AN EXPERIMENTAL INVESTIGATION INTO THE RESTORATION OF ANCIENT AND TRADITIONAL MORTARS FOR STACKWALL CONSTRUCTION

BY

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A thesis submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

MASTER OF SCIENCE

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Appendix A

ESSENTIAL PROPERTIES FOR A GOOD QUALITY MORTAR

All mortars should meet a number of important requirements, regardless of the type of building units used. An examination of the essential properties for a good quality mortar, as used in conventional masonry (see Definitions), was used as the basis for developing an alternative mortar for stackwall construction. It was assumed that stackwall construction be classified as masonry work and that a person constructing a stackwall building be called a mason. The 11 essential properties considered in this study are: 1) workability, 2) water retention, 3) bond, 4) strength, 5) autogenous healing, 6) elasticity and flexibility (internal accommodation), 7) efflorescence, 8) durability, 9) volumetric changes (shrinkage), 10) economy, and 11) appearance.

A.1 WORKABILITY [38, 40, 48, 57, 60, 68]

Probably the single most important property of a good quality plastic mortar is workability. Workability may be defined as the characteristic of a mortar which makes it free-flowing and easy to spread without the separation of water or segregation of the solid materials of the mix.

Mortar with good workability should spread easily on the masonry unit, cling to vertical surfaces, extrude readily from joints without dropping as the building unit is placed and at the same time have body so that it can support the units and many courses without undergoing distortion. A mortar with good workability allows the mason to fill the joints without undue effort, thereby promoting better quality workmanship and increased productivity.

Interrelated factors affecting workability are: 1) the quality of the aggregate, 2) the amount of water used, 3) the consistency, 4) setting time, 5) flowability, 6) adhesion, 7) mass, and 8) the ability of the mortar to retain water.

A.2 WATER RETENTION [38, 40, 48, 57, 60, 68]

Water retentivity is the property of mortar that allows it to retain its water -- to resist loss to the air or to absorptive masonry units.

Mortar with high water retention means that the mortar resists suction or absorption by the masonry unit. Conversely, a mortar with low water retention loses its moisture quickly and may lead to a condition of "pancaking". Pancaking is a term used when the mortar stiffens so quickly that intimate contact is not made with the building unit and hence results to leaky walls.

High water retention is also important with low-absorption masonry units since it minimizes bleeding or formations of a water plane at the interface -- a condition which also leads towards poor bond. High water retention has one construction advantage, it minimizes the need for retempering (see Definitions).

Poor water retentivity may be caused by: 1) poorly graded aggregate, 2) aggregate of too large a size, 3) insufficient mixing, or 4) the wrong type of cement.

A.3 BOND [9, 38, 40, 48, 57, 60, 68]

The bond between mortar and a masonry unit involves a combination of the degree of contact and the adhesion of the two materials. Bond strength has no relation to the crushing or tensile strength of mortar. A wall built with good bond strength will be weathertight (non-leaking between the masonry unit and the mortar). It will also be strong enough to withstand stresses from high winds, vibrations, volume changes and temperature changes.

Three requirements are required for a good bond: 1) the bond must have adequate tensile bond strength, 2) the extent of the bond must be complete (mortar in complete contact with the masonry unit, with no discontinuities), and 3) the bond must be durable so as to last the lifetime of the structure. Of the above, 2) and 3) are more important, as they are key factors which promote watertight walls and wall integrity.

Factors affecting bond in masonry are: 1) the type of mortar used, 2) the type of masonry unit used, and 3) the workmanship. Only the mortar aspect of masonry will be dealt with. Some of the properties of mortar that affect the quality of bond are its workability (or initial flow), water retention, setting characteristics, air content, strength, volume change and resilience. Other factors affecting the bond strength are the workmanship, the ambient temperature and relative humidity.

In general, studies have shown that high bond strength is attained through use of mortars having high workability, high water retention, high strength and low air content. Protection must also be provided against harmful hot or cold weather and extra moisture must be provided during times of low relative humidity.

Summarizing, two key properties are required for a mortar to have good bonding capabilities: 1) the mortar should be a highly workable plastic material that tends to fill the interstices and irregularities of the masonry unit; this will provide a "keying" action which strengthens the bond, and 2) the mortar should be able to retain its moisture so as to produce a more intimate bond (see water retention).

A.4 STRENGTH [12, 38, 40, 48, 57, 60, 68]

Before 1920 mortars were tested approximately equally for both tensile and compressive strengths, and to a much lesser extent, in transverse (shear tension) strength. In the past 60 years though, most strength tests have been in compression.

With conventional Portland cement-lime-sand mortars, the compressive strength increases as the amount of cement in the mix is increased in relation to the amount of water used. This is true provided the mix remains workable. An increase in water content, air entrainment or lime content will reduce the compressive strength of a mortar.

Some have the false impression that the stronger a mortar is in compressive strength, the better it is. Actually as mortars are made stronger, they become more rigid and brittle, and consequently become unable to accommodate the movements and stresses caused by settlement, strong winds, vibrations, earthquakes, thermal changes, wetting and drying. In areas of strong winds, vibrations and earthquakes, reinforcement may however be required, in addition to tough mortar.

Knowing that mortar must support various kinds and degrees of loads, it must possess an **adequate strength** with a generous safety factor. At the same time, the other properties listed in this appendix must be considered just as important or even more so.

A.5 AUTOGENOUS HEALING [38, 48, 68]

Autogenous healing is the ability of a mortar to reknit itself after fine cracking has occurred. This is important if voids are present or if small cracks develop in the mortar or between the mortar and the masonry unit. To have this property, a mortar should have the composition and properties which allow it to combine with constituents extracted from its environment to rebuild breaks and to restore integrality and stability.

A.6 ELASTICITY AND FLEXIBILITY [38, 48, 68]

A mortar with a modest but **adequate** strength has greater elasticity and flexibility than stronger/harder mortars which are more brittle. Mortar with good elasticity and flexibility will resist deflections such as wind-sway and lateral pressures with a minimal amount of cracking in the bond between the mortar and the units.

If a mortar can overcome or absorb a reasonable degree of movement, it is said that it possess a degree of internal accommodation to resist stress. As the density and rigidity (lack of flexibility) of a mortar increases, the chances of internal accommodation decreases.

If the mortar is dense and rigid, lateral movements, whether due to deflection or to expansion and contraction, induce stresses exceeding the bond strength resulting in leaky walls. The reason for this is that rigid mortars provide no relief planes to absorb the applied strains and deformations. As a result, these strains and deformations are passed along the brick courses in an accumulative fashion, often resulting in cracks such as a step crack.

If the density and rigidity are low, the strains and deformations are accommodated at a large number of levels and tend to prevent excessive accumulated bond stresses. In addition, the stresses due to expansion or contraction are much lower because of the capacity of the mortar to yield.

A.7 EFFLORESCENCE [11, 38, 48, 60, 68]

Efflorescence of masonry appears as ugly white coatings or scum that randomly accumulates on the exterior walls of buildings. Some forms of efflorescence are temporary or short-lived but there also exists a troublesome permanent form. The permanent form will subside or even disappear as a result of rains, but will recur again and again for many years. This latter form will not only destroy the appearance of the structure, but will in time cause the disintegration of the mortar and spalling of the masonry units. The end result is leaky walls and costly restorative maintenance.

The composition of these deposits known as permanent efflorescence is usually some salt of either the sulfate, carbonate or chloride variety. These salts may be those of sodium, potassium or calcium. The primary types of soluble alkali salts is usually sodium sulfate and potassium sulfate. Less often these salts are found in the carbonate and even bicarbonate forms, ones of sodium or potassium. Other chemical forms of efflorescence exist, but to a much lesser degree than those mentioned above.

The permanent form of efflorescence is due primarily to the soluble alkali salts that migrate from the masonry interior as a solution, and upon drying recrystallize on the masonry facade, leaving the stains. The tendency for this to occur is enhanced by the presence of water in a masonry wall and by sufficient time to allow the water to dissolve the salts and seep to the outside.

Without going into great detail, the causes of efflorescence can be broken down into four categories: 1) faulty workmanship/construction practices/design that a) allow excessive moisture to penetrate the building units during construction, and/or, b) allow excessive moisture to penetrate into the finished masonry work, and/or, c) prevent the masonry from drying out in the event of excessive moisture penetration; 2) efflorescence potential within the masonry units containing any form of alkali salt; 3) efflorescence potential from the mortar materials -- Portland cement, lime, unwashed mason's sand, water that is partially salty or extremely hard; and 4) environmental conditions such as areas of high rainfall or air containing sulfurous pollution.

A.8 DURABILITY [10, 38, 40, 48, 60, 68]

In any form of masonry, durability refers to the ability of a structure to maintain substantially its original appearance, strength and soundness for years. A mortar that is durable should be able to resist elements of weather such as high winds, freezing, thawing, wetting and drying cycles. Chemical attack from atmospheric contamination (air pollution) and sulfate soils may also affect masonry's durability.

A mortar that forms a permanent and complete bond, and is properly tooled so not to produce ledges to collect and hold water, thereby making the structure watertight, is a prime prerequisite for durability. Under freezing conditions, weathertightness prevents the disruptive effect of subsequent ice crystals in the wall.

For about 20 years some researchers have attempted to correlate durability of masonry solely on laboratory (artificial) cycles of freezing and thawing. If the mortar disintegrates in relatively few cycles, they declare that it lacks durability.

When dealing with the subject of durability of mortars, one must really consider all of the following interrelated considerations: empirical information, statistical data, autogenous healing, efflorescence, air content, effect of freezing and permeability.

Empirical information on the durability of mortars is based purely on history, observation and experience. Statistical data is also empirical but based on a statistical analysis of the mortar practices that have been both successful and unsuccessful. Autogenous healing -- the ability of a mortar to reknit or reconstitute itself after fine cracking or in filling up original mortar voids, is a definite asset towards durability. Existence of permanent forms of efflorescence contribute to the disintegration of mortar and masonry. Air entrainment improves the durability of mortars but the volumetric content should be limited to five to 10 percent so as not to affect the bond at the mortar and building unit interface. Dried mortars are sensitive to freezing only if they get completely saturated with water (due to separation cracking or poor workmanship) and are not able to lose this moisture rapidly. Permeability is the absorption of moisture through pores in mortar and building units and by leaks through voids and cracks in the mortar joints. Permeability is detrimental to the durability of mortar or building unit if it has a difficult time drying out rapidly.

A.9 VOLUMETRIC CHANGES (SHRINKAGE) [40, 48, 68]

Cyclic volume changes occur in all mortars when subjected to wetting and drying. However, there is less shrinkage with mortars of lower but **adequate** strength. Hard, high-strength mortars tend to shrink after hardening, producing separation cracking between the mortar and building units, resulting in a loss of bond.

Weaker mortars are also able to accommodate greater building unit shrinkage than stronger mortars through longer time lapse (greater creep effects) prior to failure. It has been shown that walls containing weaker mortars, when subjected to full shrinkage restraint, have a higher tensile strength [40].

A.10 ECONOMY [38, 48]

A mortar should be economical to use. The initial cost to obtain the materials to make the mortar is one factor to consider. However, this is not enough. Secondary economic factors must also be taken into account.

If the mortar tends to stick well to the building units, this is an economic factor since there is less mortar wasted by droppings. If labour cost is involved, high workability will lower the labour time spent in mixing and laying the mortar. Mortar that has slow setting characteristics also offers economy by minimizing the time spent in retempering (see Definitions). Finally, a mortar that is durable and requires a minimum amount of maintenance contributes to an economical mortar.

A.11 APPEARANCE [60]

The overall appearance of a masonry structure is affected by the appearance of the mortar joints. It follows that the mortar itself must then have a pleasant appearance. Factors contributing to the appearance of mortar joints include uniformity of color and shade, uniformity of texture and thickness and the workmanship involved in tooling the joints.

The color and shade of the joints are affected by the moisture content of the masonry, admixtures in the mortar, atmospheric conditions, uniformity of proportions of the mortar mix and the time of tooling. Good uniformity of texture depends on careful measurement of batch proportions from batch to batch and also on thorough mixing. Even joint thickness and consistent tooling, both the results of good workmanship, contribute to good appearance.

Appendix B

TESTING DATA AND PROPERTIES OF CLAYS

For the clay mortar testing, the volume of tests dictated the use of two bags of clay. Although the two bags of clay came from the same area of sampling, just different boreholes, a set of soil property testing was carried out for each bag. The clays used from the first and second bag were designated as Clay Samples and/or Nos. 1 and 2 respectively. The property testing done on each of the clays were: moisture content, hydrometer analysis (for the equivalent grain size distribution curve), Atterberg limits (liquid and plastic limit) and specific gravity.

Clay Nos. 1 and 2 both came from the southwest part of Winnipeg, Canada. Upon inspection of the samples, Clay No. 1 was described as a firm, varved, greyish-brown, silty clay with traces of gypsum and organic matter; Clay No. 2 was described as a soft, varved, brown and grey, silty clay with traces of gypsum, organic matter and pebbles. The depth at which Clay Nos. 1 and 2 were sampled was one to nine feet, and one to 10 feet respectively. Clay Nos. 1 and 2 were used for Mix Nos. 1 to 5 and 6 to 11 respectively.

To preserve its in-situ moisture content, the soil was always kept in closed, clear thick plastic bags. The length of storage before the first use in a mortar mixture was approximately six months.

Periodic moisture content tests showed Clay Nos. 1 and 2 to remain at a constant moisture content of 33 and 39 percent respectively -- this indicated that the thick plastic bags were effective in preserving the natural moisture content. Tables B-I and B-II shows the first series, as an example, of the moisture content tests performed for Clay Nos. 1 and 2 respectively.

The hydrometer analysis, liquid limit, plastic limit and specific tests were performed following the procedures used by the Soil Mechanics Laboratory of the University of Manitoba. These procedures follow closely the following ASTM standards: ASTM D 421-58, Standard Method for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants [1] -- Photograph B-1 shows the mortar and pestle used for breaking up aggregations of soil particles for the clay property tests; ASTM D 422-63, Standard Method for Particle-Size Analysis of Soils [2]; ASTM D 423-66, Standard Test Method for Liquid Limit of Soils [3]; ASTM D 424-59, Standard Test Method for Plastic Limit and Plasticity Index of Soils [4]; and ASTM D 854-58, Standard Test Method for Specific Gravity of Soils [5].

For the hydrometer analysis, changes were made to Sections 8.2 and 8.3 of Standard ASTM D 422-63 [2]. With

Table B-I

Moisture Content of Clay No. 1

Sample No.	1	2	3
Tare No.	XV11	A29	HV11
Weight Tare and Wet Soil (g.)	1,676	38.99	999
Weight Tare and Dry Soil (g.)	1,326	32.16	814
Weight Water (g.)	350	6.83	185
Weight Tare (g.)	266	10.51	266
Weight Dry Soil Solids (g.)	1,060	21.65	548
Moisture Content (%)	33.0	31.5	33.8
Average Moisture Content (%)	33		

Table B-II

Moisture Content of Clay No. 2

Sample No.	1	2	3
Tare No.	AJ	AP	59
Weight Tare and Wet Soil (g.)	120.58	132.14	122.73
Weight Tare and Dry Soil (g.)	93.43	102.22	95.29
Weight Water (g.)	27.15	29.92	27.44
Weight Tare (g.)	24.64	23.05	24.30
Weight Dry Soil Solids (g.)	68.79	79.17	70.99
Moisture Content (%)	39.47	37.79	38.65
Average Moisture Content (%)	39		

Photograph B-1: Mortar and Pestle Used for Breaking Up Aggregations of Soil Particles for Clays Property Tests -- Pestle Also Used in Clay Mortar Mixing and in Breaking Up Hardened Lime-Sand Mortar for Remix Mixes

respect to Section 8.2, a 60 grams-per-litre solution of sodium hexametaphosphate was used to disperse the clay sample instead of the specified 40 grams per litre. When calibrating the hydrometer, the same solution of 60 grams per litre was used. This stronger solution is recommended for Winnipeg area clays. With Section 8.3, the soil mixture was dispersed in Apparatus A (electric mechanical mixer) for two minutes instead of the specified one minute.

Two independent hydrometer analyses were performed for each clay. For Clay No. 1, the resultant first and second hydrometer analyses are respectively shown in Tables B-III and B-IV. The respective equivalent grain-size distribution curves for these two tests are shown in Figures B-1 and B-2. Comparing these two figures, negligible difference is seen, thereby indicating the accuracy of the two tests.

For Clay No. 2, the resultant first and second hydrometer analyses are respectively shown in Tables B-V and B-VI. The respective equivalent grain-size distribution curves for these two tests are shown in Figures B-3 and B-4. The similarity of the two curves indicates the accuracy of the two tests.

Figures B-1 to B-4 indicate that both soils are silty clays. The level of silt in both clays are about the same; for Clay Nos. 1 and 2, the level was eight and 10 percent respectively. Percentage of clay particles in Clay Nos. 1 and 2 were respectively 82 and 72 percent by weight. This 10 percent difference gave the vertical shift between the grain-size distribution curves of the two clays. Besides this shift difference, the shape of the grain-size distribution curves for the two clays are identical.

The results of the liquid and plastic limit (Atterberg limits) tests for Clay No. 1 are shown respectively in Tables B-VII and B-VIII. Resultant liquid limit (w_L) from the flow curve at 25 blows is 88 percent. The plastic limit (w_P) was found to be 36 percent. With these results for Clay No. 1, the plasticity index (I_P), defined as

$$I_P = w_L - w_P,$$

yields $$I_P = 88 - 36$$

$$I_P = 52\%.$$

For Clay No. 2, the results of the liquid and plastic limit tests are shown respectively in Tables B-IX and B-X. These tables show the liquid limit to be 81 percent and the plastic limit to be 32 percent. The plasticity index (I_P) of Clay No. 2 is calculated to be 49 percent.

With respect to the Atterberg limits and the plasticity index, little difference was noted between the two clays.

The results of the specific gravity tests for Clay Nos. 1 and 2 are shown respectively in Tables B-XI and B-XII. These tables show the specific gravity for Clay Nos. 1 and 2 to be 2.85 and 2.81 respectively. Little difference is noted between these values.

Using the soil testing results of the two clays examined, and the Unified Soil Classification table (which includes a plasticity chart) in Reference 6 [p. 16], both clays are classified as inorganic clays of high plasticity: fat clays (CH). This type of clay, as recorded in the

Engineering Use Chart in Reference 6 [p. 17], is listed as being poor in terms of its workability as a construction material.

Table B-III

Hydrometer Analysis No. 1 for Clay No. 1

HYDROMETER ANALYSIS No. 1 Data Sheet 1 of 2

PROJECT Clay - Mortar The Northern Housing Committee
JOB No. MSc. Thesis TEST HOLE NO. A-5 SAMPLE NO. 1 (Clay) DEPTH 1 To 9 Feet
DESCRIPTION OF SOIL Firm, Varved, Greyish-Brown, Silty Clay With Traces Of Gypsum And Organic Matter.
SAMPLE PREPARATION Sample Oven-Dried And Ground To 100% Passing No. 10 Sieve.
REMARKS Soil Was Ground In A Mortar With A Cast-Iron Pestle.

HYDROMETER DATA
- Hydrometer No. = 57639
- Meniscus Correction, c_m = 0.0001
- Dispersing Agent Used 6% Sodium Hexametaphosphate
- Quantity of Dispersing Agent, ml = 125
- Dispersing Agent Correction, c_d = 0.0041

DRY WEIGHT OF HYDROMETER SAMPLE
(Use Appropriate Method)

METHOD No 1 - W BASED ON AIR-DRY WEIGHT
REPRESENTATIVE w% OF AIR-DRY SAMPLE
- Wt. Soil + Water + Tare, gm =
- Wt. Soil + Tare, gm =
- Tare No. ____ Tare Weight, gm =
- Wt. Water, gm =
- Wt. Soil, gm =
- Percent Moisture, w% =

WEIGHT OF SAMPLE USED
- Wt. Air-Dry Sample + Tare, gm =
- Tare No. ____ Tare Weight, gm =
- Wt. Air-Dry Sample, W_A gm =
- Wt. Dry Sample, $W = \frac{W_A}{1 + w\%/100}$ gm =

METHOD NO.2 - W BASED ON OVEN-DRY WEIGHT
- Oven-Dry Sample + Tare, gm = 397.08
- Tare No. MMXIII Tare Weight, gm = 340.50
- Dry Sample, W gm = 56.58

RESULTS OF SIEVE TEST
Percent Passing Sieve No. 200 = 99.7 %

SPECIFIC GRAVITY
From Test ☑ Assumed ☐ = 2.85

DATE	TIME	ELAPSED TIME	TEMPERATURE °C	HYDROMETER READING R_h'	$R_h = R_h' + c_m$	DIAMETER mm	TEMPERATURE CORRECTION m_t	R	PERCENT FINER THAN SIEVED SAMPLE	PERCENT FINER THAN ORIGINAL SAMPLE*
25/02/82	16:23									
25/02/82	16:23.5	0.5 Min.	24.2	1.0360	1.0361	0.058	0.84	32.84	89.4	
"	16:24	1 Min.	24.2	1.0360	1.0361	0.040	0.84	32.84	89.4	
"	16:25	2 Mins.	24.2	1.0360	1.0361	0.0282	0.84	32.84	89.4	
"	16:27	4 Mins.	24.2	1.0360	1.0361	0.0201	0.84	32.84	89.4	
"	16:31	8 Mins.	24.2	1.0360	1.0361	0.0141	0.84	32.84	89.4	
"	16:53	30 Mins.	24.1	1.0357	1.0358	0.0074	0.82	32.52	88.5	
"	17:23	1 Hr.	23.9	1.0355	1.0356	0.0053	0.80	32.30	87.9	
"	18:23	2 Hrs.	23.7	1.0350	1.0351	0.0037	0.74	31.74	86.4	
"	20:23	4 Hrs.	23.2	1.0345	1.0346	0.0026	0.64	31.14	84.8	
26/02/82	00:23	8 Hrs.	22.7	1.0330	1.0331	0.0019	0.52	29.52	80.4	
26/02/82	09:23	17 Hrs.	21.8	1.0310	1.0311	0.00133	0.35	27.35	74.5	
"	16:23	24 Hrs.	22.9	1.0299	1.0300	0.00[illegible]	0.57	26.47	72.1	
27/02/82	16:23	48 Hrs.	22.0	1.0280	1.0281	0.00078	0.40	24.40	66.4	

* FORMULA USED

$$\% \text{ Finer Than} = \frac{R_h + m_t - c_d}{W} \times 100\%$$

Diameter From Nomograph
m_t, c_m, c_d, From Charts

TESTED: R.L.Z. DATE: 26/02/82 – 01/03/82
COMPUTED: R.L.Z. DATE: 23/11/82
CHECKED: R.L.Z. DATE: 24/11/82

SOIL MECHANICS LABORATORY
DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF MANITOBA
FORT GARRY MANITOBA

* Formula for bouyoucos hydrometer only.

Table B-III

(Continued)

HYDROMETER ANALYSIS No. 1 Data Sheet 2 of 2

PROJECT Clay-Mortar The Northern Housing Committee
JOB No. MSc Thesis TEST HOLE NO. A-5 SAMPLE NO. 1 (Clay) DEPTH 1 To 9 Feet
DESCRIPTION OF SOIL Firm, Varved, Greyish Brown, Silty Clay With Traces Of Gypsum And Organic Matter.
SAMPLE PREPARATION Sample Oven-Dried And Ground To 100% Passing No. 10 Sieve.
REMARKS Soil Was Ground In A Mortar With A Cast-Iron Pestle.

HYDROMETER DATA

- Hydrometer No. = 57639
- Meniscus Correction c_m = 0.0001
- Dispersing Agent Used 6% Sodium Hexametaphosphate
- Quantity of Dispersing Agent, ml = 125
- Dispersing Agent Correction, c_d = 0.0041

DRY WEIGHT OF HYDROMETER SAMPLE
(Use Appropriate Method)

METHOD No 1 - W BASED ON AIR-DRY WEIGHT

REPRESENTATIVE w% OF AIR-DRY SAMPLE

- Wt. Soil + Water + Tare, gm = ____
- Wt. Soil + Tare, gm = ____
- Tare No. ____ Tare Weight, gm = ____
- Wt. Water, gm = ____
- Wt. Soil, gm = ____
- Percent Moisture, w% = ____

WEIGHT OF SAMPLE USED

- Wt. Air-Dry Sample + Tare, gm = ____
- Tare No. ____ Tare Weight, gm = ____
- Wt. Air-Dry Sample, W_A gm = ____
- Wt. Dry Sample, $W = \frac{W_A}{1 + w\%/100}$ gm = ____

METHOD NO.2 - W BASED ON OVEN-DRY WEIGHT

- Oven-Dry Sample + Tare, gm = 397.08
- Tare No. MX×111 Tare Weight, gm = 340.50
- Dry Sample, W gm = 56.58

RESULTS OF SIEVE TEST

Percent Passing Sieve No. 200 = 99.7 %

SPECIFIC GRAVITY

From Test ☑ Assumed ☐ = 2.85

DATE	TIME	ELAPSED TIME	TEMPERATURE °C	HYDROMETER READING R_h'	$R_h = R_h' + c_m$	DIAMETER mm	TEMPERATURE CORRECTION m_t	R	PERCENT FINER THAN: SIEVED SAMPLE	PERCENT FINER THAN: ORIGINAL SAMPLE*
27/02/82	23:23	55 Hrs.	21.2	1.0276	1.0277	0.00074	0.22	23.82	64.9	
01/03/82	09:23	89 Hrs.	20.9	1.0266	1.0267	0.00060	0.18	22.78	62.0	
01/03/82	20:23	100 Hrs.	22.4	1.0265	1.0266	0.00055	0.46	22.96	62.5	

* FORMULA USED

$$\% \text{ Finer Than} = \frac{R_h + m_t - c_d}{W} \times 100\%,$$

Diameter From Nomograph
m_t, c_m, c_d, From Charts

TESTED: R.L.Z. DATE: 25/02/82 - 01/03/82
COMPUTED: R.L.Z. DATE: 23/11/82
CHECKED: R.L.Z. DATE: 24/11/82

SOIL MECHANICS LABORATORY
DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF MANITOBA
FORT GARRY MANITOBA

* Formula for bouyoucos hydrometer only.

Table B-IV

Hydrometer Analysis No. 2 for Clay No. 1

HYDROMETER ANALYSIS No. 2 — Data Sheet 1 of 2

HYDROMETER DATA

- Hydrometer No. = 57639
- Meniscus Correction, c_m = 0.0001
- Dispersing Agent Used: 6% Sodium Hexametaphosphate
- Quantity of Dispersing Agent, ml = 125
- Dispersing Agent Correction, c_d = 0.0041

DRY WEIGHT OF HYDROMETER SAMPLE (Use Appropriate Method)

METHOD No 1 - W BASED ON AIR-DRY WEIGHT

REPRESENTATIVE w% OF AIR-DRY SAMPLE

- Wt. Soil + Water + Tare, gm = ______
- Wt. Soil + Tare, gm = ______
- Tare No. ____ Tare Weight, gm = ______
- Wt. Water, gm = ______
- Wt. Soil, gm = ______
- Percent Moisture, w% = ______

WEIGHT OF SAMPLE USED

- Wt. Air-Dry Sample + Tare, gm = ______
- Tare No. ____ Tare Weight, gm = ______
- Wt. Air-Dry Sample, W_A gm = ______
- Wt. Dry Sample, $W = \frac{W_A}{1 + w\%/100}$ gm = ______

METHOD NO.2 - W BASED ON OVEN-DRY WEIGHT

- Oven-Dry Sample + Tare, gm = 404.26
- Tare No. HXIV Tare Weight, gm = 350.19
- Dry Sample, W gm = 54.07

RESULTS OF SIEVE TEST

Percent Passing Sieve No. 200 = 99.6%

SPECIFIC GRAVITY

From Test ☑ Assumed ☐ = 2.85

PROJECT: Clay - Mortar — The Northern Housing Committee
JOB No. MSc Thesis TEST HOLE NO. A-5 SAMPLE NO. 1 (Clay) DEPTH 1 To 9 Feet
DESCRIPTION OF SOIL: Firm, Varved, Grayish-Brown, Silty Clay With Traces Of Gypsum And Organic Matter.
SAMPLE PREPARATION: Sample Oven Dried And Ground To 100% Passing No. 10 Sieve.
REMARKS: Soil Was Ground In A Mortar With A Cast - Iron Pestle.

DATE	TIME	ELAPSED TIME	TEMPERATURE °C	HYDROMETER READING R_h'	$R_h = R_h' + c_m$	DIAMETER mm	TEMPERATURE CORRECTION m_t	R	PERCENT FINER THAN: SIEVED SAMPLE	PERCENT FINER THAN: ORIGINAL SAMPLE
18/07/83	13:49									
"	13:49.5	0.5 Min.	29.4	1.0335	1.0336	0.056	2.15	31.65	90.2	
"	13:50	1 Min.	29.4	1.0335	1.0336	0.0392	2.15	31.65	90.2	
"	13:51	2 Mins	29.4	1.0335	1.0336	0.0274	2.15	31.65	90.2	
"	13:53	4 Mins	29.4	1.0335	1.0336	0.0193	2.15	31.65	90.2	
"	13:57	8 Mins	29.4	1.0335	1.0336	0.0138	2.15	31.65	90.2	
"	14:04	15 Mins	29.3	1.0335	1.0336	0.0100	2.14	31.64	90.1	
"	14:19	30 Mins.	29.1	1.0333	1.0334	0.0072	2.05	31.35	89.3	
"	14:49	1 Hr.	29.1	1.0330	1.0331	0.0050	2.05	31.05	88.5	
"	15:49	2 Hrs.	29.1	1.0321	1.0322	0.0036	2.05	30.15	85.9	
"	17:49	4 Hrs	29.0	1.0312	1.0313	0.0025	2.03	29.23	83.3	
"	21:49	8 Hrs	28.6	1.0302	1.0303	0.00[illegible]3	1.93	28.13	80.1	
19/07/83	13:49	24 Hrs.	27.8	1.0280	1.0281	0.001[illegible]	1.73	25.73	73.3	
20/07/83	13:49	48 Hrs.	29.0	1.0277	1.0278	0.00073	2.03	25.73	73.3	

* FORMULA USED

$$\% \text{ Finer Than} = \frac{R_h + m_t - c_d}{W} \times 100\%$$

Diameter From Nomograph
m_t, c_m, c_d, From Charts

TESTED: RLZ DATE: 18-22/07/83
COMPUTED: RLZ DATE: 13/09/83
CHECKED: RLZ DATE: 04/10/83

SOIL MECHANICS LABORATORY
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* Formula for bouyoucos hydrometer only.

Table B-IV

(Continued)

HYDROMETER ANALYSIS No. 2 Data Sheet 2 of 2

PROJECT Clay - Mortar The Northern Housing Committee
JOB No. MSc Thesis TEST HOLE NO. A-5 SAMPLE NO. 1 (Clay) DEPTH 1 To 9 Feet
DESCRIPTION OF SOIL Firm, Varved, Grayish-Brown, Silty Clay With Traces Of Gypsum And Organic Matter.
SAMPLE PREPARATION Sample Oven Dried And Ground To 100% Passing No. 10 Sieve.
REMARKS Soil Was Ground In A Mortar With A Cast-Iron Pestle.

HYDROMETER DATA

Hydrometer No. = 57639
Meniscus Correction c_m = 0.0001
Dispersing Agent Used 6% Sodium Hexametaphosphate
Quantity of Dispersing Agent, ml = 125
Dispersing Agent Correction, c_d = 0.0041

DRY WEIGHT OF HYDROMETER SAMPLE
(Use Appropriate Method)

METHOD No 1 - W BASED ON AIR-DRY WEIGHT
REPRESENTATIVE w% OF AIR-DRY SAMPLE
Wt. Soil + Water + Tare, gm = ____
Wt. Soil + Tare, gm = ____
Tare No. ____ Tare Weight, gm = ____
Wt. Water, gm = ____
Wt. Soil, gm = ____
Percent Moisture, w% = ____

WEIGHT OF SAMPLE USED
Wt. Air-Dry Sample + Tare, gm = ____
Tare No. ____ Tare Weight, gm = ____
Wt. Air-Dry Sample, W_A gm = ____
Wt. Dry Sample, $W = \frac{W_A}{1 + w\%/100}$ gm = ____

METHOD NO.2 - W BASED ON OVEN-DRY WEIGHT
Oven-Dry Sample + Tare, gm = 404.26
Tare No. HXIV Tare Weight, gm = 350.19
Dry Sample, W gm = 54.07

RESULTS OF SIEVE TEST
Percent Passing Sieve No. 200 = 99.6 %

SPECIFIC GRAVITY
From Test ☑ Assumed ☐ = 2.85

DATE	TIME	ELAPSED TIME	TEMPERATURE °C	HYDROMETER READING R_h'	$R_h = R_h' + c_m$	DIAMETER mm	TEMPERATURE CORRECTION m_t	R	PERCENT FINER THAN: SIEVED SAMPLE	PERCENT FINER THAN: ORIGINAL SAMPLE*
21/07/83	13:49	72 Hrs.	29.7	1.0276	1.0277	0.00058	2.23	25.83	73.6	
22/07/83	13:49	96 Hrs.	29.9	1.0275	1.0276	0.00052	2.30	25.80	73.5	

* FORMULA USED
$\% \text{ Finer Than} = \frac{R_h + m_t - c_d}{W} \times 100\%$,

Diameter From Nomograph
m_t, c_m, c_d, From Charts

TESTED: R.L.Z. DATE: 18-22/07/83
COMPUTED: R.L.Z. DATE: 13/09/83
CHECKED: R.L.Z. DATE: 04/10/83

SOIL MECHANICS LABORATORY
DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF MANITOBA
FORT GARRY MANITOBA

* Formula for bouyoucos hydrometer only.

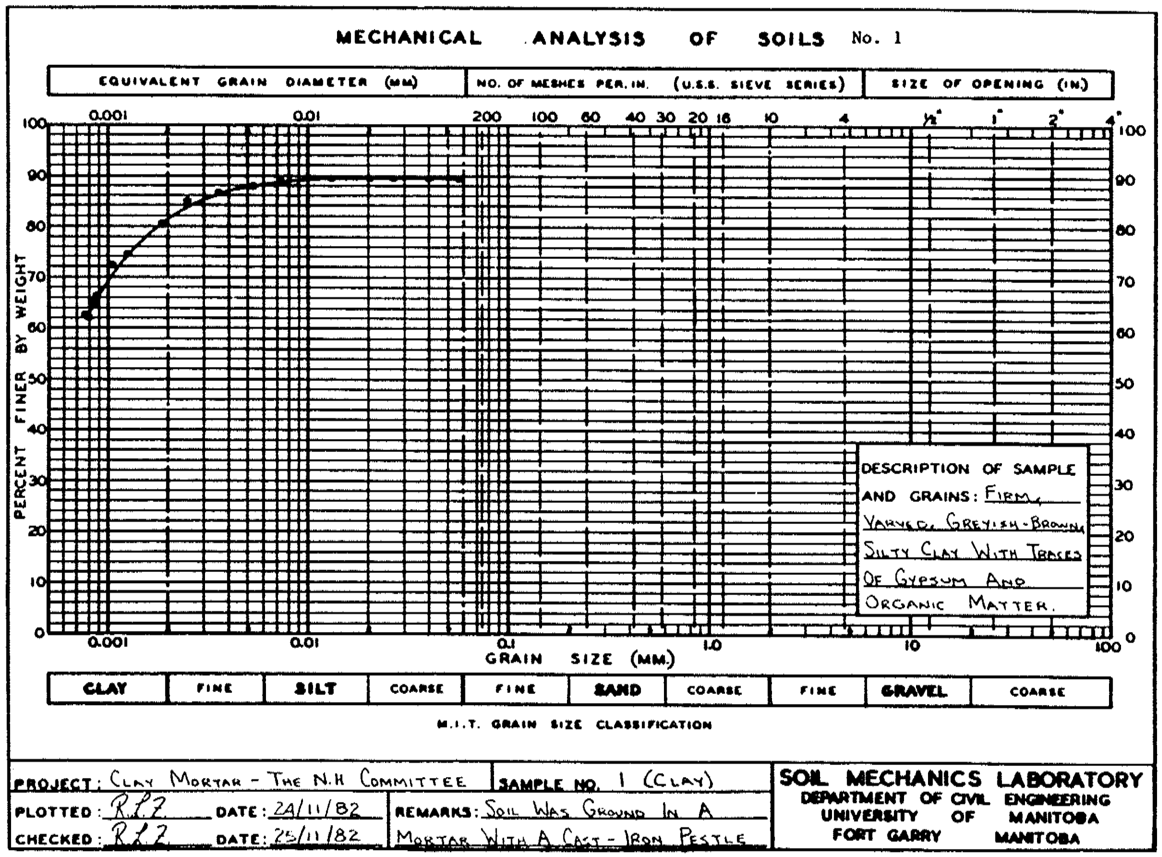

Figure B-1: Equivalent Grain Size Distribution Curve for Hydrometer Analysis No. 1 of Clay No. 1

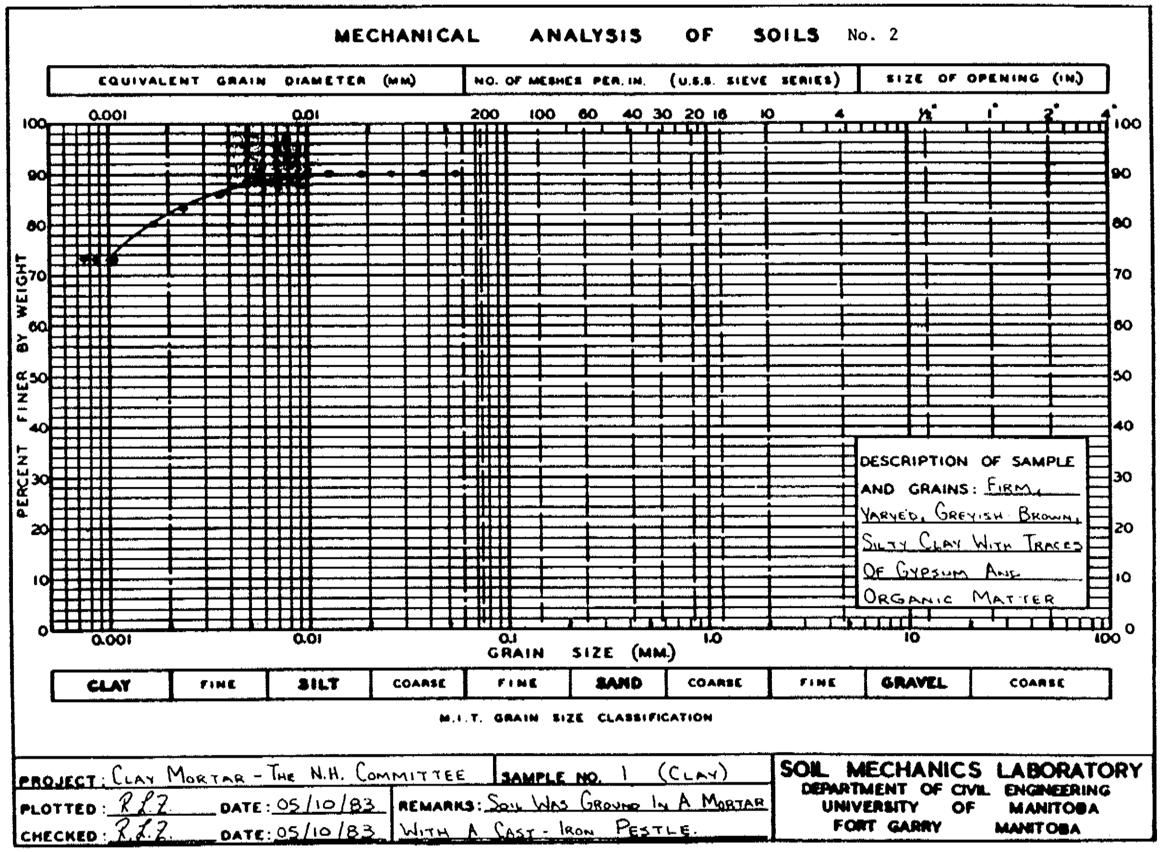

Figure B-2: Equivalent Grain Size Distribution Curve for Hydrometer Analysis No. 2 of Clay No. 1

Table B-V

Hydrometer Analysis No. 1 for Clay No. 2

HYDROMETER ANALYSIS No. 1 Data Sheet 1 of 2

PROJECT Clay-Mortar The Northern Housing Committee
JOB NO. MSc Thesis. TEST HOLE NO. — SAMPLE NO. 2 (Clay) DEPTH 1 To 10 Feet
DESCRIPTION OF SOIL Soft, Varved, Brown And Grey, Silty Clay With Traces Of Gypsum, Organics And Pebbles.
SAMPLE PREPARATION Sample Oven Dried And Ground To 100% Passing No. 10 Sieve.
REMARKS Soil Was Ground In A Mortar With A Cast-Iron Pestle.

HYDROMETER DATA
- Hydrometer No. = 57639
- Meniscus Correction c_m = 0.0001
- Dispersing Agent Used 6% Sodium Hexametaphosphate
- Quantity of Dispersing Agent, ml = 125
- Dispersing Agent Correction, c_d = 0.0041

DRY WEIGHT OF HYDROMETER SAMPLE (Use Appropriate Method)

METHOD No 1 - W BASED ON AIR-DRY WEIGHT

REPRESENTATIVE w% OF AIR-DRY SAMPLE
- Wt. Soil + Water + Tare, gm =
- Wt. Soil + Tare, gm =
- Tare No. ____ Tare Weight, gm =
- Wt. Water, gm =
- Wt. Soil, gm =
- Percent Moisture, w% =

WEIGHT OF SAMPLE USED
- Wt. Air-Dry Sample + Tare, gm =
- Tare No. ____ Tare Weight, gm =
- Wt. Air-Dry Sample, W_A gm =
- Wt. Dry Sample, $W = \frac{W_A}{1 + w\%/100}$ gm =

METHOD NO.2 - W BASED ON OVEN-DRY WEIGHT
- Oven-Dry Sample + Tare, gm = 422.98
- Tare No. Hx111 Tare Weight, gm = 367.91
- Dry Sample, W gm = 55.07

RESULTS OF SIEVE TEST
- Percent Passing Sieve No. 200 = 96.1 %

SPECIFIC GRAVITY
- From Test ☑ Assumed ☐ = 2.81

DATE	TIME	ELAPSED TIME	TEMPERATURE °C	HYDROMETER READING R_h'	$R_h = R_h' + c_m$	DIAMETER mm	TEMPERATURE CORRECTION m_t	R	PERCENT FINER THAN SIEVED SAMPLE	PERCENT FINER THAN ORIGINAL SAMPLE
18/07/83	11:06									
"	11:06.5	0.5 Min.	29.1	1.0311	1.0312	0.058	2.05	29.15	82.2	
"	11:07	1 Min.	29.1	1.0311	1.0312	0.041	2.05	29.15	82.2	
"	11:08	2 Mins.	29.1	1.0311	1.0312	0.0282	2.05	29.15	82.2	
"	11:10	4 Mins.	29.1	1.0311	1.0312	0.0200	2.05	29.15	82.2	
"	11:14	8 Mins.	29.1	1.0311	1.0312	0.0141	2.05	29.15	82.2	
"	11:21	15 Mins.	29.0	1.0309	1.0310	0.0104	2.03	28.93	81.6	
"	11:36	30 Mins.	28.8	1.0304	1.0305	0.0075	1.98	28.38	80.0	
"	12:06	1 Hr.	28.7	1.0296	1.0297	0.0053	1.95	27.55	77.7	
"	13:06	2 Hrs.	28.5	1.0291	1.0292	0.0038	1.89	26.99	76.1	
"	15:06	4 Hrs.	28.8	1.0284	1.0285	0.00264	1.98	26.38	74.4	
"	19:06	8 Hrs.	28.9	1.0271	1.0272	0.00191	2.00	25.10	70.8	
19/07/83	11:06	24 Hrs.	27.2	1.0251	1.0252	0.00111	1.58	22.68	63.9	
20/07/83	11:06	48 Hrs.	27.9	1.0235	1.0236	0.00079	1.75	21.25	59.9	

*FORMULA USED

$$\%\ \text{Finer Than} = \frac{R_h + m_t - c_d}{W} \times 100\%$$

Diameter From Nomograph
m_t, c_m, c_d, From Charts

TESTED: RLZ DATE: 18-22/07/83
COMPUTED: RLZ DATE: 13/09/83
CHECKED: RLZ DATE: 04/10/83

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FORT GARRY MANITOBA

*Formula for bouyoucos hydrometer only.

Table B-V

(Continued)

HYDROMETER ANALYSIS No. 1

Data Sheet 2 of 2

PROJECT Clay Mortar — The Northern Housing Committee
JOB No. MSc Thesis TEST HOLE NO. — SAMPLE NO. 2 (Clay) DEPTH 1 To 10 Feet
DESCRIPTION OF SOIL Soft Varved Brown And Grey, Silty Clay With Traces Of Gypsum, Organics And Pebbles.
SAMPLE PREPARATION Sample Oven Dried And Ground To 100% Passing No. 10 Sieve.
REMARKS Soil Was Ground In A Mortar With A Cast-Iron Pestle.

HYDROMETER DATA

Hydrometer No. = 57639
Meniscus Correction c_m = 0.0001
Dispersing Agent Used 6% Sodium Hexametaphosphate
Quantity of Dispersing Agent, ml = 125
Dispersing Agent Correction, c_d = 0.0041

DRY WEIGHT OF HYDROMETER SAMPLE
(Use Appropriate Method)

METHOD No 1 - W BASED ON AIR-DRY WEIGHT

REPRESENTATIVE w% OF AIR-DRY SAMPLE
Wt. Soil + Water + Tare, gm = ____
Wt. Soil + Tare, gm = ____
Tare No. ____ Tare Weight, gm = ____
Wt. Water, gm = ____
Wt. Soil, gm = ____
Percent Moisture, w% = ____

WEIGHT OF SAMPLE USED
Wt. Air-Dry Sample + Tare, gm = ____
Tare No. ____ Tare Weight, gm = ____
Wt. Air-Dry Sample, W_A gm = ____
Wt. Dry Sample, $W = \frac{W_A}{1 + w\%/100}$ gm = ____

METHOD NO.2 - W BASED ON OVEN-DRY WEIGHT
Oven-Dry Sample + Tare, gm = 422.98
Tare No. HX111 Tare Weight, gm = 367.91
Dry Sample, W gm = 55.07

RESULTS OF SIEVE TEST
Percent Passing Sieve No. 200 = 96.1 %

SPECIFIC GRAVITY
From Test ☑ Assumed ☐ = 2.81

DATE	TIME	ELAPSED TIME	TEMPERATURE °C	HYDROMETER READING R_h'	$R_h = R_h' + c_m$	DIAMETER mm	TEMPERATURE CORRECTION m_t	R	PERCENT FINER THAN: SIEVED SAMPLE	PERCENT FINER THAN: ORIGINAL SAMPLE*
21/07/83	11:06	72 Hrs.	28.8	1.0223	1.0224	0.00064	1.98	20.28	57.2	
22/07/83	11:06	96 Hrs.	29.1	1.0215	1.0216	0.00056	2.05	19.55	55.1	

*FORMULA USED
% Finer Than = $\frac{R_h + m_t - c_d}{W} \times 100\%$,
Diameter From Nomograph
m_t, c_m, c_d, From Charts

TESTED: RLZ DATE: 18-22/07/83
COMPUTED: RLZ DATE: 13/09/83
CHECKED: RLZ DATE: 04/10/83

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UNIVERSITY OF MANITOBA
FORT GARRY MANITOBA

* Formula for bouyoucos hydrometer only.

Table B-VI

Hydrometer Analysis No. 2 for Clay No. 2

HYDROMETER ANALYSIS No. 2 Data Sheet 1 Of 2

HYDROMETER DATA

Hydrometer No. = 57639
Meniscus Correction c_m = 0.0001
Dispersing Agent Used 6% Sodium Hexametaphosphate
Quantity of Dispersing Agent, ml = 125
Dispersing Agent Correction, c_d = 0.0041

DRY WEIGHT OF HYDROMETER SAMPLE (Use Appropriate Method)

METHOD No 1 - W BASED ON AIR-DRY WEIGHT

REPRESENTATIVE w% OF AIR-DRY SAMPLE

Wt. Soil + Water + Tare, gm = ____
Wt. Soil + Tare, gm = ____
Tare No. ____ Tare Weight, gm = ____
Wt. Water, gm = ____
Wt. Soil, gm = ____
Percent Moisture, w% = ____

WEIGHT OF SAMPLE USED

Wt. Air-Dry Sample + Tare, gm = ____
Tare No. ____ Tare Weight, gm = ____
Wt. Air-Dry Sample, W_A gm = ____
Wt. Dry Sample, $W = \frac{W_A}{1 + w\%/100}$ gm = ____

METHOD NO.2 - W BASED ON OVEN-DRY WEIGHT

Oven-Dry Sample + Tare, gm = 304.27
Tare No. HXVIII Tare Weight, gm = 249.15
Dry Sample, W gm = 55.12

RESULTS OF SIEVE TEST

Percent Passing Sieve No. 200 = 96.4 %

SPECIFIC GRAVITY

From Test ☑ Assumed ☐ = 2.81

PROJECT Clay-Mortar The Northern Housing Committee
JOB No. MSc Thesis TEST HOLE NO. — SAMPLE NO. 2 (Clay) DEPTH 1 To 10 Feet
DESCRIPTION OF SOIL Soft, Varved, Brown And Grey, Silty Clay With Traces Of Gypsum, Organics And Pebbles.
SAMPLE PREPARATION Sample Oven Dried And Ground To 100% Passing No. 10 Sieve.
REMARKS Soil Was Ground In A Mortar With A Cast-Iron Pestle.

DATE	TIME	ELAPSED TIME	TEMPERATURE °C	HYDROMETER READING R_h'	$R_h = R_h' + c_m$	DIAMETER mm	TEMPERATURE CORRECTION m_t	R	PERCENT FINER THAN SIEVED SAMPLE	PERCENT FINER THAN ORIGINAL SAMPLE*
18/07/83	12:55									
"	12:55.5	0.5 Min.	29.0	1.0311	1.0312	0.058	2.03	29.13	82.0	
"	12:56	1 Min.	29.0	1.0311	1.0312	0.042	2.03	29.13	82.0	
"	12:57	2 Mins.	29.0	1.0311	1.0312	0.029	2.03	29.13	82.0	
"	12:59	4 Mins.	29.0	1.0311	1.0312	0.020	2.03	29.13	82.0	
"	13:03	8 Mins.	29.0	1.0311	1.0312	0.0144	2.03	29.13	82.0	
"	13:10	15 Mins.	29.0	1.0309	1.0310	0.0104	2.03	28.93	81.5	
"	13:25	30 Mins.	29.0	1.0304	1.0305	0.0075	2.03	28.43	80.1	
"	13:55	1 Hr.	28.9	1.0296	1.0297	0.0056	2.00	27.60	77.7	
"	14:55	2 Hrs.	29.0	1.0290	1.0291	0.00379	2.03	27.03	76.1	
"	16:55	4 Hrs.	29.0	1.0280	1.0281	0.00261	2.03	26.03	73.3	
"	20:55	8 Hrs.	28.6	1.0273	1.0274	0.00192	1.93	25.23	71.1	
19/07/83	12:55	24 Hrs.	27.8	1.0251	1.0252	0.00110	1.73	22.83	64.3	
20/07/83	12:55	48 Hrs.	28.7	1.0233	1.0234	0.00078	1.95	21.25	59.9	

*FORMULA USED

$$\% \text{ Finer Than} = \frac{R_h + m_t - c_d}{W} \times 100\% .$$

Diameter From Nomograph
m_t, c_m, c_d, From Charts

TESTED: R.L.Z. DATE: 18-22/07/83
COMPUTED: R.L.Z. DATE: 13/09/83
CHECKED: R.L.Z. DATE: 04/10/83

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*Formula for bouyoucos hydrometer only.

Table B-VI

(Continued)

HYDROMETER ANALYSIS No. 2   Data Sheet 2 of 2

HYDROMETER DATA

Hydrometer No. = 57639
Meniscus Correction, c_m = 0.0001
Dispersing Agent Used 6% Sodium Hexametaphosphate
Quantity of Dispersing Agent, ml = 125
Dispersing Agent Correction, c_d = 0.0041

DRY WEIGHT OF HYDROMETER SAMPLE
(Use Appropriate Method)

METHOD No 1 - W BASED ON AIR-DRY WEIGHT

REPRESENTATIVE w% OF AIR-DRY SAMPLE

Wt. Soil + Water + Tare, gm = ____
Wt. Soil + Tare, gm = ____
Tare No. ____ Tare Weight, gm = ____
Wt. Water, gm = ____
Wt. Soil, gm = ____
Percent Moisture, w% = ____

WEIGHT OF SAMPLE USED

Wt. Air-Dry Sample + Tare, gm = ____
Tare No. ____ Tare Weight, gm = ____
Wt. Air-Dry Sample, W_A gm = ____
Wt. Dry Sample, $W = \frac{W_A}{1 + w\%/100}$ gm = ____

METHOD NO.2 - W BASED ON OVEN-DRY WEIGHT

Oven-Dry Sample + Tare, gm = 304.27
Tare No. HK VIII Tare Weight, gm = 249.15
Dry Sample, W gm = 55.12

RESULTS OF SIEVE TEST

Percent Passing Sieve No. 200 = 96.4 %

SPECIFIC GRAVITY

From Test ☑ Assumed ☐ = 2.81

PROJECT Clay - Mortar The Northern Housing Committee
JOB No. MSc. Thesis TEST HOLE NO. — SAMPLE NO. 2 (Clay) DEPTH 1 To 10 Feet
DESCRIPTION OF SOIL Soft, Varved, Brown And Grey, Silty Clay With Traces Of Gypsum, Organics And Pebbles.
SAMPLE PREPARATION Sample Oven Dried And Ground To 100% Passing No. 10 Sieve.
REMARKS Soil Was Ground In A Mortar With A Cast - Iron Pestle.

DATE	TIME	ELAPSED TIME	TEMPERATURE °C	HYDROMETER READING R_h'	$R_h = R_h' + c_m$	DIAMETER mm	TEMPERATURE CORRECTION m_t	R	PERCENT FINER THAN SIEVED SAMPLE	PERCENT FINER THAN ORIGINAL SAMPLE
21/07/83	12:55	72 Hrs.	29.4	1.0222	1.0223	0.00063	2.15	20.35	57.3	
22/07/83	12:55	96 Hrs.	29.9	1.0217	1.0218	0.00055	2.30	20.00	56.3	

* FORMULA USED

$\%\ \text{Finer Than} = \frac{R_h + m_t - c_d}{W} \times 100\%$,

Diameter From Nomograph
m_t, c_m, c_d, From Charts

TESTED: RLZ DATE: 18-22/07/83
COMPUTED: RLZ DATE: 13/09/83
CHECKED: RLZ DATE: 04/10/83

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UNIVERSITY OF MANITOBA
FORT GARRY MANITOBA

* Formula for bouyoucos hydrometer only.

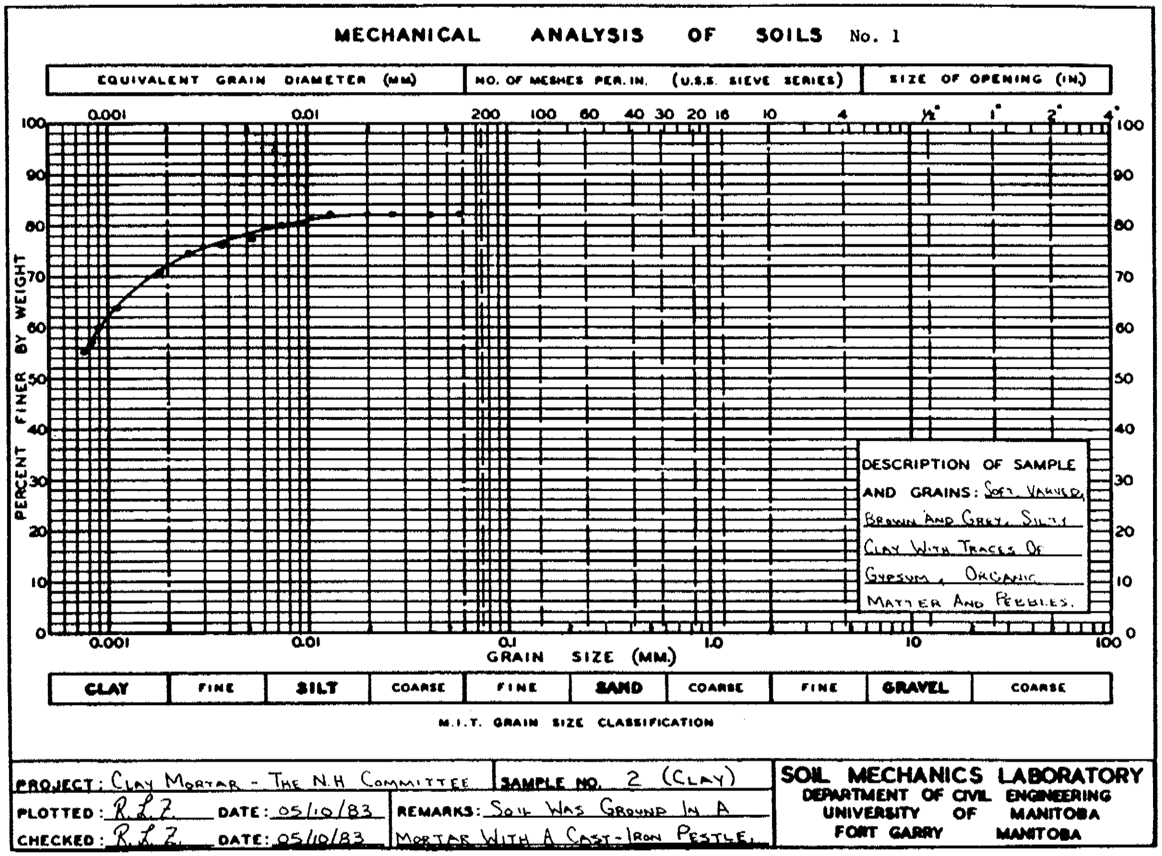


Figure B-3: Equivalent Grain Size Distribution Curve for Hydrometer Analysis No. 1 of Clay No. 2

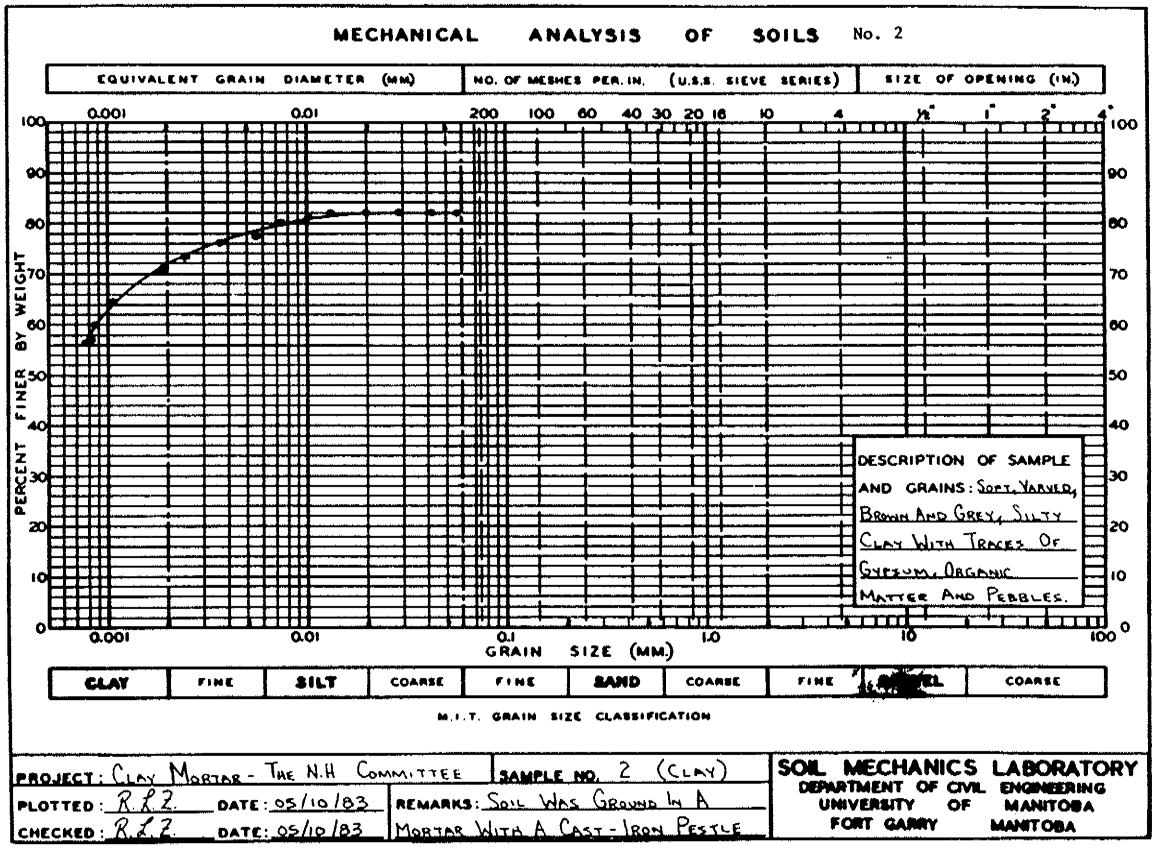


Figure B-4: Equivalent Grain Size Distribution Curve for Hydrometer Analysis No. 2 of Clay No. 2

Table B-VII

Liquid Limit Test Data for Clay No. 1

ATTERBERG LIMITS SM ______

PROJECT Clay Mortar - The Northern Housing Committee

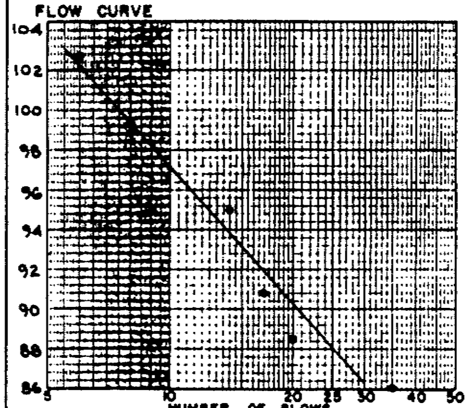
TEST HOLE NO. A-5 SAMPLE 1 (Clay) DEPTH 1 To 9 Feet

SAMPLE DESCRIPTION Greyish - Brown, Silty Clay, Ground With Mortar And Pestle Till 100% Passing No. 40 Sieve.

LIQUID LIMIT	1	2	3	4	5	6
TARE NO.	K65	U5	U34	U35	61	71
NO. BLOWS	35	20	17	14	8	6
WT. WET SOIL + TARE	33.66	36.50	40.06	36.71	36.43	42.94
WT. DRY SOIL + TARE	26.74	27.92	29.83	27.68	27.50	33.76
WT. WATER	6.92	8.58	10.23	9.03	8.93	9.18
WT. TARE	18.70	18.23	18.56	18.17	18.52	24.82
WT. DRY SOIL	8.04	9.69	11.27	9.51	8.98	8.94
WATER CONTENT, %	86.1	88.5	90.8	95.0	99.4	102.7

PLASTIC LIMIT	1	2	3	WATER CONTENT		
TARE NO.						
WT. WET SOIL + TARE						
WT. DRY SOIL + TARE						
WT. WATER						
WT. TARE						
WT. DRY SOIL						
WATER CONTENT, %						

FLOW CURVE



AVERAGE VALUES

LIQUID LIMIT,	w_L = 88%
PLASTIC LIMIT,	w_p = 36%
PLASTICITY INDEX,	I_P = 52%
FLOW INDEX,	I_f =
TOUGHNESS INDEX,	I_T =
WATER CONTENT,	w =

TESTED R.J.Z. DATE 15/07/83
COMPUTED R.J.Z. DATE 22/07/83
CHECKED R.J.Z. DATE 04/08/83

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FORT GARRY MANITOBA

Table B-VIII

Plastic Limit Test Data for Clay No. 1

ATTERBERG LIMITS SM ______

PROJECT Clay Mortar - The Northern Housing Committee

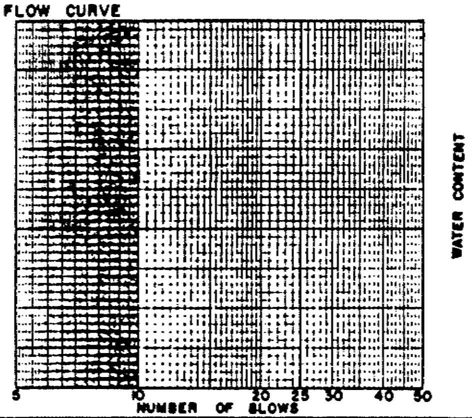
TEST HOLE NO. A-5 SAMPLE 1 (Clay) DEPTH 1 To 9 Feet

SAMPLE DESCRIPTION Greyish - Brown, Silty Clay, Ground With Mortar And Pestle Till 100 % Passing No. 40 Sieve.

