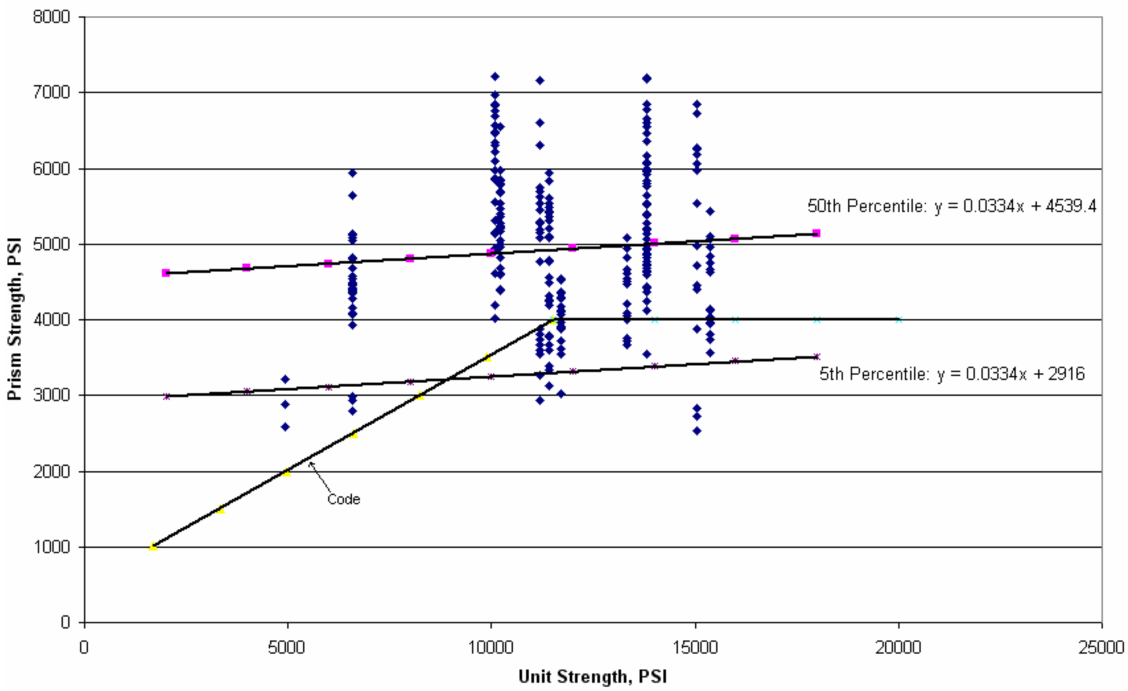

Figure 4.49: Type S Mortar.

Equation 4.37 (Type S Mortar, 50th Percentile) $$f'_m = 0.033 \times (f_u) + 4{,}539$$

Equation 4.38 (Type S Mortar, 5th Percentile) $$f'_m = 0.033 \times (f_u) + 2{,}916$$

f'_m: specified compressive strength of masonry, psi,

f_u: average compressive strength of brick, psi.

Coefficient of determination (R^2) = 0.007.

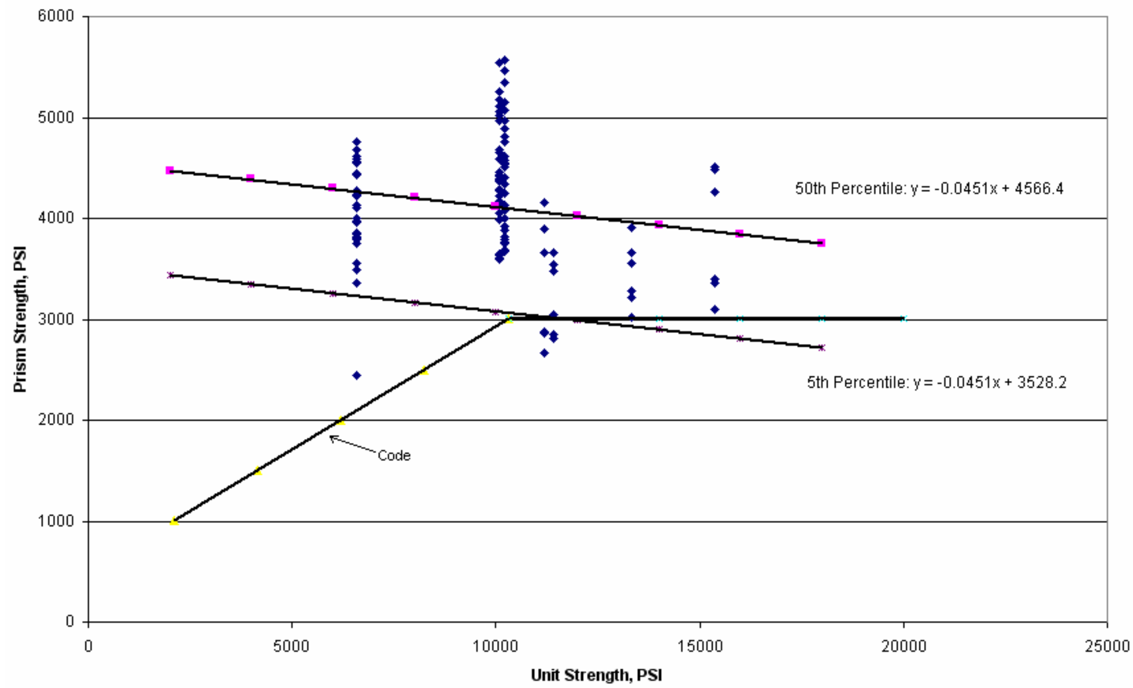

Figure 4.50: Type N Mortar.

Equation 4.39 (Type N Mortar, 50th Percentile) $$f'_m = -0.045 \times (f_u) + 4{,}566$$

Equation 4.40 (Type N Mortar, 5th Percentile) $$f'_m = -0.045 \times (f_u) + 3{,}528$$

f'_m: specified compressive strength of masonry, psi,

f_u: average compressive strength of brick, psi.

Coefficient of determination (R^2) = 0.033.

4.2.7 Model "G"

Model "G" examines the data collected only from testing performed for this research. The compressive strengths are based on gross areas. All prisms were moist cured and tested at 28 days. All units were solid and all mortar joints were full-bed. The predictor variables investigated are as follows:

- The natural logarithm (logarithm base e) of the compressive strength of the clay masonry units,
- Mortar type,
- Height-to-thickness ratio (h/t ratio).

There also exist interactions between the variables listed above. The following interactions were included in the model:

- Mortar type and h/t ratio,
- The natural logarithm of the compressive strength of clay masonry units and h/t ratio,
- Mortar type and the natural logarithm of the compressive strength of clay masonry units,
- Mortar type, h/t ratio, and the natural logarithm of the compressive strength of clay masonry units.

In Model "G" there are two possible levels for mortar type, see Table 4.15.

The following apply to table 4.15.

- Comb.: Counts the number of various combinations for which data is available,
- Mortar Type: M, S, or N,
- Freq.: The number of observations available for the corresponding category,
- Prism Strength: The mean of all prism strengths reported for that combination in psi.

Table 4.15: Available 2 Combinations

Comb.	Mortar Type	Freq.	Prism Strength
1	S	89	3,867
2	N	89	3,173

The following relationship between mean prism strength and the predictor variables was established by the model.

$$Mean\ Prism\ Strength = -14{,}898.5 + 9{,}020.2B_5 + 995.1B_9 + 2{,}139.2B_{10} - 128.9B_9B_{10} + 434.6B_5B_9 - 1{,}089.4B_5B_{10} - 50.2B_5B_9B_{10}$$

$$B5 = \begin{Bmatrix} 1 \\ 0 \end{Bmatrix} \begin{matrix} Type\ N\ Mortar \\ Otherwise \end{matrix} \qquad B9 = h/t\ ratio$$

$$B10 = Ln(Unit\ Compressive\ Strength)$$

The distribution of the prism strength values at each unit strength value fits a normal distribution. Thus, the following can be used to deduce the fifth quantile values for the response variable.

$$\xi_{0.05}\left(\hat{\mu}, \hat{\sigma}\right) = \hat{\mu} + \hat{\sigma}\,\xi_{0.05}(0,1)$$

$$\xi_{0.05}\left(\hat{\mu}, \hat{\sigma}\right) = Fifth\ Quantile$$

$$\hat{\mu} = Mean\ Prism\ Strength\ Predicted\ by\ the\ Model.$$

$$\hat{\sigma} = Conditional\ Standard\ Deviation = 473.8$$

$$\xi_{0.05}(0,1) = -1.64$$

$$\xi_{0.05}\left(\hat{\mu},\hat{\sigma}\right)=\hat{\mu}-473.8\times 1.64=\hat{\mu}-777.0$$

The coefficient of determination (R^2) for model "G" is 0.56. The type III sum of squares (Type III SS) generated by model "G" are shown in Table 4.16. The predictor variables or interactions with relatively larger type III SS values are the terms that explain more of the variation of the prism strengths.

Table 4.16: Model "G" Type III SS Values

Source	Type III SS
Mortar type: M, S, or N	977,875
h/t ratio	326,926
$Ln(f_u)$	9,627,958
Interaction between $Ln(f_u)$ & h/t ratio	416,432
Interaction between h/t ratio & mortar type	10,502
Interaction between $Ln(f_u)$ & mortar type	1,123,717
Interaction between $Ln(f_u)$, h/t ratio, & mortar type	11,066

The variable that explains most of the variation in prism strength in the model is the natural logarithm of the compressive strength of masonry unit. The average prism strength fifth quantile values for each mortar type predicted by model "G" - targeting h/t ratio value of two - and an equation best presenting those values are shown in Figure 4.51 and 4.52 for mortar types S and N, respectively. The Code values are also shown for each case. Prism strength values cannot be reliably predicted for all ranges of unit compressive strengths due to insufficient test data. There was no testing done with type

M mortar. However, using type S mortar prism strength predictions of the model for type M mortar is conservative.

Equations 4.41 and 4.42 represent the best fit equations for the average prism strength fifth quantile values across all available categories predicted by model “F” - targeting h/t ratio value of two – for mortar type S and N, respectively.

Equation 4.41 (Type S Mortar) $$f'_m = 2{,}139.2 \times Ln(f_u) - 15{,}678$$

Equation 4.42 (Type N Mortar) $$f'_m = 1{,}049.7 \times Ln(f_u) - 6{,}658$$

f'_m: specified compressive strength of masonry, psi,

f_u: average compressive strength of brick, psi.

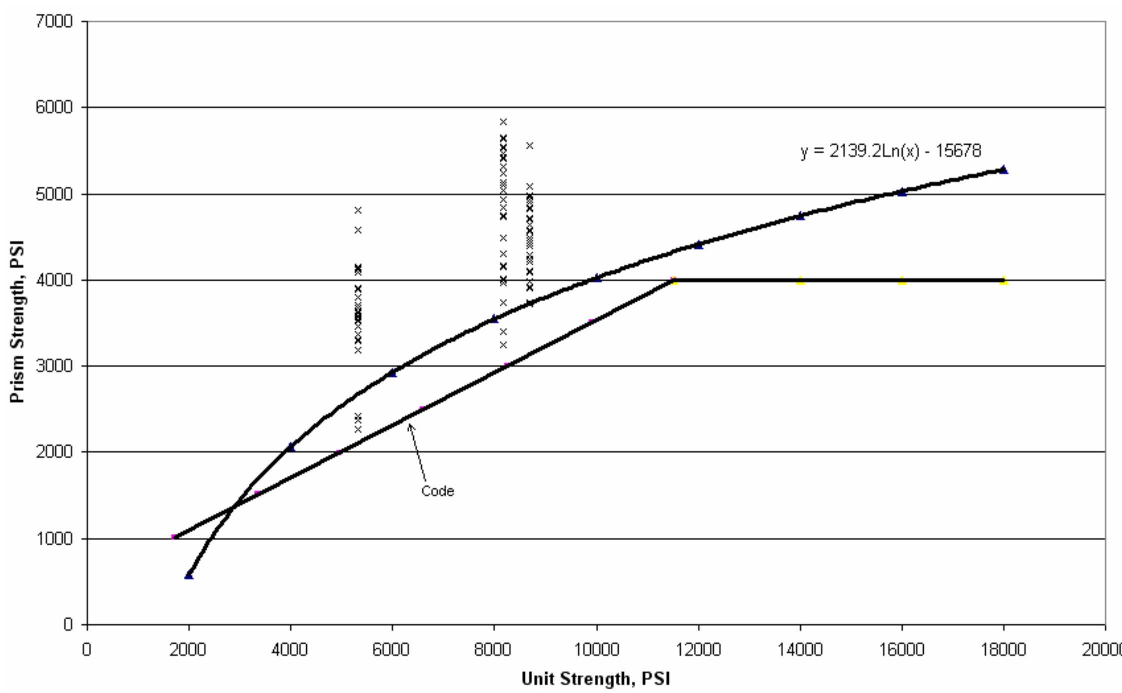

Figure 4.51: Type S Mortar.

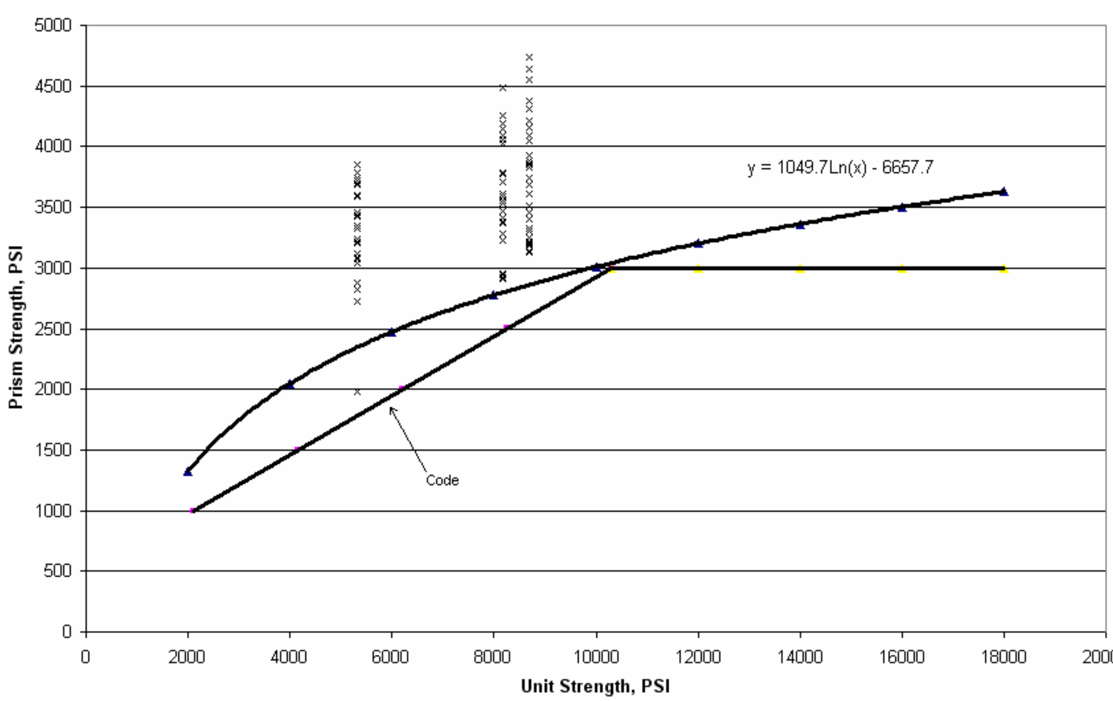

Figure 4.52: Type N Mortar.

4.2.7.1 Linear Regression of Model "G" Data Set

The Model "G" data set was adjusted to h/t value of two based on the correction factors presented in Table 2.1. The data was analyzed based on mortar type using liner regression that related prism compressive strength to the compressive strength of the clay masonry unit for each mortar type. Figures 4.53 and 4.54 show the data and the prism compressive strength values (50^{th} and 5^{th} percentiles) along with equations that are best fits for those values for mortar types S and N, respectively.

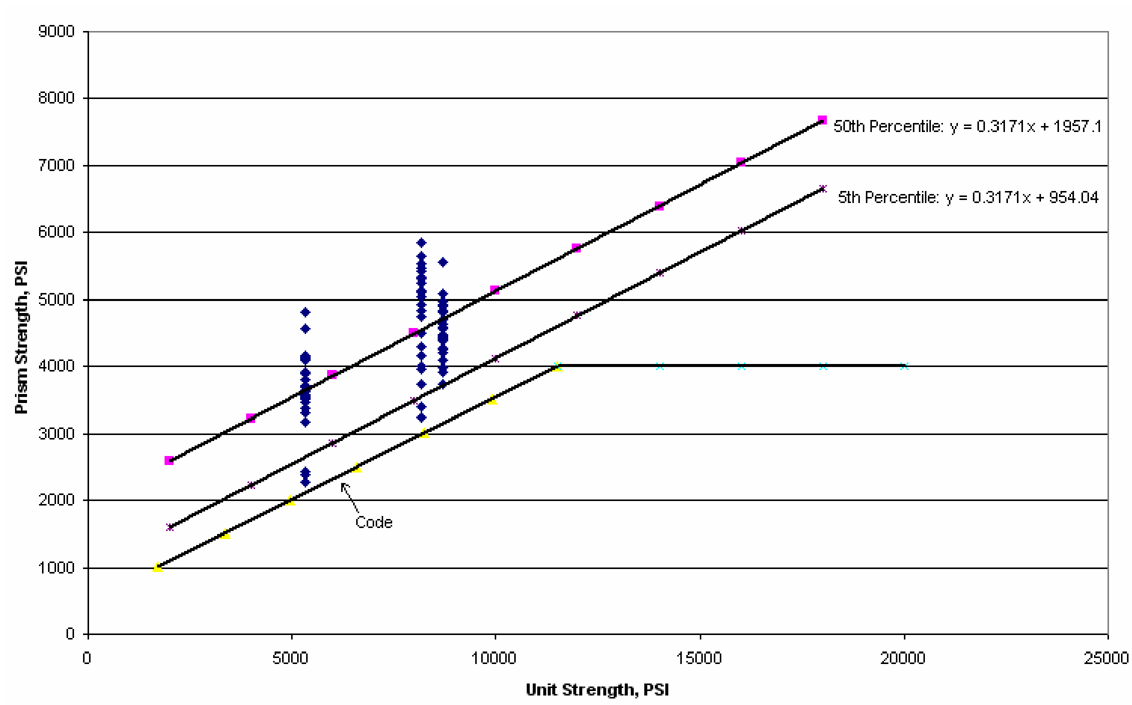

Figure 4.53: Type S Mortar.

Equation 4.43 (Type S Mortar, 50th Percentile) $f'_m = 0.317 \times (f_u) + 1{,}957$

Equation 4.44 (Type S Mortar, 5th Percentile) $f'_m = 0.317 \times (f_u) + 954$

f'_m: specified compressive strength of masonry, psi,

f_u: average compressive strength of brick, psi.

Coefficient of determination (R^2) = 0.372.

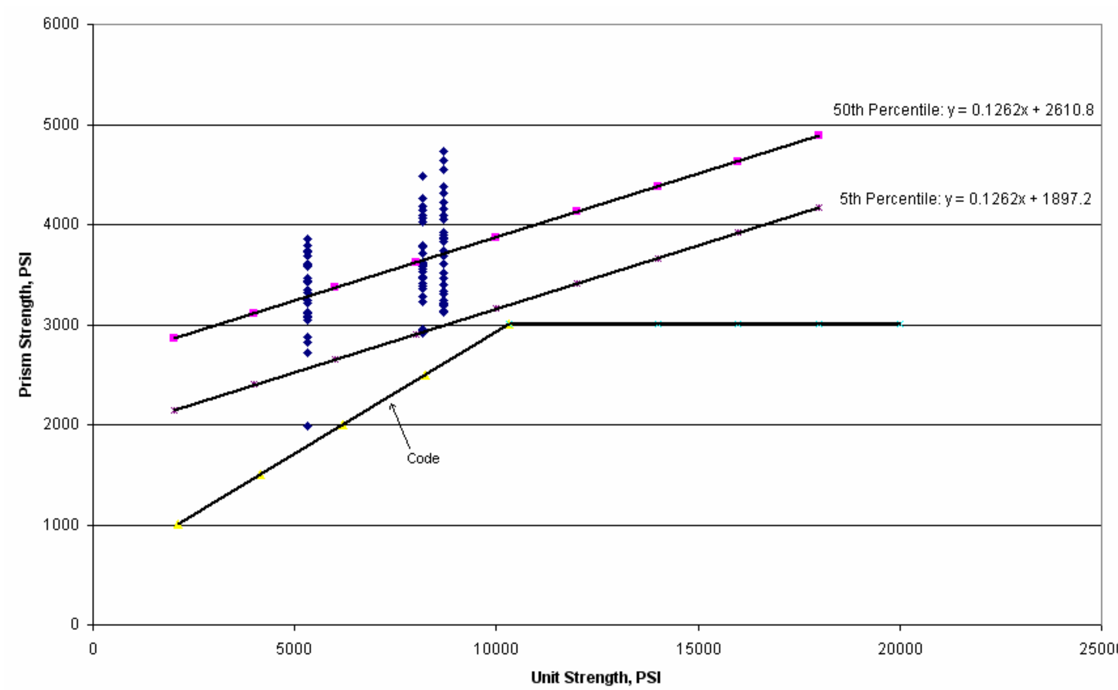

Figure 4.54: Type N Mortar.

