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Appendix A - Questionnaire

Water Treatment Plant Sludge Survey

Please fill the following questionnaire as accurately as possible

Contact Information

Respondent's Name: Designation: Address:	Telephone No: Fax: E-mail address:

1. General

i. Name of WTP:

ii. Year of establishment:

iii. Treatment Plant Installed Capacity:

iv. Quantity of water treated/day:

v. Location:

vi. Region/District:

vii. No. of Beneficiaries:

viii. Coverage Area:
(GN Divisions & DS divisions)

2. Source and Flow

	Name of the Sources	Avg.Flow (m^3/day)	Max.Flow (m^3/day)
Reservoir			
River			

3. Raw Water Quality

	Average	Range
Turbidity NTU		
Total Alkalinity as $CaCO_3$, mg/L		
Total Hardness as $CaCO_3$, mg/L		
Total Suspended Solids, mg/L		
Total Solids, mg/L		
pH		
Temperature		
Conductivity		

4. Treatment Process

(Eg: Aeration, Coagulation, Flocculation, Sedimentation, Filtration, disinfection, etc.)

5. Chemical Usage in Treatment Process

	Average (kg/day)	Range (kg/day)
Alum		
Ferric Sulfate		
Polymer		
PAC		
GAC		
Lime		
Copper Sulfate		

6. **Basin Information**

	Flocculator	**Sedimentation**		
Number				
Capacity (m^3)				
Depth (m)				
Detention time at avg.flow (min)				
Sludge generated (m^3/d)				
Dry Sludge generated (kg/d)				

7. **Filters**

i. Number:

ii. Max.loadingrate:

iii. Size:

iv. Filter aid:

v. Filter run:

vi. Media depth:

  a. Anthracite:

  b. Sand:

  c. GAC:

vii. Max. Back wash rate:

viii. Turbidity (In flow):

ix. Turbidity (Out flow):

x. TSS (In flow):

xi. TSS (Out flow):

xii. Water usage for back washing in % Wash water to average flow:

8. Sludge Production and Disposal

i. Type of Sludge:
- Alum sludge:
- Lime sludge:
- Brine wastes:

ii. Total quantity:
- Dry (kg/day):
- Wet (m^3/day):

9. Sludge Characteristics

	Basin sludge	Filter wash water	Brine
% solids			
pH			
TSS, mg/L			
TDS, mg/L			
Al, mg/L			
Fe, mg/L			
Ba, mg/L			
Radioactivity			

**** If not measure please indicate it.**

10. Sludge Discharge and Removal

i. Basin sludge discharged to:

Stream ☐ Sewer system ☐
Lake/reservoir ☐ Recirculation to Treatment facility ☐
Low ground ☐ Impounding basin ☐

If any other please specifies:

ii. Spent GAC disposal to:

iii. Brine disposal to:

iv. Flocculator sludge discharged to:

v. Filter wash water discharged to:

Recovery basin (recycle): Yes ☐ No ☐

Methods of removing sludge from basins:

- Flushing with fire hose ☐
- Dragline or dozer ☐
- Continuous removal ☐
- Manual ☐
- Combination of the above ☐
- Any other please specify:

11. Sludge Treatment

i. Thickening:

- Gravity ☐
- Flotation ☐
- Centrifuge ☐

ii. Stabilization & Disinfection:

- Lime treatment ☐
- Cl2 treatment ☐

iii. Recycle : Yes ☐ No ☐

If yes, With Settling ☐
Without settling ☐

iv. Dewatering: Yes ☐ No ☐

12. Sludge Dewatering

	Number	Size	Ton/Y generated	% solids
Drying beds				
Drying lagoons				
Centrifuge				
Belt filter				
Filter press				

13. Sludge Final Disposal

i. Composting: Yes ☐ No ☐

ii. Utilization for:

a. Land reclamation ☐

b. Filling material ☐

iii. Land Disposal:

a. Sanitary / Engineered landfill ☐

b. Public land ☐

c. Dumping into private land ☐

iv. Beneficial uses

Land Application - Agricultural use ☐

Cement manufacturing ☐

Brick making ☐

Road Subgrade ☐

Landfill cover ☐

Any other, please specify:

14. Sludge Disposal Limitations

A. Has your utility been ordered by a regulatory agency to stop the discharge of WTP sludge into the water source? (Yes/No)

B. If YES to A, in your opinion, has the stopping of sludge disposal to the water source significantly improved the water quality of the water source? (Yes/No)

C. If No to B, would your utility resume sludge disposal to the water source if the regulatory barriers were removed? (Yes/No)

D. If Yes to C, and your utility was allowed to resume sludge disposal to the water source, what would you estimate the annual cost savings to your utility?

15. Costs

i. Total Annual cost for solids handling & disposal:
ii. Total annual cost for the treatment plant:

Note:

i. Is there additional land/space available in WTP? (Yes/No)
ii. If Yes, Extent (Approximately, m^2) :
iii. Did you make any improvement to treatment process: (Yes/No)
iv. If Yes, Please specify the modification you have done and benefits obtained:
v. Did you face any problems with sludge (treatment & Disposal): (Yes/No)
vi. If Yes, Please specify in detail:
vii. Photos

Remarks: (Use additional Papers for this)

Appendix B - Standard Test Methods

8 DETERMINATION OF UNPOLISHSED SLIP RESISTANCE VALUE (USRV)

8.1 Principle

The measurement of USRV on the specimen is made using the pendulum friction test equipment evaluate the frictional properties of the specimen on the upper face.

The pendulum friction test equipment incorporates a spring loaded slider made of a standard rubber attached to the end of the pendulum. On swinging the pendulum the frictional force between the slider and test surface is measured by the reduction in length of the wing using a calibrated scale.