LIQUID LIMIT	1	2	3	4	5	6
TARE NO.						
NO. BLOWS						
WT. WET SOIL + TARE						
WT. DRY SOIL + TARE						
WT. WATER						
WT. TARE						
WT. DRY SOIL						
WATER CONTENT, %						

PLASTIC LIMIT	1	2	3	WATER CONTENT		
TARE NO.	T23	Z24	66			
WT. WET SOIL + TARE	28.050	28.171	33.298			
WT. DRY SOIL + TARE	25.432	25.718	30.999			
WT. WATER	2.618	2.453	2.299			
WT. TARE	18.646	18.778	24.451			
WT. DRY SOIL	6.786	6.940	6.548			
WATER CONTENT, %	38.58	35.35	35.11			

FLOW CURVE



AVERAGE VALUES

LIQUID LIMIT,	w_L = 88%
PLASTIC LIMIT,	w_P = 36%
PLASTICITY INDEX,	I_P = 52%
FLOW INDEX,	I_f =
TOUGHNESS INDEX,	I_T =
WATER CONTENT,	w =

TESTED R.L.Z. DATE 20/07/83

COMPUTED R.L.Z. DATE 22/07/83

CHECKED R.L.Z. DATE 04/08/83

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Table B-IX

Liquid Limit Test Data for Clay No. 2

ATTERBERG LIMITS BM ______

PROJECT Clay Mortar - The Northern Housing Committee

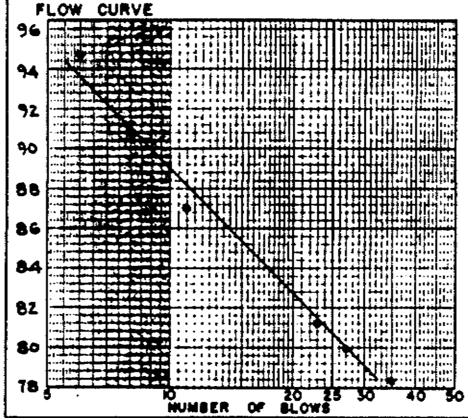
TEST HOLE NO. — SAMPLE 2 (Clay) DEPTH 1 To 10 Feet

SAMPLE DESCRIPTION Brown And Grey Silty Clay With Traces Of Pebbles. Ground With Mortar And Pestle Till 100 % Passing No. 40 Sieve.

LIQUID LIMIT	1	2	3	4	5	6
TARE NO.	T20	U16	Z44	83	86	89
NO. BLOWS	35	27	23	11	8	6
WT. WET SOIL + TARE	35.85	34.80	35.51	35.17	40.45	38.56
WT. DRY SOIL + TARE	28.29	27.61	27.94	27.50	33.43	30.08
WT. WATER	7.56	7.19	7.57	7.67	7.02	8.48
WT. TARE	18.63	18.61	18.62	18.68	25.70	21.13
WT. DRY SOIL	9.66	9.00	9.32	8.82	7.73	8.95
WATER CONTENT, %	78.3	79.9	81.2	87.0	90.8	94.7

PLASTIC LIMIT	1	2	3	WATER CONTENT		
TARE NO.						
WT. WET SOIL + TARE						
WT. DRY SOIL + TARE						
WT. WATER						
WT. TARE						
WT. DRY SOIL						
WATER CONTENT, %						

FLOW CURVE



AVERAGE VALUES

LIQUID LIMIT,	w_L = 81 %
PLASTIC LIMIT,	w_P = 32 %
PLASTICITY INDEX,	I_P = 49 %
FLOW INDEX,	I_f =
TOUGHNESS INDEX,	I_T =
WATER CONTENT,	w =

TESTED R.L.Z. DATE 15/07/83
COMPUTED R.L.Z. DATE 22/07/83
CHECKED R.L.Z. DATE 04/08/83

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Table B-X

Plastic Limit Test Data for Clay No. 2

ATTERBERG LIMITS SM ______

PROJECT Clay Mortar – The Northern Housing Committee

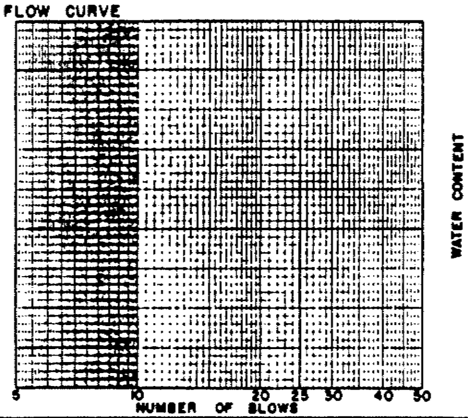
TEST HOLE NO. — SAMPLE 2 (Clay) DEPTH 1 To 10 Feet

SAMPLE DESCRIPTION Brown And Grey Silty Clay With Traces Of Pebbles. Ground With Mortar And Pestle Till 100% Passing No. 40. Sieve.

LIQUID LIMIT	1	2	3	4	5	6
TARE NO.						
NO. BLOWS						
WT. WET SOIL + TARE						
WT. DRY SOIL + TARE						
WT. WATER						
WT. TARE						
WT. DRY SOIL						
WATER CONTENT, %						

PLASTIC LIMIT	1	2	3	WATER CONTENT		
TARE NO.	A3	A15	A24			
WT. WET SOIL + TARE	23.141	23.191	25.888			
WT. DRY SOIL + TARE	20.195	19.968	22.118			
WT. WATER	2.946	3.223	3.770			
WT. TARE	11.021	10.289	10.285			
WT. DRY SOIL	9.174	9.679	11.833			
WATER CONTENT, %	32.11	33.30	31.86			

FLOW CURVE



AVERAGE VALUES

LIQUID LIMIT,	w_L = 81 %
PLASTIC LIMIT,	w_P = 32 %
PLASTICITY INDEX,	I_P = 49 %
FLOW INDEX,	I_f =
TOUGHNESS INDEX,	I_T =
WATER CONTENT,	w =

TESTED R.J.J. DATE 21/07/83
COMPUTED R.J.J. DATE 22/07/83
CHECKED R.J.J. DATE 02/08/83

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Table B-XI

Specific Gravity Test Data for Clay No. 1

SPECIFIC GRAVITY TESTS SM ______

PROJECT Clay - Mortar - The Northern Housing Committee

TEST HOLE NO. A-5 SAMPLE NO. 1 (Clay) DEPTH 1 To 9 Feet

DESCRIPTION OF SAMPLE: Firm, Varved, Greyish - Brown, Silty Clay With Traces Of Gypsum And Organic Matter.

REMARKS: Sample Was Oven Dried And Grounded In A Mortar With A Cast-Iron Pestle. Care Was Taken So As Not To Break Individual Particles. Ground Till 100% Passing No. 10 Sieve.

FLASK NO.		BB	O	
THERMOMETER NO.		14-985B	14-985B	
COHESIONLESS SOILS ONLY	WT. FLASK + DRY SOIL	-	-	
	WT. FLASK	-	-	
	WT. DRY SOIL, W_s	-	-	
TIME UNDER VACUUM		30 Mins.	30 Mins.	
WT. FLASK + WATER + SOIL, W_{bws}		704.04 g.	697.60 g.	
TEMP. OF SUSPENSION, T° C.		23.5	23.9	
WT. FLASK + WATER, W_{bw}		659.74 g.	661.93 g.	
COHESIVE SOILS ONLY	EVAP. DISH NO.	L-VIII	H XVII	
	WT. DRY SOIL + TARE	272.99 g.	412.67 g.	
	WT. TARE	204.58 g.	357.72 g.	
	WT. DRY SOIL, W_s	68.41 g.	54.95 g.	
SPECIFIC GRAVITY, G_s		2.84	2.85	
AVERAGE SPECIFIC GRAVITY		2.85		

FORMULA:

$$G_s = \frac{W_s}{(W_s + W_{bw} - W_{bws})} \times \frac{G_T}{G_{20}}$$

WHERE G_s = SPECIFIC GRAVITY OF SOLIDS (based at 20°C)

W_s = WT. OF DRY SOIL

W_{bw} = WT. OF FLASK + WATER AT T° C. (FROM CALIBRATION CURVE FOR FLASK)

W_{bws} = WT. OF FLASK + WATER + SOIL AT T° C.

G_T = Relative Density of Water at T°C

G_{20} = Relative Density of Water at 20°C

TESTED: R.L.Z.	DATE: 23/02/82	SOIL MECHANICS LABORATORY
COMPUTED: R.L.Z.	DATE: 24/02/82	DEPARTMENT OF CIVIL ENGINEERING UNIVERSITY OF MANITOBA
CHECKED: R.L.Z.	DATE: 25/02/82	FORT GARRY MANITOBA

Table B-XII

Specific Gravity Test Data for Clay No. 2

SPECIFIC GRAVITY TESTS SM ______

PROJECT: Clay Mortar - The Northern Housing Committee

TEST HOLE NO. — SAMPLE NO. 2 (Clay) DEPTH 1 To 10 Feet

DESCRIPTION OF SAMPLE: Soft, Varved, Brown And Grey, Silty Clay With Traces Of Gypsum, Organic Matter And Pebbles.

REMARKS: Sample Was Oven Dried And Grounded In A Mortar With A Cast-Iron Pestle. Care Was Taken So As Not To Break Individual Particles. Ground Till 100% Passing No. 10 Sieve.

FLASK NO.		BC	H	
THERMOMETER NO.		Z 40397	Z 40397	
COHESIONLESS SOILS ONLY	WT. FLASK + DRY SOIL	—	—	
	WT. FLASK	—	—	
	WT. DRY SOIL, W_s	—	—	
TIME UNDER VACUUM, Minutes		30	30	
WT. FLASK + WATER + SOIL, W_{bws}, g.		678.60	683.31	
TEMP. OF SUSPENSION, T° C.		35.0	31.0	
WT. FLASK + WATER, W_{bw}, g.		647.52	652.05	
COHESIVE SOILS ONLY	EVAP. DISH NO.	AL	HXIV	
	WT. DRY SOIL + TARE, g.	353.05	398.85	
	WT. TARE, g.	304.98	350.18	
	WT. DRY SOIL, W_s, g.	48.07	48.67	
SPECIFIC GRAVITY, G_s		2.82	2.79	
AVERAGE SPECIFIC GRAVITY		2.81		

FORMULA: $$G_s = \frac{W_s}{(W_s + W_{bw} - W_{bws})} \times \frac{G_T}{G_{20}}$$

WHERE
G_s = SPECIFIC GRAVITY OF SOLIDS (based at 20°C)
W_s = WT. OF DRY SOIL
W_{bw} = WT. OF FLASK + WATER AT T° C. (FROM CALIBRATION CURVE FOR FLASK)
W_{bws} = WT. OF FLASK + WATER + SOIL AT T° C.
G_T = Relative Density of Water at T°C
G_{20} = Relative Density of Water at 20°C

TESTED: R.L.Z. DATE: 14/07/83
COMPUTED: R.L.Z. DATE: 26/07/83
CHECKED: R.L.Z. DATE: 28/07/83

SOIL MECHANICS LABORATORY
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FORT GARRY MANITOBA

Appendix C

TESTING DATA AND PROPERTIES OF SAND

Throughout all of the tests, sand was used in every mortar mix. The source of the sand was kept constant, thereby keeping the properties of the sand constant. Visually, the sand was described as a light brown, dry, loose, homogeneous, poorly graded, clean sand consisting of sub-angular particles.

Table C-I shows the moisture content test results of the sand. The moisture content, as suspected, proved to be negligible at 0.075 percent. The sand was always in this dry state whenever used, and was assumed to have a zero moisture content.

Table C-I

Moisture Content of Sand

Weight of Tare No. L-V111 and Wet Sand (g.)	808.69
Weight of Tare No. L-V111 and Dried Sand (g.)	808.24
Weight of Water in Sand (g.)	0.45
Tare Weight of Tare No. L-V111 (g.)	204.60
Weight of Dried Sand (g.)	603.64
Moisture Content of Sand (%)	0.075

To determine the properties of the sand, a sieve analysis and specific gravity tests were performed following the procedures used by the Soil Mechanics Laboratory of the University of Manitoba. These procedures follow closely the following ASTM standards: ASTM D 421-58, Standard Method for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants [1]; ASTM D 422-63, Standard Method for Particle-Size Analysis of Soils [2]; and ASTM D 854-58, Standard Test for Specific Gravity of Soils [5].

Results of the sieve analysis is shown in Table C-II. From this analysis, the grain distribution curve (mechanical analysis) is shown in Figure C-1; this curve is identical to the one shown with Table C-II but is in more detail for further analysis.

To help describe the particle size distribution of the mortar sand, three parameters were used -- effective diameter D_{10}, coefficient of uniformity C_U, and coefficient of curvature C_C. Effective diameter, also known as the effective size, is defined as the maximum particle size at 10 percent passing of the sieve analysis. The uniformity and curvature coefficients are defined by the following mathematical equations:

$$C_U = D_{60}/D_{10}$$

$$C_C = (D_{30})^2/(D_{60} \times D_{10}).$$

Table C-II

Sieve Analysis of Sand

SIEVE ANALYSIS

SM ______

PROJECT Clay-Mortar The Northern Housing Committee

TEST HOLE NO. — SAMPLE NO. Sand DEPTH —

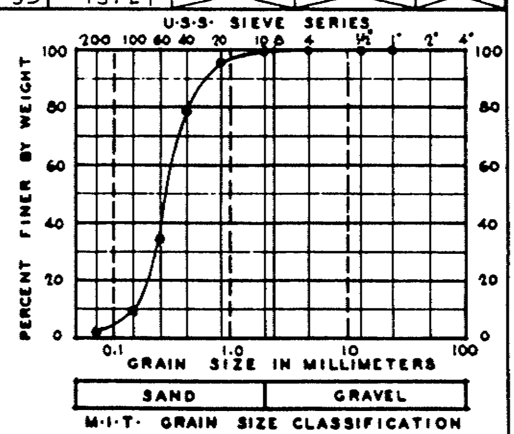
DESCRIPTION OF SAMPLE AND GRAINS: Light Brown, Dry, Loose, Homogeneous, Poorly Graded, Clean Sand Consisting Of Sub-Angular Particles.

REMARKS:

WT. OF SAMPLE + TARE = 1155.72 GM.	EVAPORATING DISH NO. ______
WT. OF TARE = 357.70 GM.	SIZE OF LARGEST STONE = ______ MM.
INITIAL WT. OF SAMPLE = 798.02 GM.	DRYING OVEN: IN ______ OUT ______
FINAL WT. OF SAMPLE = 797.45 GM.	ROTAP: IN ______ OUT ______

SIEVE NO (U.S.S.)	TOTAL WT. RETAINED + TARE (GM.)	TARE (GM.)	TOTAL WT. RETAINED (GM.)	TOTAL WT. PASSING (GM.)	PERCENT PASSING	SIEVE OPENING (MM.)
1	522.65	522.65	0	797.45	100.0	26.67
½	554.73	554.73	0	797.45	100.0	12.7
4	520.69	520.69	0	797.45	100.0	4.76
10	451.09	448.47	2.62	794.83	99.7	2.00
20	479.82	450.13	29.69	765.14	95.9	0.84
40	522.74	387.95	134.79	630.35	79.0	0.42
60	729.59	370.47	359.12	271.23	34.0	0.25
100	555.65	356.87	198.78	72.45	9.1	0.149
200	413.64	354.46	59.18	13.27	1.7	0.074
PAN	359.62	346.35	13.27			

GRAIN SIZE DISTRIBUTION CURVE



TESTED : R.L.Z. DATE: 03/03/82	SOIL MECHANICS LABORATORY
PLOTTED : R.L.Z. DATE: 22/11/82	DEPARTMENT OF CIVIL ENGINEERING
COMPUTED: R.L.Z. DATE: 22/11/82	UNIVERSITY OF MANITOBA
CHECKED : R.L.Z. DATE: 23/11/82	FORT GARRY MANITOBA

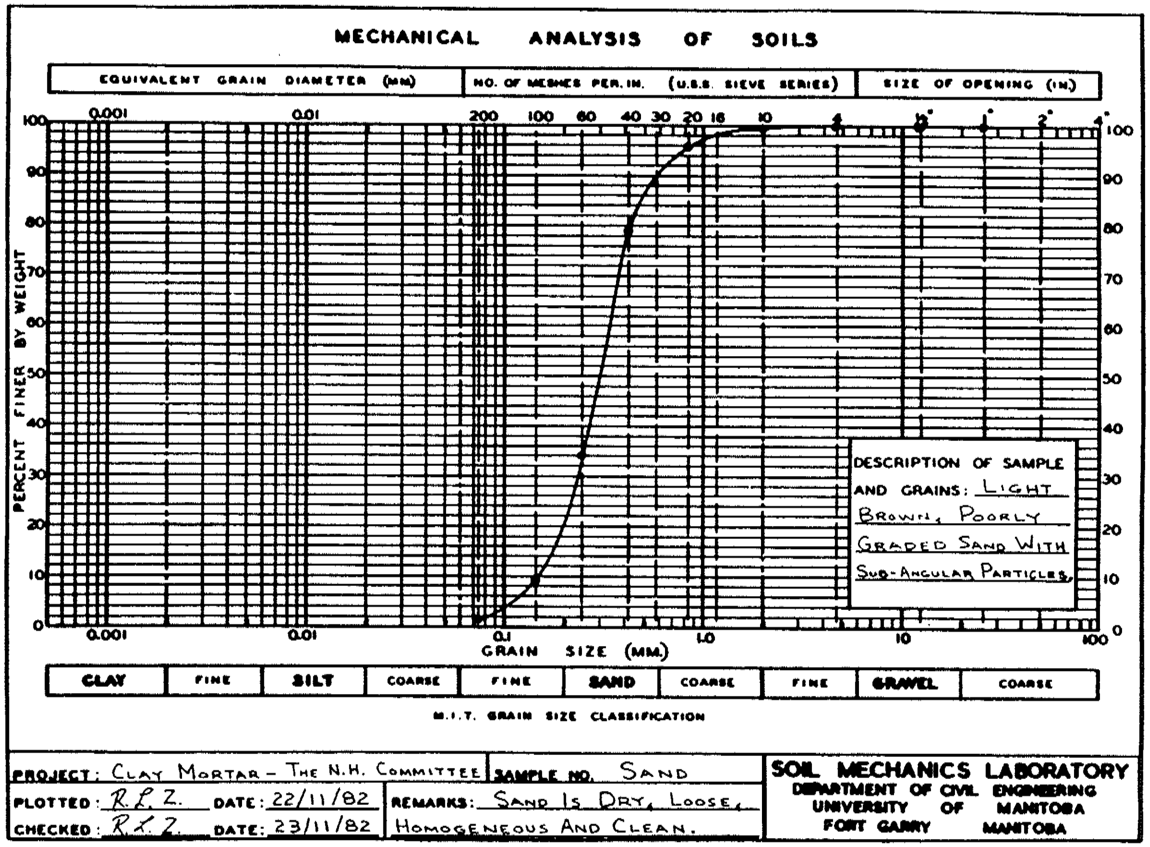


Figure C-1: Grain Size Distribution Curve of Sand

D_{60} and D_{30} are respectively the maximum particle size at 60 and 30 percent passing of the sieve analysis. From Figure C-1, page 322, D_{10}, D_{30} and D_{60} were found to have the following values:

$$D_{10} = 0.16 \text{ mm.}$$

$$D_{30} = 0.24 \text{ mm.}$$

$$D_{60} = 0.34 \text{ mm.}$$

Hence: $C_U = 0.34/0.16 = 2.1$

$$C_C = (0.24)^2/(0.34 \times 0.16) = 1.1.$$

Using the soil testing results of the sand examined, and the Unified Soil Classification table in Reference 6 [p. 16], the sand is classified as poorly graded sand with small amount of fines (SP). This confirms the initial visual description of being poorly graded. It is important to note at this point that the term "poorly graded" as used above is defined as used in soil testing -- soil material predominantly one size or a range of sizes with some intermediate sizes missing. For a geologist, the above definition would instead be termed "well graded". This type of sand, as recorded in the Engineering Use Chart of Reference 6 [p. 17], is listed as being fair in terms of its workability as a construction material.

The results of the specific gravity tests for the sand is shown in Table C-III. From this table, the specific gravity of the sand was calculated to be 2.71.

To determine the weight of sand to be used in the volumetric proportioned lime-sand mortar mixes and to be able to convert the weight of sand used in the clay mortar mixes to volumetric proportions, the apparent density of the sand used is needed. To determine this, two density measurements were taken of the sand. One measurement involved rough shaking of the volume measuring container while filling it up with sand. For the second measurement, there was no shaking involved. Table C-IV shows the results of these two respective measurements to be 109 and 97 pcf. The average of these two values is 103 pcf; this value will be assumed to represent a condition of gentle shaking of the container.

With reference to Lea [45, p. 361], dry sand poured into a container with gentle shaking is listed as having an apparent density of 95 to 105 pcf. The above value of 103 pcf. is within this range of values. Midway in this range is the value of 100 pcf. -- this is the apparent density value used for the above sand.

Table C-III

Specific Gravity Test Data for Sand

SPECIFIC GRAVITY TESTS SM ______

PROJECT Clay Mortar The Northern Housing Committee

TEST HOLE NO. — SAMPLE NO. Sand DEPTH —

DESCRIPTION OF SAMPLE: Light Brown, Dry, Loose, Homogeneous, Poorly Graded, Clean Sand Consisting Of Sub-Angular Particles.

REMARKS: All Weights Are In Grams, g.

FLASH NO.		L	BC	
THERMOMETER NO.		Z 40290	Z 40290	
COHESIONLESS SOILS ONLY	WT. FLASK + DRY SOIL	250.79	231.65	
	WT. FLASK	166.37	151.00	
	WT. DRY SOIL, W_s	84.42	80.65	
TIME UNDER VACUUM		30 Mins.	30 Mins.	
WT. FLASK + WATER + SOIL, W_{bws}		717.97	700.38	
TEMP. OF SUSPENSION, T° C.		22.0	21.9	
WT. FLASK + WATER, W_{bw}		664.63	649.43	
COHESIVE SOILS ONLY	EVAP. DISH NO.	L-XIV	HXVIII	
	WT. DRY SOIL + TARE	275.61	329.83	
	WT. TARE	191.16	249.12	
	WT. DRY SOIL, W_s	84.45	80.71	
SPECIFIC GRAVITY, G_s		2.71	2.71	
AVERAGE SPECIFIC GRAVITY		2.71		

FORMULA: $$G_s = \frac{W_s}{(W_s + W_{bw} - W_{bws})} \times \frac{G_T}{G_{20}}$$

WHERE
G_s = SPECIFIC GRAVITY OF SOLIDS (based at 20°C)
W_s = WT. OF DRY SOIL
W_{bw} = WT. OF FLASK + WATER AT T° C. (FROM CALIBRATION CURVE FOR FLASK)
W_{bws} = WT. OF FLASK + WATER + SOIL AT T° C.
G_T = Relative Density of Water at T°C.
G_{20} = Relative Density of Water at 20°C.

TESTED: R.L.Z. DATE: 03-04/03/82
COMPUTED: R.L.Z. DATE: 05/03/82
CHECKED: R.L.Z. DATE: 23/11/82

SOIL MECHANICS LABORATORY
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FORT GARRY MANITOBA

Table C-IV

Measured Apparent Density of Sand

Degree of Container Shaking	Volume of Container/ Sand ($ft.^3$)	Weight of Sand Alone (g.) [(lbs.)]	Apparent Density (pcf.)
Rough	0.125	6,207 [13.68]	109
None	0.125	5,515 [12.16]	97
Average Apparent Density			103

Appendix D

INFORMATION ON FLAX STRAW (FIBRES)

Flax straw was used as the source of fibres for the clay mortar mixes. For the description of a flax plant, see Definitions -- "flax". Flax straw can become readily available wherever grain farming takes place.

Obtained for the clay mortar mixes was one bale of flax straw. The approximate dimensions of this bale was 14 inches high by 18 inches wide by 40 inches in length. In its dry state, the bale weighed 28 pounds giving it a bale density of 4.8 pcf. It is realized however, that this bale density is only indicative and can change depending upon the degree of packing when the bale is made.

Figure D-1 shows the two basic parts of flax straw, the stem and the flowering cluster. Both of these parts consist of a straw like core material with threadlike fibres ("linen" -- see Definitions: "flax") wrapped around.

To determine what approximate length to cut the flax straw, an initial aspect ratio (length to diameter -- l/d) of 30 was used. This aspect ratio was found to be favourable for steel fibre reinforced concrete so as to prevent the balling of the fibres when incorporated into the

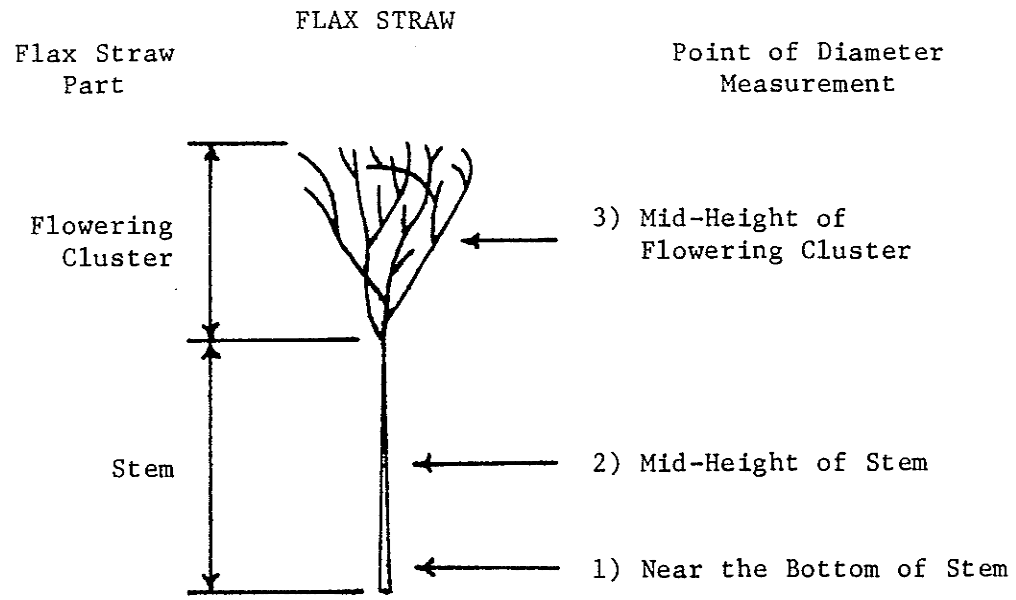

Figure D-1: Flax Straw and its Points of Diameter Measurement

mix (see Subsection 3.1.1, Preliminary Literature Search). Before the aspect ratio could be determined, the diameter of the flax straw was first measured.

The diameter of flax straw is non-uniform. To get an average diameter, on 10 samples of flax straw, three points of measurements were taken -- one near the bottom of the stem, one at the mid-height of the stem, and one at the mid-height of the flowering cluster. These three points of measurements are shown in Figure D-1. The results of these measurements are in Table D-I. From these measurements and a study of the aspect ratio with Table D-I, it was decided to use the flax straw in one-inch lengths. The average aspect ratio of flax straw cut to one-inch lengths was 18.

Table D-I

Flax Straw Diameter Measurements

Measurement No.	Diameter of Flax Straw Part[1]		
	Stem		Flowering Cluster
	Near Bottom (inch)	Mid-Height (inch)	Mid-Height (inch)
1	0.065	0.055	0.035
2	0.069	0.059	0.033
3	0.092	0.059	0.029
4	0.091	0.060	0.027
5	0.078	0.056	0.041
6	0.071	0.076	0.030
7	0.065	0.060	0.030
8	0.075	0.052	0.034
9	0.071	0.060	0.034
10	0.080	0.059	0.033
Average	0.076	0.060	0.033
Overall Average		0.056	

Notes: 1) The length of flax straw required for an aspect ratio (l/d) of 30, using the overall average diameter, is:

$$l = 30 \times d = 30(0.056) = 1.68 \text{ inches}$$

Use l = one inch;

2) The average aspect ratio with flax straw cut to one inch lengths is:

$$\text{Average aspect ratio} = l/d = 1.0/0.056 = 18.$$

[1]See Figure D-1, page 328.

To cut the flax straw into one-inch lengths, four different methods were tried: 1) knife, 2) tin shears, 3) tin shear press, and 4) household scissors. For each method, the cutting edge was sharp and a bundle/group of straw (Photograph 2, page 18) of about one-half inch in diameter was cut at a time. The method of using a knife (with an eight-inch blade) on a cutting board proved to be labourious and difficult at times. Cutting with the tin shears involved less effort in accomplishing the cut but the short length of the cutting edge (two and one-half inches) and the long handle (seven inches) made it an awkward job. The tin shear press also accomplished the cut with ease but the setup of the press made it difficult to see the cut length without some form of scale setup on the table. Another problem with the tin shear press was that it was a relatively high-cost piece of equipment, thereby making it not as readily available in practice. The fourth method of using an ordinary pair of household scissors, with a cutting edge length of three and one-half inches, proved to be excellent. The scissors required very little effort in making the cut and were easy to handle.

The rate at which the straw was cut into one-inch lengths was 0.86 pounds per man-hour. This rate was calculated from the straw cut using all of the above methods but with the majority of the cutting performed with the household scissors.

To be more precise, it should be noted that the flax straw was cut to one-inch average lengths; lengths shorter and longer than one inch were included. Figure D-2 illustrates how a straw not positioned evenly in a bundle can be cut shorter than one inch. Straw that is bent in a bundle can be cut into a length that is longer or shorter than one inch; this phenomenon is illustrated in Figure D-3. Bent flax straw is more prone to occur with the flowering part due to its smaller diameter.

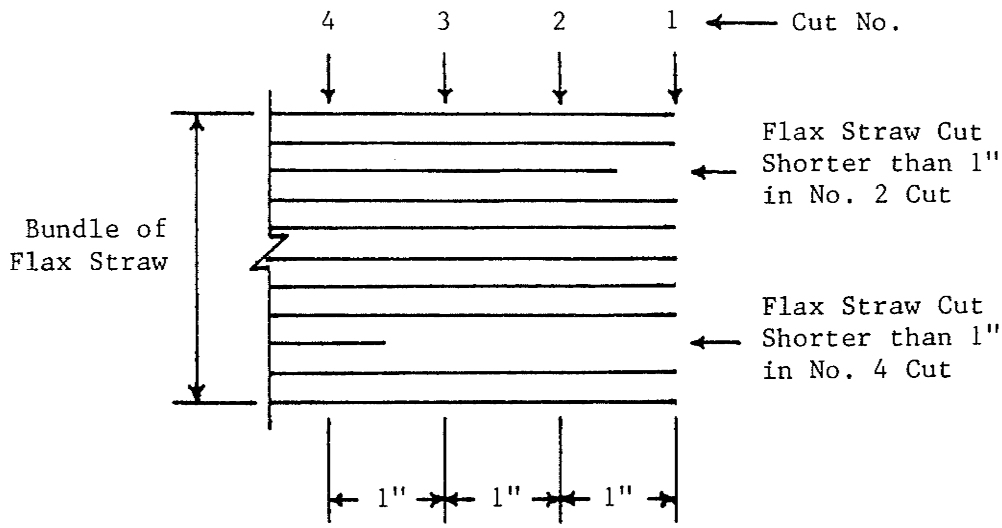

Figure D-2: Flax Straw Not Positioned Evenly in a Bundle Being Cut Shorter than One Inch

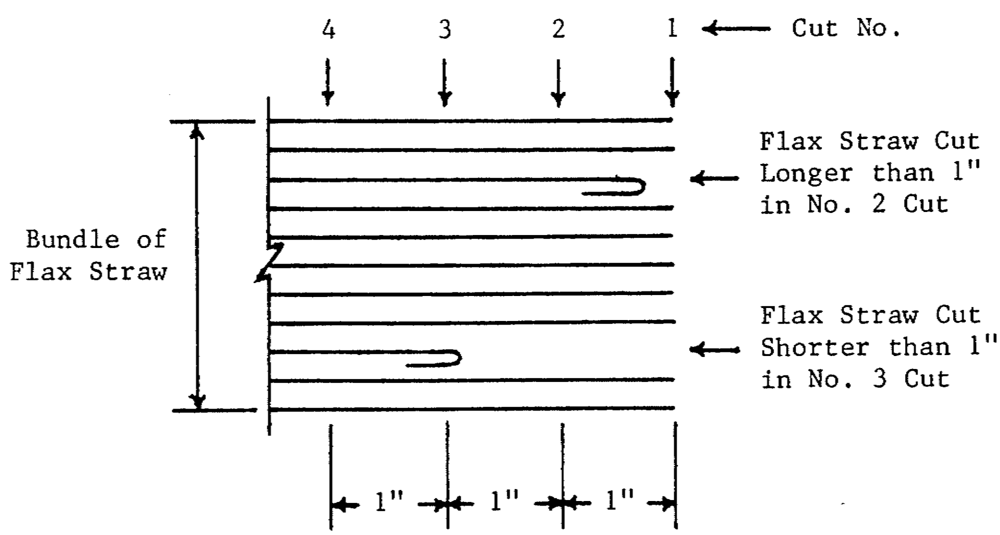

Figure D-3: Flax Straw Bent in a Bundle Being Cut Longer or Shorter than One Inch

Appendix E

INFORMATION ON LIME

For this investigation, two different brand names of lime were used. The brand names were designated as "Brand A" and "Brand B". Information on the bag of lime Brand A classified it as a high calcium, normal hydrated lime suited for both chemical and agriculture use. The manufacturer of lime Brand A was Steel Brothers, Canada, Limited, Lime Division Kananaskis, Alberta. Lime Brand B was also classified as a high calcium, normal hydrated lime. Labelled "SLW Spredwel", lime Brand B was manufactured in Canada by Summit Lime Works Limited of Lethbridge, Alberta at the Crows Nest Plant in British Columbia.

Lea [45, p. 361] lists the apparent density of hydrated lime to be 30 to 40 pcf. This range of values is to be taken for hydrated lime placed in a container with gentle shaking. When required, the apparent density of hydrated lime was taken at the midpoint of the above range, 35 pcf.

For the clay mortar mixes, Mix Nos. 2 to 5 contained lime which came from an unmarked plastic bag stored in the laboratory under dry conditions. It was assumed that the lime in this plastic bag was lime Brand A. For Mix Nos. 6 to 11, lime from a second bag labelled lime Brand A was used. This second bag came from the Northern Housing Committee's [51] outdoor storage shed and showed evidence of being previously wetted.

For the lime-sand mortar mixes, Mix Nos. 12 to 17 contained lime Brand A. For Mix Nos. 18 to 23, lime Brand B was used. All of the lime used for the lime-sand mortars were obtained from the laboratory, stored under dry conditions.

The basic chemical reactions of limestone to quicklime to hydrated lime and back to a form of limestone (as hardened mortar) are as follows:

Calcination	$CaCO_3$	+	Heat	$\longrightarrow$	CaO	+	CO_2
	calcium carbonate (high calcium limestone)				calcium oxide (quicklime or unslaked lime)		carbon dioxide
Normal Hydration	CaO	+	H_2O	$\longrightarrow$	$Ca(OH)_2$	+	Heat
	calcium oxide		water		calcium hydroxide (slaked or normal hydrated lime)		
Carbonization	$Ca(OH)_2$	+	CO_2	$\longrightarrow$	$CaCO_3$	+	H_2O
	calcium hydroxide		carbon dioxide		calcium carbonate		water

The above reactions are strictly for a theoretical pure high-calcium lime, 100 percent calcium carbonate. In reality, a small amount of magnesium carbonate usually exists.

For a high-magnesium lime, the percentage of magnesium oxide present increases markedly but calcium oxide is still present as a significant proportion (see Definitions on the different types of limes). Simultaneously with the above reactions, the following additional reactions occur for the magnesium part of the lime:

Calcination	$MgCO_3$	+	Heat	$\longrightarrow$	MgO	+	CO_2
	magnesium carbonate				magnesium oxide		carbon dioxide
Normal Hydration	MgO	+	H_2O	$\longrightarrow$	MgO	+	H_2O
	magnesium oxide		water		magnesium oxide		water
Carbonization	MgO	+	CO_2	$\longrightarrow$	$MgCO_3$		
	magnesium oxide		carbon dioxide		magnesium carbonate		

Looking at the normal hydration reaction, the magnesium oxide remains inert and does not chemically combine with the water. However, under pressure hydration, the magnesium oxide will combine with the water as shown in the following reaction:

Pressure Hydration	MgO	+	H_2O	$\longrightarrow$	$Mg(OH)_2$	+	Heat
	magnesium oxide		water		magnesium hydroxide		

The resultant magnesium hydroxide from the pressure hydration should then have the following carbonization reaction:

Carbonization of Pressure Hydrated Magnesium Oxide	$Mg(OH)_2$	+	CO_2	$\longrightarrow$	$MgCO_3$	+	H_2O
	magnesium hydroxide		carbon dioxide		magnesium carbonate		water

E.1 AUTOGENOUS HEALING CAPABILITY [38, 48, 68]

For the description of the property of autogenous healing, see Appendix A.

Hydrated lime, which is very slightly soluble in pure water at low temperatures, will dissolve in rain water containing carbon dioxide even when it is already carbonated to calcium carbonate. Dissolved, the lime then becomes recarbonated into a more readily soluble carbonate, calcium bicarbonate which in turn can revert to the stable carbonate of limestone (calcium carbonate) upon drying out. While in the soluble calcium bicarbonate form, this solution can migrate into the small voids or cracks of the mortar. Then after drying out, calcium carbonate is precipitated in the void or crack. After many cycles of this solution-drying, the carbonate build-up plugs the void or crack.

The above reaction of autogenous healing is expressed chemically as follows:

Autogenous Healing	$CaCO_3$	+	H_2O	+	CO_2	$\rightleftharpoons$	$Ca(HCO_3)_2$
	calcium carbonate		water		carbon dioxide		calcium bicarbonate

The double arrow indicates that the reaction is reversible. This reaction is similar to the development of stalactites and stalagmites in limestone caves, although the latter occurs at an infinitely slower rate.

Appendix F

SHRINKAGE DATA FOR CLAY MORTAR MIXES

Tabulated in this appendix is the shrinkage data for the clay mortar mixes. Following are notes pertaining to Tables F-I to F-XII:

1. Vol. indicates volume/volumetric;
2. Disp. indicates displacement;
3. n.d. indicates not done;
4. original moulded volume of cube specimens = 8.0 in.^{3};
5. adjustment factor = $\frac{\text{Vol. shrinkage by water Disp.}}{\text{Vol. shrinkage by calipers}}$;
6. adjusted measured volume = (Vol. shrinkage by calipers) x (adjustment factor);
7. listed Vol. shrinkage by calipers are the average of three cube specimens.

Table F-I

Shrinkage Data
Mix No. 1

Measurement No.	Vol. Shrinkage by Calipers (%)	Vol. Shrinkage by Water Disp. (%)	Adjustment Factor	Age (days)	Adjusted Vol. Shrinkage (%)
1	0.0	n.d.	↑	0.0	0.0
2	29.95	n.d.		4.75	32.18
3	37.23	n.d.		9.54	40.01
4	37.27	n.d.		16.42	40.05
5	37.46	n.d.		23.84	40.25
6	37.06	n.d.		30.42	39.82
n.d.	n.d.	n.d.	1.0746[1]		

Note: See page 338 for notes pertaining to this table.

[1]Average adjustment factor based on Mix Nos. 2, 3, 4, and 5^A (air dry).

Table F-II

Shrinkage Data
Mix No. 2

Measurement No.	Vol. Shrinkage by Calipers (%)	Vol. Shrinkage by Water Disp. (%)	Adjustment Factor	Age (days)	Adjusted Vol. Shrinkage (%)
1	0.0	n.d.	↑	0.0	0.0
2	30.73	n.d.	↑	4.25	32.84
3	48.93	n.d.	↑	8.97	52.29
4	49.31	n.d.	↑	15.84	52.70
5	49.52	n.d.	↑	23.27	52.92
6	49.32 ↓	n.d.	↑	30.27	52.71
7	49.32	52.71	1.0687	33.38	

Note: See page 338 for notes pertaining to this table.

Table F-III

Shrinkage Data
Mix No. 3

Measurement No.	Vol. Shrinkage by Calipers (%)	Vol. Shrinkage by Water Disp. (%)	Adjustment Factor	Age (days)	Adjusted Vol. Shrinkage (%)
1	0.0	n.d.	↑	0.0	0.0
2	24.90	n.d.		3.75	26.54
3	45.39	n.d.		7.95	48.37
4	45.93	n.d.		14.81	48.95
5	45.88	n.d.		22.25	48.89
6	46.11 ↓	n.d.		30.27	49.14
7	46.11	49.14	1.0657	31.19	

Note: See page 338 for notes pertaining to this table.

Table F-IV

Shrinkage Data
Mix No. 4

Measurement No.	Vol. Shrinkage by Calipers (%)	Vol. Shrinkage by Water Disp. (%)	Adjustment Factor	Age (days)	Adjusted Vol. Shrinkage (%)
1	0.0	n.d.	↑	0.0	0.0
2	19.46	n.d.		3.63	21.09
3	44.01	n.d.		7.65	47.69
4	45.02	n.d.		14.51	48.78
5	45.13	n.d.		21.94	48.90
6	44.88 ↓	n.d.		29.96	48.63
7	44.88	48.63	1.0836	32.63	

Note: See page 338 for notes pertaining to this table.

Table F-V

Shrinkage Data
Mix No. 5A (Air Dry)

Measurement No.	Vol. Shrinkage by Calipers (%)	Vol. Shrinkage by Water Disp. (%)	Adjustment Factor	Age (days)	Adjusted Vol. Shrinkage (%)
1	0.0	n.d.	↑	0.0	0.0
2	42.21	n.d.	↑	7.88	45.60
3	42.57	n.d.	↑	14.42	45.98
4	42.81	n.d.	↑	23.92	46.24
5	42.91 ↓	n.d.	↑	30.83	46.35
6	42.91	46.35	1.0802	31.08	

Note: See page 338 for notes pertaining to this table.

Table F-VI

Shrinkage Data
Mix No. 5B (Moist Cured)

Measurement No.	Vol. Shrinkage by Calipers (%)	Vol. Shrinkage by Water Disp. (%)	Adjustment Factor	Age (days)	Adjusted Vol. Shrinkage (%)
1	0.0	n.d.	↑	0.0	0.0
2	40.84	n.d.	↑	24.10	46.15
3	42.14 ↓	n.d.	↑	30.88	47.62
4	42.14	47.62	1.1300	31.08	

Note: See page 338 for notes pertaining to this table.

Table F-VII

Shrinkage Data
Mix No. 6

Measurement No.	Vol. Shrinkage by Calipers (%)	Vol. Shrinkage by Water Disp. (%)	Adjustment Factor	Age (days)	Adjusted Vol. Shrinkage (%)
1	0.0	n.d.		0.0	0.0
2	38.01	n.d.		7.31	43.77
3	38.63	n.d.		16.79	44.48
4	38.99	n.d.		23.79	44.90
5	39.15	n.d.		30.92	45.08
	↓		↑		
6	39.15	45.08	1.1515	34.85	

Note: See page 338 for notes pertaining to this table.

Table F-VIII

Shrinkage Data
Mix No. 7

Measurement No.	Vol. Shrinkage by Calipers (%)	Vol. Shrinkage by Water Disp. (%)	Adjustment Factor	Age (days)	Adjusted Vol. Shrinkage (%)
1	0.0	n.d.	↑	0.0	0.0
2	35.05	n.d.		14.04	39.34
3	35.12	n.d.		20.90	39.42
4	35.41 ↓	n.d.		32.81	39.74
5	35.41	39.74	1.1223	34.02	

Note: See page 338 for notes pertaining to this table.

Table F-IX

Shrinkage Data
Mix No. 8

Measurement No.	Vol. Shrinkage by Calipers (%)	Vol. Shrinkage by Water Disp. (%)	Adjustment Factor	Age (days)	Adjusted Vol. Shrinkage (%)
1	0.0	n.d.	↑	0.0	0.0
2	34.20	n.d.		13.65	37.50
3	34.39	n.d.		20.48	37.71
4	34.62 ↓	n.d.		32.40	37.96
5	34.62	37.96	1.0965	33.65	

Note: See page 338 for notes pertaining to this table.

Table F-X

Shrinkage Data
Mix No. 9

Measurement No.	Vol. Shrinkage by Calipers (%)	Vol. Shrinkage by Water Disp. (%)	Adjustment Factor	Age (days)	Adjusted Vol. Shrinkage (%)
1	0.0	n.d.	↑	0.0	0.0
2	38.82	n.d.	↑	8.33	43.43
3	39.11	n.d.	↑	16.66	43.76
4	39.14	n.d.	↑	23.74	43.79
5	39.38 ↓	n.d.	↑	29.50	44.06
6	39.38	44.06	1.1188	29.69	

Note: See page 338 for notes pertaining to this table.

Table F-XI

**Shrinkage Data
Mix No. 10**

Measurement No.	Vol. Shrinkage by Calipers (%)	Vol. Shrinkage by Water Disp. (%)	Adjustment Factor	Age (days)	Adjusted Vol. Shrinkage (%)
1	0.0	n.d.	↑	0.0	0.0
2	34.35	n.d.		8.13	41.79
3	34.83	n.d.		16.08	42.37
4	34.84	n.d.		23.18	42.38
5	34.97 ↓	n.d.		28.96	42.54
6	34.97	42.54	1.2165	29.90	

Note: See page 338 for notes pertaining to this table.

Table F-XII

Shrinkage Data
Mix No. 11

Measurement No.	Vol. Shrinkage by Calipers (%)	Vol. Shrinkage by Water Disp. (%)	Adjustment Factor	Age (days)	Adjusted Vol. Shrinkage (%)
1	0.0	n.d.	↑	0.0	0.0
2	30.62	n.d.	↑	5.69	37.61
3	31.89	n.d.	↑	12.80	39.17
4	31.86	n.d.	↑	19.90	39.14
5	32.00	n.d.	↑	31.81	39.31
6	32.35 ↓	n.d.	↑	39.88	39.74
7	32.35	39.74	1.2284	40.63	

Note: See page 338 for notes pertaining to this table.

Appendix G

COMPUTER PROGRAMS

Listed in this appendix are the computer programs written and used for this investigation. These programs are presented as they were last used.

G.1 COMPUTER PROGRAM NO. 1 [25, 27]

Computer Program No. 1 was used to plot out the shrinkage behaviour curve for the clay mortar mixes -- Figure 3, page 93. Details of this program are included in the program itself.

SHRINKPLOT "Computer Program No. 1"

```
//SHRINK JOB ',,,T=1M,L=5,I=10,C=0','RANDY ZAPOTOTSKY',CLASS=F,
// MSGLEVEL=(1,1)
/*ROUTE PRINT SELF
/*D800 VPLOT
// EXEC FORTHCLG,USERLIB='SYS3.VPLOTLIB',SIZE=256K
//FORT.SYSIN DD *
C
C
C
C                             --- SHRINKPLOT ---
C
C       --- THIS IS THE PROGRAM FOR PREDETERMINED PLOTTING ---
C                           --- SHRINKAGE PLOT ---
C
C
C
C       IN THIS PROGRAM THE FIRST THING THAT IS READ IN IS THE NUMBER
C OF PLOTS TO BE DRAWN AND THE NUMBER OF SETS OF DATA PER PLOT.
C THE CHARACTERISTICS, NAMELY THE ORGIN AND AXES, ARE THEN DEFINED
C AND PLOTTED OUT.  FOR AESTHETICS PURPOSES ONLY, A FRAME IS DRAWN
C AROUND THIS SET OF AXES.
C
C       FOLLOWING THE ABOVE, THE DATA POINTS ARE THEN READ IN,
C PLOTTED OUT WITHIN THE LIMITS OF THE CHARACTERISTICS OF THE
C PLOT.  A PREDETERMINED BEST FIT CURVE IS THEN DRAWN IN.
C
C       IN THE END, A LEGEND IS INSERTED IN THE INNER, UPPER
C RIGHT HAND CORNER OF THE PLOT.  IF NO LEGEND IS DESIRED, THIS PART
C CAN BE SKIPPED.
C
C       WHEN SUBMITTING A JOB, THE ORDER OF SUBMISSION IS:
C
C             1)  SHRINKPLOT
C             2)  NOPLOT
C             3)  "FIRST DATA FILE"
C             4)  "SECOND DATA FILE"
C             5)  "THIRD DATA FILE"
C             |)      |     |    |
C             |)      |     |    |
C             N)  "N-2TH DATA FILE (LAST ONE)"
C
C       WHERE:
C               SHRINKPLOT:  IS THE NAME OF THIS PLOTTING PROGRAM.
C
C                   NOPLOT:  CONTAINS THE FIRST JCL STATEMENT AND
C                            SPECIFIES THE NUMBER OF PLOTS TO BE
C                            PLOTTED AND THE NUMBER OF SETS OF DATA
C                            PER PLOT.  THE FORM OF THIS FILE IS:
C
C                            1. //GO.SYSIN.DD *
C                            2. "NUMBER OF PLOTS"
C                            3. "NUMBER OF SETS OF DATA PER PLOT"
C
C                DATA FILE:  THE FIRST OR ANY OTHER DATA FILE
C                            CONTAINS SOME BASIC INFORMATION ABOUT
C                            THE PLOT AND ITS DATA POINTS.  THE
C                            FORM OF A DATA FILE IS:
C
C                            1. MIXNO N REMIX
C                            2. X1       Y1
C                            3. X2       Y2
C                            |.  |        |
C                            |.  |        |
```

```
C                         N. X(N-1)  Y(N-1)
C
C                         WHERE:  MIXNO = THE MIX NUMBER
C                                     N = THE TOTAL NUMBER OF
C                                         DATA POINTS FOR THE
C                                         MIX.
C                                 REMIX = "0" WHEN THE MIX WAS
C                                             NOT REMIXED.
C                                         "1" WHEN THE MIX WAS
C                                             REMIXED.
C                                 X&Y'S = THE DATA POINTS.
C
C     AFTER ALL OF THE DATA FOR A SINGLE PLOT HAS BEEN READ IN,
C THE NECESSARY DATA INFORMATION FOR THE PREDETERMINED PLOT MUST
C THEN BE READ IN BEFORE THE NEXT PLOT'S INFORMATION.
C
C     ALSO, WHEN SUBMITTING A JOB, ONE MUST MAKE SURE THAT THE
C JCL ENDING THE DATA INFORMATION MUST BE PLACED AT THE CORRECT
C POSITION.  IF ONLY ONE PLOT IS TO BE PLOTTED, IT GOES AFTER
C THE PREDETERMINED PLOT DATA INFORMATION WHICH IS PLACED AT THE
C END OF THE SET OF DATA FILES.  IN THE CASE WHERE MORE THAN TWO
C PLOTS ARE TO BE DRAWN, THE JCL MUST BE PLACED AFTER THE
C PREDETERMINED PLOT DATA INFORMATION FOR THE LAST PLOT WHICH IS
C PLACED AT THE END OF THE LAST SET OF DATA FILES.
C
C     DEPENDING ON THE NUMBER AND TYPE OF PLOTS TO BE DONE, THE
C "DEVELOP A LEGEND" PART OF THE PROGRAM MUST BE MODIFIED
C ACCORDINGLY, IF USED.
C
C     LIMITATIONS OF THE DIMENSION STATEMENTS ARE AS FOLLOWS:
C
C           1)  X(___),Y(___)
C               MAXIMUM ALLOWABLE NUMBER OF DATA POINTS PER MIX
C               READ IN IS 102 - 2 = 100
C
C           2)  XPLOT(__),YPLOT(__)
C               THE MAXIMUM NUMBER OF ALLOWABLE OF PLOTTING POINTS
C               FOR THE BEST FIT CURVE IS 12 - 2 = 10
C
C
C
      DIMENSION IBUF(4000),X(102),Y(102),XPLOT(12),YPLOT(12)
      INTEGER REMIX
C
C     READ AND WRITE OUT THE NUMBER OF PLOTS TO BE DRAWN
C
      READ (5,*) NOPLOT,NODATA
      WRITE (6,10) NOPLOT
   10 FORMAT ('1',////////,4X,'THE NUMBER OF PLOTS THAT ',
     &'ARE TO BE DRAWN IS',3X,I3)
      WRITE (6,20) NODATA
   20 FORMAT (////////,4X,'THE NUMBER OF SETS OF DATA TO BE ',
     &'PLOTTED PER PLOT IS',3X,I3)
      DO 140 NP=1,NOPLOT
      CALL PLOTS (IBUF,4000)
C
C      DEFINE SOME CHARACTERISTICS OF THE PLOT.
C
      CALL PLOT (0.0,-11.0,-3)
      CALL PLOT (0.0,2.50,-3)
      CALL FACTOR (1.0)
      CALL AXIS (0.0,0.0,'AGE - DAYS',-10,7.0,0.0,0.0,8.0)
      CALL AXIS (0.0,0.0,'% OF ORIGINAL VOLUME',20,4.0,90.0,0.0,25.0)
```

SHRINKPLOT "Computer Program No. 1"

```
C
C      ------ DRAW A RECTANGULAR FRAME AROUND THE PLOT ------
C
       CALL NEWPEN (4)
       CALL RECT (-1.0,-1.25,6.0,9.0,0.0,3)
       CALL NEWPEN (1)
C
       DO 120 ND=1,NODATA
C
C
C      ------ READ AND WRITE OUT SOME BASIC INFORMATION ------
C
       READ (5,*) MIXNO,N,REMIX
       WRITE (6,30) MIXNO
    30 FORMAT ('1',////////,4X,'THIS IS THE PLOT ',
      &'PROGRAM INFORMATION FOR MIX NUMBER',I5)
       WRITE (6,40) MIXNO,N
    40 FORMAT (////////,4X,
      &'THE TOTAL NUMBER OF DATA POINTS READ IN FOR MIX NUMBER',
      &I6,4X,'IS',I7)
       IF (REMIX.EQ.1) GO TO 60
       WRITE (6,50)
    50 FORMAT (////////,4X,'THE FOLLOWING DATA IS FOR THE MIX ',
      &'WHEN ITS COMPONENTS WERE COMBINED FOR THE FIRST TIME')
       GO TO 80
    60 WRITE (6,70)
    70 FORMAT (////////,4X,'THE FOLLOWING DATA IS FOR WHEN THE ',
      &'HARDENED ORIGINAL MIXTURE WAS CRUSHED AND REMIXED')
C
C      READ AND WRITE OUT THE DATA POINTS FOR THE MIX.
C
    80 READ (5,*) (X(I),Y(I),I=1,N)
       WRITE (6,90) MIXNO
    90 FORMAT ('1',////////,33X,'DATA POINTS',//,31X,
      &'MIX NUMBER',1X,I4)
       WRITE(6,100)
   100 FORMAT(//,4X,'DATA NUMBER',10X,'X-VALUES (DAYS)',10X,
      &'Y-VALUES (% OF ORIGINAL VOLUME)',/)
       WRITE (6,110) (I,X(I),Y(I),I=1,N)
   110 FORMAT (' ',7X,I3,18X,F7.3,25X,F8.3)
C
C      PLOT OUT THE DATA POINTS
C
       X (N+1) =  0.0
       Y (N+1) =  0.0
       X (N+2) =  8.0
       Y (N+2) = 25.0
C
       CALL LINE (X,Y,N,1,-1,0)
C
   120 CONTINUE
C
C      READ AND WRITE OUT THE PLOTTING POINTS
C
       READ (5,*) (XPLOT(J),YPLOT(J),J=1,3)
       WRITE (6,130) NP
   130 FORMAT ('1',////////,29X,'PLOTTING DATA POINTS',//,
      &34X,'PLOT NO.',1X,I2)
       WRITE (6,100)
       WRITE (6,110) (J,XPLOT(J),YPLOT(J),J=1,3)
C
C      PLOT OUT THE BEST FIT CURVE
C
```

SHRINKPLOT "Computer Program No. 1"

```
      XPLOT (4) =  0.0
      YPLOT (4) =  0.0
      XPLOT (5) =  8.0
      YPLOT (5) = 25.0
C
      CALL NEWPEN (8)
      CALL LINE (XPLOT,YPLOT,3,1,0,0)
      CALL NEWPEN (1)
C
      CALL PLOT (12.0,0.0,999)
  140 CONTINUE
      CALL PLOT (0.0,0.0,9999)
      STOP
      END
```

G.2 COMPUTER PROGRAM NO. 2 [27, 39 -- PP. 309-312]

Computer Program No. 2 was used to determine the constants of the best-fit polynomial curves that were used to describe the compressive strength and failure characteristics of all the mixes. The title of this program, Least-Squares Fit of a Polynomial, is self-explanatory of the method used to obtain these constants. Details of this program are included in the program itself.

BESTFIT "Computer Program No. 2"

```
//ZAP JOB '0726,,,C=0,R=256K',NOTIFY=LANSDWN
// EXEC WATFIV,SIZE=220K
GO.SISIN DD *
$JOB WATFIV RANDY ZAPOTOTSKY,NOEXT,NOCHECK
C
C
C
C ***************************************************
C *                                                 *
C *                                                 *
C *      THIS IS THE MAIN PROGRAM OF "BESTFIT"      *
C *                                                 *
C *                                                 *
C ***************************************************
C
C
C
C      THIS PROGRAM HAS THE CAPACITY OF DETERMINING FROM TWO (2)
C TO A MAXIMUM OF TEN (10) CONSTANTS (C'S), FOR A LEAST-SQUARES,
C BEST FIT POLYNOMIAL.  FOR EXAMPLE:  AN EQUATION WITH
C WITH THREE (3) CONSTANTS CAN BE IN THE FORM SUCH AS:
C
C                 Y = C1 + C2*X + C3*X*X
C
C                            OR
C
C                 Y = C1*X + C2*X*X + C3*X*X*X
C
C THE SECOND EXAMPLE WOULD MAKE "Y" TOTALLY DEPENDANT
C UPON "X".  THEREFORE AT X=0.0, "Y" WOULD ALSO EQUAL 0.0.
C THIS WOULD MAKE THE BEST FIT CURVE PASS THROUGH THE
C ORIGIN (0.0,0.0).
C
C      THE MAXIMUM NUMBER OF DATA POINTS THAT CAN BE READ IN
C IS TWO HUNDRED (200).
C
C      THE FUNCTIONS CAN BE ADJUSTED TO FIT ONE'S NEED.  TO DO
C THIS, THREE (3) MAJOR ADJUSTMENTS ARE REQUIRED AT THE
C FOLLOWING AREAS:
C
C          1)  "DEFINE THE FUNCTIONS"
C               IN THE MAIN PROGRAM
C
C          2)  "GENERATE THE F MATRIX"
C               IN THE MAIN PROGRAM
C
C          3)  THE NUMBER "M" (NUMBER OF CONSTANTS, C'S)
C              IN THE DATA FILE.  THIS NUMBER "M" MUST
C              EQUAL THE NUMBER OF FUNCTIONS.
C
C      THE DATA FILE FOR THIS PROGRAM SHOULD HAVE RECORDS IN
C THE ORDER AS SHOWN BELOW:
C
C      1.$ENTRY
C      2.  MIXNO  M   N  N1   N2  N3 DASH
C      3.    X1  Y1
C      4.    X2  Y2
C      5.    X3  Y3
C             |   |
C             |   |
C             |   |
C      N+2. XN   YN
C
```

BESTFIT "Computer Program No. 2"

```
C       WHERE MIXNO = THE MIX NUMBER
C                 M = THE NUMBER OF CONSTANTS (C'S)
C                 N = THE TOTAL NUMBER OF DATA POINTS
C                N1 = THE NUMBER OF DATA POINTS FOR CUBE NUMBER 1
C                N2 =  "      "    "   "     "    "    "     "   2
C                N3 =  "      "    "   "     "    "    "     "   3
C              DASH = "0" IF A PEAK LOAD OCCURRED FOR ALL OF THE
C                         CUBES DURING THE COMPRESSION TEST
C                   = "1" IF PEAK LOADS DID NOT OCCUR FOR ALL OF
C                         THE CUBES DURING THE COMPRESSION TEST
C                     NOTE:  THE USE OF DASH COMES IN USE WHEN
C                            PLOTTING OUT THE BESTFIT CURVE IN
C                            THE PLOT PROGRAM.
C
C
C
C ------ LEAST SQUARES CURVE FITTING ------
C
        DIMENSION X(200),Y(200,10),F(200,10),FT(10,200)
       &,A(10,11),B(10,11),C(10)
        INTEGER DASH
C
C ------ "DEFINE THE FUNCTIONS" ------
C
        F1(X)=X
        F2(X)=X*X
        F3(X)=X*X*X
        F4(X)=X*X*X*X
C
C READ IN THE MIX NUMBER, THE NUMBER OF C'S, THE TOTAL NUMBER
C OF DATA POINTS, THE NUMBER OF DATA POINTS FOR EACH CUBE AND
C THE VALUE OF DASH.
C (IN FREE FORMAT)
C
        READ(5,*) MIXNO,M,N,N1,N2,N3,DASH
C
C WRITE OUT SOME GENERAL INFORMATION ABOUT THIS PROGRAM
C
        WRITE (6,1) MIXNO
      1 FORMAT ('1',////////,4X,
       &'THIS IS THE BESTFIT PROGRAM FOR MIX NUMBER',I6)
        WRITE (6,2) M
      2 FORMAT (////////,4X,
       &'THE NUMBER OF CONSTANTS "M" READ IN FOR THIS PROGRAM IS',
       &I5)
        WRITE (6,3) MIXNO,N
      3 FORMAT (////////,4X,
       &'THE TOTAL NUMBER OF DATA POINTS READ IN FOR MIX NUMBER',
       &I6,4X,'IS',I7)
        WRITE (6,4) N1,N2,N3
      4 FORMAT (////////,4X,
       &'THE NUMBER OF DATA POINTS READ IN FOR CUBE NUMBER  1 =',
       &1X,I3,//,42X,'CUBE NUMBER  2 =',1X,I3,//,42X,
       &'CUBE NUMBER  3 =',1X,I3)
        IF (DASH.EQ.0) GO TO 6
        WRITE (6,5)
      5 FORMAT (////////,4X,'DURING THE COMPRESSION TEST,',
       &' THIS MIX DID NOT HAVE PEAK LOADS FOR ALL OF THE CUBES.')
        GO TO 8
      6 WRITE (6,7)
      7 FORMAT (////////,4X,'DURING THE COMPRESSION TEST,',
       &' THIS MIX HAD PEAK LOADS FOR ALL OF THE CUBES.')
C
```

BESTFIT "Computer Program No. 2"

```
C READ AND WRITE OUT THE X-Y VALUES OF DATA POINTS.
C (READING DONE IN FREE FORMAT)
C
    8 READ(5,*) (X(I),Y(I,1),I=1,N)
      WRITE(6,9) MIXNO
    9 FORMAT('1',////////,32X,'DATA POINTS',//,30X,
     &'MIX NUMBER',I5)
      WRITE(6,10)
   10 FORMAT(//,4X,'DATA NUMBER',10X,'X-VALUES (STRAIN-%)',10X,
     &'Y-VALUES (STRESS-PSI)',/)
      WRITE(6,11) (I,X(I),Y(I,1),I=1,N)
   11 FORMAT (' ',7X,I3,17X,F10.3,19X,F10.1)
C
C ------ "GENERATE THE F MATRIX" ------
C
      DO 12 I=1,N
      F(I,1)=F1(X(I))
      F(I,2)=F2(X(I))
      F(I,3)=F3(X(I))
   12 F(I,4)=F4(X(I))
C
C GENERATE THE TRANSPOSE OF THE F MATRIX
C
      DO 13 I=1,N
      DO 13 J=1,M
   13 FT(J,I)=F(I,J)
C
C DETERMINE COEFFICIENT MATRIX A OF SIMULTANEOUS EQUATION
C SYSTEM
C
      CALL MATMPY(FT,F,A,M,N,M)
C
C DETERMINE THE COLUMN OF CONSTANTS FOR SIMULTANEOUS EQUATION
C SYSTEM
C
      CALL MATMPY(FT,Y,B,M,N,1)
      DO 14 I=1,M
   14 A(I,M+1)=B(I,1)
C
C DETERMINE C VALUES BY SOLVING SIMULTANEOUS EQUATIONS USING
C CHOLESKY METHOD
C
      MP1=M+1
      CALL CHLSKY(A,M,MP1,C)
C
C WRITE OUT THE C VALUES
C
      WRITE(6,15) MIXNO
   15 FORMAT('1',////////,4X,'C(01) THROUGH C(M) FOR MIX NUMBER',
     &I5,//)
      WRITE (6,16) (I,C(I),I=1,M)
   16 FORMAT('0',3X,'C(',I2,')=',3X,E14.7)
      WRITE (6,17)
   17 FORMAT (//////////////////)
      STOP
      END
C
C
C
C ******************************************************
C *                                                    *
C *                                                    *
C *       THE SUBROUTINE SUBPROGRAM MATMPY FOR         *
```

BESTFIT "Computer Program No. 2"

```
C *                                                *
C *       THE REQUIRED MATRIX MULTIPLICATION       *
C *                                                *
C *                                                *
C **************************************************
C
C
C
      SUBROUTINE MATMPY(A,B,C,M,N,L)
C
C THIS SUBROUTINE DETERMINES MATRIX C AS THE PRODUCT
C OF A AND B MATRICES.
C
      DIMENSION A(10,200),B(200,10),C(10,11)
      DO 1 I=1,M
      DO 1 J=1,L
      C(I,J)=0.0
      DO 1 K=1,N
    1 C(I,J)=C(I,J)+A(I,K)*B(K,J)
      RETURN
      END
C
C
C
C *********************************************************
C *                                                       *
C *                                                       *
C *          THE SUBROUTINE SUBPROGRAM UTILIZING          *
C *                                                       *
C *         CHOLESKY'S METHOD FOR THE SOLUTION OF         *
C *                                                       *
C *      THE SIMULTANEOUS LINEAR ALGEBRAIC EQUATIONS      *
C *                                                       *
C *                                                       *
C *********************************************************
C
C
C
      SUBROUTINE CHLSKY (A,N,M,X)
      DIMENSION A(10,11),X(10)
C
C CALCULATE FIRST ROW OF UPPER UNIT TRIANGULAR MATRIX
C
      DO 1 J=2,M
    1 A(1,J)=A(1,J)/A(1,1)
C
C CALCULATE OTHER ELEMENTS OF U AND L MATRICES
C
      DO 6 I=2,N
      J=I
      DO 3 II=J,N
      SUM=0.0
      JM1=J-1
      DO 2 K=1,JM1
    2 SUM=SUM+A(II,K)*A(K,J)
    3 A(II,J)=A(II,J)-SUM
      IP1=I+1
      DO 5 JJ=IP1,M
      SUM=0.0
      IM1=I-1
      DO 4 K=1,IM1
    4 SUM=SUM+A(I,K)*A(K,JJ)
    5 A(I,JJ)=(A(I,JJ)-SUM)/A(I,I)
```

BESTFIT "Computer Program No. 2"

```
    6 CONTINUE
C
C SOLVE FOR X(I) BY BACK SUBSTITUTION
C
      X(N)=A(N,N+1)
      L=N-1
      DO 8 NN=1,L
      SUM=0.0
      I=N-NN
      IP1=I+1
      DO 7 J=IP1,N
    7 SUM=SUM+A(I,J)*X(J)
    8 X(I)=A(I,M)-SUM
      RETURN
      END
```

G.3 COMPUTER PROGRAM NO. 3 [25, 27, 29 -- PP. 479-480]

Using the constants of the best-fit polynomial determined in Computer Program No. 2, this program plots out the best-fit curve along with its associated data points. To give an indication of how well a best-fit polynomial described the behaviour of the data points for a given mix, this program also calculates the value of the adjusted coefficient of multiple determination -- R_A^2. More details of this program are included in the program itself.