Equation 4.45 (Type N Mortar, 50th Percentile) $$f'_m = 0.126 \times (f_u) + 2{,}611$$

Equation 4.46 (Type N Mortar, 5th Percentile) $$f'_m = 0.126 \times (f_u) + 1{,}897$$

f'_m: specified compressive strength of masonry, psi,

f_u: average compressive strength of brick, psi.

Coefficient of determination (R^2) = 0.158.

4.2.7.2 Comparison of Linear Regression of Model "G" and Code Values

Compressive strength of masonry as predicted by Model "G" and the linear regression of Model "G" data set for clay masonry units ranging in compressive strength from 5,000 to 9,000 psi are shown in Tables 4.17 and 4.18.

Table 4.17: MSJC Design Values and Results from Model "G", Types M & S Mortar

Compressive Strength of Clay Masonry Unit, psi	Compressive Strength of Masonry, psi		
	Types M & S Mortar		
	MSJC	Model "G"	Linear Regression
5,000	2,013	2,542	2,539
6,000	2,318	2,932	2,856
7,000	2,623	3,262	3,173
8,000	2,928	3,547	3,490
9,000	3,233	3,799	3,807

Table 4.18: MSJC Design Values and Results from Model "G", Type N Mortar

Compressive Strength of Clay Masonry Unit, psi	Compressive Strength of Masonry, psi		
	Type N Mortar		
	MSJC	Model "G"	Linear Regression
5,000	1,708	2,282	2,527
6,000	1,952	2,474	2,653
7,000	2,196	2,636	2,779
8,000	2,440	2,776	2,905
9,000	2,680	2,899	3,031

Model “G” is a better predictor of the prism compressive strength than the linear regression because Model “G” examines several predictor variables and the interaction between them. Both Model “G” and the linear regression are reliable in the range of unit compressive strength tabulated in Tables 4.17 and 4.18 (5,000 thru 9,000 psi), due to the average compressive strengths of the clay masonry units used in testing. Model “G” results (Equations 4.41 and 4.42) are used to provide a comparison between the units compressive strengths and the corresponding masonry compressive strength as presented in the MSJC Specification and predicted by model “G” in Tables 4.19 & 4.20.

Table 4.19: Comparison of MSJC Specification and Model “G” (Types M & S Mortar)

Compressive Strength of Clay Masonry Unit, psi (Types M & S Mortar)	Compressive Strength of Masonry, psi	
	MSJC	Model “G”
3,350	1,500	1,685
4,950	2,000	2,520
6,600	2,500	3,136
8,250	3,000	3,613
9,900	3,500	4,003
11,515	4,000	4,327

Table 4.20: Comparison of MSJC Specification and Model "G" (Type N Mortar)

Compressive Strength of Clay Masonry Unit, psi (Type N Mortar)	Compressive Strength of Masonry, psi	
	MSJC	Model "G"
2,100	1,000	1,372
4,150	1,500	2,087
6,200	2,000	2,508
8,250	2,500	2,808
10,300	3,000	3,041

4.2.8 Height-to-Thickness Ratio Correction Factors

As shown in Table 2.1 there are correction factors suggested by ASTM C 1314-03b for varying h/t ratios. The correction factors in Table 2.1 basically convert the prism compressive strength of a prism with h/t ration other than two to an equivalent prism compressive strength of a prism with h/t ratio of two. Average predicted prism compressive strength values for h/t ratios of two, three, four, and five are extracted from Models "E" and "G". The average prism compressive strength values for various h/t ratios from each model are divided by the average prism compressive strength predicted by that model for h/t ratio of two and the results are compared with the correction factors from Table 2.1, see Table 4.21. The average of the results from the models mentioned above are provided in Table 4.21, and are comparable to the correction factors from ASTM C 1314-03b.

Table 4.21: Height-to-Thickness Ratio Correction Factors

h/t ratio[1]	2.0	3.0	4.0	5.0
ASTM C 1314-03b	1.0	1.07	1.15	1.22
Model "E" Type N Mortar	1.0	1.06	1.13	1.21
Model "E" Type S Mortar	1.0	1.02	1.05	1.08
Model "G" Type N Mortar	1.0	1.07	1.15	1.25
Model "G" Type S Mortar	1.0	1.05	1.10	1.16
Average Type N Mortar	1.0	1.07	1.14	1.23
Average Type S Mortar	1.0	1.04	1.08	1.12
Average	1.0	1.05	1.11	1.18

1-"h/t ratio" refers to the ratio of prism height to least lateral dimension of prism.

4.3 Summary, Conclusion & Recommendations

All the North American prism compressive strength data available since 1980 was assembled in a database. The gaps in the data were identified and additional testing was performed. Several mathematical models were built and used to analyze the entire data set or portion of it depending on the purpose of the model. Overall, seven models were developed to examine the data. The fifth quantile predictions by these models are shown graphically in Figures 4.55, 4.56, and 4.57 for mortar types M, S, and N, respectively. These models studied a range of predictor variables and their interactions and explored their relationship with the prism compressive strength values, as shown in

Table 4.1. The list of predictor variables investigated in whole or parts by each model is as follow:

- The natural logarithm of the compressive strength of the clay masonry units,
- Curing method,
- Curing time,
- Mortar type,
- Presence or lack of grout in the assemblage,
- Units being solid or hollow,
- Mortar joints being face-shell or full-bed,
- Height-to-thickness ratio (h/t ratio).

Depending on the model and the data set assessed the predicted values of the prism compressive strengths vary. Examining the design values suggested by the MSJC Specification and comparing them with the fifth percentile prism compressive strength values from the models reveals that lack of data in many categories (levels), the non-factorial characteristics of the data set, and the interactions between the predictor variables cause not only shift but also change in shape of the best fit regression surface between categories. In a factorial design, a number of levels (in this research levels would be combinations of qualitative predictors) are selected by an investigator and experiments are run with all possible combinations. An extended and thorough study based on new test results that have a factorial design and a vigorous quality control to reduce the number and the effects of potential confounders would yield a statistically reliable relationship between the prism compressive strength and the predictor factors.

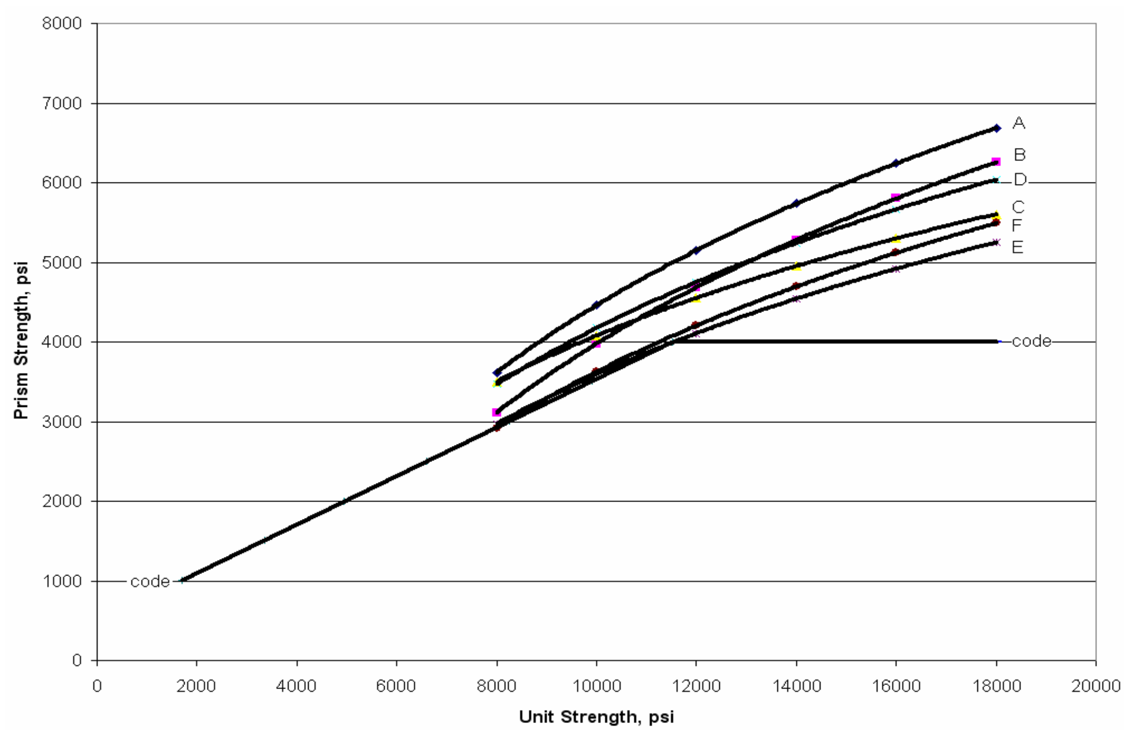

Figure 4.55: Fifth Percentile Predictions by All Models, Type M Mortar.

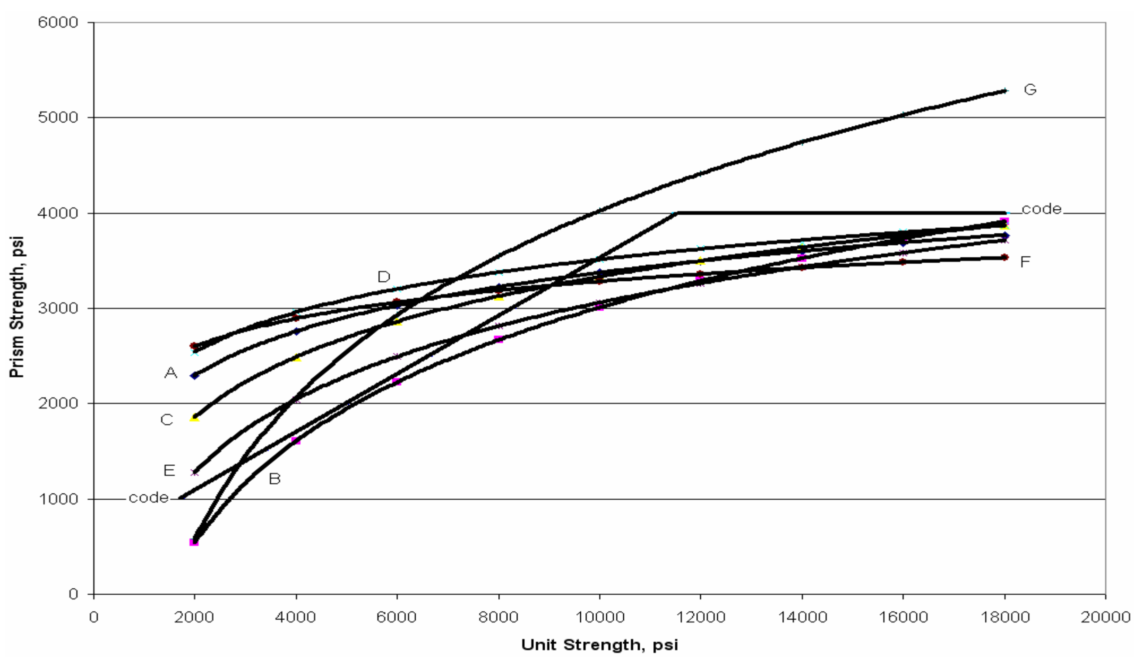

Figure 4.56: Fifth Percentile Predictions by All Models, Type S Mortar.

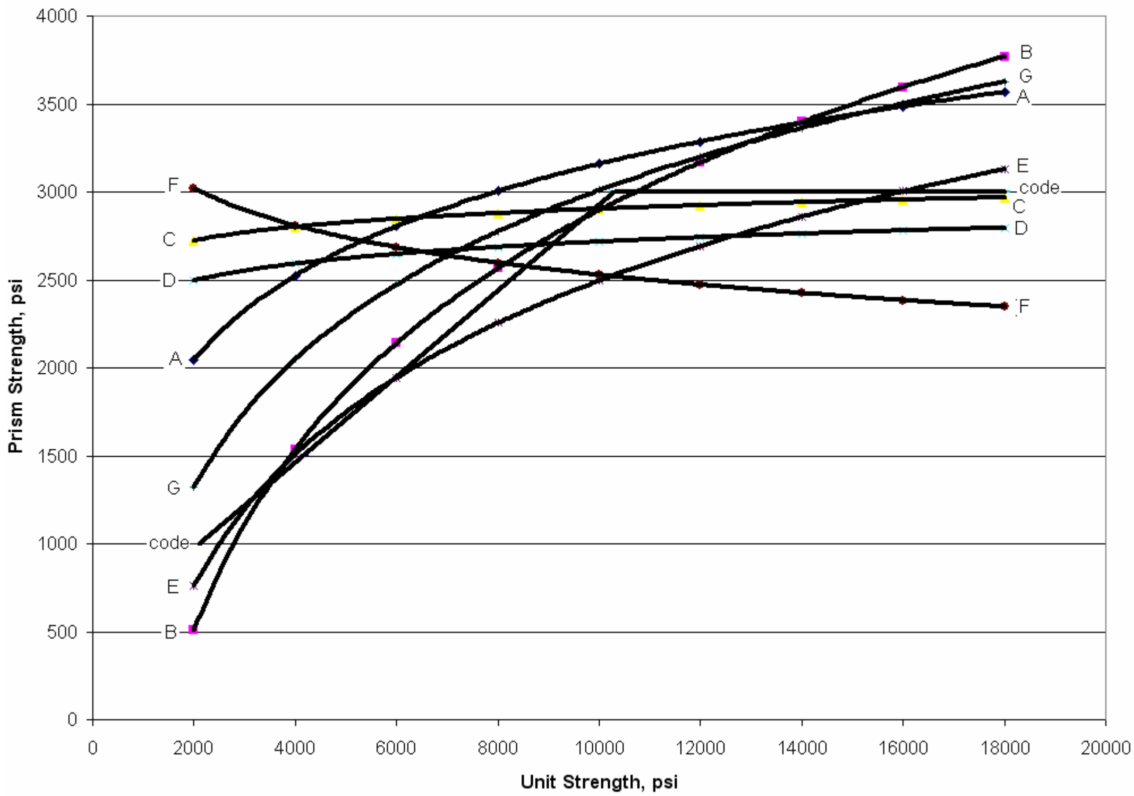

Figure 4.57: Fifth Percentile Predictions by All Models, Type N Mortar.

The most current ASTM standards require prisms to be moist cured for 28 days. A factorial design should be such that all prisms are moist cured for 28 days. Thus, curing method and duration would not be predictor variables. The current MSJC Specification design values are based on h/t ratio of two. Therefore, the number of units in each prism should be such that the resulting h/t ratios are close to two. The correction factors in ASTM C 1314-03b, which are in agreement with the results of this study as shown in Table 4.19, should be used to adjust the recorded prism strengths to h/t ratio of two. Then, h/t ratio would not be a predictor variable. The remaining predictor variables are as follow:

- Unit compressive strength (quantitative variable),
- Mortar type, M, S or N (qualitative variable),
- Presence or absence of grout (qualitative variable),
- Units being solid or hollow (qualitative variable),
- Full-bed or face-shell bedding (qualitative variable).

Other variables of interest such as joint thickness can be included, keeping in mind that every variable added can significantly increase the number of prisms that are required to be built and tested. Additional variables would also increase the amount of information that needs to be recorded and the complicity of the mathematical model needed to analyze the data.

The list above includes three possible values for mortar type, two for grout, two for unit type, and two for bedding type, which would create 24 categories. The range of unit compressive strength to be investigated should include the range covered by MSJC Specification and represent the materials available in the market. A unit compressive strength range of 2,000 to 18,000 psi is suggested for each category. If tests are to be done using units with compressive strengths between 2,000 and 18,000 psi at increments of 2,000 psi and five prisms are to be built with each, there would be a total of 45 prisms built for each category and a total of 1,080 prisms for all categories. Once such a factorial design is complete, the data can be used to build statistically reliable relationships between masonry compressive strength and the investigated predictor variables.

At this point, the largest single study based on current ASTM standards is the subject research. Amongst various models used in this study, Model “G” is the one that analyzes the data generated by this research without inclusion of other data. Model “G” considers various predictor variables and their interactions, and explores their relationship with the prism compressive strength. The predictor variables and interactions investigated are as follows:

- The natural logarithm (logarithm base e) of the compressive strength of the clay masonry units,
- Mortar type,
- Height-to-thickness ratio (h/t ratio).
- Mortar type and h/t ratio,
- The natural logarithm of the compressive strength of clay masonry units and h/t ratio,
- Mortar type and the natural logarithm of the compressive strength of clay masonry units,
- Mortar type, h/t ratio, and the natural logarithm of the compressive strength of clay masonry units.

The variable that explains most of the variation in prism strength in the model is the natural logarithm of the compressive strength of masonry unit. However, due to the clay masonry units used in testing only covering an approximate range of 5,000 to 9,000 psi in mean compressive strength Model “G” cannot be reliably used for clay masonry units with average compressive strengths less than 5,000 psi or more than 9,000 psi.

Additional testing would be required to establish mean masonry compressive strengths associated with unit compressive strengths outside the range covered in Table 4.22. The fifth percentile prism compressive strengths targeted at h/t ratio of two predicted by Model "G" are shown and compared with MSJC design values in Tables 4.17, 4.18, and 4.22.

Table 4.22: Model "G" Results and MSJC Design Values

Compressive Strength of Clay Masonry Unit, psi	Compressive Strength of Masonry, psi			
	Mortar Types M & S		Mortar Type N	
	MSJC	Model "G"	MSJC	Model "G"
5,000	2,013	2,542	1,708	2,282
6,000	2,318	2,932	1,952	2,474
7,000	2,623	3,262	2,196	2,636
8,000	2,928	3,547	2,440	2,776
9,000	3,233	3,799	2,680	2,899

APPENDIX A

LITERATURE SURVEY

Note: The following apply to entire Appendix A contents.

- Ref. No.: Refers to the source of the information, which can be found in the "References" section of this report.
- Curing Method:
    - Moist: The prisms were reported to have been cured in moist conditions for the entire duration of their curing period.
    - Dry: The prisms were cured in air-dry conditions for the entire duration of their curing period.
    - Moist/Dry: The prisms were cured in moist conditions for the first seven days and in air-dry conditions for the remaining of their curing period.
- Grout:
    - No: The prisms were not grouted.
    - Yes: The prisms were grouted; in the case of solid units that were grouted, the prisms were double Wythe.
- All the prism strength values are unadjusted for their h/t ratios.
- Compressive strengths area based on gross area for solid units and net area for hollow units.

