Appendix E:

Mortar Analysis

MORTAR ANALYSIS

For The

BLUE BALL PROPERTIES

WILMINGTON, DELAWARE

Prepared For

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Prepared By

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INTRODUCTION

Mortar analysis is an evaluation of the composition of historic mortar materials performed to aid in the specification of appropriate replacement materials. Generally, the combination of microscopic and acid digestion (gravimetric or weight-based) methods used for the analysis gives valuable, objective information about the sand, including composition and size distribution. Characterization of the binder is inherently more subjective due to the chemical changes that take place as the mortar cures. However, mortars can generally be classified as hydraulic or non-hydraulic, and some sense of the original starting ingredients obtained through the process. Other cementitious construction materials such as stucco and plaster can also be evaluated using the same techniques.

SAMPLING

This analysis is an assessment of the mortars used in the construction of the residence foundations and foundations and wall remnants of outbuildings and structures of the Blue Ball Properties in Wilmington, Delaware. The objective of the analysis was to evaluate the relationships between different parts of the residence and between the residence and the outbuilding and wall remnants on the site.

A total of 19 mortar samples and 6 stucco samples were taken by Lorraine Schnabel of 1:1:6 Technologies Incorporated (1:1:6) March 23, 2004 as follows (sample locations are indicated on SK-01 and SK-02 in the Appendix—names for various features were those used during a tour of the site with Barbara Schaffer of McCormick, Taylor & Associates):

BB1S: Stucco, exterior barn ramp, north side
BB2M: Mortar, top of north barn ramp wall
BB3M: Barn wall end mortar
BB4M: Barn wall end mortar
BB5S: Barn stucco, north side of wall
BB6M: Barn yard perimeter wall mortar-west side
BB7M: Barn yard perimeter wall mortar-west side, east wall
BB8S: Barn yard perimeter wall stucco-west side, east wall
BB9M: Barn yard perimeter wall mortar-north side, south wall
BB10S: Barn yard perimeter wall stucco-north side, southeast wall
BB11M: Barn yard perimeter wall mortar-east end, southwest wall
BB12M: Structure D mortar-northwest wall
BB13M: Structure D mortar-southeast wall
BB14M: Structure D mortar-southwest wall
BB15S: Structure C stucco
BB16M: Structure C mortar
BB17M: Structure C mortar
BB18M: Structure B mortar
BB19M: Structure B mortar
BB20S: Structure B stucco
BB21M: House (Structure A), northeast corner, mortar
BB22M: House (Structure A), northeast corner, mortar

BB23M: House (Structure A), chinking at joint
BB24M: House (Structure A), center wall, mortar
BB25M: House (Structure A), south elevation

In addition, 8 mortar samples were provided that had been taken by McCormick, Taylor & Associates from the house (Structure A) foundations as follows:

MT1: Feature #2 Kitchen wing
MT2: Feature 32 Piazza pillar
MT3: South Piazza wall
MT4: West half of the house
MT5: Feature 29
MT6: East half of the house
MT7: Feature 32 front step addition
MT8: Feature 39 possible detached kitchen

After visual and microscopic examination of the available samples, the project objectives were discussed further with Ms. Barbara Schaffer. She indicated that determining the relationships between the various parts of the house was more important than determining relationships between the house and the outbuildings. Therefore, the following ten mortar samples were selected for thin-section and gravimetric analysis:

BB2M: Mortar, top of north barn ramp wall
BB6M: Barn yard perimeter wall mortar
BB12: Structure D mortar
BB18: Structure B mortar
BB21M: House (Structure A), northeast corner
MT1: Feature #2 Kitchen wing
MT2: Feature 32 Piazza pillar
MT4: West half of the house
MT6: East half of the house
MT7: Feature 32 front step addition

ANALYSIS

All the samples from the site were first examined visually in hand sample and microscopically with a Nikon stereo-binocular microscope at magnifications from 10x to 63x. Multiple surfaces of each sample were examined, including the exposed weathered surface, the joint surfaces, and the surface of a fresh break. This examination was used to select material for thin-sectioning and acid digestion, and for a preliminary assessment of binder color and characteristics, proportion and characteristics of voids, and relationship between aggregate and binder. This preliminary visual analysis was also used to group the samples by type to facilitate selection of materials for further analysis.

Once samples were selected, a portion of each was submitted to Omni Laboratories, Inc. for preparation of the thin section. There, each sample was impregnated with clear epoxy, mounted on a microscope slide, and ground in oil to a thickness of approximately 25 microns. The thin

sections were examined in polarized transmitted light with a Nikon petrographic microscope. The binder composition and characteristics, the aggregate composition, and the proportion and characteristics of the voids were all evaluated at magnifications from 40x to 400x.

A second portion of each sample was ground in a ceramic mortar to separate the binder from the aggregate without crushing the aggregate. The ground samples were oven-dried to a constant weight, then digested in dilute hydrochloric acid to free the acid-insoluble aggregate and fines for examination and weighing; the acid soluble portion of the mortar was calculated by difference. The aggregate was then sieved to determine the size distribution, and examined microscopically.

OBSERVATIONS

Stuccos

The stuccos were only examined visually, as they could easily have been refreshed over time and are therefore less likely to be original than the mortars. Samples BB1S from the barn ramp wall, BB5S from the barn foundation, and BB20S from the exterior of Structure B are all visually similar. They are soft and grey-white, with abundant lime nodules visible in the binder. Sample BB15S from the east side of the wall adjacent to Structure C is similar to samples BB1S, BB5S, and BB20S, but not identical. Samples BB8S and BB10S, taken from the barn yard perimeter walls are visually similar to each other, with a hard, yellow binder and abundant dark, large aggregate.

Mortars

After preliminary visual examination, the mortars were divided into the following groups based on the color and texture of the binder, the size distribution and composition of the aggregate, the ratio of binder to aggregate, and the proportion and character of the voids (samples selected for thin-section and gravimetric analysis are indicated in bold):

Group 1:
- **BB2M (barn ramp wall)**
- BB11M (barn wall)
- **MT7 (Feature 32 front step addition) similar**

Group 2:
- BB3M (barn wall fragment)
- BB4M (barn wall)

Group 3:
- BB7M (east barn yard perimeter wall)
- BB9M (south barn yard perimeter wall, east end)

Group 4:
- **BB6M (wall fragment perpendicular to barn yard perimeter wall)**
- **BB21M (house foundation)**
- **MT2 (Feature 32 piazza pillar)**
- MT3 (South piazza wall)
- **MT4 (West half of house)**
- MT8 (Feature 39, possible detached kitchen)

- BB25 (House foundation, west end of south wall, exterior)

Group 5:

- **BB12M (Structure D mortar)**
- **BB18M (Structure B mortar)**
- BB16M (Structure C mortar)
- **MT1 (Feature 2 kitchen wing)**

Group 6:

- BB24M (south end of house foundation center wall)
- BB22M (northeast interior corner of east half of house)
- **MT6 (East half of house)**

Group 7:

- BB13M (Structure D mortar)
- BB14M (Structure D mortar)

The following mortars did not seem to be similar to any of the other materials:

BB17M
BB19M: This is a modern Portland cement-based pointing mortar
BB23M: This is a hard, clayey chinking material from what would have been in the interior of the cellar.

The samples selected for analysis are representative of these groups, with a focus on materials from the house. Some of the mortars, such as those from the southern end of Structure D (Group 7) and the barn yard perimeter walls (Group 3) were so visually distinctive from the other mortars that they clearly represent different periods of construction, making further analysis unnecessary. A description of the mortars of each group for which samples were analyzed is provided. Data sheets for each of the samples analyzed are included in the Appendix, as is a color chart with samples of the different colors referred to in the data sheets and text.

Group 1

The mortars are pale tan (FN114—see color chart in the Appendix), matte-textured and granular. There are abundant orange specks in the binder. Small lime nodules are observed in samples BB2M and BB11M, but not in MT7 (but the sample size for MT7 is much smaller than the other two mortars). The binder to aggregate ratio is typically low. The aggregate is yellow-brown (FN125) and consists of sub-angular to rounded grains of quartz, feldspar, and traces (less than 5%) of lithic (rock) grains. Small shell fragments are observed in samples BB2M and MT7 but not BB1M (but they are extremely small). Void volume is high (15%, ±) as entrapped air voids larger than the aggregate. Both samples contain abundant fine material; the fines are more abundant and darker (FN125) in sample MT7 than in BB2M (FN117). This is most likely due to soil contamination of sample MT7, which was much smaller in volume than BB2M.

In thin-section, the binder is pale brown in plane-polarized light (PPL), but virtually opaque in cross-polarized light (XPL). This opacity, which is more typical of Portland cement-based materials, is attributed to the high iron oxide-rich clay content of the binder which gives it its brown color. The binder is partially carbonated at grain boundaries and at fissure voids. The carbonated material is coarsely crystalline ("sparry") which is not typical of carbonated mortars. The shell fragments though rare are clearly identifiable in thin-section. The aggregate in thin-

section is composed of quartz and feldspar, including a significant proportion of microcline, distinctive because of its characteristic twinning. Many of the quartz grains are polycrystalline, which is also distinctive.