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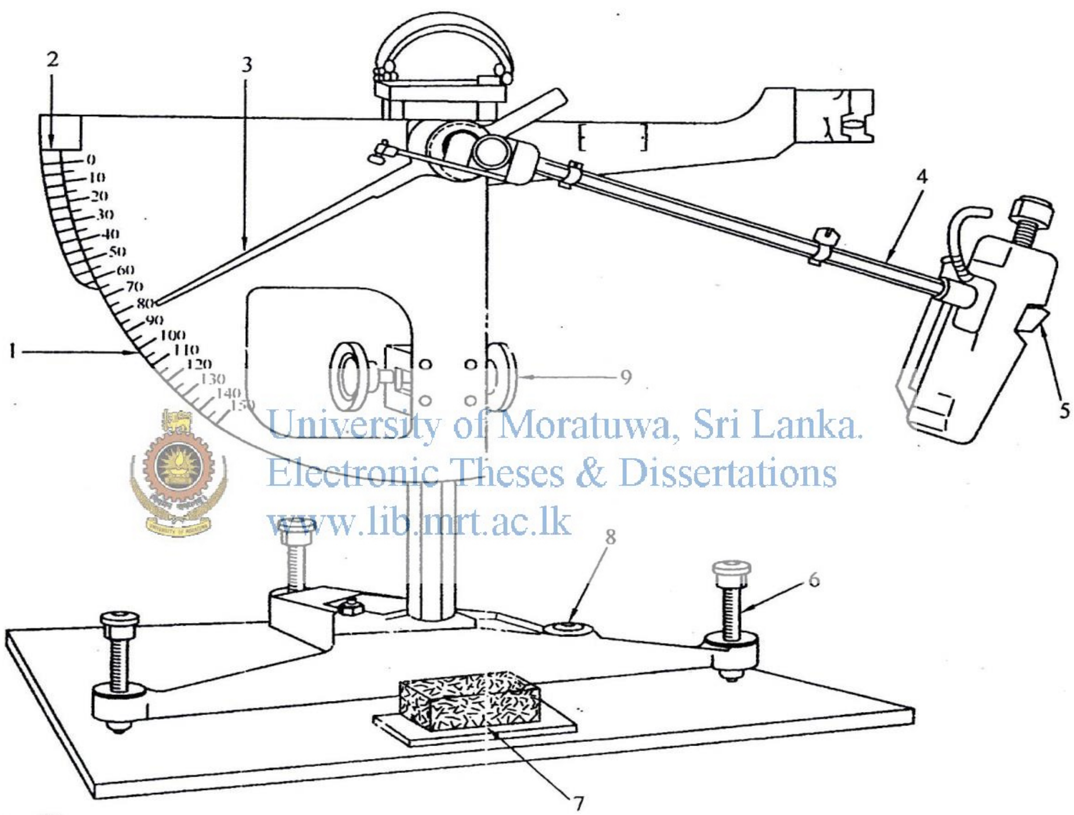
8.2 Apparatus

8.2.1 *Pendulum friction tester*

8.2.1.1 The pendulum friction test equipment shall be manufactured as shown in Figure **8**. All bearings and working parts shall be enclosed as far as possible, and all materials used shall be treated to prevent corrosion under wet conditions.



Key

1 C scale (126 mm sliding length)
2 F scale (76 mm sliding length)
3 Pointer
4 Pendulum
5 Rubber slider
6 Levelling screw
7 Test specimen holder
8 Spirit level
9 Vertical adjustment screw

FIGURE 8 - Pendulum friction test equipment

8.2.1.2 The pendulum friction test equipment shall have the following features:

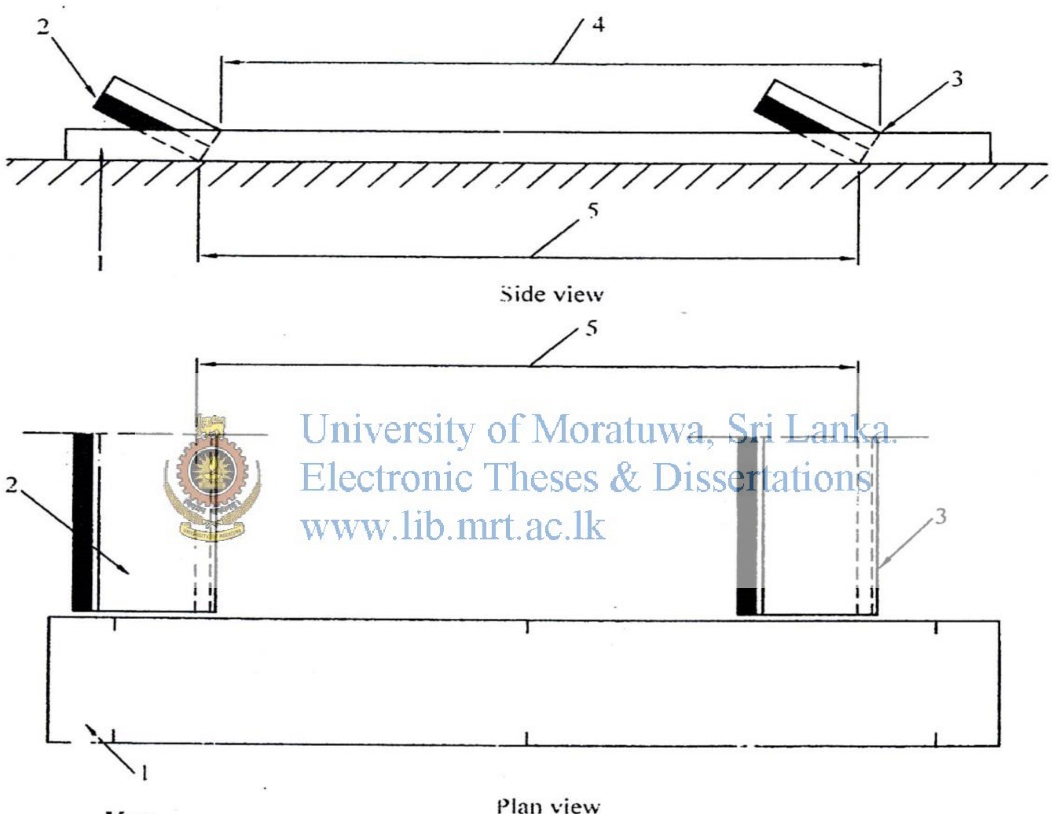
1) a spring loaded rubber coasted slider as specified in **8.2.1.4** to **8.2.1.10**. It shall be mounted on the end of a pendulum arm so that the sliding edge is (510 ± 1) mm from the axis of suspension;