Table A.1: Literature Survey since 1980

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
1	5.88	2015	Moist	28	4931	S	No	Solid	Full Bed
1	5.88	2506	Moist	28	4931	S	No	Solid	Full Bed
1	5.88	2248	Moist	28	4931	S	No	Solid	Full Bed
1	2.76	4112	Moist	28	4931	S	Yes	Solid	Full Bed
1	2.76	3274	Moist	28	4931	S	Yes	Solid	Full Bed
1	2.76	3886	Moist	28	4931	S	Yes	Solid	Full Bed

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
1	2.81	4421	Moist	28	4931	S	Yes	Solid	Full Bed
1	2.81	4273	Moist	28	4931	S	Yes	Solid	Full Bed
1	2.81	4514	Moist	28	4931	S	Yes	Solid	Full Bed
1	2.91	5172	Moist	28	4931	S	Yes	Solid	Full bed
1	2.91	5104	Moist	28	4931	S	Yes	Solid	Full bed
1	2.91	5217	Moist	28	4931	S	Yes	Solid	Full bed
1	2.88	5117	Moist	28	4931	S	Yes	Solid	Full bed
1	2.88	5265	Moist	28	4931	S	Yes	Solid	Full bed
1	2.88	5584	Moist	28	4931	S	Yes	Solid	Full bed
2	2.25	3520	Moist	7	11693	S	No	Solid	Full bed
2	2.25	3370	Moist	7	11693	S	No	Solid	Full bed
2	2.12	3210	Moist	7	11693	S	No	Solid	Full bed
2	2.25	3100	Moist	7	11693	S	No	Solid	Full bed
2	2.25	3220	Moist	7	11693	S	No	Solid	Full bed
2	2.25	3100	Moist	7	11693	S	No	Solid	Full bed
2	2.12	3240	Moist	7	11693	S	No	Solid	Full bed
2	2.25	3450	Moist	7	11693	S	No	Solid	Full bed
2	2.25	3090	Moist	7	11693	S	No	Solid	Full bed
2	2.12	3480	Moist	7	11693	S	No	Solid	Full bed

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
2	2.12	2860	Moist	7	11693	S	No	Solid	Full bed
2	2.25	3140	Moist	7	11693	S	No	Solid	Full bed
2	2.25	3470	Moist	7	11693	S	No	Solid	Full bed
2	2.12	3130	Moist	7	11693	S	No	Solid	Full bed
2	2.25	2720	Moist	7	11693	S	No	Solid	Full bed
2	2.12	2920	Moist	7	11693	S	No	Solid	Full bed
2	2.12	3040	Moist	7	11693	S	No	Solid	Full bed
2	2.12	3290	Moist	7	11693	S	No	Solid	Full bed
2	2.25	3370	Moist	7	11693	S	No	Solid	Full bed
2	2.12	3200	Moist	7	11693	S	No	Solid	Full bed
2	2.12	4510	Moist	28	11693	S	No	Solid	Full bed
2	2.25	4290	Moist	28	11693	S	No	Solid	Full bed
2	2.12	4140	Moist	28	11693	S	No	Solid	Full bed
2	2.12	3880	Moist	28	11693	S	No	Solid	Full bed
2	2.12	2990	Moist	28	11693	S	No	Solid	Full bed
2	2.25	4440	Moist	28	11693	S	No	Solid	Full bed
2	2.12	4080	Moist	28	11693	S	No	Solid	Full bed
2	2.12	3870	Moist	28	11693	S	No	Solid	Full bed
2	2.25	3820	Moist	28	11693	S	No	Solid	Full bed

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
2	2.12	3580	Moist	28	11693	S	No	Solid	Full bed
2	2.12	3840	Moist	28	11693	S	No	Solid	Full bed
2	2.25	3660	Moist	28	11693	S	No	Solid	Full bed
2	2.12	4250	Moist	28	11693	S	No	Solid	Full bed
2	2.12	4310	Moist	28	11693	S	No	Solid	Full bed
2	2.12	4260	Moist	28	11693	S	No	Solid	Full Bed
2	2.25	4040	Moist	28	11693	S	No	Solid	Full Bed
2	2.12	4030	Moist	28	11693	S	No	Solid	Full Bed
2	2.12	3520	Moist	28	11693	S	No	Solid	Full Bed
2	2.12	3930	Moist	28	11693	S	No	Solid	Full Bed
2	2.25	4050	Moist	28	11693	S	No	Solid	Full Bed
3	2	6256	Moist	28	15039	S	No	Hollow	Full Bed
3	2	5538	Moist	28	15039	S	No	Hollow	Full Bed
3	2	5975	Moist	28	15039	S	No	Hollow	Full Bed
3	2	2728	Moist	28	15039	S	No	Hollow	Face Shell
3	2	2821	Moist	28	15039	S	No	Hollow	Face Shell
3	2	2532	Moist	28	15039	S	No	Hollow	Face Shell
3	2	6189	Moist	28	15039	S	No	Hollow	Full Bed
3	2	6252	Moist	28	15039	S	No	Hollow	Full Bed

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
3	2	6058	Moist	28	15039	S	No	Hollow	Full Bed
3	2	3879	Moist	28	15039	S	No	Hollow	Face Shell
3	2	3872	Moist	28	15039	S	No	Hollow	Face Shell
3	2	4399	Moist	28	15039	S	No	Hollow	Face Shell
3	2	6726	Moist	28	15039	S	No	Hollow	Full Bed
3	2	6845	Moist	28	15039	S	No	Hollow	Full Bed
3	2	6268	Moist	28	15039	S	No	Hollow	Full Bed
3	2	4974	Moist	28	15039	S	No	Hollow	Face Shell
3	2	4458	Moist	28	15039	S	No	Hollow	Face Shell
3	2	4716	Moist	28	15039	S	No	Hollow	Face Shell
3	2	7153	Moist	28	15039	M	No	Hollow	Full Bed
3	2	7264	Moist	28	15039	M	No	Hollow	Full Bed
3	2	7605	Moist	28	15039	M	No	Hollow	Full Bed
3	2	5688	Moist	28	15039	M	No	Hollow	Face Shell
3	2	6072	Moist	28	15039	M	No	Hollow	Face Shell
3	2	5404	Moist	28	15039	M	No	Hollow	Face Shell
3	2	7197	Moist	28	15039	M	No	Hollow	Full Bed
3	2	7584	Moist	28	15039	M	No	Hollow	Full Bed
3	2	7061	Moist	28	15039	M	No	Hollow	Full Bed

Table A.1- continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
3	2	5328	Moist	28	15039	M	No	Hollow	Face Shell
3	2	5297	Moist	28	15039	M	No	Hollow	Face Shell
3	2	5979	Moist	28	15039	M	No	Hollow	Face Shell
3	2	7264	Moist	28	15039	M	No	Hollow	Full Bed
3	2	7974	Moist	28	15039	M	No	Hollow	Full Bed
3	2	7535	Moist	28	15039	M	No	Hollow	Full Bed
3	2	5382	Moist	28	15039	M	No	Hollow	Face Shell
3	2	5183	Moist	28	15039	M	No	Hollow	Face Shell
3	2	5826	Moist	28	15039	M	No	Hollow	Face Shell
3	2.02	4474	Moist	28	15371	N	No	Hollow	Full Bed
3	2.02	4249	Moist	28	15371	N	No	Hollow	Full Bed
3	2.02	4504	Moist	28	15371	N	No	Hollow	Full Bed
3	2.02	3399	Moist	28	15371	N	No	Hollow	Face Shell
3	2.02	3357	Moist	28	15371	N	No	Hollow	Face Shell
3	2.02	3089	Moist	28	15371	N	No	Hollow	Face Shell
3	2.01	3664	Moist	28	13332	N	No	Hollow	Full Bed
3	2.01	3555	Moist	28	13332	N	No	Hollow	Full Bed
3	2.01	3903	Moist	28	13332	N	No	Hollow	Full Bed
3	2.01	3022	Moist	28	13332	N	No	Hollow	Face Shell

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
3	2.01	3212	Moist	28	13332	N	No	Hollow	Face Shell
3	2.01	3279	Moist	28	13332	N	No	Hollow	Face Shell
3	2.01	4609	Moist	28	13332	S	No	Hollow	Full Bed
3	2.01	4825	Moist	28	13332	S	No	Hollow	Full Bed
3	2.01	4467	Moist	28	13332	S	No	Hollow	Full Bed
3	2.01	3995	Moist	28	13332	S	No	Hollow	Face Shell
3	2.01	4201	Moist	28	13332	S	No	Hollow	Face Shell
3	2.01	4046	Moist	28	13332	S	No	Hollow	Face Shell
3	2.01	4663	Moist	28	13332	S	No	Hollow	Full Bed
3	2.01	4495	Moist	28	13332	S	No	Hollow	Full Bed
3	2.01	4538	Moist	28	13332	S	No	Hollow	Full Bed
3	2.01	3725	Moist	28	13332	S	No	Hollow	Face Shell
3	2.01	3748	Moist	28	13332	S	No	Hollow	Face Shell
3	2.01	3660	Moist	28	13332	S	No	Hollow	Face Shell
3	2.01	4607	Moist	28	13332	S	No	Hollow	Full Bed
3	2.01	4936	Moist	28	13332	S	No	Hollow	Full Bed
3	2.01	5074	Moist	28	13332	S	No	Hollow	Full Bed
3	2.01	4077	Moist	28	13332	S	No	Hollow	Face Shell
3	2.01	4208	Moist	28	13332	S	No	Hollow	Face Shell

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
3	2.01	4053	Moist	28	13332	S	No	Hollow	Face Shell
3	2.01	5990	Moist	28	13332	M	No	Hollow	Full Bed
3	2.01	6258	Moist	28	13332	M	No	Hollow	Full Bed
3	2.01	5930	Moist	28	13332	M	No	Hollow	Full Bed
3	2.01	4507	Moist	28	13332	M	No	Hollow	Face Shell
3	2.01	4219	Moist	28	13332	M	No	Hollow	Face Shell
3	2.01	4262	Moist	28	13332	M	No	Hollow	Face Shell
3	2.01	6232	Moist	28	13332	M	No	Hollow	Full Bed
3	2.01	6271	Moist	28	13332	M	No	Hollow	Full Bed
3	2.01	5978	Moist	28	13332	M	No	Hollow	Full Bed
3	2.01	4255	Moist	28	13332	M	No	Hollow	Face Shell
3	2.01	4636	Moist	28	13332	M	No	Hollow	Face Shell
3	2.01	4386	Moist	28	13332	M	No	Hollow	Face Shell
3	2.01	5988	Moist	28	13332	M	No	Hollow	Full Bed
3	2.01	6180	Moist	28	13332	M	No	Hollow	Full Bed
3	2.01	5860	Moist	28	13332	M	No	Hollow	Full Bed
3	2.01	4737	Moist	28	13332	M	No	Hollow	Face Shell
3	2.01	4698	Moist	28	13332	M	No	Hollow	Face Shell
3	2.01	4030	Moist	28	13332	M	No	Hollow	Face Shell

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
3	1.96	7283	Moist	28	11188	M	No	Hollow	Full Bed
3	1.96	7169	Moist	28	11188	M	No	Hollow	Full Bed
3	1.96	6852	Moist	28	11188	M	No	Hollow	Full Bed
3	1.96	5147	Moist	28	11188	M	No	Hollow	Face Shell
3	1.96	5176	Moist	28	11188	M	No	Hollow	Face Shell
3	1.96	4809	Moist	28	11188	M	No	Hollow	Face Shell
3	1.96	5553	Moist	28	11188	S	No	Hollow	Full Bed
3	1.96	5197	Moist	28	11188	S	No	Hollow	Full Bed
3	1.96	5470	Moist	28	11188	S	No	Hollow	Full Bed
3	1.96	3740	Moist	28	11188	S	No	Hollow	Face Shell
3	1.96	2942	Moist	28	11188	S	No	Hollow	Face Shell
3	1.96	3562	Moist	28	11188	S	No	Hollow	Face Shell
3	1.96	5173	Moist	28	11188	S	No	Hollow	Full Bed
3	1.96	5095	Moist	28	11188	S	No	Hollow	Full Bed
3	1.96	5300	Moist	28	11188	S	No	Hollow	Full Bed
3	1.96	3616	Moist	28	11188	S	No	Hollow	Face Shell
3	1.96	3680	Moist	28	11188	S	No	Hollow	Face Shell
3	1.96	3281	Moist	28	11188	S	No	Hollow	Face Shell
3	1.96	5704	Moist	28	11188	S	No	Hollow	Full Bed

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
3	1.96	5764	Moist	28	11188	S	No	Hollow	Full Bed
3	1.96	5638	Moist	28	11188	S	No	Hollow	Full Bed
3	1.96	3558	Moist	28	11188	S	No	Hollow	Face Shell
3	1.96	3889	Moist	28	11188	S	No	Hollow	Face Shell
3	1.96	3810	Moist	28	11188	S	No	Hollow	Face Shell
3	1.96	7174	Moist	28	11188	S	No	Hollow	Full Bed
3	1.96	6317	Moist	28	11188	S	No	Hollow	Full Bed
3	1.96	6615	Moist	28	11188	S	No	Hollow	Full Bed
3	1.96	5092	Moist	28	11188	S	No	Hollow	Face Shell
3	1.96	4788	Moist	28	11188	S	No	Hollow	Face Shell
3	1.96	5283	Moist	28	11188	S	No	Hollow	Face Shell
3	1.96	6756	Moist	28	11188	M	No	Hollow	Full Bed
3	1.96	6429	Moist	28	11188	M	No	Hollow	Full Bed
3	1.96	6355	Moist	28	11188	M	No	Hollow	Full Bed
3	1.96	4801	Moist	28	11188	M	No	Hollow	Face Shell
3	1.96	4933	Moist	28	11188	M	No	Hollow	Face Shell
3	1.96	5112	Moist	28	11188	M	No	Hollow	Face Shell
3	1.96	3665	Moist	28	11188	N	No	Hollow	Full Bed
3	1.96	4175	Moist	28	11188	N	No	Hollow	Full Bed

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
3	1.96	3900	Moist	28	11188	N	No	Hollow	Full Bed
3	1.96	2668	Moist	28	11188	N	No	Hollow	Face Shell
3	1.96	2889	Moist	28	11188	N	No	Hollow	Face Shell
3	1.96	2866	Moist	28	11188	N	No	Hollow	Face Shell
3	2.02	5063	Moist	28	15371	S	No	Hollow	Full Bed
3	2.02	4664	Moist	28	15371	S	No	Hollow	Full Bed
3	2.02	4947	Moist	28	15371	S	No	Hollow	Full Bed
3	2.02	3735	Moist	28	15371	S	No	Hollow	Face Shell
3	2.02	4024	Moist	28	15371	S	No	Hollow	Face Shell
3	2.02	3941	Moist	28	15371	S	No	Hollow	Face Shell
3	2.02	4618	Moist	28	15371	S	No	Hollow	Full Bed
3	2.02	4839	Moist	28	15371	S	No	Hollow	Full Bed
3	2.02	4743	Moist	28	15371	S	No	Hollow	Full Bed
3	2.02	3562	Moist	28	15371	S	No	Hollow	Face Shell
3	2.02	3567	Moist	28	15371	S	No	Hollow	Face Shell
3	2.02	3803	Moist	28	15371	S	No	Hollow	Face Shell
3	2.02	5088	Moist	28	15371	S	No	Hollow	Full Bed
3	2.02	4750	Moist	28	15371	S	No	Hollow	Full Bed
3	2.02	5421	Moist	28	15371	S	No	Hollow	Full Bed

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
3	2.02	3961	Moist	28	15371	S	No	Hollow	Face Shell
3	2.02	4138	Moist	28	15371	S	No	Hollow	Face Shell
3	2.02	4108	Moist	28	15371	S	No	Hollow	Face Shell
3	2.02	7128	Moist	28	15371	M	No	Hollow	Full Bed
3	2.02	7360	Moist	28	15371	M	No	Hollow	Full Bed
3	2.02	7840	Moist	28	15371	M	No	Hollow	Full Bed
3	2.02	5821	Moist	28	15371	M	No	Hollow	Face Shell
3	2.02	5640	Moist	28	15371	M	No	Hollow	Face Shell
3	2.02	5546	Moist	28	15371	M	No	Hollow	Face Shell
3	2.02	7062	Moist	28	15371	M	No	Hollow	Full Bed
3	2.02	6920	Moist	28	15371	M	No	Hollow	Full Bed
3	2.02	6889	Moist	28	15371	M	No	Hollow	Full Bed
3	2.02	5463	Moist	28	15371	M	No	Hollow	Face Shell
3	2.02	4954	Moist	28	15371	M	No	Hollow	Face Shell
3	2.02	5121	Moist	28	15371	M	No	Hollow	Face Shell
3	2.02	7032	Moist	28	15371	M	No	Hollow	Full Bed
3	2.02	6722	Moist	28	15371	M	No	Hollow	Full Bed
3	2.02	6926	Moist	28	15371	M	No	Hollow	Full Bed
3	2.02	5327	Moist	28	15371	M	No	Hollow	Face Shell

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
3	2.02	5333	Moist	28	15371	M	No	Hollow	Face Shell
3	2.02	5209	Moist	28	15371	M	No	Hollow	Face Shell
3	2.02	4474	Moist	28	15371	N	No	Hollow	Full Bed
3	2.02	4249	Moist	28	15371	N	No	Hollow	Full Bed
3	2.02	4504	Moist	28	15371	N	No	Hollow	Full Bed
3	2.02	3399	Moist	28	15371	N	No	Hollow	Face Shell
3	2.02	3357	Moist	28	15371	N	No	Hollow	Face Shell
3	2.02	3089	Moist	28	15371	N	No	Hollow	Face Shell
3	2.03	3647	Moist	28	11400	N	No	Hollow	Full Bed
3	2.03	3468	Moist	28	11400	N	No	Hollow	Full Bed
3	2.03	3539	Moist	28	11400	N	No	Hollow	Full Bed
3	2.03	3033	Moist	28	11400	N	No	Hollow	Face Shell
3	2.03	2847	Moist	28	11400	N	No	Hollow	Face Shell
3	2.03	2803	Moist	28	11400	N	No	Hollow	Face Shell
3	2.03	5085	Moist	28	11400	S	No	Hollow	Full Bed
3	2.03	5078	Moist	28	11400	S	No	Hollow	Full Bed
3	2.03	5291	Moist	28	11400	S	No	Hollow	Full Bed
3	2.03	4243	Moist	28	11400	S	No	Hollow	Face Shell
3	2.03	4175	Moist	28	11400	S	No	Hollow	Face Shell

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
3	2.03	3762	Moist	28	11400	S	No	Hollow	Face Shell
3	2.03	5349	Moist	28	11400	S	No	Hollow	Full Bed
3	2.03	5525	Moist	28	11400	S	No	Hollow	Full Bed
3	2.03	5602	Moist	28	11400	S	No	Hollow	Full Bed
3	2.03	3669	Moist	28	11400	S	No	Hollow	Face Shell
3	2.03	3590	Moist	28	11400	S	No	Hollow	Face Shell
3	2.03	3777	Moist	28	11400	S	No	Hollow	Face Shell
3	2.03	5095	Moist	28	11400	S	No	Hollow	Full Bed
3	2.03	4775	Moist	28	11400	S	No	Hollow	Full Bed
3	2.03	4762	Moist	28	11400	S	No	Hollow	Full Bed
3	2.03	3378	Moist	28	11400	S	No	Hollow	Face Shell
3	2.03	3325	Moist	28	11400	S	No	Hollow	Face Shell
3	2.03	3790	Moist	28	11400	S	No	Hollow	Face Shell
3	2.03	6174	Moist	28	11400	M	No	Hollow	Full Bed
3	2.03	6648	Moist	28	11400	M	No	Hollow	Full Bed
3	2.03	6696	Moist	28	11400	M	No	Hollow	Full Bed
3	2.03	4286	Moist	28	11400	M	No	Hollow	Face Shell
3	2.03	4061	Moist	28	11400	M	No	Hollow	Face Shell
3	2.03	4664	Moist	28	11400	M	No	Hollow	Face Shell

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
3	2.03	6273	Moist	28	11400	M	No	Hollow	Full Bed
3	2.03	6398	Moist	28	11400	M	No	Hollow	Full Bed
3	2.03	6644	Moist	28	11400	M	No	Hollow	Full Bed
3	2.03	3909	Moist	28	11400	M	No	Hollow	Face Shell
3	2.03	3897	Moist	28	11400	M	No	Hollow	Face Shell
3	2.03	3929	Moist	28	11400	M	No	Hollow	Face Shell
3	2.03	6444	Moist	28	11400	M	No	Hollow	Full Bed
3	2.03	6353	Moist	28	11400	M	No	Hollow	Full Bed
3	2.03	6238	Moist	28	11400	M	No	Hollow	Full Bed
3	2.03	4054	Moist	28	11400	M	No	Hollow	Face Shell
3	2.03	4261	Moist	28	11400	M	No	Hollow	Face Shell
3	2.03	4513	Moist	28	11400	M	No	Hollow	Face Shell
4, 5	6.28	3597	Air Dry	28	12100	N	No	Hollow	Face Shell
4, 5	6.36	3144	Air Dry	28	12100	N	No	Hollow	Face Shell
4, 5	6.20	3381	Air Dry	28	12100	N	No	Hollow	Face Shell
4, 5	6.24	3053	Air Dry	28	12100	N	No	Hollow	Face Shell
4, 5	6.32	3720	Air Dry	28	12100	N	No	Hollow	Face Shell
4, 5	6.28	2456	Air Dry	28	8220	N	No	Hollow	Face Shell
4, 5	6.33	2214	Air Dry	28	8220	N	No	Hollow	Face Shell

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
4, 5	6.32	1894	Air Dry	28	8220	N	No	Hollow	Face Shell
4, 5	6.21	2690	Air Dry	28	8220	N	No	Hollow	Face Shell
6	2.28	5040	Air Dry	28	13810	S	No	Hollow	Face Shell
6	2.43	4800	Air Dry	28	13810	S	No	Hollow	Face Shell
6	2.34	4880	Air Dry	28	13810	S	No	Hollow	Face Shell
6	2.38	5690	Air Dry	28	13810	S	No	Hollow	Face Shell
6	2.42	5900	Air Dry	28	13810	S	No	Hollow	Face Shell
6	2.37	4130	Air Dry	28	13810	S	No	Hollow	Face Shell
6	2.33	5160	Air Dry	28	13810	S	No	Hollow	Face Shell
6	2.41	5790	Air Dry	28	13810	S	No	Hollow	Face Shell
6	2.35	4610	Air Dry	28	13810	S	No	Hollow	Face Shell
6	2.36	6310	Air Dry	28	13810	S	No	Hollow	Face Shell
6	2.22	6080	Air Dry	28	13810	S	No	Hollow	Face Shell
6	2.40	5480	Air Dry	28	13810	S	No	Hollow	Face Shell
6	2.30	5420	Air Dry	28	13810	S	No	Hollow	Face Shell
6	2.28	5870	Air Dry	28	13810	S	No	Hollow	Face Shell
6	2.34	6400	Air Dry	28	13810	S	No	Hollow	Face Shell
6	2.39	6980	Air Dry	28	13810	S	No	Hollow	Face Shell
6	2.33	5630	Air Dry	28	13810	S	No	Hollow	Face Shell