There are differences between the samples. BB2M has more aggregate than MT7, with more large-sized grains. BB2M also has less fine material sample and it is lighter in color. BB2M has significantly more lime nodules than MT7 (but the sample size is larger). There are also yellowish nodules in BB2M that were not observed in MT7. These appear to be aggregates of iron hydroxide (goethite). These differences are not believed to be significant, but characteristic of the range of variability of job-mixed mortars.

Sample BB11M is visually similar to BB2M and MT7. The principal differences are the slightly darker color, more abundant lime nodules, and overall greater homogeneity. No shell fragments were observed in the hand sample of BB11M, but they are small even in sample BB2M, and difficult to identify in hand sample.

Although samples BB3M and BB4M have been broken out into a separate group, the differences between them and sample BB2M are small. Samples BB3M and BB4M have more and finer aggregate, and no shell fragments were observed. However, the color and texture of the binder of these two mortars is similar to that of BB2M, and the composition of the aggregate is the same.

Group 4

These mortars are dark yellow-brown in color (FN116-117) with a matte-textured very granular binder. There are abundant lime nodules, most of which are the size of the aggregate, but some are much larger. In thin-section, the binder is observed to be almost completely carbonated. The calcite crystal aggregates are microcrystalline and discontinuous rather than sparry. The lime nodules are typically carbonated as well. Voids include entrapped air voids the size of the aggregate and fissure voids; in thin-section, many of the fissure voids are observed to be filled with microcrystalline calcium carbonate. Void volume is approximately 10%. The aggregate in all the samples consists of sub-angular to sub-rounded grains of mono-crystalline quartz and traces of dark, opaque material including biotite mica, magnetite, and lithic grains. Many of the quartz grains have almost polished surfaces. Traces of organic material (probably straw or grass) were also observed in all the samples.

Although preliminary visual inspection suggests similarities between these 7 samples, closer examination indicates they can be divided into two subgroups as follows:

- BB6M, MT4 and BB25M
- BB21M, MT2, MT3 and MT8

The samples of the first subgroup are overall darker in color, with more yellow-orange material in the binder. The aggregate of this group is typically better graded than the more uniform grains of the second subgroup, and is finer and more yellow in color than the slightly coarser, pinker sand of the second subgroup (see the sand size chart in the Appendix). It is not possible to state definitively if the mortars of these two subgroups are contemporaneous.

Group 5

These mortars are white (FN106), with matte-textured granular binder. The binder to aggregate ratio is low. There is abundant void volume as large entrapped air voids larger than the aggregate and as smaller fissure voids. In thin-section, the binder is partially carbonated, with the calcium carbonate in the form of micro crystals.

The aggregate is also light in color (FN81, FN109), and consists of sub-angular to sub-rounded grains of quartz with traces of feldspar and dark opaque grains. Many of the grains are poly-crystalline; microcline feldspar was observed in addition to plagioclase. One of the samples, BB12M contained large shell fragments. The fine material is variable in color, and less abundant than in the darker samples. Some of the color variability of the fines may relate to the degree of surface soiling on the samples analyzed.

Samples BB12M and BB18M are more similar to each other than MT1 is to either of them. BB16M is visually indistinguishable from BB18M and BB12M.

Group 6

Only one sample from this group of three taken from various locations in the foundation at the east half of the house was analyzed due to the extreme visual similarity of the three samples. The binder of sample MT6 is cream-colored (FN114), matte-textured and granular with nodules of lime. The binder to aggregate ratio is low, and there is moderate void volume as both entrapped air voids and fissures.

The aggregate is sub-angular to sub-rounded quartz and feldspar with traces of dark material and numerous yellow nodules. In thin-section, these nodules appear to be iron hydroxide. The aggregate is tan (FN109) in color. The aggregate from this sample is the finest overall of all the mortar samples analyzed.

CONCLUSIONS

According to the information provided by McCormick, Taylor, the first period of construction of the house was c. 1740; the kitchen and porch were added c. 1800. Then, c. 1865, the kitchen was demolished and the house substantially enlarged. The precise dates of the outbuildings were not provided, but Ms. Schaffer indicated they all were believed to date from the second half of the 19th century. Several photographs were provided that date to 1927 in which most of the outbuildings can be seen.

With the exception of BB19M, which is clearly a modern, Portland cement-based mortar, the mortars and stuccos from the east and south barn yard perimeter walls (Group 3), and the mortars from the south end of Structure D (Group 7) which may also contain cement, all the mortars are believed to lime mortars.

Three basic lime mortar types were observed: the white mortars, the cream to tan mortars, and the yellow-brown mortars. The yellow-brown mortars clearly contain a proportion of clay based on their comparatively high fines content and the relative opacity of the binders when viewed in

thin-section. The tan mortars also apparently contain clay. Clay was frequently used as an extender for lime mortars, especially in vernacular buildings. Both types of mortar exhibit characteristic properties of lime mortars: they are soft and easily broken by hand, they typically contain white nodules (either hard-burnt lime that would not hydrate or hydrated lime putty that was not effectively blended into the mortar), and they have significant air volume as entrapped air and fissure-shaped drying shrinkage voids.

Within these three basic types, there are also variations. These relate to the composition of the aggregate, the presence or absence of lime nodules, and the proportion of clay added. Aside from the groupings indicated above, without gravimetric analysis of more, larger samples it is not possible to say if these differences are significant enough to represent different construction periods.

The information gathered regarding relationships between the mortars of the various wall areas sampled is summarized in the two sketches attached in the Appendix. Mortars believed to be similar enough to represent similar construction periods are indicated in one color; those that may also belong to a group based on some of their characteristics are indicated in a lighter shade of the same color. For example, the sample location for Group 1 mortars BB2M and MT7 are colored dark green; sample locations for Group 1 mortar BB11M and Group 2 mortars BB3M and BB4M are colored light green.

To further aid in interpretation of the results, the yellow mortars are represented with orange, the cream-colored mortars are represented with green and blue, and the white mortars are represented with purple. The cement-containing mortars are shown in brown.

The distribution of mortar types supports the information on periods of construction provided by McCormick, Taylor, but suggests four separate periods rather than three: one for each half of the house, one for the porch elements, and one for the kitchen area. Comparison of mortars taken from the house and the outbuildings suggests that most of the outbuilding features may be contemporaneous with the construction of the eastern half of the house, rather than the western half.