2) means of setting the support column of the equipment vertical;

3) a base of sufficient mass to ensure the equipment remains stable during the test;

4) means of raising and lowering the axis of suspension of the pendulum arm so that the slider can;

- swing clear of the surface of the specimen; and
- be set to traverse a surface over a fixed length of (126 ± 1) mm. A gauge with the distance marked is required as shown in Figure **9**.



Key
1. Gauge
2. Slider
3. Reference edge
4. Sliding length measured
5. Actual sliding length

FIGURE 9 - Sliding length gauge

5) means of holding and releasing the pendulum arm so that it falls freely from a horizontal position;
6) A pointer of nominal length 300 mm, balanced about the axis of suspension, indicating the position of the pendulum arm throughout its forward swing and moving over the circular scale. The mass of the pointer shall be not more than 85 g;

7) the friction in the pointer mechanism shall be adjustable so that, with the pendulum arm swinging freely from a horizontal position, the outward tip of thc pointer may be brought to rest on the forward wing of the arm at a point (10 ± 1) mm below the horizontal. This is the 0 reading;
8) A circular C scale, calibrated for a sliding length of 126 mm on a flat surface, marked from 0 to 150 at intervals of five units;

8.2.1.3 The mass of the pendulum arm, including the slider, shall be (1.50 ± 0.03) kg. The centre of gravity shall be on the axis of the arm at a distance of (410 ± 5) mm from the axis of suspension.

8.2.1.4 The wide slider shall consist of a rubber pad (76.2 ± 0.5) mm wide; (25.4 ± 1.0) mm long (in the direction of swing) and (6.4 ± 0.5) mm thick, the combined mass of slider and base shall be (32 ± 5) g.

8.2.1.5 The slider shall be held on a rigid base with a centre pivoting axis which shall be mounted on the end of the pendulum arm in such a way that, when the arm is at the lowest point of its swing with the trailing edge of the slider in contact with the test surface, the plane of the slider is angled at $(26 \pm 3)^0$ to the horizontal. In this configuration the slider can turn about its axis without obstruction to follow unevenness of the surface of the test specimen as the pendulum swings.

8.2.1.6 The slider shall be spring-loaded against the test surface. When calibrated, the static force on the slider as set by the equipment calibration procedure shall be (22.2 ± 0.5) N in its median position. The change in the static force on the slider shall be not greater than 0.2 N per millimeter deflection of the slider.

8.2.1.7 The initial resilience and hardness of the slider shall conform to Table **3**, and shall have a certificate of conformity including the name of the manufacturer and date of manufacture. A slider shall be discarded when the IRHD value measured in accordance with **SLS ISO 7619** fails to conform to the requirements of the table or not later than three years after manufacture.

TABLE 3 – Properties of the slider rubber

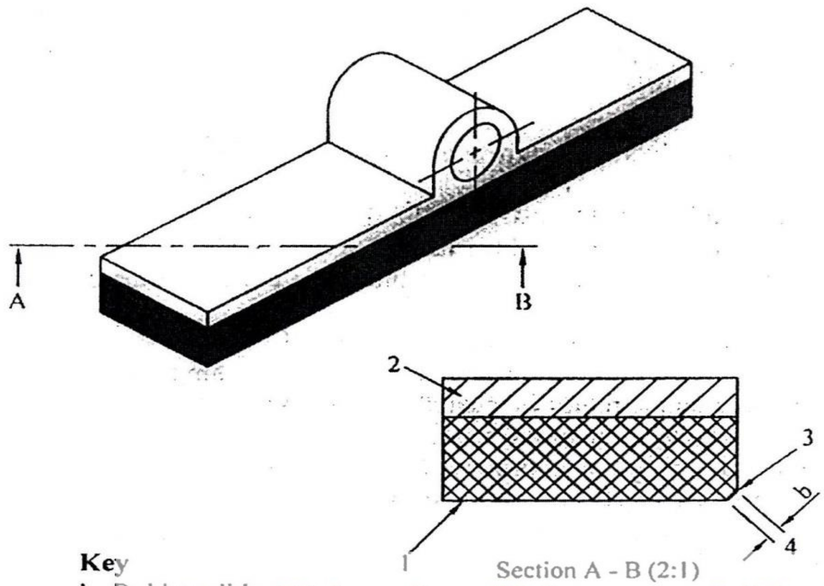
	Temperature ^{0}C				
Property	0	10	20	30	40
Resilience (%)[a]	43 to 49	58 to 65	66 to 73	71 to 77	74 to 79
Hardness (IRHD)[b]	53 to 65				

[a] Rebound test in accordance with **SLS ISO 4662**
[b] International Rubber Hardness Degrees ion accordance with **SLS ISO 48**.

8.2.1.8 The edges of the slider be square and clean-cut, and the rubber free from contamination by for example, abrasive or oil. The slider shall be stored in the dark at a temperature in the range 5 ^{0}C to 20 ^{0}C.

8.2.1.9 Before using a new slider it shall be conditioned to produce a minimum width of striking edge of 1 mm as shown in Figure **10**.