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
6	2.33	5840	Air Dry	28	13810	S	No	Hollow	Face Shell
6	2.36	5920	Air Dry	28	13810	S	No	Hollow	Face Shell
6	2.34	5860	Air Dry	28	13810	S	No	Hollow	Face Shell
6	2.37	6440	Air Dry	28	13810	S	No	Hollow	Face Shell
6	2.42	6180	Air Dry	28	13810	S	No	Hollow	Face Shell
6	2.33	6700	Air Dry	28	13810	S	No	Hollow	Face Shell
6	2.37	7020	Air Dry	28	13810	S	No	Hollow	Face Shell
6	2.32	5680	Air Dry	28	13810	S	No	Hollow	Face Shell
6	2.38	6610	Air Dry	28	13810	S	No	Hollow	Face Shell
6	2.31	5100	Air Dry	28	13810	S	No	Hollow	Face Shell
6	2.31	5790	Air Dry	28	13810	S	No	Hollow	Face Shell
6	2.43	6280	Air Dry	28	13810	S	No	Hollow	Face Shell
6	2.30	6510	Air Dry	28	13810	S	No	Hollow	Face Shell
6	2.29	4680	Moist	28	13810	S	No	Hollow	Full Bed
6	2.31	4500	Moist	28	13810	S	No	Hollow	Full Bed
6	2.27	4650	Moist	28	13810	S	No	Hollow	Full Bed
6	2.26	4980	Moist	28	13810	S	No	Hollow	Full Bed
6	2.33	3460	Moist	28	13810	S	No	Hollow	Full Bed
6	2.29	4780	Moist	28	13810	S	No	Hollow	Full Bed

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
6	2.30	4350	Moist	28	13810	S	No	Hollow	Full Bed
6	2.32	5020	Moist	28	13810	S	No	Hollow	Full Bed
6	2.31	4280	Moist	28	13810	S	No	Hollow	Full Bed
6	2.30	5280	Moist	28	13810	S	No	Hollow	Full Bed
6	2.37	4150	Air Dry	28	13810	S	Yes	Hollow	Face Shell
6	2.36	3420	Air Dry	28	13810	S	Yes	Hollow	Face Shell
6	2.36	3130	Air Dry	28	13810	S	Yes	Hollow	Face Shell
6	2.39	3700	Air Dry	28	13810	S	Yes	Hollow	Face Shell
6	2.37	3540	Air Dry	28	13810	S	Yes	Hollow	Face Shell
6	2.43	3700	Air Dry	28	13810	S	Yes	Hollow	Face Shell
6	2.48	4220	Air Dry	28	13810	S	Yes	Hollow	Face Shell
6	2.44	3680	Air Dry	28	13810	S	Yes	Hollow	Face Shell
6	2.35	3560	Air Dry	28	13810	S	Yes	Hollow	Face Shell
6	2.45	3980	Air Dry	28	13810	S	Yes	Hollow	Face Shell
6	2.46	3070	Air Dry	28	13810	S	Yes	Hollow	Face Shell
6	2.43	4010	Air Dry	28	13810	S	Yes	Hollow	Face Shell
6	2.44	3170	Air Dry	28	13810	S	Yes	Hollow	Face Shell
6	2.41	3410	Air Dry	28	13810	S	Yes	Hollow	Face Shell
6	2.50	2920	Air Dry	28	13810	S	Yes	Hollow	Face Shell

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
6	2.41	3480	Air Dry	28	13810	S	Yes	Hollow	Face Shell
6	2.35	4130	Air Dry	28	13810	S	Yes	Hollow	Face Shell
6	2.28	3940	Air Dry	28	13810	S	Yes	Hollow	Face Shell
6	2.35	3910	Air Dry	28	13810	S	Yes	Hollow	Face Shell
6	2.34	4510	Air Dry	28	13810	S	Yes	Hollow	Face Shell
6	2.30	5060	Air Dry	28	13810	S	Yes	Hollow	Face Shell
6	2.29	5610	Air Dry	28	13810	S	Yes	Hollow	Face Shell
6	2.33	5560	Air Dry	28	13810	S	Yes	Hollow	Face Shell
6	2.35	5750	Air Dry	28	13810	S	Yes	Hollow	Face Shell
6	2.39	4260	Air Dry	28	13810	S	Yes	Hollow	Face Shell
6	2.41	4610	Air Dry	28	13810	S	Yes	Hollow	Face Shell
6	2.46	4480	Air Dry	28	13810	S	Yes	Hollow	Face Shell
6	2.40	5070	Air Dry	28	13810	S	Yes	Hollow	Face Shell
6	2.41	4250	Air Dry	28	13810	S	Yes	Hollow	Face Shell
6	2.38	4260	Air Dry	28	13810	S	Yes	Hollow	Face Shell
6	2.34	3760	Moist	28	13810	S	Yes	Hollow	Full Bed
6	2.33	4490	Moist	28	13810	S	Yes	Hollow	Full Bed
6	2.35	3590	Moist	28	13810	S	Yes	Hollow	Full Bed
6	2.34	3880	Moist	28	13810	S	Yes	Hollow	Full Bed

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
6	2.31	3850	Moist	28	13810	S	Yes	Hollow	Full Bed
6	2.33	3320	Moist	28	13810	S	Yes	Hollow	Full Bed
6	2.30	4520	Moist	28	13810	S	Yes	Hollow	Full Bed
6	2.34	4680	Moist	28	13810	S	Yes	Hollow	Full Bed
6	2.32	4410	Moist	28	13810	S	Yes	Hollow	Full Bed
6	2.31	4430	Moist	28	13810	S	Yes	Hollow	Full Bed
6	2.34	4340	Moist	28	13810	S	Yes	Hollow	Full Bed
6	2.30	4100	Moist	28	13810	S	Yes	Hollow	Full Bed
6	2.32	4520	Moist	28	13810	S	Yes	Hollow	Full Bed
6	2.33	4990	Moist	28	13810	S	Yes	Hollow	Full Bed
6	2.35	3870	Moist	28	13810	S	Yes	Hollow	Full Bed
6	2.29	4130	Moist	28	13810	S	Yes	Hollow	Full Bed
6	2.34	3910	Moist	28	13810	S	Yes	Hollow	Full Bed
6	2.33	3630	Moist	28	13810	S	Yes	Hollow	Full Bed
6	2.33	3790	Moist	28	13810	S	Yes	Hollow	Full Bed
6	2.37	4170	Moist	28	13810	S	Yes	Hollow	Full Bed
6	2.37	4640	Moist	28	13810	S	Yes	Hollow	Full Bed
6	2.30	4760	Moist	28	13810	S	Yes	Hollow	Full Bed
6	2.35	4560	Moist	28	13810	S	Yes	Hollow	Full Bed

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
6	2.27	4460	Moist	28	13810	S	Yes	Hollow	Full Bed
6	2.35	4570	Moist	28	13810	S	Yes	Hollow	Full Bed
6	2.35	5270	Moist	28	13810	S	Yes	Hollow	Full Bed
6	2.36	4670	Moist	28	13810	S	Yes	Hollow	Full Bed
6	2.36	4600	Moist	28	13810	S	Yes	Hollow	Full Bed
6	2.25	4250	Moist	28	13810	S	Yes	Hollow	Full Bed
6	2.33	4240	Moist	28	13810	S	Yes	Hollow	Full Bed
7	2.14	4533	Air Dry	28	16090	N	No	Hollow	Full Bed
7	2.14	5324	Air Dry	28	16090	N	No	Hollow	Face Shell
7	3.28	4320	Air Dry	28	16090	N	No	Hollow	Full Bed
7	3.28	4692	Air Dry	28	16090	N	No	Hollow	Face Shell
7	4.43	3724	Air Dry	28	16090	N	No	Hollow	Full Bed
7	4.43	3821	Air Dry	28	16090	N	No	Hollow	Face Shell
7	5.57	3560	Air Dry	28	16090	N	No	Hollow	Full Bed
7	5.57	3837	Air Dry	28	16090	N	No	Hollow	Face Shell
7	2.14	5127	Air Dry	28	16090	S	No	Hollow	Full Bed
7	2.14	5830	Air Dry	28	16090	S	No	Hollow	Face Shell
7	3.28	5770	Air Dry	28	16090	S	No	Hollow	Full Bed
7	3.28	6274	Air Dry	28	16090	S	No	Hollow	Face Shell

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
7	4.43	5266	Air Dry	28	16090	S	No	Hollow	Full Bed
7	4.43	5469	Air Dry	28	16090	S	No	Hollow	Face Shell
7	5.57	4852	Air Dry	28	16090	S	No	Hollow	Full Bed
7	5.57	4927	Air Dry	28	16090	S	No	Hollow	Face Shell
7	2.14	7976	Air Dry	28	16090	M	No	Hollow	Full Bed
7	2.14	8158	Air Dry	28	16090	M	No	Hollow	Face Shell
7	3.28	5819	Air Dry	28	16090	M	No	Hollow	Full Bed
7	3.28	6296	Air Dry	28	16090	M	No	Hollow	Face Shell
7	4.43	6617	Air Dry	28	16090	M	No	Hollow	Full Bed
7	4.43	6238	Air Dry	28	16090	M	No	Hollow	Face Shell
7	5.57	4580	Air Dry	28	16090	M	No	Hollow	Full Bed
7	5.57	4831	Air Dry	28	16090	M	No	Hollow	Face Shell
7	2.04	4552	Air Dry	28	9750	N	No	Hollow	Full Bed
7	2.04	4210	Air Dry	28	9750	N	No	Hollow	Face Shell
7	3.44	3946	Air Dry	28	9750	N	No	Hollow	Full Bed
7	3.44	3681	Air Dry	28	9750	N	No	Hollow	Face Shell
7	4.14	4533	Air Dry	28	9750	N	No	Hollow	Full Bed
7	4.14	4070	Air Dry	28	9750	N	No	Hollow	Face Shell
7	5.61	4691	Air Dry	28	9750	N	No	Hollow	Full Bed

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
7	5.61	4290	Air Dry	28	9750	N	No	Hollow	Face Shell
7	2.04	5248	Air Dry	28	9750	S	No	Hollow	Full Bed
7	2.04	5900	Air Dry	28	9750	S	No	Hollow	Face Shell
7	3.44	5322	Air Dry	28	9750	S	No	Hollow	Full Bed
7	3.44	5060	Air Dry	28	9750	S	No	Hollow	Face Shell
7	4.14	5048	Air Dry	28	9750	S	No	Hollow	Full Bed
7	4.14	4920	Air Dry	28	9750	S	No	Hollow	Face Shell
7	5.61	4968	Air Dry	28	9750	S	No	Hollow	Full Bed
7	5.61	4870	Air Dry	28	9750	S	No	Hollow	Face Shell
7	2.04	5073	Air Dry	28	9750	M	No	Hollow	Full Bed
7	2.04	5378	Air Dry	28	9750	M	No	Hollow	Face Shell
7	3.44	6306	Air Dry	28	9750	M	No	Hollow	Full Bed
7	3.44	5558	Air Dry	28	9750	M	No	Hollow	Face Shell
7	4.14	6096	Air Dry	28	9750	M	No	Hollow	Full Bed
7	4.14	5954	Air Dry	28	9750	M	No	Hollow	Face Shell
7	5.61	6289	Air Dry	28	9750	M	No	Hollow	Full Bed
7	5.61	5630	Air Dry	28	9750	M	No	Hollow	Face Shell
7	2.04	4230	Air Dry	28	9012	N	No	Hollow	Full Bed
7	2.04	4650	Air Dry	28	9012	N	No	Hollow	Face Shell

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
7	3.11	4160	Air Dry	28	9012	N	No	Hollow	Full Bed
7	3.11	4650	Air Dry	28	9012	N	No	Hollow	Face Shell
7	4.15	4330	Air Dry	28	9012	N	No	Hollow	Full Bed
7	4.15	4890	Air Dry	28	9012	N	No	Hollow	Face Shell
7	5.18	3730	Air Dry	28	9012	N	No	Hollow	Full Bed
7	5.18	3600	Air Dry	28	9012	N	No	Hollow	Face Shell
7	2.04	5090	Air Dry	28	9012	S	No	Hollow	Full Bed
7	2.04	6080	Air Dry	28	9012	S	No	Hollow	Face Shell
7	3.11	5520	Air Dry	28	9012	S	No	Hollow	Full Bed
7	3.11	5750	Air Dry	28	9012	S	No	Hollow	Face Shell
7	4.15	4850	Air Dry	28	9012	S	No	Hollow	Full Bed
7	4.15	5350	Air Dry	28	9012	S	No	Hollow	Face Shell
7	5.18	5490	Air Dry	28	9012	S	No	Hollow	Full Bed
7	5.18	5010	Air Dry	28	9012	S	No	Hollow	Face Shell
7	2.04	6690	Air Dry	28	9012	M	No	Hollow	Full Bed
7	2.04	6610	Air Dry	28	9012	M	No	Hollow	Face Shell
7	3.11	6230	Air Dry	28	9012	M	No	Hollow	Full Bed
7	3.11	6180	Air Dry	28	9012	M	No	Hollow	Face Shell
7	4.15	6080	Air Dry	28	9012	M	No	Hollow	Full Bed

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
7	4.15	6240	Air Dry	28	9012	M	No	Hollow	Face Shell
7	5.18	5400	Air Dry	28	9012	M	No	Hollow	Full Bed
7	5.18	5660	Air Dry	28	9012	M	No	Hollow	Face Shell
7	2.05	5700	Air Dry	28	9311	N	No	Hollow	Full Bed
7	2.05	5330	Air Dry	28	9311	N	No	Hollow	Face Shell
7	3.32	5070	Air Dry	28	9311	N	No	Hollow	Full Bed
7	3.32	5210	Air Dry	28	9311	N	No	Hollow	Face Shell
7	4.16	5500	Air Dry	28	9311	N	No	Hollow	Full Bed
7	4.16	5190	Air Dry	28	9311	N	No	Hollow	Face Shell
7	5.40	4920	Air Dry	28	9311	N	No	Hollow	Full Bed
7	5.40	4060	Air Dry	28	9311	N	No	Hollow	Face Shell
7	2.05	4690	Air Dry	28	9311	S	No	Hollow	Full Bed
7	2.05	5670	Air Dry	28	9311	S	No	Hollow	Face Shell
7	3.32	4940	Air Dry	28	9311	S	No	Hollow	Full Bed
7	3.32	5760	Air Dry	28	9311	S	No	Hollow	Face Shell
7	4.16	5520	Air Dry	28	9311	S	No	Hollow	Full Bed
7	4.16	5590	Air Dry	28	9311	S	No	Hollow	Face Shell
7	5.40	5310	Air Dry	28	9311	S	No	Hollow	Full Bed
7	5.40	5776	Air Dry	28	9311	S	No	Hollow	Face Shell

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
7	2.05	6980	Air Dry	28	9311	M	No	Hollow	Full Bed
7	2.05	7750	Air Dry	28	9311	M	No	Hollow	Face Shell
7	3.32	6630	Air Dry	28	9311	M	No	Hollow	Full Bed
7	3.32	6680	Air Dry	28	9311	M	No	Hollow	Face Shell
7	4.16	6190	Air Dry	28	9311	M	No	Hollow	Full Bed
7	4.16	6630	Air Dry	28	9311	M	No	Hollow	Face Shell
7	5.40	6480	Air Dry	28	9311	M	No	Hollow	Full Bed
7	5.40	6610	Air Dry	28	9311	M	No	Hollow	Face Shell
7	2.07	5762	Air Dry	28	18730	S	No	Hollow	Full Bed
7	2.07	4044	Air Dry	28	18730	S	No	Hollow	Face Shell
7	3.17	4578	Air Dry	28	18730	S	No	Hollow	Full Bed
7	3.17	5764	Air Dry	28	18730	S	No	Hollow	Face Shell
7	4.27	5029	Air Dry	28	18730	S	No	Hollow	Full Bed
7	4.27	5290	Air Dry	28	18730	S	No	Hollow	Face Shell
7	5.30	4718	Air Dry	28	18730	S	No	Hollow	Full Bed
7	5.30	5623	Air Dry	28	18730	S	No	Hollow	Face Shell
7	5.30	5147	Air Dry	28	18730	S	No	Hollow	Full Bed
7	5.30	5266	Air Dry	28	18730	S	No	Hollow	Face Shell
7	2.10	3226	Air Dry	28	14405	S	No	Hollow	Full Bed

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
7	2.10	3709	Air Dry	28	14405	S	No	Hollow	Face Shell
7	3.17	3149	Air Dry	28	14405	S	No	Hollow	Full Bed
7	3.17	4518	Air Dry	28	14405	S	No	Hollow	Face Shell
7	4.25	2657	Air Dry	28	14405	S	No	Hollow	Full Bed
7	4.25	4000	Air Dry	28	14405	S	No	Hollow	Face Shell
7	5.28	3002	Air Dry	28	14405	S	No	Hollow	Full Bed
7	5.28	3865	Air Dry	28	14405	S	No	Hollow	Face Shell
7	5.28	3352	Air Dry	28	14405	S	No	Hollow	Full Bed
7	5.28	3747	Air Dry	28	14405	S	No	Hollow	Face Shell
7	2.11	4177	Air Dry	28	19120	S	No	Hollow	Full Bed
7	2.11	7047	Air Dry	28	19120	S	No	Hollow	Face Shell
7	3.16	4549	Air Dry	28	19120	S	No	Hollow	Full Bed
7	3.16	5785	Air Dry	28	19120	S	No	Hollow	Face Shell
7	4.21	3960	Air Dry	28	19120	S	No	Hollow	Full Bed
7	4.21	4985	Air Dry	28	19120	S	No	Hollow	Face Shell
7	5.26	3893	Air Dry	28	19120	S	No	Hollow	Full Bed
7	5.26	4822	Air Dry	28	19120	S	No	Hollow	Face Shell
7	5.26	5330	Air Dry	28	19120	S	No	Hollow	Full Bed
7	5.26	4978	Air Dry	28	19120	S	No	Hollow	Face Shell

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
8	4.16	4490	Air Dry	28	15844	S	Yes	Hollow	Face Shell
8	4.16	4100	Air Dry	28	15844	S	Yes	Hollow	Face Shell
8	4.16	4970	Air Dry	28	15844	S	Yes	Hollow	Face Shell
8	3.05	4370	Air Dry	28	13676	S	Yes	Hollow	Face Shell
8	3.05	4370	Air Dry	28	13676	S	Yes	Hollow	Face Shell
8	3.05	4370	Air Dry	28	13676	S	Yes	Hollow	Face Shell
9	2.0	6936	Air Dry	28	20044	N	No	Solid	Full Bed
9	2.0	6499	Air Dry	28	20044	N	No	Solid	Full Bed
9	2.0	5281	Air Dry	28	20044	N	No	Solid	Full Bed
9	3.87	6850	Air Dry	28	20044	N	No	Solid	Full Bed
9	3.87	6350	Air Dry	28	20044	N	No	Solid	Full Bed
9	3.87	5900	Air Dry	28	20044	N	No	Solid	Full Bed
10, 11	3.79	3069	Air Dry	7	10362	N	No	Solid	Full Bed
10, 11	3.79	3069	Air Dry	7	10362	N	No	Solid	Full Bed
10, 11	3.79	3193	Air Dry	28	10362	N	No	Solid	Full Bed
10, 11	3.79	3193	Air Dry	28	10362	N	No	Solid	Full Bed
10, 11	3.79	2616	Air Dry	7	10362	N	No	Solid	Full Bed
10, 11	3.79	2616	Air Dry	7	10362	N	No	Solid	Full Bed
10, 11	3.79	3098	Air Dry	28	10362	N	No	Solid	Full Bed

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
10, 11	3.79	3098	Air Dry	28	10362	N	No	Solid	Full Bed
10, 11	3.79	2436	Air Dry	7	10362	N	No	Solid	Full Bed
10, 11	3.79	2436	Air Dry	7	10362	N	No	Solid	Full Bed
10, 11	3.79	2579	Air Dry	28	10362	N	No	Solid	Full Bed
10, 11	3.79	2579	Air Dry	28	10362	N	No	Solid	Full Bed
10, 11	3.79	1587	Air Dry	7	10362	N	No	Solid	Full Bed
10, 11	3.79	1587	Air Dry	7	10362	N	No	Solid	Full Bed
10, 11	3.79	1889	Air Dry	28	10362	N	No	Solid	Full Bed
10, 11	3.79	1889	Air Dry	28	10362	N	No	Solid	Full Bed
10, 11	3.64	2559	Air Dry	7	21145	N	No	Solid	Full Bed
10, 11	3.64	2559	Air Dry	7	21145	N	No	Solid	Full Bed
10, 11	3.64	2748	Air Dry	28	21145	N	No	Solid	Full Bed
10, 11	3.64	2748	Air Dry	28	21145	N	No	Solid	Full Bed
10, 11	3.64	2290	Air Dry	7	21145	N	No	Solid	Full Bed
10, 11	3.64	2290	Air Dry	7	21145	N	No	Solid	Full Bed
10, 11	3.64	2210	Air Dry	28	21145	N	No	Solid	Full Bed
10, 11	3.64	2210	Air Dry	28	21145	N	No	Solid	Full Bed
10, 11	3.64	2012	Air Dry	7	21145	N	No	Solid	Full Bed
10, 11	3.64	2012	Air Dry	7	21145	N	No	Solid	Full Bed