APPENDIX

STATE ROUTE 261

WELDIN ROAD

Structure A

Structure B

Structure C

Structure D

Barn Yard

BB20S

BB19M

BB13M

BB17M

BB16M

BB15S

BB2M

BB1S

BB5S

BB12M

BB4M

BB3M

BB14M

BB6M

BB13M

BB11M

BB7M

BB8S

BB9M

BB10S

GROUP 1

GROUP 2

GROUP 3

GROUP 4

GROUP 5

GROUP 6

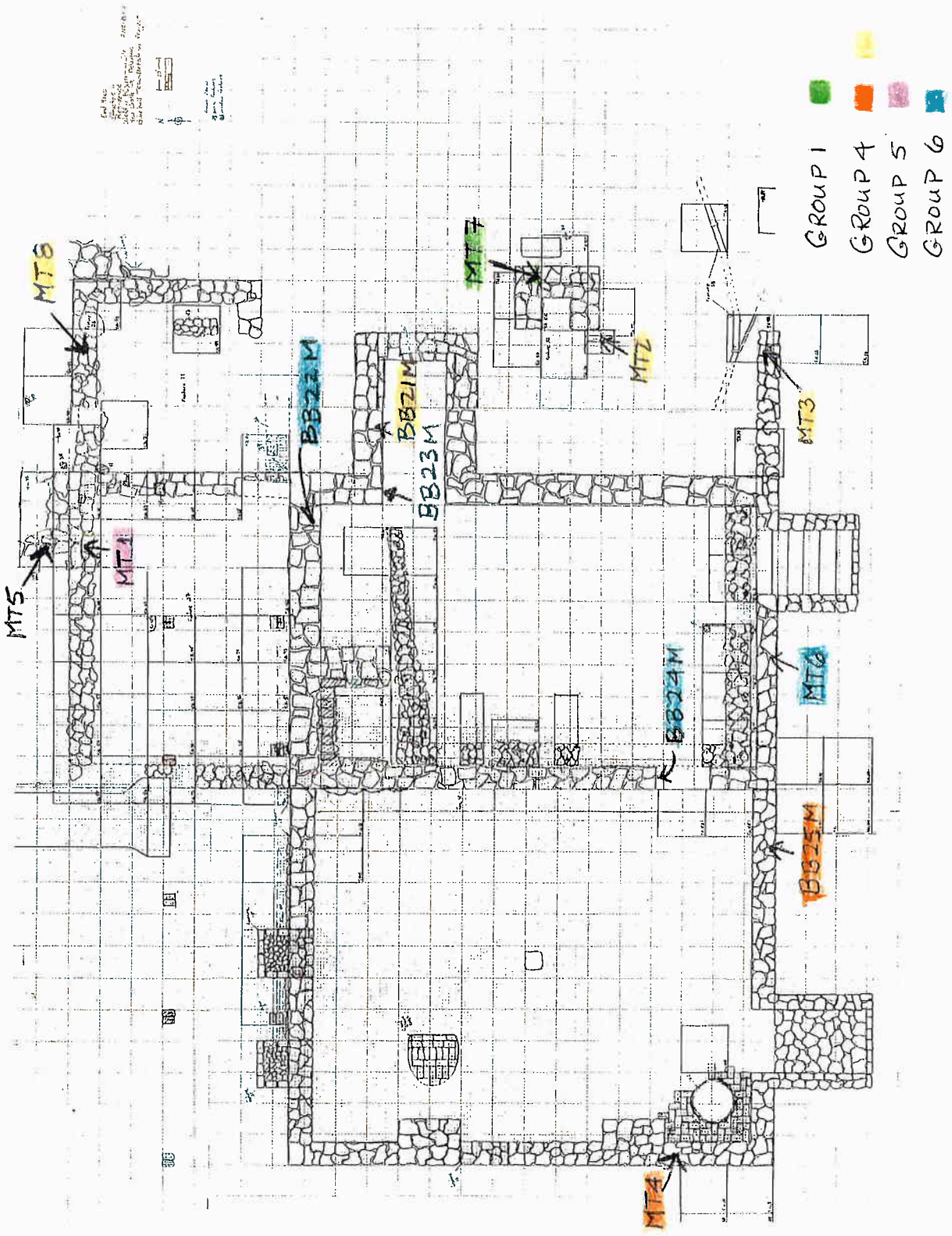
NEW CASTLE COUNTY, DELAWARE
BLUE BALL PROPERTIES AREA
TRANSPORTATION IMPROVEMENT PROJECT
NEW CASTLE COUNTY, DELAWARE
7NC-B-11, WELDIN PLANTATION
ARCHAEOLOGICAL SITE

Drawing No. SK-01

Project: Blue Ball Properties Mortar Analysis Sample Locations

Date: October 12, 2004
Scale: N.T.S.

1:1:6 TECHNOLOGIES INCORPORATED
103 N. Jackson St. • Media, Pennsylvania 19063 • 610-565-3340



1:1:6 TECHNOLOGIES INCORPORATED
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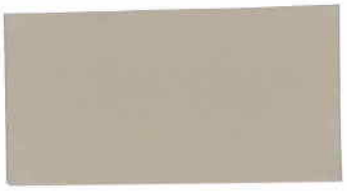
Project: Blue Ball Properties Mortar Analysis
Sample Locations - Structure A

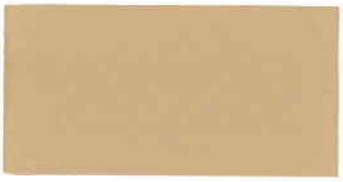
Date: October 12, 2004
Scale: N.T.S.