This shall be achieved by setting up the tester and carrying out five swings on a dry surface with a friction value above 40 on the C scale followed by a further 20 swings on the same surface after wetting.



Key
1. Rubber slider
2. Aluminium backing
3. Striking edge
4. Worn width

FIGURE 10 - Slider assembly illustrating the maximum wear of striking edge

8.2.1.10 The slider shall be discarded when the width of the striking edge as shown in Figure **10** exceeds 3 mm or becomes excessively scored or burred. The slider can be reversed to expose a new edge, which will need to be conditioned.

8.2.2 A container with potable water at (27 ± 2) ^{0}C for wetting the surfaces of the test specimen and slider.

8.3 Calibration

The apparatus shall be recalibrated at least annually.

8.4 Sampling

Obtain a representative sample in accordance with **6** of Part **1**.
Each block in the sample shall permit a test area of 136 mm x 86 mm which is representative of the whole block. This area shall be tested using the 76 mm wide slider over a nominal swept length of 126 mm, readings being taken on the C scale.

In the case of large blocks, representative samples shall be cut from them for test.

8.5 Procedure

Keep the friction test equipment, and slider, in a room at a temperature of (27 ± 2) ^{0}C for at least 30 min before the test begins.

Immediately prior to testing with the friction tester, immerse the sample in water at (27 ± 2) ^{0}C for at least 30 min.

Place the friction tester upon a firm level surface and adjust the leveling screws so that the pendulum support column is vertical. Then raise the axis of suspension of the pendulum so that the arm swings freely, and adjust the friction in the pointer mechanism so that when the pendulum arm and pointer are released from the right-had horizontal position the pointer cones to rest at the zero position on the test scale.

Before using a new slider, condition it using the method described in **8.2.1.9**.

Discard any slider that exceeds the requirements given in **8.2.1.10**.

Rigidly locate the test specimen with its longer dimension lying in the track of the pendulum, and centrally with respect to the rubber slider and to the axis of the suspension of the pendulum. Ensure that the track of the slider is parallel to the long axis of the specimen across the sliding distance.

Adjust the height of the pendulum arm so that in traversing the specimen the rubber slider is in contact with it over the whole width of the slider and over the specified swept length. Wet the surfaces of the specimen and the rubber slider with a copious supply of water, being careful not to disturb the slider from its set position. Release the pendulum and pointer from the horizontal position, catch the pendulum arm on its return swing. Record the position of the pointer on the scale (the pendulum test value).. Perform this operation five times, rewetting the specimen each time, and record the mean of the last three readings. Relocate the specimen after rotating though 180^0 and repeat the procedure.

8.6 Calculation of test results

When the wide slider is used over a swept length of 126 mm, calculate the pendulum value of each specimen as the mean of the two recorded mean values measured in opposite directions to the nearest 1 unit on the C scale.

8.7 Test report

The test report shall include the following information;

1) the mean pendulum test value of each specimen; and

2) the mean USRV of the sample.

9 DETERMINATION OF TOTAL WATER ABSORPTION

9.1 Principle

After conditioning the specimen to (27 ± 2) ^{0}C it is soaked to constant mass and dried to constant mass. The loss in mass is expressed as a percentage of the mass of the dry specimen.

9.2 Specimen

If a block weighs more than 5.0 kg it shall be cut through its full height to provide a specimen not greater than 5.0 kg.

9.3 Materials

Potable water.

9.4 Apparatus

9.4.1 Ventilated drying oven with a capacity in litres to an area of ventilation channels in square millimetres less than 0.2 in which the temperature may be controlled to (105 ± 5) ^{0}C. It shall have a volume at least 2.5 times greater than the volume of specimens to be dried at any one time.

9.4.2 Flat based vessel having a capacity at least 2.5 times the volume of the samples to be soaked and a depth at least 50 mm greater than the height of the specimens in the attitude that they will be soaked.

9.4.3 Weighing balance capable of measuring more than 5 kg and accurate to 0.1 % of the reading in grams.

9.4.4 Stiff brush.

9.4.5 Cloth

9.5 Preparation of the test specimens

Remove all dust, flashing, etc. with a brush and ensure that each specimen is at a temperature of (27 ± 2) ^{0}C.

9.6 Procedure

Immerse the specimens in potable water at a temperature of (27 ± 2) ^{0}C using the vessel until constant mass M_1 is reached. Separate the specimens from each other by at least 15 mm and ensure a minimum of 20 mm water above them. The minimum period of immersion shall be three days and constant mass shall be deemed to have been reached when two weighings performed at an interval of 24 h show a difference in mass of the specimen of less than 0.1%. Before each weighing wipe the specimen with the cloth which has been moistened and squeezed to remove any excess of water. The drying is correct when the surface of the concrete is dull.

Place each specimen insides the oven in such a way that the distance between each specimen is at least 15 mm. Dry the specimen at a temperature of (105 ± 5) ^{0}C until reached constant mass M_2 . The minimum period of drying shall be three days and constant mass shall be deemed to have been reached when two weighing performed at an interval of 24 h show a difference in mass of the specimen of less than 0.1%. Allow the specimen to cool to room temperature before they are weighed.

9.7 Calculation of test results

Calculate the water absorption W_a of each specimen as a percentage of its mass from the equation:

$$W_a = \frac{M_1 - M_2}{M_2} \times 100\ \%$$

where

M_1 is the initial mass of the specimen (g);

M_2 is the final mass of the specimen (g).

Calculate the water absorption of the sample as the mean of the water absorption values of the specimens.

9.8 Test report

The test report shall give the value of water absorption for each of the specimens.

Methods

1 Scope

This Part of BS 812 describes two methods for the determination of the particle size distribution of samples of aggregates and fillers by sieving.

NOTE 1. For sampling and testing lightweight aggregates for concrete see BS 3681.

NOTE 2. The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this Part of BS 812 the definitions given in BS 812 : Part 101 and Part 102 apply.