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
10, 11	3.64	2833	Air Dry	28	21145	N	No	Solid	Full Bed
10, 11	3.64	2833	Air Dry	28	21145	N	No	Solid	Full Bed
10, 11	3.64	1606	Air Dry	7	21145	N	No	Solid	Full Bed
10, 11	3.64	1606	Air Dry	7	21145	N	No	Solid	Full Bed
10, 11	3.64	1624	Air Dry	28	21145	N	No	Solid	Full Bed
10, 11	3.64	1624	Air Dry	28	21145	N	No	Solid	Full Bed
12	2.91	5765	Air Dry	28	12936	N	Yes	Hollow	Full Bed
12	4.57	3946	Air Dry	28	8974	N	Yes	Hollow	Full Bed
12	2.13	4523	Air Dry	28	11344	N	Yes	Hollow	Full Bed
12	2.91	5704	Air Dry	28	12936	N	Yes	Hollow	Full Bed
12	2.13	5373	Air Dry	28	11344	N	Yes	Hollow	Full Bed
12	2.91	4745	Air Dry	28	12936	N	Yes	Hollow	Full Bed
12	2.91	5595	Air Dry	28	12936	S	Yes	Hollow	Full Bed
12	2.91	5993	Air Dry	28	12936	N	Yes	Hollow	Full Bed
12	2.91	3551	Air Dry	28	12936	N	Yes	Hollow	Full Bed
12	2.91	4774	Air Dry	28	12936	N	Yes	Hollow	Full Bed
13	2.1	3464	Air Dry	7	3920	S	No	Solid	Full Bed
13	2.8	2967	Air Dry	7	3920	S	No	Solid	Full Bed
13	3.5	2710	Air Dry	7	3920	S	No	Solid	Full Bed

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
13	4.3	2352	Air Dry	7	3920	S	No	Solid	Full Bed
13	5.0	2292	Air Dry	7	3920	S	No	Solid	Full Bed
13	2.1	7773	Air Dry	7	13780	S	No	Solid	Full Bed
13	2.8	6367	Air Dry	7	13780	S	No	Solid	Full Bed
13	3.5	5435	Air Dry	7	13780	S	No	Solid	Full Bed
13	4.3	5184	Air Dry	7	13780	S	No	Solid	Full Bed
13	5.0	5236	Air Dry	7	13780	S	No	Solid	Full Bed
13	2.8	3105	Air Dry	28	3920	S	No	Solid	Full Bed
13	5.0	2553	Air Dry	28	3920	S	No	Solid	Full Bed
13	2.8	5396	Air Dry	28	13780	S	No	Solid	Full Bed
13	5.0	4206	Air Dry	28	13780	S	No	Solid	Full Bed
14	3.57	4850	Moist/ Dry	7	11400	S	No	Solid	Full Bed
14	3.57	3820	Moist/ Dry	7	11400	S	No	Solid	Full Bed
14	3.57	4870	Moist/ Dry	7	11400	S	No	Solid	Full Bed
14	3.57	4670	Moist/ Dry	7	11400	S	No	Solid	Full Bed
14	3.57	4030	Moist/ Dry	7	11400	S	No	Solid	Full Bed
14	3.57	4080	Moist/ Dry	7	11400	S	No	Solid	Full Bed
14	3.57	4970	Moist/ Dry	7	11400	S	No	Solid	Full Bed
14	3.57	4920	Moist/ Dry	7	11400	S	No	Solid	Full Bed

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
14	3.57	4230	Moist/ Dry	7	11400	S	No	Solid	Full Bed
14	3.57	4330	Moist/ Dry	7	11400	S	No	Solid	Full Bed
14	3.57	2810	Moist/ Dry	7	11400	S	No	Solid	Full Bed
14	3.57	3860	Moist/ Dry	7	11400	S	No	Solid	Full Bed
15	5.2	2219	Moist/ Dry	28	4844	S	No	Solid	Face Shell
15	5.0	2553	Moist/ Dry	28	4844	S	No	Solid	Face Shell
15	2.8	2596	Moist/ Dry	28	4844	S	No	Solid	Face Shell
15	2.8	2118	Moist/ Dry	7	4844	S	No	Solid	Face Shell
15	5.0	2770	Moist/ Dry	28	4844	S	No	Solid	Face Shell
15	5.1	3931	Moist/ Dry	28	16534	S	No	Solid	Face Shell
15	5.0	4192	Moist/ Dry	28	16534	S	No	Solid	Face Shell
15	2.8	4554	Moist/ Dry	28	16534	S	No	Solid	Face Shell
15	2.8	3655	Moist/ Dry	7	16534	S	No	Solid	Face Shell
15	5.0	6309	Moist/ Dry	28	16534	S	No	Solid	Face Shell
16	5.43	3887	Air Dry	28	17245	S	No	Solid	Full Bed
16	5.43	3423	Air Dry	28	17172	S	No	Solid	Full Bed
16	5.43	4380	Air Dry	28	17245	S	No	Solid	Full Bed
16	5.43	3989	Air Dry	28	17172	S	No	Solid	Full Bed
16	5.43	3553	Air Dry	28	17245	S	No	Solid	Full Bed

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
16	5.43	3597	Air Dry	28	17172	S	No	Solid	Full Bed
16	5.43	3698	Air Dry	28	17245	S	No	Solid	Full Bed
16	5.43	4264	Air Dry	28	17172	S	No	Solid	Full Bed
16	5.43	3989	Air Dry	28	17245	S	No	Solid	Full Bed
16	5.43	3800	Air Dry	28	17172	S	No	Solid	Full Bed
16	5.43	3844	Moist/ Dry	28	17245	S	No	Solid	Full Bed
16	5.43	4409	Moist/ Dry	28	17172	S	No	Solid	Full Bed
16	5.43	4743	Moist/ Dry	28	17245	S	No	Solid	Full Bed
16	5.43	4728	Moist/ Dry	28	17172	S	No	Solid	Full Bed
16	5.43	5250	Moist/ Dry	28	17245	S	No	Solid	Full Bed
16	5.43	4366	Moist/ Dry	28	17172	S	No	Solid	Full Bed
16	5.43	5207	Moist/ Dry	28	17245	S	No	Solid	Full Bed
16	5.43	4235	Moist/ Dry	28	17172	S	No	Solid	Full Bed
16	5.43	5410	Moist/ Dry	28	17245	S	No	Solid	Full Bed
16	5.43	4888	Moist/ Dry	28	17172	S	No	Solid	Full Bed
16	5.43	3162	Air Dry	28	17245	N	No	Solid	Full Bed
16	5.43	3046	Air Dry	28	17172	N	No	Solid	Full Bed
16	5.43	2785	Air Dry	28	17245	N	No	Solid	Full Bed
16	5.43	2611	Air Dry	28	17172	N	No	Solid	Full Bed

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
16	5.43	2741	Air Dry	28	17245	N	No	Solid	Full Bed
16	5.43	2625	Air Dry	28	17172	N	No	Solid	Full Bed
16	5.43	3945	Air Dry	28	17245	N	No	Solid	Full Bed
16	5.43	3698	Air Dry	28	17172	N	No	Solid	Full Bed
17, 18	3.3	7420	Moist/ Dry	28	14785	M	No	Solid	Full Bed
17, 18	3.3	6935	Moist/ Dry	28	14785	M	No	Solid	Full Bed
17, 18	3.3	6613	Moist/ Dry	28	14785	M	No	Solid	Full Bed
17, 18	3.3	6130	Moist/ Dry	28	14785	S	No	Solid	Full Bed
17, 18	3.3	4520	Moist/ Dry	28	14785	S	No	Solid	Full Bed
17, 18	3.3	5900	Moist/ Dry	28	14785	S	No	Solid	Full Bed
17, 18	3.3	5960	Moist/ Dry	28	14785	S	No	Solid	Full Bed
17, 18	3.3	6500	Moist/ Dry	28	14785	S	No	Solid	Full Bed
17, 18	3.3	6574	Moist/ Dry	28	14785	S	No	Solid	Full Bed
17, 18	3.3	4675	Moist/ Dry	28	14785	N	No	Solid	Full Bed
17, 18	3.3	4590	Moist/ Dry	28	14785	N	No	Solid	Full Bed
17, 18	3.3	5000	Moist/ Dry	28	14785	N	No	Solid	Full Bed
17, 18	3.3	4590	Moist/ Dry	28	14785	N	No	Solid	Full Bed
17, 18	3.35	1159	Moist/ Dry	28	2477	M	No	Solid	Full Bed
17, 18	3.35	1015	Moist/ Dry	28	2477	M	No	Solid	Full Bed

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
17, 18	3.35	1015	Moist/ Dry	28	2477	M	No	Solid	Full Bed
17, 18	3.35	1024	Moist/ Dry	28	2477	S	No	Solid	Full Bed
17, 18	3.35	1189	Moist/ Dry	28	2477	S	No	Solid	Full Bed
17, 18	3.35	987	Moist/ Dry	28	2477	S	No	Solid	Full Bed
17, 18	3.35	894	Moist/ Dry	28	2477	N	No	Solid	Full Bed
17, 18	3.35	1098	Moist/ Dry	28	2477	N	No	Solid	Full Bed
17, 18	3.35	987	Moist/ Dry	28	2477	N	No	Solid	Full Bed
17, 18	3.55	6000	Moist/ Dry	28	10152	M	No	Solid	Full Bed
17, 18	3.55	4952	Moist/ Dry	28	10152	M	No	Solid	Full Bed
17, 18	3.55	5430	Moist/ Dry	28	10152	M	No	Solid	Full Bed
17, 18	3.55	4952	Moist/ Dry	28	10152	S	No	Solid	Full Bed
17, 18	3.55	4762	Moist/ Dry	28	10152	S	No	Solid	Full Bed
17, 18	3.55	5362	Moist/ Dry	28	10152	S	No	Solid	Full Bed
17, 18	3.55	3933	Moist/ Dry	28	10152	N	No	Solid	Full Bed
17, 18	3.55	3810	Moist/ Dry	28	10152	N	No	Solid	Full Bed
17, 18	3.55	4015	Moist/ Dry	28	10152	N	No	Solid	Full Bed
19, 20	2.25	2100	Air Dry	28	3957	S	Yes	Solid	Full Bed
19, 20	2.25	2025	Air Dry	28	3957	S	Yes	Solid	Full Bed
19, 20	2.21	1902	Air Dry	28	3957	S	Yes	Solid	Full Bed

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
19, 20	2.25	2094	Air Dry	28	3957	S	Yes	Solid	Full Bed
19, 20	2.21	2092	Air Dry	28	3957	S	Yes	Solid	Full Bed
19, 20	2.3	2009	Air Dry	28	3957	S	Yes	Solid	Full Bed
19, 20	2.29	2205	Air Dry	28	3957	S	Yes	Solid	Full Bed
19, 20	2.32	2154	Air Dry	28	3957	S	Yes	Solid	Full Bed
19, 20	2.3	2109	Air Dry	28	3957	S	Yes	Solid	Full Bed
19, 20	2.3	2009	Air Dry	28	3957	S	Yes	Solid	Full Bed
19, 20	2.22	4200	Air Dry	28	15507	S	Yes	Solid	Full Bed
19, 20	2.22	4008	Air Dry	28	15507	S	Yes	Solid	Full Bed
19, 20	2.19	4682	Air Dry	28	15507	S	Yes	Solid	Full Bed
19, 20	2.22	4433	Air Dry	28	15507	S	Yes	Solid	Full Bed
19, 20	2.20	4620	Air Dry	28	15507	S	Yes	Solid	Full Bed
19, 20	2.22	5098	Air Dry	28	15507	S	Yes	Solid	Full Bed
19, 20	2.22	4896	Air Dry	28	15507	S	Yes	Solid	Full Bed
19, 20	2.22	5221	Air Dry	28	15507	S	Yes	Solid	Full Bed
19, 20	2.22	5549	Air Dry	28	15507	S	Yes	Solid	Full Bed
19, 20	2.22	4912	Air Dry	28	15507	S	Yes	Solid	Full Bed
21	5.48	8383	Air Dry	28	17172	S	Yes	Solid	Full Bed
21	2.25	8615	Air Dry	28	17172	S	Yes	Solid	Full Bed

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
22	4.9	3375	Air Dry	28	15998	M	Yes	Hollow	Full Bed
22	4.9	4882	Air Dry	28	18568	M	No	Hollow	Full Bed
22	4.9	3669	Air Dry	28	18568	S	Yes	Hollow	Full Bed
22	4.9	5743	Air Dry	28	15998	S	No	Hollow	Full Bed
22	4.9	2545	Air Dry	28	15998	N	Yes	Hollow	Full Bed
22	4.9	2598	Air Dry	28	15998	N	Yes	Hollow	Full Bed
22	4.9	2725	Air Dry	28	15998	N	No	Hollow	Full Bed
22	3.7	3068	Air Dry	28	13703	M	Yes	Hollow	Full Bed
22	3.7	3694	Air Dry	28	13703	M	No	Hollow	Full Bed
22	3.7	2318	Air Dry	28	13703	S	Yes	Hollow	Full Bed
22	3.7	3039	Air Dry	28	13703	S	No	Hollow	Full Bed
22	3.7	1769	Air Dry	28	13703	N	Yes	Hollow	Full Bed
22	3.7	2621	Air Dry	28	13703	N	No	Hollow	Full Bed
22	3.1	4234	Air Dry	28	12337	M	Yes	Hollow	Full Bed
22	3.1	5362	Air Dry	28	12337	M	No	Hollow	Full Bed
22	3.1	2737	Air Dry	28	12337	N	Yes	Hollow	Full Bed
22	3.1	3359	Air Dry	28	12337	N	No	Hollow	Full Bed
22	4.4	4118	Air Dry	28	15088	M	Yes	Hollow	Full Bed
22	4.4	3852	Air Dry	28	15088	M	Yes	Hollow	Full Bed

Table A.1 - continued

Ref. No.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
22	4.4	4518	Air Dry	28	15088	M	No	Hollow	Full Bed
22	4.4	5406	Air Dry	28	15088	M	No	Hollow	Full Bed
22	4.4	2994	Air Dry	28	15088	S	Yes	Hollow	Full Bed
22	4.4	3519	Air Dry	28	15088	S	No	Hollow	Full Bed
22	4.4	2099	Air Dry	28	15088	N	Yes	Hollow	Full Bed
22	4.4	3224	Air Dry	28	15088	N	No	Hollow	Full Bed
22	4.8	2331	Air Dry	28	9993	S	Yes	Hollow	Full Bed
22	4.8	3842	Air Dry	28	9993	S	No	Hollow	Full Bed
22	4.8	2138	Air Dry	28	9993	N	Yes	Hollow	Full Bed
22	4.8	2891	Air Dry	28	9993	N	No	Hollow	Full Bed
23	2.16	4177	Air Dry	28	9979	M	No	Solid	Full Bed
23	2.16	3539	Air Dry	28	9979	S	No	Solid	Full Bed
23	2.16	2973	Air Dry	28	9979	N	No	Solid	Full Bed
23	2.27	7237	Air Dry	28	18666	M	No	Solid	Full Bed
23	2.27	6324	Air Dry	28	18666	S	No	Solid	Full Bed
23	2.27	4772	Air Dry	28	18666	N	No	Solid	Full Bed

APPENDIX B

UTA PRISM TEST RESULTS

Note: The following apply to entire Appendix B contents.

- Brick Type: Three types of brick were tested at UTA, “A”, “B”, and “C”.
- Curing Method:
  - Moist: The prisms were reported to have been cured in moist conditions for the entire duration of their curing period.
  - Dry: The prisms were cured in air-dry conditions for the entire duration of their curing period.
  - Moist/Dry: The prisms were cured in moist conditions for the first seven days and in air-dry conditions for the remaining of their curing period.
- Grout:
  - No: The prisms were not grouted.
  - Yes: The prisms were grouted; in the case of solid units that were grouted, the prisms were double Wythe.

All the prism strength values are unadjusted for their h/t ratios.

Table B.1: UTA Test Results, Brick “A”

Brick Type.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
A	2.41	3759	Moist	28	8690	N	No	Solid	Full Bed
A	2.42	3971	Moist	28	8690	N	No	Solid	Full Bed
A	2.41	4042	Moist	28	8690	N	No	Solid	Full Bed
A	2.41	3413	Moist	28	8690	N	No	Solid	Full Bed
A	2.42	4191	Moist	28	8690	N	No	Solid	Full Bed
A	4.84	3489	Moist	28	8690	N	No	Solid	Full Bed
A	4.82	3923	Moist	28	8690	N	No	Solid	Full Bed
A	4.82	3843	Moist	28	8690	N	No	Solid	Full Bed

Table B.1 - continued

Brick Type.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
A	4.81	3769	Moist	28	8690	N	No	Solid	Full bed
A	4.77	3639	Moist	28	8690	N	No	Solid	Full bed
A	2.38	3642	Moist	28	8690	N	No	Solid	Full bed
A	2.40	3158	Moist	28	8690	N	No	Solid	Full bed
A	2.38	3941	Moist	28	8690	N	No	Solid	Full bed
A	2.38	3766	Moist	28	8690	N	No	Solid	Full bed
A	2.42	3363	Moist	28	8690	N	No	Solid	Full bed
A	4.88	3239	Moist	28	8690	N	No	Solid	Full bed
A	4.89	3161	Moist	28	8690	N	No	Solid	Full bed
A	4.87	2979	Moist	28	8690	N	No	Solid	Full bed
A	4.88	3178	Moist	28	8690	N	No	Solid	Full bed
A	4.88	3210	Moist	28	8690	N	No	Solid	Full bed
A	2.38	3316	Moist	28	8690	N	No	Solid	Full bed
A	2.35	3127	Moist	28	8690	N	No	Solid	Full bed
A	2.38	3055	Moist	28	8690	N	No	Solid	Full bed
A	2.41	3038	Moist	28	8690	N	No	Solid	Full bed
A	2.38	3216	Moist	28	8690	N	No	Solid	Full bed
A	4.85	2634	Moist	28	8690	N	No	Solid	Full bed
A	4.86	2640	Moist	28	8690	N	No	Solid	Full bed

Table B.1 - continued

Brick Type.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
A	4.88	2657	Moist	28	8690	N	No	Solid	Full bed
A	4.85	2753	Moist	28	8690	N	No	Solid	Full bed
A	4.81	3060	Moist	28	8690	N	No	Solid	Full bed
A	2.38	4950	Moist	28	8690	S	No	Solid	Full bed
A	2.38	4780	Moist	28	8690	S	No	Solid	Full bed
A	2.38	4806	Moist	28	8690	S	No	Solid	Full bed
A	2.41	4824	Moist	28	8690	S	No	Solid	Full bed
A	2.38	4712	Moist	28	8690	S	No	Solid	Full bed
A	4.88	3702	Moist	28	8690	S	No	Solid	Full bed
A	4.88	4106	Moist	28	8690	S	No	Solid	Full bed
A	4.88	3786	Moist	28	8690	S	No	Solid	Full bed
A	4.9	3757	Moist	28	8690	S	No	Solid	Full bed
A	4.89	4590	Moist	28	8690	S	No	Solid	Full bed
A	2.35	4116	Moist	28	8690	S	No	Solid	Full bed
A	2.38	4314	Moist	28	8690	S	No	Solid	Full bed
A	2.36	4289	Moist	28	8690	S	No	Solid	Full bed
A	2.38	4318	Moist	28	8690	S	No	Solid	Full bed
A	2.38	3631	Moist	28	8690	S	No	Solid	Full bed
A	4.84	3294	Moist	28	8690	S	No	Solid	Full bed

Table B.1 - continued

Brick Type.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
A	4.84	3239	Moist	28	8690	S	No	Solid	Full bed
A	4.87	3684	Moist	28	8690	S	No	Solid	Full bed
A	4.89	3088	Moist	28	8690	S	No	Solid	Full bed
A	4.85	3384	Moist	28	8690	S	No	Solid	Full bed
A	2.34	4185	Moist	28	8690	S	No	Solid	Full bed
A	2.37	3997	Moist	28	8690	S	No	Solid	Full bed
A	2.34	4709	Moist	28	8690	S	No	Solid	Full bed
A	2.33	3817	Moist	28	8690	S	No	Solid	Full bed
A	2.34	4144	Moist	28	8690	S	No	Solid	Full bed
A	4.79	3905	Moist	28	8690	S	No	Solid	Full bed
A	4.84	3656	Moist	28	8690	S	No	Solid	Full bed
A	2.38	3842	Moist	28	8690	S	No	Solid	Full bed
A	2.36	3901	Moist	28	8690	S	No	Solid	Full bed
A	4.79	3724	Moist	28	8690	S	No	Solid	Full bed

Table B.2: UTA Test Results, Brick "B".