Drawing No.
SK-02

Blue Ball Properties Mortar Color Chart

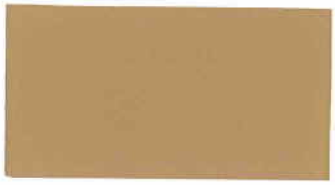


FN81



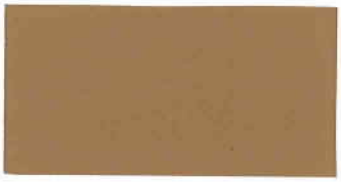
FN116

FN106

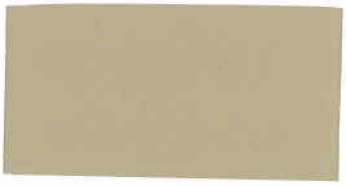


FN117

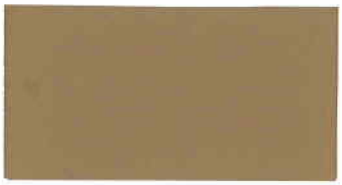
FN108



FN118

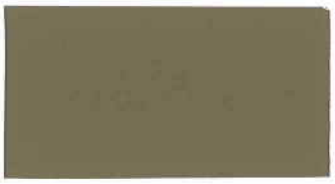


FN109

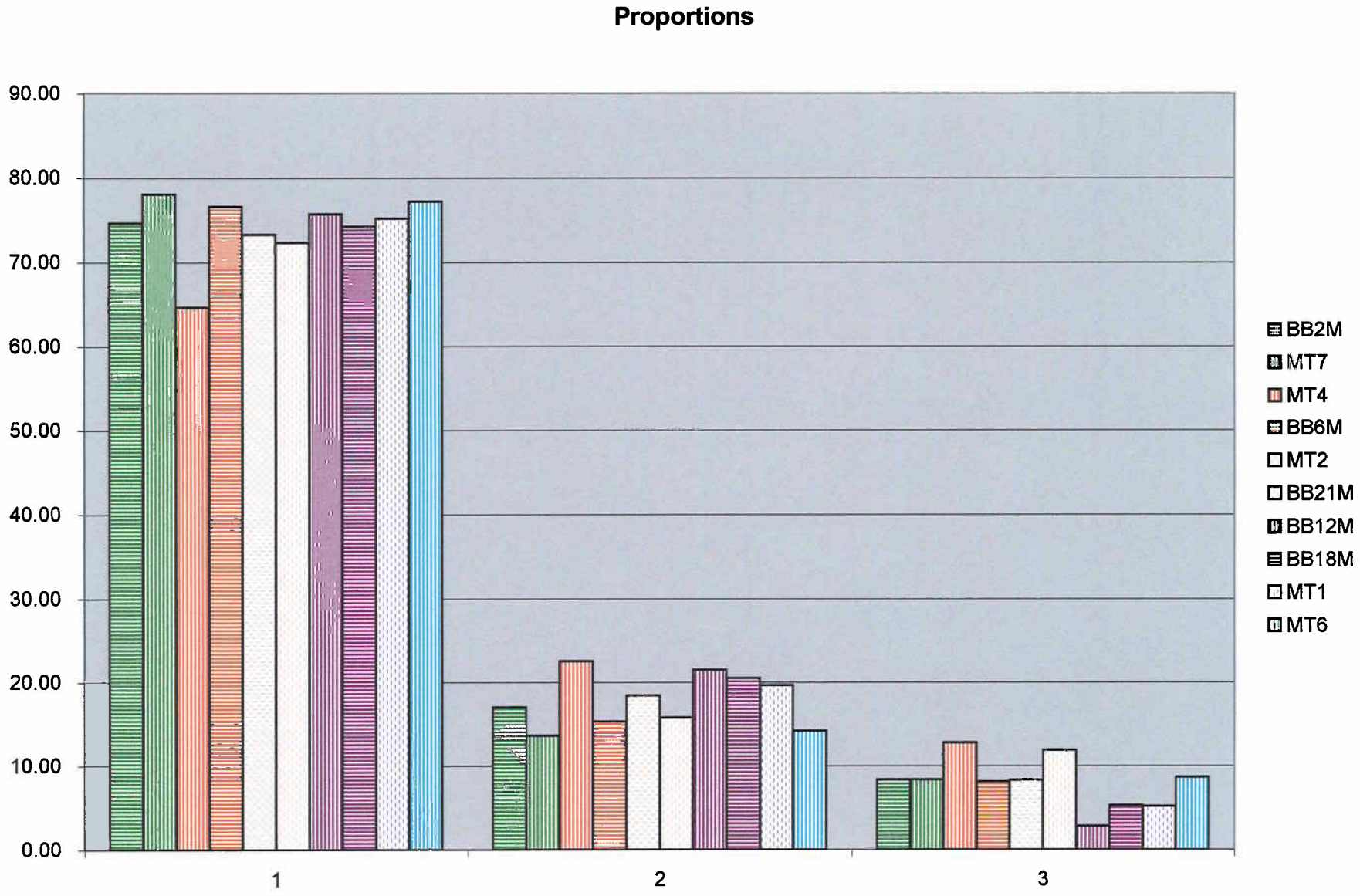


FN125

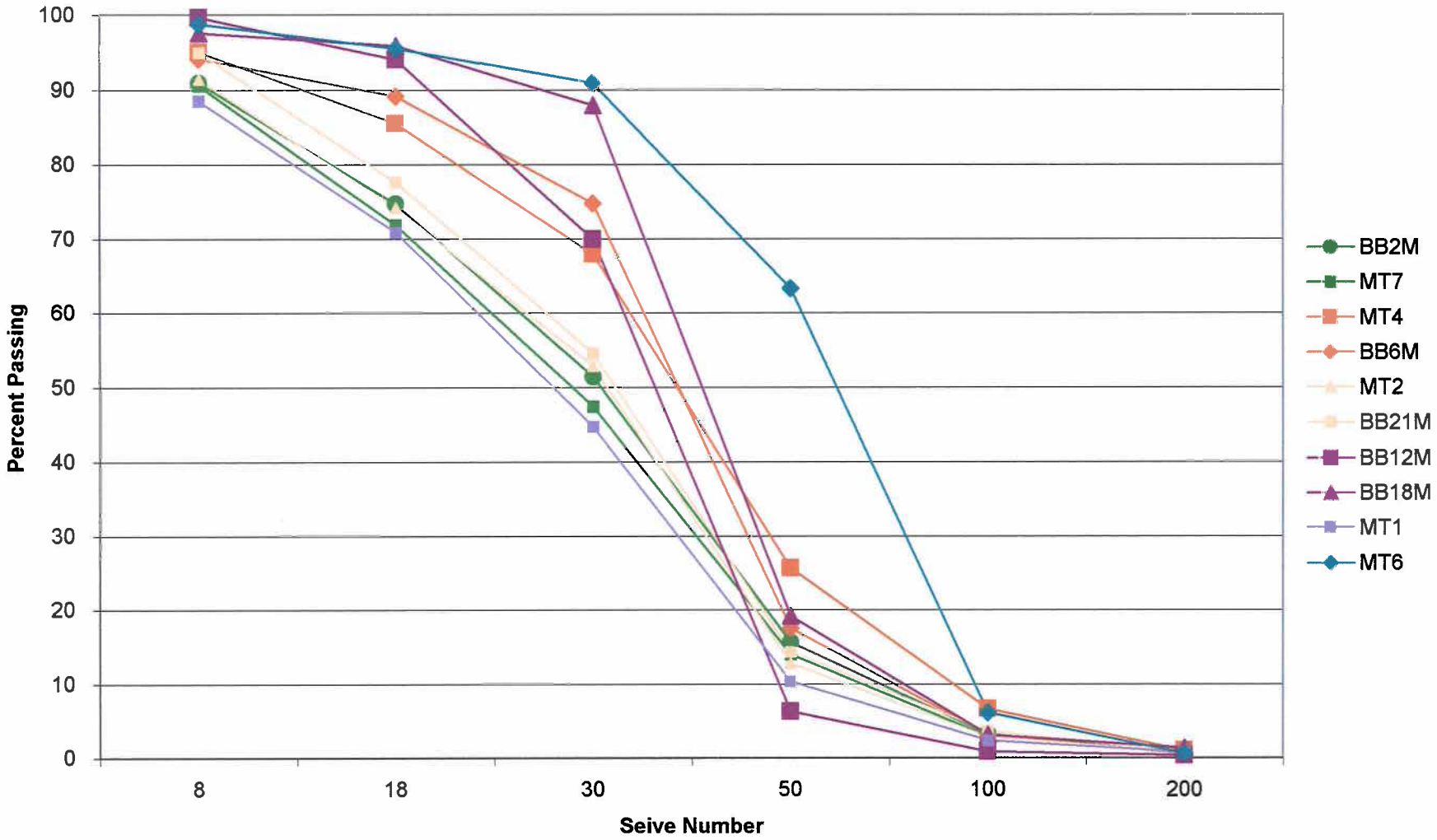
FN114



FN146


Proportions
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1
2
3
BB2M
MT7
MT4
BB6M
MT2
BB21M
BB12M
BB18M
MT1
MT6

Sand Size Distribution



MORTAR ANALYSIS SUMMARY SHEET

Project Name: Blue Ball Properties
Location: Mortar, top of north barn ramp wall
Sample No.: BB2M
Date: 6/2004

Chemical Analysis

A. CALCULATIONS (weight in grams)

1. Container Weight:	41.29
2. Sample Weight	50.00
3. Filter Paper Weight	4.52
4. Container + Sand Weight:	78.59
5. Sand Weight:	37.30
6. Paper + Fines Weight:	8.71
7. Fines Weight:	4.19
8. Sand + Fines Weight:	41.49
9. Acid Soluble Weight	8.51
10. Weight Percent Sand	74.60
11. Weight Percent Acid Soluble	17.02
12. Weight Percent Fines	8.38

B. MORTAR CHARACTERISTICS
Mortar Color: Pale tan (FN114)

	soft									hard
Relative Hardness:	**1**	2	3	4	5	6	7	8	9	10

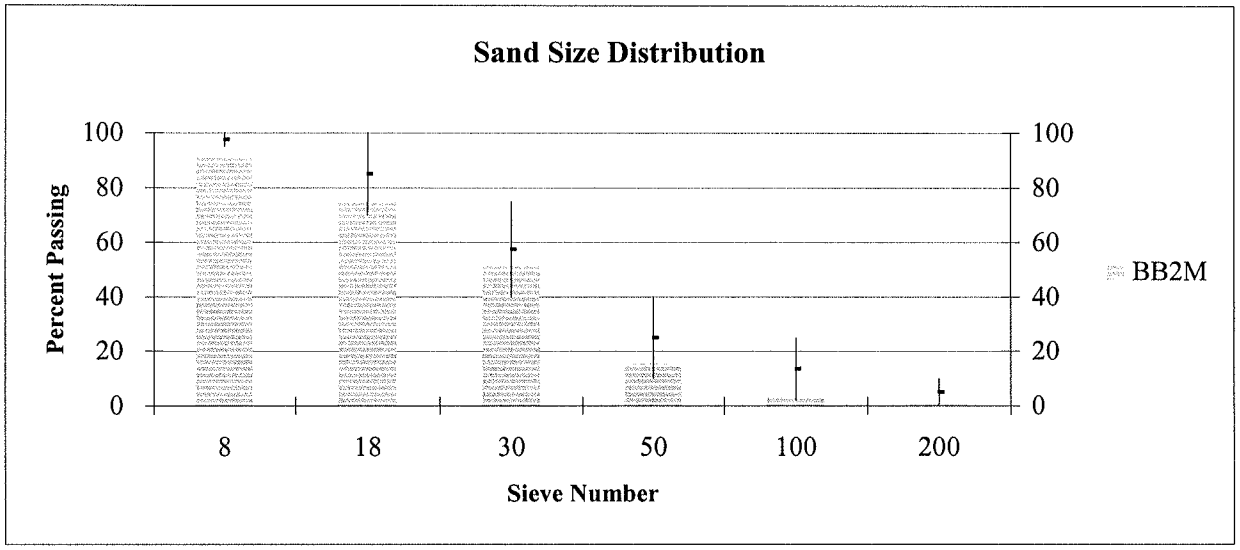
C. SAND CHARACTERISTICS
Color: Yellow-brown (FN125)
Opacity: 2 % Opaque 94 % Translucent 2 % Transparent
Angularity: Sub-angular to rounded. Large grains typ. rounded.
Composition: Quartz, feldspar, traces dark mineral grains. Some undigested material--mostly small bits and small amounts clinging to aggregate grains.

Size: Sieve No.	Weight	Percent Passing
8	3.39 grams	91 %
18	6.05 grams	75 %
30	8.69 grams	51 %
50	13.35 grams	16 %
100	4.63 grams	3 %
200	0.86 grams	1 %
<200	0.18 grams	0 %

Fines Color: Pale tan (FN117--lighter than MT7)

D. NOTES: Brisk effervescence with large bubbles that persisted.

E. CONSERVATOR: Lorraine Schnabel, 1:1:6 Technologies Incorporated



Note: Each thin, black vertical line represents the range allowable in a mortar sand for a given particle size as specified by ASTM C 144 Standard Specification for Aggregate for Masonry Mortar. Allowable percentages are different for natural and manufactured sands; this chart represents the absolute maximum and minimum of both aggregate types considered together. The bars represent the particle size distribution of the sample analyzed.