3 Principle

3.1 Washing and sieving

This is the preferred method (see **7.2**) for aggregates which may contain clay or other materials likely to cause agglomeration of particles. It involves preliminary separation by washing through a fine sieve before determining particle size distribution by dry sieving.

3.2 Dry sieving

This is an alternative method (see **7.3**) which may be used for coarse and fine aggregates free from particles which cause agglomeration.

NOTE 1. Dry sieving gives inaccurate results for aggregates containing clay but is quicker and less laborious to carry out than washing and sieving.

NOTE 2. It is not possible to specify accurately the amount of clay or other materials which will make the method given in **7.3** inappropriate and unless it can be demonstrated (e.g. by previous experience) that that method gives accurate results, it is recommended that the method described in **7.2** should always be used. Because of this some materials specifications may call for washing and sieving to be followed at all times.

4 Sampling

The sample used for the test (the laboratory sample) shall be taken in accordance with the procedures described in clause **5** of BS 812 : Part 102 : 1984.

5 Apparatus

5.1 *A sample divider*, of size appropriate to the maximum particle size to be handled or alternatively a flat shovel and a clean, flat, hard horizontal surface, e.g. a metal tray for use in quartering.

NOTE. A suitable divider is the riffle box illustrated in BS 812 : Part 102.

5.2 *A ventilated oven*, thermostatically controlled to maintain a temperature of 105 ± 5 °C.

5.3 *A balance, or balances,* of suitable capacity accurate to 0.1 % of the mass of the test portion.

NOTE. In general, two balances, one of approximately 5 kg capacity accurate to 1 g and the other of approximately 500 g capacity accurate to 0.1 g, will suffice. If aggregate of larger than 28 mm nominal size is to be tested a balance of 50 kg capacity accurate to 10 g will also be required.

5.4 *Test sieves and nesting guard sieve*, of the sizes and apertures appropriate to the specification of the material being tested, complying with BS 410 and with the appropriate sizes of lid(s) and receivers.

NOTE 1. A set of sieves of the sizes and apertures given in table 1 will cover most applications of the method.

NOTE 2. Some advice on cleaning and checking sieves is given in appendices A and B.

Table 1. Particulars of sieves for sieve analysis

Nominal aperture sizes	
Square hole perforated plate, 450 mm or 300 mm diameter	**Wire cloth, 300 mm or 200 mm diameter**
mm	mm
75.0	3.35
63.0	2.36
50.0	1.70
37.5	1.18
28.0	µm
20.0	850
14.0	600
10.0	425
6.30	300
5.00	212
	150
	75*

*For some applications, 63 µm is appropriate.

5.5 *A mechanical sieve shaker* (optional).

5.6 *Trays*, that can be heated in the ventilated oven (**5.2**) without damage or change in mass.

5.7 *Containers*, of a size sufficient to contain the test portion plus five times its volume of water (for washing and sieving method only).

6 Preparation of test portion

Reduce the sample in accordance with the procedures described in clause **6** of BS 812 : Part 102 : 1984 to produce the required number of test portions each of which complies with the minimum mass given in table 2. Dry the test portions by heating at a temperature of 105 ± 5 °C to achieve a dry mass which is constant to within 0.1 %. Allow to cool, weigh and record as M_1.

Table 2. Minimum mass of test portion for sieve analysis

Nominal size of material	Minimum mass of test portion
mm	kg
63	50
50	35
40	15
28	5
20	2
14	1
10	0.5
6	0.2
5	0.2
3	0.2
<3	0.1

7 Procedure

7.1 General

7.1.1 For some materials, e.g. all in aggregates or hoggin, the particle size distribution may result in excess mass on one or more sieves particularly on the finer sizes. Therefore, if it is not possible to include extra sieves of appropriate intermediate size to reduce the loading, adopt one of the following procedures.

(a) Subdivide the test portion into two or more sub-portions. Determine the particle size distribution for each portion and combine the results for the purpose of reporting.

(b) Separate the test portion on an appropriate sieve, e.g. 20 mm or 5 mm. Weigh the retained and passing fractions to determine the proportion of each present. Determine the particle size distribution of each fraction separately, reducing where necessary by quartering or by means of a sample divider (**5.1**) as described in clause **6** of BS 812 : Part 102 : 1984. Calculate the particle size distribution of the original sample by combining the results for each fraction in the proportions present.

7.1.2 When special procedures for fillers are required to measure the amount finer than 75 µm, carry these out either in accordance with **7.2** of BS 812 : Part 1 : 1975 or BS 812 : Part 104*.

7.2 Washing and sieving method

7.2.1 *Preliminary separation*

7.2.1.1 Wet both sides of a 75 µm test sieve (**5.4**), reserved for use in this test only, and fit a nesting guard sieve (e.g. 1.18 mm) on top. Mount the sieves in such a way that the suspension passing the test sieve can be run to waste or, when required, collected in a suitable vessel.

7.2.1.2 Place the weighed oven dried test portion in a container (**5.7**) and add sufficient water to half fill the container. Agitate the contents so that particles smaller than 75 µm are completely separated from coarser particles.

NOTE. Soaking or continued agitation or, in the case of large particles, brushing may be required to achieve complete separation.

7.2.1.3 Pour the suspension of fine solids on to the guarded 75 µm test sieve.

NOTE. The suspension passing the test sieve may be run to waste unless it is required for other purposes.

7.2.1.4 Continue washing the coarse residue until the water passing the test sieve is clear (see note 2) and then wash all the residues from the container and sieve(s) into the tray (**5.6**). Remove excess free water by careful decantation through the test sieve, avoiding transfer of solids (see note 2) and dry the residue in the oven (**5.2**) at 105 ± 5 °C until constant mass is achieved. Cool, weigh and record as M_2.

NOTE 1. Avoid excess water flows which may damage or flood the sieves.