CPLOT "Computer Program No. 3"

```
//NOLINEC JOB ',,,T=1M,L=10,I=10,C=0','RANDY ZAPOTOTSKY',CLASS=F,
// MSGLEVEL=(1,1)
/*ROUTE PRINT SELF
/*D800 VPLOT
// EXEC FORTHCLG,USERLIB='SYS3.VPLOTLIB',SIZE=256K
//FORT.SYSIN DD *
C
C
C
C        --- THIS IS THE PROGRAM FOR BEST FIT PLOTTING ---
C                  --- CLAY MORTAR MIXES ---
C
C
C
C      WHEN RUNNING THIS PROGRAM, THE FILES AND ITS ORDER OF
C SUBMISSION IS AS FOLLOWS:
C
C      1.  CPLOT
C      2.  NOFIT
C      3.  "DATA FILES"
C
C      WHERE:
C
C             CPLOT - IS THE NAME OF THIS PROGRAM
C
C             NOFIT - HAS THREE RECORDS IN THE FORM AS FOLLOWS:
C
C                     1.//GO.SYSIN DD *
C                     2. "NUMBER OF SETS OF DATA"
C                     3. "VALUE OF M"
C
C                         WHERE:
C
C                              M = THE NUMBER OF CONSTANTS (C'S)
C                                  THAT WILL BE USED IN PLOTTING
C                                  EACH OF THE BEST FIT CURVES.
C
C      "DATA FILES" - HAS THE FORM AS FOLLOWS:
C
C         1. MIXNO N N1 N2 N3 DAY REMIX XSTART MAX10 YMAX DASH
C         2. X1        Y1
C         3. X2        Y2
C         4. |         |
C         5. |         |
C       N+1. X(N-1)    Y(N-1)
C       N+2. C1
C       N+_. |
C       N+_. |
C    N+1+CN. CN
C
C      WHERE:
C
C     MIXNO = THE MIX NUMBER
C         N = THE TOTAL NUMBER OF DATA POINTS POINTS
C        N1 = THE NUMBER OF DATA POINTS FOR SPECIMEN NO. 1
C        N2 =  "    "    "  "    "     "     "     NO. 2
C        N3 =  "    "    "  "    "     "     "     NO. 3
C       DAY = THE AGE OF THE MIX, IN DAYS
C     REMIX = "0" IF THE MIX WAS MIXED TOGETHER FOR THE FIRST TIME
C           = "1" IF THE HARDENED ORIGINAL MIX WAS CRUSHED AND REMIXED
C    XSTART = THE EXPERIMENTAL CORRECTION FACTOR TO THE X-VALUES;
C             XSTART IS POSITIVE IF MOVING THE X-VALUES TO THE LEFT
C     MAX10 = (SEE DESCRIPTION BELOW)
```

CPLOT "Computer Program No. 3"

```
C      YMAX = THE MAXIMUM Y-VALUE OBTAINED IN A SET OF TESTS
C      DASH = (SEE DESCRIPTION BELOW)
C     X&Y'S = THE DATA POINTS
C        C_ = THE CONSTANTS OF THE BEST FIT EQUATION
C
C
C       TO SATISFY THE "DO" STATEMENT RULE OF ONLY USING INTEGERS
C GREATER THAN ZERO AND TO OBTAIN AN INCREMENT OF 0.1% STRAIN
C (X-VALUES) WHEN PLOTTING THE BEST FIT CURVE, MAX10 IS
C DEFINED AS FOLLOWS:
C
C             MAX10 = (MAX STRAIN(%) - XSTART + 0.1) * 10
C
C FROM THIS MODIFICATION TO THE MAXIMUM STRAIN VALUE, ONLY
C THE INTEGER PART OF THE NUMBER IS PUT INTO THE DATA FILE.
C WHEN PLOTTING IT WILL BECOME CLOSE ENOUGH TO THE MAXIMUM
C STRAIN VALUE OBTAINED IN A MIX.  THIS WILL SATISFY THE
C INTEGER RULE OF A DO LOOP.
C
C       FROM THE PROGRAM THIS MODIFICATION COMES FROM:
C
C             X(I) = ((RI/10.0) - 0.1)
C
C       THE "-0.1" IS NEEDED SO THAT X IS EQUAL TO ZERO FOR THE
C FIRST VALUE.  THIS WILL MAKE THE BEST FIT CURVE PASS THROUGH
C THE ORIGIN.
C
C       MAX10 MUST BE DEFINED FOR EACH INDEPENDANT MIX.
C IN ADDITION, IT MUST BE PUT INTO A DATA FILE AS AN
C INTEGER, NOT A REAL NUMBER, TO SATISFY THE INTEGER
C RULES OF A DO LOOP.
C
C       A CHECK WILL BE DONE NEAR THE DEFINED FUNCTION SO AS TO
C PREVENT THE BEST FIT CURVE HAVING A NEGATIVE SLOPE AND A
C Y VALUE GREATER THAN THAT OBTAINED IN A SET OF TESTS.
C A NEGATIVE SLOPE IS UNFAVORABLE SINCE IT DOES NOT REPRESENT
C WHAT HAPPENED IN THE ACTUAL TESTS.
C
C       IF THE MIX DID NOT HAVE PEAK LOADS FOR ALL OF THE CUBES,
C A STRAIGHT DASHED LINE WILL BE DRAWN HORIZONTALLY FROM THE
C END OF THE BEST FIT CURVE TO THE FAR RIGHT OF THE PLOT.  THIS
C DASHED LINE WILL REPRESENT THAT LOADING WAS CONTINUED AFTER
C THIS CUT-OFF POINT, BUT NO PEAK LOAD OCCURRED.  IT SHOULD BE
C NOTED THOUGH THAT THE PATH OF THIS DASHED LINE DOES NOT
C NECESSARILY REPRESENT THE ACTUAL PATH TAKEN DURING THE TEST OR
C OF THE BEST FIT CURVE.
C       THIS DASHED LINE WILL NOT BE DRAWN WHEN THE VALUE OF
C "DASH" IS EQUAL TO "0" (ZERO).  WHEN "DASH" IS EQUAL TO
C "1" (ONE), A DASHED LINE WILL BE DRAWN.
C
C      AT THE END OF THE DATA FILE(S), THE PROPER JCL MUST BE
C DEFINED IN ORDER FOR THE PROGRAM TO RUN.
C
C       DUE TO THE LIMITS ON THE DIMENSION STATEMENTS THE
C FOLLOWING LIMITS ARE DEFINED:
C
C             1)  XRAY_(__), YRAY_(__)
C                 MAXIMUM ALLOWABLE NUMBER OF DATA POINTS PER
C                 SPECIMEN READ IN IS 77 - 2 = 75
C
C             2)  C(__)
C                 MAXIMUM ALLOWABLE NUMBER OF CONSTANTS
C                 READ IN IS 10
```

```
C
C              3)  X(___), Y(___)
C                  MAXIMUM ALLOWABLE STRAIN IN THE TESTS
C                  IS (502 - 2)/10 = 50%
C
C              4)  XNEW_(__)
C                  AS FOR XRAY_(__)
C
C              5)  MXDATA(___), MYDATA(___)
C                  MAXIMUM ALLOWABLE NUMBER OF DATA POINTS
C                  POINTS PER MIX PER MIXED X AND Y
C                  DATA ARRAYS = 225
C
C
C     IN ORDER FOR THIS PROGRAM TO RUN SATISFACTORY FOR DIFFERENT
C RUNS, ONE MUST ENSURE THAT THE FOLLOWING IS DONE:
C
C     A.  CHECK TO SEE THAT THE BEST FIT EQUATION AT THE FOLLOWING
C         TWO (2) LOCATIONS IS THE ONE THAT IS WANTED AND THAT THEY
C         ARE BOTH THE SAME:
C
C         1.  IN THE PLOTTING SECTION AND
C
C         2.  IN THE ADJUSTED COEFFICIENT OF MULTIPLE DETERMINATION
C             CALCULATION PART.
C
C     B.  ADJUST THE DEVELOP A LEGEND ACCORDINGLY TO THE DATA OR SKIP
C         OVER THIS PART OF THE PROGRAM BY A SIMPLE GO TO STATEMENT.
C
C
C
      DIMENSION IBUF(4000),
     &XRAY1(77),YRAY1(77),XRAY2(77),YRAY2(77),XRAY3(77),YRAY3(77),
     &C(10),X(502),Y(502),XNEW1(77),XNEW2(77),XNEW3(77)
      REAL MXDATA(225),MYDATA(225)
      INTEGER DAY,DASH,P1,P2,P3,P4,P5,P6,DP
C
C     READ AND WRITE OUT THE NUMBER OF PLOTS TO BE DRAWN AND THE
C NUMBER OF CONSTANTS (C'S) THAT ARE TO BE USED.
C
      READ (5,*) NOFIT,M
      WRITE (6,70) NOFIT
   70 FORMAT ('1',////////,4X,'THE NUMBER OF PLOT(S) THAT ',
     &'ARE TO BE DRAWN IS',3X,I3)
      WRITE (6,80) M
   80 FORMAT (//////,4X,
     &'THE NUMBER OF CONSTANTS "M" READ IN FOR THIS PROGRAM IS',I5)
C
      DO 780 NF=1,NOFIT
      CALL PLOTS (IBUF,4000)
C
C      DEFINE SOME CHARACTERISTICS OF THE PLOT.
C
      CALL PLOT (0.0,-11.0,-3)
      CALL PLOT (0.0,2.0625,-3)
      CALL FACTOR (1.0)
      CALL AXIS (0.0,0.0,'STRAIN - %',-10,4.0,0.0,0.0,5.0)
      CALL AXIS (0.0,0.0,'STRESS - PSI',12,7.0,90.0,0.0,160.0)
C
C     DRAW A RECTANGULAR FRAME AROUND THE PLOT
C
      CALL NEWPEN (4)
      CALL RECT (-0.75,-1.25,9.0,5.5,0.0,3)
```

CPLOT "Computer Program No. 3"

```
      CALL NEWPEN (1)
C
C      READ AND WRITE OUT SOME BASIC INFORMATION ABOUT THE MIX.
C
      READ (5,*) MIXNO,N,N1,N2,N3,DAY,REMIX,XSTART,MAX10,YMAX,DASH
      WRITE (6,90) MIXNO,DAY
   90 FORMAT ('1',//////,4X,
     &'THIS IS THE PLOT PROGRAM FOR MIX NUMBER',3X,
     &I3,3X,'AT THE',3X,I2,3X,'DAY STRENGTH')
      IF (REMIX.EQ.1) GO TO 110
      WRITE (6,100)
  100 FORMAT (//////,4X,'THE FOLLOWING DATA IS FOR THE MIX ',
     &'WHEN ITS COMPONENTS WERE COMBINED FOR THE FIRST TIME')
      GO TO 130
  110 WRITE (6,120)
  120 FORMAT (//////,4X,'THE FOLLOWING DATA IS FOR WHEN THE ',
     &'HARDENED ORIGINAL MIXTURE WAS CRUSHED AND REMIXED')
  130 WRITE (6,140) XSTART
  140 FORMAT (//////,4X,'THE VALUE OF XSTART READ IN IS',
     &2X,F6.3)
      WRITE (6,150) MIXNO,MAX10
  150 FORMAT (//////,4X,
     &'THE VALUE OF MAX10 THAT WAS READ IN FOR MIX NUMBER',I5,
     &3X,'IS',3X,I4)
      WRITE (6,160) YMAX
  160 FORMAT (//////,4X,'THE HIGHEST STRESS THAT WAS REACHED ',
     &'DURING THE TEST WAS',3X,F6.1,3X,'PSI')
      IF (DASH.EQ.0) GO TO 180
      WRITE (6,170)
  170 FORMAT (//////,4X,'DURING THE TESTING,',
     &' THIS MIX DID NOT HAVE PEAK LOADS FOR ALL OF THE SPECIMENS.')
      GO TO 200
  180 WRITE (6,190)
  190 FORMAT (//////,4X,'DURING THE TESTING,',
     &' THIS MIX HAD PEAK LOADS FOR ALL OF THE SPECIMENS.')
  200 WRITE (6,210) MIXNO,N
  210 FORMAT (//////,4X,
     &'THE TOTAL NUMBER OF DATA POINTS READ IN FOR MIX NUMBER',
     &I6,4X,'IS',I7)
      WRITE (6,220) N1,N2,N3
  220 FORMAT (//////,4X,
     &'THE NUMBER OF DATA POINTS READ IN FOR SPECIMEN NUMBER  1 =',
     &1X,I3,//,42X,'SPECIMEN NUMBER  2 =',1X,I3,//,42X,
     &'SPECIMEN NUMBER  3 =',1X,I3)
C
C      READ AND WRITE OUT THE DATA POINTS FOR THE MIX.
C
      READ (5,*) (XRAY1(I),YRAY1(I),I=1,N1)
      READ (5,*) (XRAY2(J),YRAY2(J),J=1,N2)
      READ (5,*) (XRAY3(K),YRAY3(K),K=1,N3)
C
      WRITE (6,230) MIXNO,DAY
  230 FORMAT ('1',////////,32X,'DATA POINTS',//,30X,
     &'MIX NUMBER',I5,//,29X,I2,3X,'DAY STRENGTH')
      IF (REMIX.EQ.0) GO TO 250
      WRITE (6,240)
  240 FORMAT (/,35X,'REMIX')
  250 WRITE(6,260)
  260 FORMAT(//,4X,'DATA NUMBER',10X,'X-VALUES (STRAIN-%)',10X,
     &'Y-VALUES (STRESS-PSI)',/)
      WRITE (6,270)
  270 FORMAT (/,4X,'SPECIMEN NUMBER  1',/)
      WRITE (6,300) (I,XRAY1(I),YRAY1(I),I=1,N1)
```

CPLOT "Computer Program No. 3"

```
      WRITE (6,280)
  280 FORMAT (//,4X,'SPECIMEN NUMBER  2',/)
      WRITE (6,300) (J,XRAY2(J),YRAY2(J),J=1,N2)
      WRITE (6,290)
  290 FORMAT (//,4X,'SPECIMEN NUMBER  3',/)
      WRITE (6,300) (K,XRAY3(K),YRAY3(K),K=1,N3)
  300 FORMAT (' ',7X,I3,17X,F10.3,19X,F10.1)
C
C       ADJUST THE X-VALUES WITH XSTART TO CORRECT FOR
C EXPERIMENTAL ERROR.
C
      DO 310 I=1,N1
      XNEW1(I) = XRAY1(I) - XSTART
  310 CONTINUE
      DO 320 J=1,N2
      XNEW2(J) = XRAY2(J) - XSTART
  320 CONTINUE
      DO 330 K=1,N3
      XNEW3(K) = XRAY3(K) - XSTART
  330 CONTINUE
C
C       WRITE OUT THE NEW ADJUSTED X-VALUES AND ITS CORRESPONDING
C Y-VALUES.
C
      WRITE (6,340) MIXNO,DAY
  340 FORMAT ('1',////////,27X,'ADJUSTED DATA POINTS',//,30X,
     &'MIX NUMBER',I5,//,29X,I2,3X,'DAY STRENGTH')
      IF (REMIX.EQ.0) GO TO 360
      WRITE (6,350)
  350 FORMAT (/,35X,'REMIX')
  360 WRITE(6,370)
  370 FORMAT(//,4X,'DATA NUMBER',10X,'X-VALUES (STRAIN-%)',10X,
     &'Y-VALUES (STRESS-PSI)',/)
      WRITE (6,380)
  380 FORMAT (/,4X,'SPECIMEN NUMBER  1',/)
      WRITE (6,410) (I,XNEW1(I),YRAY1(I),I=1,N1)
      WRITE (6,390)
  390 FORMAT (//,4X,'SPECIMEN NUMBER  2',/)
      WRITE (6,410) (J,XNEW2(J),YRAY2(J),J=1,N2)
      WRITE (6,400)
  400 FORMAT (//,4X,'SPECIMEN NUMBER  3',/)
      WRITE (6,410) (K,XNEW3(K),YRAY3(K),K=1,N3)
  410 FORMAT (' ',7X,I3,17X,F10.3,19X,F10.1)
C
C       PLOT OUT THE ADJUSTED DATA POINTS.
C
      XNEW1 (N1+1)=    0.0
      YRAY1 (N1+1)=    0.0
      XNEW1 (N1+2)=    5.0
      YRAY1 (N1+2)=  160.0
C
      XNEW2 (N2+1)=    0.0
      YRAY2 (N2+1)=    0.0
      XNEW2 (N2+2)=    5.0
      YRAY2 (N2+2)=  160.0
C
      XNEW3 (N3+1)=    0.0
      YRAY3 (N3+1)=    0.0
      XNEW3 (N3+2)=    5.0
      YRAY3 (N3+2)=  160.0
C
      CALL LINE (XNEW1,YRAY1,N1,1,-1,0)
      CALL LINE (XNEW2,YRAY2,N2,1,-1,2)
```

CPLOT "Computer Program No. 3"

```
      CALL LINE (XNEW3,YRAY3,N3,1,-1,3)
C
C      READ AND WRITE OUT THE CONSTANTS (C-VALUES).
C
      READ (5,*) (C(I),I=1,M)
      WRITE (6,420) MIXNO,DAY
  420 FORMAT ('1',////////,11X,'C VALUES',//,9X,'MIX NUMBER',
     &1X,I2,//,8X,I2,1X,'DAY STRENGTH')
      IF (REMIX.EQ.0) GO TO 440
      WRITE (6,430)
  430 FORMAT (/,13X,'REMIX')
  440 WRITE (6,450)
  450 FORMAT (//,4X,'C( )',15X,'VALUE',/)
      WRITE (6,460) (I,C(I),I=1,M)
  460 FORMAT('0',4X,I2,12X,F12.7)
C
C      CALCULATE THE PLOTTING POINTS FOR THE BEST FIT CURVE.
C
      NSUM = 0
      DO 480 I=1,MAX10,1
      RI = I
      X(I) = ((RI/10.0) - 0.1)
      XTEMP = X(I) + XSTART
C
C     THE USER OF THIS PROGRAM SHOULD TAKE NOTE OF THE
C FOLLOWING:
C
C                1)  THE FUNCTION DEFINED ON THE NEXT RECORD OF THE
C                    PROGRAM.  THIS IS THE FUNCTION OF THE BEST FIT
C                    CURVE THAT WILL BE DRAWN THROUGH THE DATA
C                    POINTS.
C
C                2)  THE NUMBER OF CONSTANT'S (C'S) READ INTO THE
C                    PROGRAM MUST BE EQUAL TO AMOUNT DEFINED IN
C                    THIS FUNCTION.
C
C                3)  ONE MUST MAKE SURE THAT THE CONSTANTS ARE READ
C                    IN THE PROPER ORDER TO THE CORRESPONDING ONES
C                    DEFINED BY THE FUNCTION.
C
      Y(I) = (C(1)*XTEMP) + (C(2)*(XTEMP**2))
C
      IF (I.EQ.1) GO TO 470
      IF (Y(I).LT.Y(I-1)) GO TO 490
      IF (Y(I).GT.YMAX) GO TO 490
  470 NSUM = NSUM + 1
  480 CONTINUE
C
C      LIST THE BEST FIT CURVE PLOTTING VALUES.
C
  490 WRITE (6,500) MIXNO,DAY
  500 FORMAT ('1',////////,24X,
     &'BEST FIT CURVE PLOTTING VALUES',//,31X,'MIX NUMBER',I5,
     &//,29X,I2,3X,'DAY STRENGTH')
      IF (REMIX.EQ.0) GO TO 520
      WRITE (6,510)
  510 FORMAT (/,35X,'REMIX')
  520 WRITE (6,530)
  530 FORMAT (//,4X,'PLOTTING NUMBER',10X,'X-VALUES (STRAIN-%)',
     &10X,'Y-VALUES (STRESS-PSI)',/)
      WRITE (6,540) (I,X(I),Y(I),I=1,NSUM)
  540 FORMAT (' ',9X,I3,21X,F8.3,22X,F7.1)
C
```

CPLOT "Computer Program No. 3"

```
C      PLOT OUT THE BEST FIT CURVE.
C
       X (NSUM+1)=    0.0
       Y (NSUM+1)=    0.0
       X (NSUM+2)=    5.0
       Y (NSUM+2)=  160.0
C
       CALL NEWPEN (8)
       CALL FLINE (X,Y,-NSUM,1,0,0)
       IF (DASH.EQ.0) GO TO 550
       XDASH = (X(NSUM)/5.0) + 0.12
       YDASH = Y(NSUM)/160.0
       XEND = 4.0 - XDASH
       CALL PLOT (XDASH,YDASH,-3)
       CALL DASHP (XEND,0.0,0.12)
       CALL PLOT (-XDASH,-YDASH,-3)
   550 CALL NEWPEN (1)
C
C      ------ DEVELOP A LEGEND ------
C
C      PUT MAJOR AND MINOR INFORMATION INTO THE LEGEND.
C
       IF (NF.NE.1) GO TO 551
       CALL SYMBOL (2.74,6.86,0.14,'MIX NO. 1',0.0,9)
       CALL SYMBOL (2.88,6.58,0.14,'0% LIME',0.0,7)
       CALL SYMBOL (2.845,6.37,0.07,'ONE UNIT CLAY',0.0,13)
       CALL SYMBOL (3.055,6.23,0.07,'33.3% SAND',0.0,10)
       CALL SYMBOL (3.055,6.09,0.07,'1.75% FIBRES',0.0,12)
       CALL SYMBOL (3.055,5.95,0.07,'  83% M.C.',0.0,10)
       CALL SYMBOL (2.845,5.74,0.07,'28-DAY STRENGTH',0.0,15)
       CALL SYMBOL (3.16,5.53,0.07,'= CUBE 1',0.0,8)
       CALL SYMBOL (3.16,5.39,0.07,'= CUBE 2',0.0,8)
       CALL SYMBOL (3.16,5.25,0.07,'= CUBE 3',0.0,8)
       GO TO 600
   551 IF (NF.NE.2) GO TO 552
       CALL SYMBOL (2.74,6.86,0.14,'MIX NO. 2',0.0,9)
       CALL SYMBOL (2.88,6.58,0.14,'3% LIME',0.0,7)
       CALL SYMBOL (2.845,6.37,0.07,'ONE UNIT CLAY',0.0,13)
       CALL SYMBOL (3.055,6.23,0.07,'33.3% SAND',0.0,10)
       CALL SYMBOL (3.055,6.09,0.07,'1.75% FIBRES',0.0,12)
       CALL SYMBOL (3.055,5.95,0.07,' 140% M.C.',0.0,10)
       CALL SYMBOL (2.845,5.74,0.07,'28-DAY STRENGTH',0.0,15)
       CALL SYMBOL (3.16,5.53,0.07,'= CUBE 1',0.0,8)
       CALL SYMBOL (3.16,5.39,0.07,'= CUBE 2',0.0,8)
       CALL SYMBOL (3.16,5.25,0.07,'= CUBE 3',0.0,8)
       GO TO 600
   552 IF (NF.NE.3) GO TO 553
       CALL SYMBOL (2.74,6.86,0.14,'MIX NO. 3',0.0,9)
       CALL SYMBOL (2.74,6.58,0.14,'4.5% LIME',0.0,9)
       CALL SYMBOL (2.845,6.37,0.07,'ONE UNIT CLAY',0.0,13)
       CALL SYMBOL (3.055,6.23,0.07,'33.3% SAND',0.0,10)
       CALL SYMBOL (3.055,6.09,0.07,'1.75% FIBRES',0.0,12)
       CALL SYMBOL (3.055,5.95,0.07,' 142% M.C.',0.0,10)
       CALL SYMBOL (2.845,5.74,0.07,'28-DAY STRENGTH',0.0,15)
       CALL SYMBOL (3.16,5.53,0.07,'= CUBE 1',0.0,8)
       CALL SYMBOL (3.16,5.39,0.07,'= CUBE 2',0.0,8)
       CALL SYMBOL (3.16,5.25,0.07,'= CUBE 3',0.0,8)
       GO TO 600
   553 IF (NF.NE.4) GO TO 554
       CALL SYMBOL (2.74,6.86,0.14,'MIX NO. 4',0.0,9)
       CALL SYMBOL (2.88,6.58,0.14,'6% LIME',0.0,7)
       CALL SYMBOL (2.845,6.37,0.07,'ONE UNIT CLAY',0.0,13)
       CALL SYMBOL (3.055,6.23,0.07,'33.3% SAND',0.0,10)
```

CPLOT "Computer Program No. 3"

```
      CALL SYMBOL (3.055,6.09,0.07,'1.75% FIBRES',0.0,12)
      CALL SYMBOL (3.055,5.95,0.07,' 144% M.C.',0.0,10)
      CALL SYMBOL (2.845,5.74,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (3.16,5.53,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (3.16,5.39,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (3.16,5.25,0.07,'= CUBE 3',0.0,8)
      GO TO 600
  554 IF (NF.NE.5) GO TO 555
      CALL SYMBOL (4.00,6.95,0.14,'A',0.0,1)
      CALL SYMBOL (2.74,6.86,0.14,'MIX NO. 5',0.0,9)
      CALL SYMBOL (2.88,6.58,0.14,'8% LIME',0.0,7)
      CALL SYMBOL (2.845,6.37,0.07,'ONE UNIT CLAY',0.0,13)
      CALL SYMBOL (3.055,6.23,0.07,'33.3% SAND',0.0,10)
      CALL SYMBOL (3.055,6.09,0.07,'1.75% FIBRES',0.0,12)
      CALL SYMBOL (3.055,5.95,0.07,' 147% M.C.',0.0,10)
      CALL SYMBOL (2.845,5.74,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (3.16,5.53,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (3.16,5.39,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (3.16,5.25,0.07,'= CUBE 3',0.0,8)
      GO TO 600
  555 IF (NF.NE.6) GO TO 556
      CALL SYMBOL (4.00,6.95,0.14,'B',0.0,1)
      CALL SYMBOL (2.74,6.86,0.14,'MIX NO. 5',0.0,9)
      CALL SYMBOL (2.88,6.58,0.14,'8% LIME',0.0,7)
      CALL SYMBOL (2.845,6.37,0.07,'ONE UNIT CLAY',0.0,13)
      CALL SYMBOL (3.055,6.23,0.07,'33.3% SAND',0.0,10)
      CALL SYMBOL (3.055,6.09,0.07,'1.75% FIBRES',0.0,12)
      CALL SYMBOL (3.055,5.95,0.07,' 147% M.C.',0.0,10)
      CALL SYMBOL (2.845,5.74,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (3.16,5.53,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (3.16,5.39,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (3.16,5.25,0.07,'= CUBE 3',0.0,8)
      GO TO 600
  556 IF (NF.NE.7) GO TO 557
      CALL SYMBOL (2.74,6.86,0.14,'MIX NO. 6',0.0,9)
      CALL SYMBOL (2.81,6.58,0.14,'20% SAND',0.0,8)
      CALL SYMBOL (2.845,6.37,0.07,'ONE UNIT CLAY',0.0,13)
      CALL SYMBOL (3.055,6.23,0.07,'1.75% FIBRES',0.0,12)
      CALL SYMBOL (3.055,6.09,0.07,' 4.5% LIME',0.0,10)
      CALL SYMBOL (3.055,5.95,0.07,' 130% M.C.',0.0,10)
      CALL SYMBOL (2.845,5.74,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (3.16,5.53,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (3.16,5.39,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (3.16,5.25,0.07,'= CUBE 3',0.0,8)
      GO TO 600
  557 IF (NF.NE.8) GO TO 558
      CALL SYMBOL (2.74,6.86,0.14,'MIX NO. 7',0.0,9)
      CALL SYMBOL (2.81,6.58,0.14,'45% SAND',0.0,8)
      CALL SYMBOL (2.845,6.37,0.07,'ONE UNIT CLAY',0.0,13)
      CALL SYMBOL (3.055,6.23,0.07,'1.75% FIBRES',0.0,12)
      CALL SYMBOL (3.055,6.09,0.07,' 4.5% LIME',0.0,10)
      CALL SYMBOL (3.055,5.95,0.07,' 141% M.C.',0.0,10)
      CALL SYMBOL (2.845,5.74,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (3.16,5.53,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (3.16,5.39,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (3.16,5.25,0.07,'= CUBE 3',0.0,8)
      GO TO 600
  558 IF (NF.NE.9) GO TO 559
      CALL SYMBOL (2.74,6.86,0.14,'MIX NO. 8',0.0,9)
      CALL SYMBOL (2.81,6.58,0.14,'60% SAND',0.0,8)
      CALL SYMBOL (2.845,6.37,0.07,'ONE UNIT CLAY',0.0,13)
      CALL SYMBOL (3.055,6.23,0.07,'1.75% FIBRES',0.0,12)
      CALL SYMBOL (3.055,6.09,0.07,' 4.5% LIME',0.0,10)
```

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```
      CALL SYMBOL (3.055,5.95,0.07,' 136% M.C.',0.0,10)
      CALL SYMBOL (2.845,5.74,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (3.16,5.53,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (3.16,5.39,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (3.16,5.25,0.07,'= CUBE 3',0.0,8)
      GO TO 600
  559 IF (NF.NE.10) GO TO 560
      CALL SYMBOL (2.74,6.86,0.14,'MIX NO. 9',0.0,9)
      CALL SYMBOL (2.60,6.58,0.14,'1.0% FIBRES',0.0,11)
      CALL SYMBOL (2.92,6.37,0.07,'ONE UNIT CLAY',0.0,13)
      CALL SYMBOL (3.13,6.23,0.07,'33.3% SAND',0.0,10)
      CALL SYMBOL (3.20,6.09,0.07,'4.5% LIME',0.0,9)
      CALL SYMBOL (3.20,5.95,0.07,'124% M.C.',0.0,9)
      CALL SYMBOL (2.845,5.74,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (3.16,5.53,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (3.16,5.39,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (3.16,5.25,0.07,'= CUBE 3',0.0,8)
      GO TO 600
  560 IF (NF.NE.11) GO TO 561
      CALL SYMBOL (2.67,6.86,0.14,'MIX NO. 10',0.0,10)
      CALL SYMBOL (2.60,6.58,0.14,'2.5% FIBRES',0.0,11)
      CALL SYMBOL (2.92,6.37,0.07,'ONE UNIT CLAY',0.0,13)
      CALL SYMBOL (3.13,6.23,0.07,'33.3% SAND',0.0,10)
      CALL SYMBOL (3.20,6.09,0.07,'4.5% LIME',0.0,9)
      CALL SYMBOL (3.20,5.95,0.07,'138% M.C.',0.0,9)
      CALL SYMBOL (2.845,5.74,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (3.16,5.53,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (3.16,5.39,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (3.16,5.25,0.07,'= CUBE 3',0.0,8)
      GO TO 600
  561 IF (NF.NE.12) GO TO 562
      CALL SYMBOL (2.67,6.86,0.14,'MIX NO. 11',0.0,10)
      CALL SYMBOL (2.60,6.58,0.14,'5.0% FIBRES',0.0,11)
      CALL SYMBOL (2.92,6.37,0.07,'ONE UNIT CLAY',0.0,13)
      CALL SYMBOL (3.13,6.23,0.07,'33.3% SAND',0.0,10)
      CALL SYMBOL (3.20,6.09,0.07,'4.5% LIME',0.0,9)
      CALL SYMBOL (3.20,5.95,0.07,'148% M.C.',0.0,9)
      CALL SYMBOL (2.845,5.74,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (3.16,5.53,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (3.16,5.39,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (3.16,5.25,0.07,'= CUBE 3',0.0,8)
      GO TO 600
  562 IF (NF.NE.13) GO TO 600
      CALL SYMBOL (2.74,6.86,0.14,'MIX NO. 1',0.0,9)
      CALL SYMBOL (2.88,6.58,0.14,'0% LIME',0.0,7)
      CALL SYMBOL (2.845,6.37,0.07,'ONE UNIT CLAY',0.0,13)
      CALL SYMBOL (3.055,6.23,0.07,'33.3% SAND',0.0,10)
      CALL SYMBOL (3.055,6.09,0.07,'1.75% FIBRES',0.0,12)
      CALL SYMBOL (3.055,5.95,0.07,'  83% M.C.',0.0,10)
      CALL SYMBOL (2.845,5.74,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (3.16,5.53,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (3.16,5.39,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (3.16,5.25,0.07,'= CUBE 3',0.0,8)
      GO TO 600
C
C      THE FOLLOWING RECORDS WILL PLACE THE SYMBOLS USED FOR
C PLOTTING THE DATA POINTS INTO THE LEGEND.  ONE SYMBOL WILL BE
C USED FOR EACH DIFFERENT CUBE.
C
  600 IF (REMIX.EQ.1) GO TO 610
      CALL SYMBOL (3.055,5.565,0.07,0,0.0,-1)
      CALL SYMBOL (3.055,5.41333,0.07,2,0.0,-1)
      CALL SYMBOL (3.055,5.285,0.07,3,0.0,-1)
```

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```
      GO TO 620
  610 CALL SYMBOL (3.055,5.285,0.07,0,0.0,-1)
      CALL SYMBOL (3.055,5.13333,0.07,2,0.0,-1)
      CALL SYMBOL (3.055,5.005,0.07,3,0.0,-1)
C
  620 CALL PLOT (12.0,0.0,999)
C
C       ------ END OF PLOTTING ------
C
C
C
C ************************************************************
C *                                                          *
C *                                                          *
C *      ADJUSTED COEFFICIENT OF MULTIPLE DETERMINATION      *
C *                                                          *
C *                                                          *
C ************************************************************
C
C
C
C NOTES:  1)  THIS PROGRAM FOR CALCULATING THE ADJUSTED COEFFICIENT
C             OF MULTIPLE DETERMINATION WILL TAKE INTO ACCOUNT ALL
C             THE DATA POINTS READ IN, UP TO AND INCLUDING BOTH THE
C             MAXIMUM X AND Y VALUES.  IT IS REMINDED THOUGH, THAT
C             THE BEST FIT CURVE IS PLOTTED JUST TO THE POINT BEFORE
C             A NEGATIVE SLOPE STARTS OR AFTER YMAX IS REACHED.
C             THEREFORE THE BEST FIT CURVE MAY OR MAY NOT OF BEEN
C             DRAWN TO THE MAXIMUM X-VALUE DATA POINT.
C
C         2)  FOR THE ADJUSTED COEFFICIENT OF MULTIPLE DETERMINATION
C             TO BE CORRECTLY CALCULATED, THE BEST FIT EQUATION USED
C             IN THIS PART MUST MATCH WITH THE ONE USED ABOVE
C             (SEE "THE BEST FIT EQUATION").
C
C
C       TRANSFER THE ARRAYS XRAY1,2,3 AND YRAY1,2,3 TO ARRAYS
C MXDATA AND MYDATA RESPECTIVELY.
C
C
      P1 = 1
      P2 = P1 + (N1-1)
      DO 630 DP=P1,P2
      I = DP
      MXDATA(DP) = XRAY1(I)
      MYDATA(DP) = YRAY1(I)
  630 CONTINUE
      P3 = P2 + 1
      P4 = P3 + (N2-1)
      DO 640 DP=P3,P4
      J = DP - N1
      MXDATA(DP) = XRAY2(J)
      MYDATA(DP) = YRAY2(J)
  640 CONTINUE
      P5 = P4 + 1
      P6 = P5 + (N3-1)
      DO 650 DP=P5,P6
      K = DP - N2 - N1
      MXDATA(DP) = XRAY3(K)
      MYDATA(DP) = YRAY3(K)
  650 CONTINUE
C
C       CHECK TO SEE IF THE TRANSFER OF THE ARRAYS WAS
```

```
C SUCCESSFULLY DONE BY WRITING OUT THE ARRAYS MXDATA AND MYDATA.
C
      WRITE (6,660) MIXNO,DAY
  660 FORMAT ('1',////////,32X,'DATA POINTS',//,30X,
     &'MIX NUMBER',I5,//,29X,I2,3X,'DAY STRENGTH')
      IF (REMIX.EQ.0) GO TO 680
      WRITE (6,670)
  670 FORMAT (/,35X,'REMIX')
  680 WRITE (6,690)
  690 FORMAT (//,26X,'"ARRAY TRANSFER CHECK"')
      WRITE (6,700)
  700 FORMAT(//,4X,'DATA NUMBER',10X,'X-VALUES (STRAIN-%)',10X,
     &'Y-VALUES (STRESS-PSI)',/)
      WRITE (6,710) (L,MXDATA(L),MYDATA(L),L=1,N)
  710 FORMAT (' ',7X,I3,17X,F10.3,19X,F10.1)
C
C      DETERMINE THE ERROR SUM OF SQUARES
C WITH RESPECT TO Y - (SSEY).
C
C     ----- "THE BEST FIT EQUATION" -----
C
      SSEY = 0.0
      DO 720 NR=1,N
      XR2 = MXDATA(NR)
      YBF = (C(1)*XR2) + (C(2)*(XR2**2))
      DIFFE = MYDATA(NR) - YBF
      ADIFFE = ABS(DIFFE)
      SSEY = SSEY + ((ADIFFE)**2)
  720 CONTINUE
C
C      DETERMINE THE TOTAL SUM OF SQUARES
C WITH RESPECT TO Y - (SSTY).
C
      SSTY = 0.0
      SUMY = 0.0
      DO 730 NR=1,N
      SUMY = SUMY + MYDATA(NR)
  730 CONTINUE
      RN = N
      AVGY = SUMY/RN
      DO 740 NR=1,N
      DIFFY = (MYDATA(NR) - AVGY)
      ADIFFY = ABS(DIFFY)
      SSTY = SSTY + ((ADIFFY)**2)
  740 CONTINUE
C
C      DEFINE THE R-SQUARED ADJUSTMENT FACTOR.
C
C      THE PURPOSE OF THE R-SQUARED ADJUSTMENT FACTOR IS TO
C BALANCE THE COST OF USING MORE PARAMETERS (A HIGHER DEGREE
C POLYNOMIAL) AGAINST THE GAIN IN R-SQUARED.  SUCH THAT, AS
C ONE USES A HIGHER DEGREE POLYNOMINAL AS A BEST FIT CURVE,
C THE R-SQUARED WILL ALSO RISE.
C
      RN = N
      RM = M
      ADJFAC = (RN - 1.0)/(RN - (RM + 1.0))
C
C      CALCULATE AND WRITE OUT THE ADJUSTED COEFFICIENT OF
C MULTIPLE DETERMINATION (R-SQUARED).
C
      R2 = 1.0 - (ADJFAC * (SSEY/SSTY))
      IF (REMIX.EQ.0) GO TO 760
```

CPLOT "Computer Program No. 3"

```
      WRITE (6,750) MIXNO,DAY,R2
  750 FORMAT ('1',////////////////,62X,'2',/,9X,
     &'THE ADJUSTED COEFFICIENT OF MULTIPLE DETERMINATION (R )',
     &' FOR MIX NUMBER',3X,I2,',',//,4X,'REMIX AT THE',3X,I2,3X,
     &'DAY STRENGTH, RELATIVE TO THE BEST FIT EQUATION',//,4X,
     &'WHICH WAS USED, IS:',3X,F10.7)
      GO TO 780
  760 WRITE (6,770) MIXNO,DAY,R2
  770 FORMAT ('1',////////////////,62X,'2',/,9X,
     &'THE ADJUSTED COEFFICIENT OF MULTIPLE DETERMINATION (R )',
     &' FOR MIX NUMBER',3X,I2,',',//,4X,'AT THE',3X,I2,3X,
     &'DAY STRENGTH, RELATIVE TO THE BEST FIT EQUATION',//,4X,
     &'WHICH WAS USED, IS:',3X,F10.7)
C
  780 CONTINUE
      CALL PLOT (0.0,0.0,9999)
      STOP
      END
```

G.4 COMPUTER PROGRAM NO. 4 [25, 27]

Computer Program No. 4 performs simple plotting. Three sets of data points are plotted within specified axes and then for each set, a separate smooth curve is drawn from data point to data point. More details of this program are included in the program itself.

CSIMPLOT "Computer Program No. 4"

```
//NOFAILC JOB ',,,T=1M,L=5,I=10,C=0','RANDY ZAPOTOTSKY',
// MSGLEVEL=(1,1)
/*ROUTE PRINT SELF
/*D800 VPLOT
// EXEC FORTHCLG,USERLIB='SYS3.VPLOTLIB',SIZE=256K
//FORT.SYSIN DD *
C
C
C
C                   --- CSIMPLOT ---
C
C     --- THIS IS THE PROGRAM FOR SIMPLE PLOTTING ---
C               --- CLAY MORTAR MIXES ---
C
C
C
C     IN THIS PROGRAM THE FIRST THING THAT IS READ IN IS THE
C NUMBER OF PLOTS TO BE DRAWN.  THE CHARACTERISTICS, NAMELY
C THE ORGIN AND AXES, ARE THEN DEFINED AND PLOTTED OUT.
C FOR AESTHETICS PURPOSES ONLY, A FRAME IS THEN DRAWN AROUND
C THIS SET OF AXES.
C
C     FOLLOWING THE ABOVE, THE DATA POINTS ARE THEN READ IN,
C PLOTTED OUT WITHIN THE LIMITS OF THE CHARACTERISTICS OF THE
C PLOT AND THEN A SMOOTH LINE JOINS EACH SET OF POINTS.
C FOR EACH PLOT THREE SETS OF CURVES ARE SET OUT TO BE PLOTTED.
C
C     IN THE END, A LEGEND IS INSERTED IN THE INNER, UPPER
C RIGHT HAND CORNER OF THE PLOT.  IF NO LEGEND IS DESIRED, THIS
C PART CAN BE SKIPPED.
C
C     WHEN SUBMITTING A JOB, THE ORDER OF SUBMISSION IS:
C
C          1)  CSIMPLOT
C          2)  NOPLOT
C          3)  "FIRST DATA FILE"
C          4)  "SECOND DATA FILE"
C          5)  "THIRD DATA FILE"
C          |)    |     |    |
C          |)    |     |    |
C          N)  "N-2TH DATA FILE (LAST ONE)"
C
C     WHERE:
C               CSIMPLOT:  IS THE NAME OF THIS SIMPLE PLOTTING
C                          PROGRAM.
C
C                 NOPLOT:  CONTAINS THE FIRST JCL STATEMENT AND
C                          SPECIFIES THE NUMBER OF PLOTS TO BE
C                          PLOTTED.  THE FORM OF THIS FILE IS:
C
C                          1. //GO.SYSIN.DD *
C                          2. "NUMBER OF PLOTS"
C
C              DATA FILE:  THE FIRST OR ANY OTHER DATA FILE
C                          CONTAINS SOME BASIC INFORMATION ABOUT
C                          THE PLOT AND ITS DATA POINTS.  THE
C                          FORM OF A DATA FILE IS:
C
C                          1. MIXNO N N1 N2 N3 DAY REMIX
C                          2. X1       Y1
C                          3. X2       Y2
C                          |.  |        |
C                          |.  |        |
```

```
C                              N. X(N-1)  Y(N-1)
C
C                              WHERE:  MIXNO = THE MIX NUMBER
C                                          N = THE TOTAL NUMBER OF
C                                              DATA POINTS FOR THE
C                                              MIX.
C                                         N1 = THE TOTAL NUMBER OF
C                                              DATA POINTS FOR CUBE
C                                              NUMBER 1.
C                                         N2 = THE TOTAL NUMBER OF
C                                              DATA POINTS FOR CUBE
C                                              NUMBER 2.
C                                         N3 = THE TOTAL NUMBER OF
C                                              DATA POINTS FOR CUBE
C                                              NUMBER 3.
C                                        DAY = THE AGE (IN DAYS) OF
C                                              THE MIX AT THE TIME
C                                              OF TESTING.
C                                      REMIX = "0" WHEN THE MIX WAS
C                                                  NOT REMIXED.
C                                              "1" WHEN THE MIX WAS
C                                                  REMIXED.
C                                      X&Y'S = THE DATA POINTS.
C
C
C     ALSO, WHEN SUBMITTING A JOB, ONE MUST MAKE SURE THAT THE
C JCL ENDING THE DATA INFORMATION MUST BE PLACED AT THE CORRECT
C POSITION.  IF ONLY ONE PLOT IS TO BE PLOTTED, IT GOES AT THE
C END OF THE FIRST DATA FILE.  IN THE CASE WHERE TWO OR MORE
C PLOTS WILL BE DRAWN, THE JCL MUST BE PUT AT THE END OF THE
C LAST DATA FILE.
C
C     DEPENDING ON THE NUMBER AND TYPE OF PLOTS TO BE DONE, THE
C "DEVELOP A LEGEND" PART OF THE PROGRAM MUST BE MODIFIED
C ACCORDINGLY, IF USED.
C
C     LIMITATIONS OF THE DIMENSION STATEMENTS ARE AS FOLLOWS:
C
C          1)  STRAN_(__),STRES_(__)
C              MAXIMUM ALLOWABLE NUMBER OF DATA POINTS PER CUBE
C              READ IN IS 102 - 2 = 100
C
C
C
      DIMENSION IBUF(4000),STRAN1(102),STRES1(102),STRAN2(102),
     &STRES2(102),STRAN3(102),STRES3(102)
      INTEGER DAY,REMIX
C
C     READ AND WRITE OUT THE NUMBER OF PLOTS TO BE DRAWN
C
      READ (5,*) NOPLOT
      WRITE (6,5) NOPLOT
    5 FORMAT ('1',////////,4X,'THE NUMBER OF PLOTS THAT ',
     &'ARE TO BE DRAWN IS',3X,I3)
      DO 100 NP=1,NOPLOT
      CALL PLOTS (IBUF,4000)
C
C      DEFINE SOME CHARACTERISTICS OF THE PLOT.
C
      CALL PLOT (0.0,-11.0,-3)
      CALL PLOT (0.0,2.0625,-3)
      CALL FACTOR (1.0)
      CALL AXIS (0.0,0.0,'STRAIN - %',-10,4.0,0.0,0.0,16.0)
```

```
      CALL AXIS (0.0,0.0,'STRESS - PSI',12,7.0,90.0,0.0,160.0)
C
C       ------ DRAW A RECTANGULAR FRAME AROUND THE PLOT ------
C
      CALL NEWPEN (4)
      CALL RECT (-0.75,-1.25,9.0,5.5,0.0,3)
      CALL NEWPEN (1)
C
C       ------ READ AND WRITE OUT SOME BASIC INFORMATION ------
C
      READ (5,*) MIXNO,N,N1,N2,N3,DAY,REMIX
      WRITE (6,6) MIXNO,DAY
    6 FORMAT ('1',////////,4X,'THIS IS THE SIMPLE PLOT ',
     &'PROGRAM FOR MIX NUMBER',I5,3X,'AT THE',3X,I2,3X,
     &'DAY STRENGTH')
      WRITE (6,7) MIXNO,N
    7 FORMAT (////////,4X,
     &'THE TOTAL NUMBER OF DATA POINTS READ IN FOR MIX NUMBER',
     &I6,4X,'IS',I7)
      WRITE (6,8) N1,N2,N3
    8 FORMAT (////////,4X,
     &'THE NUMBER OF DATA POINTS READ IN FOR CUBE NUMBER  1 =',
     &1X,I3,//,42X,'CUBE NUMBER  2 =',1X,I3,//,42X,
     &'CUBE NUMBER  3 =',1X,I3)
      IF (REMIX.EQ.1) GO TO 10
      WRITE (6,9)
    9 FORMAT (////////,4X,'THE FOLLOWING DATA IS FOR THE MIX ',
     &'WHEN ITS COMPONENTS WERE COMBINED FOR THE FIRST TIME')
      GO TO 12
   10 WRITE (6,11)
   11 FORMAT (////////,4X,'THE FOLLOWING DATA IS FOR WHEN THE ',
     &'HARDENED ORIGINAL MIXTURE WAS CRUSHED AND REMIXED')
C
C       READ AND WRITE OUT THE DATA POINTS FOR THE MIX.
C
   12 READ (5,*) (STRAN1(I),STRES1(I),I=1,N1)
      READ (5,*) (STRAN2(J),STRES2(J),J=1,N2)
      READ (5,*) (STRAN3(K),STRES3(K),K=1,N3)
      WRITE (6,13) MIXNO,DAY
   13 FORMAT ('1',////////,32X,'DATA POINTS',//,30X,
     &'MIX NUMBER',I5,//,29X,I2,3X,'DAY STRENGTH')
      WRITE(6,14)
   14 FORMAT(//,4X,'DATA NUMBER',10X,'X-VALUES (STRAIN-%)',10X,
     &'Y-VALUES (STRESS-PSI)',/)
      WRITE (6,15)
   15 FORMAT (/,4X,'CUBE NUMBER  1',/)
      WRITE (6,18) (I,STRAN1(I),STRES1(I),I=1,N1)
      WRITE (6,16)
   16 FORMAT (//,4X,'CUBE NUMBER  2',/)
      WRITE (6,18) (J,STRAN2(J),STRES2(J),J=1,N2)
      WRITE (6,17)
   17 FORMAT (//,4X,'CUBE NUMBER  3',/)
      WRITE (6,18) (K,STRAN3(K),STRES3(K),K=1,N3)
   18 FORMAT (' ',7X,I3,17X,F10.3,19X,F10.1)
C
C     PLOT OUT THE DATA POINTS AND JOIN THE POINTS WITH A
C SMOOTH LINE.
C
      STRAN1 (N1+1)=   0.0
      STRES1 (N1+1)=   0.0
      STRAN1 (N1+2)=  16.0
      STRES1 (N1+2)= 160.0
C
```

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```
      STRAN2 (N2+1)=   0.0
      STRES2 (N2+1)=   0.0
      STRAN2 (N2+2)=  16.0
      STRES2 (N2+2)= 160.0
C
      STRAN3 (N3+1)=   0.0
      STRES3 (N3+1)=   0.0
      STRAN3 (N3+2)=  16.0
      STRES3 (N3+2)= 160.0
C
      CALL FLINE (STRAN1,STRES1,-N1,1,1,0)
      CALL FLINE (STRAN2,STRES2,-N2,1,1,2)
      CALL FLINE (STRAN3,STRES3,-N3,1,1,3)
C
C
C      ------ DEVELOP A LEGEND ------
C
C      PUT MAJOR AND MINOR INFORMATION INTO THE LEGEND.
C
      IF (NP.NE.1) GO TO 21
      CALL SYMBOL (2.74,6.86,0.14,'MIX NO. 7',0.0,9)
      CALL SYMBOL (2.81,6.58,0.14,'45% SAND',0.0,8)
      CALL SYMBOL (2.845,6.37,0.07,'ONE UNIT CLAY',0.0,13)
      CALL SYMBOL (3.055,6.23,0.07,'1.75% FIBRES',0.0,12)
      CALL SYMBOL (3.055,6.09,0.07,' 4.5% LIME',0.0,10)
      CALL SYMBOL (3.055,5.95,0.07,' 141% M.C.',0.0,10)
      CALL SYMBOL (2.845,5.74,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (3.16,5.53,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (3.16,5.39,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (3.16,5.25,0.07,'= CUBE 3',0.0,8)
      GO TO 97
   21 IF (NP.NE.2) GO TO 22
      CALL SYMBOL (2.74,6.86,0.14,'MIX NO. 8',0.0,9)
      CALL SYMBOL (2.81,6.58,0.14,'60% SAND',0.0,8)
      CALL SYMBOL (2.845,6.37,0.07,'ONE UNIT CLAY',0.0,13)
      CALL SYMBOL (3.055,6.23,0.07,'1.75% FIBRES',0.0,12)
      CALL SYMBOL (3.055,6.09,0.07,' 4.5% LIME',0.0,10)
      CALL SYMBOL (3.055,5.95,0.07,' 136% M.C.',0.0,10)
      CALL SYMBOL (2.845,5.74,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (3.16,5.53,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (3.16,5.39,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (3.16,5.25,0.07,'= CUBE 3',0.0,8)
      GO TO 97
   22 IF (NP.NE.3) GO TO 23
      CALL SYMBOL (2.67,6.86,0.14,'MIX NO. 10',0.0,10)
      CALL SYMBOL (2.60,6.58,0.14,'2.5% FIBRES',0.0,11)
      CALL SYMBOL (2.92,6.37,0.07,'ONE UNIT CLAY',0.0,13)
      CALL SYMBOL (3.13,6.23,0.07,'33.3% SAND',0.0,10)
      CALL SYMBOL (3.20,6.09,0.07,'4.5% LIME',0.0,9)
      CALL SYMBOL (3.20,5.95,0.07,'138% M.C.',0.0,9)
      CALL SYMBOL (2.845,5.74,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (3.16,5.53,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (3.16,5.39,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (3.16,5.25,0.07,'= CUBE 3',0.0,8)
      GO TO 97
   23 IF (NP.NE.4) GO TO 24
      CALL SYMBOL (2.67,6.86,0.14,'MIX NO. 11',0.0,10)
      CALL SYMBOL (2.60,6.58,0.14,'5.0% FIBRES',0.0,11)
      CALL SYMBOL (2.92,6.37,0.07,'ONE UNIT CLAY',0.0,13)
      CALL SYMBOL (3.13,6.23,0.07,'33.3% SAND',0.0,10)
      CALL SYMBOL (3.20,6.09,0.07,'4.5% LIME',0.0,9)
      CALL SYMBOL (3.20,5.95,0.07,'148% M.C.',0.0,9)
      CALL SYMBOL (2.845,5.74,0.07,'28-DAY STRENGTH',0.0,15)
```

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```
      CALL SYMBOL (3.16,5.53,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (3.16,5.39,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (3.16,5.25,0.07,'= CUBE 3',0.0,8)
      GO TO 97
   24 IF (NP.NE.5) GO TO 97
      CALL SYMBOL (2.74,6.86,0.14,'MIX NO. 7',0.0,9)
      CALL SYMBOL (2.81,6.58,0.14,'45% SAND',0.0,8)
      CALL SYMBOL (2.845,6.37,0.07,'ONE UNIT CLAY',0.0,13)
      CALL SYMBOL (3.055,6.23,0.07,'1.75% FIBRES',0.0,12)
      CALL SYMBOL (3.055,6.09,0.07,' 4.5% LIME',0.0,10)
      CALL SYMBOL (3.055,5.95,0.07,' 141% M.C.',0.0,10)
      CALL SYMBOL (2.845,5.74,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (3.16,5.53,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (3.16,5.39,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (3.16,5.25,0.07,'= CUBE 3',0.0,8)
C
C       THE FOLLOWING RECORDS WILL PLACE THE SYMBOLS USED FOR
C PLOTTING THE DATA POINTS INTO THE LEGEND.  ONE SYMBOL WILL BE
C USED FOR EACH DIFFERENT CUBE.
C
   97 IF (REMIX.EQ.1) GO TO 98
      CALL SYMBOL (3.055,5.565,0.07,0,0.0,-1)
      CALL SYMBOL (3.055,5.41333,0.07,2,0.0,-1)
      CALL SYMBOL (3.055,5.285,0.07,3,0.0,-1)
      GO TO 99
   98 CALL SYMBOL (3.055,5.285,0.07,0,0.0,-1)
      CALL SYMBOL (3.055,5.13333,0.07,2,0.0,-1)
      CALL SYMBOL (3.055,5.005,0.07,3,0.0,-1)
C
   99 CALL PLOT (12.0,0.0,999)
  100 CONTINUE
      CALL PLOT (0.0,0.0,9999)
      STOP
      END
```

G.5 COMPUTER PROGRAM NO. 5 [25, 27]

Using the best-fit curves plotted out in Computer Program 3, Computer Program No. 5 can take various combinations of these curves and plot them together on one plot. As set up, the maximum number of curves that this program can put together on one plot is six. If more than one combination plot is to be plotted upon the submission of this program, the number of curves for each plot must be the same along with the nature of the defined best-fit equation for each of the curves. More details of this program are included in the program itself.