MORTAR ANALYSIS SUMMARY SHEET

Project Name: Blue Ball Properties
Location: Feature 32 front step addition
Sample No.: MT7
Date: 5/2004

Chemical Analysis

A. CALCULATIONS (weight in grams)

1. Container Weight:	41.14
2. Sample Weight	50.02
3. Filter Paper Weight	4.24
4. Container + Sand Weight:	80.18
5. Sand Weight:	39.04
6. Paper + Fines Weight:	8.41
7. Fines Weight:	4.17
8. Sand + Fines Weight:	43.21
9. Acid Soluble Weight	6.81
10. Weight Percent Sand	78.05
11. Weight Percent Acid Soluble	13.61
12. Weight Percent Fines	8.34

B. MORTAR CHARACTERISTICS
Mortar Color: Pale tan (FN114)

	soft									hard
Relative Hardness:	**1**	2	3	4	5	6	7	8	9	10

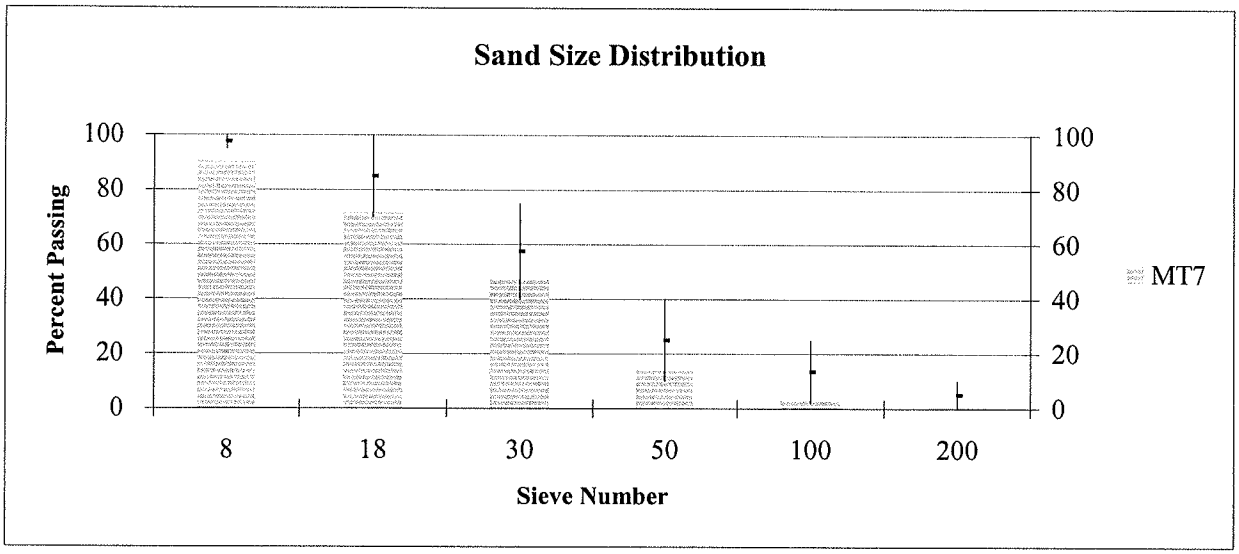
C. SAND CHARACTERISTICS
Color: Yellow-brown (FN125)
Opacity: 2 % Opaque 94 % Translucent 2 % Transparent
Angularity: Sub-angular to rounded. Large grains typ. rounded.
Composition: Quartz, feldspar, traces dark mineral grains. Some undigested material--mostly small bits and small amounts clinging to aggregate grains.

Size: Sieve No.	Weight	Percent Passing
8	3.70 grams	91 %
18	7.30 grams	72 %
30	9.53 grams	47 %
50	13.05 grams	14 %
100	4.31 grams	3 %
200	0.90 grams	1 %
<200	0.22 grams	0 %

Fines Color: Yellow-brown (FN125). Darker than BB2M

D. NOTES: May contain some soil contamination. Had to use crumbs from bag to make weight. Large, foamy bubbles that persisted.

E. CONSERVATOR: Lorraine Schnabel, 1:1:6 Technologies Incorporated



Note: Each thin, black vertical line represents the range allowable in a mortar sand for a given particle size as specified by ASTM C 144 Standard Specification for Aggregate for Masonry Mortar. Allowable percentages are different for natural and manufactured sands; this chart represents the absolute maximum and minimum of both aggregate types considered together. The bars represent the particle size distribution of the sample analyzed.

MORTAR ANALYSIS SUMMARY SHEET

Project Name: Blue Ball Properties
Location: West half of the house
Sample No.: MT4
Date: 5/2004

Chemical Analysis

A. CALCULATIONS (weight in grams)

1. Container Weight:	41.29
2. Sample Weight	50.00
3. Filter Paper Weight	4.46
4. Container + Sand Weight:	73.63
5. Sand Weight:	32.34
6. Paper + Fines Weight:	10.85
7. Fines Weight:	6.39
8. Sand + Fines Weight:	38.73
9. Acid Soluble Weight	11.27
10. Weight Percent Sand	64.68
11. Weight Percent Acid Soluble	22.54
12. Weight Percent Fines	12.78

B. MORTAR CHARACTERISTICS
Mortar Color: Yellow-brown (FN117)

	soft									hard
Relative Hardness:	**1**	2	3	4	5	6	7	8	9	10

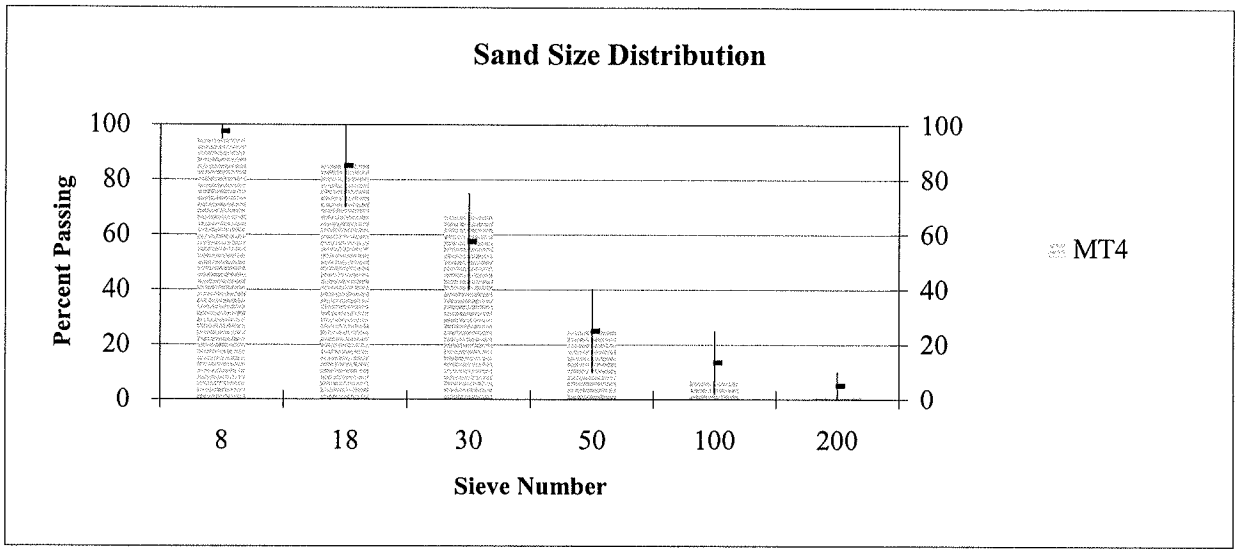
C. SAND CHARACTERISTICS
Color: Yellow-brown (FN117)
Opacity: 2 % Opaque 98 % Translucent 0 % Transparent
Angularity: Sub-angular to rounded. Rounded grains sim. To BB6M
Composition: Quartz, traces feldspar. Some undigested material. Some yellow agglomerates with aggregate.

Size:	Sieve No.	Weight	Percent Passing
	8	1.60 grams	95 %
	18	3.10 grams	85 %
	30	5.68 grams	68 %
	50	13.68 grams	26 %
	100	6.14 grams	7 %
	200	1.81 grams	1 %
	<200	0.29 grams	0 %

Fines Color: Yellow-brown (FN117)

D. NOTES: Brisk efferevescence with foamy bubbles. Bubbles smaller than observed in some other samples.

E. CONSERVATOR: Lorraine Schnabel, 1:1:6 Technologies Incorporated



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MORTAR ANALYSIS SUMMARY SHEET

Project Name: Blue Ball Properties
Location: Barn yard perimeter wall mortar-west side
Sample No.: BB6M
Date: 5/2004

Chemical Analysis

A. CALCULATIONS (weight in grams)

1. Container Weight:	39.71
2. Sample Weight	50.01
3. Filter Paper Weight	4.29
4. Container + Sand Weight:	78.01
5. Sand Weight:	38.30
6. Paper + Fines Weight:	8.35
7. Fines Weight:	4.06
8. Sand + Fines Weight:	42.36
9. Acid Soluble Weight	7.65
10. Weight Percent Sand	76.58
11. Weight Percent Acid Soluble	15.30
12. Weight Percent Fines	8.12