NOTE 2. If some transfer of solids does occur wash them back into the tray and repeat the operation.

NOTE 3. Fine sieves are fragile and the integrity of the mesh should be checked frequently (see appendix B).

7.2.1.5 Determine the mass of material passing the test sieve as $M_1 - M_2$.

7.2.2 *Sieving the dried residue*

7.2.2.1 Nest the clean and dry sieves on a fitting receiver in order of increasing aperture size from bottom to top. Place the dried residue on the top coarsest sieve and cover with a fitting lid. Either by hand or using the mechanical sieve shaker (**5.5**), shake the sieves for a sufficient time to separate the test sample into the size fractions determined by the sieve apertures used.

NOTE. Experience has shown that the preliminary separation (**7.2.1**) does not necessarily remove all the particles smaller than 75 µm because of capillary action of water on particle surfaces. It is therefore necessary to incorporate a 75 µm test sieve in the series of test sieves used to sieve the dried residue.

7.2.2.2 When the mechanical sieve shaker is used, after sieving, check that separation is complete by briefly hand sieving. When sieving is done by hand alone start with the coarsest sieve and shake each sieve separately over a clean tray or receiver until not more than a trace passes, but in any case for a period of not less than 2 min. Do the shaking with a varied motion, backwards and forwards, left to right, circular, clockwise and anti-clockwise, and with frequent jarring so that the material is kept moving over the sieve surface in frequently changing directions. Do not force materials through the sieve by hand pressure but placing of particles is permitted. Break lumps of agglomerated material which consist of particles representative of the bulk by gentle pressure with the fingers against the side of the sieve.

7.2.2.3 Record any extraneous material not representative of the bulk that will not readily break down into individual particles, such as clay lumps, and remove from the sieve for separate weighing.

*At the time of publication, BS 812 : Part 104 is in preparation. When published, it will supersede 7.2 of BS 812 : Part 1 : 1975.

7.2.2.4 Do not apply pressure to the surface of the sieve to force particles through the mesh. Light brushing with a soft brush on the underside of the sieve may be used to clear sieve openings. Light brushing with a fine camel-hair brush may be used on the 150 µm and 75 µm sieves to prevent agglomeration of the powder and blinding of the apertures. Do not use stiff or worn-down brushes for this purpose.

7.2.2.5 In order to prevent blinding of the sieve apertures by overloading, ensure that the mass of aggregate retained on the sieve at completion of the operation does not exceed the value for that sieve shown in table 3.

NOTE 1. Some sample masses shown in table 1 will thus require additional operations on some sieves, as described in **7.1.**

NOTE 2. In some cases it may be possible to reduce sufficiently the load on a sieve by incorporating an intermediate sieve into the test series.

7.2.2.6 Weigh the material retained on each sieve, together with any material cleaned from the mesh, on completion of sieving on that sieve.

NOTE. Samples containing dust should be sieved into a receiver to prevent loss.

7.2.2.7 Add the aggregate passing the sieve to the next sieve in the series before commencing the operation on that sieve.

7.3 Dry sieving method

Use the procedure described in 7.2.2.

8 Calculation and expression of results

Calculate the mass retained on each sieve as a percentage of the original dry mass (M_1). For the mass of material passing the finest sieve, add that passing during washing ($M_1 - M_2$) to that found during the dry sieving.

Calculate the mass passing each sieve as a cumulative percentage of the total sample mass.

9 Precision

Estimates of the repeatability and reproducibility of sieve analysis using the methods described in this Part of BS 812 are given in table 4 for a limited range of materials.

NOTE 1. Reference should be made to BS 812 : Part 101 for guidance on assessing the precision of the methods given in this standard.

NOTE 2. There is insufficient data available to permit the inclusion of values for V_s (variance arising from sampling errors) in table 4. When data is available it will be incorporated by amendment. Some values of V_s for a single experiment are given in Supplementary Report 831 published by the Transport and Road Research Laboratory.

10 Test report

The report shall affirm that the particle size distribution was determined in accordance with this Part of BS 812 and whether or not a certificate of sampling is available. If available, a copy of the certificate of sampling shall be provided. The test report shall include the following additional information:

(a) sample identification;

(b) either the cumulative percentage of the mass of the total sample passing each of the sieves, to the nearest whole number; or the percentage of the mass of the total sample passing one sieve and retained on the next smaller sieve, to the nearest whole number;

NOTE. A specimen chart which may be used for illustrating the results graphically is shown in figure 3.

(c) the method used by reference to either **7.2** or **7.3** of this Part of BS 812;

Table 3. Maximum mass to be retained at the completion of sieving

BS test sieve nominal aperture size	Maximum mass		BS test sieve nominal aperture size		Maximum mass	
	450 mm diameter sieves	300 mm diameter sieves			300 mm diameter sieves	200 mm diameter sieves
mm	kg	kg	mm	µm	g	g
50.0	14	5	5.00		750	350
37.5	10	4	3.35		550	250
			2.36		450	200
28.0	8	3	1.70		375	150
20.0	6	2.5	1.18		300	125
14.0	4	2				
10.0	3	1.5		850	260	115
				600	225	100
				425	180	80
6.30	2	1		300	150	65
5.00	1.5	0.75		212	130	60
3.35	1	0.55		150	110	50
				75	75	30

(d) whether or not lumps of material not representative of the bulk, such as clay lumps, were found to be present and the sieve sizes on which they were retained, together with the total amount present expressed as an overall percentage by mass of the total sample.