CLAYCOMB "Computer Program No. 5"

```
//LIMECLAY JOB ',,,T=1M,L=5,I=10,C=0','RANDY ZAPOTOTSKY',CLASS=F,
// MSGLEVEL=(1,1)
/*ROUTE PRINT SELF
/*D800 VPLOT
// EXEC FORTHCLG,USERLIB='SYS3.VPLOTLIB',SIZE=256K
//FORT.SYSIN DD *
C
C
C
C          --- THIS IS THE COMBINATION PLOTTING PROGRAM ---
C                   --- CLAY MORTAR MIXES ---
C
C
C
C     WHAT THIS PROGRAM BASICALLY DOES IS THAT IT DRAWS FROM ONE
C UP TO SIX CURVES ON ONE SET OF AXES.  ONE SUCH PLOT IS CALLED A
C COMBINATION PLOT.  THE NUMBER OF COMBINATION PLOT(S) TO BE DRAWN
C IS DEPENDANT UPON THE VALUE OF NOCOMB, OF WHICH IS READ IN.
C
C     THE ORDER OF FILE SUBMISSION IS:  CLAYCOMB
C                                       NOCOMB
C                                       COMBDATA - "COMBINATION DATA"
C
C     WHERE:  CLAYCOMB = THE NAME OF THIS PROGRAM
C
C                NOCOMB - HAS THE FORM AS FOLLOWS:
C                         1.//GO.SYSIN DD *
C                         2. "NUMBER OF COMBINATION PLOT(S) THAT ARE
C                             TO BE DRAWN - NOCOMB"
C                         3. "NUMBER OF CURVES TO BE DRAWN ON EACH
C                             COMBINATION PLOT - NOCURV"
C
C              COMBDATA - HAS THE FORM AS FOLLOWS:
C
C                1. MIXNO,M,DAY,REMIX,XSTART,MAX10,XLAST,YMAX,DASH
C                2. C1
C                3. C2
C                4. |
C              M+1. CM
C
C     WHERE:
C
C   MIXNO = THE MIX NUMBER
C       M = THE NUMBER OF CONSTANT(S) USED FOR THE BEST FIT EQUATION
C     DAY = THE AGE OF THE MIX, IN DAYS
C   REMIX = "0" IF THE MIX WAS MIXED TOGETHER FOR THE FIRST TIME
C         = "1" IF THE HARDENED ORIGINAL MIX WAS CRUSHED AND REMIXED
C  XSTART = THE EXPERIMENTAL CORRECTION FACTOR TO THE X-VALUES;
C           XSTART IS POSITIVE IF MOVING THE X-VALUES TO THE LEFT
C   MAX10 = (SEE DESCRIPTION BELOW)
C   XLAST = THE MAXIMUM X-VALUE OBTAINED DURING THE BEST FIT PLOTTING
C    YMAX =  "      "    Y-VALUE      "         "     "    "    "     "
C    DASH = (SEE DESCRIPTION BELOW)
C      C_ = THE CONSTANT(S) OF THE BEST FIT EQUATION
C
C     IT SHOULD BE NOTED HERE THAT LINES 1 TO M+1 ARE TO BE REPEATED
C THE SAME NUMBER OF TIMES (UP TO A MAXIMUM OF SIX) AS THE NUMBER OF
C CURVES THAT ARE TO BE PLOTTED ON EACH COMBINATION PLOT.
C
C     ALSO, THE NUMBER AND THE CORRESPONDING CONSTANT(S) MUST MATCH
C THOSE DEFINED FOR EACH CURVE DRAWN ON ANY COMBINATION PLOT.
C IF MORE THAN ONE COMBINATION PLOT IS TO BE DRAWN, THEY MUST ALL BE
C SIMILAR IN NATURE DUE TO THE DEFINED BEST FIT EQUATION(S) FOR
```

```
C EACH OF THE CURVE(S).
C
C      TO SATISFY THE "DO" STATEMENT RULE OF ONLY USING INTEGERS
C GREATER THAN ZERO AND TO OBTAIN AN INCREMENT OF 0.1% STRAIN
C (X-VALUES) WHEN PLOTTING THE BEST FIT CURVE, MAX10 IS
C DEFINED AS FOLLOWS:
C
C            MAX10 = (MAX STRAIN(%) - XSTART + 0.1) * 10
C
C FROM THIS MODIFICATION TO THE MAXIMUM STRAIN VALUE, ONLY
C THE INTEGER PART OF THE NUMBER IS PUT INTO THE DATA FILE,
C IN ORDER TO SATISY THE INTEGER RULE OF A DO LOOP.
C WHEN PLOTTING IT WILL BECOME CLOSE ENOUGH TO THE MAXIMUM
C STRAIN VALUE OBTAINED IN A MIX.  THE LAST DATA POINT PLOTTED
C DURING THE BEST FIT PLOTTING WILL BE OBTAINED WITH THE USE
C OF XLAST.
C
C      FROM THE PROGRAM THIS MODIFICATION COMES FROM:
C
C            X_(I) = ((R_/10.0) - 0.1)
C
C      THE "-0.1" IS NEEDED SO THAT X IS EQUAL TO ZERO FOR THE
C FIRST VALUE.  THIS WILL MAKE THE BEST FIT CURVE PASS THROUGH
C THE ORIGIN.
C
C      MAX10 MUST BE DEFINED FOR EACH INDEPENDANT MIX.
C AGAIN, IT MUST BE PUT INTO A DATA FILE AS AN
C INTEGER, NOT A REAL NUMBER, TO SATISFY THE INTEGER
C RULE OF A DO LOOP.
C
C      A CHECK WILL BE DONE NEAR THE DEFINED FUNCTION SO AS TO
C PREVENT THE BEST FIT CURVE HAVING A NEGATIVE SLOPE AND A
C Y VALUE GREATER THAN THAT OBTAINED DURING THE BEST FIT PLOTTING.
C THIS IS DONE WITH THE USE OF YMAX AS DEFINED ABOVE.
C A NEGATIVE SLOPE IS UNFAVORABLE SINCE IT DOES NOT REPRESENT
C WHAT HAPPENED IN THE ACTUAL TESTS.
C
C      IF THE MIX DID NOT HAVE PEAK LOADS FOR ALL OF THE CUBES,
C A STRAIGHT DASHED LINE WILL BE DRAWN HORIZONTALLY FROM THE
C END OF THE BEST FIT CURVE TO THE FAR RIGHT OF THE PLOT.  THIS
C DASHED LINE WILL REPRESENT THAT LOADING WAS CONTINUED AFTER
C THIS CUT-OFF POINT, BUT NO PEAK LOAD OCCURRED.  IT SHOULD BE
C NOTED THOUGH THAT THE PATH OF THIS DASHED LINE DOES NOT
C NECESSARILY REPRESENT THE ACTUAL PATH TAKEN DURING THE TEST OR
C OF THE BEST FIT CURVE.
C      THIS DASHED LINE WILL NOT BE DRAWN WHEN THE VALUE OF
C "DASH" IS EQUAL TO "0" (ZERO).  WHEN "DASH" IS EQUAL TO
C "1" (ONE), A DASHED LINE WILL BE DRAWN.
C
C     A LEGEND MAY BE INSERTED AT THE END OF EACH COMBINATION
C PLOT(S) BY INSERTING THE PROPER "CALL SYMBOL" STATEMENTS AT THE
C END OF THE OUTER DO LOOP.
C
C     AT THE END OF THE DATA FILE(S), THE PROPER JCL MUST BE
C DEFINED IN ORDER FOR THE PROGRAM TO RUN.
C
C      DUE TO THE LIMITS ON THE DIMENSION STATEMENTS THE
C FOLLOWING LIMITS ARE DEFINED:
C
C            1)  C(__)
C                MAXIMUM ALLOWABLE NUMBER OF CONSTANT(S)
C                PER PLOTTED CURVE IS 10
C
```

```
C            2)  X_(__),Y_(__)
C                MAXIMUM ALLOWABLE NUMBER OF PLOTTING DATA POINTS
C                PER CURVE IS 502 - 2 = 500
C
C
C
      DIMENSION IBUF(4000),
     &C(10),X1(502),Y1(502),X2(502),Y2(502),X3(502),Y3(502),
     &X4(502),Y4(502),X5(502),Y5(502),X6(502),Y6(502)
      INTEGER DAY,REMIX
C
C      READ AND WRITE OUT THE NUMBER OF COMBINATION PLOT(S) AND THE
C      NUMBER OF CURVE(S) PER PLOT THAT ARE TO BE DRAWN
C
      READ (5,*) NOCOMB,NOCURV
      WRITE (6,50) NOCOMB
   50 FORMAT ('1',////,4X,'THE NUMBER OF COMBINATION PLOT(S) ',
     &'THAT ARE TO BE DRAWN IS',3X,I3)
      WRITE (6,60) NOCURV
   60 FORMAT (////,4X,'THE NUMBER OF CURVE(S) TO BE DRAWN ON ',
     &'EACH PLOT IS',3X,I3)
C
      DO 610 NC=1,NOCOMB
      CALL PLOTS (IBUF,4000)
C
C      DEFINE SOME CHARACTERISTICS OF THE PLOT
C
      CALL PLOT (0.0,-11.0,-3)
      CALL PLOT (0.0,2.0625,-3)
      CALL FACTOR (1.0)
      CALL AXIS (0.0,0.0,'STRAIN - %',-10,4.0,0.0,0.0,5.0)
      CALL AXIS (0.0,0.0,'STRESS - PSI',12,7.0,90.0,0.0,160.0)
C
C     DRAW A RECTANGULAR FRAME AROUND THE PLOT
C
      CALL NEWPEN (4)
      CALL RECT (-0.75,-1.25,9.0,5.5,0.0,3)
      CALL NEWPEN (1)
C
      DO 590 NCURV=1,NOCURV
C
C     READ AND WRITE OUT SOME BASIC INFORMATION ABOUT THE MIX
C
      READ (5,*) MIXNO,M,DAY,REMIX,XSTART,MAX10,XLAST,YMAX,DASH
C
      WRITE (6,70) MIXNO,DAY
   70 FORMAT ('1',//////,4X,
     &'THIS IS THE CLAYCOMB PROGRAM INFORMATION FOR MIX NUMBER',3X,
     &I3,3X,'AT THE',3X,I2,3X,'DAY STRENGTH')
      WRITE (6,80) MIXNO,M
   80 FORMAT (//////,4X,'THE NUMBER OF CONSTANT(S)-M READ IN FOR ',
     &'MIX NUMBER',3X,I3,3X,'IS',3X,I3,3X)
      IF (REMIX.EQ.1) GO TO 100
      WRITE (6,90)
   90 FORMAT (//////,4X,'THE FOLLOWING DATA IS FOR THE MIX ',
     &'WHEN ITS COMPONENTS WERE COMBINED FOR THE FIRST TIME')
      GO TO 120
  100 WRITE (6,110)
  110 FORMAT (//////,4X,'THE FOLLOWING DATA IS FOR WHEN THE ',
     &'HARDENED ORIGINAL MIXTURE WAS CRUSHED AND REMIXED')
  120 WRITE (6,130) XSTART
  130 FORMAT (//////,4X,'THE VALUE OF XSTART READ IN IS',
     &2X,F6.3)
```

```
      WRITE (6,140) MIXNO,MAX10
  140 FORMAT (//////,4X,
     &'THE VALUE OF MAX10 THAT WAS READ IN FOR MIX NUMBER',I5,
     &3X,'IS',3X,I4)
      WRITE (6,150) XLAST
  150 FORMAT (//////,4X,'THE HIGHEST STRAIN THAT WAS REACHED ',
     &'DURING THE BEST FIT PLOTTING IS',3X,F7.3,3X,'%')
      WRITE (6,160) YMAX
  160 FORMAT (//////,4X,'THE HIGHEST STRESS THAT WAS REACHED ',
     &'DURING THE BEST FIT PLOTTING IS',3X,F6.1,3X,'PSI')
      IF (DASH.EQ.0) GO TO 180
      WRITE (6,170)
  170 FORMAT (//////,4X,'DURING THE TESTING,',
     &' THIS MIX DID NOT HAVE PEAK LOADS FOR ALL OF THE SPECIMENS.')
      GO TO 200
  180 WRITE (6,190)
  190 FORMAT (//////,4X,'DURING THE TESTING,',
     &' THIS MIX HAD PEAK LOADS FOR ALL OF THE SPECIMENS.')
C
C       READ AND WRITE OUT THE CONSTANTS (C-VALUES)
C
  200 READ (5,*) (C(I),I=1,M)
C
      WRITE (6,210) MIXNO,DAY
  210 FORMAT ('1',////////,11X,'C VALUES',//,9X,'MIX NUMBER',
     &1X,I2,//,8X,I2,1X,'DAY STRENGTH')
      IF (REMIX.EQ.0) GO TO 230
      WRITE (6,220)
  220 FORMAT (/,13X,'REMIX')
  230 WRITE (6,240)
  240 FORMAT (//,4X,'C( )',15X,'VALUE',/)
      WRITE (6,250) (I,C(I),I=1,M)
  250 FORMAT('0',4X,I2,12X,F12.7)
C
C      CALCULATE THE BEST FIT CURVE PLOTTING POINTS - CURVE NO. 1
C
      IF (NCURV.NE.1) GO TO 340
      NSUM1 = 0
      DO 260 I=1,MAX10
      RI=I
      X1(I) = ((RI/10.0) - 0.1)
      IF (X1(I).GE.XLAST) GO TO 270
      XTEMP = X1(I) + XSTART
      Y1(I) = (C(1)) + (C(2)*XTEMP) + (C(3)*(XTEMP**2)) +
     &(C(4)*(XTEMP**3))
      IF (Y1(I).GT.YMAX) GO TO 270
      NSUM1 = NSUM1 + 1
  260 CONTINUE
  270 X1(NSUM1 + 1) = XLAST
      XLTEMP = XLAST + XSTART
      Y1(NSUM1 + 1) = (C(1)) + (C(2)*XLTEMP) + (C(3)*(XLTEMP**2)) +
     &(C(4)*(XLTEMP**3))
      NSUM1 = NSUM1 + 1
C
C       LIST THE BEST FIT CURVE PLOTTING VALUES - CURVE NO. 1
C
      WRITE (6,280) MIXNO,DAY
  280 FORMAT ('1',////////,24X,
     &'BEST FIT CURVE PLOTTING VALUES',//,31X,'MIX NUMBER',I5,
     &//,29X,I2,3X,'DAY STRENGTH')
      IF (REMIX.EQ.0) GO TO 300
      WRITE (6,290)
  290 FORMAT (/,35X,'REMIX')
```

```
      300 WRITE (6,310)
      310 FORMAT (//,4X,'PLOTTING NUMBER',10X,'X-VALUES (STRAIN-%)',
         &10X,'Y-VALUES (STRESS-PSI)',/)
          WRITE (6,320) (I,X1(I),Y1(I),I=1,NSUM1)
      320 FORMAT (' ',9X,I3,21X,F8.3,22X,F7.1)
C
C         PLOT OUT THE BEST FIT CURVE - CURVE NO. 1
C
          X1(NSUM1+1)=   0.0
          Y1(NSUM1+1)=   0.0
          X1(NSUM1+2)=   5.0
          Y1(NSUM1+2)= 160.0
C
          CALL NEWPEN(8)
          CALL FLINE (X1,Y1,-NSUM1,1,0,0)
          IF (DASH.EQ.0) GO TO 330
          XDASH = (X1(NSUM1)/5.0) + 0.12
          YDASH = Y1(NSUM1)/160.0
          XEND = 4.0 - XDASH
          CALL PLOT (XDASH,YDASH,-3)
          CALL DASHP (XEND,0.0,0.12)
          CALL PLOT (-XDASH,-YDASH,-3)
      330 CALL PLOT (0.0,0.0,3)
          CALL NEWPEN(1)
          GO TO 590
C
C         CALCULATE THE BEST FIT CURVE PLOTTING POINTS - CURVE NO. 2
C
      340 IF (NCURV.NE.2) GO TO 390
          NSUM2 = 0
          DO 350 J=1,MAX10
          RJ=J
          X2(J) = ((RJ/10.0) - 0.1)
          IF (X2(J).GE.XLAST) GO TO 360
          XTEMP = X2(J) + XSTART
          Y2(J) = (C(1)) + (C(2)*XTEMP) + (C(3)*(XTEMP**2)) +
         &(C(4)*(XTEMP**3))
          IF (Y2(J).GT.YMAX) GO TO 360
          NSUM2 = NSUM2 + 1
      350 CONTINUE
      360 X2(NSUM2 + 1) = XLAST
          XLTEMP = XLAST + XSTART
          Y2(NSUM2 + 1) = (C(1)) + (C(2)*XLTEMP) + (C(3)*(XLTEMP**2)) +
         &(C(4)*(XLTEMP**3))
          NSUM2 = NSUM2 + 1
C
C         LIST THE BEST FIT CURVE PLOTTING VALUES - CURVE NO. 2
C
          WRITE (6,280) MIXNO,DAY
          IF (REMIX.EQ.0) GO TO 370
          WRITE (6,290)
      370 WRITE (6,310)
          WRITE (6,320) (J,X2(J),Y2(J),J=1,NSUM2)
C
C         PLOT OUT THE BEST FIT CURVE - CURVE NO. 2
C
          X2(NSUM2+1)=   0.0
          Y2(NSUM2+1)=   0.0
          X2(NSUM2+2)=   5.0
          Y2(NSUM2+2)= 160.0
C
          CALL NEWPEN(8)
          CALL FLINE (X2,Y2,-NSUM2,1,0,0)
```

```
      IF (DASH.EQ.0) GO TO 380
      XDASH = (X2(NSUM2)/5.0) + 0.12
      YDASH = Y2(NSUM2)/160.0
      XEND = 4.0 - XDASH
      CALL PLOT (XDASH,YDASH,-3)
      CALL DASHP (XEND,0.0,0.12)
      CALL PLOT (-XDASH,-YDASH,-3)
  380 CALL PLOT (0.0,0.0,3)
      CALL NEWPEN(1)
      GO TO 590
C
C     CALCULATE THE BEST FIT CURVE PLOTTING POINTS - CURVE NO. 3
C
  390 IF (NCURV.NE.3) GO TO 440
      NSUM3 = 0
      DO 400 K=1,MAX10
      RK=K
      X3(K) = ((RK/10.0) - 0.1)
      IF (X3(K).GE.XLAST) GO TO 410
      XTEMP = X3(K) + XSTART
      Y3(K) = (C(1)) + (C(2)*XTEMP) + (C(3)*(XTEMP**2)) +
     &(C(4)*(XTEMP**3))
      IF (Y3(K).GT.YMAX) GO TO 410
      NSUM3 = NSUM3 + 1
  400 CONTINUE
  410 X3(NSUM3 + 1) = XLAST
      XLTEMP = XLAST + XSTART
      Y3(NSUM3 + 1) = (C(1)) + (C(2)*XLTEMP) + (C(3)*(XLTEMP**2)) +
     &(C(4)*(XLTEMP**3))
      NSUM3 = NSUM3 + 1
C
C     LIST THE BEST FIT CURVE PLOTTING POINTS - CURVE NO. 3
C
      WRITE (6,280) MIXNO,DAY
      IF (REMIX.EQ.0) GO TO 420
      WRITE (6,290)
  420 WRITE (6,310)
      WRITE (6,320) (K,X3(K),Y3(K),K=1,NSUM3)
C
C     PLOT OUT THE BEST FIT CURVE - CURVE NO. 3
C
      X3(NSUM3+1)=   0.0
      Y3(NSUM3+1)=   0.0
      X3(NSUM3+2)=   5.0
      Y3(NSUM3+2)= 160.0
C
      CALL NEWPEN(8)
      CALL FLINE (X3,Y3,-NSUM3,1,0,0)
      IF (DASH.EQ.0) GO TO 430
      XDASH = (X3(NSUM3)/5.0) + 0.12
      YDASH = Y3(NSUM3)/160.0
      XEND = 4.0 - XDASH
      CALL PLOT (XDASH,YDASH,-3)
      CALL DASHP (XEND,0.0,0.12)
      CALL PLOT (-XDASH,-YDASH,-3)
  430 CALL PLOT (0.0,0.0,3)
      CALL NEWPEN(1)
      GO TO 590
C
C     CALCULATE THE BEST FIT CURVE PLOTTING POINTS - CURVE NO. 4
C
  440 IF (NCURV.NE.4) GO TO 490
      NSUM4 = 0
```

```
      DO 450 L=1,MAX10
      RL=L
      X4(L) = ((RL/10.0) - 0.1)
      IF (X4(L).GE.XLAST) GO TO 460
      XTEMP = X4(L) + XSTART
      Y4(L) = (C(1)) + (C(2)*XTEMP) + (C(3)*(XTEMP**2)) +
     &(C(4)*(XTEMP**3))
      IF (Y4(L).GT.YMAX) GO TO 460
      NSUM4 = NSUM4 + 1
  450 CONTINUE
  460 X4(NSUM4 + 1) =XLAST
      XLTEMP = XLAST + XSTART
      Y4(NSUM4 + 1) = (C(1)) + (C(2)*XLTEMP) + (C(3)*(XLTEMP**2)) +
     &(C(4)*(XLTEMP**3))
      NSUM4 = NSUM4 + 1
C
C     LIST THE BEST FIT CURVE PLOTTING POINTS - CURVE NO. 4
C
      WRITE (6,280) MIXNO,DAY
      IF (REMIX.EQ.0) GO TO 470
      WRITE (6,290)
  470 WRITE (6,310)
      WRITE (6,320) (L,X4(L),Y4(L),L=1,NSUM4)
C
C     PLOT OUT THE BEST FIT CURVE - CURVE NO. 4
C
      X4(NSUM4+1)=   0.0
      Y4(NSUM4+1)=   0.0
      X4(NSUM4+2)=   5.0
      Y4(NSUM4+2)= 160.0
C
      CALL NEWPEN(8)
      CALL FLINE (X4,Y4,-NSUM4,1,0,0)
      IF (DASH.EQ.0) GO TO 480
      XDASH = (X4(NSUM4)/5.0) + 0.12
      YDASH = Y4(NSUM4)/160.0
      XEND = 4.0 - XDASH
      CALL PLOT (XDASH,YDASH,-3)
      CALL DASHP (XEND,0.0,0.12)
      CALL PLOT (-XDASH,-YDASH,-3)
  480 CALL PLOT (0.0,0.0,3)
      CALL NEWPEN(1)
      GO TO 590
C
C     CALCULATE THE BEST FIT CURVE PLOTTING POINTS - CURVE NO. 5
C
  490 IF (NCURV.NE.5) GO TO 540
      NSUM5 = 0
      DO 500 MJ=1,MAX10
      RMJ=MJ
      X5(MJ) = ((RMJ/10.0) - 0.1)
      IF (X5(MJ).GE.XLAST) GO TO 510
      XTEMP = X5(MJ) + XSTART
      Y5(MJ) = (C(1)) + (C(2)*XTEMP) + (C(3)*(XTEMP**2)) +
     &(C(4)*(XTEMP**3))
      IF (Y5(MJ).GT.YMAX) GO TO 510
      NSUM5 = NSUM5 + 1
  500 CONTINUE
  510 X5(NSUM5 + 1) = XLAST
      XLTEMP = XLAST + XSTART
      Y5(NSUM5 + 1) = (C(1)) + (C(2)*XLTEMP) + (C(3)*(XLTEMP**2)) +
     &(C(4)*(XLTEMP**3))
      NSUM5 = NSUM5 + 1
```

```
C
C     LIST THE BEST FIT CURVE PLOTTING POINTS - CURVE NO. 5
C
      WRITE (6,280) MIXNO,DAY
      IF (REMIX.EQ.0) GO TO 520
      WRITE (6,290)
  520 WRITE (6,310)
      WRITE (6,320) (MJ,X5(MJ),Y5(MJ),MJ=1,NSUM5)
C
C     PLOT OUT THE BEST FIT CURVE - CURVE NO. 5
C
      X5(NSUM5+1)=   0.0
      Y5(NSUM5+1)=   0.0
      X5(NSUM5+2)=   5.0
      Y5(NSUM5+2)= 160.0
C
      CALL NEWPEN(8)
      CALL FLINE (X5,Y5,-NSUM5,1,0,0)
      IF (DASH.EQ.0) GO TO 530
      XDASH = (X5(NSUM5)/5.0) + 0.12
      YDASH = Y5(NSUM5)/160.0
      XEND = 4.0 - XDASH
      CALL PLOT (XDASH,YDASH,-3)
      CALL DASHP (XEND,0.0,0.12)
      CALL PLOT (-XDASH,-YDASH,-3)
  530 CALL PLOT (0.0,0.0,3)
      CALL NEWPEN(1)
      GO TO 590
C
C     CALCULATE THE BEST FIT CURVE PLOTTING POINTS - CURVE NO. 6
C
  540 IF (NCURV.NE.6) GO TO 590
      NSUM6 = 0
      DO 550  NJ=1,MAX10
      RNJ=NJ
      X6(NJ) = ((RNJ/10.0) - 0.1)
      IF (X6(NJ).GE.XLAST) GO TO 560
      XTEMP = X6(NJ) + XSTART
      Y6(NJ) = (C(1)) + (C(2)*XTEMP) + (C(3)*(XTEMP**2)) +
     &(C(4)*(XTEMP**3))
      IF (Y6(NJ).GT.YMAX) GO TO 560
      NSUM6 = NSUM6 + 1
  550 CONTINUE
  560 X6(NSUM6 + 1) = XLAST
      XLTEMP = XLAST + XSTART
      Y6(NSUM6 + 1) = (C(1)) + (C(2)*XLTEMP) + (C(3)*(XLTEMP**2)) +
     &(C(4)*(XLTEMP**3))
      NSUM6 = NSUM6 + 1
C
C     LIST THE BEST FIT CURVE PLOTTING POINTS - CURVE NO. 6
C
      WRITE (6,280) MIXNO,DAY
      IF (REMIX.EQ.0) GO TO 570
      WRITE (6,290)
  570 WRITE (6,310)
      WRITE (6,320) (NJ,X6(NJ),Y6(NJ),NJ=1,NSUM6)
C
C     PLOT OUT THE BEST FIT CURVE - CURVE NO. 6
C
      X6(NSUM6+1)=   0.0
      Y6(NSUM6+1)=   0.0
      X6(NSUM6+2)=   5.0
      Y6(NSUM6+2)= 160.0
```

CLAYCOMB "Computer Program No. 5"

```
C
      CALL NEWPEN(8)
      CALL FLINE (X6,Y6,-NSUM6,1,0,0)
      IF (DASH.EQ.0) GO TO 580
      XDASH = (X6(NSUM6)/5.0) + 0.12
      YDASH = Y6(NSUM6)/160.0
      XEND = 4.0 - XDASH
      CALL PLOT (XDASH,YDASH,-3)
      CALL DASHP (XEND,0.0,0.12)
      CALL PLOT (-XDASH,-YDASH,-3)
  580 CALL PLOT (0.0,0.0,3)
      CALL NEWPEN(1)
C
  590 CONTINUE
C
C     DEVELOP A LEGEND FOR COMBINATION PLOT NO. 1
C
      IF (NC.NE.1) GO TO 591
      CALL SYMBOL (2.46,6.86,0.14,'CLAY MORTAR',0.0,11)
      CALL SYMBOL (2.53,6.58,0.14,'LIME STUDY',0.0,10)
      CALL SYMBOL (3.615,6.37,0.07,'A',0.0,1)
      CALL SYMBOL (2.775,6.32,0.07,'MIX NOS. 1-5',0.0,12)
      CALL SYMBOL (2.705,6.18,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (2.705,5.97,0.07,'ONE UNIT CLAY',0.0,13)
      CALL SYMBOL (2.915,5.83,0.07,'33.3% SAND',0.0,10)
      CALL SYMBOL (2.915,5.69,0.07,'1.75% FIBRES',0.0,12)
      GO TO 609
C
C     DEVELOP A LEGEND FOR COMBINATION PLOT NO. 2
C
  591 IF (NC.NE.2) GO TO 609
      CALL SYMBOL (2.46,6.86,0.14,'CLAY MORTAR',0.0,11)
      CALL SYMBOL (2.53,6.58,0.14,'LIME STUDY',0.0,10)
      CALL SYMBOL (3.615,6.37,0.07,'A',0.0,1)
      CALL SYMBOL (2.775,6.32,0.07,'MIX NOS. 1-5',0.0,12)
      CALL SYMBOL (2.705,6.18,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (2.705,5.97,0.07,'ONE UNIT CLAY',0.0,13)
      CALL SYMBOL (2.915,5.83,0.07,'33.3% SAND',0.0,10)
      CALL SYMBOL (2.915,5.69,0.07,'1.75% FIBRES',0.0,12)
C
  609 CALL PLOT (12.0,0.0,999)
  610 CONTINUE
      CALL PLOT (0.0,0.0,9999)
      STOP
      END
```

G.6 COMPUTER PROGRAM NO. 6 [25, 27]

Computer Program No. 6 performs the same job as Computer Program No. 4 but is modified to be used for the lime-sand mortar mixes. Modifications were necessary due to the lower stress-strain values obtained with the lime-sand mortar mixes. This involved a reduction of the plot scales. More details of this program can be obtained from the description of Computer Program No. 4 and within the program itself.

LSIMPLOT "Computer Program No. 6"

```
//DAY28 JOB ',,,T=1M,L=5,I=10,C=0','RANDY ZAPOTOTSKY',CLASS=F,
// MSGLEVEL=(1,1)
/*ROUTE PRINT SELF
/*D800 VPLOT
// EXEC FORTHCLG,USERLIB='SYS3.VPLOTLIB',SIZE=256K
//FORT.SYSIN DD *
C
C
C
C                       --- LSIMPLOT ---
C
C     --- THIS IS THE PROGRAM FOR SIMPLE PLOTTING ---
C             --- LIME-SAND MORTAR MIXES ---
C
C
C
C     IN THIS PROGRAM THE FIRST THING THAT IS READ IN IS THE
C NUMBER OF PLOTS TO BE DRAWN.  THE CHARACTERISTICS, NAMELY
C THE ORGIN AND AXES, ARE THEN DEFINED AND PLOTTED OUT.
C FOR AESTHETICS PURPOSES ONLY, A FRAME IS THEN DRAWN AROUND
C THIS SET OF AXES.
C
C     FOLLOWING THE ABOVE, THE DATA POINTS ARE THEN READ IN,
C PLOTTED OUT WITHIN THE LIMITS OF THE CHARACTERISTICS OF THE
C PLOT AND THEN A SMOOTH LINE JOINS EACH SET OF POINTS.
C FOR EACH PLOT THREE SETS OF CURVES ARE SET OUT TO BE PLOTTED.
C
C     IN THE END, A LEGEND IS INSERTED IN THE INNER, UPPER
C RIGHT HAND CORNER OF THE PLOT.  IF NO LEGEND IS DESIRED, THIS
C PART CAN BE SKIPPED.
C
C     WHEN SUBMITTING A JOB, THE ORDER OF SUBMISSION IS:
C
C          1)  LSIMPLOT
C          2)  NOPLOT
C          3)  "FIRST DATA FILE"
C          4)  "SECOND DATA FILE"
C          5)  "THIRD DATA FILE"
C          |)   |    |    |
C          |)   |    |    |
C          N)  "N-2TH DATA FILE (LAST ONE)"
C
C     WHERE:
C               LSIMPLOT:  IS THE NAME OF THIS SIMPLE PLOTTING
C                          PROGRAM.
C
C                 NOPLOT:  CONTAINS THE FIRST JCL STATEMENT AND
C                          SPECIFIES THE NUMBER OF PLOTS TO BE
C                          PLOTTED.  THE FORM OF THIS FILE IS:
C
C                          1. //GO.SYSIN.DD *
C                          2. "NUMBER OF PLOTS"
C
C              DATA FILE:  THE FIRST OR ANY OTHER DATA FILE
C                          CONTAINS SOME BASIC INFORMATION ABOUT
C                          THE PLOT AND ITS DATA POINTS.  THE
C                          FORM OF A DATA FILE IS:
C
C                          1. MIXNO N N1 N2 N3 DAY REMIX
C                          2. X1       Y1
C                          3. X2       Y2
C                          |.  |       |
C                          |.  |       |
```

LSIMPLOT "Computer Program No. 6"

```
      C                          N. X(N-1)  Y(N-1)
      C
      C                          WHERE:  MIXNO = THE MIX NUMBER
      C                                      N = THE TOTAL NUMBER OF
      C                                          DATA POINTS FOR THE
      C                                          MIX.
      C                                     N1 = THE TOTAL NUMBER OF
      C                                          DATA POINTS FOR CUBE
      C                                          NUMBER 1.
      C                                     N2 = THE TOTAL NUMBER OF
      C                                          DATA POINTS FOR CUBE
      C                                          NUMBER 2.
      C                                     N3 = THE TOTAL NUMBER OF
      C                                          DATA POINTS FOR CUBE
      C                                          NUMBER 3.
      C                                    DAY = THE AGE (IN DAYS) OF
      C                                          THE MIX AT THE TIME
      C                                          OF TESTING.
      C                                  REMIX = "0" WHEN THE MIX WAS
      C                                              NOT REMIXED.
      C                                          "1" WHEN THE MIX WAS
      C                                              REMIXED.
      C                                  X&Y'S = THE DATA POINTS.
      C
      C
      C     ALSO, WHEN SUBMITTING A JOB, ONE MUST MAKE SURE THAT THE
      C JCL ENDING THE DATA INFORMATION MUST BE PLACED AT THE CORRECT
      C POSITION.  IF ONLY ONE PLOT IS TO BE PLOTTED, IT GOES AT THE
      C END OF THE FIRST DATA FILE.  IN THE CASE WHERE TWO OR MORE
      C PLOTS WILL BE DRAWN, THE JCL MUST BE PUT AT THE END OF THE
      C LAST DATA FILE.
      C
      C     DEPENDING ON THE NUMBER AND TYPE OF PLOTS TO BE DONE, THE
      C "DEVELOP A LEGEND" PART OF THE PROGRAM MUST BE MODIFIED
      C ACCORDINGLY, IF USED.
      C
      C     LIMITATIONS OF THE DIMENSION STATEMENTS ARE AS FOLLOWS:
      C
      C          1)  STRAN_(__),STRES_(__)
      C              MAXIMUM ALLOWABLE NUMBER OF DATA POINTS PER CUBE
      C              READ IN IS 102 - 2 = 100
      C
      C
      C
            DIMENSION IBUF(4000),STRAN1(102),STRES1(102),STRAN2(102),
           &STRES2(102),STRAN3(102),STRES3(102)
            INTEGER DAY,REMIX
      C
      C     READ AND WRITE OUT THE NUMBER OF PLOTS TO BE DRAWN
      C
            READ (5,*) NOPLOT
            WRITE (6,5) NOPLOT
          5 FORMAT ('1',////////,4X,'THE NUMBER OF PLOTS THAT ',
           &'ARE TO BE DRAWN IS',3X,I3)
            DO 100 NP=1,NOPLOT
            CALL PLOTS (IBUF,4000)
      C
      C      DEFINE SOME CHARACTERISTICS OF THE PLOT.
      C
            CALL PLOT (0.0,-11.0,-3)
            CALL PLOT (0.0,2.0625,-3)
            CALL FACTOR (1.0)
            CALL AXIS (0.0,0.0,'STRAIN - %',-10,4.0,0.0,0.0,1.0)
```

LSIMPLOT "Computer Program No. 6"

```
C
      CALL AXIS (0.0,0.0,'STRESS - PSI',12,7.0,90.0,0.0,25.0)
C
C       ------ DRAW A RECTANGULAR FRAME AROUND THE PLOT ------
C
      CALL NEWPEN (4)
      CALL RECT (-0.75,-1.25,9.0,5.5,0.0,3)
      CALL NEWPEN (1)
C
C       ------ READ AND WRITE OUT SOME BASIC INFORMATION ------
C
      READ (5,*) MIXNO,N,N1,N2,N3,DAY,REMIX
      WRITE (6,6) MIXNO,DAY
    6 FORMAT ('1',////////,4X,'THIS IS THE SIMPLE PLOT ',
     &'PROGRAM FOR MIX NUMBER',I5,3X,'AT THE',3X,I2,3X,
     &'DAY STRENGTH')
      WRITE (6,7) MIXNO,N
    7 FORMAT (////////,4X,
     &'THE TOTAL NUMBER OF DATA POINTS READ IN FOR MIX NUMBER',
     &I6,4X,'IS',I7)
      WRITE (6,8) N1,N2,N3
    8 FORMAT (////////,4X,
     &'THE NUMBER OF DATA POINTS READ IN FOR CUBE NUMBER  1 =',
     &1X,I3,//,42X,'CUBE NUMBER  2 =',1X,I3,//,42X,
     &'CUBE NUMBER  3 =',1X,I3)
      IF (REMIX.EQ.1) GO TO 10
      WRITE (6,9)
    9 FORMAT (////////,4X,'THE FOLLOWING DATA IS FOR THE MIX ',
     &'WHEN ITS COMPONENTS WERE COMBINED FOR THE FIRST TIME')
      GO TO 12
   10 WRITE (6,11)
   11 FORMAT (////////,4X,'THE FOLLOWING DATA IS FOR WHEN THE ',
     &'HARDENED ORIGINAL MIXTURE WAS CRUSHED AND REMIXED')
C
C       READ AND WRITE OUT THE DATA POINTS FOR THE MIX.
C
   12 READ (5,*) (STRAN1(I),STRES1(I),I=1,N1)
      READ (5,*) (STRAN2(J),STRES2(J),J=1,N2)
      READ (5,*) (STRAN3(K),STRES3(K),K=1,N3)
      WRITE (6,13) MIXNO,DAY
   13 FORMAT ('1',////////,32X,'DATA POINTS',//,30X,
     &'MIX NUMBER',I5,//,29X,I2,3X,'DAY STRENGTH')
      WRITE(6,14)
   14 FORMAT(//,4X,'DATA NUMBER',10X,'X-VALUES (STRAIN-%)',10X,
     &'Y-VALUES (STRESS-PSI)',/)
      WRITE (6,15)
   15 FORMAT (/,4X,'CUBE NUMBER  1',/)
      WRITE (6,18) (I,STRAN1(I),STRES1(I),I=1,N1)
      WRITE (6,16)
   16 FORMAT (//,4X,'CUBE NUMBER  2',/)
      WRITE (6,18) (J,STRAN2(J),STRES2(J),J=1,N2)
      WRITE (6,17)
   17 FORMAT (//,4X,'CUBE NUMBER  3',/)
      WRITE (6,18) (K,STRAN3(K),STRES3(K),K=1,N3)
   18 FORMAT (' ',7X,I3,17X,F10.3,19X,F10.1)
C
C     PLOT OUT THE DATA POINTS AND JOIN THE POINTS WITH A
C SMOOTH LINE.
C
      STRAN1 (N1+1)=  0.0
      STRES1 (N1+1)=  0.0
      STRAN1 (N1+2)=  1.0
      STRES1 (N1+2)= 25.0
C
```

```
      STRAN2 (N2+1)=  0.0
      STRES2 (N2+1)=  0.0
      STRAN2 (N2+2)=  1.0
      STRES2 (N2+2)= 25.0
C
      STRAN3 (N3+1)=  0.0
      STRES3 (N3+1)=  0.0
      STRAN3 (N3+2)=  1.0
      STRES3 (N3+2)= 25.0
C
      CALL FLINE (STRAN1,STRES1,-N1,1,1,0)
      CALL FLINE (STRAN2,STRES2,-N2,1,1,2)
      CALL FLINE (STRAN3,STRES3,-N3,1,1,3)
C
C
C      ------ DEVELOP A LEGEND ------
C
C      PUT MAJOR AND MINOR INFORMATION INTO THE LEGEND.
C
      IF (NP.NE.1) GO TO 36
      CALL SYMBOL (2.25,6.86,0.14,'MIX NO. 12',0.0,10)
      CALL SYMBOL (1.90,6.58,0.14,'LIME:SAND = 1:6',0.0,15)
      CALL SYMBOL (2.53,6.37,0.07,'LIME BRAND A',0.0,12)
      CALL SYMBOL (2.425,6.23,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (2.60,6.09,0.07,'20.4% M.C.',0.0,10)
      CALL SYMBOL (2.74,5.88,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (2.74,5.74,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (2.74,5.60,0.07,'= CUBE 3',0.0,8)
      GO TO 97
   36 IF (NP.NE.2) GO TO 37
      CALL SYMBOL (2.25,6.86,0.14,'MIX NO. 13',0.0,10)
      CALL SYMBOL (1.90,6.58,0.14,'LIME:SAND = 1:5',0.0,15)
      CALL SYMBOL (2.53,6.37,0.07,'LIME BRAND A',0.0,12)
      CALL SYMBOL (2.425,6.23,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (2.60,6.09,0.07,'20.8% M.C.',0.0,10)
      CALL SYMBOL (2.74,5.88,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (2.74,5.74,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (2.74,5.60,0.07,'= CUBE 3',0.0,8)
      GO TO 97
   37 IF (NP.NE.3) GO TO 38
      CALL SYMBOL (2.25,6.86,0.14,'MIX NO. 14',0.0,10)
      CALL SYMBOL (1.76,6.58,0.14,'LIME:SAND = 1:4.5',0.0,17)
      CALL SYMBOL (2.53,6.37,0.07,'LIME BRAND A',0.0,12)
      CALL SYMBOL (2.425,6.23,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (2.60,6.09,0.07,'20.8% M.C.',0.0,10)
      CALL SYMBOL (2.74,5.88,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (2.74,5.74,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (2.74,5.60,0.07,'= CUBE 3',0.0,8)
      GO TO 97
   38 IF (NP.NE.4) GO TO 39
      CALL SYMBOL (2.25,6.86,0.14,'MIX NO. 15',0.0,10)
      CALL SYMBOL (1.69,6.58,0.14,'LIME:SAND = 1:3.65',0.0,18)
      CALL SYMBOL (2.53,6.37,0.07,'LIME BRAND A',0.0,12)
      CALL SYMBOL (2.425,6.23,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (2.60,6.09,0.07,'21.3% M.C.',0.0,10)
      CALL SYMBOL (2.74,5.88,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (2.74,5.74,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (2.74,5.60,0.07,'= CUBE 3',0.0,8)
      GO TO 97
   39 IF (NP.NE.5) GO TO 40
      CALL SYMBOL (2.25,6.86,0.14,'MIX NO. 16',0.0,10)
      CALL SYMBOL (1.90,6.58,0.14,'LIME:SAND = 1:3',0.0,15)
      CALL SYMBOL (2.53,6.37,0.07,'LIME BRAND A',0.0,12)
```

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```
      CALL SYMBOL (2.425,6.23,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (2.60,6.09,0.07,'22.7% M.C.',0.0,10)
      CALL SYMBOL (2.74,5.88,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (2.74,5.74,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (2.74,5.60,0.07,'= CUBE 3',0.0,8)
      GO TO 97
   40 IF (NP.NE.6) GO TO 41
      CALL SYMBOL (2.25,6.86,0.14,'MIX NO. 17',0.0,10)
      CALL SYMBOL (1.90,6.58,0.14,'LIME:SAND = 1:2',0.0,15)
      CALL SYMBOL (2.53,6.37,0.07,'LIME BRAND A',0.0,12)
      CALL SYMBOL (2.425,6.23,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (2.60,6.09,0.07,'29.6% M.C.',0.0,10)
      CALL SYMBOL (2.74,5.88,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (2.74,5.74,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (2.74,5.60,0.07,'= CUBE 3',0.0,8)
      GO TO 97
   41 IF (NP.NE.7) GO TO 42
      CALL SYMBOL (0.725,6.86,0.14,'MIX NO. 17',0.0,10)
      CALL SYMBOL (1.075,6.58,0.14,'REMIX',0.0,5)
      CALL SYMBOL (0.375,6.30,0.14,'LIME:SAND = 1:2',0.0,15)
      CALL SYMBOL (1.005,6.09,0.07,'LIME BRAND A',0.0,12)
      CALL SYMBOL (0.795,5.95,0.07,'REMIX AGE = 5 DAYS',0.0,18)
      CALL SYMBOL (0.900,5.81,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (1.075,5.67,0.07,'26.7% M.C.',0.0,10)
      CALL SYMBOL (1.215,5.46,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (1.215,5.32,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (1.215,5.18,0.07,'= CUBE 3',0.0,8)
      CALL SYMBOL (1.110,5.495,0.07,0,0.0,-1)
      CALL SYMBOL (1.110,5.343333,0.07,2,0.0,-1)
      CALL SYMBOL (1.110,5.215,0.07,3,0.0,-1)
      GO TO 99
   42 IF (NP.NE.8) GO TO 43
      CALL SYMBOL (2.25,6.86,0.14,'MIX NO. 18',0.0,10)
      CALL SYMBOL (1.90,6.58,0.14,'LIME:SAND = 1:6',0.0,15)
      CALL SYMBOL (2.53,6.37,0.07,'LIME BRAND B',0.0,12)
      CALL SYMBOL (2.425,6.23,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (2.60,6.09,0.07,'19.0% M.C.',0.0,10)
      CALL SYMBOL (2.74,5.88,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (2.74,5.74,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (2.74,5.60,0.07,'= CUBE 3',0.0,8)
      GO TO 97
   43 IF (NP.NE.9) GO TO 44
      CALL SYMBOL (2.25,6.86,0.14,'MIX NO. 19',0.0,10)
      CALL SYMBOL (1.90,6.58,0.14,'LIME:SAND = 1:5',0.0,15)
      CALL SYMBOL (2.53,6.37,0.07,'LIME BRAND B',0.0,12)
      CALL SYMBOL (2.425,6.23,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (2.60,6.09,0.07,'18.4% M.C.',0.0,10)
      CALL SYMBOL (2.74,5.88,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (2.74,5.74,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (2.74,5.60,0.07,'= CUBE 3',0.0,8)
      GO TO 97
   44 IF (NP.NE.10) GO TO 45
      CALL SYMBOL (2.25,6.86,0.14,'MIX NO. 20',0.0,10)
      CALL SYMBOL (1.76,6.58,0.14,'LIME:SAND = 1:4.5',0.0,17)
      CALL SYMBOL (2.53,6.37,0.07,'LIME BRAND B',0.0,12)
      CALL SYMBOL (2.425,6.23,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (2.60,6.09,0.07,'18.1% M.C.',0.0,10)
      CALL SYMBOL (2.74,5.88,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (2.74,5.74,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (2.74,5.60,0.07,'= CUBE 3',0.0,8)
      GO TO 97
   45 IF (NP.NE.11) GO TO 46
      CALL SYMBOL (2.25,6.86,0.14,'MIX NO. 20',0.0,10)
```

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```
      CALL SYMBOL (2.60,6.58,0.14,'REMIX',0.0,5)
      CALL SYMBOL (1.76,6.30,0.14,'LIME:SAND = 1:4.5',0.0,17)
      CALL SYMBOL (2.53,6.09,0.07,'LIME BRAND B',0.0,12)
      CALL SYMBOL (2.285,5.95,0.07,'REMIX AGE = 19 DAYS',0.0,19)
      CALL SYMBOL (2.425,5.81,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (2.60,5.67,0.07,'18.0% M.C.',0.0,10)
      CALL SYMBOL (2.74,5.46,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (2.74,5.32,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (2.74,5.18,0.07,'= CUBE 3',0.0,8)
      GO TO 97
   46 IF (NP.NE.12) GO TO 47
      CALL SYMBOL (2.25,6.86,0.14,'MIX NO. 21',0.0,10)
      CALL SYMBOL (1.69,6.58,0.14,'LIME:SAND = 1:3.65',0.0,18)
      CALL SYMBOL (2.53,6.37,0.07,'LIME BRAND B',0.0,12)
      CALL SYMBOL (2.425,6.23,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (2.60,6.09,0.07,'17.8% M.C.',0.0,10)
      CALL SYMBOL (2.74,5.88,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (2.74,5.74,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (2.74,5.60,0.07,'= CUBE 3',0.0,8)
      GO TO 97
   47 IF (NP.NE.13) GO TO 48
      CALL SYMBOL (2.25,6.86,0.14,'MIX NO. 21',0.0,10)
      CALL SYMBOL (2.60,6.58,0.14,'REMIX',0.0,5)
      CALL SYMBOL (1.69,6.30,0.14,'LIME:SAND = 1:3.65',0.0,18)
      CALL SYMBOL (2.53,6.09,0.07,'LIME BRAND B',0.0,12)
      CALL SYMBOL (2.285,5.95,0.07,'REMIX AGE = 19 DAYS',0.0,19)
      CALL SYMBOL (2.425,5.81,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (2.60,5.67,0.07,'17.5% M.C.',0.0,10)
      CALL SYMBOL (2.74,5.46,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (2.74,5.32,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (2.74,5.18,0.07,'= CUBE 3',0.0,8)
      GO TO 97
   48 IF (NP.NE.14) GO TO 49
      CALL SYMBOL (2.25,6.86,0.14,'MIX NO. 22',0.0,10)
      CALL SYMBOL (1.90,6.58,0.14,'LIME:SAND = 1:3',0.0,15)
      CALL SYMBOL (2.53,6.37,0.07,'LIME BRAND B',0.0,12)
      CALL SYMBOL (2.425,6.23,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (2.60,6.09,0.07,'17.4% M.C.',0.0,10)
      CALL SYMBOL (2.74,5.88,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (2.74,5.74,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (2.74,5.60,0.07,'= CUBE 3',0.0,8)
      GO TO 97
   49 IF (NP.NE.15) GO TO 50
      CALL SYMBOL (2.25,6.86,0.14,'MIX NO. 22',0.0,10)
      CALL SYMBOL (2.60,6.58,0.14,'REMIX',0.0,5)
      CALL SYMBOL (1.90,6.30,0.14,'LIME:SAND = 1:3',0.0,15)
      CALL SYMBOL (2.53,6.09,0.07,'LIME BRAND B',0.0,12)
      CALL SYMBOL (2.285,5.95,0.07,'REMIX AGE = 16 DAYS',0.0,19)
      CALL SYMBOL (2.425,5.81,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (2.60,5.67,0.07,'17.3% M.C.',0.0,10)
      CALL SYMBOL (2.74,5.46,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (2.74,5.32,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (2.74,5.18,0.07,'= CUBE 3',0.0,8)
      GO TO 97
   50 IF (NP.NE.16) GO TO 51
      CALL SYMBOL (2.25,6.86,0.14,'MIX NO. 23',0.0,10)
      CALL SYMBOL (1.90,6.58,0.14,'LIME:SAND = 1:2',0.0,15)
      CALL SYMBOL (2.53,6.37,0.07,'LIME BRAND B',0.0,12)
      CALL SYMBOL (2.425,6.23,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (2.60,6.09,0.07,'16.2% M.C.',0.0,10)
      CALL SYMBOL (2.74,5.88,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (2.74,5.74,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (2.74,5.60,0.07,'= CUBE 3',0.0,8)
```

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```
      GO TO 97
   51 IF (NP.NE.17) GO TO 97
      CALL SYMBOL (2.25,6.86,0.14,'MIX NO. 23',0.0,10)
      CALL SYMBOL (2.60,6.58,0.14,'REMIX',0.0,5)
      CALL SYMBOL (1.90,6.30,0.14,'LIME:SAND = 1:2',0.0,15)
      CALL SYMBOL (2.53,6.09,0.07,'LIME BRAND B',0.0,12)
      CALL SYMBOL (2.285,5.95,0.07,'REMIX AGE = 17 DAYS',0.0,19)
      CALL SYMBOL (2.425,5.81,0.07,'28-DAY STRENGTH',0.0,15)
      CALL SYMBOL (2.60,5.67,0.07,'15.8% M.C.',0.0,10)
      CALL SYMBOL (2.74,5.46,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (2.74,5.32,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (2.74,5.18,0.07,'= CUBE 3',0.0,8)
C
C      THE FOLLOWING RECORDS WILL PLACE THE SYMBOLS USED FOR
C PLOTTING THE DATA POINTS INTO THE LEGEND.  ONE SYMBOL WILL BE
C USED FOR EACH DIFFERENT CUBE.
C
   97 IF (REMIX.EQ.1) GO TO 98
      CALL SYMBOL (2.635,5.915,0.07,0,0.0,-1)
      CALL SYMBOL (2.635,5.763333,0.07,2,0.0,-1)
      CALL SYMBOL (2.635,5.635,0.07,3,0.0,-1)
      GO TO 99
   98 CALL SYMBOL (2.635,5.495,0.07,0,0.0,-1)
      CALL SYMBOL (2.635,5.343333,0.07,2,0.0,-1)
      CALL SYMBOL (2.635,5.215,0.07,3,0.0,-1)
C
   99 CALL PLOT (12.0,0.0,999)
  100 CONTINUE
      CALL PLOT (0.0,0.0,9999)
      STOP
      END
```

G.7 COMPUTER PROGRAM NO. 7 [25, 27, 29 -- PP. 479-480]

Computer Program No. 7 performs the same job as Computer Program No. 3 but is modified to be used for the lime-sand mortar mixes. Modifications were necessary primarily due to the lower stress-strain values obtained with the lime-sand mortar mixes. This meant a reduction of the plot scales and a reduction in the increment of calculating and plotting of the best-fit curve. The defined best-fit curve is also different but can be easily changed as in Computer Program No. 3. More details of this program can be obtained from the description of Computer Program No. 3 and within the program itself.

LPLOT "Computer Program No. 7"

```
//DAY7P2DB JOB ',,,T=1M,L=10,I=10,C=0','RANDY ZAPOTOTSKY',CLASS=F,
// MSGLEVEL=(1,1)
/*ROUTE PRINT SELF
/*D800 VPLOT
// EXEC FORTHCLG,USERLIB='SYS3.VPLOTLIB',SIZE=256K
//FORT.SYSIN DD *
C
C
C
C       --- THIS IS THE PROGRAM FOR BEST FIT PLOTTING ---
C                    --- LIME-SAND MIXES ---
C
C
C
C     WHEN RUNNING THIS PROGRAM, THE FILES AND ITS ORDER OF
C SUBMISSION IS AS FOLLOWS:
C
C     1.  LPLOT
C     2.  NOFIT
C     3.  "DATA FILES"
C
C     WHERE:
C
C            LPLOT - IS THE NAME OF THIS PROGRAM
C
C            NOFIT - HAS THREE RECORDS IN THE FORM AS FOLLOWS:
C
C                    1.//GO.SYSIN DD *
C                    2. "NUMBER OF SETS OF DATA"
C                    3. "VALUE OF M"
C
C                        WHERE:
C
C                             M = THE NUMBER OF CONSTANTS (C'S)
C                                 THAT WILL BE USED IN PLOTTING
C                                 EACH OF THE BEST FIT CURVES.
C
C     "DATA FILES" - HAS THE FORM AS FOLLOWS:
C
C        1. MIXNO N N1 N2 N3 DAY REMIX XSTART MAX100 YMAX DASH
C        2. X1       Y1
C        3. X2       Y2
C        4. |        |
C        5. |        |
C      N+1. X(N-1)   Y(N-1)
C      N+2. C1
C      N+_. |
C      N+_. |
C  N+1+CN. CN
C
C     WHERE:
C
C    MIXNO = THE MIX NUMBER
C        N = THE TOTAL NUMBER OF DATA POINTS POINTS
C       N1 = THE NUMBER OF DATA POINTS FOR SPECIMEN NO. 1
C       N2 =  "    "    "   "     "     "      "    NO. 2
C       N3 =  "    "    "   "     "     "      "    NO. 3
C      DAY = THE AGE OF THE MIX, IN DAYS
C    REMIX = "0" IF THE MIX WAS MIXED TOGETHER FOR THE FIRST TIME
C          = "1" IF THE HARDENED ORIGINAL MIX WAS CRUSHED AND REMIXED
C   XSTART = THE EXPERIMENTAL CORRECTION FACTOR TO THE X-VALUES;
C            XSTART IS POSITIVE IF MOVING THE X-VALUES TO THE LEFT
C   MAX100 = (SEE DESCRIPTION BELOW)
```

```
C     YMAX = THE MAXIMUM Y-VALUE OBTAINED IN A SET OF TESTS
C     DASH = (SEE DESCRIPTION BELOW)
C    X&Y'S = THE DATA POINTS
C       C_ = THE CONSTANTS OF THE BEST FIT EQUATION
C
C      TO SATISFY THE "DO" STATEMENT RULE OF ONLY USING INTEGERS
C GREATER THAN ZERO AND TO OBTAIN AN INCREMENT OF 0.01% STRAIN
C (X-VALUES) WHEN PLOTTING THE BEST FIT CURVE, MAX100 IS
C DEFINED AS FOLLOWS:
C
C           MAX100 = (MAX STRAIN(%) - XSTART + 0.01) * 100
C
C FROM THIS MODIFICATION TO THE MAXIMUM STRAIN VALUE, ONLY
C THE INTEGER PART OF THE NUMBER IS PUT INTO THE DATA FILE.
C WHEN PLOTTING IT WILL BECOME CLOSE ENOUGH TO THE MAXIMUM
C STRAIN VALUE OBTAINED IN A MIX.  THIS WILL SATISFY THE
C INTEGER RULE OF A DO LOOP.
C
C      FROM THE PROGRAM THIS MODIFICATION COMES FROM:
C
C           X(I) = ((RI/100.0) - 0.01)
C
C      THE "-0.01" IS NEEDED SO THAT X IS EQUAL TO ZERO FOR THE
C FIRST VALUE.  THIS WILL MAKE THE BEST FIT CURVE PASS THROUGH
C THE ORIGIN.
C
C      MAX100 MUST BE DEFINED FOR EACH INDEPENDANT MIX.
C IN ADDITION, IT MUST BE PUT INTO A DATA FILE AS AN
C INTEGER, NOT A REAL NUMBER, TO SATISFY THE INTEGER
C RULES OF A DO LOOP.
C
C      A CHECK WILL BE DONE NEAR THE DEFINED FUNCTION SO AS TO
C PREVENT THE BEST FIT CURVE HAVING A NEGATIVE SLOPE AND A
C Y VALUE GREATER THAN THAT OBTAINED IN A SET OF TESTS.
C A NEGATIVE SLOPE IS UNFAVORABLE SINCE IT DOES NOT REPRESENT
C WHAT HAPPENED IN THE ACTUAL TESTS.
C
C      IF THE MIX DID NOT HAVE PEAK LOADS FOR ALL OF THE CUBES,
C A STRAIGHT DASHED LINE WILL BE DRAWN HORIZONTALLY FROM THE
C END OF THE BEST FIT CURVE TO THE FAR RIGHT OF THE PLOT.  THIS
C DASHED LINE WILL REPRESENT THAT LOADING WAS CONTINUED AFTER
C THIS CUT-OFF POINT, BUT NO PEAK LOAD OCCURRED.  IT SHOULD BE
C NOTED THOUGH THAT THE PATH OF THIS DASHED LINE DOES NOT
C NECESSARILY REPRESENT THE ACTUAL PATH TAKEN DURING THE TEST OR
C OF THE BEST FIT CURVE.
C      THIS DASHED LINE WILL NOT BE DRAWN WHEN THE VALUE OF
C "DASH" IS EQUAL TO "0" (ZERO).  WHEN "DASH" IS EQUAL TO
C "1" (ONE), A DASHED LINE WILL BE DRAWN.
C
C     AT THE END OF THE DATA FILE(S), THE PROPER JCL MUST BE
C DEFINED IN ORDER FOR THE PROGRAM TO RUN.
C
C      DUE TO THE LIMITS ON THE DIMENSION STATEMENTS THE
C FOLLOWING LIMITS ARE DEFINED:
C
C           1)  XRAY_(__), YRAY_(__)
C               MAXIMUM ALLOWABLE NUMBER OF DATA POINTS PER
C               SPECIMEN READ IN IS 77 - 2 = 75
C
C           2)  C(__)
C               MAXIMUM ALLOWABLE NUMBER OF CONSTANTS
C               READ IN IS 10
C
```

```
C             3)  X(____), Y(____)
                  MAXIMUM ALLOWABLE STRAIN IN THE TESTS
                  IS (5002 - 2)/100 = 50%
C
C             4)  XNEW_(__)
                  AS FOR XRAY_(__)
C
C             5)  MXDATA(___), MYDATA(___)
                  MAXIMUM ALLOWABLE NUMBER OF DATA POINTS
                  POINTS PER MIX PER MIXED X AND Y
                  DATA ARRAYS = 225
C
C
C       IN ORDER FOR THIS PROGRAM TO RUN SATISFACTORY FOR DIFFERENT
C RUNS, ONE MUST ENSURE THAT THE FOLLOWING IS DONE:
C
C       A.  CHECK TO SEE THAT THE BEST FIT EQUATION AT THE FOLLOWING
C           TWO (2) LOCATIONS IS THE ONE THAT IS WANTED AND THAT THEY
C           ARE BOTH THE SAME:
C
C           1.  IN THE PLOTTING SECTION AND
C
C           2.  IN THE ADJUSTED COEFFICIENT OF MULTIPLE DETERMINATION
C               CALCULATION PART.
C
C       B.  ADJUST THE DEVELOP A LEGEND ACCORDINGLY TO THE DATA OR SKIP
C           OVER THIS PART OF THE PROGRAM BY A SIMPLE GO TO STATEMENT.
C
C
C
        DIMENSION IBUF(4000),
       &XRAY1(77),YRAY1(77),XRAY2(77),YRAY2(77),XRAY3(77),YRAY3(77),
       &C(10),X(5002),Y(5002),XNEW1(77),XNEW2(77),XNEW3(77)
        REAL MXDATA(225),MYDATA(225)
        INTEGER DAY,DASH,P1,P2,P3,P4,P5,P6,DP
C
C       READ AND WRITE OUT THE NUMBER OF PLOTS TO BE DRAWN AND THE
C NUMBER OF CONSTANTS (C'S) THAT ARE TO BE USED.
C
        READ (5,*) NOFIT,M
        WRITE (6,70) NOFIT
     70 FORMAT ('1',////////,4X,'THE NUMBER OF PLOT(S) THAT ',
       &'ARE TO BE DRAWN IS',3X,I3)
        WRITE (6,80) M
     80 FORMAT (//////,4X,
       &'THE NUMBER OF CONSTANTS "M" READ IN FOR THIS PROGRAM IS',I5)
        DO 780 NF=1,NOFIT
        CALL PLOTS (IBUF,4000)
C
C        DEFINE SOME CHARACTERISTICS OF THE PLOT.
C
        CALL PLOT (0.0,-11.0,-3)
        CALL PLOT (0.0,2.0625,-3)
        CALL FACTOR (1.0)
        CALL AXIS (0.0,0.0,'STRAIN - %',-10,4.0,0.0,0.0,1.0)
        CALL AXIS (0.0,0.0,'STRESS - PSI',12,7.0,90.0,0.0,25.0)
C
C       DRAW A RECTANGULAR FRAME AROUND THE PLOT
C
        CALL NEWPEN (4)
        CALL RECT (-0.75,-1.25,9.0,5.5,0.0,3)
        CALL NEWPEN (1)
C
```

LPLOT "Computer Program No. 7"

```
C       READ AND WRITE OUT SOME BASIC INFORMATION ABOUT THE MATERIAL.
C
        READ (5,*) MIXNO,N,N1,N2,N3,DAY,REMIX,XSTART,MAX100,YMAX,DASH
        WRITE (6,90) MIXNO,DAY
     90 FORMAT ('1',//////,4X,
      &'THIS IS THE PLOT PROGRAM FOR MIX NUMBER',3X,
      &I3,3X,'AT THE',3X,I2,3X,'DAY STRENGTH')
        IF (REMIX.EQ.1) GO TO 110
        WRITE (6,100)
    100 FORMAT (//////,4X,'THE FOLLOWING DATA IS FOR THE MIX ',
      &'WHEN ITS COMPONENTS WERE COMBINED FOR THE FIRST TIME')
        GO TO 130
    110 WRITE (6,120)
    120 FORMAT (//////,4X,'THE FOLLOWING DATA IS FOR WHEN THE ',
      &'HARDENED ORIGINAL MIXTURE WAS CRUSHED AND REMIXED')
    130 WRITE (6,140) XSTART
    140 FORMAT (//////,4X,'THE VALUE OF XSTART READ IN IS',
      &2X,F6.3)
        WRITE (6,150) MIXNO,MAX100
    150 FORMAT (//////,4X,
      &'THE VALUE OF MAX100 THAT WAS READ IN FOR MIX NUMBER',I5,
      &3X,'IS',3X,I4)
        WRITE (6,160) YMAX
    160 FORMAT (//////,4X,'THE HIGHEST STRESS THAT WAS REACHED ',
      &'DURING THE TEST WAS',3X,F6.1,3X,'PSI')
        IF (DASH.EQ.0) GO TO 180
        WRITE (6,170)
    170 FORMAT (//////,4X,'DURING THE TESTING,',
      &' THIS MIX DID NOT HAVE PEAK LOADS FOR ALL OF THE SPECIMENS.')
        GO TO 200
    180 WRITE (6,190)
    190 FORMAT (//////,4X,'DURING THE TESTING,',
      &' THIS MIX HAD PEAK LOADS FOR ALL OF THE SPECIMENS.')
    200 WRITE (6,210) MIXNO,N
    210 FORMAT (//////,4X,
      &'THE TOTAL NUMBER OF DATA POINTS READ IN FOR MIX NUMBER',
      &I6,4X,'IS',I7)
        WRITE (6,220) N1,N2,N3
    220 FORMAT (//////,4X,
      &'THE NUMBER OF DATA POINTS READ IN FOR SPECIMEN NUMBER  1 =',
      &1X,I3,//,42X,'SPECIMEN NUMBER  2 =',1X,I3,//,42X,
      &'SPECIMEN NUMBER  3 =',1X,I3)
C
C       READ AND WRITE OUT THE DATA POINTS FOR THE MIX.
C
        READ (5,*) (XRAY1(I),YRAY1(I),I=1,N1)
        READ (5,*) (XRAY2(J),YRAY2(J),J=1,N2)
        READ (5,*) (XRAY3(K),YRAY3(K),K=1,N3)
C
        WRITE (6,230) MIXNO,DAY
    230 FORMAT ('1',////////,32X,'DATA POINTS',//,30X,
      &'MIX NUMBER',I5,//,29X,I2,3X,'DAY STRENGTH')
        IF (REMIX.EQ.0) GO TO 250
        WRITE (6,240)
    240 FORMAT (/,35X,'REMIX')
    250 WRITE(6,260)
    260 FORMAT(//,4X,'DATA NUMBER',10X,'X-VALUES (STRAIN-%)',10X,
      &'Y-VALUES (STRESS-PSI)',/)
        WRITE (6,270)
    270 FORMAT (/,4X,'SPECIMEN NUMBER  1',/)
        WRITE (6,300) (I,XRAY1(I),YRAY1(I),I=1,N1)
        WRITE (6,280)
    280 FORMAT (//,4X,'SPECIMEN NUMBER  2',/)
```

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```
      WRITE (6,300) (J,XRAY2(J),YRAY2(J),J=1,N2)
      WRITE (6,290)
  290 FORMAT (//,4X,'SPECIMEN NUMBER  3',/)
      WRITE (6,300) (K,XRAY3(K),YRAY3(K),K=1,N3)
  300 FORMAT (' ',7X,I3,17X,F10.3,19X,F10.1)
C
C       ADJUST THE X-VALUES WITH XSTART TO CORRECT FOR
C EXPERIMENTAL ERROR.
C
      DO 310 I=1,N1
      XNEW1(I) = XRAY1(I) - XSTART
  310 CONTINUE
      DO 320 J=1,N2
      XNEW2(J) = XRAY2(J) - XSTART
  320 CONTINUE
      DO 330 K=1,N3
      XNEW3(K) = XRAY3(K) - XSTART
  330 CONTINUE
C
C       WRITE OUT THE NEW ADJUSTED X-VALUES AND ITS CORRESPONDING
C Y-VALUES.
C
      WRITE (6,340) MIXNO,DAY
  340 FORMAT ('1',////////,27X,'ADJUSTED DATA POINTS',//,30X,
     &'MIX NUMBER',I5,//,29X,I2,3X,'DAY STRENGTH')
      IF (REMIX.EQ.0) GO TO 360
      WRITE (6,350)
  350 FORMAT (/,35X,'REMIX')
  360 WRITE(6,370)
  370 FORMAT(//,4X,'DATA NUMBER',10X,'X-VALUES (STRAIN-%)',10X,
     &'Y-VALUES (STRESS-PSI)',/)
      WRITE (6,380)
  380 FORMAT (/,4X,'SPECIMEN NUMBER  1',/)
      WRITE (6,410) (I,XNEW1(I),YRAY1(I),I=1,N1)
      WRITE (6,390)
  390 FORMAT (//,4X,'SPECIMEN NUMBER  2',/)
      WRITE (6,410) (J,XNEW2(J),YRAY2(J),J=1,N2)
      WRITE (6,400)
  400 FORMAT (//,4X,'SPECIMEN NUMBER  3',/)
      WRITE (6,410) (K,XNEW3(K),YRAY3(K),K=1,N3)
  410 FORMAT (' ',7X,I3,17X,F10.3,19X,F10.1)
C
C       PLOT OUT THE ADJUSTED DATA POINTS.
C
      XNEW1 (N1+1)=   0.0
      YRAY1 (N1+1)=   0.0
      XNEW1 (N1+2)=   1.0
      YRAY1 (N1+2)=  25.0
C
      XNEW2 (N2+1)=   0.0
      YRAY2 (N2+1)=   0.0
      XNEW2 (N2+2)=   1.0
      YRAY2 (N2+2)=  25.0
C
      XNEW3 (N3+1)=   0.0
      YRAY3 (N3+1)=   0.0
      XNEW3 (N3+2)=   1.0
      YRAY3 (N3+2)=  25.0
C
      CALL LINE (XNEW1,YRAY1,N1,1,-1,0)
      CALL LINE (XNEW2,YRAY2,N2,1,-1,2)
      CALL LINE (XNEW3,YRAY3,N3,1,-1,3)
C
```