Brick Type.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
B	2.10	4034	Moist	28	8164	N	No	Solid	Full bed
B	2.12	3504	Moist	28	8164	N	No	Solid	Full bed
B	2.12	4450	Moist	28	8164	N	No	Solid	Full bed
B	2.13	3754	Moist	28	8164	N	No	Solid	Full bed
B	2.14	4103	Moist	28	8164	N	No	Solid	Full bed
B	5.50	3337	Moist	28	8164	N	No	Solid	Full bed
B	5.51	3004	Moist	28	8164	N	No	Solid	Full bed
B	5.50	2575	Moist	28	8164	N	No	Solid	Full bed
B	5.44	3274	Moist	28	8164	N	No	Solid	Full bed
B	5.55	3200	Moist	28	8164	N	No	Solid	Full bed
B	2.09	4233	Moist	28	8164	N	No	Solid	Full bed
B	2.15	3514	Moist	28	8164	N	No	Solid	Full bed
B	2.10	3687	Moist	28	8164	N	No	Solid	Full bed
B	2.14	3549	Moist	28	8164	N	No	Solid	Full bed
B	2.12	3583	Moist	28	8164	N	No	Solid	Full bed
B	5.51	2344	Moist	28	8164	N	No	Solid	Full bed
B	5.52	2877	Moist	28	8164	N	No	Solid	Full bed
B	5.51	2691	Moist	28	8164	N	No	Solid	Full bed
B	5.49	2683	Moist	28	8164	N	No	Solid	Full bed

Table B.2 - continued

Brick Type.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
B	5.51	2761	Moist	28	8164	N	No	Solid	Full bed
B	2.10	3447	Moist	28	8164	N	No	Solid	Full bed
B	2.12	2928	Moist	28	8164	N	No	Solid	Full bed
B	2.12	3253	Moist	28	8164	N	No	Solid	Full bed
B	2.13	2930	Moist	28	8164	N	No	Solid	Full bed
B	2.12	2896	Moist	28	8164	N	No	Solid	Full bed
B	5.45	2839	Moist	28	8164	N	No	Solid	Full bed
B	5.51	2317	Moist	28	8164	N	No	Solid	Full bed
B	5.53	2871	Moist	28	8164	N	No	Solid	Full bed
B	5.50	2863	Moist	28	8164	N	No	Solid	Full bed
B	5.49	2724	Moist	28	8164	N	No	Solid	Full bed
B	2.10	5284	Moist	28	8164	S	No	Solid	Full bed
B	2.09	5010	Moist	28	8164	S	No	Solid	Full bed
B	2.13	5422	Moist	28	8164	S	No	Solid	Full bed
B	2.10	3378	Moist	28	8164	S	No	Solid	Full bed
B	2.13	4889	Moist	28	8164	S	No	Solid	Full bed
B	5.49	4658	Moist	28	8164	S	No	Solid	Full bed
B	5.50	4504	Moist	28	8164	S	No	Solid	Full bed
B	5.49	3779	Moist	28	8164	S	No	Solid	Full bed

Table B.2 - continued

Brick Type.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
B	5.50	4414	Moist	28	8164	S	No	Solid	Full bed
B	5.50	4241	Moist	28	8164	S	No	Solid	Full bed
B	2.12	3221	Moist	28	8164	S	No	Solid	Full bed
B	2.13	3968	Moist	28	8164	S	No	Solid	Full bed
B	2.11	3706	Moist	28	8164	S	No	Solid	Full bed
B	2.13	3934	Moist	28	8164	S	No	Solid	Full bed
B	2.13	4132	Moist	28	8164	S	No	Solid	Full bed
B	5.50	3310	Moist	28	8164	S	No	Solid	Full bed
B	5.51	4494	Moist	28	8164	S	No	Solid	Full bed
B	5.49	4174	Moist	28	8164	S	No	Solid	Full bed
B	5.50	4065	Moist	28	8164	S	No	Solid	Full bed
B	5.52	4090	Moist	28	8164	S	No	Solid	Full bed
B	2.12	3974	Moist	28	8164	S	No	Solid	Full bed
B	2.11	5371	Moist	28	8164	S	No	Solid	Full bed
B	2.11	4719	Moist	28	8164	S	No	Solid	Full bed
B	2.09	5499	Moist	28	8164	S	No	Solid	Full bed
B	2.10	4806	Moist	28	8164	S	No	Solid	Full bed
B	5.49	4181	Moist	28	8164	S	No	Solid	Full bed
B	5.44	3801	Moist	28	8164	S	No	Solid	Full bed

Table B.2 - continued

Brick Type.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
B	5.50	3580	Moist	28	8164	S	No	Solid	Full bed
B	5.51	4316	Moist	28	8164	S	No	Solid	Full bed
B	5.50	3425	Moist	28	8164	S	No	Solid	Full bed

Table B.3: UTA Test Results, Brick "C"

Brick Type.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
C	2.12	3754	Moist	28	5328	N	No	Solid	Full bed
C	2.12	3710	Moist	28	5328	N	No	Solid	Full bed
C	2.11	3572	Moist	28	5328	N	No	Solid	Full bed
C	2.12	1965	Moist	28	5328	N	No	Solid	Full bed
C	2.12	3018	Moist	28	5328	N	No	Solid	Full bed
C	5.11	2817	Moist	28	5328	N	No	Solid	Full bed
C	5.06	3014	Moist	28	5328	N	No	Solid	Full bed
C	5.05	2739	Moist	28	5328	N	No	Solid	Full bed
C	5.07	2794	Moist	28	5328	N	No	Solid	Full bed
C	5.06	3148	Moist	28	5328	N	No	Solid	Full bed
C	2.10	2803	Moist	28	5328	N	No	Solid	Full bed
C	2.08	3054	Moist	28	5328	N	No	Solid	Full bed
C	2.11	3186	Moist	28	5328	N	No	Solid	Full bed

Table B.3 - continued

Brick Type.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
C	2.09	3068	Moist	28	5328	N	No	Solid	Full bed
C	2.10	2857	Moist	28	5328	N	No	Solid	Full bed
C	5.08	2547	Moist	28	5328	N	No	Solid	Full bed
C	5.08	3036	Moist	28	5328	N	No	Solid	Full bed
C	5.03	2354	Moist	28	5328	N	No	Solid	Full bed
C	5.06	2521	Moist	28	5328	N	No	Solid	Full bed
C	5.06	2632	Moist	28	5328	N	No	Solid	Full bed
C	2.09	2707	Moist	28	5328	N	No	Solid	Full bed
C	2.09	3303	Moist	28	5328	N	No	Solid	Full bed
C	2.09	3408	Moist	28	5328	N	No	Solid	Full bed
C	2.08	3100	Moist	28	5328	N	No	Solid	Full bed
C	2.07	3228	Moist	28	5328	N	No	Solid	Full bed
C	5.02	2951	Moist	28	5328	N	No	Solid	Full bed
C	5.01	2814	Moist	28	5328	N	No	Solid	Full bed
C	5.01	3025	Moist	28	5328	N	No	Solid	Full bed
C	5.03	2943	Moist	28	5328	N	No	Solid	Full bed
C	5.03	2934	Moist	28	5328	N	No	Solid	Full bed
C	2.09	3614	Moist	28	5328	S	No	Solid	Full bed
C	2.09	4782	Moist	28	5328	S	No	Solid	Full bed

Table B.3 - continued

Brick Type.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
C	2.09	2251	Moist	28	5328	S	No	Solid	Full bed
C	2.11	3491	Moist	28	5328	S	No	Solid	Full bed
C	2.09	3592	Moist	28	5328	S	No	Solid	Full bed
C	5.03	3744	Moist	28	5328	S	No	Solid	Full bed
C	5.07	3006	Moist	28	5328	S	No	Solid	Full bed
C	5.03	2836	Moist	28	5328	S	No	Solid	Full bed
C	5.06	3394	Moist	28	5328	S	No	Solid	Full bed
C	2.09	4097	Moist	28	5328	S	No	Solid	Full bed
C	2.08	3511	Moist	28	5328	S	No	Solid	Full bed
C	2.09	2409	Moist	28	5328	S	No	Solid	Full bed
C	2.08	3775	Moist	28	5328	S	No	Solid	Full bed
C	2.09	3656	Moist	28	5328	S	No	Solid	Full bed
C	5.04	2602	Moist	28	5328	S	No	Solid	Full bed
C	5.03	3187	Moist	28	5328	S	No	Solid	Full bed
C	5.03	3389	Moist	28	5328	S	No	Solid	Full bed
C	5.04	3344	Moist	28	5328	S	No	Solid	Full bed
C	5.02	3203	Moist	28	5328	S	No	Solid	Full bed
C	2.09	2360	Moist	28	5328	S	No	Solid	Full bed
C	2.09	3564	Moist	28	5328	S	No	Solid	Full bed

Table B.3 - continued

Brick Type.	H/T Ratio	Prism Strength, psi	Curing Method	Curing Time, days	Unit Strength, psi	Mortar Type	Grout	Unit Type	Joint Type
C	2.09	3288	Moist	28	5328	S	No	Solid	Full bed
C	2.11	3518	Moist	28	5328	S	No	Solid	Full bed
C	2.09	3612	Moist	28	5328	S	No	Solid	Full bed
C	5.06	2753	Moist	28	5328	S	No	Solid	Full bed
C	5.06	2916	Moist	28	5328	S	No	Solid	Full bed
C	5.03	2700	Moist	28	5328	S	No	Solid	Full bed
C	5.05	3026	Moist	28	5328	S	No	Solid	Full bed
C	5.03	2955	Moist	28	5328	S	No	Solid	Full bed

APPENDIX C

STATISTICAL ANALYSIS

The following definitions apply to all tables in Appendix C.

f'_m: Fifth percentile compressive strength of masonry as predicted by the model, psi,

f_u: average compressive strength of brick, psi,

Face stands for face-shell and full for full-bed mortar joints,

"se" is the standard error for the fifth percentile prism compressive strength predicted by the model.

Table C.1: Model "A" Fifth Percentile Prism Compressive Strength Predictions Targeted at Height-to-Thickness Ratio of Two

Curing Method	Curing Time, days	Mortar Type	Grout	Solid Hollow	Mortar Joint	f_u	f'_m	se
Air dry	28	M	No	Hollow	Face	2,000	-1,285.5	961.2
Air dry	28	M	No	Hollow	Face	4,000	1,128.3	607.1
Air dry	28	M	No	Hollow	Face	6,000	2,540.3	403.4
Air dry	28	M	No	Hollow	Face	8,000	3,542.1	264.3
Air dry	28	M	No	Hollow	Face	10,000	4,319.2	168.0
Air dry	28	M	No	Hollow	Face	12,000	4,954.1	118.0
Air dry	28	M	No	Hollow	Face	14,000	5,490.9	125.3
Air dry	28	M	No	Hollow	Face	16,000	5,955.9	165.8
Air dry	28	M	No	Hollow	Full	18,000	6,366.1	214.0
Air dry	28	M	No	Hollow	Full	2,000	-1,700.4	940.9
Air dry	28	M	No	Hollow	Full	4,000	1,279.5	591.5
Air dry	28	M	No	Hollow	Full	6,000	3,022.6	391.6
Air dry	28	M	No	Hollow	Full	8,000	4,259.4	257.1
Air dry	28	M	No	Hollow	Full	10,000	5,218.7	168.3

Table C.1 - continued

Curing Method	Curing Time, days	Mortar Type	Grout	Solid Hollow	Mortar Joint	f_u	f'_m	se
Air dry	28	M	No	Hollow	Full	12,000	6,002.5	129.6
Air dry	28	M	No	Hollow	Full	14,000	6,665.2	143.7
Air dry	28	M	No	Hollow	Full	16,000	7,239.2	184.5
Air dry	28	M	No	Hollow	Full	18,000	7,745.6	231.5
Air dry	28	M	No	Solid	Full	2,000	-5,765.7	1,045.6
Air dry	28	M	No	Solid	Full	4,000	-1,528.9	663.2
Air dry	28	M	No	Solid	Full	6,000	949.6	445.0
Air dry	28	M	No	Solid	Full	8,000	2,708.0	298.8
Air dry	28	M	No	Solid	Full	10,000	4,072.0	202.1
Air dry	28	M	No	Solid	Full	12,000	5,186.5	156.8
Air dry	28	M	No	Solid	Full	14,000	6,128.7	164.9
Air dry	28	M	No	Solid	Full	16,000	6,944.9	203.9
Air dry	28	M	No	Solid	Full	18,000	7,664.9	252.2
Air dry	28	M	Yes	Hollow	Full	2,000	201.76	1,086.5
Air dry	28	M	Yes	Hollow	Full	4,000	2,172.6	684.9
Air dry	28	M	Yes	Hollow	Full	6,000	3,325.5	455.1
Air dry	28	M	Yes	Hollow	Full	8,000	4,143.5	300.3
Air dry	28	M	Yes	Hollow	Full	10,000	4,778.0	197.3
Air dry	28	M	Yes	Hollow	Full	12,000	5,296.4	150.4
Air dry	28	M	Yes	Hollow	Full	14,000	5,734.7	163.64
Air dry	28	M	Yes	Hollow	Full	16,000	6,114.4	209.0
Air dry	28	M	Yes	Hollow	Full	18,000	6,449.3	262.3

Table C.1 - continued

Curing Method	Curing Time, days	Mortar Type	Grout	Solid Hollow	Mortar Joint	f_u	f'_m	se
Air dry	28	N	No	Hollow	Face	2,000	2,478.6	807.1
Air dry	28	N	No	Hollow	Face	4,000	2,762.9	505.5
Air dry	28	N	No	Hollow	Face	6,000	2,929.2	333.8
Air dry	28	N	No	Hollow	Face	8,000	3,047.1	219.7
Air dry	28	N	No	Hollow	Face	10,000	3,138.6	147.1
Air dry	28	N	No	Hollow	Face	12,000	3,213.4	120.0
Air dry	28	N	No	Hollow	Face	14,000	3,276.6	135.9
Air dry	28	N	No	Hollow	Face	16,000	3,331.4	171.8
Air dry	28	N	No	Hollow	Face	18,000	3,379.7	212.3
Air dry	28	N	No	Hollow	Full	2,000	2,063.7	845.0
Air dry	28	N	No	Hollow	Full	4,000	2,914.0	528.2
Air dry	28	N	No	Hollow	Full	6,000	3,411.5	348.3
Air dry	28	N	No	Hollow	Full	8,000	3,764.4	229.4
Air dry	28	N	No	Hollow	Full	10,000	4,038.1	155.3
Air dry	28	N	No	Hollow	Full	12,000	4,261.8	129.8
Air dry	28	N	No	Hollow	Full	14,000	4,450.9	148.2
Air dry	28	N	No	Hollow	Full	16,000	4,614.7	186.4
Air dry	28	N	No	Hollow	Full	18,000	4,759.2	229.0
Air dry	28	N	No	Solid	Full	2,000	-2,001.6	619.8
Air dry	28	N	No	Solid	Full	4,000	105.72	392.6
Air dry	28	N	No	Solid	Full	6,000	1,338.4	267.6
Air dry	28	N	No	Solid	Full	8,000	2,213.0	190.5

Table C.1 - continued

Curing Method	Curing Time, days	Mortar Type	Grout	Solid Hollow	Mortar Joint	f_u	f'_m	se
Air dry	28	N	No	Solid	Full	10,000	2,891.5	148.9
Air dry	28	N	No	Solid	Full	12,000	3,445.8	138.8
Air dry	28	N	No	Solid	Full	14,000	3,914.4	151.2
Air dry	28	N	No	Solid	Full	16,000	4,320.4	174.6
Air dry	28	N	No	Solid	Full	18,000	4,678.5	201.6
Air dry	28	N	Yes	Hollow	Full	2,000	3,965.9	1,053.3
Air dry	28	N	Yes	Hollow	Full	4,000	3,807.2	659.7
Air dry	28	N	Yes	Hollow	Full	6,000	3,714.4	435.0
Air dry	28	N	Yes	Hollow	Full	8,000	3,648.5	284.9
Air dry	28	N	Yes	Hollow	Full	10,000	3,597.5	187.8
Air dry	28	N	Yes	Hollow	Full	12,000	3,555.7	149.7
Air dry	28	N	Yes	Hollow	Full	14,000	3,520.4	169.7
Air dry	28	N	Yes	Hollow	Full	16,000	3,489.9	217.2
Air dry	28	N	Yes	Hollow	Full	18,000	3,462.9	270.5
Air dry	28	S	No	Hollow	Face	2,000	2,866.9	754.0
Air dry	28	S	No	Hollow	Face	4,000	3,283.0	479.0
Air dry	28	S	No	Hollow	Face	6,000	3,526.4	320.9
Air dry	28	S	No	Hollow	Face	8,000	3,699.2	213.3
Air dry	28	S	No	Hollow	Face	10,000	3,833.1	138.9
Air dry	28	S	No	Hollow	Face	12,000	3,942.6	99.2
Air dry	28	S	No	Hollow	Face	14,000	4,035.1	101.0
Air dry	28	S	No	Hollow	Face	16,000	4,115.3	129.4

Table C.1 - continued

Curing Method	Curing Time, days	Mortar Type	Grout	Solid Hollow	Mortar Joint	f_u	f'_m	se
Air dry	28	S	No	Hollow	Full	18,000	4,186.0	165.2
Air dry	28	S	No	Hollow	Full	2,000	2,451.9	799.4
Air dry	28	S	No	Hollow	Full	4,000	3,434.2	506.1
Air dry	28	S	No	Hollow	Full	6,000	4,008.7	338.3
Air dry	28	S	No	Hollow	Full	8,000	4,416.4	225.4
Air dry	28	S	No	Hollow	Full	10,000	4,732.6	145.0
Air dry	28	S	No	Hollow	Full	12,000	4,991.0	114.2
Air dry	28	S	No	Hollow	Full	14,000	5,209.4	120.9
Air dry	28	S	No	Hollow	Full	16,000	5,398.6	152.0
Air dry	28	S	No	Hollow	Full	18,000	5,565.5	189.9
Air dry	28	S	No	Solid	Full	2,000	-1,613.4	619.8
Air dry	28	S	No	Solid	Full	4,000	625.9	393.2
Air dry	28	S	No	Solid	Full	6,000	1,935.7	267.3
Air dry	28	S	No	Solid	Full	8,000	2,865.1	188.0
Air dry	28	S	No	Solid	Full	10,000	3,586.0	142.9
Air dry	28	S	No	Solid	Full	12,000	4,175.0	129.3
Air dry	28	S	No	Solid	Full	14,000	4,673.0	139.8
Air dry	28	S	No	Solid	Full	16,000	5,104.3	162.5
Air dry	28	S	No	Solid	Full	18,000	5,484.8	189.3
Air dry	28	S	Yes	Hollow	Face	2,000	4,769.0	883.2
Air dry	28	S	Yes	Hollow	Face	4,000	4,176.2	561.7
Air dry	28	S	Yes	Hollow	Face	6,000	3,829.4	376.9

Table C.1 - continued

Curing Method	Curing Time, days	Mortar Type	Grout	Solid Hollow	Mortar Joint	f_u	f'_m	se
Air dry	28	S	Yes	Hollow	Face	8,000	3,583.3	250.9
Air dry	28	S	Yes	Hollow	Face	10,000	3,392.5	163.6
Air dry	28	S	Yes	Hollow	Face	12,000	3,236.5	116.1
Air dry	28	S	Yes	Hollow	Face	14,000	3,104.7	117.0
Air dry	28	S	Yes	Hollow	Face	16,000	2,990.5	149.5
Air dry	28	S	Yes	Hollow	Face	18,000	2,889.7	191.1
Air dry	28	S	Yes	Hollow	Full	2,000	4,354.1	916.7
Air dry	28	S	Yes	Hollow	Full	4,000	4,327.3	581.4
Air dry	28	S	Yes	Hollow	Full	6,000	4,311.7	388.8
Air dry	28	S	Yes	Hollow	Full	8,000	4,300.6	258.0
Air dry	28	S	Yes	Hollow	Full	10,000	4,292.0	168.3
Air dry	28	S	Yes	Hollow	Full	12,000	4,284.9	121.9
Air dry	28	S	Yes	Hollow	Full	14,000	4,279.0	126.2
Air dry	28	S	Yes	Hollow	Full	16,000	4,273.8	161.5
Air dry	28	S	Yes	Hollow	Full	18,000	4,269.3	205.3
Air dry	28	S	Yes	Solid	Full	2,000	288.8	443.9
Air dry	28	S	Yes	Solid	Full	4,000	1,519.0	284.7
Air dry	28	S	Yes	Solid	Full	6,000	2,238.7	201.4
Air dry	28	S	Yes	Solid	Full	8,000	2,749.3	155.3
Air dry	28	S	Yes	Solid	Full	10,000	3,145.3	135.6
Air dry	28	S	Yes	Solid	Full	12,000	3,468.9	135.1
Air dry	28	S	Yes	Solid	Full	14,000	3,742.5	146.0

Table C.1 - continued

Curing Method	Curing Time, days	Mortar Type	Grout	Solid Hollow	Mortar Joint	f_u	f'_m	se
Air dry	28	S	Yes	Solid	Full	16,000	3,979.5	162.3
Air dry	28	S	Yes	Solid	Full	18,000	4,188.5	180.5
Air dry	7	S	No	Solid	Full	2,000	859.9	908.6
Air dry	7	S	No	Solid	Full	4,000	1,712.2	553.6
Air dry	7	S	No	Solid	Full	6,000	2,210.8	358.8
Air dry	7	S	No	Solid	Full	8,000	2,564.6	242.9
Air dry	7	S	No	Solid	Full	10,000	2,839.0	192.7
Air dry	7	S	No	Solid	Full	12,000	3,063.2	200.4
Air dry	7	S	No	Solid	Full	14,000	3,252.7	239.5
Air dry	7	S	No	Solid	Full	16,000	3,416.9	288.3
Air dry	7	S	No	Solid	Full	18,000	3,561.8	338.0
Moist	28	M	No	Hollow	Face	2,000	2,168.3	963.6
Moist	28	M	No	Hollow	Face	4,000	2,848.4	611.6
Moist	28	M	No	Hollow	Face	6,000	3,246.2	407.9
Moist	28	M	No	Hollow	Face	8,000	3,528.4	266.8
Moist	28	M	No	Hollow	Face	10,000	3,747.3	165.0
Moist	28	M	No	Hollow	Face	12,000	3,926.2	103.3
Moist	28	M	No	Hollow	Face	14,000	4,077.4	101.2
Moist	28	M	No	Hollow	Face	16,000	4,208.4	141.2
Moist	28	M	No	Hollow	Face	18,000	4,324.0	190.3
Moist	28	M	No	Hollow	Full	2,000	153.4	940.0
Moist	28	M	No	Hollow	Full	4,000	2,999.5	596.4