Table 4. Precision data for determination of particle size distribution

Description of material used	All values as cumulative percentage passing stated sieve							Details of precision experiment		
								Number of		
	Sieve size	Mean value	r	r_1	R	R_1	R_2	Participating laboratories	Outliers	Date
Chippings (1)	75 µm	0.38	—	0.2	—	0.35	—	17	—	1982
(2)	75 µm	0.81	—	0.2	—	0.35	—	17	1	1982
Type 2 granular sub-base	20 mm	90	—	5	5	6	9	9	—	1983
	10 mm	75	—	7	6	9	12			
	5 mm	65	—	6	3	9	11			
	600 µm	35	—	4	3	5	7			
	150 µm	15	—	2	—	3	4			
	75 µm	10	—	1	2	2	3			
20 mm crushed rock	600 µm	6.6	—	1.6	—	1.6	—	8	—	1983
	150 µm	3.6	—	0.3	—	1.0	—			
	75 µm	2.6	—	0.5	—	1.1	—			
14 mm single sized basalt or sandstone	14 mm	90	—	4.3	—	5.6	—	8	—	1982
	10 mm	25	—	5.2	—	8.5	—			
	2.36 mm	1.0	—	0.2	—	1.1	—			
	75 µm	0.75	—	0.2	—	1.0	—			
Building sands (means of 11 different sands)	600 µm	90	—	0.8	—	1.4	—	11	—	1981
	300 µm	57	—	1.8	—	4.8	—			
	150 µm	19	—	1.8	—	6.6	—			
	75 µm	5.5	—	0.8	—	1.5	—			

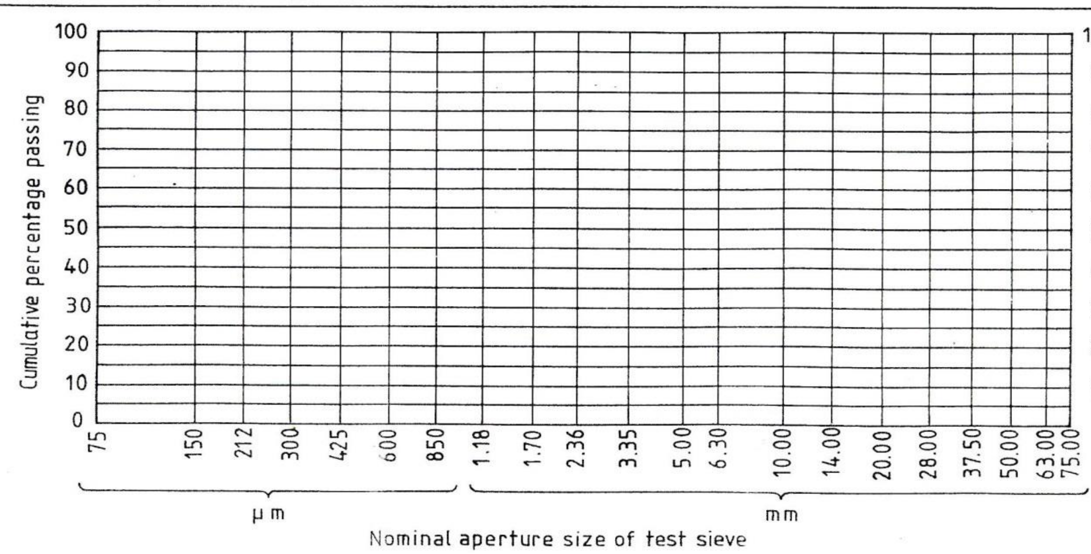


Figure 1. Chart for recording sieve analysis results

Appendix C - Summary of Questionnaire Returns

Appendix C-1: Water Treatment Plants Facility Information

No	Water Treatment Plants	Year of Establishment	Installed Capacity (m3/day)	Quantity Treated (m3/day)	Location	Region	Population served
1	Ambatale WTP		517,500	603,000	Ambatale		
2	Biyagama WTP		180,000	177,000		Gampaka	1,000,000
3	Kalatuwawa WTP	1960	91,000	70,000	KakatywawaTumodara	Ratnapura	282,495
4	Labugama WTP		65,000	41,000	Labugama		
5	Kandana WTP	2006	60,000	73,000	KandanaHorana	Kalutara	400,000
6	Kethhena WTP	1986	54,000	41,500	Thebuwana	Kalutara	
7	Paradeka WTP	2009	6,000	5,400	Kandy South	Kandy	33,000
8	Ulapane WTP	2009	8,000	8,000	Kandy South	Kandy	
9	Katugastota WTP	2007	48,000	48,000	Katugastota	Kandy	
10	Wakwella WTP	1976	30,000	24,000	Galle	Galle	
11	Hallalla WTP	1995,2007	8,000	8,000	welpitiya	Matara	60,000
12	Malimbada WTP	1985, 1996, 2006	45,000	42,000	Malimbada	Matara	
13	Nadugala WTP	1963	6,500	6,500	Nadugala	Matara	
14	Ambalantota/Hambantota	2010	15,000	13,800	Ambalantota	Hambantota	
15	RannaWTP	2005	13,000	12,500	Ranna	Hambantota	
16	Tangalle WTP	1958	7,500	7,500	Nalagama	Hambantota	57,500
17	Eluduwa WTP	1993	9,100	9,100	Badulla	Bandarewela	40,000
No.	**Water Treatment**	**Year of Establi**	**Installed Capacity**	**Quantity Treated**	**Location**	**Region**	**Population served**

	Plants	shment	(m3/day)	(m3/day)			
18	Ruhunupura WTP	2015	17,500	17,500	Sooriyawe wa	Hambanto ta	55,000
19	Kanthale WTP		54,000	48,000	Kantale	Trincomal e	
20	Pothuvil WTP	2008	5,600	1,700	Ulla	Ampara	3,343
21	Thirukkovil WTP	2009	6,500	600		Ampara	1,500
22	Konduwattuwan a	2002	72,000	35,000	Ampara	Ampara	400,000
23	Vavunathivu WTP	2012	40,000	13,000	Wawnathi wu	Batticalo	300,000
24	Eachchalampatt u	2011	6,000	6,000		Trincomal e	16,400
25	Seethawaka WTP	1999	9,450	9,450		Ratnapura	