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```
C       READ AND WRITE OUT THE CONSTANTS (C-VALUES).
C
        READ (5,*) (C(I),I=1,M)
        WRITE (6,420) MIXNO,DAY
    420 FORMAT ('1',////////,11X,'C VALUES',//,9X,'MIX NUMBER',
       &1X,I2,//,8X,I2,1X,'DAY STRENGTH')
        IF (REMIX.EQ.0) GO TO 440
        WRITE (6,430)
    430 FORMAT (/,13X,'REMIX')
    440 WRITE (6,450)
    450 FORMAT (//,4X,'C( )',15X,'VALUE',/)
        WRITE (6,460) (I,C(I),I=1,M)
    460 FORMAT('0',4X,I2,12X,F12.7)
C
C       CALCULATE THE PLOTTING POINTS FOR THE BEST FIT CURVE.
C
        NSUM = 0
        DO 480 I=1,MAX100,1
        RI = I
        X(I) = ((RI/100.0) - 0.01)
        XTEMP = X(I) + XSTART
C
C       THE USER OF THIS PROGRAM SHOULD TAKE NOTE OF THE
C FOLLOWING:
C
C                1)   THE FUNCTION DEFINED ON THE NEXT RECORD OF THE
C                     PROGRAM.  THIS IS THE FUNCTION OF THE BEST FIT
C                     CURVE THAT WILL BE DRAWN THROUGH THE DATA
C                     POINTS.
C
C                2)   THE NUMBER OF CONSTANT'S (C'S) READ INTO THE
C                     PROGRAM MUST BE EQUAL TO AMOUNT DEFINED IN
C                     THIS FUNCTION.
C
C                3)   ONE MUST MAKE SURE THAT THE CONSTANTS ARE READ
C                     IN THE PROPER ORDER TO THE CORRESPONDING ONES
C                     DEFINED BY THE FUNCTION.
C
        Y(I) = (C(1)) + (C(2)*XTEMP) + (C(3)*(XTEMP**2))
C
        IF (I.EQ.1) GO TO 470
        IF (Y(I).LT.Y(I-1)) GO TO 490
        IF (Y(I).GT.YMAX) GO TO 490
    470 NSUM = NSUM + 1
    480 CONTINUE
C
C       LIST THE BEST FIT CURVE PLOTTING VALUES.
C
    490 WRITE (6,500) MIXNO,DAY
    500 FORMAT ('1',////////,24X,
       &'BEST FIT CURVE PLOTTING VALUES',//,31X,'MIX NUMBER',I5,
       &//,29X,I2,3X,'DAY STRENGTH')
        IF (REMIX.EQ.0) GO TO 520
        WRITE (6,510)
    510 FORMAT (/,35X,'REMIX')
    520 WRITE (6,530)
    530 FORMAT (//,4X,'PLOTTING NUMBER',10X,'X-VALUES (STRAIN-%)',
       &10X,'Y-VALUES (STRESS-PSI)',/)
        WRITE (6,540) (I,X(I),Y(I),I=1,NSUM)
    540 FORMAT (' ',9X,I3,21X,F8.3,22X,F7.1)
C
C       PLOT OUT THE BEST FIT CURVE.
C
```

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```
      X (NSUM+1)=   0.0
      Y (NSUM+1)=   0.0
      X (NSUM+2)=   1.0
      Y (NSUM+2)=  25.0
C
      CALL NEWPEN (8)
      CALL FLINE (X,Y,-NSUM,1,0,0)
      IF (DASH.EQ.0) GO TO 550
      XDASH = (X(NSUM)/1.0) + 0.12
      YDASH = Y(NSUM)/25.0
      XEND = 4.0 - XDASH
      CALL PLOT (XDASH,YDASH,-3)
      CALL DASHP (XEND,0.0,0.12)
      CALL PLOT (-XDASH,-YDASH,-3)
  550 CALL NEWPEN (1)
C
C       ------ DEVELOP A LEGEND ------
C
C       PUT MAJOR AND MINOR INFORMATION INTO THE LEGEND.
C
      IF (NF.NE.1) GO TO 551
      CALL SYMBOL (2.25,6.86,0.14,'MIX NO. 18',0.0,10)
      CALL SYMBOL (1.90,6.58,0.14,'LIME:SAND = 1:6',0.0,15)
      CALL SYMBOL (2.53,6.37,0.07,'LIME BRAND B',0.0,12)
      CALL SYMBOL (2.46,6.23,0.07,'7-DAY STRENGTH',0.0,14)
      CALL SYMBOL (2.60,6.09,0.07,'19.0% M.C.',0.0,10)
      CALL SYMBOL (2.74,5.88,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (2.74,5.74,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (2.74,5.60,0.07,'= CUBE 3',0.0,8)
      GO TO 600
  551 IF (NF.NE.2) GO TO 552
      CALL SYMBOL (2.25,6.86,0.14,'MIX NO. 19',0.0,10)
      CALL SYMBOL (1.90,6.58,0.14,'LIME:SAND = 1:5',0.0,15)
      CALL SYMBOL (2.53,6.37,0.07,'LIME BRAND B',0.0,12)
      CALL SYMBOL (2.46,6.23,0.07,'7-DAY STRENGTH',0.0,14)
      CALL SYMBOL (2.60,6.09,0.07,'18.4% M.C.',0.0,10)
      CALL SYMBOL (2.74,5.88,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (2.74,5.74,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (2.74,5.60,0.07,'= CUBE 3',0.0,8)
      GO TO 600
  552 IF (NF.NE.3) GO TO 553
      CALL SYMBOL (2.25,6.86,0.14,'MIX NO. 20',0.0,10)
      CALL SYMBOL (1.76,6.58,0.14,'LIME:SAND = 1:4.5',0.0,17)
      CALL SYMBOL (2.53,6.37,0.07,'LIME BRAND B',0.0,12)
      CALL SYMBOL (2.46,6.23,0.07,'7-DAY STRENGTH',0.0,14)
      CALL SYMBOL (2.60,6.09,0.07,'18.1% M.C.',0.0,10)
      CALL SYMBOL (2.74,5.88,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (2.74,5.74,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (2.74,5.60,0.07,'= CUBE 3',0.0,8)
      GO TO 600
  553 IF (NF.NE.4) GO TO 554
      CALL SYMBOL (2.25,6.86,0.14,'MIX NO. 20',0.0,10)
      CALL SYMBOL (2.60,6.58,0.14,'REMIX',0.0,5)
      CALL SYMBOL (1.76,6.30,0.14,'LIME:SAND = 1:4.5',0.0,17)
      CALL SYMBOL (2.53,6.09,0.07,'LIME BRAND B',0.0,12)
      CALL SYMBOL (2.285,5.95,0.07,'REMIX AGE = 19 DAYS',0.0,19)
      CALL SYMBOL (2.46,5.81,0.07,'7-DAY STRENGTH',0.0,14)
      CALL SYMBOL (2.60,5.67,0.07,'18.0% M.C.',0.0,10)
      CALL SYMBOL (2.74,5.46,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (2.74,5.32,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (2.74,5.18,0.07,'= CUBE 3',0.0,8)
      GO TO 600
  554 IF (NF.NE.5) GO TO 555
```

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```
      CALL SYMBOL (2.25,6.86,0.14,'MIX NO. 21',0.0,10)
      CALL SYMBOL (1.69,6.58,0.14,'LIME:SAND = 1:3.65',0.0,18)
      CALL SYMBOL (2.53,6.37,0.07,'LIME BRAND B',0.0,12)
      CALL SYMBOL (2.46,6.23,0.07,'7-DAY STRENGTH',0.0,14)
      CALL SYMBOL (2.60,6.09,0.07,'17.8% M.C.',0.0,10)
      CALL SYMBOL (2.74,5.88,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (2.74,5.74,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (2.74,5.60,0.07,'= CUBE 3',0.0,8)
      GO TO 600
  555 IF (NF.NE.6) GO TO 556
      CALL SYMBOL (2.25,6.86,0.14,'MIX NO. 21',0.0,10)
      CALL SYMBOL (2.60,6.58,0.14,'REMIX',0.0,5)
      CALL SYMBOL (1.69,6.30,0.14,'LIME:SAND = 1:3.65',0.0,18)
      CALL SYMBOL (2.53,6.09,0.07,'LIME BRAND B',0.0,12)
      CALL SYMBOL (2.285,5.95,0.07,'REMIX AGE = 19 DAYS',0.0,19)
      CALL SYMBOL (2.46,5.81,0.07,'7-DAY STRENGTH',0.0,14)
      CALL SYMBOL (2.60,5.67,0.07,'17.5% M.C.',0.0,10)
      CALL SYMBOL (2.74,5.46,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (2.74,5.32,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (2.74,5.18,0.07,'= CUBE 3',0.0,8)
      GO TO 600
  556 IF (NF.NE.7) GO TO 557
      CALL SYMBOL (2.25,6.86,0.14,'MIX NO. 22',0.0,10)
      CALL SYMBOL (1.90,6.58,0.14,'LIME:SAND = 1:3',0.0,15)
      CALL SYMBOL (2.53,6.37,0.07,'LIME BRAND B',0.0,12)
      CALL SYMBOL (2.46,6.23,0.07,'7-DAY STRENGTH',0.0,14)
      CALL SYMBOL (2.60,6.09,0.07,'17.4% M.C.',0.0,10)
      CALL SYMBOL (2.74,5.88,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (2.74,5.74,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (2.74,5.60,0.07,'= CUBE 3',0.0,8)
      GO TO 600
  557 IF (NF.NE.8) GO TO 558
      CALL SYMBOL (2.25,6.86,0.14,'MIX NO. 22',0.0,10)
      CALL SYMBOL (2.60,6.58,0.14,'REMIX',0.0,5)
      CALL SYMBOL (1.90,6.30,0.14,'LIME:SAND = 1:3',0.0,15)
      CALL SYMBOL (2.53,6.09,0.07,'LIME BRAND B',0.0,12)
      CALL SYMBOL (2.285,5.95,0.07,'REMIX AGE = 16 DAYS',0.0,19)
      CALL SYMBOL (2.46,5.81,0.07,'7-DAY STRENGTH',0.0,14)
      CALL SYMBOL (2.60,5.67,0.07,'17.3% M.C.',0.0,10)
      CALL SYMBOL (2.74,5.46,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (2.74,5.32,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (2.74,5.18,0.07,'= CUBE 3',0.0,8)
      GO TO 600
  558 IF (NF.NE.9) GO TO 559
      CALL SYMBOL (2.25,6.86,0.14,'MIX NO. 23',0.0,10)
      CALL SYMBOL (1.90,6.58,0.14,'LIME:SAND = 1:2',0.0,15)
      CALL SYMBOL (2.53,6.37,0.07,'LIME BRAND B',0.0,12)
      CALL SYMBOL (2.46,6.23,0.07,'7-DAY STRENGTH',0.0,14)
      CALL SYMBOL (2.60,6.09,0.07,'16.2% M.C.',0.0,10)
      CALL SYMBOL (2.74,5.88,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (2.74,5.74,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (2.74,5.60,0.07,'= CUBE 3',0.0,8)
      GO TO 600
  559 IF (NF.NE.10) GO TO 560
      CALL SYMBOL (2.25,6.86,0.14,'MIX NO. 23',0.0,10)
      CALL SYMBOL (2.60,6.58,0.14,'REMIX',0.0,5)
      CALL SYMBOL (1.90,6.30,0.14,'LIME:SAND = 1:2',0.0,15)
      CALL SYMBOL (2.53,6.09,0.07,'LIME BRAND B',0.0,12)
      CALL SYMBOL (2.285,5.95,0.07,'REMIX AGE = 17 DAYS',0.0,19)
      CALL SYMBOL (2.46,5.81,0.07,'7-DAY STRENGTH',0.0,14)
      CALL SYMBOL (2.60,5.67,0.07,'15.8% M.C.',0.0,10)
      CALL SYMBOL (2.74,5.46,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (2.74,5.32,0.07,'= CUBE 2',0.0,8)
```

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```
      CALL SYMBOL (2.74,5.18,0.07,'= CUBE 3',0.0,8)
      GO TO 600
  560 IF (NF.NE.11) GO TO 600
      CALL SYMBOL (2.25,6.86,0.14,'MIX NO. 18',0.0,10)
      CALL SYMBOL (1.90,6.58,0.14,'LIME:SAND = 1:6',0.0,15)
      CALL SYMBOL (2.53,6.37,0.07,'LIME BRAND B',0.0,12)
      CALL SYMBOL (2.46,6.23,0.07,'7-DAY STRENGTH',0.0,14)
      CALL SYMBOL (2.60,6.09,0.07,'19.0% M.C.',0.0,10)
      CALL SYMBOL (2.74,5.88,0.07,'= CUBE 1',0.0,8)
      CALL SYMBOL (2.74,5.74,0.07,'= CUBE 2',0.0,8)
      CALL SYMBOL (2.74,5.60,0.07,'= CUBE 3',0.0,8)
      GO TO 600
C
C       THE FOLLOWING RECORDS WILL PLACE THE SYMBOLS USED FOR
C PLOTTING THE DATA POINTS INTO THE LEGEND.  ONE SYMBOL WILL BE
C USED FOR EACH DIFFERENT CUBE.
C
  600 IF (REMIX.EQ.1) GO TO 610
      CALL SYMBOL (2.635,5.915,0.07,0,0.0,-1)
      CALL SYMBOL (2.635,5.763333,0.07,2,0.0,-1)
      CALL SYMBOL (2.635,5.635,0.07,3,0.0,-1)
      GO TO 620
  610 CALL SYMBOL (2.635,5.495,0.07,0,0.0,-1)
      CALL SYMBOL (2.635,5.343333,0.07,2,0.0,-1)
      CALL SYMBOL (2.635,5.215,0.07,3,0.0,-1)
C
  620 CALL PLOT (12.0,0.0,999)
C
C       ------ END OF PLOTTING ------
C
C
C
C ************************************************************
C *                                                          *
C *                                                          *
C *      ADJUSTED COEFFICIENT OF MULTIPLE DETERMINATION      *
C *                                                          *
C *                                                          *
C ************************************************************
C
C
C
C NOTES:  1)  THIS PROGRAM FOR CALCULATING THE ADJUSTED COEFFICIENT
C             OF MULTIPLE DETERMINATION WILL TAKE INTO ACCOUNT ALL
C             THE DATA POINTS READ IN, UP TO AND INCLUDING BOTH THE
C             MAXIMUM X AND Y VALUES.  IT IS REMINDED THOUGH, THAT
C             THE BEST FIT CURVE IS PLOTTED JUST TO THE POINT
C             BEFORE A NEGATIVE SLOPE STARTS OR AFTER YMAX IS
C             REACHED.  THEREFORE THE BEST FIT CURVE MAY OR MAY NOT
C             OF BEEN DRAWN TO THE MAXIMUM X-VALUE DATA POINT.
C
C         2)  FOR THE ADJUSTED COEFFICIENT OF MULTIPLE DETERMINATION
C             TO BE CORRECTLY CALCULATED, THE BEST FIT EQUATION USED
C             IN THIS PART MUST MATCH WITH THE ONE USED ABOVE
C             (SEE "THE BEST FIT EQUATION").
C
C
C       TRANSFER THE ARRAYS XRAY1,2,3 AND YRAY1,2,3 TO ARRAYS
C MXDATA AND MYDATA RESPECTIVELY.
C
C
      P1 = 1
      P2 = P1 + (N1-1)
```

```
      DO 630 DP=P1,P2
      I = DP
      MXDATA(DP) = XRAY1(I)
      MYDATA(DP) = YRAY1(I)
  630 CONTINUE
      P3 = P2 + 1
      P4 = P3 + (N2-1)
      DO 640 DP=P3,P4
      J = DP - N1
      MXDATA(DP) = XRAY2(J)
      MYDATA(DP) = YRAY2(J)
  640 CONTINUE
      P5 = P4 + 1
      P6 = P5 + (N3-1)
      DO 650 DP=P5,P6
      K = DP - N2 - N1
      MXDATA(DP) = XRAY3(K)
      MYDATA(DP) = YRAY3(K)
  650 CONTINUE
C
C       CHECK TO SEE IF THE TRANSFER OF THE ARRAYS WAS
C SUCCESSFULLY DONE BY WRITING OUT THE ARRAYS MXDATA AND MYDATA.
C
      WRITE (6,660) MIXNO,DAY
  660 FORMAT ('1',////////,32X,'DATA POINTS',//,30X,
     &'MIX NUMBER',I5,//,29X,I2,3X,'DAY STRENGTH')
      IF (REMIX.EQ.0) GO TO 680
      WRITE (6,670)
  670 FORMAT (/,35X,'REMIX')
  680 WRITE (6,690)
  690 FORMAT (//,26X,'"ARRAY TRANSFER CHECK"')
      WRITE (6,700)
  700 FORMAT(//,4X,'DATA NUMBER',10X,'X-VALUES (STRAIN-%)',10X,
     &'Y-VALUES (STRESS-PSI)',/)
      WRITE (6,710) (L,MXDATA(L),MYDATA(L),L=1,N)
  710 FORMAT (' ',7X,I3,17X,F10.3,19X,F10.1)
C
C       DETERMINE THE ERROR SUM OF SQUARES
C WITH RESPECT TO Y - (SSEY).
C
C       ----- "THE BEST FIT EQUATION" -----
C
      SSEY = 0.0
      DO 720 NR=1,N
      XR2 = MXDATA(NR)
      YBF = (C(1)) + (C(2)*XR2) + (C(3)*(XR2**2))
      DIFFE = MYDATA(NR) - YBF
      ADIFFE = ABS(DIFFE)
      SSEY = SSEY + ((ADIFFE)**2)
  720 CONTINUE
C
C       DETERMINE THE TOTAL SUM OF SQUARES
C WITH RESPECT TO Y - (SSTY).
C
      SSTY = 0.0
      SUMY = 0.0
      DO 730 NR=1,N
      SUMY = SUMY + MYDATA(NR)
  730 CONTINUE
      RN = N
      AVGY = SUMY/RN
      DO 740 NR=1,N
      DIFFY = (MYDATA(NR) - AVGY)
```

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```
      ADIFFY = ABS(DIFFY)
      SSTY = SSTY + ((ADIFFY)**2)
  740 CONTINUE
C
C      DEFINE THE R-SQUARED ADJUSTMENT FACTOR.
C
C      THE PURPOSE OF THE R-SQUARED ADJUSTMENT FACTOR IS TO
C BALANCE THE COST OF USING MORE PARAMETERS (A HIGHER DEGREE
C POLYNOMIAL) AGAINST THE GAIN IN R-SQUARED.  SUCH THAT, AS
C ONE USES A HIGHER DEGREE POLYNOMINAL AS A BEST FIT CURVE,
C THE R-SQUARED WILL ALSO RISE.
C
      RN = N
      RM = M
      ADJFAC = (RN - 1.0)/(RN - (RM + 1.0))
C
C      CALCULATE AND WRITE OUT THE ADJUSTED COEFFICIENT OF
C MULTIPLE DETERMINATION (R-SQUARED).
C
      R2 = 1.0 - (ADJFAC * (SSEY/SSTY))
      IF (REMIX.EQ.0) GO TO 760
      WRITE (6,750) MIXNO,DAY,R2
  750 FORMAT ('1',////////////////,62X,'2',/,9X,
     &'THE ADJUSTED COEFFICIENT OF MULTIPLE DETERMINATION (R )',
     &' FOR MIX NUMBER',3X,I2,',',//,4X,'REMIX AT THE',3X,I2,3X,
     &'DAY STRENGTH, RELATIVE TO THE BEST FIT EQUATION',//,4X,
     &'WHICH WAS USED, IS:',3X,F10.7)
      GO TO 780
  760 WRITE (6,770) MIXNO,DAY,R2
  770 FORMAT ('1',////////////////,62X,'2',/,9X,
     &'THE ADJUSTED COEFFICIENT OF MULTIPLE DETERMINATION (R )',
     &' FOR MIX NUMBER',3X,I2,',',//,4X,'AT THE',3X,I2,3X,
     &'DAY STRENGTH, RELATIVE TO THE BEST FIT EQUATION',//,4X,
     &'WHICH WAS USED, IS:',3X,F10.7)
C
  780 CONTINUE
      CALL PLOT (0.0,0.0,9999)
      STOP
      END
```

G.8 COMPUTER PROGRAM NO. 8 [25, 27]

Computer Program No. 8 performs the same job as Computer Program No. 5 but is modified to be used for the lime-sand mortar mixes. Modifications were necessary due to the lower stress-strain values obtained with the lime-sand mortar mixes. This involved a reduction of the plot scales. More details of this program can be obtained from the description of Computer Program No. 5 and within the program itself.

LIMECOMB "Computer Program No. 8"

```
//LIMBRAND JOB ',,,T=1M,L=10,I=10,C=0','RANDY ZAPOTOTSKY',CLASS=F,
// MSGLEVEL=(1,1)
/*ROUTE PRINT SELF
/*D800 VPLOT
// EXEC FORTHCLG,USERLIB='SYS3.VPLOTLIB',SIZE=256K
//FORT.SYSIN DD *
C
C
C
C           --- THIS IS THE COMBINATION PLOTTING PROGRAM ---
C                    --- LIME-SAND MORTAR MIXES ---
C
C
C
C     WHAT THIS PROGRAM BASICALLY DOES IS THAT IT DRAWS FROM ONE
C UP TO SIX CURVES ON ONE SET OF AXES.  ONE SUCH PLOT IS CALLED A
C COMBINATION PLOT.  THE NUMBER OF COMBINATION PLOT(S) TO BE DRAWN
C IS DEPENDANT UPON THE VALUE OF NOCOMB, OF WHICH IS READ IN.
C
C     THE ORDER OF FILE SUBMISSION IS:  LIMECOMB
C                                       NOCOMB
C                                       COMBDATA - "COMBINATION DATA"
C
C     WHERE:  LIMECOMB = THE NAME OF THIS PROGRAM
C
C               NOCOMB - HAS THE FORM AS FOLLOWS:
C                        1.//GO.SYSIN DD *
C                        2. "NUMBER OF COMBINATION PLOT(S) THAT ARE
C                            TO BE DRAWN - NOCOMB"
C                        3. "NUMBER OF CURVES TO BE DRAWN ON EACH
C                            COMBINATION PLOT - NOCURV"
C
C             COMBDATA - HAS THE FORM AS FOLLOWS:
C
C               1. MIXNO,M,DAY,REMIX,XSTART,MAX10,XLAST,YMAX,DASH
C               2. C1
C               3. C2
C               4. |
C             M+1. CM
C
C     WHERE:
C
C   MIXNO = THE MIX NUMBER
C       M = THE NUMBER OF CONSTANT(S) USED FOR THE BEST FIT EQUATION
C     DAY = THE AGE OF THE MIX, IN DAYS
C   REMIX = "0" IF THE MIX WAS MIXED TOGETHER FOR THE FIRST TIME
C         = "1" IF THE HARDENED ORIGINAL MIX WAS CRUSHED AND REMIXED
C  XSTART = THE EXPERIMENTAL CORRECTION FACTOR TO THE X-VALUES;
C           XSTART IS POSITIVE IF MOVING THE X-VALUES TO THE LEFT
C   MAX10 = (SEE DESCRIPTION BELOW)
C   XLAST = THE MAXIMUM X-VALUE OBTAINED DURING THE BEST FIT PLOTTING
C    YMAX =  "      "    Y-VALUE     "         "     "    "    "     "
C    DASH = (SEE DESCRIPTION BELOW)
C      C_ = THE CONSTANT(S) OF THE BEST FIT EQUATION
C
C     IT SHOULD BE NOTED HERE THAT LINES 1 TO M+1 ARE TO BE REPEATED
C THE SAME NUMBER OF TIMES (UP TO A MAXIMUM OF SIX) AS THE NUMBER OF
C CURVES THAT ARE TO BE PLOTTED ON EACH COMBINATION PLOT.
C
C     ALSO, THE NUMBER AND THE CORRESPONDING CONSTANT(S) MUST MATCH
C THOSE DEFINED FOR EACH CURVE DRAWN ON ANY COMBINATION PLOT.
C IF MORE THAN ONE COMBINATION PLOT IS TO BE DRAWN, THEY MUST ALL BE
C SIMILAR IN NATURE DUE TO THE DEFINED BEST FIT EQUATION(S) FOR
```

```
C EACH OF THE CURVE(S).
C
C      TO SATISFY THE "DO" STATEMENT RULE OF ONLY USING INTEGERS
C GREATER THAN ZERO AND TO OBTAIN AN INCREMENT OF 0.1% STRAIN
C (X-VALUES) WHEN PLOTTING THE BEST FIT CURVE, MAX10 IS
C DEFINED AS FOLLOWS:
C
C            MAX10 = (MAX STRAIN(%) - XSTART + 0.1) * 10
C
C FROM THIS MODIFICATION TO THE MAXIMUM STRAIN VALUE, ONLY
C THE INTEGER PART OF THE NUMBER IS PUT INTO THE DATA FILE,
C IN ORDER TO SATISY THE INTEGER RULE OF A DO LOOP.
C WHEN PLOTTING IT WILL BECOME CLOSE ENOUGH TO THE MAXIMUM
C STRAIN VALUE OBTAINED IN A MIX.  THE LAST DATA POINT PLOTTED
C DURING THE BEST FIT PLOTTING WILL BE OBTAINED WITH THE USE
C OF XLAST.
C
C      FROM THE PROGRAM THIS MODIFICATION COMES FROM:
C
C            X_(I) = ((R_/10.0) - 0.1)
C
C      THE "-0.1" IS NEEDED SO THAT X IS EQUAL TO ZERO FOR THE
C FIRST VALUE.  THIS WILL MAKE THE BEST FIT CURVE PASS THROUGH
C THE ORIGIN.
C
C      MAX10 MUST BE DEFINED FOR EACH INDEPENDANT MIX.
C AGAIN, IT MUST BE PUT INTO A DATA FILE AS AN
C INTEGER, NOT A REAL NUMBER, TO SATISFY THE INTEGER
C RULE OF A DO LOOP.
C
C      A CHECK WILL BE DONE NEAR THE DEFINED FUNCTION SO AS TO
C PREVENT THE BEST FIT CURVE HAVING A NEGATIVE SLOPE AND A
C Y VALUE GREATER THAN THAT OBTAINED DURING THE BEST FIT PLOTTING.
C THIS IS DONE WITH THE USE OF YMAX AS DEFINED ABOVE.
C A NEGATIVE SLOPE IS UNFAVORABLE SINCE IT DOES NOT REPRESENT
C WHAT HAPPENED IN THE ACTUAL TESTS.
C
C      IF THE MIX DID NOT HAVE PEAK LOADS FOR ALL OF THE CUBES,
C A STRAIGHT DASHED LINE WILL BE DRAWN HORIZONTALLY FROM THE
C END OF THE BEST FIT CURVE TO THE FAR RIGHT OF THE PLOT.  THIS
C DASHED LINE WILL REPRESENT THAT LOADING WAS CONTINUED AFTER
C THIS CUT-OFF POINT, BUT NO PEAK LOAD OCCURRED.  IT SHOULD BE
C NOTED THOUGH THAT THE PATH OF THIS DASHED LINE DOES NOT
C NECESSARILY REPRESENT THE ACTUAL PATH TAKEN DURING THE TEST OR
C OF THE BEST FIT CURVE.
C      THIS DASHED LINE WILL NOT BE DRAWN WHEN THE VALUE OF
C "DASH" IS EQUAL TO "0" (ZERO).  WHEN "DASH" IS EQUAL TO
C "1" (ONE), A DASHED LINE WILL BE DRAWN.
C
C     A LEGEND MAY BE INSERTED AT THE END OF EACH COMBINATION
C PLOT(S) BY INSERTING THE PROPER "CALL SYMBOL" STATEMENTS AT THE
C END OF THE OUTER DO LOOP.
C
C     AT THE END OF THE DATA FILE(S), THE PROPER JCL MUST BE
C DEFINED IN ORDER FOR THE PROGRAM TO RUN.
C
C      DUE TO THE LIMITS ON THE DIMENSION STATEMENTS THE
C FOLLOWING LIMITS ARE DEFINED:
C
C            1)  C(__)
C                MAXIMUM ALLOWABLE NUMBER OF CONSTANT(S)
C                PER PLOTTED CURVE IS 10
C
```

```
C             2)  X_(__),Y_(__)
C                 MAXIMUM ALLOWABLE NUMBER OF PLOTTING DATA POINTS
C                 PER CURVE IS 502 - 2 = 500
C
C
C
       DIMENSION IBUF(4000),
      &C(10),X1(502),Y1(502),X2(502),Y2(502),X3(502),Y3(502),
      &X4(502),Y4(502),X5(502),Y5(502),X6(502),Y6(502)
       INTEGER DAY,REMIX
C
C       READ AND WRITE OUT THE NUMBER OF COMBINATION PLOT(S) AND THE
C       NUMBER OF CURVE(S) PER PLOT THAT ARE TO BE DRAWN
C
       READ (5,*) NOCOMB,NOCURV
       WRITE (6,50) NOCOMB
    50 FORMAT ('1',////,4X,'THE NUMBER OF COMBINATION PLOT(S) ',
      &'THAT ARE TO BE DRAWN IS',3X,I3)
       WRITE (6,60) NOCURV
    60 FORMAT (////,4X,'THE NUMBER OF CURVE(S) TO BE DRAWN ON ',
      &'EACH PLOT IS',3X,I3)
C
       DO 610 NC=1,NOCOMB
       CALL PLOTS (IBUF,4000)
C
C       DEFINE SOME CHARACTERISTICS OF THE PLOT
C
       CALL PLOT (0.0,-11.0,-3)
       CALL PLOT (0.0,2.0625,-3)
       CALL FACTOR (1.0)
       CALL AXIS (0.0,0.0,'STRAIN - %',-10,4.0,0.0,0.0,1.0)
       CALL AXIS (0.0,0.0,'STRESS - PSI',12,7.0,90.0,0.0,25.0)
C
C      DRAW A RECTANGULAR FRAME AROUND THE PLOT
C
       CALL NEWPEN (4)
       CALL RECT (-0.75,-1.25,9.0,5.5,0.0,3)
       CALL NEWPEN (1)
C
       DO 590 NCURV=1,NOCURV
C
C      READ AND WRITE OUT SOME BASIC INFORMATION ABOUT THE MIX
C
       READ (5,*) MIXNO,M,DAY,REMIX,XSTART,MAX10,XLAST,YMAX,DASH
C
       WRITE (6,70) MIXNO,DAY
    70 FORMAT ('1',//////,4X,
      &'THIS IS THE LIMECOMB PROGRAM INFORMATION FOR MIX NUMBER',3X,
      &I3,3X,'AT THE',3X,I2,3X,'DAY STRENGTH')
       WRITE (6,80) MIXNO,M
    80 FORMAT (//////,4X,'THE NUMBER OF CONSTANT(S)-M READ IN FOR ',
      &'MIX NUMBER',3X,I3,3X,'IS',3X,I3,3X)
       IF (REMIX.EQ.1) GO TO 100
       WRITE (6,90)
    90 FORMAT (//////,4X,'THE FOLLOWING DATA IS FOR THE MIX ',
      &'WHEN ITS COMPONENTS WERE COMBINED FOR THE FIRST TIME')
       GO TO 120
   100 WRITE (6,110)
   110 FORMAT (//////,4X,'THE FOLLOWING DATA IS FOR WHEN THE ',
      &'HARDENED ORIGINAL MIXTURE WAS CRUSHED AND REMIXED')
   120 WRITE (6,130) XSTART
   130 FORMAT (//////,4X,'THE VALUE OF XSTART READ IN IS',
      &2X,F6.3)
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```
      WRITE (6,140) MIXNO,MAX10
  140 FORMAT (//////,4X,
     &'THE VALUE OF MAX10 THAT WAS READ IN FOR MIX NUMBER',I5,
     &3X,'IS',3X,I4)
      WRITE (6,150) XLAST
  150 FORMAT (//////,4X,'THE HIGHEST STRAIN THAT WAS REACHED ',
     &'DURING THE BEST FIT PLOTTING IS',3X,F7.3,3X,'%')
      WRITE (6,160) YMAX
  160 FORMAT (//////,4X,'THE HIGHEST STRESS THAT WAS REACHED ',
     &'DURING THE BEST FIT PLOTTING IS',3X,F6.1,3X,'PSI')
      IF (DASH.EQ.0) GO TO 180
      WRITE (6,170)
  170 FORMAT (//////,4X,'DURING THE TESTING,',
     &' THIS MIX DID NOT HAVE PEAK LOADS FOR ALL OF THE SPECIMENS.')
      GO TO 200
  180 WRITE (6,190)
  190 FORMAT (//////,4X,'DURING THE TESTING,',
     &' THIS MIX HAD PEAK LOADS FOR ALL OF THE SPECIMENS.')
C
C      READ AND WRITE OUT THE CONSTANTS (C-VALUES)
C
  200 READ (5,*) (C(I),I=1,M)
C
      WRITE (6,210) MIXNO,DAY
  210 FORMAT ('1',////////,11X,'C VALUES',//,9X,'MIX NUMBER',
     &1X,I2,//,8X,I2,1X,'DAY STRENGTH')
      IF (REMIX.EQ.0) GO TO 230
      WRITE (6,220)
  220 FORMAT (/,13X,'REMIX')
  230 WRITE (6,240)
  240 FORMAT (//,4X,'C( )',15X,'VALUE',/)
      WRITE (6,250) (I,C(I),I=1,M)
  250 FORMAT('0',4X,I2,12X,F12.7)
C
C     CALCULATE THE BEST FIT CURVE PLOTTING POINTS - CURVE NO. 1
C
      IF (NCURV.NE.1) GO TO 340
      NSUM1 = 0
      DO 260 I=1,MAX10
      RI=I
      X1(I) = ((RI/10.0) - 0.1)
      IF (X1(I).GE.XLAST) GO TO 270
      XTEMP = X1(I) + XSTART
      Y1(I) = (C(1)) + (C(2)*XTEMP) + (C(3)*(XTEMP**2)) +
     &(C(4)*(XTEMP**3))
      IF (Y1(I).GT.YMAX) GO TO 270
      NSUM1 = NSUM1 + 1
  260 CONTINUE
  270 X1(NSUM1 + 1) = XLAST
      XLTEMP = XLAST + XSTART
      Y1(NSUM1 + 1) = (C(1)) + (C(2)*XLTEMP) + (C(3)*(XLTEMP**2)) +
     &(C(4)*(XLTEMP**3))
      NSUM1 = NSUM1 + 1
C
C      LIST THE BEST FIT CURVE PLOTTING VALUES - CURVE NO. 1
C
      WRITE (6,280) MIXNO,DAY
  280 FORMAT ('1',////////,24X,
     &'BEST FIT CURVE PLOTTING VALUES',//,31X,'MIX NUMBER',I5,
     &//,29X,I2,3X,'DAY STRENGTH')
      IF (REMIX.EQ.0) GO TO 300
      WRITE (6,290)
  290 FORMAT (/,35X,'REMIX')
```

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```
  300 WRITE (6,310)
  310 FORMAT (//,4X,'PLOTTING NUMBER',10X,'X-VALUES (STRAIN-%)',
     &10X,'Y-VALUES (STRESS-PSI)',/)
      WRITE (6,320) (I,X1(I),Y1(I),I=1,NSUM1)
  320 FORMAT (' ',9X,I3,21X,F8.3,22X,F7.1)
C
C     PLOT OUT THE BEST FIT CURVE - CURVE NO. 1
C
      X1(NSUM1+1)=  0.0
      Y1(NSUM1+1)=  0.0
      X1(NSUM1+2)=  1.0
      Y1(NSUM1+2)= 25.0
C
      CALL NEWPEN(8)
      CALL FLINE (X1,Y1,-NSUM1,1,0,0)
      IF (DASH.EQ.0) GO TO 330
      XDASH = (X1(NSUM1)/1.0) + 0.12
      YDASH = Y1(NSUM1)/25.0
      XEND = 4.0 - XDASH
      CALL PLOT (XDASH,YDASH,-3)
      CALL DASHP (XEND,0.0,0.12)
      CALL PLOT (-XDASH,-YDASH,-3)
  330 CALL PLOT (0.0,0.0,3)
      CALL NEWPEN(1)
      GO TO 590
C
C     CALCULATE THE BEST FIT CURVE PLOTTING POINTS - CURVE NO. 2
C
  340 IF (NCURV.NE.2) GO TO 390
      NSUM2 = 0
      DO 350 J=1,MAX10
      RJ=J
      X2(J) = ((RJ/10.0) - 0.1)
      IF (X2(J).GE.XLAST) GO TO 360
      XTEMP = X2(J) + XSTART
      Y2(J) = (C(1)) + (C(2)*XTEMP) + (C(3)*(XTEMP**2)) +
     &(C(4)*(XTEMP**3))
      IF (Y2(J).GT.YMAX) GO TO 360
      NSUM2 = NSUM2 + 1
  350 CONTINUE
  360 X2(NSUM2 + 1) = XLAST
      XLTEMP = XLAST + XSTART
      Y2(NSUM2 + 1) = (C(1)) + (C(2)*XLTEMP) + (C(3)*(XLTEMP**2)) +
     &(C(4)*(XLTEMP**3))
      NSUM2 = NSUM2 + 1
C
C     LIST THE BEST FIT CURVE PLOTTING VALUES - CURVE NO. 2
C
      WRITE (6,280) MIXNO,DAY
      IF (REMIX.EQ.0) GO TO 370
      WRITE (6,290)
  370 WRITE (6,310)
      WRITE (6,320) (J,X2(J),Y2(J),J=1,NSUM2)
C
C     PLOT OUT THE BEST FIT CURVE - CURVE NO. 2
C
      X2(NSUM2+1)=  0.0
      Y2(NSUM2+1)=  0.0
      X2(NSUM2+2)=  1.0
      Y2(NSUM2+2)= 25.0
C
      CALL NEWPEN(8)
      CALL FLINE (X2,Y2,-NSUM2,1,0,0)
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```
      IF (DASH.EQ.0) GO TO 380
      XDASH = (X2(NSUM2)/1.0) + 0.12
      YDASH = Y2(NSUM2)/25.0
      XEND = 4.0 - XDASH
      CALL PLOT (XDASH,YDASH,-3)
      CALL DASHP (XEND,0.0,0.12)
      CALL PLOT (-XDASH,-YDASH,-3)
  380 CALL PLOT (0.0,0.0,3)
      CALL NEWPEN(1)
      GO TO 590
C
C     CALCULATE THE BEST FIT CURVE PLOTTING POINTS - CURVE NO. 3
C
  390 IF (NCURV.NE.3) GO TO 440
      NSUM3 = 0
      DO 400 K=1,MAX10
      RK=K
      X3(K) = ((RK/10.0) - 0.1)
      IF (X3(K).GE.XLAST) GO TO 410
      XTEMP = X3(K) + XSTART
      Y3(K) = (C(1)) + (C(2)*XTEMP) + (C(3)*(XTEMP**2)) +
     &(C(4)*(XTEMP**3))
      IF (Y3(K).GT.YMAX) GO TO 410
      NSUM3 = NSUM3 + 1
  400 CONTINUE
  410 X3(NSUM3 + 1) = XLAST
      XLTEMP = XLAST + XSTART
      Y3(NSUM3 + 1) = (C(1)) + (C(2)*XLTEMP) + (C(3)*(XLTEMP**2)) +
     &(C(4)*(XLTEMP**3))
      NSUM3 = NSUM3 + 1
C
C     LIST THE BEST FIT CURVE PLOTTING POINTS - CURVE NO. 3
C
      WRITE (6,280) MIXNO,DAY
      IF (REMIX.EQ.0) GO TO 420
      WRITE (6,290)
  420 WRITE (6,310)
      WRITE (6,320) (K,X3(K),Y3(K),K=1,NSUM3)
C
C     PLOT OUT THE BEST FIT CURVE - CURVE NO. 3
C
      X3(NSUM3+1)=  0.0
      Y3(NSUM3+1)=  0.0
      X3(NSUM3+2)=  1.0
      Y3(NSUM3+2)= 25.0
C
      CALL NEWPEN(8)
      CALL FLINE (X3,Y3,-NSUM3,1,0,0)
      IF (DASH.EQ.0) GO TO 430
      XDASH = (X3(NSUM3)/1.0) + 0.12
      YDASH = Y3(NSUM3)/25.0
      XEND = 4.0 - XDASH
      CALL PLOT (XDASH,YDASH,-3)
      CALL DASHP (XEND,0.0,0.12)
      CALL PLOT (-XDASH,-YDASH,-3)
  430 CALL PLOT (0.0,0.0,3)
      CALL NEWPEN(1)
      GO TO 590
C
C     CALCULATE THE BEST FIT CURVE PLOTTING POINTS - CURVE NO. 4
C
  440 IF (NCURV.NE.4) GO TO 490
      NSUM4 = 0
```

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```
      DO 450 L=1,MAX10
      RL=L
      X4(L) = ((RL/10.0) - 0.1)
      IF (X4(L).GE.XLAST) GO TO 460
      XTEMP = X4(L) + XSTART
      Y4(L) = (C(1)) + (C(2)*XTEMP) + (C(3)*(XTEMP**2)) +
     &(C(4)*(XTEMP**3))
      IF (Y4(L).GT.YMAX) GO TO 460
      NSUM4 = NSUM4 + 1
  450 CONTINUE
  460 X4(NSUM4 + 1) =XLAST
      XLTEMP = XLAST + XSTART
      Y4(NSUM4 + 1) = (C(1)) + (C(2)*XLTEMP) + (C(3)*(XLTEMP**2)) +
     &(C(4)*(XLTEMP**3))
      NSUM4 = NSUM4 + 1
C
C     LIST THE BEST FIT CURVE PLOTTING POINTS - CURVE NO. 4
C
      WRITE (6,280) MIXNO,DAY
      IF (REMIX.EQ.0) GO TO 470
      WRITE (6,290)
  470 WRITE (6,310)
      WRITE (6,320) (L,X4(L),Y4(L),L=1,NSUM4)
C
C     PLOT OUT THE BEST FIT CURVE - CURVE NO. 4
C
      X4(NSUM4+1)=  0.0
      Y4(NSUM4+1)=  0.0
      X4(NSUM4+2)=  1.0
      Y4(NSUM4+2)= 25.0
C
      CALL NEWPEN(8)
      CALL FLINE (X4,Y4,-NSUM4,1,0,0)
      IF (DASH.EQ.0) GO TO 480
      XDASH = (X4(NSUM4)/1.0) + 0.12
      YDASH = Y4(NSUM4)/25.0
      XEND = 4.0 - XDASH
      CALL PLOT (XDASH,YDASH,-3)
      CALL DASHP (XEND,0.0,0.12)
      CALL PLOT (-XDASH,-YDASH,-3)
  480 CALL PLOT (0.0,0.0,3)
      CALL NEWPEN(1)
      GO TO 590
C
C     CALCULATE THE BEST FIT CURVE PLOTTING POINTS - CURVE NO. 5
C
  490 IF (NCURV.NE.5) GO TO 540
      NSUM5 = 0
      DO 500 MJ=1,MAX10
      RMJ=MJ
      X5(MJ) = ((RMJ/10.0) - 0.1)
      IF (X5(MJ).GE.XLAST) GO TO 510
      XTEMP = X5(MJ) + XSTART
      Y5(MJ) = (C(1)) + (C(2)*XTEMP) + (C(3)*(XTEMP**2)) +
     &(C(4)*(XTEMP**3))
      IF (Y5(MJ).GT.YMAX) GO TO 510
      NSUM5 = NSUM5 + 1
  500 CONTINUE
  510 X5(NSUM5 + 1) = XLAST
      XLTEMP = XLAST + XSTART
      Y5(NSUM5 + 1) = (C(1)) + (C(2)*XLTEMP) + (C(3)*(XLTEMP**2)) +
     &(C(4)*(XLTEMP**3))
      NSUM5 = NSUM5 + 1
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```
C
C     LIST THE BEST FIT CURVE PLOTTING POINTS - CURVE NO. 5
C
      WRITE (6,280) MIXNO,DAY
      IF (REMIX.EQ.0) GO TO 520
      WRITE (6,290)
  520 WRITE (6,310)
      WRITE (6,320) (MJ,X5(MJ),Y5(MJ),MJ=1,NSUM5)
C
C     PLOT OUT THE BEST FIT CURVE - CURVE NO. 5
C
      X5(NSUM5+1)=  0.0
      Y5(NSUM5+1)=  0.0
      X5(NSUM5+2)=  1.0
      Y5(NSUM5+2)= 25.0
C
      CALL NEWPEN(8)
      CALL FLINE (X5,Y5,-NSUM5,1,0,0)
      IF (DASH.EQ.0) GO TO 530
      XDASH = (X5(NSUM5)/1.0) + 0.12
      YDASH = Y5(NSUM5)/25.0
      XEND = 4.0 - XDASH
      CALL PLOT (XDASH,YDASH,-3)
      CALL DASHP (XEND,0.0,0.12)
      CALL PLOT (-XDASH,-YDASH,-3)
  530 CALL PLOT (0.0,0.0,3)
      CALL NEWPEN(1)
      GO TO 590
C
C     CALCULATE THE BEST FIT CURVE PLOTTING POINTS - CURVE NO. 6
C
  540 IF (NCURV.NE.6) GO TO 590
      NSUM6 = 0
      DO 550  NJ=1,MAX10
      RNJ=NJ
      X6(NJ) = ((RNJ/10.0) - 0.1)
      IF (X6(NJ).GE.XLAST) GO TO 560
      XTEMP = X6(NJ) + XSTART
      Y6(NJ) = (C(1)) + (C(2)*XTEMP) + (C(3)*(XTEMP**2)) +
     &(C(4)*(XTEMP**3))
      IF (Y6(NJ).GT.YMAX) GO TO 560
      NSUM6 = NSUM6 + 1
  550 CONTINUE
  560 X6(NSUM6 + 1) = XLAST
      XLTEMP = XLAST + XSTART
      Y6(NSUM6 + 1) = (C(1)) + (C(2)*XLTEMP) + (C(3)*(XLTEMP**2)) +
     &(C(4)*(XLTEMP**3))
      NSUM6 = NSUM6 + 1
C
C     LIST THE BEST FIT CURVE PLOTTING POINTS - CURVE NO. 6
C
      WRITE (6,280) MIXNO,DAY
      IF (REMIX.EQ.0) GO TO 570
      WRITE (6,290)
  570 WRITE (6,310)
      WRITE (6,320) (NJ,X6(NJ),Y6(NJ),NJ=1,NSUM6)
C
C     PLOT OUT THE BEST FIT CURVE - CURVE NO. 6
C
      X6(NSUM6+1)=  0.0
      Y6(NSUM6+1)=  0.0
      X6(NSUM6+2)=  1.0
      Y6(NSUM6+2)= 25.0
```

```
C
      CALL NEWPEN(8)
      CALL FLINE (X6,Y6,-NSUM6,1,0,0)
      IF (DASH.EQ.0) GO TO 580
      XDASH = (X6(NSUM6)/1.0) + 0.12
      YDASH = Y6(NSUM6)/25.0
      XEND = 4.0 - XDASH
      CALL PLOT (XDASH,YDASH,-3)
      CALL DASHP (XEND,0.0,0.12)
      CALL PLOT (-XDASH,-YDASH,-3)
  580 CALL PLOT (0.0,0.0,3)
      CALL NEWPEN(1)
C
  590 CONTINUE
C
C     DEVELOP A LEGEND FOR COMBINATION PLOT NO. 1
C
      IF (NC.NE.1) GO TO 591
      CALL SYMBOL (1.76,6.86,0.14,'LIME:SAND MORTAR',0.0,16)
      CALL SYMBOL (1.76,6.58,0.14,'LIME BRAND STUDY',0.0,16)
      CALL SYMBOL (1.83,6.30,0.14,'LIME:SAND = 1:6',0.0,15)
      CALL SYMBOL (2.32,6.09,0.07,'MIX NOS. 12 & 18',0.0,16)
      CALL SYMBOL (2.39,5.95,0.07,'7-DAY STRENGTH',0.0,14)
      GO TO 609
C
C     DEVELOP A LEGEND FOR COMBINATION PLOT NO. 2
C
  591 IF (NC.NE.2) GO TO 592
      CALL SYMBOL (1.76,6.86,0.14,'LIME:SAND MORTAR',0.0,16)
      CALL SYMBOL (1.76,6.58,0.14,'LIME BRAND STUDY',0.0,16)
      CALL SYMBOL (1.83,6.30,0.14,'LIME:SAND = 1:6',0.0,15)
      CALL SYMBOL (2.32,6.09,0.07,'MIX NOS. 12 & 18',0.0,16)
      CALL SYMBOL (2.355,5.95,0.07,'28-DAY STRENGTH',0.0,15)
      GO TO 609
C
C     DEVELOP A LEGEND FOR COMBINATION PLOT NO. 3
C
  592 IF (NC.NE.3) GO TO 593
      CALL SYMBOL (1.76,6.86,0.14,'LIME:SAND MORTAR',0.0,16)
      CALL SYMBOL (1.76,6.58,0.14,'LIME BRAND STUDY',0.0,16)
      CALL SYMBOL (1.83,6.30,0.14,'LIME:SAND = 1:5',0.0,15)
      CALL SYMBOL (2.32,6.09,0.07,'MIX NOS. 13 & 19',0.0,16)
      CALL SYMBOL (2.39,5.95,0.07,'7-DAY STRENGTH',0.0,14)
      GO TO 609
C
C     DEVELOP A LEGEND FOR COMBINATION PLOT NO. 4
C
  593 IF (NC.NE.4) GO TO 594
      CALL SYMBOL (1.76,6.86,0.14,'LIME:SAND MORTAR',0.0,16)
      CALL SYMBOL (1.76,6.58,0.14,'LIME BRAND STUDY',0.0,16)
      CALL SYMBOL (1.83,6.30,0.14,'LIME:SAND = 1:5',0.0,15)
      CALL SYMBOL (2.32,6.09,0.07,'MIX NOS. 13 & 19',0.0,16)
      CALL SYMBOL (2.355,5.95,0.07,'28-DAY STRENGTH',0.0,15)
      GO TO 609
C
C     DEVELOP A LEGEND FOR COMBINATION PLOT NO. 5
C
  594 IF (NC.NE.5) GO TO 595
      CALL SYMBOL (1.69,6.86,0.14,'LIME:SAND MORTAR',0.0,16)
      CALL SYMBOL (1.69,6.58,0.14,'LIME BRAND STUDY',0.0,16)
      CALL SYMBOL (1.62,6.30,0.14,'LIME:SAND = 1:4.5',0.0,17)
      CALL SYMBOL (2.25,6.09,0.07,'MIX NOS. 14 & 20',0.0,16)
      CALL SYMBOL (2.32,5.95,0.07,'7-DAY STRENGTH',0.0,14)
```

LIMECOMB "Computer Program No. 8"

```
           GO TO 609
C
C          DEVELOP A LEGEND FOR COMBINATION PLOT NO. 6
C
      595  IF (NC.NE.6) GO TO 596
           CALL SYMBOL (1.69,6.86,0.14,'LIME:SAND MORTAR',0.0,16)
           CALL SYMBOL (1.69,6.58,0.14,'LIME BRAND STUDY',0.0,16)
           CALL SYMBOL (1.62,6.30,0.14,'LIME:SAND = 1:4.5',0.0,17)
           CALL SYMBOL (2.25,6.09,0.07,'MIX NOS. 14 & 20',0.0,16)
           CALL SYMBOL (2.285,5.95,0.07,'28-DAY STRENGTH',0.0,15)
           GO TO 609
C
C          DEVELOP A LEGEND FOR COMBINATION PLOT NO. 7
C
      596  IF (NC.NE.7) GO TO 597
           CALL SYMBOL (1.62,6.86,0.14,'LIME:SAND MORTAR',0.0,16)
           CALL SYMBOL (1.62,6.58,0.14,'LIME BRAND STUDY',0.0,16)
           CALL SYMBOL (1.48,6.30,0.14,'LIME:SAND = 1:3.65',0.0,18)
           CALL SYMBOL (2.18,6.09,0.07,'MIX NOS. 15 & 21',0.0,16)
           CALL SYMBOL (2.32,5.95,0.07,'7-DAY STRENGTH',0.0,14)
           GO TO 609
C
C          DEVELOP A LEGEND FOR COMBINATION PLOT NO. 8
C
      597  IF (NC.NE.8) GO TO 598
           CALL SYMBOL (1.62,6.86,0.14,'LIME:SAND MORTAR',0.0,16)
           CALL SYMBOL (1.62,6.58,0.14,'LIME BRAND STUDY',0.0,16)
           CALL SYMBOL (1.48,6.30,0.14,'LIME:SAND = 1:3.65',0.0,18)
           CALL SYMBOL (2.18,6.09,0.07,'MIX NOS. 15 & 21',0.0,16)
           CALL SYMBOL (2.215,5.95,0.07,'28-DAY STRENGTH',0.0,15)
           GO TO 609
C
C          DEVELOP A LEGEND FOR COMBINATION PLOT NO. 9
C
      598  IF (NC.NE.9) GO TO 599
           CALL SYMBOL (1.76,6.86,0.14,'LIME:SAND MORTAR',0.0,16)
           CALL SYMBOL (1.76,6.58,0.14,'LIME BRAND STUDY',0.0,16)
           CALL SYMBOL (1.83,6.30,0.14,'LIME:SAND = 1:3',0.0,15)
           CALL SYMBOL (2.32,6.09,0.07,'MIX NOS. 16 & 22',0.0,16)
           CALL SYMBOL (2.39,5.95,0.07,'7-DAY STRENGTH',0.0,14)
           GO TO 609
C
C          DEVELOP A LEGEND FOR COMBINATION PLOT NO. 10
C
      599  IF (NC.NE.10) GO TO 600
           CALL SYMBOL (1.76,6.86,0.14,'LIME:SAND MORTAR',0.0,16)
           CALL SYMBOL (1.76,6.58,0.14,'LIME BRAND STUDY',0.0,16)
           CALL SYMBOL (1.83,6.30,0.14,'LIME:SAND = 1:3',0.0,15)
           CALL SYMBOL (2.32,6.09,0.07,'MIX NOS. 16 & 22',0.0,16)
           CALL SYMBOL (2.355,5.95,0.07,'28-DAY STRENGTH',0.0,15)
           GO TO 609
C
C          DEVELOP A LEGEND FOR COMBINATION PLOT NO. 11
C
      600  IF (NC.NE.11) GO TO 601
           CALL SYMBOL (1.76,6.86,0.14,'LIME:SAND MORTAR',0.0,16)
           CALL SYMBOL (1.76,6.58,0.14,'LIME BRAND STUDY',0.0,16)
           CALL SYMBOL (1.83,6.30,0.14,'LIME:SAND = 1:2',0.0,15)
           CALL SYMBOL (2.32,6.09,0.07,'MIX NOS. 17 & 23',0.0,16)
           CALL SYMBOL (2.39,5.95,0.07,'7-DAY STRENGTH',0.0,14)
           GO TO 609
C
C          DEVELOP A LEGEND FOR COMBINATION PLOT NO. 12
```

LIMECOMB "Computer Program No. 8"

```
C
  601 IF (NC.NE.12) GO TO 602
      CALL SYMBOL (1.76,6.86,0.14,'LIME:SAND MORTAR',0.0,16)
      CALL SYMBOL (1.76,6.58,0.14,'LIME BRAND STUDY',0.0,16)
      CALL SYMBOL (1.83,6.30,0.14,'LIME:SAND = 1:2',0.0,15)
      CALL SYMBOL (2.32,6.09,0.07,'MIX NOS. 17 & 23',0.0,16)
      CALL SYMBOL (2.355,5.95,0.07,'28-DAY STRENGTH',0.0,15)
      GO TO 609
C
C     DEVELOP A LEGEND FOR COMBINATION PLOT NO. 13
C
  602 IF (NC.NE.13) GO TO 603
      CALL SYMBOL (1.76,6.86,0.14,'LIME:SAND MORTAR',0.0,16)
      CALL SYMBOL (1.76,6.58,0.14,'LIME BRAND STUDY',0.0,16)
      CALL SYMBOL (1.83,6.30,0.14,'LIME:SAND = 1:2',0.0,15)
      CALL SYMBOL (2.32,6.09,0.07,'MIX NOS. 17 & 23',0.0,16)
      CALL SYMBOL (2.705,5.95,0.07,'REMIX',0.0,5)
      CALL SYMBOL (2.39,5.81,0.07,'7-DAY STRENGTH',0.0,14)
      GO TO 609
C
C     DEVELOP A LEGEND FOR COMBINATION PLOT NO. 14
C
  603 IF (NC.NE.14) GO TO 604
      CALL SYMBOL (1.76,6.86,0.14,'LIME:SAND MORTAR',0.0,16)
      CALL SYMBOL (1.76,6.58,0.14,'LIME BRAND STUDY',0.0,16)
      CALL SYMBOL (1.83,6.30,0.14,'LIME:SAND = 1:2',0.0,15)
      CALL SYMBOL (2.32,6.09,0.07,'MIX NOS. 17 & 23',0.0,16)
      CALL SYMBOL (2.705,5.95,0.07,'REMIX',0.0,5)
      CALL SYMBOL (2.355,5.81,0.07,'28-DAY STRENGTH',0.0,15)
      GO TO 609
C
C     DEVELOP A LEGEND FOR COMBINATION PLOT NO. 15
C
  604 IF (NC.NE.15) GO TO 609
      CALL SYMBOL (1.76,6.86,0.14,'LIME:SAND MORTAR',0.0,16)
      CALL SYMBOL (1.76,6.58,0.14,'LIME BRAND STUDY',0.0,16)
      CALL SYMBOL (1.83,6.30,0.14,'LIME:SAND = 1:6',0.0,15)
      CALL SYMBOL (2.32,6.09,0.07,'MIX NOS. 12 & 18',0.0,16)
      CALL SYMBOL (2.39,5.95,0.07,'7-DAY STRENGTH',0.0,14)
C
  609 CALL PLOT (12.0,0.0,999)
  610 CONTINUE
      CALL PLOT (0.0,0.0,9999)
      STOP
      END
```

G.9 COMPUTER PROGRAM NO. 9 [25, 27]

Computer Program No. 9 was used only for the lime-sand mortar mixes. This program plots the maximum compressive stress, as defined by the best-fit curve using Computer Program No. 7, versus the lime-sand ratio of the mix. More details of this program are included in the program itself.

RATIOPLOT "Computer Program No. 9"

```
//FMREMIXB JOB ',,,T=1M,L=5,I=10,C=0','RANDY ZAPOTOTSKY',CLASS=F,
// MSGLEVEL=(1,1)
/*ROUTE PRINT SELF
/*D800 VPLOT
// EXEC FORTHCLG,USERLIB='SYS3.VPLOTLIB',SIZE=256K
//FORT.SYSIN DD *
C
C
C
C                                --- RATIOPLOT ---
C
C      --- THIS IS THE PROGRAM FOR STRENGTH VS RATIO PLOTTING ---
C
C
C
C      IN THIS PROGRAM THE FIRST THING THAT IS READ IN IS THE
C NUMBER OF PLOTS TO BE DRAWN.  THE CHARACTERISTICS, NAMELY
C THE ORGIN AND AXES, ARE THEN DEFINED AND PLOTTED OUT.
C FOR AESTHETICS PURPOSES ONLY, A FRAME IS THEN DRAWN AROUND
C THIS SET OF AXES.
C
C      FOLLOWING THE ABOVE, THE DATA POINTS ARE THEN READ IN,
C PLOTTED OUT WITHIN THE LIMITS OF THE CHARACTERISTICS OF THE
C PLOT AND THEN A SMOOTH LINE JOINS EACH SET OF POINTS.
C FOR EACH PLOT TWO SETS OF CURVES ARE SET OUT TO BE PLOTTED.
C ERRATIC DATA POINTS NOT INCLUDED IN THE CURVE ARE PLOTTED OUT
C AT THE END OF THE PROGRAM.
C
C      IN THE END, A LEGEND MAY BE INSERTED.
C
C      WHEN SUBMITTING A JOB, THE ORDER OF SUBMISSION IS:
C
C           1)  RATIOPLOT
C           2)  NOPLOT
C           3)  "FIRST DATA FILE"
C           4)  "SECOND DATA FILE"
C           5)  "THIRD DATA FILE"
C           |)    |    |    |
C           |)    |    |    |
C           N)  "N-2TH DATA FILE (LAST ONE)"
C
C      WHERE:
C
C              RATIOPLOT:  IS THE NAME OF THIS PLOTTING PROGRAM.
C
C                 NOPLOT:  CONTAINS THE FIRST JCL STATEMENT AND
C                          SPECIFIES THE NUMBER OF PLOTS TO BE
C                          PLOTTED.  THE FORM OF THIS FILE IS:
C
C                          1. //GO.SYSIN.DD *
C                          2. "NUMBER OF PLOTS"
C
C              DATA FILE:  THE FIRST OR ANY OTHER DATA FILE
C                          CONTAINS SOME BASIC INFORMATION ABOUT
C                          THE PLOT AND ITS DATA POINTS.  THE
C                          FORM OF A DATA FILE IS:
C
C                          1. N1       N2
C                          2. X1       Y1
C                          3. X2       Y2
C                          |.  |        |
C                          |.  |        |
C                          N. X(N-1)   Y(N-1)
```

```
C
C                 WHERE:     N1 = THE NUMBER OF DATA POINTS TO DEFINE
C                                 CURVE NUMBER 1
C
C                            N2 = THE NUMBER OF DATA POINTS TO DEFINE
C                                 CURVE NUMBER 2
C
C                         X&Y'S = THE DATA POINTS.
C
C
C     ALSO, WHEN SUBMITTING A JOB, ONE MUST MAKE SURE THAT THE
C JCL ENDING THE DATA INFORMATION MUST BE PLACED AT THE CORRECT
C POSITION.  IF ONLY ONE PLOT IS TO BE PLOTTED, IT GOES AT THE
C END OF THE FIRST DATA FILE.  IN THE CASE WHERE MORE THAN TWO
C PLOTS WILL BE DRAWN, THE JCL MUST BE PUT AT THE END OF THE
C LAST DATA FILE.
C
C     DEPENDING ON THE NUMBER AND TYPE OF PLOTS TO BE DONE, THE
C "DEVELOP A LEGEND" PART OF THE PROGRAM MUST BE MODIFIED
C ACCORDINGLY, IF USED.
C
C     LIMITATIONS OF THE DIMENSION STATEMENTS ARE AS FOLLOWS:
C
C          1)  RATIO_(__),STRES_(__)
C              MAXIMUM ALLOWABLE NUMBER OF DATA POINTS PER CUBE
C              READ IN IS 52 - 2 = 50
C
C
C
      DIMENSION IBUF(4000),RATIO1(52),STRES1(52),RATIO2(52),
     &STRES2(52)
C
C     READ AND WRITE OUT THE NUMBER OF PLOTS TO BE DRAWN
C
      READ (5,*) NOPLOT
      WRITE (6,10) NOPLOT
   10 FORMAT ('1',////////,4X,'THE NUMBER OF PLOTS THAT ',
     &'ARE TO BE DRAWN IS',3X,I3)
      DO 70 NP=1,NOPLOT
      CALL PLOTS (IBUF,4000)
C
C     DEFINE SOME CHARACTERISTICS OF THE PLOT.
C
      CALL PLOT (0.0,-11.0,-3)
      CALL PLOT (0.0,3.50,-3)
      CALL FACTOR (1.0)
      CALL AXIS (0.0,0.0,'LIME:SAND RATIO - 1:X',-21,7.0,0.0,0.0,1.0)
      CALL AXIS (0.0,0.0,'MORTAR STRENGTH - PSI',21,4.0,90.0,0.0,50.0)
C
C      ------ DRAW A RECTANGULAR FRAME AROUND THE PLOT ------
C
      CALL NEWPEN (4)
      CALL RECT (-1.0,-1.25,6.0,9.0,0.0,3)
      CALL NEWPEN (1)
C
C     WRITE OUT THE PLOT NUMBER
C
      WRITE (6,20) NP
   20 FORMAT ('1',////////,4X,'THE FOLLOWING INFORMATION IS FOR ',
     &'PLOT NUMBER',3X,I5)
C
C     READ AND WRITE OUT THE NUMBER OF DATA POINTS FOR EACH CURVE.
C
```