Table C.1 - continued

Curing Method	Curing Time, days	Mortar Type	Grout	Solid Hollow	Mortar Joint	f_u	f'_m	se
Moist	28	M	No	Hollow	Full	6,000	3,728.5	397.4
Moist	28	M	No	Hollow	Full	8,000	4,245.6	259.7
Moist	28	M	No	Hollow	Full	10,000	4,646.8	160.2
Moist	28	M	No	Hollow	Full	12,000	4,974.6	99.9
Moist	28	M	No	Hollow	Full	14,000	5,251.7	98.3
Moist	28	M	No	Hollow	Full	16,000	5,491.8	137.7
Moist	28	M	No	Hollow	Full	18,000	5,703.5	185.9
Moist	28	N	No	Hollow	Face	2,000	5,932.5	825.1
Moist	28	N	No	Hollow	Face	4,000	4,482.9	516.9
Moist	28	N	No	Hollow	Face	6,000	3,635.0	340.9
Moist	28	N	No	Hollow	Face	8,000	3,033.4	223.1
Moist	28	N	No	Hollow	Face	10,000	2,566.8	146.6
Moist	28	N	No	Hollow	Face	12,000	2,185.5	116.2
Moist	28	N	No	Hollow	Face	14,000	1,863.1	131.6
Moist	28	N	No	Hollow	Face	16,000	1,583.9	168.7
Moist	28	N	No	Hollow	Face	18,000	1,337.6	210.6
Moist	28	N	No	Hollow	Full	2,000	5,517.6	858.3
Moist	28	N	No	Hollow	Full	4,000	4,634.1	539.4
Moist	28	N	No	Hollow	Full	6,000	4,117.3	356.4
Moist	28	N	No	Hollow	Full	8,000	3,750.7	232.6
Moist	28	N	No	Hollow	Full	10,000	3,466.2	149.3
Moist	28	N	No	Hollow	Full	12,000	3,233.9	111.3

Table C.1 - continued

Curing Method	Curing Time, days	Mortar Type	Grout	Solid Hollow	Mortar Joint	f_u	f'_m	se
Moist	28	N	No	Hollow	Full	14,000	3,037.4	123.7
Moist	28	N	No	Hollow	Full	16,000	2,867.2	161.8
Moist	28	N	No	Hollow	Full	18,000	2,717.1	205.4
Moist	28	N	No	Solid	Full	2,000	1,452.2	385.0
Moist	28	N	No	Solid	Full	4,000	1,825.8	220.8
Moist	28	N	No	Solid	Full	6,000	2,044.3	137.4
Moist	28	N	No	Solid	Full	8,000	2,199.3	101.9
Moist	28	N	No	Solid	Full	10,000	2,319.6	105.0
Moist	28	N	No	Solid	Full	12,000	2,417.9	127.6
Moist	28	N	No	Solid	Full	14,000	2,500.9	154.9
Moist	28	N	No	Solid	Full	16,000	2,572.9	182.0
Moist	28	N	No	Solid	Full	18,000	2,636.4	207.5
Moist	28	S	No	Hollow	Face	2,000	6,320.7	773.7
Moist	28	S	No	Hollow	Face	4,000	5,003.1	491.0
Moist	28	S	No	Hollow	Face	6,000	4,232.3	327.7
Moist	28	S	No	Hollow	Face	8,000	3,685.4	215.1
Moist	28	S	No	Hollow	Face	10,000	3,261.3	134.9
Moist	28	S	No	Hollow	Face	12,000	2,914.7	88.3
Moist	28	S	No	Hollow	Face	14,000	2,621.7	88.1
Moist	28	S	No	Hollow	Face	16,000	2,367.8	119.4
Moist	28	S	No	Hollow	Face	18,000	2,143.9	158.1
Moist	28	S	No	Hollow	Full	2,000	5,905.8	814.0

Table C.1 - continued

Curing Method	Curing Time, days	Mortar Type	Grout	Solid Hollow	Mortar Joint	f_u	f'_m	se
Moist	28	S	No	Hollow	Full	4,000	5,154.2	517.7
Moist	28	S	No	Hollow	Full	6,000	4,714.6	346.1
Moist	28	S	No	Hollow	Full	8,000	4,402.7	227.0
Moist	28	S	No	Hollow	Full	10,000	4,160.8	140.5
Moist	28	S	No	Hollow	Full	12,000	3,963.1	86.3
Moist	28	S	No	Hollow	Full	14,000	3,795.9	81.6
Moist	28	S	No	Hollow	Full	16,000	3,651.2	114.5
Moist	28	S	No	Hollow	Full	18,000	3,523.4	155.8
Moist	28	S	No	Solid	Full	2,000	1,840.4	386.1
Moist	28	S	No	Solid	Full	4,000	2,345.9	221.9
Moist	28	S	No	Solid	Full	6,000	2,641.6	135.4
Moist	28	S	No	Solid	Full	8,000	2,851.4	93.4
Moist	28	S	No	Solid	Full	10,000	3,014.1	91.3
Moist	28	S	No	Solid	Full	12,000	3,147.1	112.1
Moist	28	S	No	Solid	Full	14,000	3,259.5	139.1
Moist	28	S	No	Solid	Full	16,000	3,356.8	166.2
Moist	28	S	No	Solid	Full	18,000	3,445.7	191.7
Moist	28	S	Yes	Hollow	Full	2,000	7,808.0	1,160.7
Moist	28	S	Yes	Hollow	Full	4,000	6,047.4	740.7
Moist	28	S	Yes	Hollow	Full	6,000	5,017.6	497.7
Moist	28	S	Yes	Hollow	Full	8,000	4,286.9	329.7
Moist	28	S	Yes	Hollow	Full	10,000	3,720.1	208.2

Table C.1 - continued

Curing Method	Curing Time, days	Mortar Type	Grout	Solid Hollow	Mortar Joint	f_u	f'_m	se
Moist	28	S	Yes	Hollow	Full	12,000	3,257.0	132.6
Moist	28	S	Yes	Hollow	Full	14,000	2,865.5	123.0
Moist	28	S	Yes	Hollow	Full	16,000	2,526.3	165.4
Moist	28	S	Yes	Hollow	Full	18,000	2,227.2	221.8
Moist	28	S	Yes	Solid	Full	2,000	3,742.6	667.2
Moist	28	S	Yes	Solid	Full	4,000	3,239.1	417.5
Moist	28	S	Yes	Solid	Full	6,000	2,944.5	280.5
Moist	28	S	Yes	Solid	Full	8,000	2,735.6	197.2
Moist	28	S	Yes	Solid	Full	10,000	2,573.4	155.2
Moist	28	S	Yes	Solid	Full	12,000	2,441.0	149.7
Moist	28	S	Yes	Solid	Full	14,000	2,329.0	168.3
Moist	28	S	Yes	Solid	Full	16,000	2,232.0	197.1
Moist	28	S	Yes	Solid	Full	18,000	2,146.5	228.7
Moist	7	S	No	Solid	Full	2,000	4,313.7	1,047.9
Moist	7	S	No	Solid	Full	4,000	3,432.3	638.4
Moist	7	S	No	Solid	Full	6,000	2,916.7	408.1
Moist	7	S	No	Solid	Full	8,000	2,550.9	261.6
Moist	7	S	No	Solid	Full	10,000	2,267.1	184.6
Moist	7	S	No	Solid	Full	12,000	2,035.3	181.7
Moist	7	S	No	Solid	Full	14,000	1,839.3	226.1
Moist	7	S	No	Solid	Full	16,000	1,669.5	284.3
Moist	7	S	No	Solid	Full	18,000	1,519.7	343.3

Table C.1 - continued

Curing Method	Curing Time, days	Mortar Type	Grout	Solid Hollow	Mortar Joint	f_u	f'_m	se
Moist/Dry	28	M	No	Solid	Full	2,000	-6,818	1,250.7
Moist/Dry	28	M	No	Solid	Full	4,000	-1,967	792.3
Moist/Dry	28	M	No	Solid	Full	6,000	870.4	552.2
Moist/Dry	28	M	No	Solid	Full	8,000	2,883.6	420.1
Moist/Dry	28	M	No	Solid	Full	10,000	4,445.2	366.8
Moist/Dry	28	M	No	Solid	Full	12,000	5,721.1	370.8
Moist/Dry	28	M	No	Solid	Full	14,000	6,799.8	407.8
Moist/Dry	28	M	No	Solid	Full	16,000	7,734.3	458.9
Moist/Dry	28	M	No	Solid	Full	18,000	8,558.5	514.4
Moist/Dry	28	N	No	Solid	Full	2,000	-3,054	1,073.1
Moist/Dry	28	N	No	Solid	Full	4,000	-332.5	678.3
Moist/Dry	28	N	No	Solid	Full	6,000	1,259.2	480.1
Moist/Dry	28	N	No	Solid	Full	8,000	2,388.6	381.8
Moist/Dry	28	N	No	Solid	Full	10,000	3,264.6	353.4
Moist/Dry	28	N	No	Solid	Full	12,000	3,980.3	369.9
Moist/Dry	28	N	No	Solid	Full	14,000	4,585.5	409.0
Moist/Dry	28	N	No	Solid	Full	16,000	5,109.7	456.9
Moist/Dry	28	N	No	Solid	Full	18,000	5,572.1	506.9
Moist/Dry	28	S	No	Solid	Face	2,000	-2,251	1,088.6
Moist/Dry	28	S	No	Solid	Face	4,000	36.4	687.7
Moist/Dry	28	S	No	Solid	Face	6,000	1,374.2	484.5
Moist/Dry	28	S	No	Solid	Face	8,000	2,323.4	381.5

Table C.1 - continued

Curing Method	Curing Time, days	Mortar Type	Grout	Solid Hollow	Mortar Joint	f_u	f'_m	se
Moist/Dry	28	S	No	Solid	Face	10,000	3,059.6	349.2
Moist/Dry	28	S	No	Solid	Face	12,000	3,661.2	363.7
Moist/Dry	28	S	No	Solid	Face	14,000	4,169.8	402.2
Moist/Dry	28	S	No	Solid	Face	16,000	4,610.3	450.3
Moist/Dry	28	S	No	Solid	Face	18,000	4,998.9	500.7
Moist/Dry	28	S	No	Solid	Full	2,000	-2,665	1,041.2
Moist/Dry	28	S	No	Solid	Full	4,000	1,87.6	659.7
Moist/Dry	28	S	No	Solid	Full	6,000	1,856.5	468.7
Moist/Dry	28	S	No	Solid	Full	8,000	3,040.6	374.4
Moist/Dry	28	S	No	Solid	Full	10,000	3,959.1	347.2
Moist/Dry	28	S	No	Solid	Full	12,000	4,709.5	362.9
Moist/Dry	28	S	No	Solid	Full	14,000	5,344.0	400.3
Moist/Dry	28	S	No	Solid	Full	16,000	5,893.7	446.2
Moist/Dry	28	S	No	Solid	Full	18,000	6,378.5	494.3
Moist/Dry	7	S	No	Solid	Face	2,000	222.7	1,327.2
Moist/Dry	7	S	No	Solid	Face	4,000	1,122.8	827.4
Moist/Dry	7	S	No	Solid	Face	6,000	1,649.3	568.1
Moist/Dry	7	S	No	Solid	Face	8,000	2,022.9	431.4
Moist/Dry	7	S	No	Solid	Face	10,000	2,312.6	385.7
Moist/Dry	7	S	No	Solid	Face	12,000	2,549.4	403.5
Moist/Dry	7	S	No	Solid	Face	14,000	2,749.6	453.7
Moist/Dry	7	S	No	Solid	Face	16,000	2,922.9	516.0

Table C.1 - continued

Curing Method	Curing Time, days	Mortar Type	Grout	Solid Hollow	Mortar Joint	f_u	f'_m	se
Moist/Dry	7	S	No	Solid	Face	18,000	3075.9	580.8
Moist/Dry	7	S	No	Solid	Full	2,000	-192.2	1,355.0
Moist/Dry	7	S	No	Solid	Full	4,000	1274.0	844.5
Moist/Dry	7	S	No	Solid	Full	6,000	2131.6	578.5
Moist/Dry	7	S	No	Solid	Full	8,000	2740.1	436.6
Moist/Dry	7	S	No	Solid	Full	10,000	3212.1	387.6
Moist/Dry	7	S	No	Solid	Full	12,000	3597.8	404.2
Moist/Dry	7	S	No	Solid	Full	14,000	3923.8	454.8
Moist/Dry	7	S	No	Solid	Full	16,000	4206.3	518.2
Moist/Dry	7	S	No	Solid	Full	18,000	4455.4	584.4

Table C.2: Model "B" Fifth Percentile Prism Compressive Strength Predictions Targeted at Height-to-Thickness Ratio of Two

Curing Method	Curing Time, days	Mortar Type	Grout	f_u	f'_m	se
Air dry	28	M	No	2,000	482.0	1,039.6
Air dry	28	M	No	4,000	2,214.4	654.6
Air dry	28	M	No	6,000	3,227.8	433.9
Air dry	28	M	No	8,000	3,946.8	285.1
Air dry	28	M	No	10,000	4,504.5	185.6

Table C.2 - continued

Curing Method	Curing Time, days	Mortar Type	Grout	f_u	f'_m	se
Air dry	28	M	No	12,000	4,960.2	140.3
Air dry	28	M	No	14,000	5,345.4	153.9
Air dry	28	M	No	16,000	5,679.2	198.4
Air dry	28	M	No	18,000	5,973.5	250.1
Air dry	28	M	Yes	2,000	-5,300.1	1,169.9
Air dry	28	M	Yes	4,000	-1,711.7	738.2
Air dry	28	M	Yes	6,000	387.4	492.2
Air dry	28	M	Yes	8,000	1,876.7	328.3
Air dry	28	M	Yes	10,000	3,031.9	222.0
Air dry	28	M	Yes	12,000	3,975.8	176.6
Air dry	28	M	Yes	14,000	4,773.8	191.8
Air dry	28	M	Yes	16,000	5,465.1	238.9
Air dry	28	M	Yes	18,000	6,074.9	294.8
Air dry	28	N	No	2,000	3,251.1	814.0
Air dry	28	N	No	4,000	3,325.6	513.6
Air dry	28	N	No	6,000	3,369.2	343.6
Air dry	28	N	No	8,000	3,400.1	231.9
Air dry	28	N	No	10,000	3,424.1	162.2
Air dry	28	N	No	12,000	3,443.7	135.5
Air dry	28	N	No	14,000	3,460.3	147.9
Air dry	28	N	No	16,000	3,474.6	180.1
Air dry	28	N	No	18,000	3,487.3	218.1

Table C.2 - continued

Curing Method	Curing Time, days	Mortar Type	Grout	f_u	f'_m	se
Air dry	28	N	Yes	2,000	-2,531.1	885.0
Air dry	28	N	Yes	4,000	-600.5	553.1
Air dry	28	N	Yes	6,000	528.8	367.1
Air dry	28	N	Yes	8,000	1,330.0	248.5
Air dry	28	N	Yes	10,000	1,951.5	181.0
Air dry	28	N	Yes	12,000	2,459.3	164.3
Air dry	28	N	Yes	14,000	2,888.7	186.3
Air dry	28	N	Yes	16,000	3,260.6	225.2
Air dry	28	N	Yes	18,000	3,588.6	268.4
Air dry	28	S	No	2,000	3,918.3	805.4
Air dry	28	S	No	4,000	3,983.1	512.5
Air dry	28	S	No	6,000	4,020.9	345.8
Air dry	28	S	No	8,000	4,047.8	234.7
Air dry	28	S	No	10,000	4,068.7	162.0
Air dry	28	S	No	12,000	4,085.7	128.1
Air dry	28	S	No	14,000	4,100.1	133.1
Air dry	28	S	No	16,000	4,112.6	161.3
Air dry	28	S	No	18,000	4,123.6	197.0
Air dry	28	S	Yes	2,000	-1,863.9	609.4
Air dry	28	S	Yes	4,000	56.93	386.7
Air dry	28	S	Yes	6,000	1,180.53	264.4
Air dry	28	S	Yes	8,000	1,977.7	189.1

Table C.2 - continued

Curing Method	Curing Time, days	Mortar Type	Grout	f_u	f'_m	se
Air dry	28	S	Yes	10,000	2,596.1	148.7
Air dry	28	S	Yes	12,000	3,101.3	138.9
Air dry	28	S	Yes	14,000	3,528.5	150.7
Air dry	28	S	Yes	16,000	3,898.5	173.2
Air dry	28	S	Yes	18,000	4,224.9	199.4
Moist/dry	28	M	No	2,000	-3,609.2	1,248.7
Moist/dry	28	M	No	4,000	-17.7	790.7
Moist/dry	28	M	No	6,000	2,083.1	543.8
Moist/dry	28	M	No	8,000	3,573.7	398.6
Moist/dry	28	M	No	10,000	4,729.9	328.9
Moist/dry	28	M	No	12,000	5,674.6	320.5
Moist/dry	28	M	No	14,000	6,473.3	351.3
Moist/dry	28	M	No	16,000	7,165.2	400.0
Moist/dry	28	M	No	18,000	7,775.4	454.6
Moist/dry	28	N	No	2,000	-840.1	1,027.9
Moist/dry	28	N	No	4,000	1,093.5	646.1
Moist/dry	28	N	No	6,000	2,224.6	448.7
Moist/dry	28	N	No	8,000	3,027.1	344.4
Moist/dry	28	N	No	10,000	3,649.5	308.0
Moist/dry	28	N	No	12,000	4,158.1	318.7
Moist/dry	28	N	No	14,000	4,588.2	354.5
Moist/dry	28	N	No	16,000	4,960.6	400.1

Table C.2 - continued

Curing Method	Curing Time, days	Mortar Type	Grout	f_u	f'_m	Se
Moist/dry	28	N	No	18,000	5,289.2	448.3
Moist/dry	28	S	No	2,000	-172.9	956.7
Moist/dry	28	S	No	4,000	1,750.9	604.9
Moist/dry	28	S	No	6,000	2,876.3	424.6
Moist/dry	28	S	No	8,000	3,674.8	330.7
Moist/dry	28	S	No	10,000	4,294.1	298.6
Moist/dry	28	S	No	12,000	4,800.1	308.4
Moist/dry	28	S	No	14,000	5,228.0	340.6
Moist/dry	28	S	No	16,000	5,598.6	381.9
Moist/dry	28	S	No	18,000	5,925.5	425.6
Moist/dry	7	S	No	2,000	-465.7	1,232.22
Moist/dry	7	S	No	4,000	1,079.1	760.2
Moist/dry	7	S	No	6,000	1,982.7	508.3
Moist/dry	7	S	No	8,000	2,623.8	367.0
Moist/dry	7	S	No	10,000	3,121.1	312.7
Moist/dry	7	S	No	12,000	3,527.4	325.4
Moist/dry	7	S	No	14,000	3,871.0	373.5
Moist/dry	7	S	No	16,000	4,168.6	434.3
Moist/dry	7	S	No	18,000	4,431.0	497.1
Moist	28	M	No	2,000	-611.1	956.8
Moist	28	M	No	4,000	1,223.4	607.6
Moist	28	M	No	6,000	2,296.6	405.6

Table C.2 - continued

Curing Method	Curing Time, days	Mortar Type	Grout	f_u	f'_m	Se
Moist	28	M	No	8,000	3,058.0	265.9
Moist	28	M	No	10,000	3,648.6	165.6
Moist	28	M	No	12,000	4,131.1	105.5
Moist	28	M	No	14,000	4,539.1	103.6
Moist	28	M	No	16,000	4,892.5	142.4
Moist	28	M	No	18,000	5,204.2	190.7
Moist	28	N	No	2,000	2,158.0	545.6
Moist	28	N	No	4,000	2,334.7	330.6
Moist	28	N	No	6,000	2,438.0	210.9
Moist	28	N	No	8,000	2,511.3	137.4
Moist	28	N	No	10,000	2,568.2	103.2
Moist	28	N	No	12,000	2,614.7	107.1
Moist	28	N	No	14,000	2,654.0	132.1
Moist	28	N	No	16,000	2,688.0	163.0
Moist	28	N	No	18,000	2,718.0	194.0
Moist	28	S	No	2,000	2,825.2	476.2
Moist	28	S	No	4,000	2,992.1	297.6
Moist	28	S	No	6,000	3,089.7	195.8
Moist	28	S	No	8,000	3,159.0	128.0
Moist	28	S	No	10,000	3,212.8	84.8
Moist	28	S	No	12,000	3,256.7	69.0
Moist	28	S	No	14,000	3,293.8	79.2