B. MORTAR CHARACTERISTICS
Mortar Color: Yellow-brown (FN116)

	soft									hard
Relative Hardness:	**1**	2	3	4	5	6	7	8	9	10

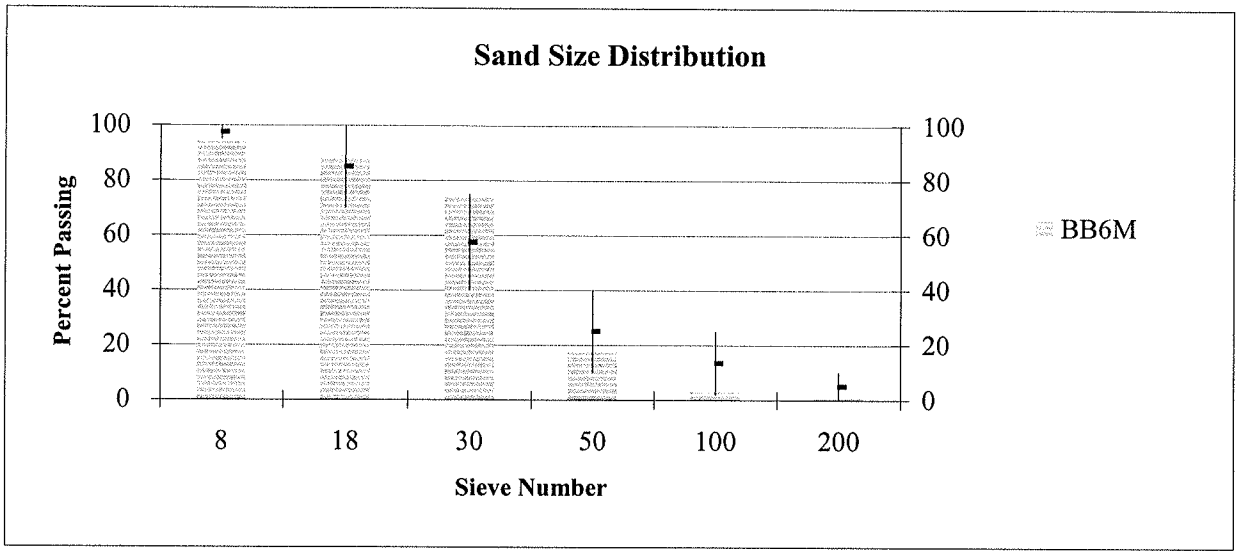
C. SAND CHARACTERISTICS
Color: Yellow-brown (FN117)
Opacity: 50 % Opaque 50 % Translucent 80 % Transparent
Angularity: Varies. Abundant well-rounded, but angular to sub-angular grains as well.
Composition: Abundand undigested material. Predominantly quartz.

Size:	Sieve No.	Weight	Percent Passing
	8	2.25 grams	94 %
	18	1.93 grams	89 %
	30	5.51 grams	75 %
	50	21.91 grams	17 %
	100	5.50 grams	3 %
	200	0.97 grams	1 %
	<200	0.20 grams	0 %

Fines Color: Yellow-brown (FN117)

D. NOTES: Brisk effervescence with medium to small bubbles.

E. CONSERVATOR: Lorraine Schnabel, 1:1:6 Technologies Incorporated



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MORTAR ANALYSIS SUMMARY SHEET

Project Name: Blue Ball Properties
Location: Feature 32 Piazza Pillar
Sample No.: MT2
Date: 5/2004

Chemical Analysis

A. CALCULATIONS (weight in grams)

1. Container Weight:	41.26
2. Sample Weight	50.00
3. Filter Paper Weight	4.41
4. Container + Sand Weight:	77.91
5. Sand Weight:	36.65
6. Paper + Fines Weight:	8.55
7. Fines Weight:	4.14
8. Sand + Fines Weight:	40.79
9. Acid Soluble Weight	9.21
10. Weight Percent Sand	73.30
11. Weight Percent Acid Soluble	18.42
12. Weight Percent Fines	8.28

B. MORTAR CHARACTERISTICS
Mortar Color: Yellow-brown (FN116)

	soft									hard
Relative Hardness:	**1**	2	3	4	5	6	7	8	9	10

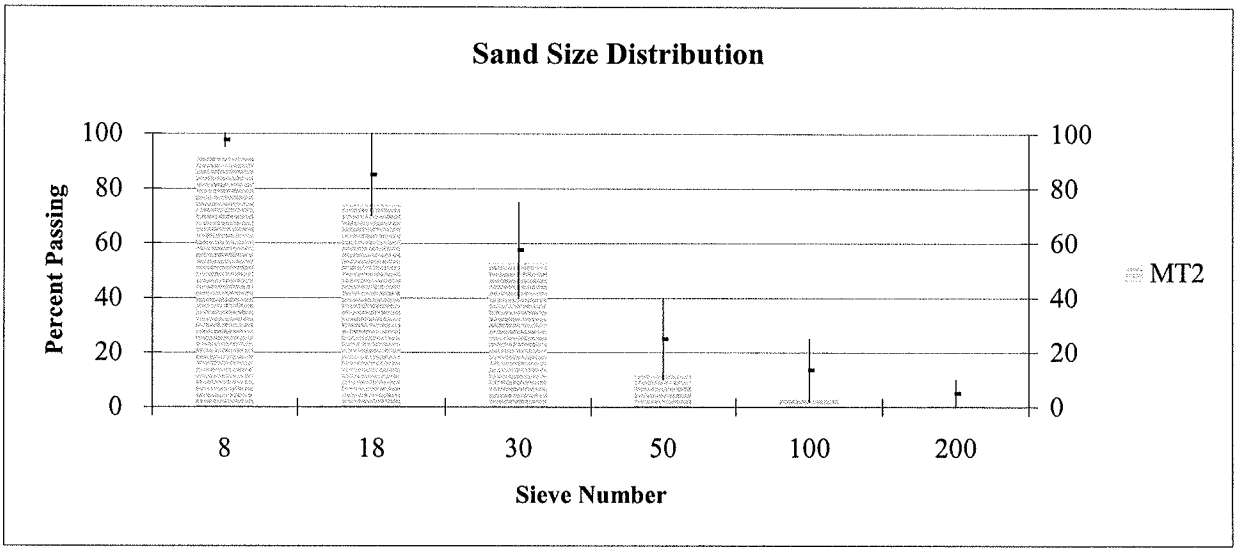
C. SAND CHARACTERISTICS
Color: Yellow-brown (FN117--but pinker/coarser than MT4/BB6M)
Opacity: 2 % Opaque 88 % Translucent 10 % Transparent
Angularity: Sub-angular to rounded. Lots of smooth, well-rounded grains
Composition: Predom. Quartz. Feldspar, particles that look like slag. Quartz and feldspar particles have binder adhered to them.

Size: Sieve No.	Weight	Percent Passing
8	3.15 grams	91 %
18	6.31 grams	74 %
30	7.84 grams	53 %
50	14.68 grams	13 %
100	3.62 grams	3 %
200	0.80 grams	1 %
<200	0.18 grams	0 %

Fines Color: Dark yellow-brown (FN118)

D. NOTES: Brisk effervescence with large, foamy bubbles that persisted (though reduced in size)

E. CONSERVATOR: Lorraine Schnabel, 1:1:6 Technologies Incorporated



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MORTAR ANALYSIS SUMMARY SHEET

Project Name: Blue Ball Properties
Location: House, (Structure A) northeast corner, mortar
Sample No.: BB21M
Date: 6/2004

Chemical Analysis

A. CALCULATIONS (weight in grams)

1. Container Weight:	41.14
2. Sample Weight	50.01
3. Filter Paper Weight	4.29
4. Container + Sand Weight:	77.30
5. Sand Weight:	36.16
6. Paper + Fines Weight:	10.24
7. Fines Weight:	5.95
8. Sand + Fines Weight:	42.11
9. Acid Soluble Weight	7.90
10. Weight Percent Sand	72.31
11. Weight Percent Acid Soluble	15.80
12. Weight Percent Fines	11.90