```
      READ (5,*) N1,N2
      WRITE (6,30) N1,N2
   30 FORMAT (////////,4X,'THE NUMBER OF DATA POINTS READ IN FOR ',
     &'CURVE NO. 1 IS:',3X,I5,//,42X,'CURVE NO. 2 IS:',3X,I5)
C
C     READ AND WRITE OUT THE DATA POINTS FOR THE MIX.
C
      READ (5,*) (RATIO1(I),STRES1(I),I=1,N1)
      READ (5,*) (RATIO2(J),STRES2(J),J=1,N2)
C
      WRITE (6,40) NP
   40 FORMAT ('1',////////,32X,'DATA POINTS',//,30X,
     &'PLOT NUMBER',I5)
      WRITE(6,50)
   50 FORMAT(//,4X,'DATA NUMBER',10X,'X-VALUES (RATIO)',10X,
     &'Y-VALUES (STRENGTH-PSI)',/)
      WRITE (6,60) (I,RATIO1(I),STRES1(I),I=1,N1)
      WRITE (6,60) (J,RATIO2(J),STRES2(J),J=1,N2)
   60 FORMAT (' ',7X,I3,15X,F10.3,19X,F10.1)
C
C     PLOT OUT THE DATA POINTS.
C
      RATIO1 (N1+1)=  0.0
      STRES1 (N1+1)=  0.0
      RATIO1 (N1+2)=  1.0
      STRES1 (N1+2)= 50.0
C
      RATIO2 (N2+1)=  0.0
      STRES2 (N2+1)=  0.0
      RATIO2 (N2+2)=  1.0
      STRES2 (N2+2)= 50.0
C
      CALL LINE (RATIO1,STRES1,N1,1,-1,0)
      CALL LINE (RATIO2,STRES2,N2,1,-1,2)
C
C     JOIN THE POINTS WITH A SMOOTH LINE.
C
      XBEG1 = RATIO1(1)/1.0
      YBEG1 = STRES1(1)/50.0
      CALL NEWPEN (4)
      CALL PLOT (XBEG1,YBEG1,3)
      CALL FLINE (RATIO1,STRES1,-N1,1,0,0)
      CALL NEWPEN (1)
C
      XBEG2 = RATIO2(1)/1.0
      YBEG2 = STRES2(1)/50.0
      CALL NEWPEN (4)
      CALL PLOT (XBEG2,YBEG2,3)
      CALL FLINE (RATIO2,STRES2,-N2,1,0,2)
      CALL NEWPEN (1)
C
C     THE FOLLOWING RECORDS WILL PLOT OUT ERRATIC DATA POINTS.
C
      CALL SYMBOL (3.65,1.866,0.08,2,0.0,-1)
C
C      ------ DEVELOP A LEGEND ------
C
C     PUT MAJOR AND MINOR INFORMATION INTO THE LEGEND.
C
      CALL SYMBOL (2.52,3.86,0.14,'LEGEND',0.0,6)
      CALL SYMBOL (2.80,3.58,0.14,'= LIME BRAND B REMIX AT  7-DAY',
     &0.0,30)
      CALL SYMBOL (2.80,3.30,0.14,'= LIME BRAND B REMIX AT 28-DAY',
```