Table C.2 - continued

Curing Method	Curing Time, days	Mortar Type	Grout	f_u	f'_m	Se
Moist	28	S	No	16,000	3,325.9	101.1
Moist	28	S	No	18,000	3,354.3	125.4
Moist	28	S	Yes	2,000	-2,957.0	1,012.9
Moist	28	S	Yes	4,000	-934.0	647.0
Moist	28	S	Yes	6,000	249.3	436.3
Moist	28	S	Yes	8,000	1,088.9	292.0
Moist	28	S	Yes	10,000	1,740.2	190.4
Moist	28	S	Yes	12,000	2,272.3	131.6
Moist	28	S	Yes	14,000	2,722.2	126.9
Moist	28	S	Yes	16,000	3,111.9	161.3
Moist	28	S	Yes	18,000	3,455.7	207.8
Moist	7	S	No	2,000	2,532.4	1,587.7
Moist	7	S	No	4,000	2,320.2	969.6
Moist	7	S	No	6,000	2,196.1	616.5
Moist	7	S	No	8,000	2,108.1	381.8
Moist	7	S	No	10,000	2,039.8	239.4
Moist	7	S	No	12,000	1,984.0	213.4
Moist	7	S	No	14,000	1,936.8	279.3
Moist	7	S	No	16,000	1,895.9	370.9
Moist	7	S	No	18,000	1,859.9	463.0

Table C.3: Model "C" Fifth Percentile Prism Compressive Strength Predictions Targeted at Height-to-Thickness Ratio of Two

Mortar Type	Solid Hollow	Mortar Joint	f_u	f'_m	se
M	Hollow	Face	2,000	1,330.4	983.1
M	Hollow	Face	4,000	2,389.5	623.0
M	Hollow	Face	6,000	3,008.9	414.9
M	Hollow	Face	8,000	3,448.5	271.2
M	Hollow	Face	10,000	3,789.4	168.5
M	Hollow	Face	12,000	4,068.0	108.5
M	Hollow	Face	14,000	4,303.5	109.4
M	Hollow	Face	16,000	4,507.5	150.6
M	Hollow	Face	18,000	4,687.5	200.6
M	Hollow	Full	2,000	1,679.9	975.0
M	Hollow	Full	4,000	2,910.8	617.9
M	Hollow	Full	6,000	3,630.8	411.5
M	Hollow	Full	8,000	4,141.7	269.1
M	Hollow	Full	10,000	4,538.0	167.4
M	Hollow	Full	12,000	4,861.8	108.3
M	Hollow	Full	14,000	5,135.5	109.3
M	Hollow	Full	16,000	5,372.6	150.0
M	Hollow	Full	18,000	5,581.8	199.5
M	Solid	Full	2,000	-3,297.0	960.0
M	Solid	Full	4,000	-192.0	605.5
M	Solid	Full	6,000	1,624.3	403.7
M	Solid	Full	8,000	2,913.0	269.5
M	Solid	Full	10,000	3,912.5	183.2

Table C.3 - continued

Mortar Type	Solid Hollow	Mortar Joint	f_u	f'_m	se
M	Solid	Full	12,000	4,729.3	147.4
M	Solid	Full	14,000	5,419.8	160.6
M	Solid	Full	16,000	6,017.9	199.4
M	Solid	Full	18,000	6,545.6	245.2
N	Hollow	Face	2,000	4,150.7	841.8
N	Hollow	Face	4,000	3,488.2	526.8
N	Hollow	Face	6,000	3,100.7	347.2
N	Hollow	Face	8,000	2,825.8	227.6
N	Hollow	Face	10,000	2,612.6	151.3
N	Hollow	Face	12,000	2,438.3	122.9
N	Hollow	Face	14,000	2,291.0	140.0
N	Hollow	Face	16,000	2,163.4	178.1
N	Hollow	Face	18,000	2,050.8	220.7
N	Hollow	Full	2,000	4,500.1	849.3
N	Hollow	Full	4,000	4,009.6	532.6
N	Hollow	Full	6,000	3,722.6	352.1
N	Hollow	Full	8,000	3,519.0	231.8
N	Hollow	Full	10,000	3,361.1	154.6
N	Hollow	Full	12,000	3,232.1	124.4
N	Hollow	Full	14,000	3,123.0	139.9
N	Hollow	Full	16,000	3,028.5	177.3
N	Hollow	Full	18,000	2,945.1	219.8
N	Solid	Full	2,000	-476.7	378.8

Table C.3 - continued

Mortar Type	Solid Hollow	Mortar Joint	f_u	f'_m	se
N	Solid	Full	4,000	906.8	222.4
N	Solid	Full	6,000	1,716.1	143.7
N	Solid	Full	8,000	2,290.3	109.4
N	Solid	Full	10,000	2,735.7	109.3
N	Solid	Full	12,000	3,100.0	127.6
N	Solid	Full	14,000	3,407.3	151.6
N	Solid	Full	16,000	3,673.8	176.3
N	Solid	Full	18,000	3,908.9	199.8
S	Hollow	Face	2,000	4,169.4	776.8
S	Hollow	Face	4,000	3,782.4	493.4
S	Hollow	Face	6,000	3,556.0	329.9
S	Hollow	Face	8,000	3,395.3	217.3
S	Hollow	Face	10,000	3,270.7	137.3
S	Hollow	Face	12,000	3,168.9	91.0
S	Hollow	Face	14,000	3,082.8	90.4
S	Hollow	Face	16,000	3,008.3	120.9
S	Hollow	Face	18,000	2,942.5	159.2
S	Hollow	Full	2,000	4,518.9	806.8
S	Hollow	Full	4,000	4,303.7	512.8
S	Hollow	Full	6,000	4,177.9	342.9
S	Hollow	Full	8,000	4,088.6	225.7
S	Hollow	Full	10,000	4,019.3	141.9
S	Hollow	Full	12,000	3,962.7	92.2

Table C.3 - continued

Mortar Type	Solid Hollow	Mortar Joint	f_u	f'_m	se
S	Hollow	Full	14,000	3,914.8	90.4
S	Hollow	Full	16,000	3,873.4	122.1
S	Hollow	Full	18,000	3,836.8	162.1
S	Solid	Face	2,000	-807.4	995.1
S	Solid	Face	4,000	,79.6	626.5
S	Solid	Face	6,000	1,549.4	416.6
S	Solid	Face	8,000	2,166.6	276.9
S	Solid	Face	10,000	2,645.3	187.2
S	Solid	Face	12,000	3,036.4	150.7
S	Solid	Face	14,000	3,367.1	165.8
S	Solid	Face	16,000	3,653.6	207.2
S	Solid	Face	18,000	3,906.2	255.4
S	Solid	Full	2,000	-458.0	348.2
S	Solid	Full	4,000	1,200.9	204.7
S	Solid	Full	6,000	2,171.3	131.4
S	Solid	Full	8,000	2,859.8	97.7
S	Solid	Full	10,000	3,393.8	95.6
S	Solid	Full	12,000	3,830.2	111.4
S	Solid	Full	14,000	4,199.1	133.1
S	Solid	Full	16,000	4,518.7	155.5
S	Solid	Full	18,000	4,800.6	177.1

Table C.4: Model "D" Fifth Percentile Prism Compressive Strength Predictions Targeted at Height-to-Thickness Ratio of Two

Mortar Type	Solid Hollow	Mortar Joint	f_u	f'_m	se
M	Hollow	Face	2,000	-1,643.6	1,127.6
M	Hollow	Face	4,000	518.0	705.5
M	Hollow	Face	6,000	1,782.5	460.4
M	Hollow	Face	8,000	2,679.6	289.6
M	Hollow	Face	10,000	3,375.5	164.8
M	Hollow	Face	12,000	3,944.1	92.3
M	Hollow	Face	14,000	4,424.8	110.3
M	Hollow	Face	16,000	4,841.2	172.4
M	Hollow	Face	18,000	5,208.5	237.2
M	Hollow	Full	2,000	-220.4	1,127.6
M	Hollow	Full	4,000	2,016.7	705.5
M	Hollow	Full	6,000	3,325.3	460.4
M	Hollow	Full	8,000	4,253.7	289.6
M	Hollow	Full	10,000	4,973.9	164.8
M	Hollow	Full	12,000	5,562.3	92.3
M	Hollow	Full	14,000	6,059.8	110.3
M	Hollow	Full	16,000	6,490.8	172.4
M	Hollow	Full	18,000	6,870.9	237.2
N	Hollow	Face	2,000	1,985.7	1,097.5
N	Hollow	Face	4,000	1,978.7	677.3
N	Hollow	Face	6,000	1,974.6	434.5
N	Hollow	Face	8,000	1,971.7	268.0
N	Hollow	Face	10,000	1,969.5	153.7

Table C.4 - continued

Mortar Type	Solid Hollow	Mortar Joint	f_u	f'_m	se
N	Hollow	Face	12,000	1,967.6	108.9
N	Hollow	Face	14,000	1,966.1	145.9
N	Hollow	Face	16,000	1,964.7	209.3
N	Hollow	Face	18,000	1,963.5	273.3
N	Hollow	Full	2,000	3,408.9	863.7
N	Hollow	Full	4,000	3,477.4	545.0
N	Hollow	Full	6,000	3,517.4	361.5
N	Hollow	Full	8,000	3,545.8	236.0
N	Hollow	Full	10,000	3,567.9	149.0
N	Hollow	Full	12,000	3,585.9	104.0
N	Hollow	Full	14,000	3,601.1	111.3
N	Hollow	Full	16,000	3,614.3	148.5
N	Hollow	Full	18,000	3,625.9	192.3
N	Solid	Full	2,000	2,098.5	333.3
N	Solid	Full	4,000	2,319.3	180.2
N	Solid	Full	6,000	2,448.5	103.7
N	Solid	Full	8,000	2,540.2	78.8
N	Solid	Full	10,000	2,611.3	94.3
N	Solid	Full	12,000	2,669.4	122.9
N	Solid	Full	14,000	2,718.5	152.3
N	Solid	Full	16,000	2,761.1	179.7
N	Solid	Full	18,000	2,798.6	204.7
S	Hollow	Face	2,000	2,027.7	1,045.1

Table C.4 - continued

Mortar Type	Solid Hollow	Mortar Joint	f_u	f'_m	se
S	Hollow	Face	4,000	2,347.3	649.7
S	Hollow	Face	6,000	2,534.3	420.1
S	Hollow	Face	8,000	2,666.9	260.2
S	Hollow	Face	10,000	2,769.8	144.3
S	Hollow	Face	12,000	2,853.8	82.4
S	Hollow	Face	14,000	2,924.9	109.4
S	Hollow	Face	16,000	2,986.5	170.5
S	Hollow	Face	18,000	3,040.8	232.1
S	Hollow	Full	2,000	3,450.9	829.4
S	Hollow	Full	4,000	3,845.9	525.1
S	Hollow	Full	6,000	4,077.0	348.6
S	Hollow	Full	8,000	4,241.0	225.9
S	Hollow	Full	10,000	4,368.2	136.2
S	Hollow	Full	12,000	4,472.1	80.3
S	Hollow	Full	14,000	4,560.0	79.5
S	Hollow	Full	16,000	4,636.1	117.1
S	Hollow	Full	18,000	4,703.2	161.3
S	Solid	Full	2,000	2,140.4	318.0
S	Solid	Full	4,000	2,687.9	176.7
S	Solid	Full	6,000	3,008.1	103.5
S	Solid	Full	8,000	3,235.4	72.7
S	Solid	Full	10,000	3,411.6	79.4
S	Solid	Full	12,000	3,555.6	102.5

Table C.4 - continued

Mortar Type	Solid Hollow	Mortar Joint	f_u	f'_m	se
S	Solid	Full	14,000	3,677.4	128.3
S	Solid	Full	16,000	3,782.8	152.8
S	Solid	Full	18,000	3,875.8	175.5

Table C.5: Model “E” Fifth Percentile Prism Compressive Strength Predictions Targeted at Height-to-Thickness Ratio of Two

Mortar Type	f_u	f'_m	se
M	2,000	-932.2	981.1
M	4,000	1,018.3	621.9
M	6,000	2,159.2	414.6
M	8,000	2,968.7	272.0
M	10,000	3,596.6	170.9
M	12,000	4,109.7	113.5
M	14,000	4,543.4	115.1
M	16,000	4,919.2	155.2
M	18,000	5,250.6	204.3
N	2,000	759.8	540.7
N	4,000	1,507.7	329.2
N	6,000	1,945.1	212.8
N	8,000	2,255.5	143.1
N	10,000	2,496.3	112.3
N	12,000	2,693.0	116.6

Table C.5 - continued

Mortar Type	f_u	f'_m	se
N	14,000	2,859.3	140.0
N	16,000	3,003.4	169.2
N	18,000	3,130.5	198.9
S	2,000	1,276.9	441.2
S	4,000	2,045.5	277.5
S	6,000	2,495.1	185.2
S	8,000	2,814.1	125.1
S	10,000	3,061.5	88.6
S	12,000	3,263.7	76.2
S	14,000	3,434.6	84.4
S	16,000	3,582.7	102.5
S	18,000	3,713.3	123.4

Table C.6: Model "F" Fifth Percentile Prism Compressive Strength Predictions Targeted at Height-to-Thickness Ratio of Two

Mortar Type	f_u	f'_m	se
M	2,000	-1,480.1	1,579.4
M	4,000	719.3	988.8
M	6,000	2,005.8	645.9
M	8,000	2,918.6	407.0
M	10,000	3,626.6	232.7
M	12,000	4,205.1	131.3
M	14,000	4,694.2	155.1

Table C.6 - continued

Mortar Type	f_u	f'_m	se
M	16,000	5,117.9	241.2
M	18,000	5,491.6	331.6
N	2,000	3,022.5	622.3
N	4,000	2,809.5	372.0
N	6,000	2,684.9	232.8
N	8,000	2,596.5	148.1
N	10,000	2,527.9	112.4
N	12,000	2,471.9	123.4
N	14,000	2,424.5	156.7
N	16,000	2,383.5	194.8
N	18,000	2,347.3	232.0
S	2,000	2,599.8	507.2
S	4,000	2,893.4	316.9
S	6,000	3,065.1	208.6
S	8,000	3,186.9	136.8
S	10,000	3,281.5	91.5
S	12,000	3,358.7	75.5
S	14,000	3,424.0	86.6
S	16,000	3,480.5	109.8
S	18,000	3,530.4	135.6

Table C.7: Model "G" Fifth Percentile Prism Compressive Strength Predictions Targeted at Height-to-Thickness Ratio of Two

Mortar Type	f_u	f'_m	se
N	2,000	1321.2	447.8
N	4,000	2048.8	217.7
N	6,000	2474.4	105.4
N	8,000	2776.4	95.9
N	10,000	3010.7	146.2
N	12,000	3202.0	200.4
N	14,000	3363.9	249.4
N	16,000	3504.0	293.2
N	18,000	3627.7	332.3
S	2,000	2581.7	445.1
S	4,000	2064.4	216.9
S	6,000	2931.8	105.0
S	8,000	3547.1	94.2
S	10,000	4024.5	143.5
S	12,000	4414.5	197.2
S	14,000	4744.3	245.8
S	16,000	5029.9	289.1
S	18,000	5281.9	327.9

REFERENCES

1. Ewing, B. D., and M. J. Kowalsky. "Compressive Behavior of Unconfined and Confined Clay Brick Masonry." ASCE Journal of Structural Engineering, April 2004.
2. Crouch, L. K., R. C. Henderson, and W. A. Sneed Jr. "Development of an Unbonded Capping System for Clay Masonry Prisms." ASTM STP 1356: Masonry: Materials, Testing, and Applications, 1999.
3. "General Shale Reports. "Brick Institute of America, 1994-1995.
4. Bennett, R. M., K. A. Boyd, and R. D. Flanagan. "Compressive Properties of Structural Clay Tile Prisms." Journal of Structural Engineering, July 1997.
5. Boyd, K. A. "Compressive Strength and Constitutive Behavior of Clay Tile Prisms." Master of Science Thesis at the University of Tennessee at Knoxville, 1993.
6. Thomas, R. D., and M. J. Scolforo. "Evaluation of the Compressive Strength of Masonry by Prism Sampling." TMS Journal, 1995.
7. Brown, R. H., and J. G. Borchelt. "Compression Tests of Hollow Brick Units and Prisms." ASTM STP 1063: Masonry: Components to Assemblages, 1990.
8. Young, J. M., and R. H. Brown. "Compressive Stress Distribution of Grouted Hollow Clay Masonry under Strain Gradient." NSF Funded Research, Department of Civil Engineering, Clemson University, 1988.

9. Chen, H. L., and S. P. Shah. "Test of Model Masonry Single Pier under Dynamic Shaking and Quasi-static Cycling Loading." ASTM STP 992: Masonry: Materials, Design, Construction, and Maintenance, 1988.

10. Matthys, J. H., J. T. Houston, and A. Dehghani. "An Investigation of an Extended Plastic Life Mortar." ASTM STP 992: Masonry: Materials, Design, Construction, and Maintenance, 1988.

11. Dehghani, A. "Extended Plastic Phase Mortar Study." Master of Science Thesis at the University of Texas at Arlington, 1985.

12. Atkinson, R. H., and G. R. Kingsley. "A Comparison of the Behavior of Clay and Concrete Masonry in Compression." NSF Funded Research by Atkinson-Noland & Associates, 1985.

13. Maurenbrecher, A. H. P. "Effect of Test Procedures on Compressive Strength of masonry Prisms." Third North American Masonry Conference, 1985.

14. Abrams, D. P., J. L. Noland, R. H. Atkinson, and P. Waugh. "Response of Clay Unit Masonry to repeated Compressive Forces." Third North American Masonry Conference, 1985.

15. Maurenbrecher, A. H. P. "Axial Compression Tests on Masonry Walls and Prisms." Third North American Masonry Conference, 1985.

16. Drysdale, R. G., and E. Gazzola. "Influence of Mortar Properties on the tensile Bond Strength of Brick Masonry." Seventh International Brick Masonry Conference, 1985.

17. Atkinson, R. H., J. L. Noland, D. P. Abrams, and W. S. McNary. "A Deformation Failure Theory for Stack-Bond Brick Masonry Prisms in Compression." Third North American Masonry Conference, 1985.

18. McNary, W. S. "Basic Properties of Clay Unit Masonry in Compression." Master of Science Thesis at the University of Colorado at Boulder, 1984.

19. Matthys, J. H. "An Ultimate Strength Investigation of Reinforced Brick Masonry Beams." Third North American Masonry Conference, 1985.

20. Chanprichar, B. "An Ultimate Strength Investigation of Reinforced Brick Masonry Beams." PhD Dissertation at the University of Texas at Arlington, 1984.

21. Drysdale, R. G., and H. E. Wong. "Interpretation of the Compressive Strength of Masonry Prisms." National Concrete Masonry Association, 1980.

22. Brown, R. H., and A. R. Whitlock. "Compressive Strength of Grouted Hollow Brick Prisms." ASTM STP 778: Masonry: Materials, Properties, and Performance, 1982.

23. Hamid, A. A., and R. G. Drysdale. "Behavior of Brick Masonry under Combined Shear and Compression Loading." Second Canadian Masonry Symposium, 1980.

24. Structural Clay Products Institute (now BIA). "Recommended Practice for Engineered Brick Masonry," McLean, VA, 1969.

25. Masonry Standards Joint Committee. "Specification for Masonry Structures (ACI 530.1-05/ASCE 5-05/TMS 402-05)," 2005.

26. Masonry Standards Joint Committee. "Commentary on Specification for Masonry Structures (ACI 530.1-05/ASCE 6-05/TMS 602-05)," 2005.

27. American Society of Testing and Materials, "Standard Practice for Capping Concrete Masonry units, Related Units and masonry Prisms for Compression Testing," ASTM C 1552-03a, Annual Book of ASTM Standards, 2005.

28. American Society of Testing and Materials, "Standard Test Method for Compressive Strength of masonry Prisms," ASTM C 1314-03b, Annual Book of ASTM Standards, 2005.

29. American Society of Testing and Materials, "Standard Specification for Mortar for Unit Masonry," ASTM C 270-03b, Annual Book of ASTM Standards, 2005.

30. American Society of Testing and Materials, "Standard Specification for Facing Brick (Solid Masonry units Made from Clay or Shale)," ASTM C 216-04b, Annual Book of ASTM Standards, 2005.

31. American Society of Testing and Materials, "Standard Test Methods for Sampling and Testing Brick and Structural Clay Tile," ASTM C 67-03a, Annual Book of ASTM Standards, 2005.

32. Box, George E. P., W. G. Hunter, and J. S. Hunter. Statistics for Experimenters. 2^{nd} Ed. Hoboken: John Wiley & Sons, 2005.

33. Ayyub, Bilal M., and R. H. McCuen. Probability, Statistics, and Reliability for Engineers and Scientists. 2^{nd} Ed. Boca Raton: Chapman & Hall, 2002.

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