B. MORTAR CHARACTERISTICS
Mortar Color: Yellow-brown (FN116)

	soft									hard
Relative Hardness:	**1**	2	3	4	5	6	7	8	9	10

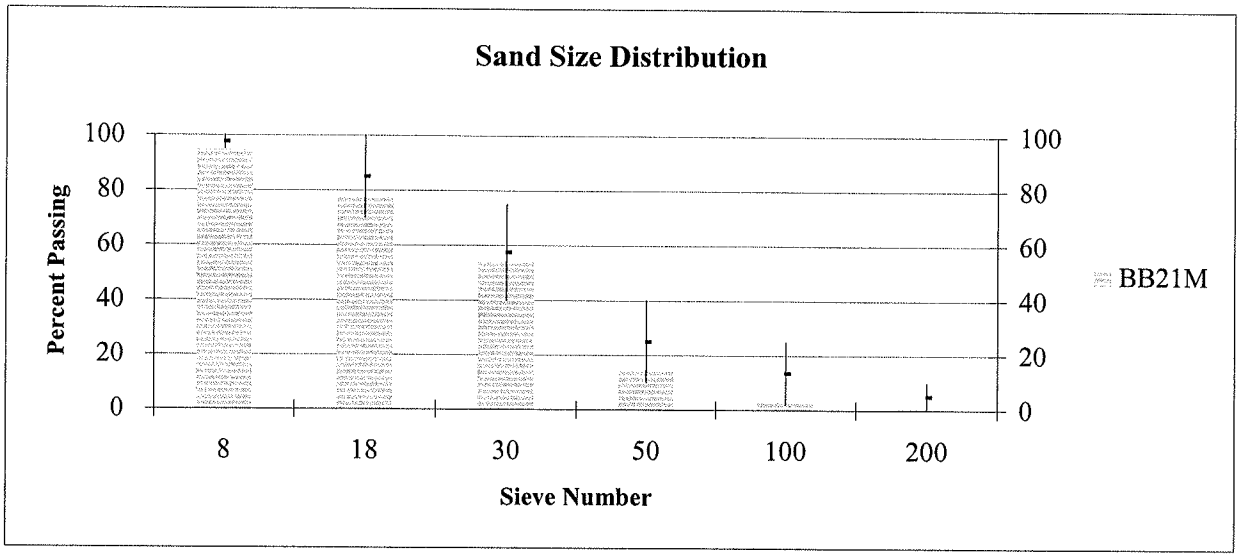
C. SAND CHARACTERISTICS
Color: Yellow-brown (FN117--though pinker/coarser than BB6M/MT4)
Opacity: 2 % Opaque 88% Translucent 10 % Transparent
Angularity: Rounded to sub-rounded
Composition: Predom. Quartz as for MT2. Traces feldspar. Some large undigested fragments

Size:	Sieve No.	Weight	Percent Passing
	8	1.83 grams	95 %
	18	6.28 grams	78 %
	30	8.33 grams	55 %
	50	14.55 grams	14 %
	100	3.85 grams	4 %
	200	1.04 grams	1 %
	<200	0.15 grams	0 %

Fines Color: Dark yellow-brown (FN117, but darker than BB6M/MT4)

D. NOTES: Brisk effervescence with large, persistant foamy bubbles.

E. CONSERVATOR: Lorraine Schnabel, 1:1:6 Technologies Incorporated



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MORTAR ANALYSIS SUMMARY SHEET

Project Name: Blue Ball Properties
Location: Structure D mortar-northwest wall
Sample No.: BB12M
Date: 5/2004

Chemical Analysis

A. CALCULATIONS (weight in grams)

1. Container Weight:	41.29
2. Sample Weight	50.00
3. Filter Paper Weight	4.48
4. Container + Sand Weight:	79.13
5. Sand Weight:	37.84
6. Paper + Fines Weight:	5.90
7. Fines Weight:	1.42
8. Sand + Fines Weight:	39.26
9. Acid Soluble Weight	10.74
10. Weight Percent Sand	75.68
11. Weight Percent Acid Soluble	21.48
12. Weight Percent Fines	2.84

B. MORTAR CHARACTERISTICS
Mortar Color: White (FN106)

	soft									hard
Relative Hardness:	**1**	2	3	4	5	6	7	8	9	10

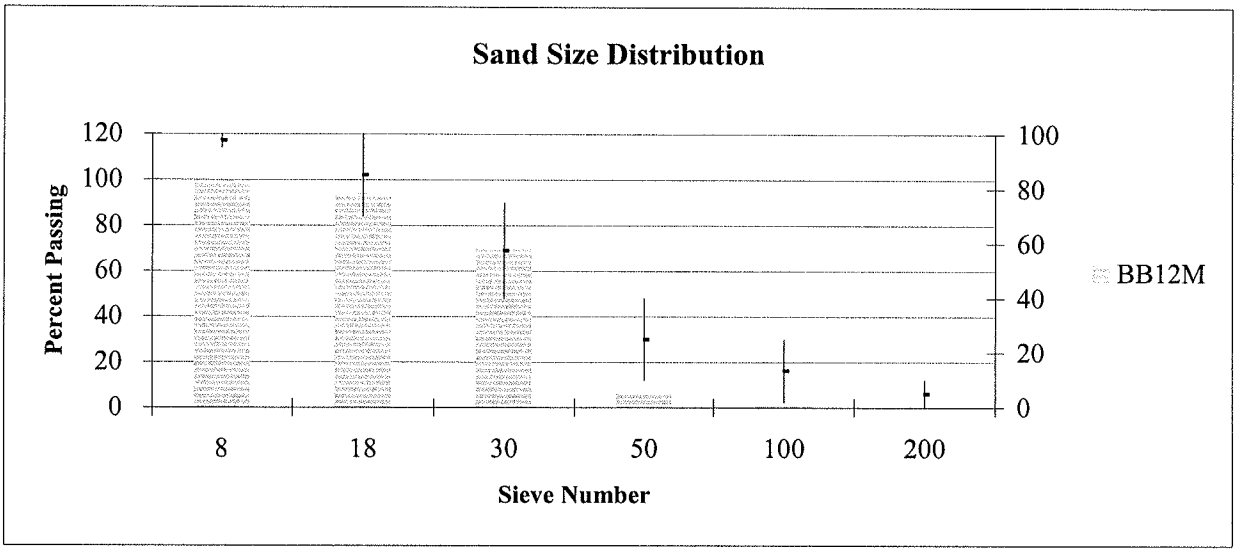
C. SAND CHARACTERISTICS
Color: Tan (FN81)
Opacity: 2 % Opaque 78 % Translucent 20 % Transparent
Angularity: Sub-rounded to rounded
Composition: Predominantly quartz with traces of feldspar, glauconite, marcasite, mica.

Size:	Sieve No.	Weight	Percent Passing
	8	0.14 grams	100 %
	18	2.12 grams	94 %
	30	9.13 grams	70 %
	50	24.08 grams	6 %
	100	2.04 grams	1 %
	200	0.20 grams	0 %
	<200	0.04 grams	0 %

Fines Color: Brown (FN146)

D. NOTES: Brisk effervescence with large, foamy bubbles.

E. CONSERVATOR: Lorraine Schnabel, 1:1:6 Technologies Incorporated



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MORTAR ANALYSIS SUMMARY SHEET

Project Name: Blue Ball Properties
Location: Structure B mortar
Sample No.: BB18M
Date: 5/2004

Chemical Analysis

A. CALCULATIONS (weight in grams)

1. Container Weight:	41.16
2. Sample Weight	50.00
3. Filter Paper Weight	4.55
4. Container + Sand Weight:	78.27
5. Sand Weight:	37.11
6. Paper + Fines Weight:	7.20
7. Fines Weight:	2.65
8. Sand + Fines Weight:	39.76
9. Acid Soluble Weight	10.24
10. Weight Percent Sand	74.22
11. Weight Percent Acid Soluble	20.48
12. Weight Percent Fines	5.30

B. MORTAR CHARACTERISTICS
Mortar Color: White (FN106)

	soft									hard
Relative Hardness:	**1**	2	3	4	5	6	7	8	9	10

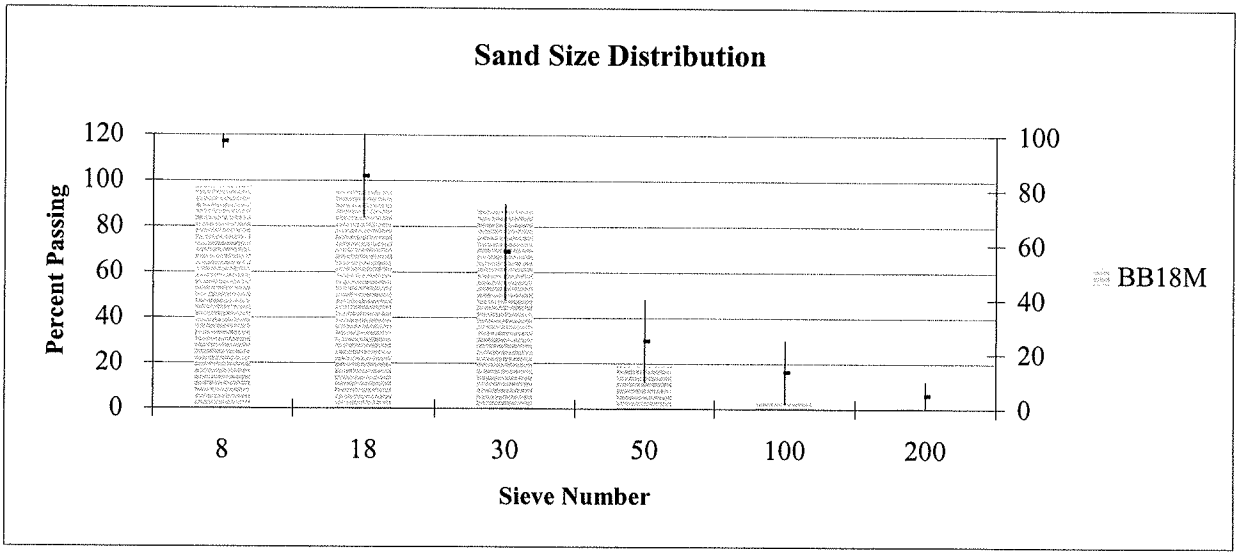
C. SAND CHARACTERISTICS
Color: Tan (FN81)
Opacity: 5 % Opaque 75 % Translucent 20 % Transparent
Angularity: Sub-rounded to sub-angular
Composition: Quartz, traces glauconite, anthracite, magnetite, tourmaline. Few dark translucent orange grains. Traces of feldspar.