```
     &0.0,30)
C
C        THE FOLLOWING RECORDS WILL PLACE THE SYMBOLS USED FOR
C  PLOTTING THE DATA POINTS INTO THE LEGEND.  ONE SYMBOL WILL BE
C  USED FOR EACH DIFFERENT LIME BRAND.
C
      CALL SYMBOL (2.59,3.65,0.14,0,0.0,-1)
      CALL SYMBOL (2.59,3.37,0.14,2,0.0,-1)
C
      CALL PLOT (12.0,0.0,999)
   70 CONTINUE
      CALL PLOT (0.0,0.0,9999)
      STOP
      END
```

Appendix H

TESTING-DATA FOR CLAY MORTAR MIXES

Testing-data for each clay mortar mix consisted of three parts: 1) pre-sanding data, 2) compression testing data, and 3) post-testing data. Detailed first and fully in this appendix is the Pre-Sanding and Post-Testing Data. Tabulated at the end of this appendix is the Compression Testing Information, which is only part of the compression testing data. The remaining compression testing data results (stress-strain data) are presented in Chapter IV, Subsection 4.1.3, Plots. In Chapter IV, the stress-strain data points are plotted to scale on computer plots.

Classified as the Pre-Sanding Data are the notes taken on the specimens prior to sanding in preparation for the compression test. Notes on the specimens included the colour, shape, surface texture, cracks, density (for Mix Nos. 7 to 11 only) plus other assorted features.

Termed the Post-Testing Data are the notes taken on the specimens after the compression test. This included the mode of fracture/failure, the angle of rupture and general notes.

Two types of mode of failure were noted throughout the compression testing of the clay mortar mixes -- 1) pyramidal/hourglass fracture, and 2) splitting failure/ columnar fracture. A sketch of a typical pyramidal fracture and splitting failure are shown respectively in Figures H-1 and H-2. Photographs H-1 and H-2, respectively show occurrence of a pyramidal fracture and splitting failure; in these photographs, the sample pyramidal fracture took place with lime-sand mortar Mix No. 17 at the 28-day age and the sample splitting failure took place with clay mortar Mix No. 2 at the 28-day age. These two respective photographs also show the general shape of the clay and lime-sand mortar specimens after testing; in the case of the clay mortar mixes, this applied only to those specimens which had a peak failure load.

Both of the above modes of failure are essentially a shear failure due to lateral tension. For the pyramidal fracture, the friction between the loaded surfaces of the specimen and the machine platens hold the material next to the loaded surfaces together, while the lateral tension shear off the free sides (see Figure H-1). If the above stated friction is eliminated or reduced, the lateral tension is able to act more evenly over the full length of the specimen. With this type of action, cracks form vertically and parallel to each other in the direction of loading, which is a characteristic of a splitting failure (see Figure

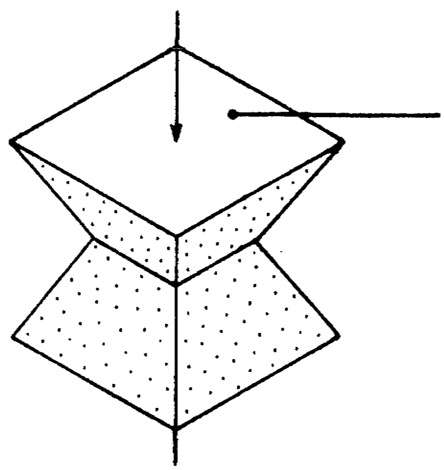


Figure H-1: Pyramidal/Hourglass Fracture

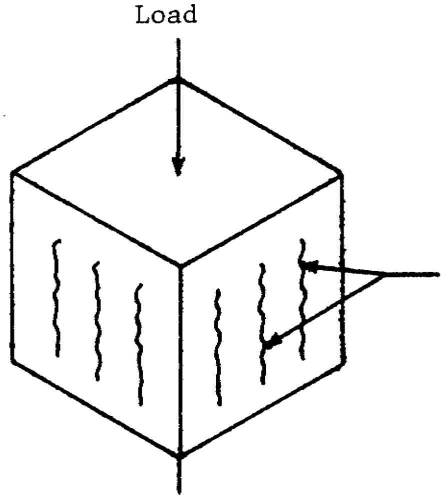


Figure H-2: Splitting Failure/Columnar Fracture

Photograph H-1: Lime-Sand Mortar Original Mix No. 17 Tested Specimens (28-Day)

H-2). Splitting failure tends to occur for brittle materials with high compressive strength and for short specimens.

Noted along with the mode of failure was the angle of rupture (θ). Figure H-3 shows the measurement of this angle. If $\theta = 45°$, the failure is due only to the cohesion of the material. In the case where θ is greater than 45°, the failure is due to internal friction as well as cohesion of the material. The angle of rupture is expressed as follows:

Photograph H-2: Clay Mortar Mix No. 2 Tested Specimens (28-Day)

$$\theta = 45 + \phi/2$$

where ϕ = the angle of internal friction.

Both θ and ϕ assume homogeneity of the material and that the material follows the Mohr theory of rupture.

In this appendix and investigation in general, when a list of numbers in a table has an index such as "x 0.001", it means to take the numbers listed and to apply that index to those numbers. It does not mean that the index was previously applied to the listed numbers. This system of tabulation was used to be consistent with the computer plotting.

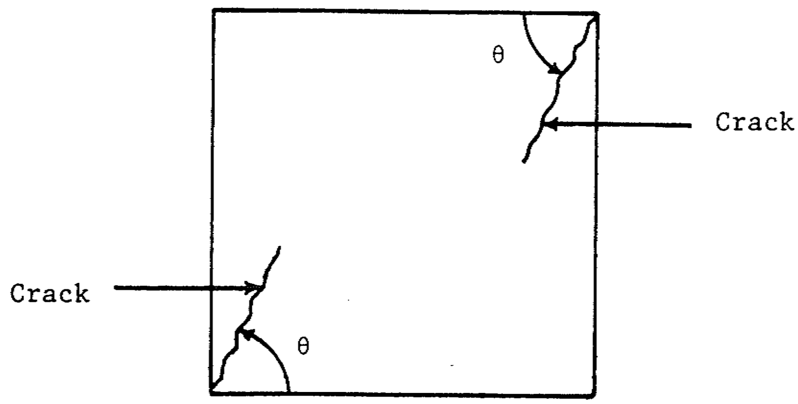


Figure H-3: Angle of Rupture (θ) Measurement

H.1 MIX NO. 1

H.1.1 Pre-Sanding Data

Colour: dark greyish-brown

Shape: top - concave

sides - concave, corners at the top and bottom point out noticeably

bottom - convex

- see Figure H-4 for a sketch of the shape

Surface Texture: top - smooth to rough

sides - " " "

bottom - rough with bumps

Cracks: - mostly hairline cracks measuring up to 3/8 inch in length

- separation crack occurred on one bottom corner of each specimen having an approximate length of one inch and a maximum width of 0.035 inch

Other Features: - the bottom separation crack/corner crack chip which occurred for each specimen was unique among all of the clay mortar mixes (Photograph H-3)

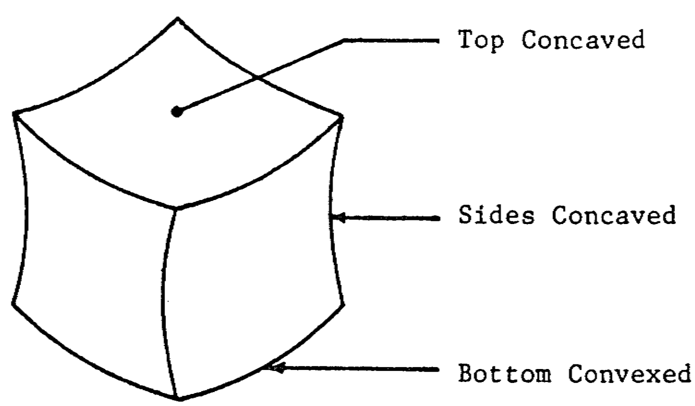
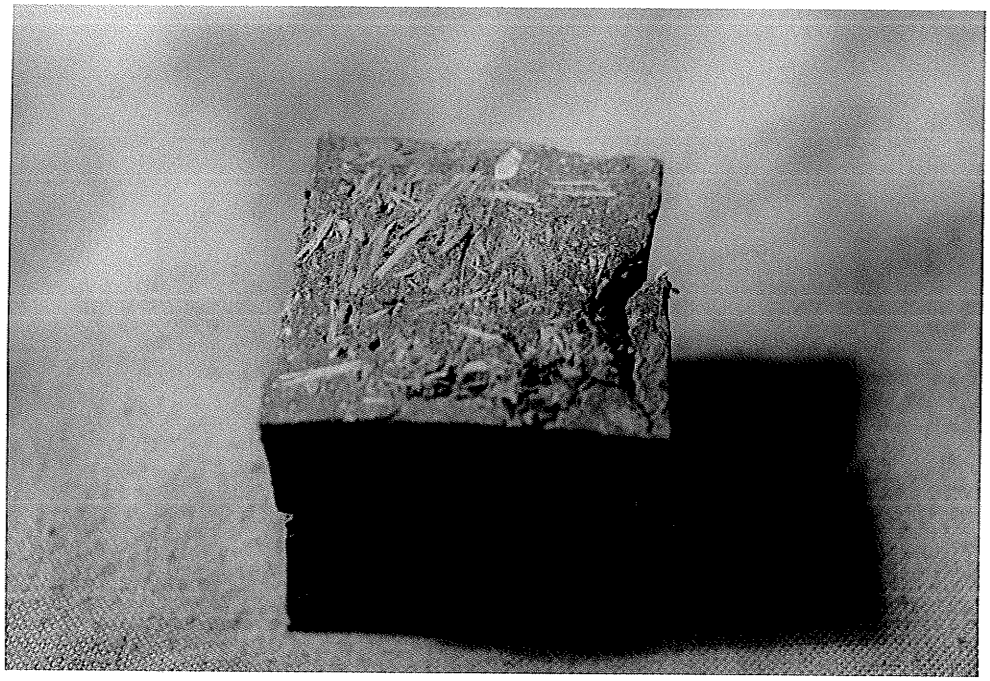


Figure H-4: Shape of Clay Mortar Mix No. 1 Specimens Before Sanding



Photograph H-3: Bottom Separation Crack/Corner Chip Characteristic of the Specimens of Clay Mortar Mix No. 1 Upon Drying

H.1.2 Post-Testing Data

Mode of Failure: - splitting failure with a sign of pyramidal fracture

Angle of Rupture -- θ: - 90°, for the splitting failure cracks

- 80°, for the pyramidal fracture cracks

General Notes: - top loading surface showed evidence of being restrained by the loading platen
- splitting failure occurred along the top perimeter on the sides

H.2 MIX NO. 2

H.2.1 Pre-Sanding Data

Colour: grey

Shape: top - concave
sides - concave but to a lesser degree than Mix No. 1
- top and bottom corners point out slightly
bottom - convex

Surface Texture: top - a thin powdery and crumbly material existed on the top with a smooth to rough surface beneath
sides - smooth to rough with odd bumps
bottom - rough with bumps

Cracks: - hairline cracks
- larger cracks with length up to 5/8 inch and a maximum width of 0.035 inch

Other Features: - most of the cracks were on the bottom of the specimens and near the bottom on the sides; none existed on the top

H.2.2 Post-Testing Data

Mode of Failure: splitting failure

Angle of Rupture -- θ: 90°

General Notes:
- specimens had a crushed appearance
- sides at mid-height slightly bowed out
- top loading surface showed evidence of being restrained by the loading platen

H.3 MIX NO. 3

H.3.1 Pre-Sanding Data

Colour: grey

Shape:
- top - concave
- sides - fairly vertical
  - the concave shape that existed in Mix Nos. 1 and 2 did not exist, especially with respect to Mix No. 1
- bottom - convex

Surface Texture: - same notes as for Mix No. 2

Cracks: - same notes as for Mix No. 2

Other Features: - same notes as for Mix No. 2

H.3.2 Post-Testing Data

- same notes as for Mix No. 2

H.4 MIX NO. 4

H.4.1 Pre-Sanding Data

- same notes as for Mix No. 2 except the larger cracks have lengths up to 7/8 inch and a maximum width of 0.065 inch

H.4.2 Post-Testing Data

- same notes as for Mix No. 2

H.5 MIX NO. 5^{A} (AIR-DRY)

H.5.1 Pre-Sanding Data

- same notes as for Mix No. 4, except the larger cracks have a maximum width of 0.075 inch and that the density of cracks, especially on the bottom, had decreased

H.5.2 Post-Testing Data

Mode of Failure:
- splitting failure
- Specimen No. 3 showed a slight pyramidal type of fracture

Angle of Rupture -- θ:
- 90°, for the splitting failure cracks
- 60°, for pyramidal fracture crack on one side of Specimen No. 3

General Notes: - same notes as for Mix No. 2 but less bowing out of the sides

H.6 MIX NO. 5^B (MOIST-CURED)

H.6.1 Pre-Sanding Data

Colour: grey

Shape: top - concave, but to a lesser degree than Mix Nos. 1 to 5^A

sides - same notes as for Mix No. 3

bottom - mostly even

Surface Texture: top - fairly smooth with slight bumps

sides - smooth to rough with odd bumps

- powdery

bottom - fairly smooth with odd bumps

- powdery

Cracks: - same notes as for Mix No. 2 except the larger cracks have lengths up to 3/4 inch and a maximum width of 0.080 inch

Other Features: - cracks were evenly distributed on the specimens

- While sanding the moist-cured specimens of Mix No. 5, the original top surface developed a cellular appearance as shown in Figure H-5 and Photograph H-4. Although it looked broken up, the specimens were in fact still intact.

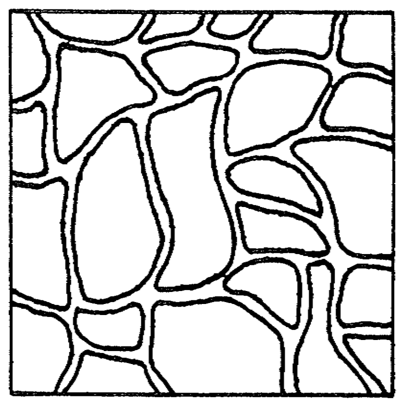
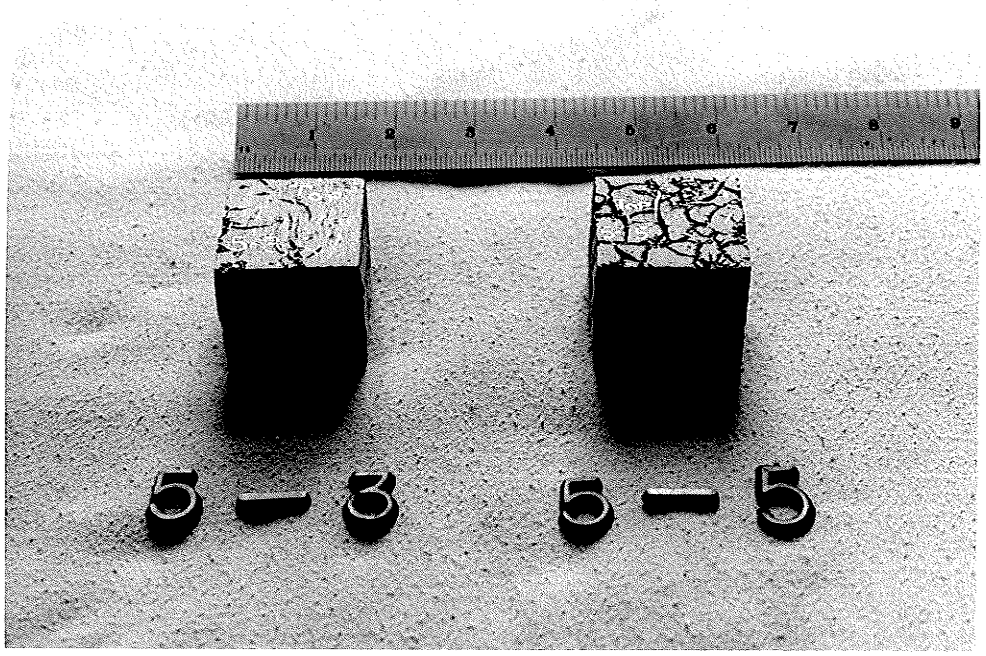


Figure H-5: General Top View of Clay Mortar Mix No. 5 Moist-Cured Specimens After Sanding



Photograph H-4: Comparison of Dry-Cured (Left) and Moist-Cured (Right) Specimens of Clay Mortar Mix No. 5 After Sanding

H.6.2 <u>Post-Testing Data</u>

- same notes as for Mix No. 5^A (air-dry)

H.7 MIX NO. 6

H.7.1 Pre-Sanding Data

Colour: grey

Shape: top - concave

- depth of concaveness = 2 to 3 mm. measured at the centre of the specimens

sides - same notes as for Mix No. 3

bottom - uneven

Surface Texture: - same notes as for Mix No. 2

Cracks: - hairline cracks

- larger cracks with length up to 5/8 inch and a maximum width of 0.035 inch
- one crack had a length of one inch
- " " " " width of 0.050 inch

Other Features: - same notes as for Mix No. 2

H.7.2 Post-Testing Data

Mode of Failure: - splitting failure with some erratic cracking patterns

Angle of Rupture -- θ: - 90°, for splitting failure

General Notes: - same notes as for Mix No. 2

H.8 MIX NO. 7

H.8.1 Pre-Sanding Data

Colour: grey

Shape: top - concave
- depth of concaveness = 1 to 3 mm. measured at the centre of the specimens

sides - fairly vertical with some concavity and convexity

bottom - uneven

Surface Texture: top - same notes as for Mix No. 2

sides - " " " " " " "

bottom - smooth with odd bumps

Cracks: - same notes as for Mix No. 2 except the larger cracks have lengths up to 13/16 inch and a maximum width of 0.065 inch

Average Density: 84 pcf.

Other Features: - cracks were evenly distributed on the specimens

- While sanding, the surfaces of the specimens became gritty and developed a cracked up appearance as shown in Figure H-6 and Photograph H-5.

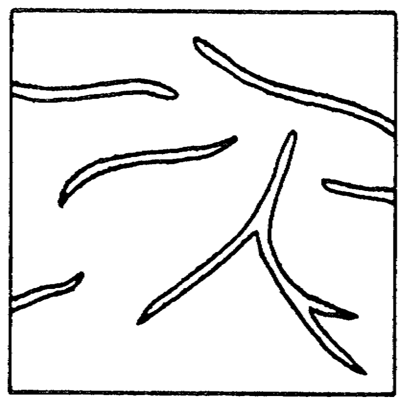


Figure H-6: General Surface View of Clay Mortar Mix No. 7 Specimens After Sanding

Photograph H-5: Clay Mortar Mix No. 7 Specimens After Being Sanded

H.8.2 Post-Testing Data

Mode of Failure: - crushed with no peak load

- no distinct type of failure mode except for a very slight indication of some splitting failure cracks

Angle of Rupture -- θ: - 90°, for the slight indication of splitting failure cracks

General Notes:

- specimens had a crushed appearance as illustrated in Photograph H-6; this is the general shape of the clay mortar specimens that had no peak failure load (Mix Nos. 7, 8, 10 and 11)
- see Table H-I for the last compression reading taken for each specimen of Mix No. 7 with no failure

Photograph H-6: Clay Mortar Mix No. 7 Tested Specimens (28-Day)

Table H-I

Last Compression Readings Taken For Mix No. 7 With No Failure

Specimen No.	Deformation (x 0.001 in.)	Strain (%)	Load (pounds)	Stress (psi.)
1	374.0	28.7	668	243.2
2	671.6	49.0	900	336.8
3	709.0	52.9	1,600	597.2

Table H-II

Last Compression Readings Taken For Mix No. 8 With No Failure

Specimen No.	Deformation (x 0.001 in.)	Strain (%)	Load (pounds)	Stress (psi.)
1	649.0	47.4	1,000	365.0
2	633.0	48.5	1,000	371.7
3	622.0	45.7	1,000	359.5

H.9 MIX NO. 8

H.9.1 Pre-Sanding Data

Colour: grey

Shape:
- top - concave
  - depth of concaveness = 1.5 to 2 mm. measured at the centre of the specimens
- sides - vertically straight with a very slight inward angle change from the vertical on some of the sides
- bottom - even

Surface Texture:
- top - same notes as for Mix No. 2
- sides - fairly smooth
- bottom - " "

Cracks: - same notes as for Mix No. 2 except the larger cracks have lengths up to 15/16 inch and a maximum width of 0.060 inch

Average Density: 88 pcf.

Other Features:
- cracks were evenly distributed on the specimens
- different from the previous mixes: very little bump formation or distortion from the shape of a cube took place for the specimens of Mix No. 8

- As with Mix No. 7, while sanding, the surfaces of the specimens became gritty and developed a cracked up appearance as shown in Figure H-6, page 444, but with only about half the amount of cracking.

H.9.2 Post-Testing Data

- same notes as for Mix No. 7
- see Table H-II, page 447 for the last compression reading taken for each specimen of Mix No. 8 with no failure

H.10 MIX NO. 9

H.10.1 Pre-Sanding Data

Colour: grey

Shape:
- top - concave
  - depth of concaveness = 1 to 2 mm. measured at the centre of the specimens
- sides - vertically straight
- bottom - two specimens convex, one specimen even

Surface Texture:
- top - same notes as for Mix No. 2
- sides - smooth with odd bumps
- bottom - " " " "

Cracks: - same notes as for Mix No. 2 except the larger cracks have lengths up to 7/8 inch and a maximum width of 0.082 inch

Average Density: 93 pcf.

Other Features: - cracks were evenly distributed on the specimens
- very little distortion from the shape of a cube took place

H.10.2 **Post-Testing Data**

Mode of Failure: - splitting failure with some erratic cracking

Angle of Rupture -- θ: - 90°, for the splitting failure cracks

General Notes: - slight bowing out of the sides at mid-height
- top and bottom loading surfaces showed evidence of being restrained by the loading platens

H.11 **MIX NO. 10**

H.11.1 **Pre-Sanding Data**

Colour: grey

Shape: - same notes as for Mix No. 6

Surface Texture: - same notes as for Mix No. 6

Cracks: - same notes as for Mix No. 2 except the larger cracks have lengths up to one inch and a maximum width of 0.074 inch

Average Density: 85 pcf.

Other Features: - same notes as for Mix No. 9

H.11.2 Post-Testing Data

- same notes as for Mix No. 7
- see Table H-III for the last compression reading taken for each specimen of Mix No. 10 with no failure

Table H-III

Last Compression Readings Taken For Mix No. 10 With No Failure

Specimen No.	Deformation (x 0.001 in.)	Strain (%)	Load (pounds)	Stress (psi.)
1	605.0	42.6	1,100	419.2
2	545.0	37.9	1,100	403.1
3	463.0	35.0	1,200	428.3

Table H-IV

Last Compression Readings Taken For Mix No. 11 With No Failure

Specimen No.	Deformation (x 0.001 in.)	Strain (%)	Load (pounds)	Stress (psi.)
1	591.5	41.5	1,500	507.6
2	510.5	35.0	1,500	502.0
3	478.0	34.3	1,525	515.6

H.12 MIX NO. 11

H.12.1 Pre-Sanding Data

Colour: grey

Shape: - same notes as for Mix No. 6

Surface Texture: - same notes as for Mix No. 6

Cracks: - mostly hairline cracks
- larger cracks with length up to 1/2 inch and a maximum width of 0.051 inch

Average Density: 77 pcf.

Other Features: - same notes as for Mix No. 5^B

H.12.2 Post-Testing Data

- same notes as for Mix No. 7 but not as crushed
- see Table H-IV, page 452 for the last compression reading taken for each specimen of Mix No. 11 with no failure

H.13 COMPRESSION TESTING INFORMATION

Included as the Compression Testing Information are the dimensions of the cube specimens, the resultant testing surface area, the time required to perform the compression test for each specimen and the age of the mix at the time of testing. This information is in Table H-V.

Table H-V

Compression Testing Information For Clay Mortar Mixes

Mix No.	Specimen No.	Length[1] (inches)	Width[1] (inches)	Height[2] (inches)	Area[2] (in.^{2})	Time[3] (minutes)	Age[4] (days)
1	1	1.372	1.290	1.310	1.77	15	33
	2	1.377	1.454	1.330	2.00	15	
	3	1.340	1.415	1.439	1.90	15	
2	1	1.489	1.500	1.390	2.23	20	38
	2	1.476	1.486	1.412	2.19	20	
	3	1.500	1.470	1.322	2.21	25	
3	1	1.510	1.547	1.404	2.34	10	37
	2	1.535	1.517	1.376	2.33	12	
	3	1.505	1.515	1.440	2.28	12	
4	1	1.529	1.510	1.425	2.31	11	37
	2	1.550	1.515	1.395	2.35	14	
	3	1.538	1.540	1.401	2.37	13	
5A	1	1.556	1.588	1.460	2.47	12	36
	2	1.544	1.573	1.433	2.43	12	
	3	1.574	1.532	1.457	2.41	13	
5B	1	1.573	1.534	1.400	2.41	12	36
	2	1.577	1.600	1.450	2.52	14	
	3	1.550	1.550	1.439	2.40	12	
6	1	1.615	1.568	1.442	2.53	10	36
	2	1.555	1.615	1.374	2.51	10	
	3	1.560	1.591	1.355	2.48	12	

Table H-V

(Continued)

Mix No.	Specimen No.	Length[1] (inches)	Width[1] (inches)	Height[2] (inches)	Area[2] ($in.^2$)	Time[3] (minutes)	Age[4] (days)
	1	1.647	1.668	1.304	2.75	9	
7	2	1.630	1.639	1.372	2.67	9	40
	3	1.619	1.655	1.340	2.68	12	
	1	1.626	1.685	1.369	2.74	10	
8	2	1.640	1.640	1.306	2.69	9	40
	3	1.674	1.662	1.360	2.78	10	
	1	1.590	1.645	1.418	2.62	7	
9	2	1.595	1.598	1.435	2.55	8	45
	3	1.630	1.643	1.431	2.68	10	
	1	1.600	1.640	1.420	2.62	11	
10	2	1.629	1.675	1.439	2.73	11	44
	3	1.688	1.660	1.324	2.80	11	
	1	1.733	1.705	1.425	2.96	13	
11	2	1.720	1.737	1.460	2.99	11	45
	3	1.730	1.710	1.395	2.96	10	

[1]Loading surface length/width.

[2]Average loading height/area.

[3]Compression test duration.

[4]Age at the time of the compression test for the set of three specimens.

Appendix I

TESTING DATA FOR LIME-SAND MORTAR MIXES

Testing data for each of the lime-sand mortar mixes consisted of three parts: 1) pre-testing data, 2) compression testing data, and 3) post-testing data. The Pre-Testing Data is summarized in Chapter IV, Subsection 4.2.2, Testing Data. Pre-testing data included notes on the colour, shape, surface texture and density measurements of the specimens.

Tabulated first in this appendix is the Compression Test Information, which is only part of the compression testing data. The remaining compression testing results (stress-strain data) are presented in Chapter IV, Subsection 4.2.3, Plots. In Chapter IV, the stress-strain data-points are plotted to scale on computer plots. Tabulated at the end of this appendix is the Post-Testing Data.

Included as the Compression Testing Information are the dimensions of the cube specimens, the resultant testing surface area, the time required to perform the compression test for each specimen, and the age of the mix at the time of the testing. All of this information is in Table I-I. The length and width dimensions in this table are average values based on three measurements: one measurement was taken at the top, one at mid-height and one at the bottom of the specimen. The loading area is also an average value but based only on the dimensions at the top and bottom of the specimen. Since the mid-height dimensions were not used for the area calculations, the average length multiplied by the average width may or may not equal the recorded average area. Average areas greater than or equal to 3.94 square inches were taken as 4.00 square inches, as directed by CSA A8-1970, Subsection 7.11.10 [15].

After the compression test, notes termed as Post-Testing Data were recorded for each set of specimens. Recorded were the mode(s) of fracture(s)/failure, the angle of rupture(s) and general notes. All of this information is in Table I-II. Each set of data in this table represents a summary of three specimens per mix per age group. Specimens with no indication of fracture(s)/failure on the surface were assumed to have fractures beneath the surface.

Three types of mode of fracture(s)/failure were noted throughout the compression testing of the lime-sand mortar specimens: 1) pyramidal/hourglass fracture; 2) splitting failure or columnar fracture; and 3) corner fracture. Details of the first two modes, how the angle of rupture is measured, and the significance of the angle of rupture is detailed in Appendix H. A sketch of a typical corner fracture is shown in Figure I-1. Photograph I-1 shows an occurrence of corner fracture with the tested specimens of Mix No. 12 at the 28-day age. The cause of a corner fracture was due to local stresses created by the corner(s) being slightly higher than the remaining loading surface.

Table I-I

Compression Testing Information for Lime-Sand Mortar Mixes

Lime Brand	Mix No.	Specimen No.	Length[1] (inches)	Width[1] (inches)	Height[2] (inches)	Area[2] (in.^{2})	Time[3] (minutes)	Age[4] (days)
A	12	1	1.969	2.000	1.960	(4.00)	4	7
		2	1.986	2.000	2.000	(4.00)	5	
		3	1.979	2.000	1.991	(4.00)	5	
		4	1.967	1.980	1.975	3.90	4	28
		5	1.958	1.982	1.976	3.89	4	
		6	1.960	1.980	1.974	3.88	5	
	13	1	1.988	1.999	1.985	(4.00)	4	9
		2	1.992	1.996	1.980	(4.00)	6	
		3	1.994	1.995	1.985	(4.00)	4	
		4	1.989	1.998	1.995	(4.00)	5	28
		5	1.982	1.998	1.999	(4.00)	4	
		6	1.979	1.994	1.998	(4.00)	4	
	14	1	1.998	1.995	1.985	(4.00)	4	8
		2	1.996	1.994	1.986	(4.00)	5	
		3	1.998	1.995	1.985	(4.00)	6	
		4	1.998	1.999	1.999	4.00	5	28
		5	1.997	1.999	1.999	4.00	4	
		6	1.972	1.998	1.920	(4.00)	4	

Table I-I

(Continued)

Lime Brand	Mix No.	Specimen No.	Length[1] (inches)	Width[1] (inches)	Height[2] (inches)	Area[2] ($in.^2$)	Time[3] (minutes)	Age[4] (days)
A	15	1	1.994	1.990	1.985	(4.00)	6	9
		2	1.974	2.000	1.999	(4.00)	6	
		3	1.967	1.997	2.000	(4.00)	6	
		4	1.953	1.967	1.965	3.86	4	28
		5	1.960	1.971	1.968	3.87	4	
		6	1.962	1.968	1.965	3.88	4	
	16	1	1.953	1.988	1.988	3.90	5	8
		2	1.960	1.989	1.986	3.91	5	
		3	1.961	1.986	1.981	3.91	4	
		4	1.938	1.962	1.956	3.82	4	28
		5	1.934	1.966	1.958	3.81	4	
		6	1.943	1.961	1.954	3.82	4	
	17	1	1.917	1.954	1.954	3.76	4	8
		2	1.915	1.958	1.955	3.79	4	
		3	1.906	1.967	1.957	3.79	4	
		4	1.882	1.924	1.933	3.65	3	28
		5	1.897	1.934	1.928	3.70	4	
		6	1.890	1.926	1.933	3.66	4	

Table I-I

(Continued)

Lime Brand	Mix No.	Specimen No.	Length[1] (inches)	Width[1] (inches)	Height[2] (inches)	Area[2] ($in.^2$)	Time[3] (minutes)	Age[4] (days)
A	17-R	1	1.931	1.989	1.973	3.86	4	7
		2	1.928	1.983	1.973	3.86	4	
		3	1.936	1.982	1.974	3.84	4	
		4	1.896	1.934	1.936	3.68	5	28
		5	1.892	1.939	1.939	3.68	4	
		6	1.899	1.944	1.938	3.71	2	
B	18	1	1.970	1.979	1.976	3.90	4	7
		2	1.980	1.979	1.979	3.92	3	
		3	1.977	1.980	1.979	3.92	5	
		4	1.970	1.977	1.976	3.90	4	28
		5	1.968	1.980	1.980	3.90	4	
		6	1.961	1.977	1.977	3.88	3	
	19	1	1.969	1.982	1.980	3.90	4	7
		2	1.977	1.982	1.980	3.92	4	
		3	1.974	1.978	1.979	3.91	4	
		4	1.973	1.977	1.978	3.90	4	28
		5	1.967	1.982	1.972	3.91	4	
		6	1.974	1.978	1.979	3.91	4	

Table I-I

(Continued)

Lime Brand	Mix No.	Specimen No.	Length[1] (inches)	Width[1] (inches)	Height[2] (inches)	Area[2] (in.^{2})	Time[3] (minutes)	Age[4] (days)
B	20	1	1.974	1.981	1.979	3.91	3	7
		2	1.969	1.981	1.979	3.90	3	
		3	1.961	1.979	1.974	3.89	4	
		4	1.965	1.977	1.969	3.89	4	28
		5	1.957	1.978	1.967	3.88	4	
		6	1.968	1.979	1.972	3.90	4	
	20-R	1	1.962	1.979	1.966	3.89	4	8
		2	1.965	1.979	1.967	3.88	4	
		3	1.963	1.982	1.969	3.89	4	
		4	1.969	1.978	1.961	3.90	4	28
		5	1.965	1.976	1.966	3.89	3	
		6	1.958	1.977	1.967	3.89	4	
	21	1	1.962	1.979	1.972	3.89	5	7
		2	1.958	1.981	1.974	3.89	6	
		3	1.963	1.978	1.976	3.88	6	
		4	1.968	1.982	1.975	3.90	4	28
		5	1.965	1.986	1.978	3.91	5	
		6	1.961	1.973	1.977	3.88	5	

Table I-I

(Continued)

Lime Brand	Mix No.	Specimen No.	Length[1] (inches)	Width[1] (inches)	Height[2] (inches)	Area[2] (in.^{2})	Time[3] (minutes)	Age[4] (days)
B	21-R	1	1.945	1.992	1.972	3.89	4	8
		2	1.954	1.981	1.972	3.88	5	
		3	1.959	1.980	1.966	3.88	4	
		4	1.953	1.984	1.968	3.88	7	28
		5	1.951	1.981	1.974	3.87	4	
		6	1.944	1.988	1.960	3.87	3	
	22	1	1.964	1.975	1.978	3.88	5	7
		2	1.965	1.977	1.979	3.89	7	
		3	1.966	1.973	1.979	3.88	6	
		4	1.962	1.970	1.977	3.88	6	28
		5	1.967	1.976	1.968	3.89	5	
		6	1.962	1.975	1.967	3.89	5	
	22-R	1	1.935	1.977	1.972	3.84	3	7
		2	1.926	1.987	1.985	3.84	3	
		3	1.933	1.977	1.976	3.82	3	
		4	1.952	1.971	1.969	3.85	5	28
		5	1.956	1.977	1.974	3.88	4	
		6	1.970	1.970	1.965	3.89	4	

Table I-I

(Continued)

Lime Brand	Mix No.	Specimen No.	Length[1] (inches)	Width[1] (inches)	Height[2] (inches)	Area[2] (in.^{2})	Time[3] (minutes)	Age[4] (days)
B	23	1	1.949	1.977	1.965	3.86	5	7
		2	1.947	1.978	1.971	3.87	4	
		3	1.959	1.977	1.970	3.88	4	
		4	1.953	1.970	1.976	3.86	5	28
		5	1.965	1.976	1.982	3.90	5	
		6	1.952	1.977	1.972	3.87	5	
	23-R	1	1.975	1.974	1.972	3.90	5	7
		2	1.952	1.979	1.973	3.87	4	
		3	1.964	1.974	1.973	3.88	4	
		4	1.950	1.975	1.977	3.87	6	27
		5	1.955	1.972	1.970	3.86	6	
		6	1.955	1.972	1.977	3.86	7	

Notes: i) Average length/width is based from three measurements: one measurement was taken at the top, one at mid-height and one at the bottom of the specimen;
ii) Average loading area is based only on the top and bottom measurements;
iii) Area shown as (4.00) indicates that the area was greater than or equal to 3.94 in.^{2} but taken as 4.00 in.^{2} as directed by CSA A8-1970, Subsection 7.11.10 [15].

[1]Average length/width of a cube specimen.
[2]Average loading height/area.
[3]Compression test duration.
[4]Age at the time of the compression test for the set of three specimens.

Table I-II

Post-Compression Testing Data for Lime-Sand Mortar Mixes

Lime Brand	Mix No.	Age (days)	Mode of Fractures(s)/Failure: Splitting $\theta_s = 90°$	Mode of Fractures(s)/Failure: Pyramidal θ_p	Mode of Fractures(s)/Failure: Corner θ_c	Angle of Rupture -- θ: θ_p (degrees)	Angle of Rupture -- θ: θ_c (degrees)	Miscellaneous Notes (See Footnotes for Definition of Numbers)
A	12	7	Yes	No	No	n.a.	n.a.	1, 5
		28	No	No	Yes	n.a.	130	1, 3
	13	9	No	No	Yes	n.a.	120	1
		28	No	Yes	No	65	n.a.	1
	14	8	No	Yes	No	70	n.a.	1, 5, 9
		28	No	No	Yes	n.a.	135	1, 2
	15	9	Yes	No	Yes	n.a.	130	1, 2
		28	No	Yes	No	60	n.a.	1, 2
	16	8	No	Yes	No	60	n.a.	1, 2
		28	No	Yes	Yes	60	130	1, 2, 5
	17	8	No	Yes	No	60, 70	n.a.	1, 2
		28	No	Yes	No	60	n.a.	1, 2
	17-R	7	No	Yes	No	60, 70	n.a.	1, 2
		28	No	Yes	No	60	n.a.	1, 2, 6
B	18	7	No	No	Yes	n.a.	120, 130	1, 2, 5
		28	No	Yes	No	60	n.a.	1, 2, 3

Table I-II

(Continued)

Lime Brand	Mix No.	Age (days)	Mode of Fracture(s)/Failure: Splitting $\theta_s = 90°$	Pyramidal θ_p	Corner θ_c	Angle of Rupture -- θ: θ_p (degrees)	θ_c (degrees)	Miscellaneous Notes (See Footnotes for Definition of Numbers)
	19	7	No	Yes	No	60	n.a.	1, 2, 5
		28	No	Yes	No	60	n.a.	1, 2
	20	7	No	Yes	No	70	n.a.	1, 2, 3, 4, 5
		28	No	Yes	No	60	n.a.	1, 2
	20-R	8	No	Yes	No	60	n.a.	1, 2, 3, 4
		28	Yes	Yes	No	75	n.a.	6, 7
	21	7	No	Yes	Yes	60	110-120	1, 2
		28	No	Yes	Yes	60	110-130	1, 2
	21-R	8	Yes	Yes	No	60	n.a.	6, 7, 8
B		28	No	Yes	No	60-70	n.a.	6, 7, 8
	22	7	No	Yes	No	70	n.a.	1, 2, 3, 5
		28	Yes	Yes	No	60, 70	n.a.	1, 2, 5
	22-R	7	Yes	Yes	No	60-70	n.a.	1, 2, 9
		28	Yes	Yes	No	60-70	n.a.	1, 2, 9
	23	7	Yes	Yes	No	60	n.a.	1, 2, 9
		28	Yes	Yes	Yes	50-70	130	1, 2, 4, 9
	23-R	7	Yes	Yes	No	35,60,70	n.a.	1, 2, 9
		27	Yes	Yes	No	60-70	n.a.	1, 2, 4, 9

Table I-II

(Continued)

Notes: i) θ_s indicates angle of rupture of splitting failure;
ii) θ_p indicates angle of rupture of pyramidal fracture;
iii) θ_c indicates angle of rupture of corner fracture (measured for informational purposes only);
iv) n.a. indicates not applicable.

[1]Top loading surface(s) showed evidence of being restrained of lateral expansion by the loading platen.

[2]Bottom loading surfaces(s) showed evidence of being restrained of lateral expansion by the loading platen.

[3]Odd vertical crack present with pyramidal and/or corner fracture dominating.

[4]Some random cracks present.

[5]Surface cracks non-existent on one specimen.

[6]Material fractured off loose from the sides.

[7]Fracture(s) occurred on the top loading surface.

[8]Fracture(s) occurred on the bottom loading surface.

[9]Pyramidal fracture lines not completely defined.

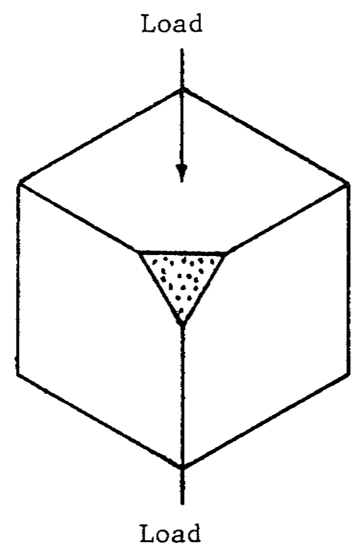


Figure I-1: Corner Fracture

Photograph I-1: Lime-Sand Mortar Mix No. 12 Tested Specimens (28-Day)

Appendix J

COMPUTER STUDY PLOTS FOR LIME-SAND MORTAR MIXES

The compressive strength and failure characteristics of each lime-sand mortar mix, at the age of seven and 28 days, is described by the curves given in Figures 33 to 66, pages 163 to 196. From these figures, different combinations of the curves were put together to obtain four different studies: 1) lime-sand ratio studies; 2) remix strength studies; 3) seven- and 28-day strength studies; and 4) lime brand studies. These studies were put together into computer plot form with the use of Computer Program No. 8 of Appendix G. More information about these studies is in, Chapter IV, Article 4.2.3.2, Study Plots. Also under this Article, are the results of the first two studies. Results of the two remaining studies are in this appendix. The Seven- and 28-Day Compressive Strength Study plots are in Figures J-1 to J-17 and the Lime Brand Study plots are in Figures J-18 to J-31.

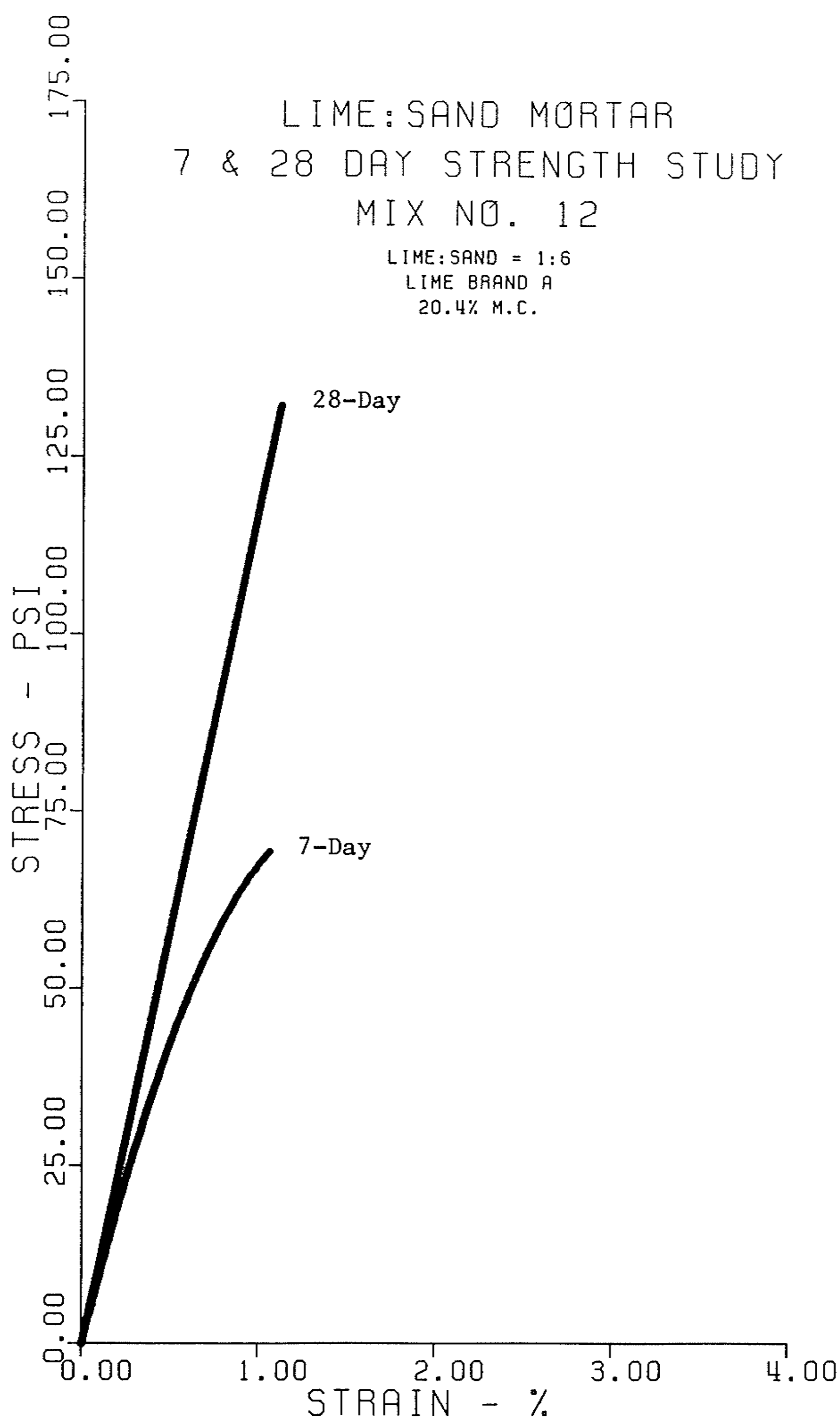


Figure J-1: Seven- and 28-Day Compressive Strength Study Plot for Lime-Sand Mortar Mix No. 12

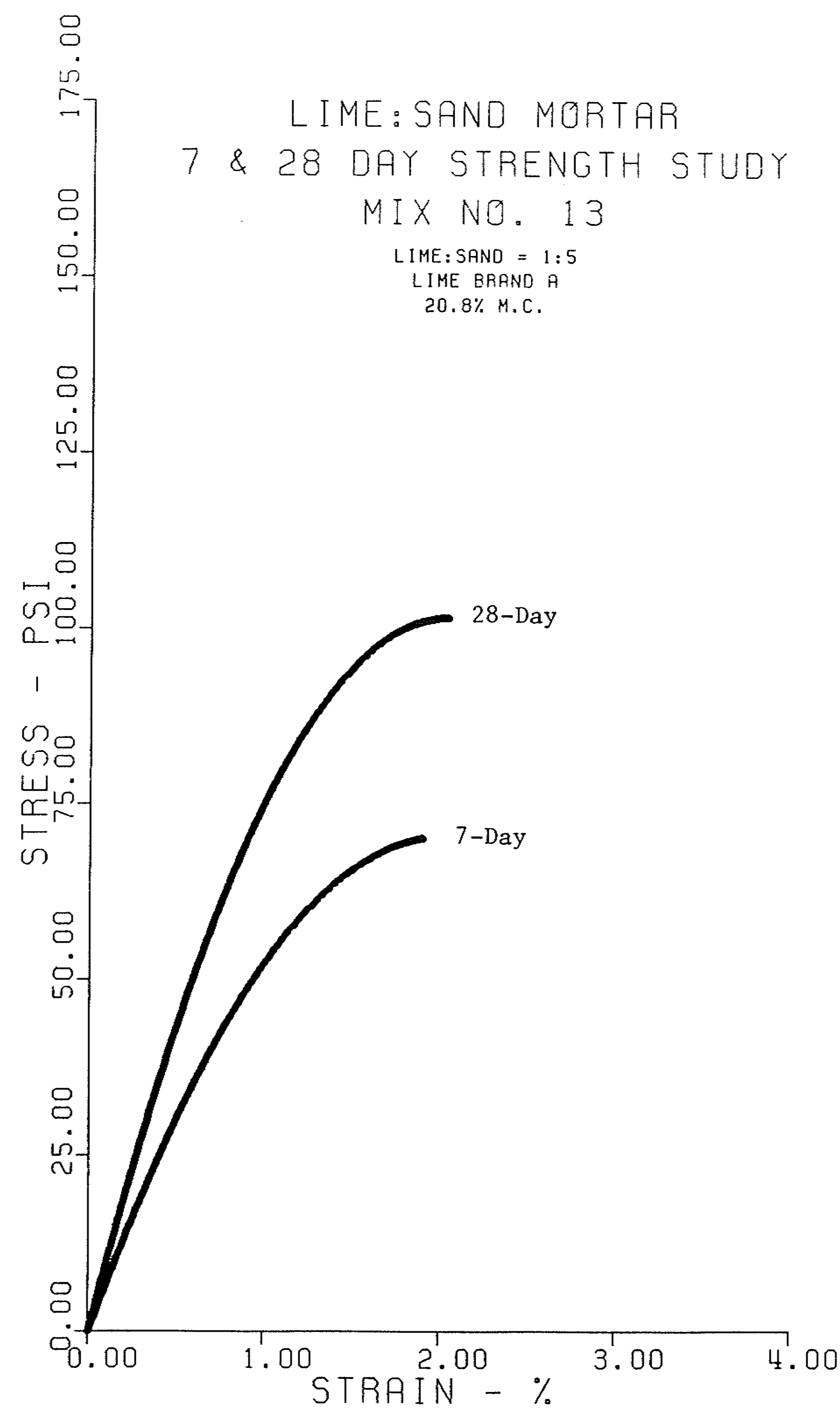


Figure J-2: Seven- and 28-Day Compressive Strength Study Plot for Lime-Sand Mortar Mix No. 13

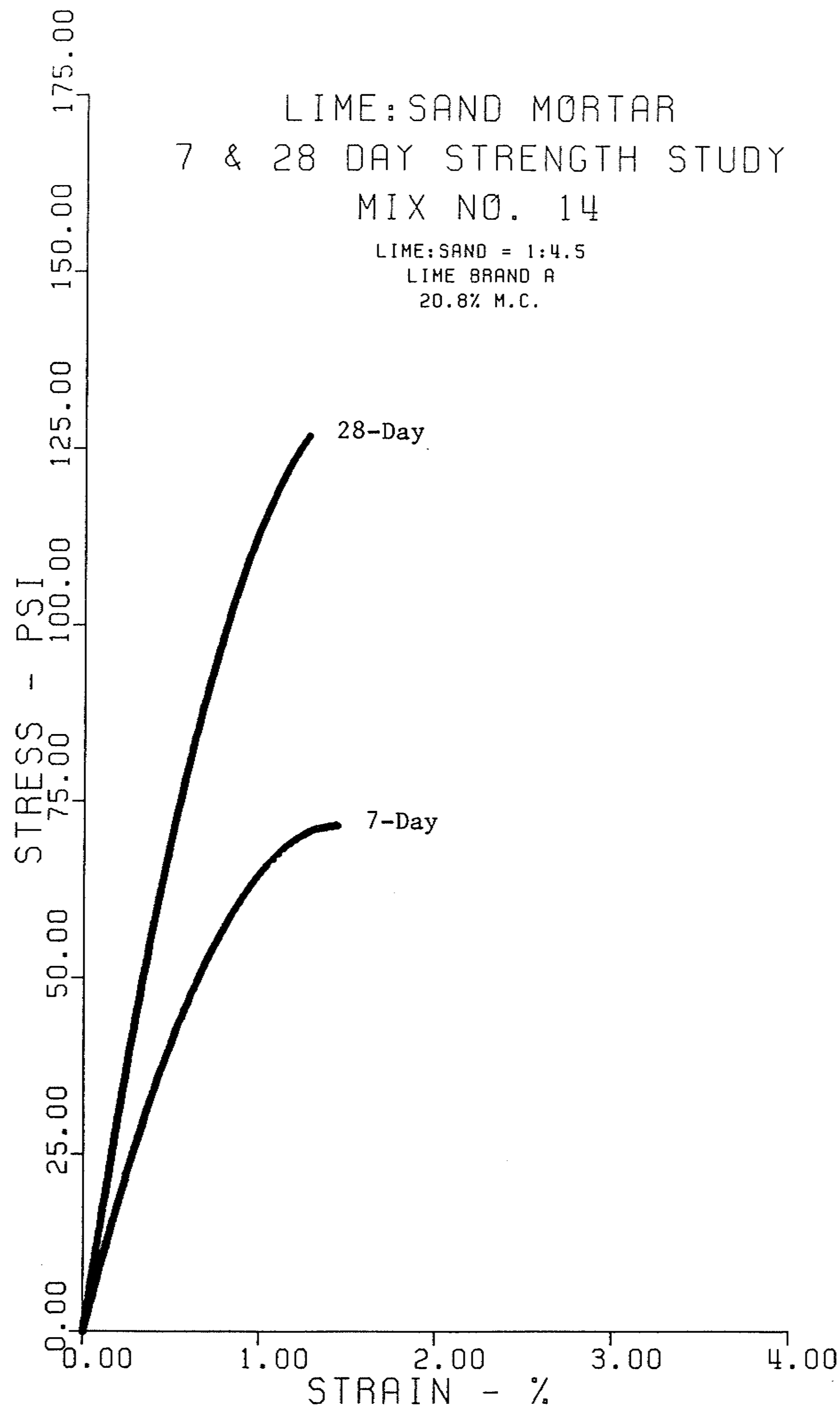


Figure J-3: Seven- and 28-Day Compressive Strength Study Plot for Lime-Sand Mortar Mix No. 14

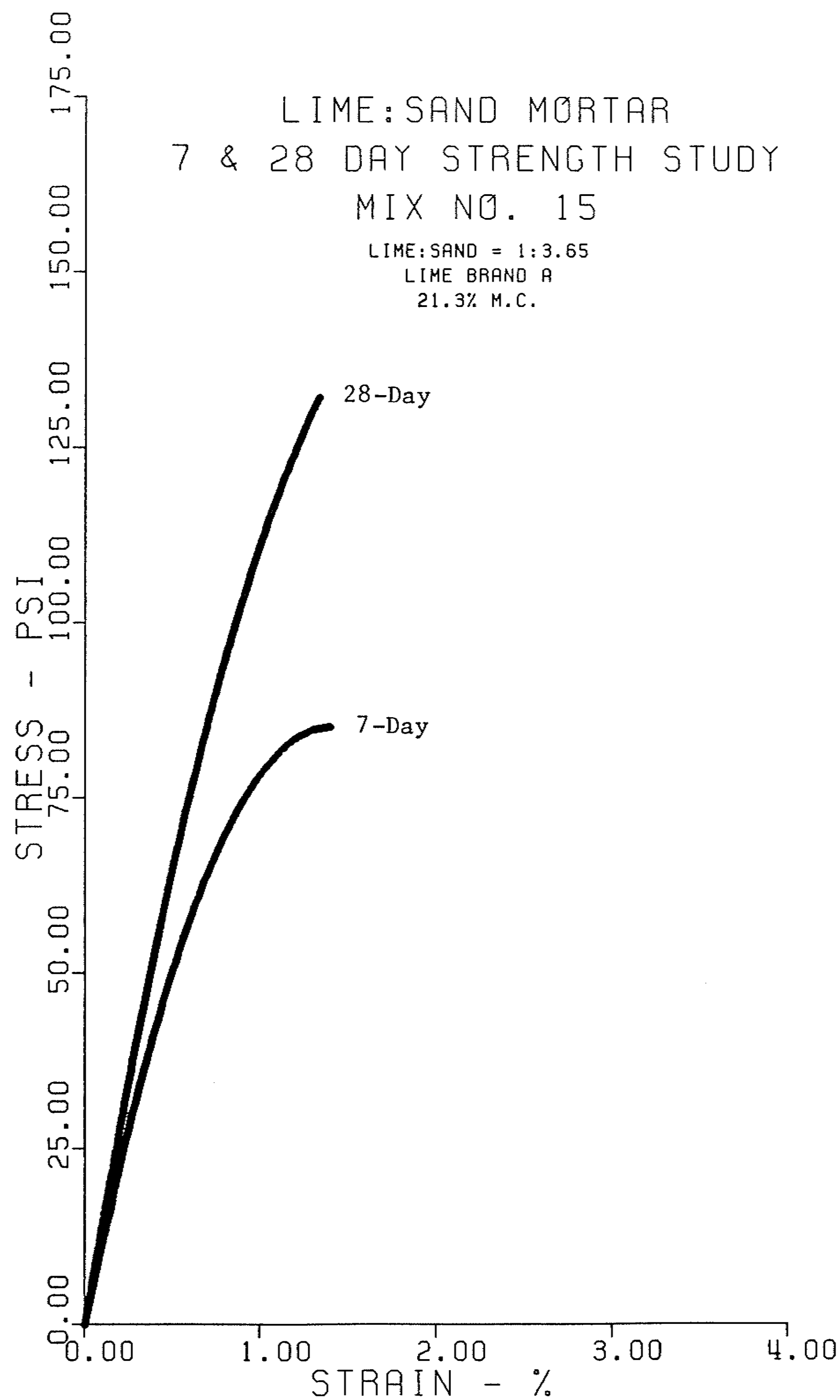


Figure J-4: Seven- and 28-Day Compressive Strength Study Plot for Lime-Sand Mortar Mix No. 15

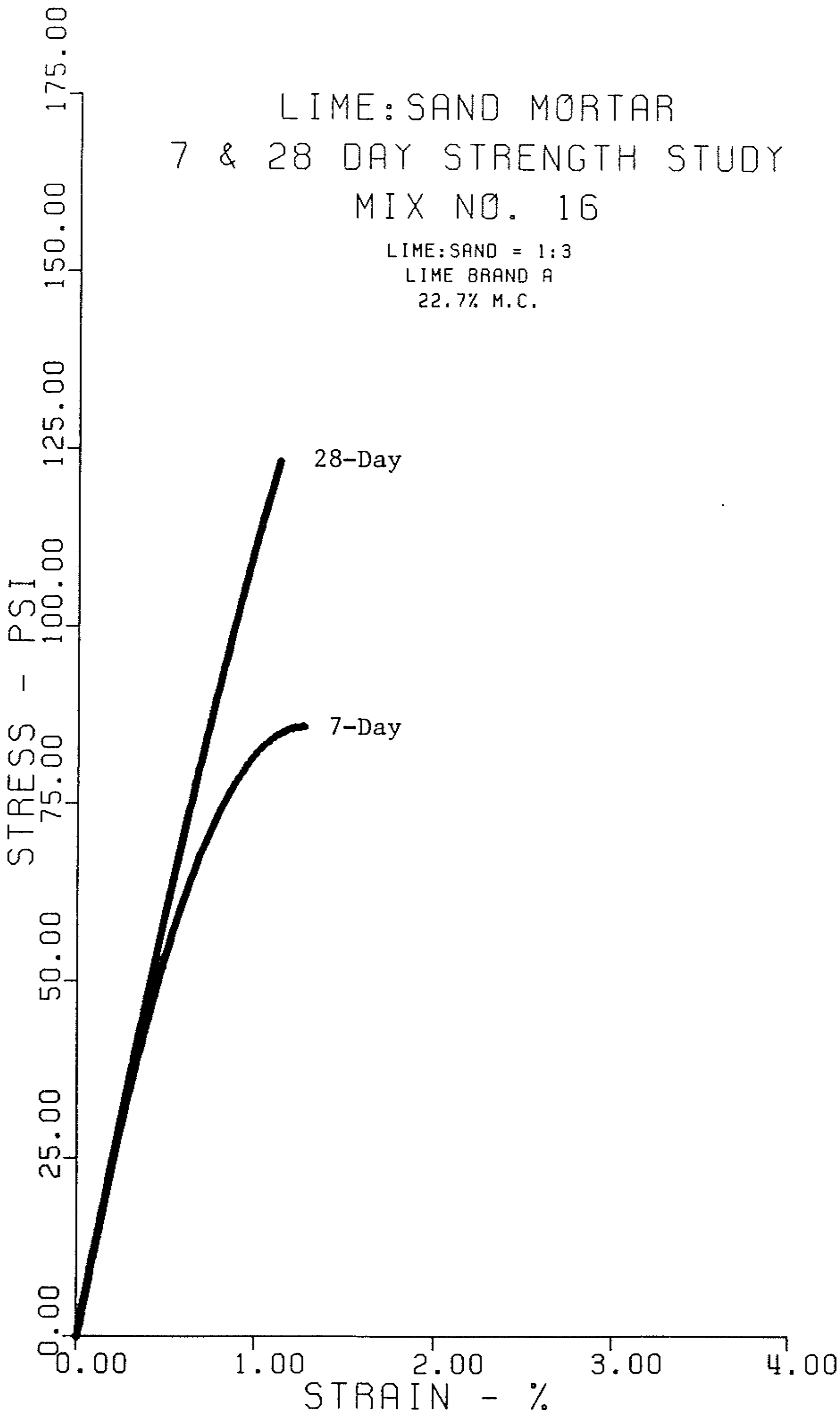


Figure J-5: Seven- and 28-Day Compressive Strength Study Plot for Lime-Sand Mortar Mix No. 16

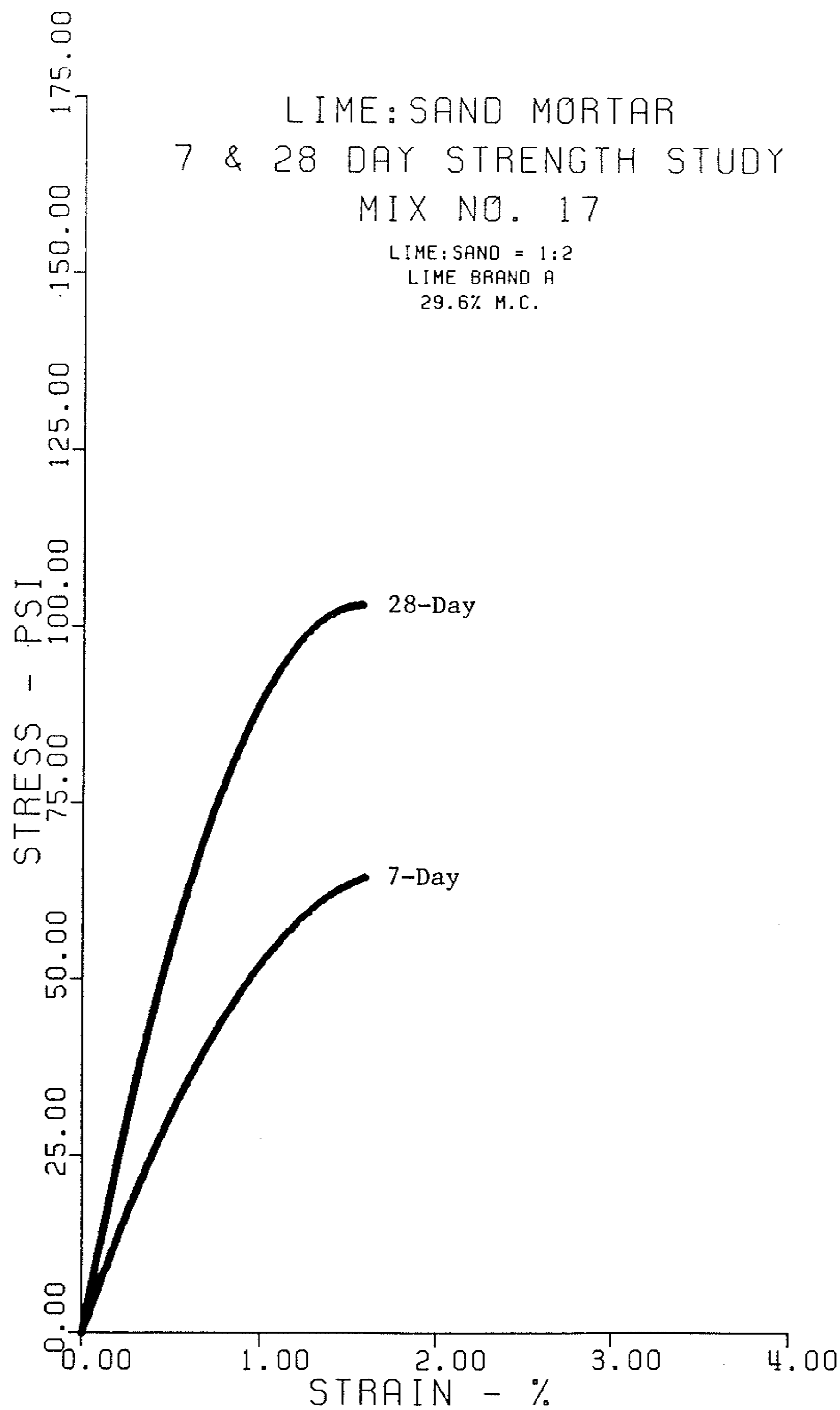


Figure J-6: Seven- and 28-Day Compressive Strength Study Plot for Lime-Sand Mortar Mix No. 17

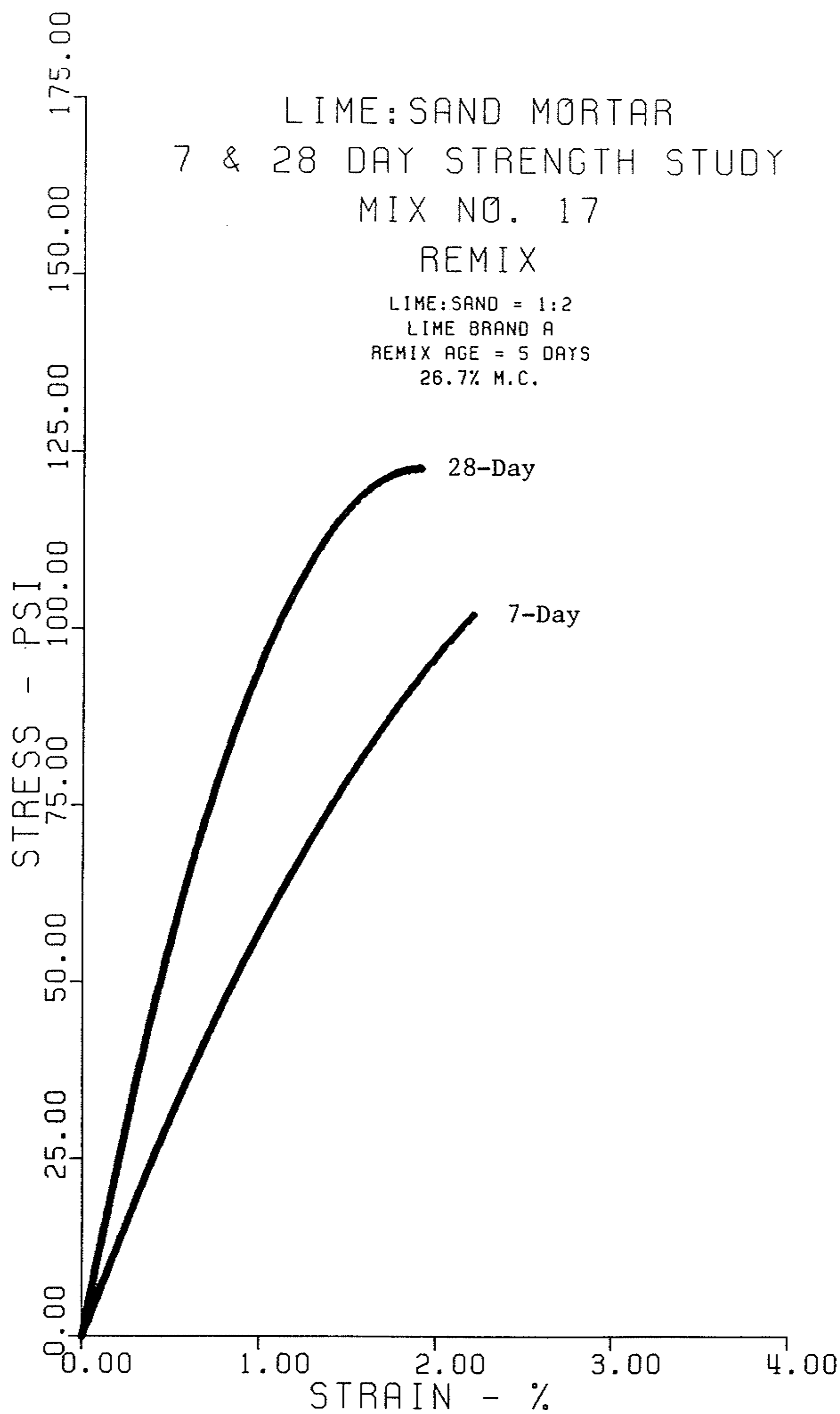


Figure J-7: Seven- and 28-Day Compressive Strength Study Plot for Lime-Sand Mortar Remix No. 17

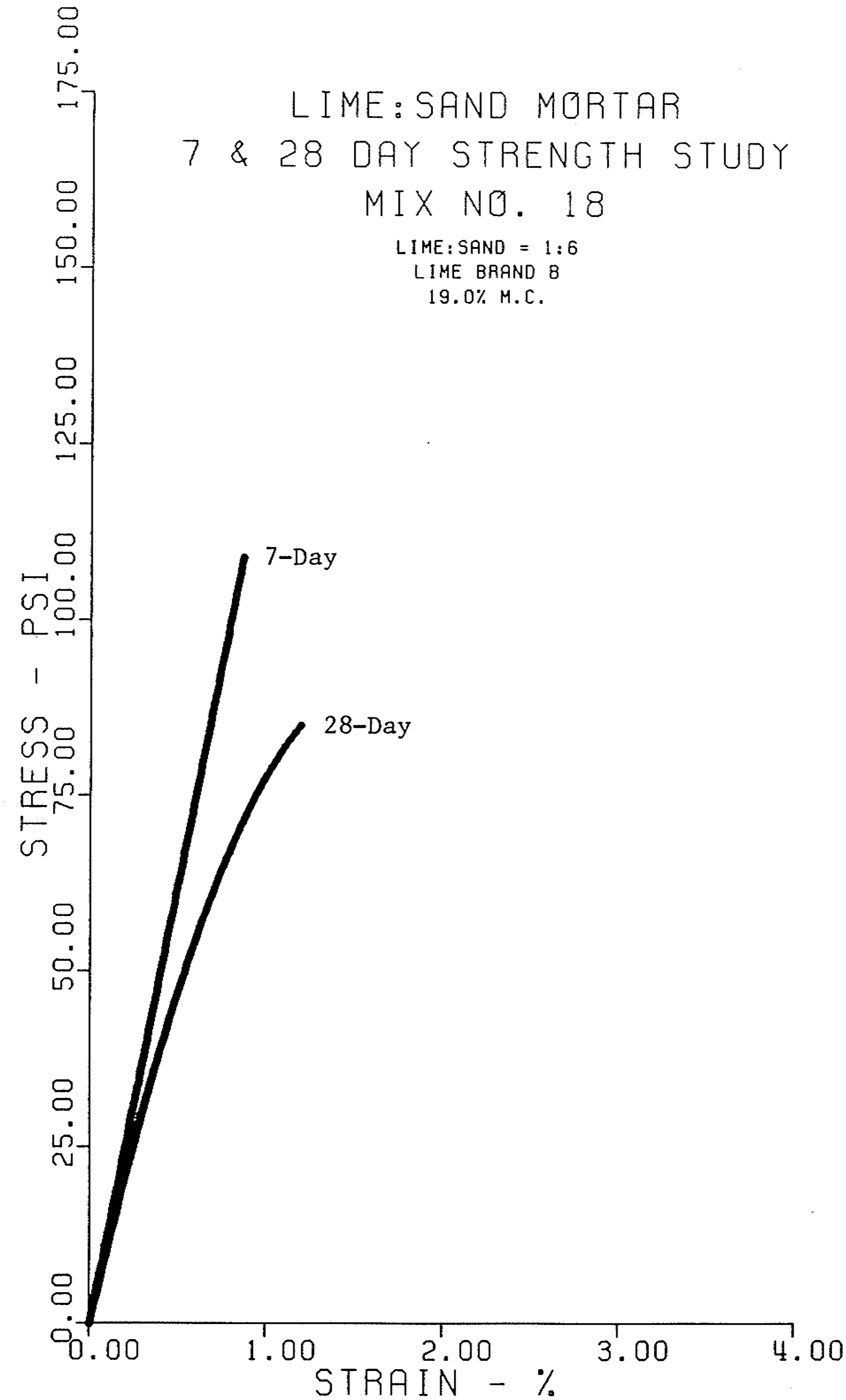


Figure J-8: Seven- and 28-Day Compressive Strength Study Plot for Lime-Sand Mortar Mix No. 18

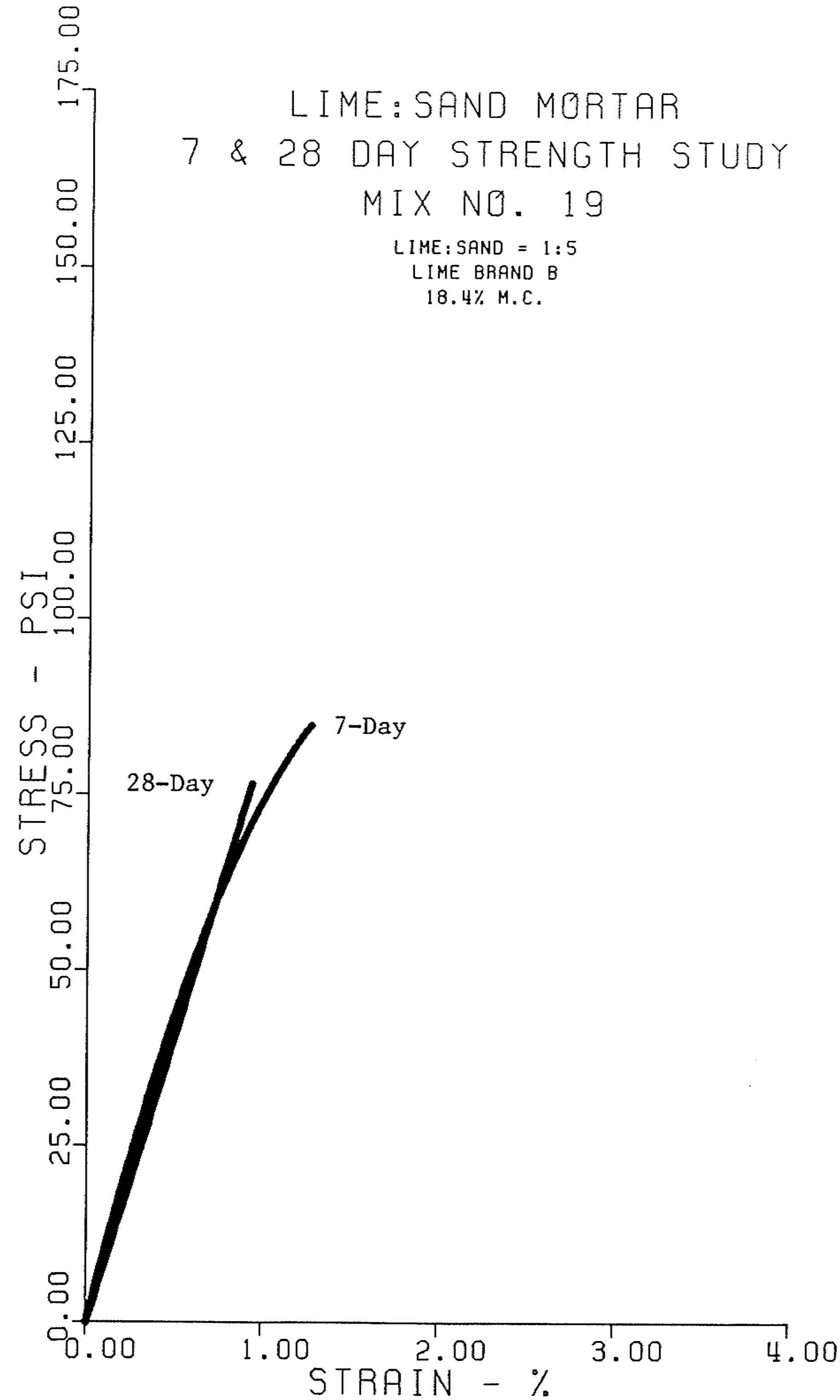


Figure J-9: Seven- and 28-Day Compressive Strength Study Plot for Lime-Sand Mortar Mix No. 19

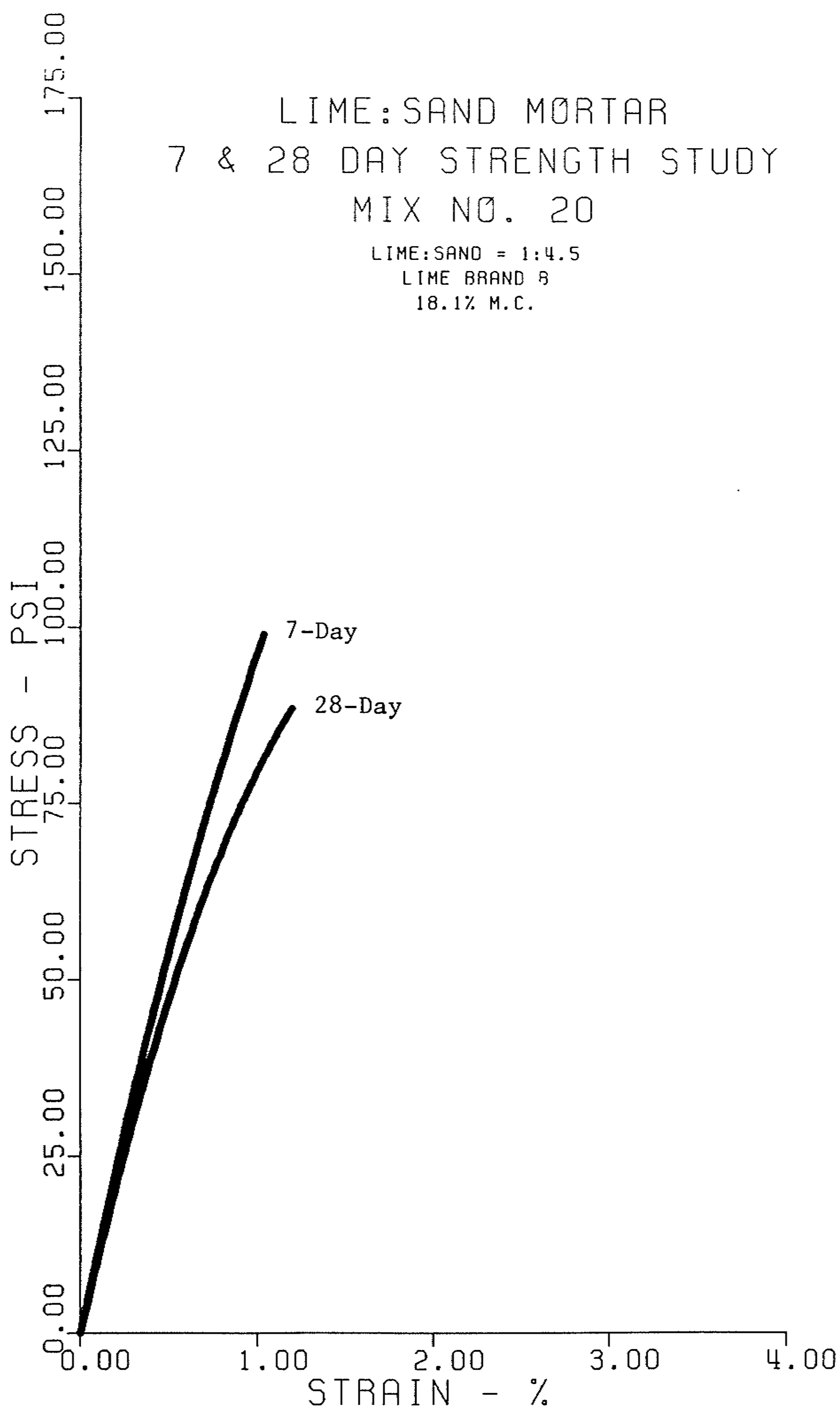


Figure J-10: Seven- and 28-Day Compressive Strength Study Plot for Lime-Sand Mortar Mix No. 20

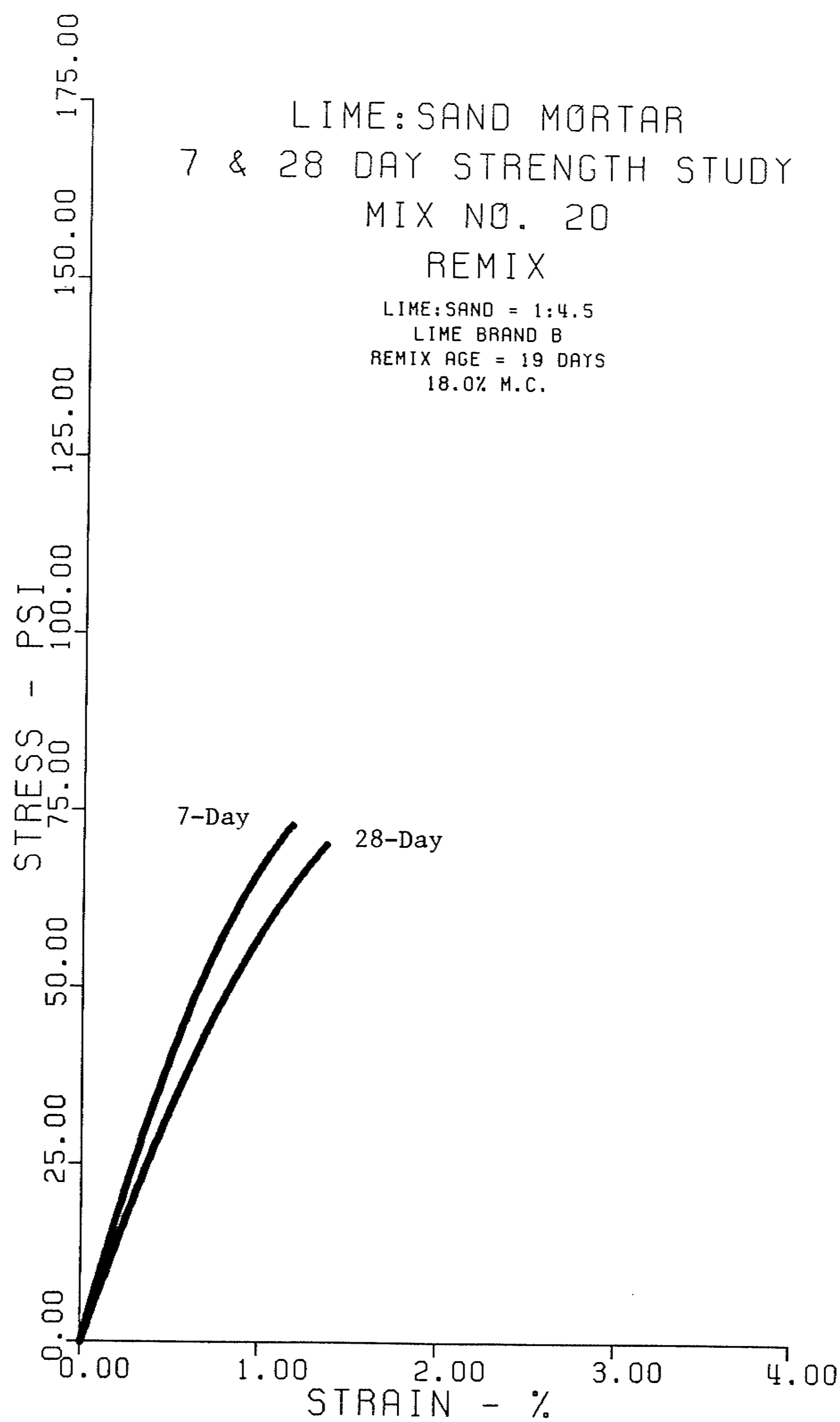


Figure J-11: Seven- and 28-Day Compressive Strength Study Plot for Lime-Sand Mortar Remix No. 20

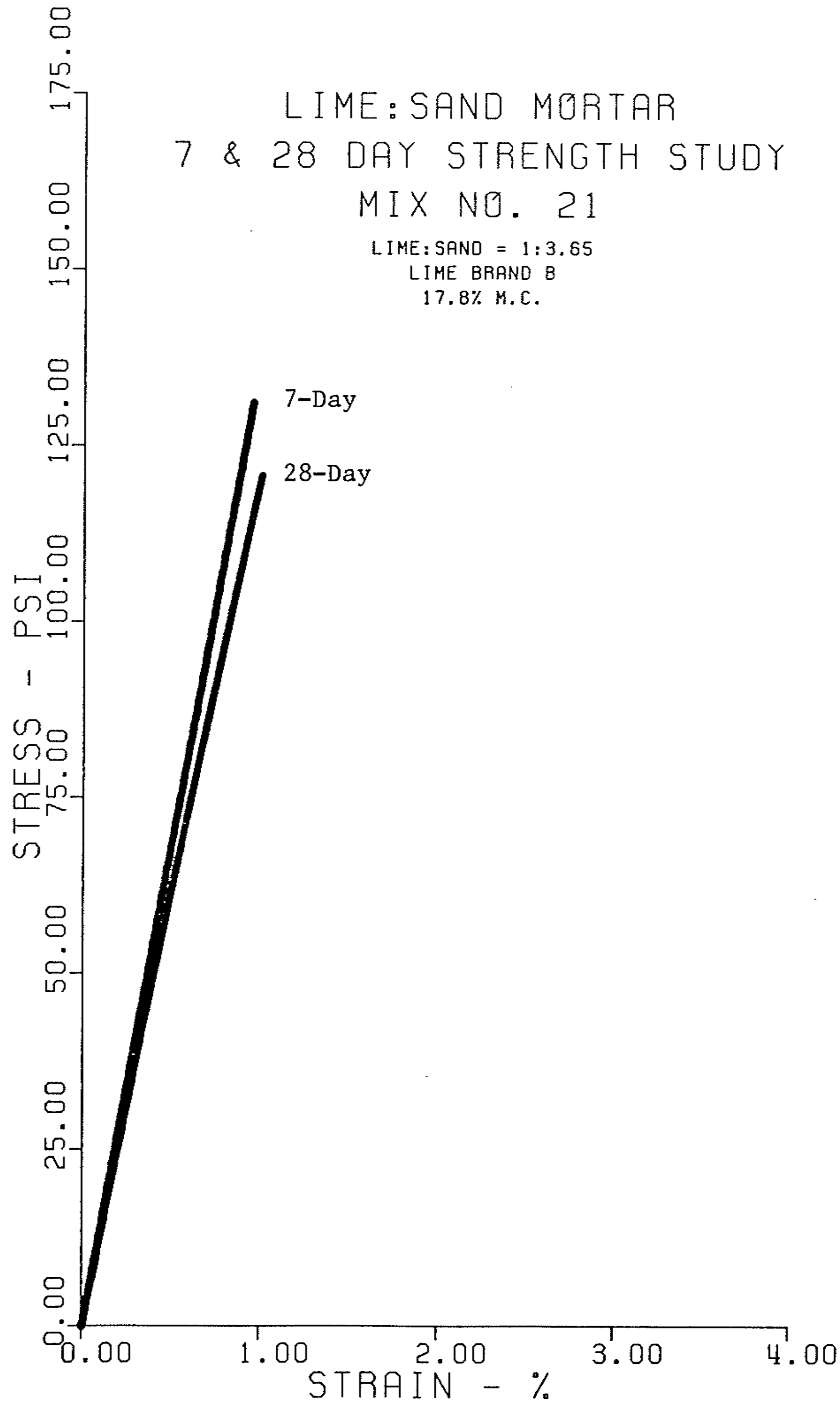


Figure J-12: Seven- and 28-Day Compressive Strength Study Plot for Lime-Sand Mortar Mix No. 21

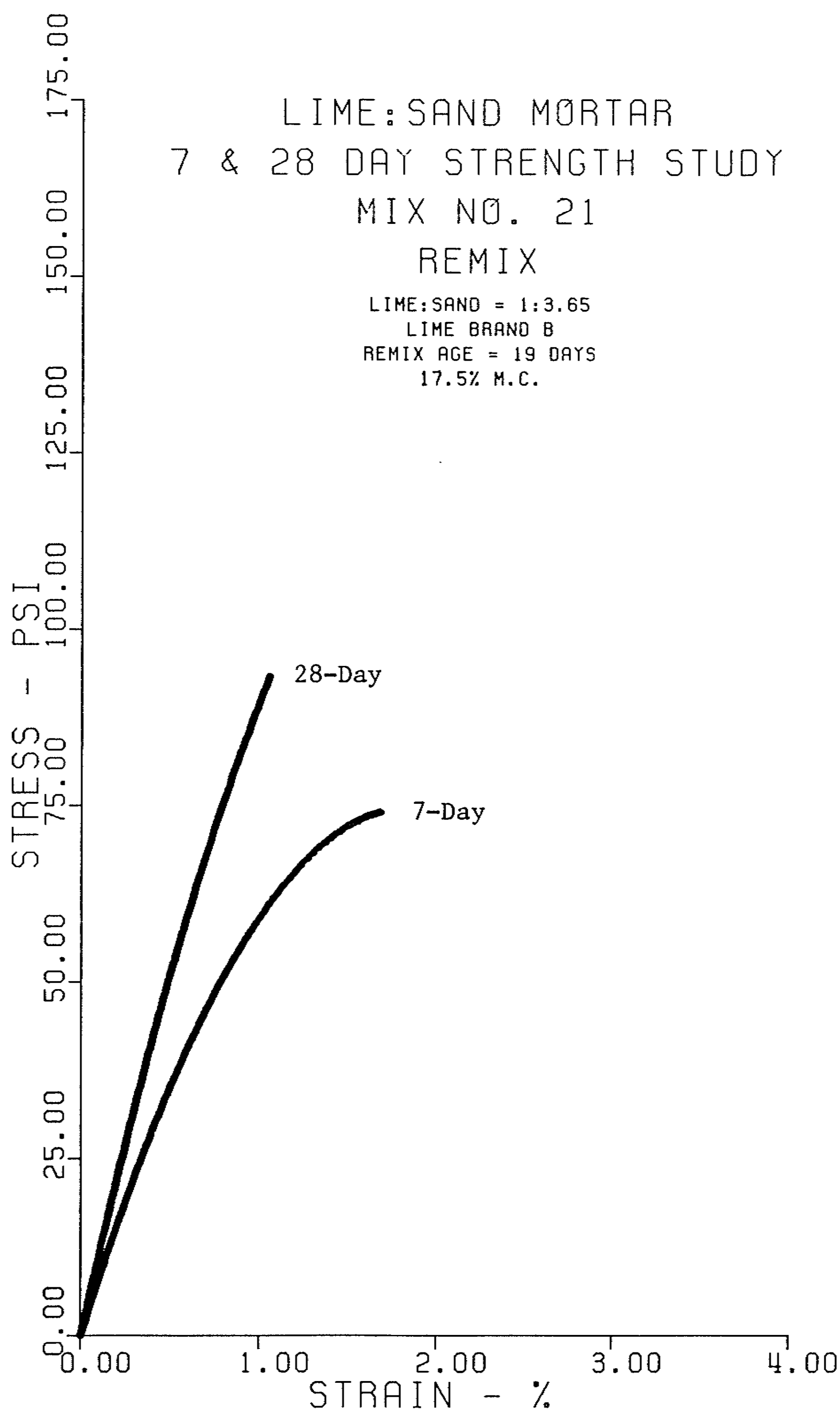


Figure J-13: Seven- and 28-Day Compressive Strength Study Plot for Lime-Sand Mortar Remix No. 21

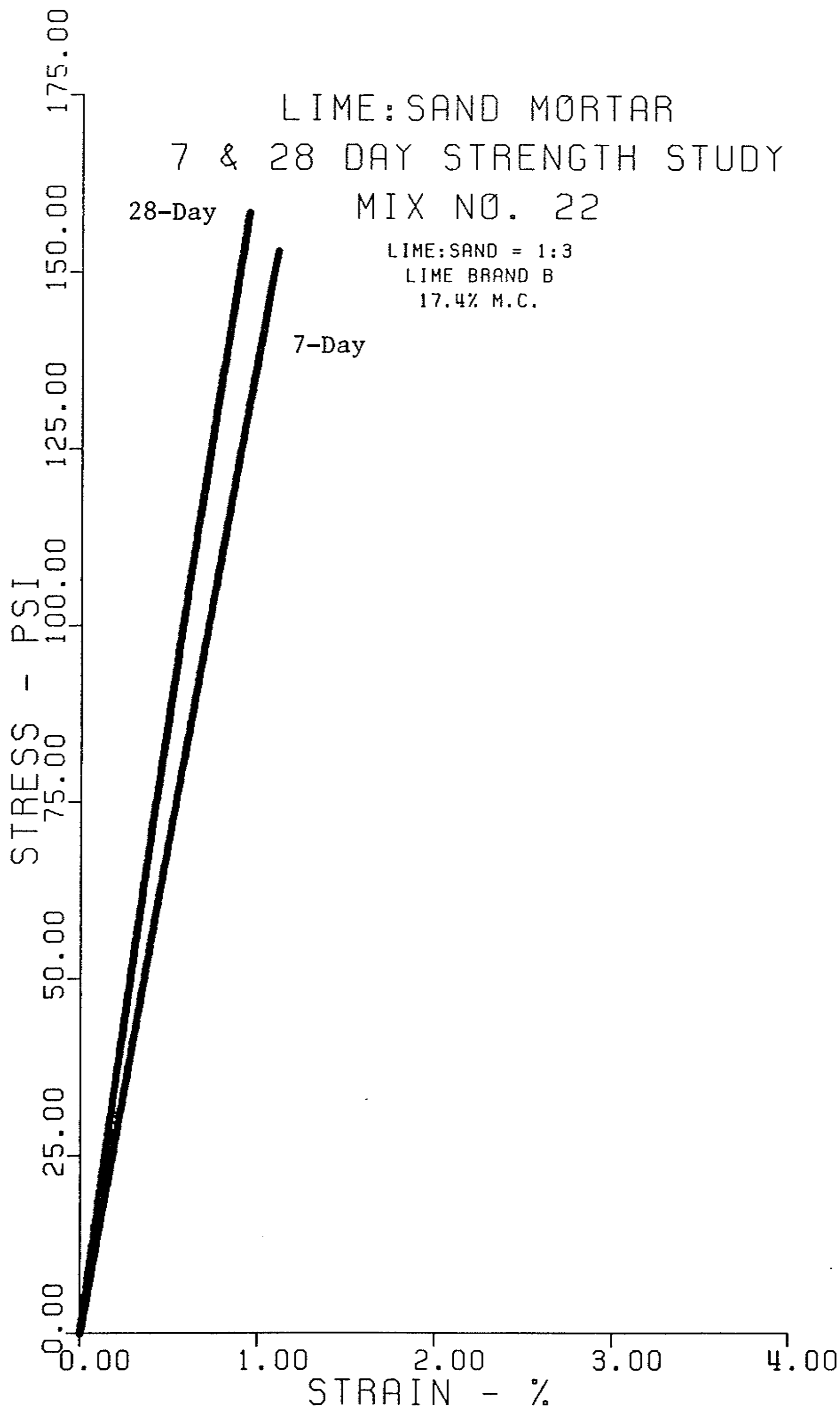


Figure J-14: Seven- and 28-Day Compressive Strength Study Plot for Lime-Sand Mortar Mix No. 22

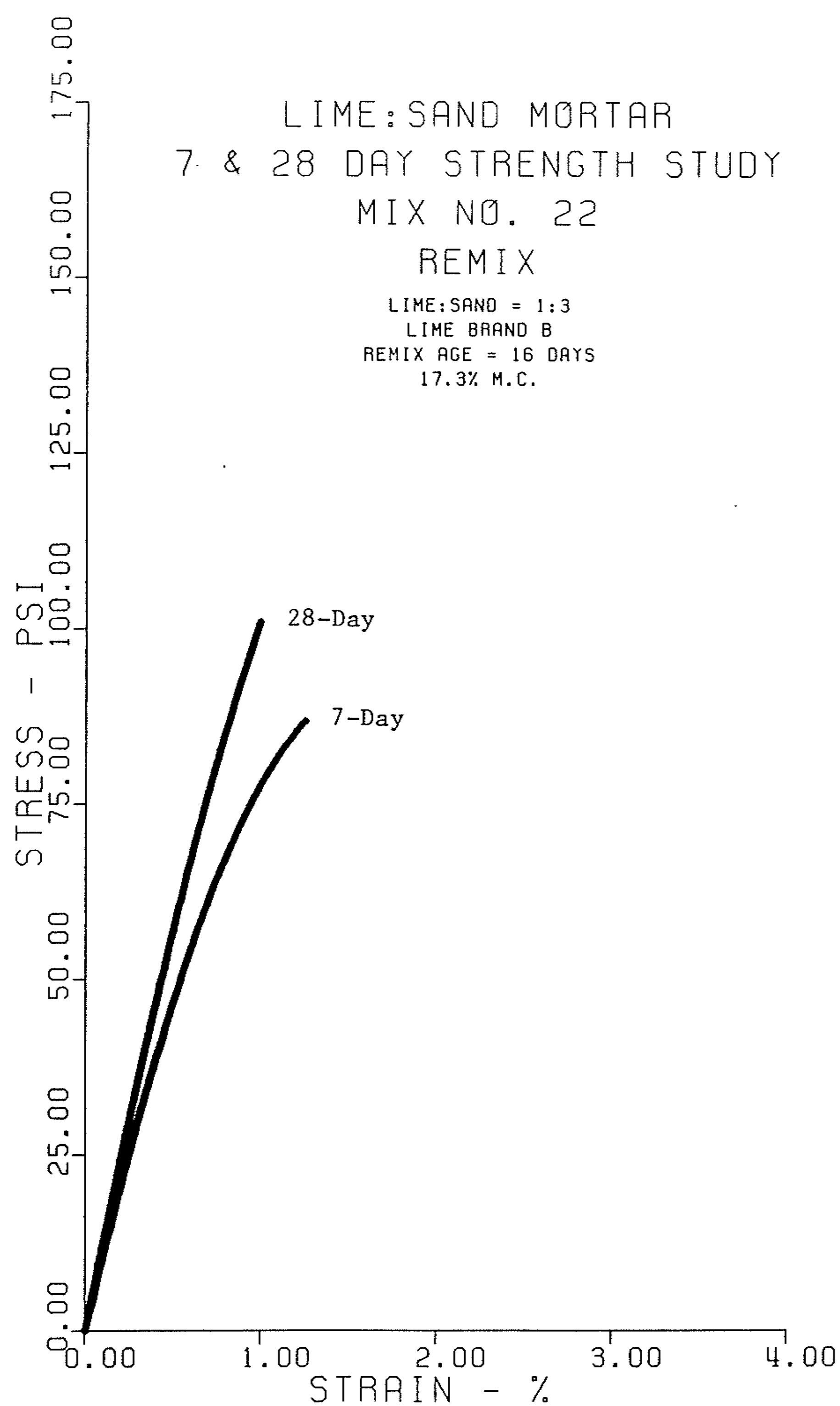


Figure J-15: Seven- and 28-Day Compressive Strength Study Plot for Lime-Sand Mortar Remix No. 22

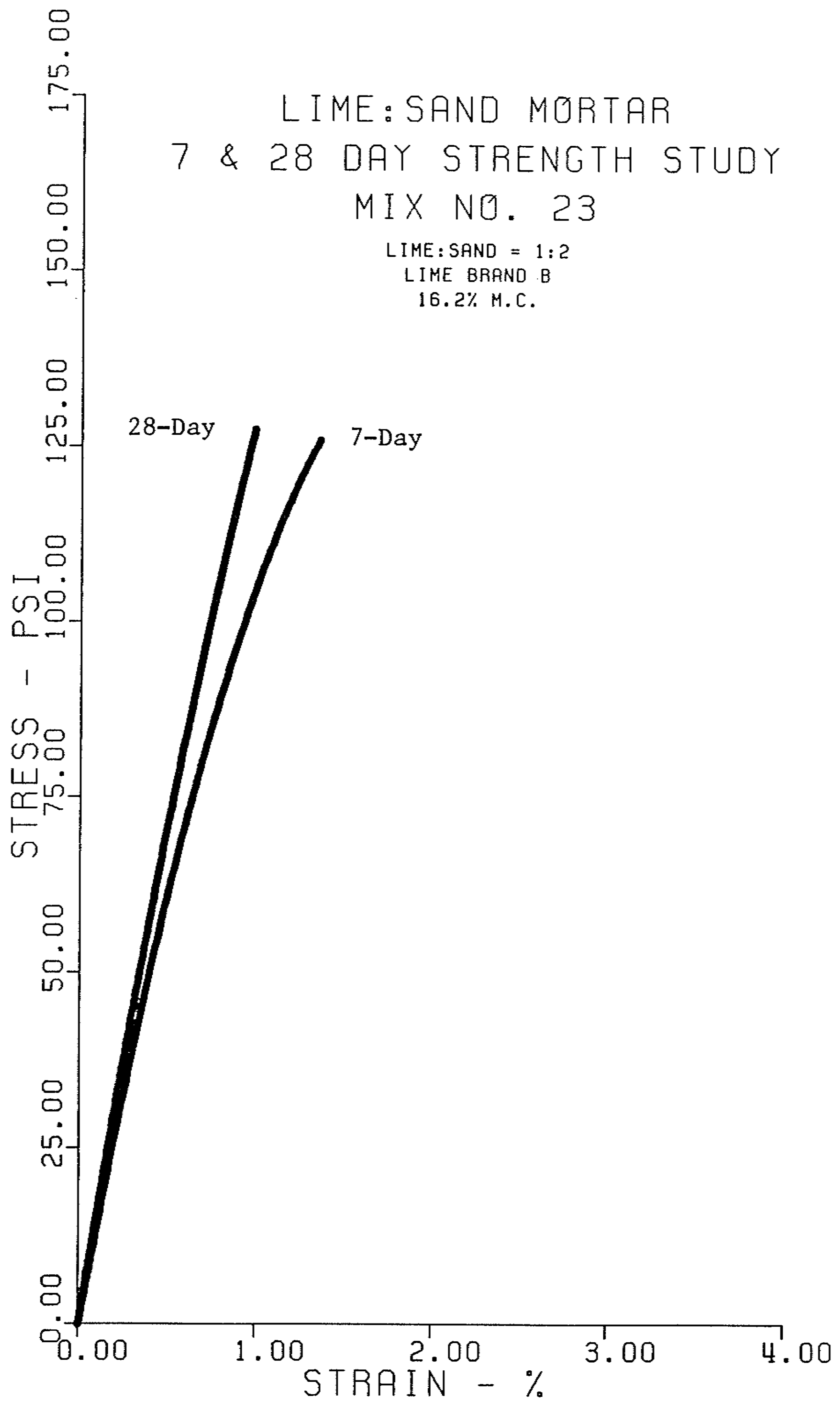


Figure J-16: Seven- and 28-Day Compressive Strength Study Plot for Lime-Sand Mortar Mix No. 23

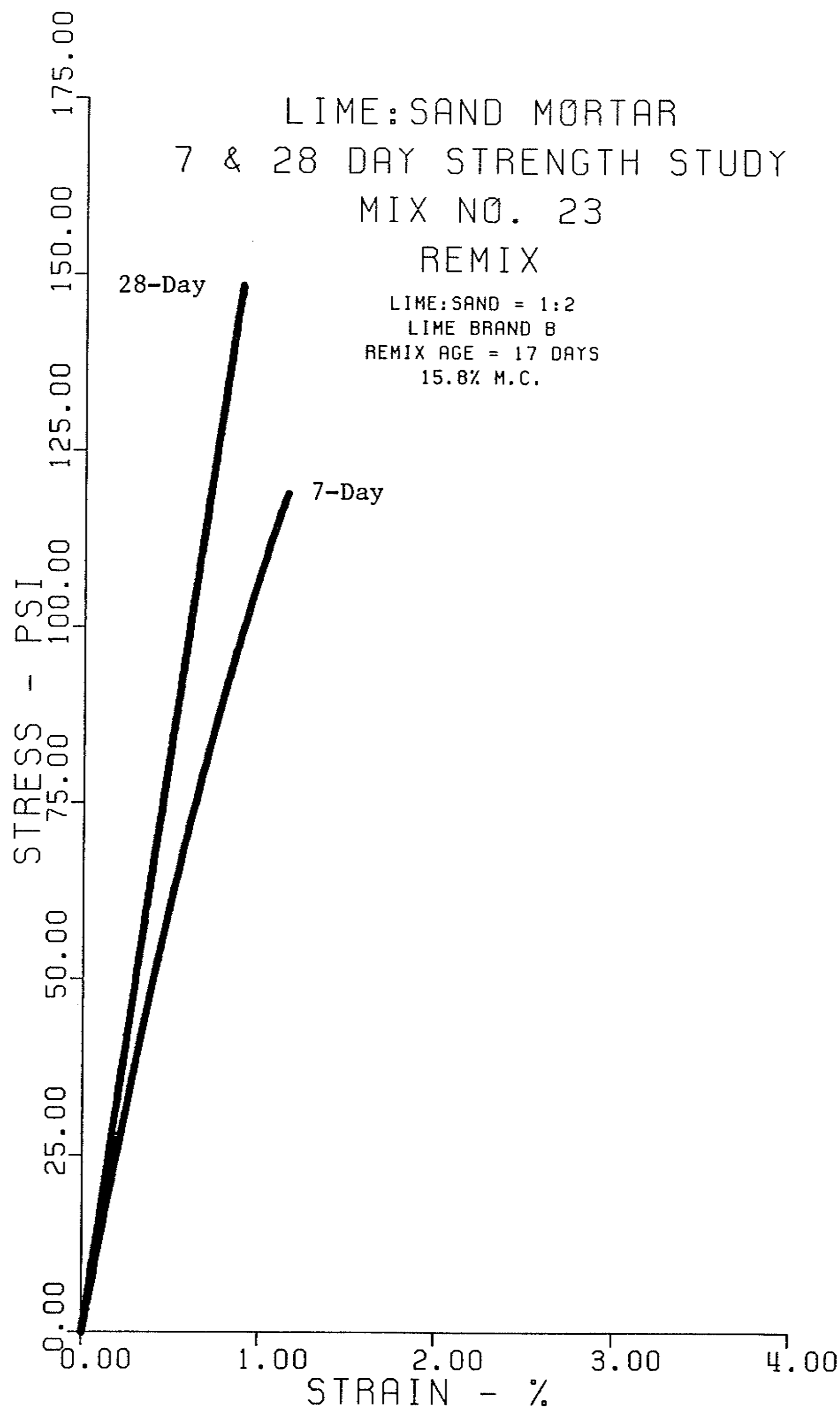


Figure J-17: Seven- and 28-Day Compressive Strength Study Plot for Lime-Sand Mortar Remix No. 23

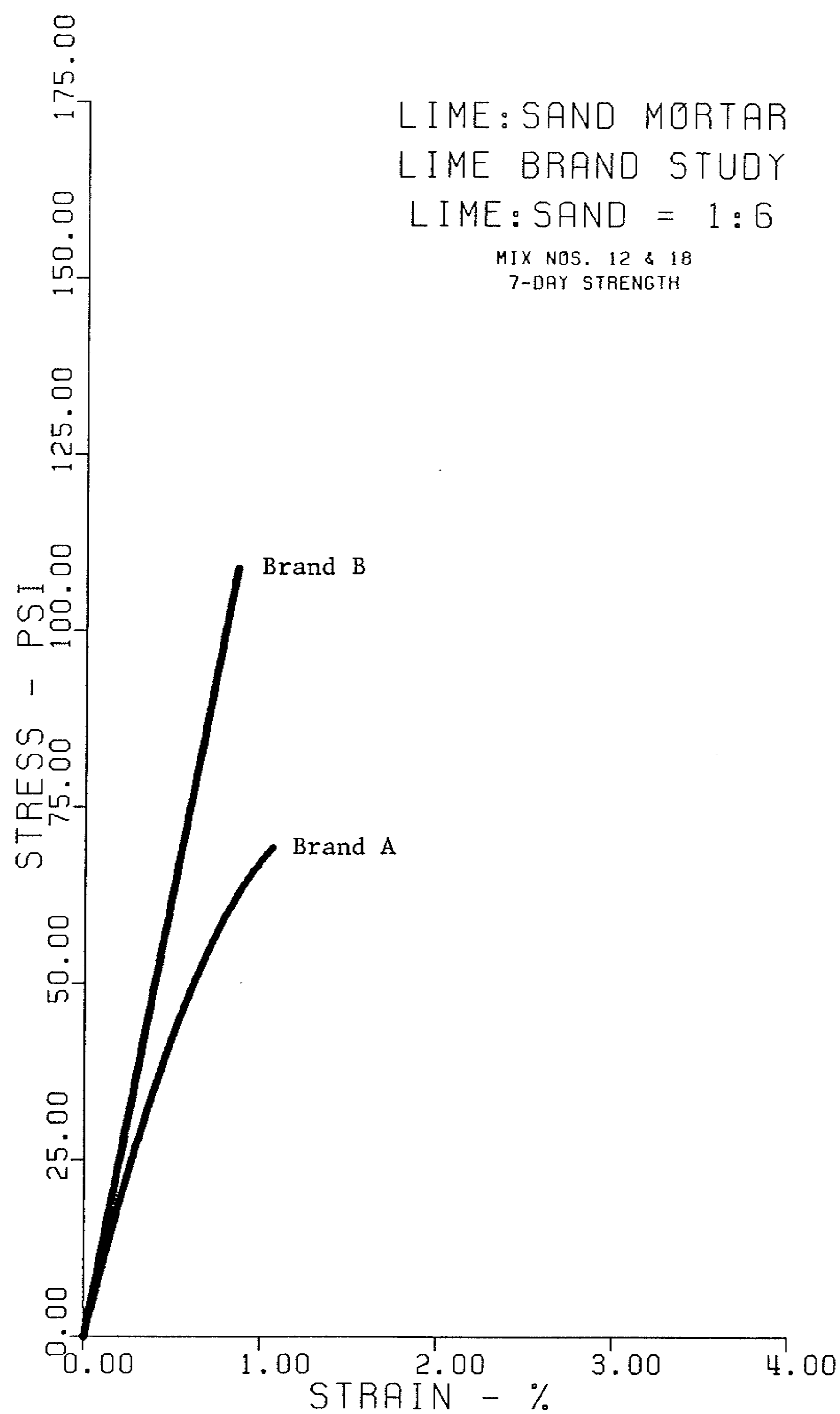


Figure J-18: Lime Brand Study Plot for Lime-Sand Mortar Original Mixes with Lime:Sand Ratio of 1:6 at the Seven-Day Compressive Strength

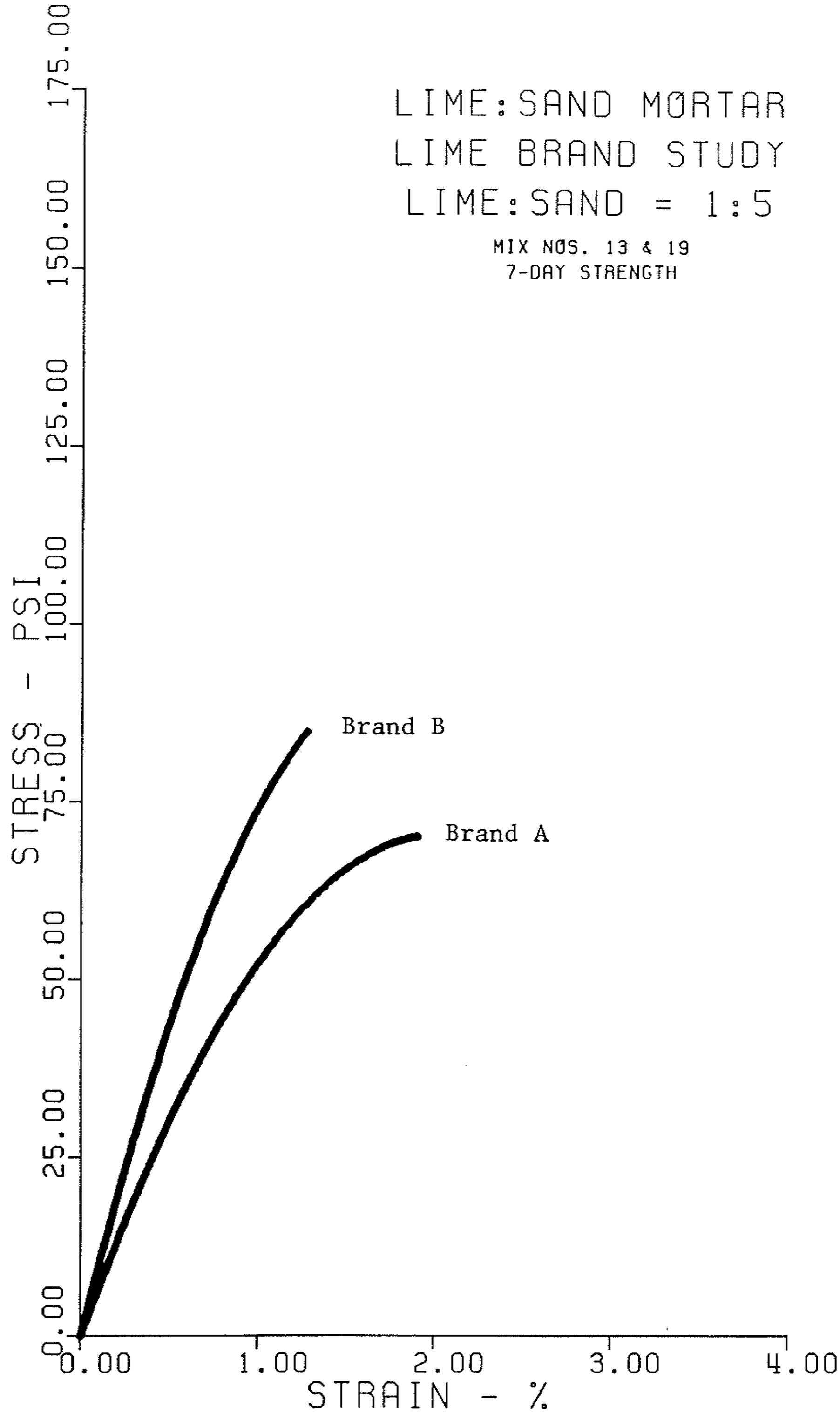


Figure J-19: Lime Brand Study Plot for Lime-Sand Mortar Original Mixes with Lime:Sand Ratio of 1:5 at the Seven-Day Compressive Strength

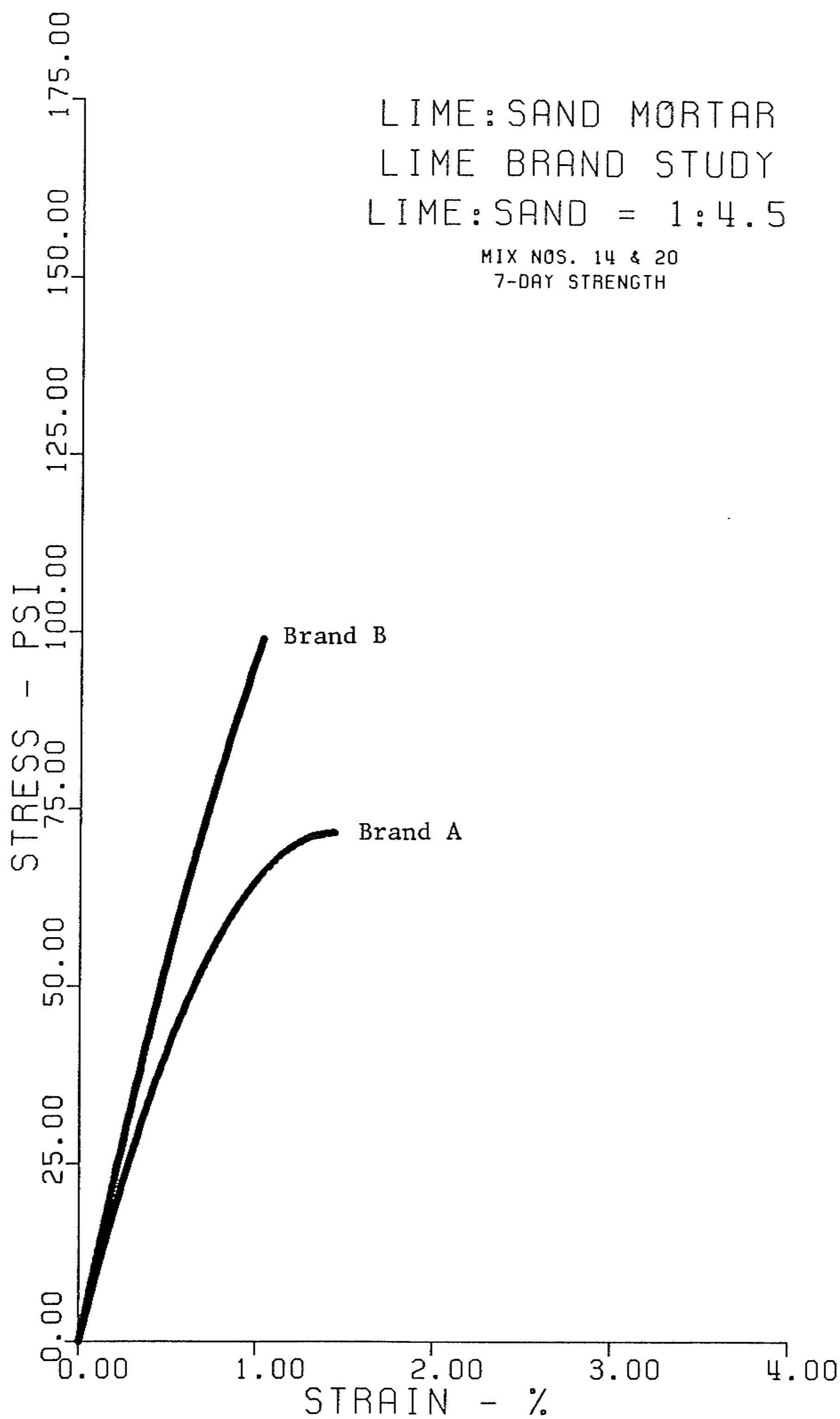


Figure J-20: Lime Brand Study Plot for Lime-Sand Mortar Original Mixes with Lime:Sand Ratio of 1:4.5 at the Seven-Day Compressive Strength

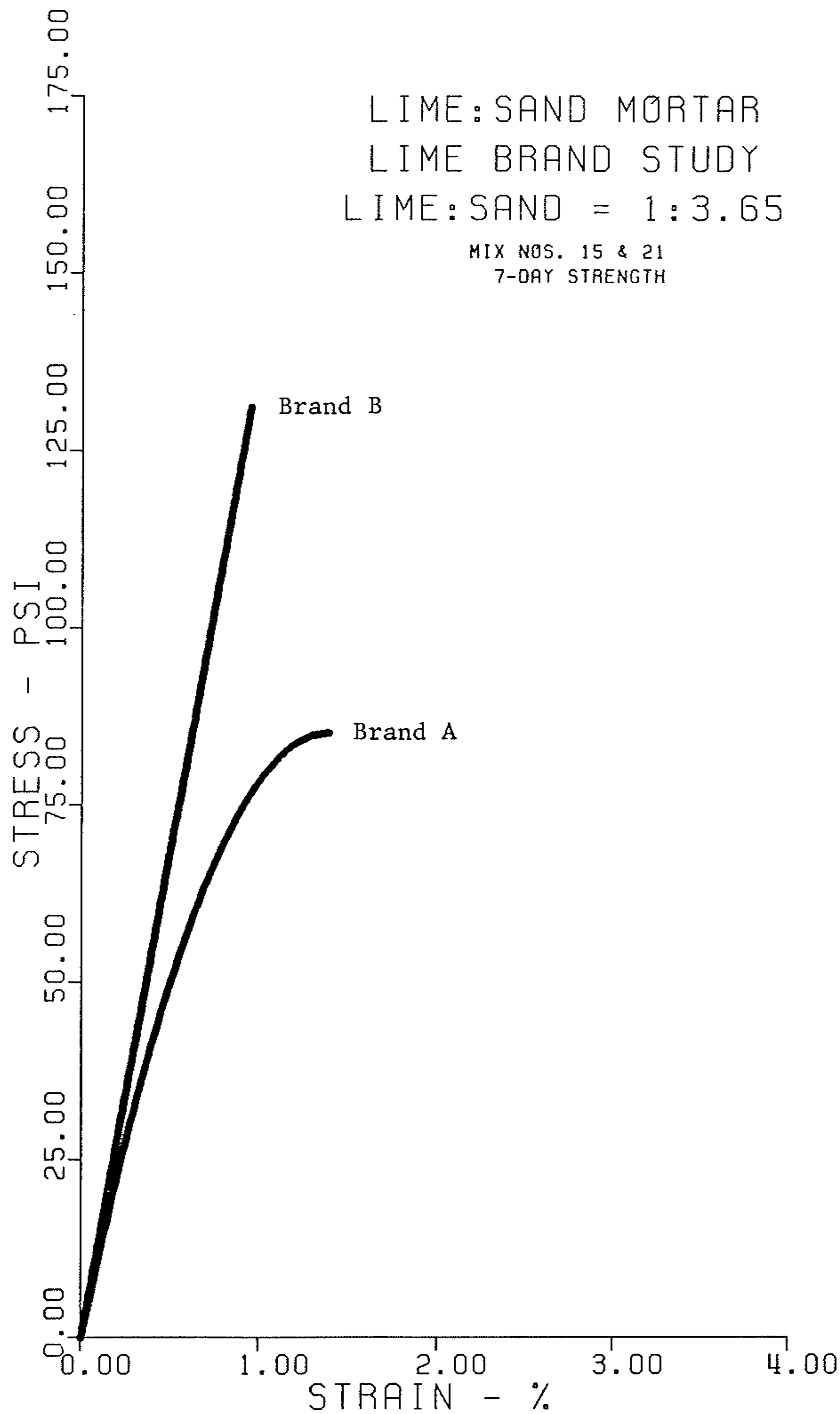


Figure J-21: Lime Brand Study Plot for Lime-Sand Mortar Original Mixes with Lime:Sand Ratio of 1:3.65 at the Seven-Day Compressive Strength

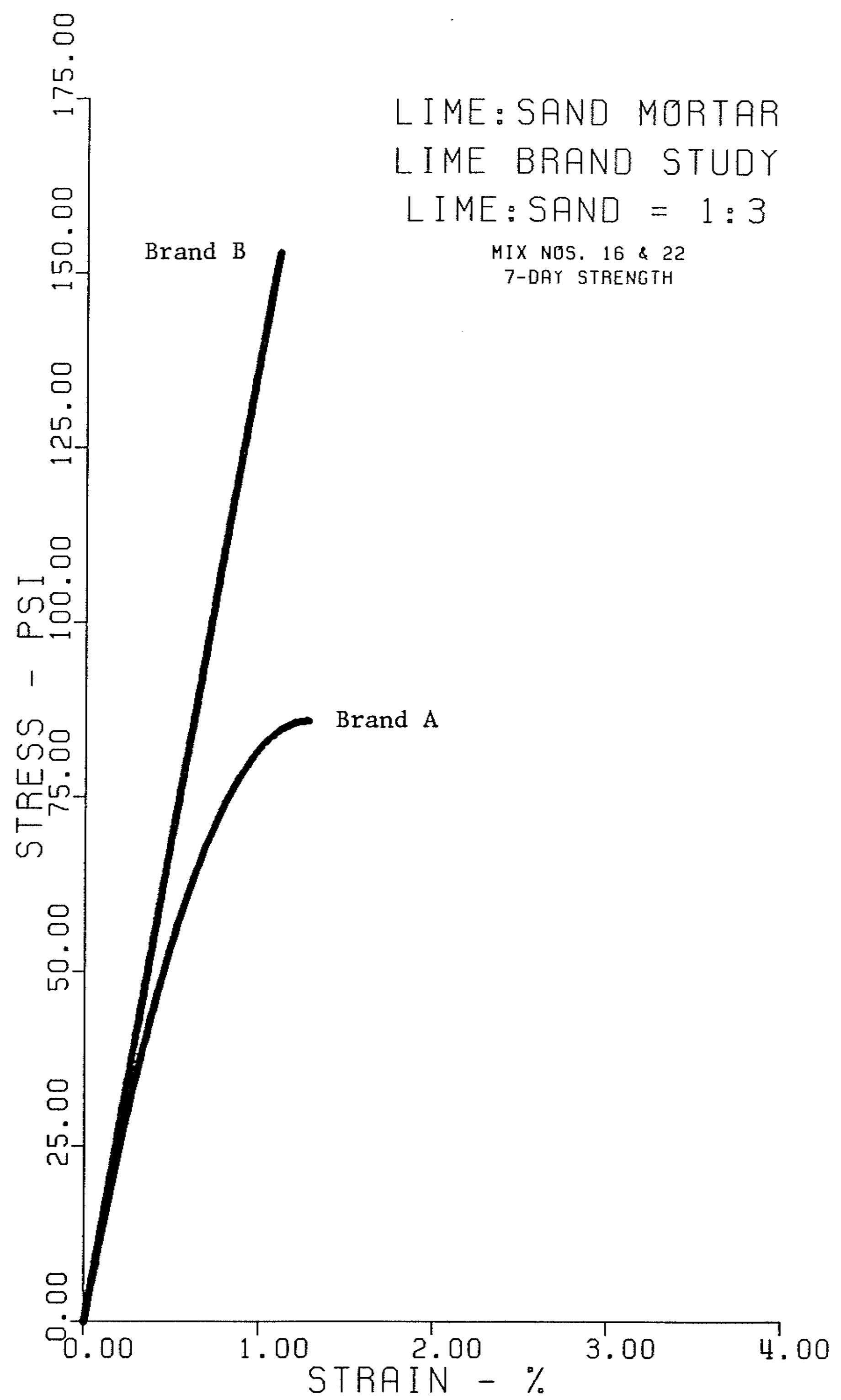


Figure J-22: Lime Brand Study Plot for Lime-Sand Mortar Original Mixes with Lime:Sand Ratio of 1:3 at the Seven-Day Compressive Strength

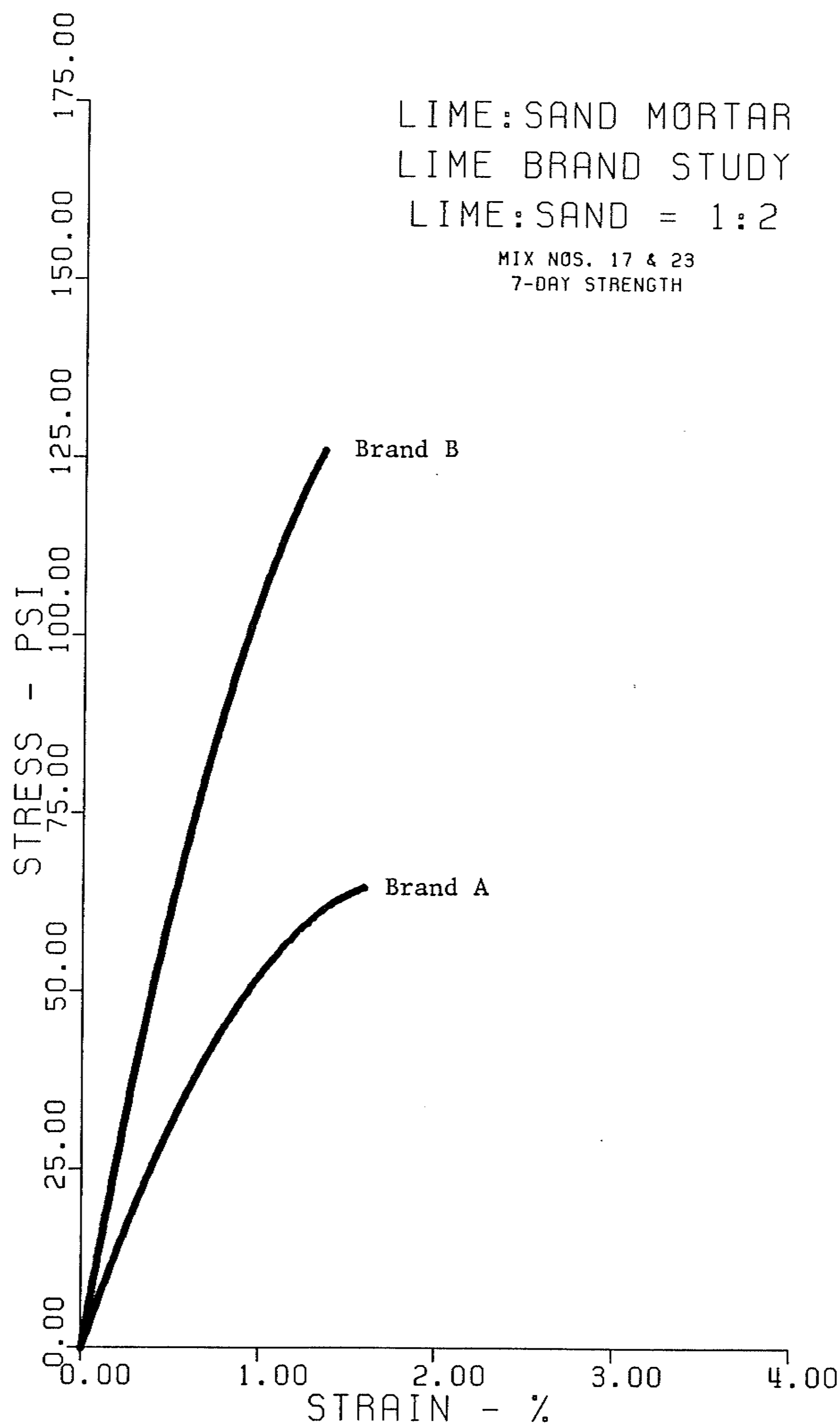


Figure J-23: Lime Brand Study Plot for Lime-Sand Mortar Original Mixes with Lime:Sand Ratio of 1:2 at the Seven-Day Compressive Strength

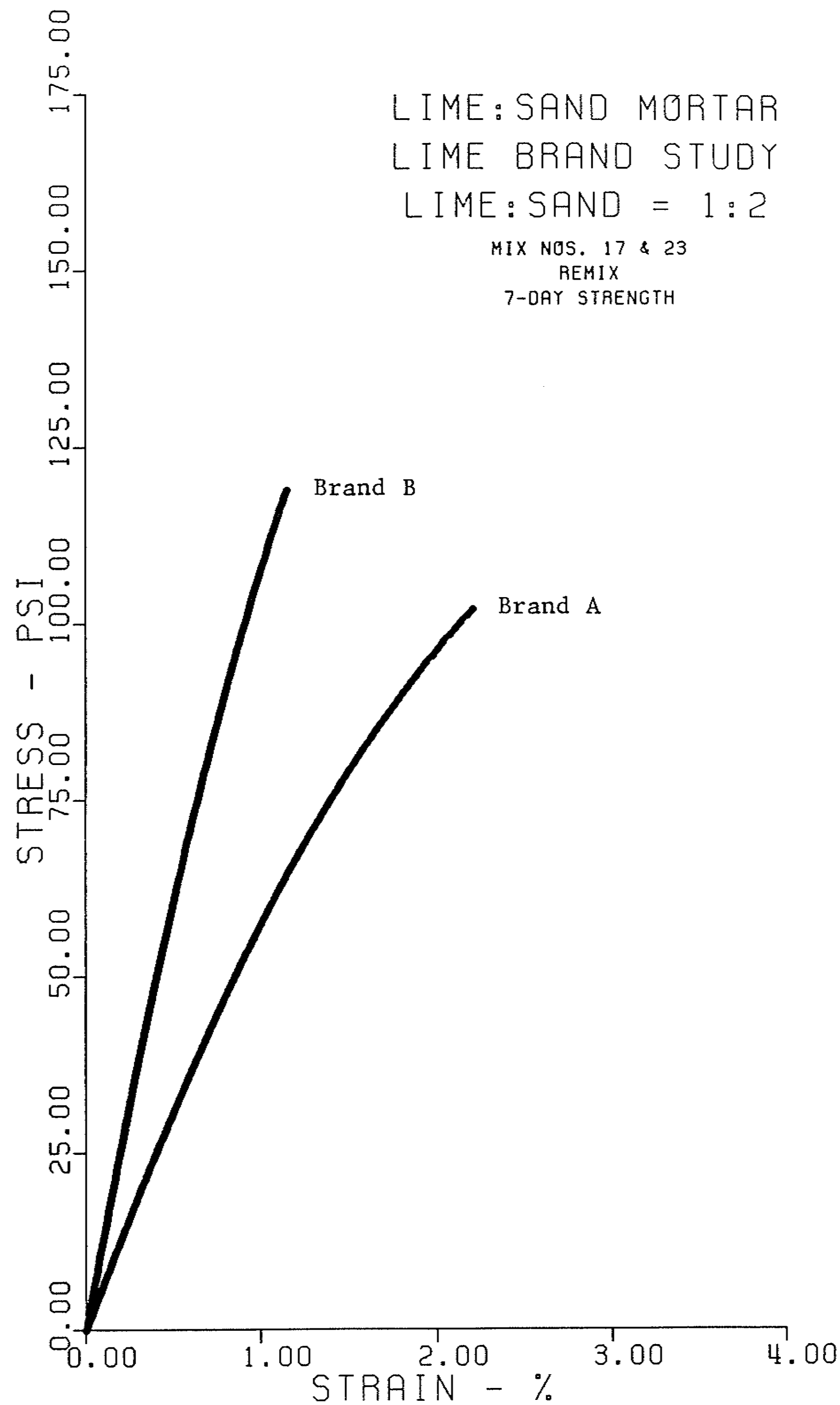


Figure J-24: Lime Brand Study Plot for Lime-Sand Mortar Remix Mixes with Lime:Sand Ratio of 1:2 at the Seven-Day Compressive Strength

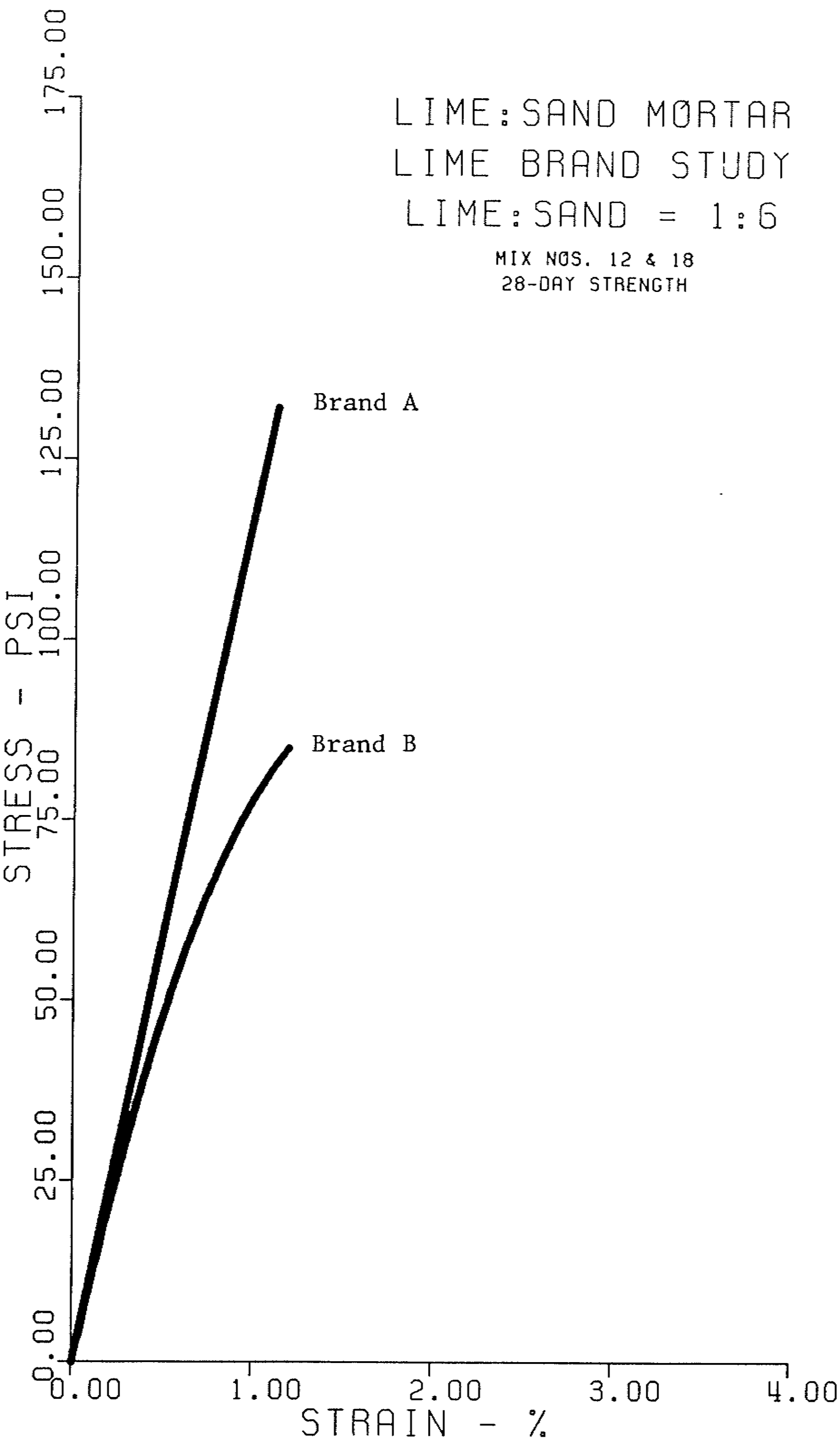


Figure J-25: Lime Brand Study Plot for Lime-Sand Mortar Original Mixes with Lime:Sand Ratio of 1:6 at the 28-Day Compressive Strength

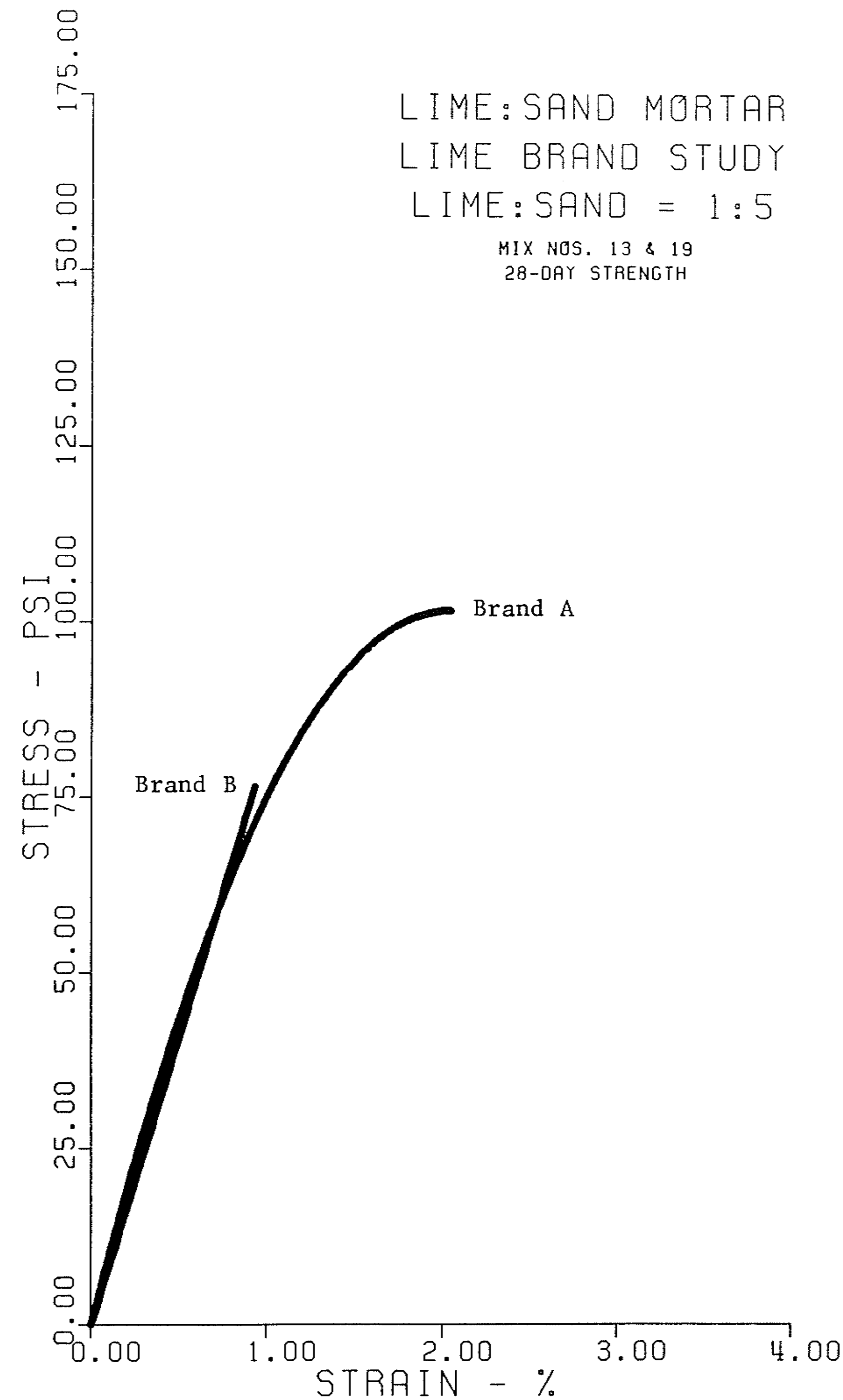


Figure J-26: Lime Brand Study Plot for Lime-Sand Mortar Original Mixes with Lime:Sand Ratio of 1:5 at the 28-Day Compressive Strength

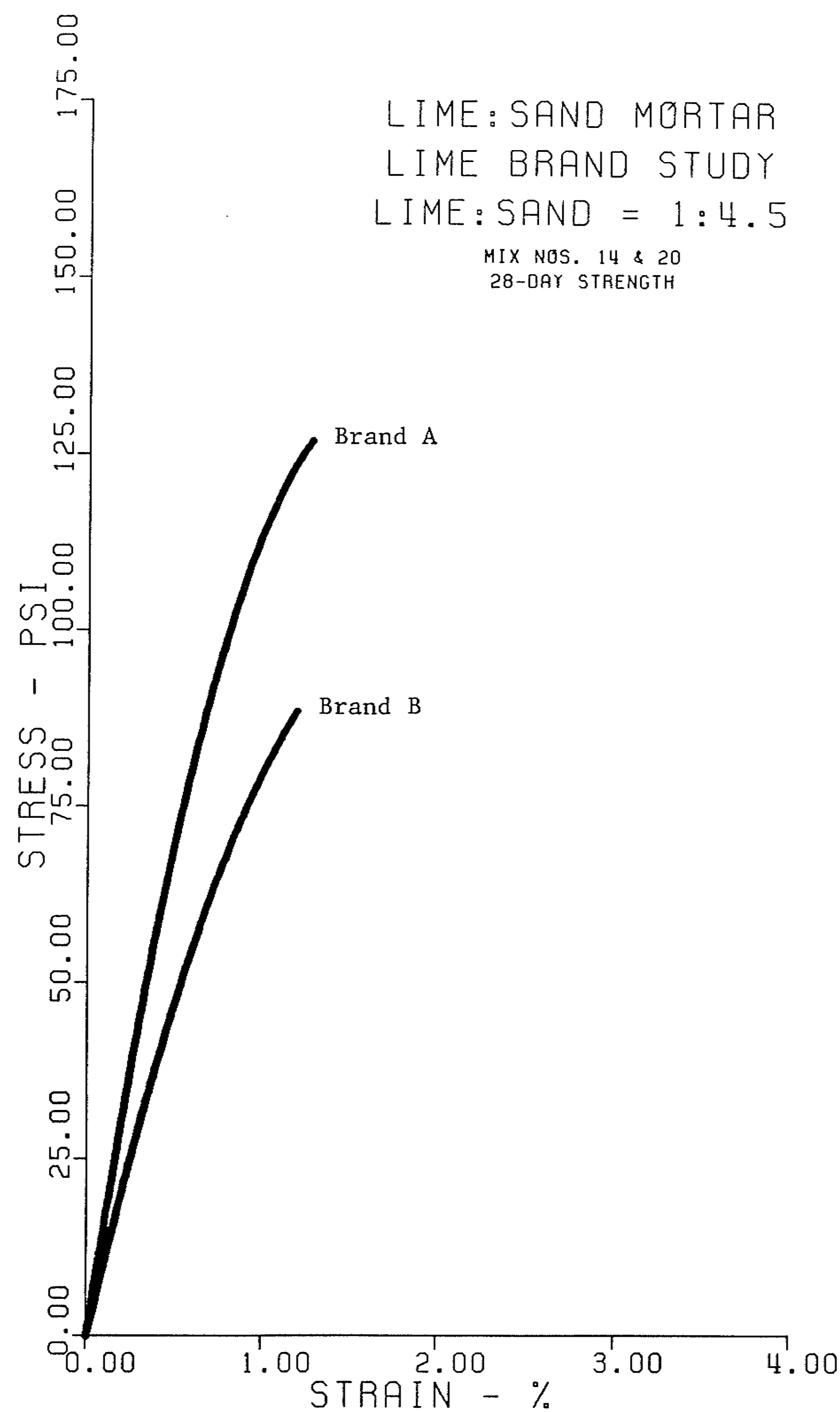


Figure J-27: Lime Brand Study Plot for Lime-Sand Mortar Original Mixes with Lime:Sand Ratio of 1:4.5 at the 28-Day Compressive Strength

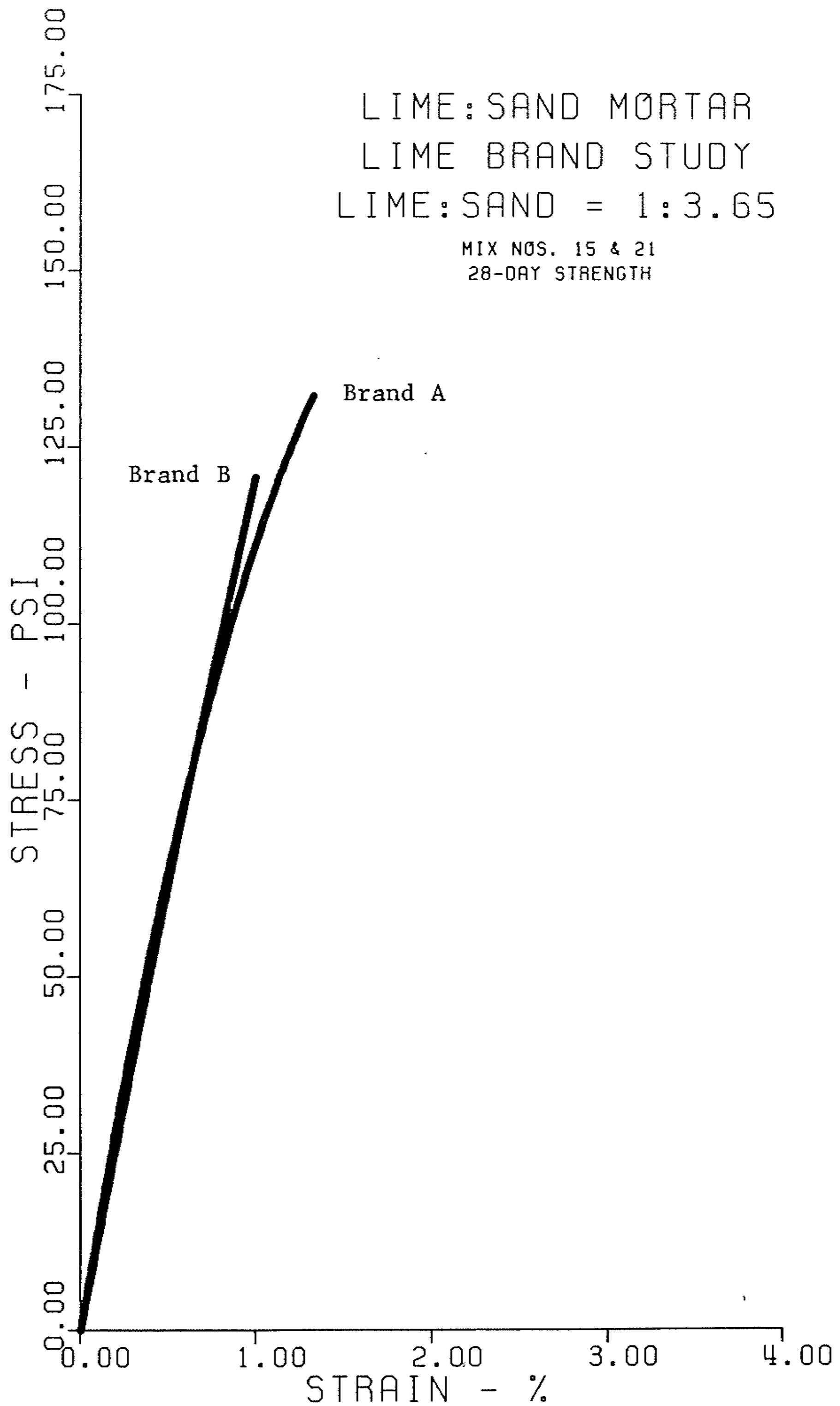


Figure J-28: Lime Brand Study Plot for Lime-Sand Mortar Original Mixes with Lime:Sand Ratio of 1:3.65 at the 28-Day Compressive Strength

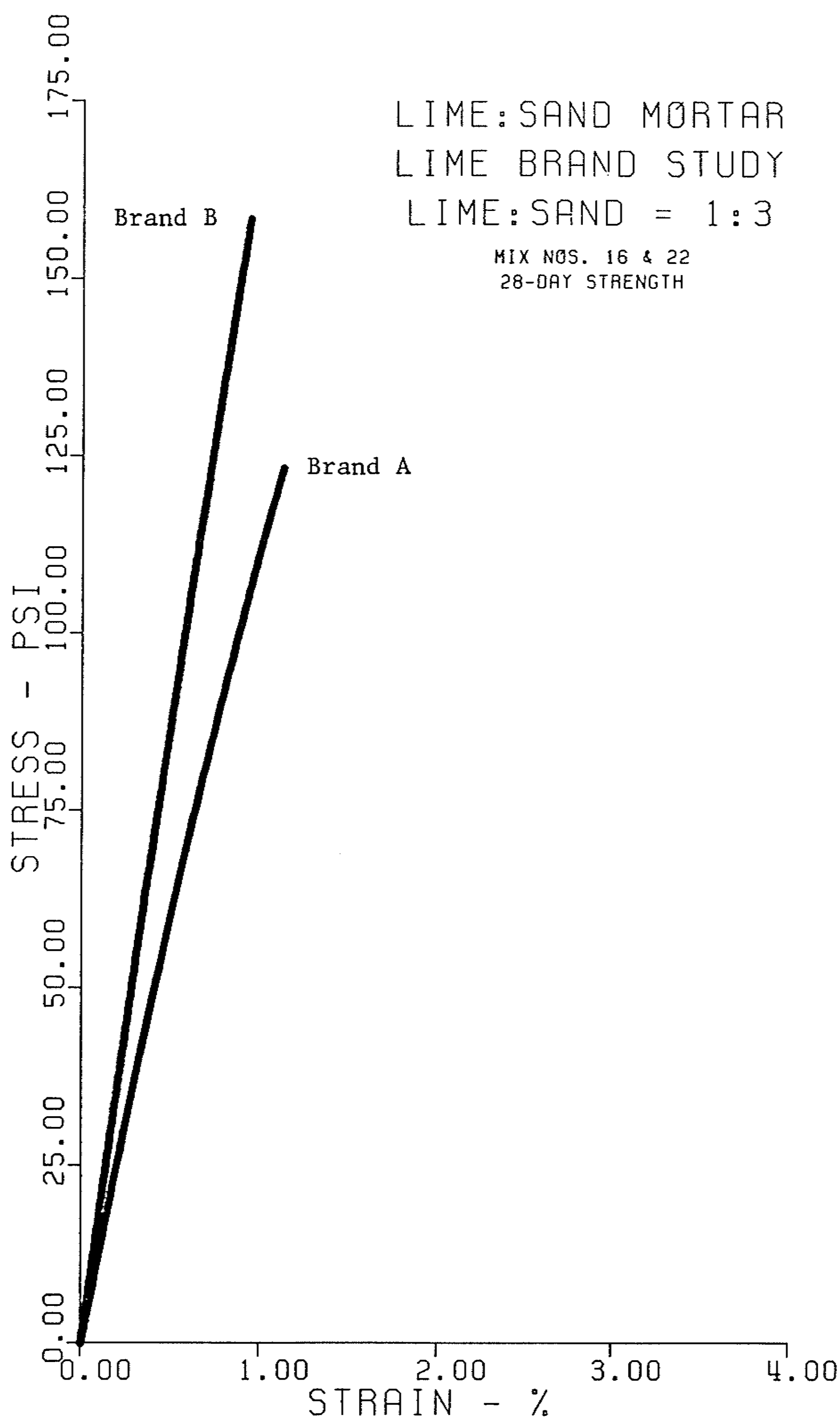


Figure J-29: Lime Brand Study Plot for Lime-Sand Mortar Original Mixes with Lime:Sand Ratio of 1:3 at the 28-Day Compressive Strength

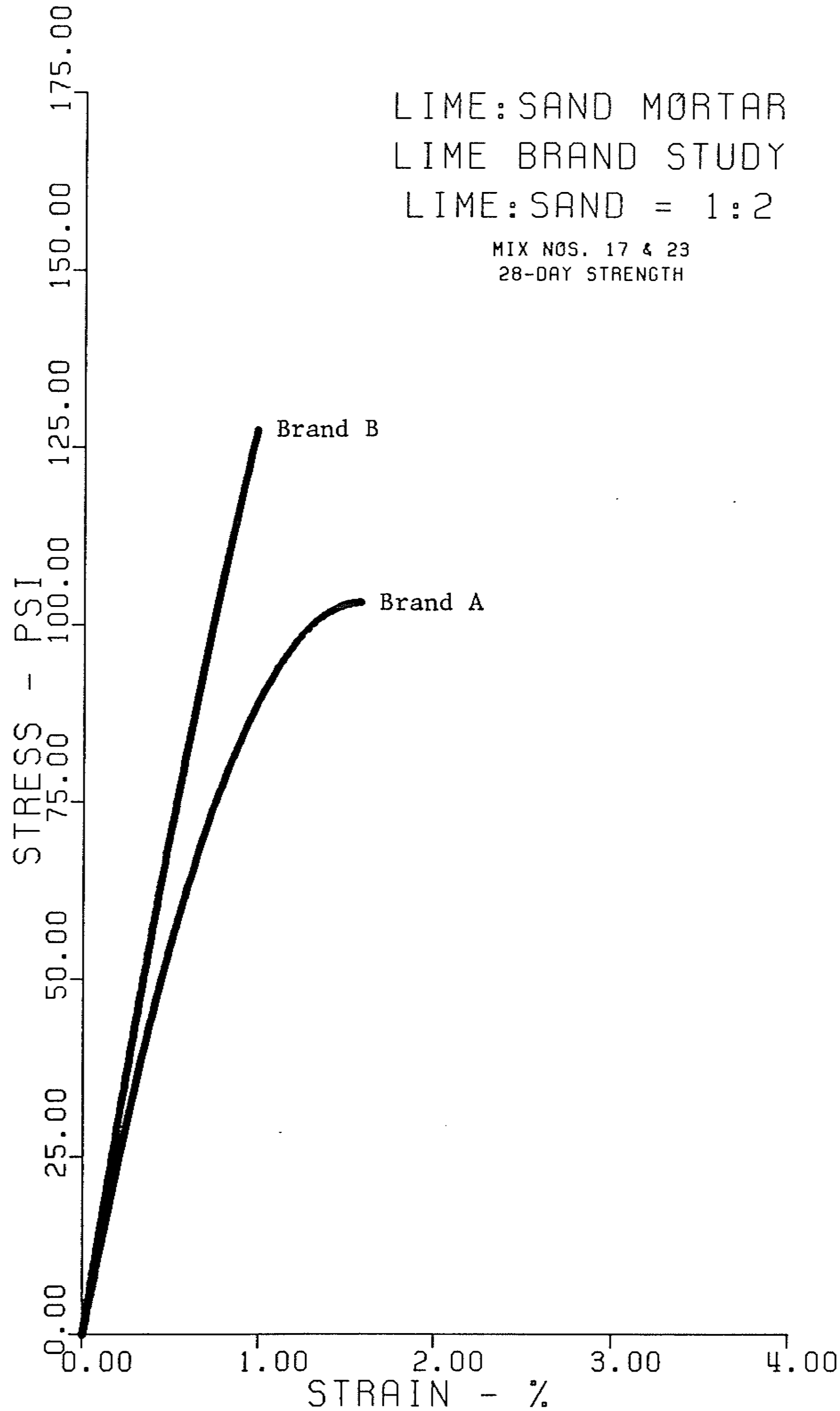


Figure J-30: Lime Brand Study Plot for Lime-Sand Mortar Original Mixes with Lime:Sand Ratio of 1:2 at the 28-Day Compressive Strength

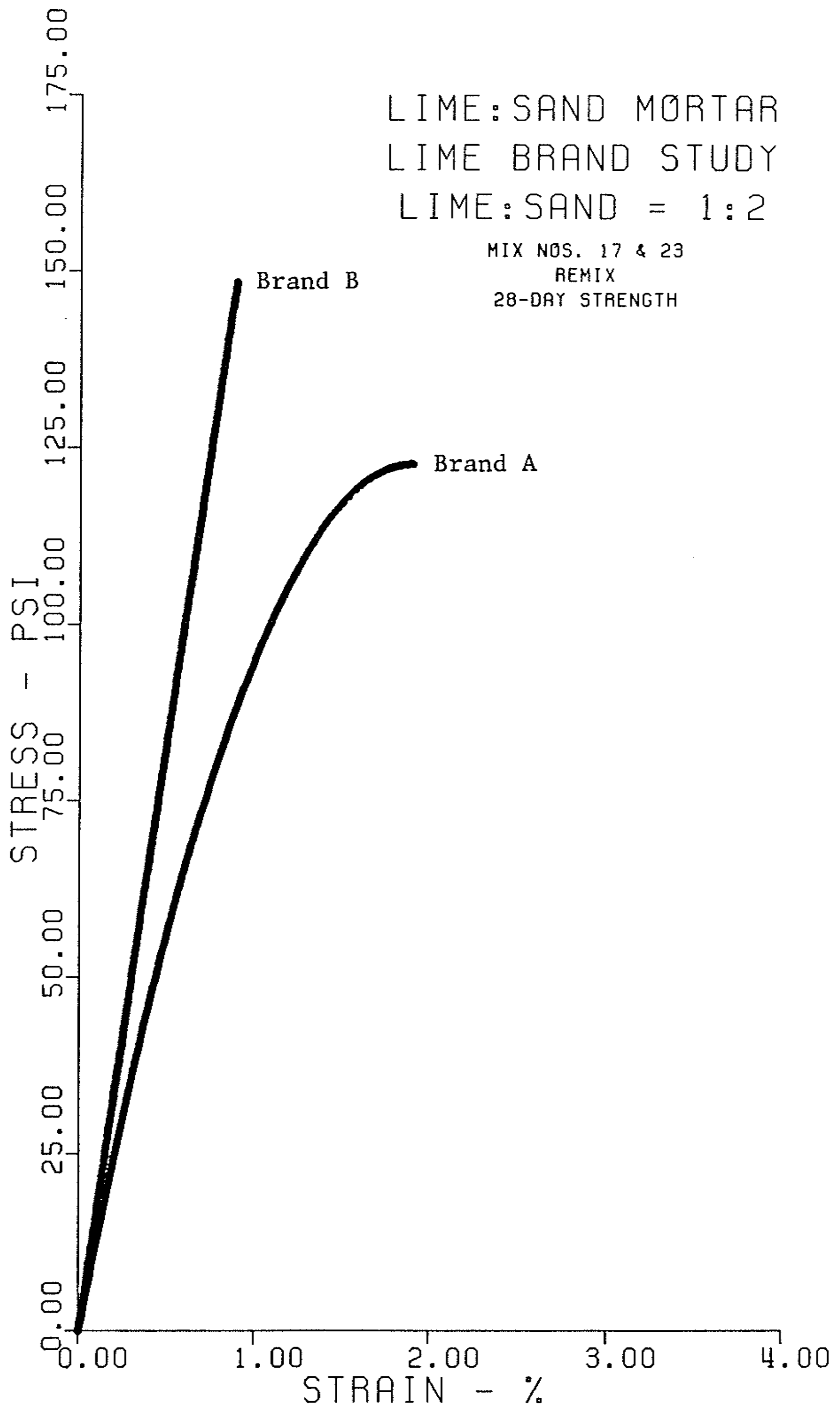


Figure J-31: Lime Brand Study Plot for Lime-Sand Mortar Remix Mixes with Lime:Sand Ratio of 1:2 at the 28-Day Compressive Strength

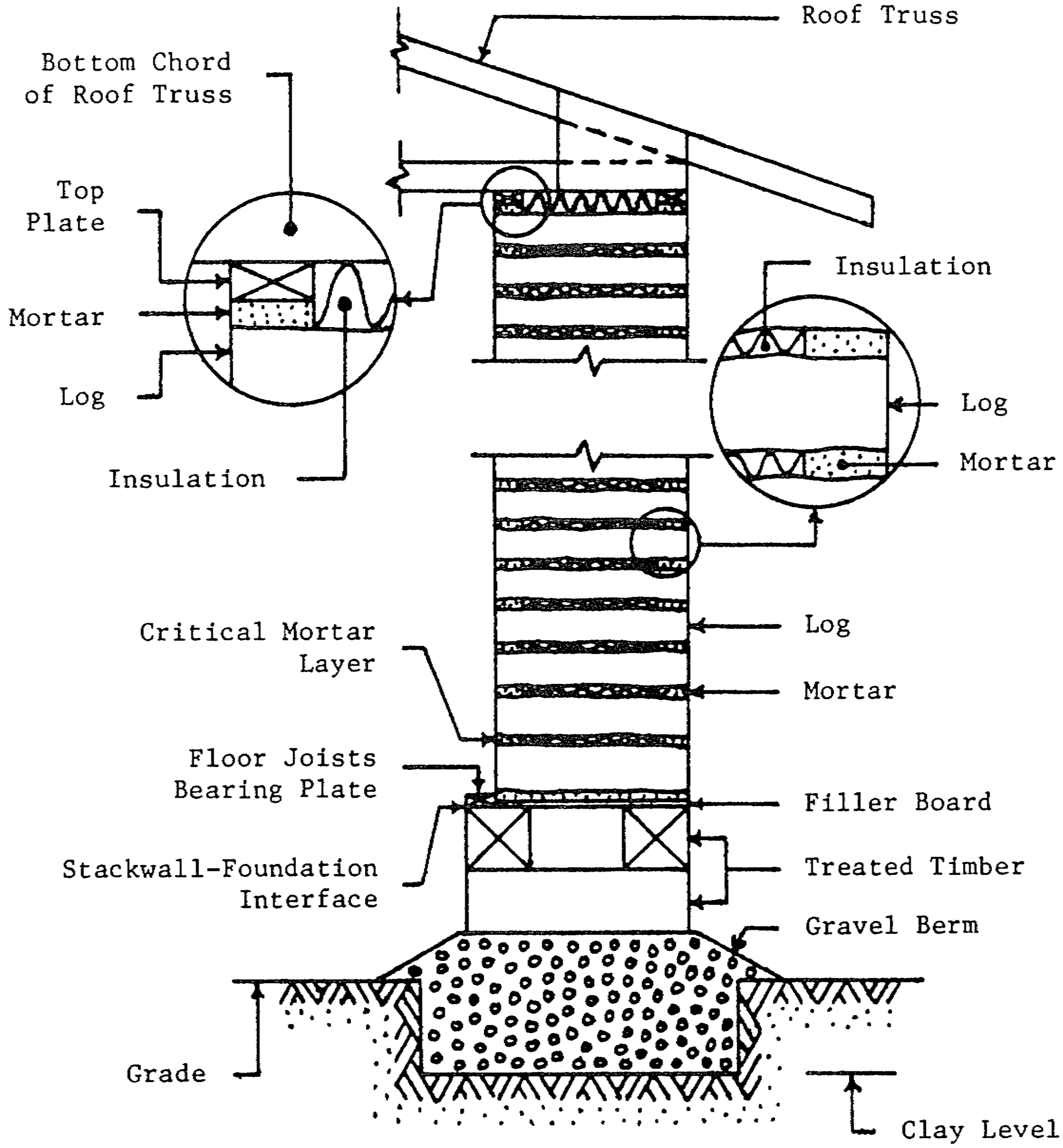
Appendix K

MORTAR STRENGTH REQUIRED FOR STACKWALL CONSTRUCTION

In the laboratory, the mortar was tested in the form of two-inch cube specimens while the mortar in a stackwall structure is in a different form. What is the laboratory mortar strength required that would correlate to the mortar strength required for stackwall construction? Sought for was an adequate strength (see Appendix A) with a generous safety factor rather than high strength.

Figure K-1 shows a typical cross-section of stackwall construction. The Northern Housing Committee of the University of Manitoba [51] evaluates the load for a one- and two-storey stackwall house to be respectively one and two kips per linear foot of wall; these figures represent the loading at the stackwall-foundation interface. This loading is assumed to be uniaxial with no eccentricity thereby creating a pure compressive state of stress.

Intermittent lateral forces such as that due to wind are assumed to be non-governing since stackwall construction consists of a wall that can be described as being stubby relative to conventional masonry (see Definitions). In addition to the compressive strength, an analysis of lateral



Notes: 1) Scale: 1/2" = 1';
2) A full layer of mortar exists between the filler board and the first layer of logs; and
3) Figure was drawn using Reference No. 51.

Figure K-1: Typical Cross-Section of Stackwall Construction forces would involve the bond strength of mortar; the bond strength of the mortars examined in this investigation was not measured.

Reference 51 [p. 44] states that the mortar joint of stackwall construction should have a width of three to four inches. In practice, the width used is usually three and one-half to four inches [51]. In calculating the compressive stress on the mortar, a width of three inches will be used; this will represent a higher stress situation than usually met in practice.

As indicated in Figure K-1, page 503, due to a lower bedding area, the critical mortar layer will be taken on top of the first layer of logs instead of the stackwall-foundation interface. The total area of mortar at this point per linear foot is:

= No. of mortar joints x (width of joint x length of joint)

= 2 (3" x 12")

= 72 in.^{2}.

Assuming that the full load is present on this area, the maximum compressive stress of the mortar for a one storey stackwall house is:

$$\sigma = \text{load/area}$$

$$= 1{,}000 \text{ lbs.}/72 \text{ in.}^2$$

$$= 14 \text{ psi.}$$

At this point, it does not mean that the strength of a two-inch cube mortar specimen, tested in the laboratory, requires a compressive strength of 14 psi. to be satisfactory for stackwall construction. The two different conditions of stress must first be correlated before any comparison can be made.

In the laboratory, the height-diameter ratio of the cube specimen is one (2/2 = 1); in stackwall construction, assuming a maximum of one inch thickness for the mortar [51, pp. 40, 43], the height-diameter ratio is 1/3 (height of mortar joint/width of mortar joint). The literature indicates that as the height (length for a cylinder) of the specimen in compression is reduced, the effect of the frictional restraint at the ends become relatively important [28, p. 139]. If the specimen is so short that a normal failure plane cannot develop within the length of the specimen (i.e. diagonal planes intersect the base), then the apparent strength is appreciably increased and other types of failure, such as crushing, may occur [28, pp. 139, 146]. The literature also indicates that as the ratio of joint thickness to the height of a building block decreases, the masonry strength increases [30, p. 32].

The effects of size and shape of the test specimen are noted in the testing of concrete -- a non-homogeneous, brittle material. To standardize tests, correction factors, to take into account the length-diameter ratio of the specimen, are set up for concrete testing [28, pp. 147 to 148].

It is suggested that for a homogeneous material, the unit compressive strength varies with the shape of the specimen, being dependent upon the ratio between the least horizontal dimension and height [12]. The mortars examined in this study as well as the conventional mortars (see Definitions) are assumed to be homogeneous materials. For a laboratory mortar cube, the above ratio is one. A mortar joint in a stackwall wall has a minimum width of three inches [51, p. 44] and a maximum of one inch thickness [51, p. 40]. In the stackwall joint, the above ratio is 3/1 = 3. The strength required of the mortar used for a one storey stackwall house should then theoretically be

14/3 = 4.7 psi. [12].

If the joint's width is increased and/or height decreased, this theoretical figure would become even lower. For example, if the mortar was given the width of four inches and a height of three-quarters of an inch, the above ratio would become 4/0.75 = 5.3. The theoretical strength required would then become

14/5.3 = 2.6 psi. [12].

The required strength can be lowered further if one closely examines the true state of stress of the mortar in the wall. In conventional masonry (see Definitions) subjected to uniaxial compression, the mortar is put into a state of triaxial compression and the masonry unit is put into a state of uniaxial compression (in the direction of loading) and lateral biaxial tension [40, pp. 34 to 35; 60, pp. 103, 128]. The biaxial tension of the masonry unit is due to the mortar having a tendency to spread out laterally under load. In response, the unit reacts in the opposite direction so as to maintain equilibrium creating lateral biaxial compressive stress on the confined mortar.

If the mortar in stackwall construction is in a state of triaxial compressive stress, as in conventional masonry (see Definitions), the strength of that mortar would be appreciably higher than the mortar tested in the laboratory which is in an unconfined and uniaxial compressive state of stress. If a correlation between these two different states of stress were known, the required laboratory strength of mortar could be reduced further. One way of getting a better indication of how the mortar and building units react together is by assemblage and wall panel type of tests.

Assemblage and wall panel type of tests is a more valuable laboratory strength test than mortar cubes, since in good masonry work, mortar becomes an integral part of the wall, even though it may occupy a small percentage of wall area. Mortar cubes do not remotely emulate masonry wall conditions such as effect of absorption by masonry units, consolidated weight of wall and particularly the profound influence of the strength of the units [12].

In masonry work, safety factors of five to 15 are completely adequate [12]. If assemblage and/or wall panel (built and seasoned as it would be in the field) tests are performed for tensile bond strength, shear strength and compressive strength, load factors between four and five may be sufficient for masonry construction; otherwise load factors of 10 or higher have to be used [30, pp. 35 to 36]. Since only mortar cubes were used in this study, a safety factor of 10 will be used.

Previously it was calculated that a theoretical mortar compressive strength of 4.7 psi. was required for a one-storey stackwall house. With the safety factor applied, the theoretical strength required becomes

$$4.7 \times 10 = 47 \text{ psi.}$$

It must be remembered that this figure assumes the highest stress situation with the mortar, having the minimum width of three inches and a maximum thickness of one inch; if the width were increased and/or the height decreased, this figure would be lower.

The loading for a two-storey stackwall house was previously found to be twice that for a one-storey house [51]; this means that the theoretical mortar strength required for a two-storey stackwall house is

$$47 \times 2 = 94 \text{ psi.}$$

Before finalizing the required mortar strength for stackwall construction, a comparison check should be performed with respect to the building unit. There is considerable support to the theory that mortar should never be stronger than the masonry unit since under settlement or deflective stresses, the unit, rather than the mortar is more likely to crack [12]. In conventional masonry (see Definitions), the primary comparison check between the mortar and the unit is simply the laboratory compressive strength of the two.

If the wood in stackwall construction experiences the same state of stress as conventional masonry (see Definitions) subjected to uniaxial compression, the wood would be in uniaxial compression (in the direction of loading) and lateral biaxial tension. Due to wood being an anisotropic material, three different types of stresses would be experienced. Figure K-2 demonstrates these stresses on a stackwall unit (log) at one of the two mortar joints which exist on a unit (see Figure K-1, page 503). The stresses are: 1) compression perpendicular to the grain, $f_{c\perp}$; 2) tension parallel to the grain, f_t; and 3) tension perpendicular to the grain, $f_{t\perp}$.

All of the above three stresses are important in determining the strength of stackwall construction. However, using the primary comparison check used in conventional masonry (see Definitions), only the compressive stress per-

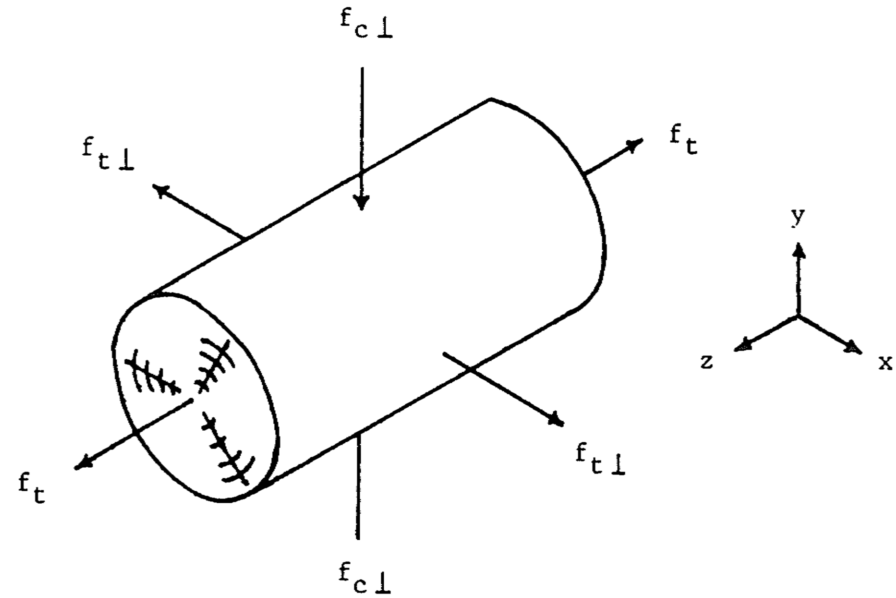


Figure K-2: Theoretical Stresses on a Stackwall Unit (Log) at One of the Two Existent Mortar Joints

pendicular to the grain of wood will be checked against the required compressive strength of the mortar. The Canadian Wood Council (CWC) Datafile WP-3 [22] tabulates the allowable stresses for different grade categories of wood. Wood in the walls of stackwall construction would fit the grade category of Post and Timbers 5" x 5" and Larger. For this grade category, the allowable compressive stress perpendicular to the grain ranges from 180 to 460 psi. The value within this range is determined by the species of wood used as given by Table K-I. Stress modification factors must be applied as follows:

$$F'_{c\perp} = F_{c\perp} K_{Sc\perp} K_F K_D \qquad [43, p. 164]$$

where: $F'_{c\perp}$ = modified allowable compressive stress perpendicular to the grain of wood;

$F_{c\perp}$ = allowable compressive stress perpendicular to the grain of wood;

$K_{Sc\perp}$ = service condition modification factor for compression perpendicular to grain of wood;

K_F = treatment modification factor for wood; and

K_D = load duration modification factor for wood.

An examination of $K_{Sc\perp}$, K_F and K_D [43] with respect to stackwall construction all prove to have the value of 1.00, thereby having no effect on the above mentioned figures.

Hence, depending upon the wood species used in stackwall construction, the laboratory compressive strength of mortar used should theoretically not exceed 180 to 460 psi. (see Table K-I).

From the calculated compressive stress requirements of mortar and the compressive strength perpendicular to the grain of wood as used in stackwall construction, a minimum and maximum range of laboratory mortar compressive strength (f'_m) is attained.

Table K-I

Allowable Compressive Stress Perpendicular to Grain ($F_{c\perp}$) of Wood for the Grade of Posts and Timbers 5" x 5" and Larger[1]

Commercial Species Group Designation	Species in Combination	$F_{c\perp}$ (psi.)
Douglas Fir-Larch (North)	Douglas Fir, Western Larch.	460
Hem-Fir (North)	Pacific Coast Hemlock, Amabilis Fir, Grand Fir.	235
Eastern Hemlock Tamarack (North)	Eastern Hemlock, Tamarack.	405
Coast Species	Douglas Fir, Western Larch, Pacific Coast Hemlock, Amabilis Fir, Grand Fir, Coast Sitka Spruce.	235
Spruce-Pine-Fir	Spruce (all species except Coast Sitka Spruce), Ponderosa Pine, Lodgepole Pine, Jack Pine, Alpine Fir, Balsam Fir.	245
Western Cedars (North)	Western Red Cedar, Pacific Coast Yellow Cedar.	280
Northern Species	All species above plus: Red Pine, Western White Pine, Eastern White Pine.	235
Northern Aspen	Trembling Aspen, Largetooth Aspen, Balsam Poplar.	180

[1]As published by the Canadian Wood Council [22].

For a one-storey stackwall house:

$$47 \text{ psi.} \leq f'_m \leq 180 \text{ to } 460 \text{ psi.}$$

For a two-storey stackwall house:

$$94 \text{ psi.} \leq f'_m \leq 180 \text{ to } 460 \text{ psi.}$$

The upper limit (180 to 460 psi.) is determined from the species of wood used in stackwall construction as given by Table K-I, page 512. These values will be assumed to be the 28-day compressive strength requirements as tested on two-inch cube specimens in the laboratory.

Appendix L

INITIAL UNIT COST OF MORTARS

Calculated in this appendix is the initial unit cost of three different type of mortars. Initial cost is defined as the cost to obtain the mortar components. The mortar types looked at are: 1) conventional mortar (see Definitions); 2) clay mortar; and 3) lime-sand mortar. The Portland cement:hydrated lime:sand (P.C.:L:S) volumetric ratio used for the conventional mortar (see Definitions) calculations is 2:1:6. This is the same mortar that is suggested for stackwall construction by the Northern Housing Committee [51, p. 20]. Mix No. 2 is used for the clay mortar calculations. For the lime-sand mortar, the initial cost is given for the lime:sand (L:S) volumetric ratios of 1:2, 1:3 and 1:3.5. An example calculation is performed for the ratio of 1:3.

Following are the assumptions made in the calculations:

1. Portland cement, hydrated lime and sand measured volumetrically with gentle shaking have the following weight per cubic foot [45, p. 361]:

   Portland cement = 85 lbs./ft.^{3}

   hydrated lime = 35 "

   sand (dry) = 100 "

2. When necessary, it is assumed that the volume of Portland cement and/or lime contribute very little to the total volume of a mortar; this assumption is based on the fact that Portland cement and lime are very fine materials that fill the gaps between the coarser materials. This implies that the volume of mortar, if needed, will be determined by the volume of the coarser dry materials.
3. Although in somewhat different quantities, the cost of water for each type of mortar is assumed to be very low and not worthwhile to include as part of the initial cost calculations. This implies that the cost calculations are based only on the dry materials.
4. The cost of obtaining clay for clay mortar is assumed to be negligible. This assumption is made on the basis that clay is usually available at or near most stackwall construction sites; this is the primary reason why clay mortar was examined.
5. Clay mortar Mix No. 2 is assumed to have a density of 85 pcf. This is the average density of Mix Nos. 7 to 11 (see Table VIII, page 97). The density measurement of Mix Nos. 1 to 6 was not performed.

Accuracy of Assumption No. 2 is checked for a lime-sand mortar mix with a lime:sand volumetric proportion of 1:3.65. One cubic foot of lime and 3.65 cubic feet of sand are used in the calculations. Using the density weights defined in Assumption No. 1, the weight of the materials in the mix should be:

$$\begin{array}{rl} 35 \text{ lbs.} & \text{lime} \\ + 365 \text{ "} & \text{sand} \\ \hline 400 \text{ lbs.} & = \text{total dry weight} \end{array}$$

Using Assumption No. 2, the dried volume of this mixture will be taken as 3.65 cubic feet, the volume of the coarser dry material, namely the sand. Therefore, the density of the mix should be:

$$\frac{400 \text{ lbs.}}{3.65 \text{ ft.}^3} = 110 \frac{\text{lbs.}}{\text{ft.}^3}$$

Checking with Table XXI, page 149, Mix No. 21, which has a lime:sand ratio of 1:3.65, was measured as having a density of 110 pcf. This figure agrees with the above theoretical figure. If the volume of the lime were included in the total volume, the density would become:

$$\frac{400 \text{ lbs.}}{(3.65 + 1) \text{ ft.}^3} = 86 \frac{\text{lbs.}}{\text{ft.}^3}$$

This figure differs significantly from the measured density of 110 pcf. From the above, it is concluded that Assumption No. 2 has validity.

Similar checks with the other mixes also show that Assumption No. 2 is reasonable.

The cost of the individual mortar components can differ from area to area, within an area, and with time. Quoted in Table L-I are the prices of the various mortar components in Winnipeg, Canada as of June, 1987. In this table, a price range exists for Portland cement and lime due to the various prices found among 11 different suppliers. These prices will be used in the initial unit cost calculations.

Table L-I

Prices of Various Mortar Components in Winnipeg, Canada June, 1987

Material	Price
Portland Cement	\$(6.99 to 8.89)[1] per 40 kg.
Normal Hydrated Lime	\$(5.55 to 9.99)[1] per 25 kg.
Mortar Sand	\$12.05 per $yd.^3$
Clay	Assumed Negligible
Flax Straw	\$0.50 per Bale (about 28 lbs.)
Water	Assumed Negligible

[1]Price range found among 11 different suppliers.

L.1 CONVENTIONAL MORTAR

The conventional mortar (see Definitions) suggested for stackwall construction by the Northern Housing Committee [51, p. 20] is:

Portland cement:lime:sand volumetric ratio = 2:1:6.

In the calculations, volumes of one cubic foot and Assumption Nos. 1 through 3 is used. First the theoretical density is determined.

Weights:

Portland cement	= 2	x	85	=	170	lbs.
hydrated lime	= 1	x	35	=	35	"
mortar sand	= 6	x	100	=	600	"
			total weight	=	805	lbs.

$$\text{theoretical density} = \frac{805 \text{ lbs.}}{6 \text{ ft.}^3} = 134 \frac{\text{lbs.}}{\text{ft.}^3}$$

Amount of individual materials per cubic foot:

Portland cement	= (170/805) x 134	=	28.3	lbs.	
hydrated lime	= (35/805) x 134	=	5.8	"	
mortar sand	= (600/805) x 134	=	99.9	"	
	total weight	=	134.0	lbs.	(check)

Cost of materials per cubic foot of mortar:

Portland cement

$$28.3 \text{ lbs.} \times \frac{\text{kg.}}{2.2046 \text{ lbs.}} \times \frac{\$(6.99 \text{ to } 8.89)}{40 \text{ kg.}} = \$(2.24 \text{ to } 2.85)$$

hydrated lime

$$5.8 \text{ lbs.} \times \frac{\text{kg.}}{2.2046 \text{ lbs.}} \times \frac{\$(5.55 \text{ to } 9.99)}{25 \text{ kg.}} = \$(0.58 \text{ to } 1.05)$$

mortar sand

$$99.9 \text{ lbs.} \times \frac{\text{ft.}^3}{100 \text{ lbs.}} \times \frac{\text{yd.}^3}{27 \text{ ft.}^3} \times \frac{\$12.05}{\text{yd.}^3} = \$0.45$$

The total cost of one cubic foot of conventional mortar (see Definitions) (P.C.:L:S = 2:1:6) is:

$$= (\$2.24 + 0.58 + 0.45) \text{ to } \$(2.85 + 1.05 + 0.45)$$
$$= \$(3.27 \text{ to } 4.35).$$

L.2 CLAY MORTAR

Mix No. 2 is used for the calculations. In these calculations volumes of one cubic foot and Assumption Nos. 1 through 5 are used. Referring to the proportion of materials of Mix No. 2 (see Chapter VI, Conclusions, page 268), and arbitrarily starting off with 100 pounds of clay, the weight of the materials used for calculation purposes is first determined.

Weights:

clay =	100 lbs.
mortar sand =	33.3 "
flax straw (fibres) =	1.75 "
hydrated lime =	3.0 "
total weight =	138.05 lbs.

Density: assumed 85 pcf. (see Assumption No. 5)

Amount of individual materials per cubic foot:

clay =	(100/138.05) x 85 =	61.6 lbs.
mortar sand =	(33.3/138.05) x 85 =	20.5 "
flax straw (fibres) =	(1.75/138.05) x 85 =	1.1 "
hydrated lime =	(3.0/138.05) x 85 =	1.8 "
	total weight =	85.0 lbs. (check)

Cost of materials per cubic foot of mortar:

clay

$0. (see Assumption No. 4)

mortar sand

$$20.5 \text{ lbs.} \times \frac{\text{ft.}^3}{100 \text{ lbs.}} \times \frac{\text{yd.}^3}{27 \text{ ft.}^3} \times \frac{\$12.05}{\text{yd.}^3} = \$0.09$$

flax straw (fibres)

$$1.1 \text{ lbs.} \times \frac{\$0.50}{28 \text{ lbs.}} = \$0.02$$

hydrated lime

$$1.8 \text{ lbs.} \times \frac{\text{kg.}}{2.2046 \text{ lbs.}} \times \frac{\$(5.55 \text{ to } 9.99)}{25 \text{ kg.}} = \$(0.18 \text{ to } 0.33)$$

The total cost of one cubic foot of clay mortar Mix No. 2 is:

$$= \$(0.09 + 0.02 + 0.18) \text{ to } \$(0.09 + 0.02 + 0.33)$$

$$= \$(0.29 \text{ to } 0.44).$$

L.3 LIME-SAND MORTAR

The lime-sand mortar used for an example calculation is:

lime:sand volumetric ratio = 1:3

In the calculations, volumes of one cubic foot and Assumption Nos. 1 through 3 are used. First the theoretical density is determined.

Weights:

hydrated lime	= 1 x 35 =	35 lbs.
mortar sand	= 3 x 100 =	300 "
	total weight =	335 lbs.

$$\text{theoretical density} = \frac{335 \text{ lbs.}}{3 \text{ ft.}^3} = 112 \frac{\text{lbs.}}{\text{ft.}^3}$$

Amount of individual materials per cubic foot:

hydrated lime = (35/335) x 112 = 11.7 lbs.

mortar sand = (300/335) x 112 = 100.3 "

total weight = 112.0 lbs. (check)

Cost of materials per cubic foot of mortar:

hydrated lime

$$11.7 \text{ lbs.} \times \frac{\text{kg.}}{2.2046 \text{ lbs.}} \times \frac{\$(5.55 \text{ to } 9.99)}{25 \text{ kg.}} = \$(1.18 \text{ to } 2.12)$$

mortar sand

$$100.3 \text{ lbs.} \times \frac{\text{ft.}^3}{100 \text{ lbs.}} \times \frac{\text{yd.}^3}{27 \text{ ft.}^3} \times \frac{\$12.05}{\text{yd.}^3} = \$0.45$$

The total cost of one cubic foot of lime-sand mortar (L:S = 1:3) is:

= $(1.18 + 0.45) to $(2.12 + 0.45)

= $(1.63 to 2.57).

Table L-II collectively shows the initial unit cost of the three different types of mortars studied in this appendix. Included as the last column of this table is a comparative cost analysis with respect to the conventional mortar (see Definitions) [P.C.:L:S = 2:1:6 as recommended for stackwall construction by the Northern Housing Committee -- Reference 51, p. 20]. The cost of clay mortar Mix No. 2 is 0.09 to 0.10 times that of the conventional mortar (see Definitions). For lime-sand mortars with lime:sand volumetric proportions of 1:2, 1:3 and 1:3.5, the cost is correspondingly 0.68 to 0.84, 0.50 to 0.59 and 0.45 to 0.52 times that

Table L-II

Initial Cost Analysis of Various Mortar Types

Mortar Type	Initial Cost Per Cubic Foot[1]	Cost Relative to Conventional Mortar[2]
Conventional[3] (P.C.:L:S = 2:1:6)	\$(3.27 to 4.35)	1.0 to 1.0
Clay (Mix No. 2)	\$(0.29 to 0.44)	0.09 to 0.10
Lime-Sand (L:S = 1:2)	\$(2.22 to 3.64)	0.68 to 0.84
Lime-Sand (L:S = 1:3)	\$(1.63 to 2.57)	0.50 to 0.59
Lime-Sand (L:S = 1:3.5)	\$(1.46 to 2.26)	0.45 to 0.52

[1]Based on assumptions listed at the beginning of this appendix and Table L-I, pages 514 to 515 and 517 respectively.

[2]Lower and higher values are comparative to the respective lower and higher costs.

[3]Mortar presently recommended for stackwall construction by the Northern Housing Committee [51, p. 20].

of the conventional mortar (see Definitions).