Size: Sieve No.	Weight	Percent Passing
8	0.90 grams	98 %
18	0.63 grams	96 %
30	2.95 grams	88 %
50	25.53 grams	19 %
100	5.93 grams	3 %
200	0.68 grams	1 %
<200	0.02 grams	1 %

Fines Color: Dark tan (FN108)

D. NOTES: Brisk effervescence with medium bubbles that dissipated fairly quickly. More dark grains than BB12M.

E. CONSERVATOR: Lorraine Schnabel, 1:1:6 Technologies Incorporated



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MORTAR ANALYSIS SUMMARY SHEET

Project Name: Blue Ball Properties
Location: Feature 2 Kitchen wing
Sample No.: MT1
Date: 6/2004

Chemical Analysis

A. CALCULATIONS (weight in grams)

1. Container Weight:	41.70
2. Sample Weight	50.02
3. Filter Paper Weight	4.24
4. Container + Sand Weight:	79.29
5. Sand Weight:	37.59
6. Paper + Fines Weight:	6.84
7. Fines Weight:	2.60
8. Sand + Fines Weight:	40.19
9. Acid Soluble Weight	9.83
10. Weight Percent Sand	75.15
11. Weight Percent Acid Soluble	19.65
12. Weight Percent Fines	5.20

B. MORTAR CHARACTERISTICS
Mortar Color: White (FN106)

	soft									hard
Relative Hardness:	**1**	2	3	4	5	6	7	8	9	10

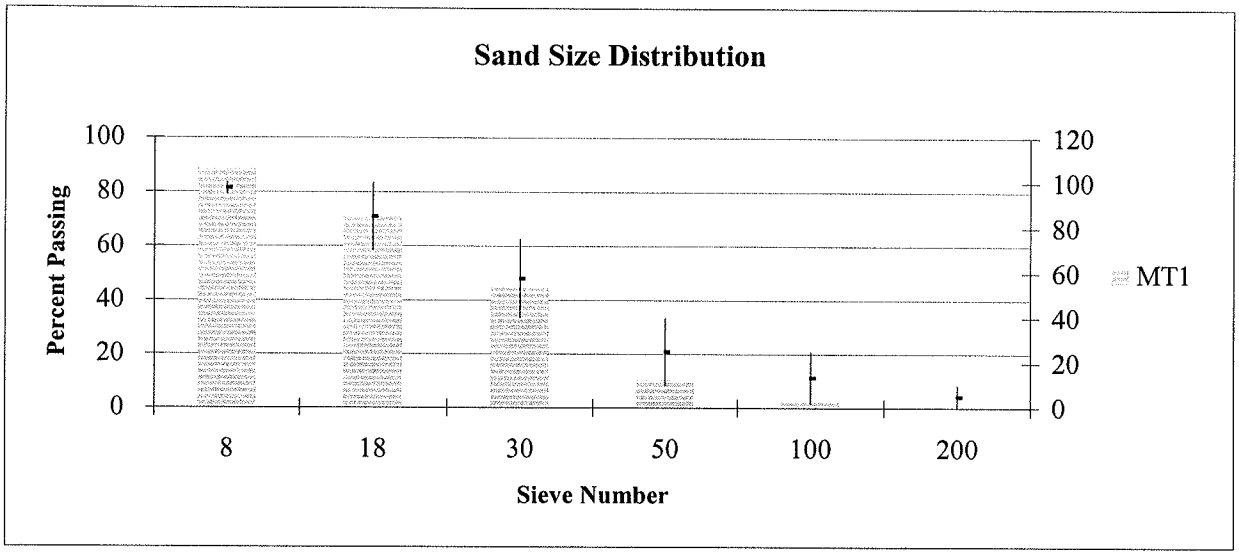
C. SAND CHARACTERISTICS
Color: Tan (FN109)
Opacity: 1 % Opaque 94 % Translucent 5 % Transparent
Angularity: Angular to sub-angular. Seems more coarse than BB18M/BB12M
Composition: Quartz, feldspar. Traces glauconite, horneblende, anthracite. Some undigested material.

Size: Sieve No.	Weight	Percent Passing
8	4.34 grams	88 %
18	6.63 grams	71 %
30	9.83 grams	45 %
50	12.91 grams	10 %
100	2.99 grams	2 %
200	0.60 grams	1 %
<200	0.17 grams	0 %

Fines Color: Brown (FN146)

D. NOTES: Brisk effervescence with large, foamy bubbles that dissipated rapidly.

E. CONSERVATOR: Lorraine Schnabel, 1:1:6 Technologies Incorporated



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MORTAR ANALYSIS SUMMARY SHEET

Project Name: Blue Ball Properties
Location: East Half of the House
Sample No.: MT6
Date: 5/2004

Chemical Analysis

A. CALCULATIONS (weight in grams)

1. Container Weight:	42.83
2. Sample Weight	50.01
3. Filter Paper Weight	4.46
4. Container + Sand Weight:	81.41
5. Sand Weight:	38.58
6. Paper + Fines Weight:	8.78
7. Fines Weight:	4.32
8. Sand + Fines Weight:	42.90
9. Acid Soluble Weight	7.11
10. Weight Percent Sand	77.14
11. Weight Percent Acid Soluble	14.22
12. Weight Percent Fines	8.64

Mortar Color: Cream (FN114)

	soft									hard
Relative Hardness:	**1**	2	3	4	5	6	7	8	9	10

C. SAND CHARACTERISTICS

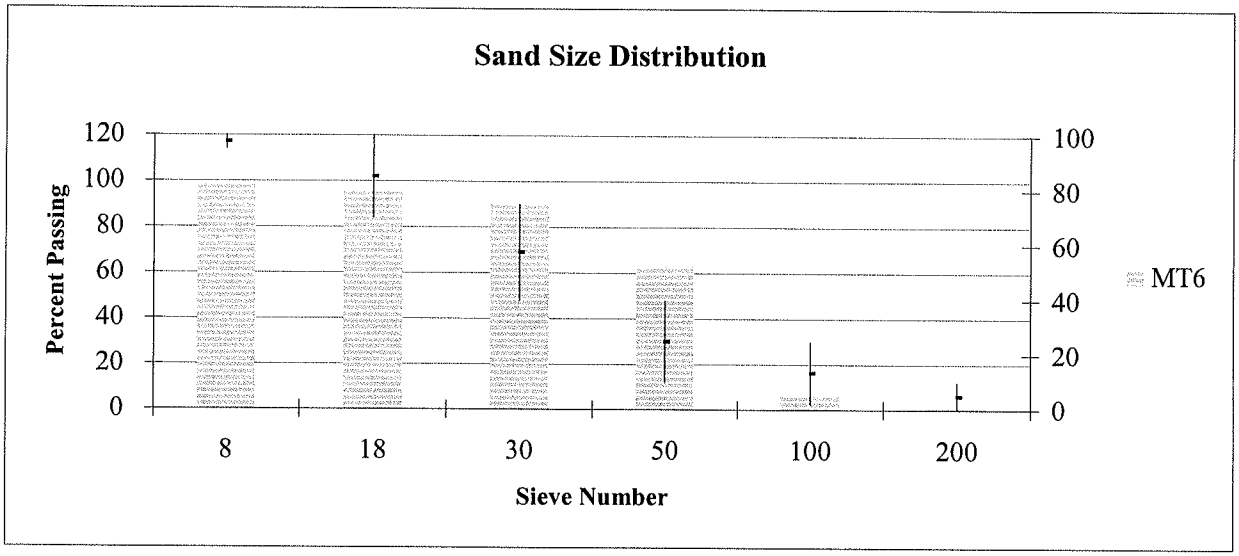
Color: Tan (FN108)
Opacity: 5 % Opaque 65 % Translucent 30 % Transparent
Angularity: Angular to subangular with some subrounded to rounded
Composition: Qtz, traces of feldspar, large clumps of limonitized material with the opaque aggregate.

Size: Sieve No.	Weight	Percent Passing
8	0.48 grams	99 %
18	1.24 grams	96 %
30	1.82 grams	91 %
50	10.64 grams	63 %
100	22.05 grams	6 %
200	2.09 grams	1 %
<200	0.22 grams	0 %

Fines Color: Tan (FN117)

D. NOTES: Foamy bubbles, but smaller--dispersed quickly.

E. CONSERVATOR: Lorraine Schnabel, 1:1:6 Technologies Incorporated



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