Appendix C-2: Source of Water

No.	Water Treatment Plants	Surface Water		Ground Water		Avg. Flow (m3/d)	Max. Flow (m3/d)
		River	Reservoir	Bore hole	Dug well		
1	Ambatale WTP	Kelani Ganga					
2	Biyagama WTP	Kelani Ganga				177,300	187,300
3	Kalatuwawa WTP		Kalatuwawa Tank			84,000	86,000
4	Labugama WTP		Labugama Tank				
5	Kandana WTP	Kalu Ganga					
6	Kethhena WTP	Kalu Ganga				44,000	46,000
7	Paradeka WTP	Paradekaoya				8,000	120,000
8	Ulapane WTP						
9	Katugastota WTP	Mahawali Ganga					
10	Wakwella WTP	Gin Ganga					
11	Hallalla WTP	Polathu Ganga				172,800	
12	Malimbada WTP	Nilwala Ganga					
13	Nadugala WTP	Nilwala Ganga					
14	Ambalantota/Hambantota	Walawe Ganga				16,000	24,000
15	RannaWTP	Kattakaduwa River				12,500	13,200
16	Tangalle WTP	KiramaOya	Nawayalawila			6,500	9,000
17	Eluduwa WTP	BadullaOya				8,500	100,000
18	Ruhunupura WTP	Walawe Ganga	Ridiyagama Tank				
19	Kanthale WTP	Mahawali Ganga	Kantale Tank				

No.	Water Treatment Plants	Surface Water		Ground Water		Avg. Flow (m3/d)	Max. Flow (m3/d)
		River	Reservoir	Bore hole	Dug well		
20	Pothuvil WTP			√		1,700	5,600
21	Thirukkovil WTP		Sagammam			600	6,500
22	Konduwattuwana WTP		Konduwattu wana Tank			38,400	
23	Vavunathivu WTP		Unnichchai Tank			14,000	15,000
24	Eachchalampattu	VerugalAru				61,395	
25	Seethawaka WTP	Kelani Ganga				9,450	

Appendix C-3: Raw Water Quality

No.	Water Treatment Plants	Raw Water Quality (Avg.)						
		Turbidity NTU	Alkalinity mg/L	Hardness mg/L	TSS mg/L	pH	Temperature	Conductivity
1	Ambatale WTP							
2	Biyagama WTP	7.78	21.3	18.3	16.62	6.67	26	66.8
3	Kalatuwawa WTP	2.3	6.8	6.3		6.1		10.8
4	Labugama WTP							
5	Kandana WTP	29.3	26.4	26.4	10.2	6.7	25.1	66.7
6	Kethhena WTP	15.5	12.0	14.0		6.6		40.1
7	Paradeka WTP	5	34.0	35.0		7.5	23	82
8	Ulapane WTP							
9	Katugastota WTP	60	34.0	30.0		7.2		94
10	Wakwella WTP	15.4	15.7	19.2		7.04		36.9
11	Hallalla WTP	12.5	20.0	30.0		6.2	30	70
12	Malimbada WTP	12	22.0	23.0		6.2		50.1
13	Nadugala WTP	18	30.0	32.0		7		62.5
14	Ambalantota/ Hambantota	14.16	140.0	130.0		7.2	30	298
15	RannaWTP	15.96	147.0	132.0		7.5		
16	Tangalle WTP	45				6.7		
17	Eluduwa WTP	80	90.0	100.0		7.5		170
18	Ruhunupura WTP	6				7.8		

No.	Water Treatment Plants	Raw Water Quality (Avg.)						
		Turbidity NTU	Alkalinity mg/L	Hardness mg/L	TSS mg/L	pH	Temperature	Conductivity
19	Kanthale WTP	45	70.0	65.0		6.5	28	200
20	Pothuvil WTP	31	146.0	91.0		7.4	28	524
21	Thirukkovil WTP	80	58.0	60.0		7.3	28	200
22	Konduwattuwana	7.55	37.0	47.0		7.49	33	88
23	Vavunathivu WTP	10	18.0	17.0		6.2	29	49
24	Eachchalampattu WTP	31.8	100.0	98.0		7.4	29.1	265
25	Seethawaka WTP	30	11.0	18.0	1.1	6.2	28	35

Appendix C-4: Water Treatment Process

No.	Water Treatment Plants	Treatment Process					
		Aeration	Coagulaion	Flocculation	Sedimentation	Filtration	Disinfection
1	Ambatale WTP						
2	Biyagama WTP	√	√	√	√	√	√
3	Kalatuwawa WTP	√	√	√	√	√	√
4	Labugama WTP						
5	Kandana WTP		√	√	√	√	√
6	Kethhena WTP	√	√	√	√	√	√
7	Paradeka WTP	√	√	√	√	√	√
8	Ulapane WTP	√	√	√	√	√	√
9	Katugastota WTP		√	√	√	√	√
10	Wakwella WTP	√	√	√	√	√	√
11	Hallalla WTP		√	√	√	√	√
12	Malimbada WTP	√			√	√	√
13	Nadugala WTP	√	√	√	√	√	√
14	Ambalantota/Hambantota	√	√	√	√	√	√
15	RannaWTP	√	√	√	√	√	√
16	Tangalle WTP	√	√		√	√	√
17	Eluduwa WTP		√	√		√	√
18	Ruhunupura WTP	√	√	√	DAF	√	√
19	Kanthale WTP	√	√		√	√	√
20	Pothuvil WTP					√	√

No.	Water Treatment Plants	Treatment Process					
		Aeration	Coagulaion	Flocculation	Sedimentation	Filtration	Disinfection
21	Thirukkovil WTP	√	√	√	√	√	√
22	Konduwattuwana		√	√	DAF	√	√
23	Vavunathivu WTP		√	√	DAF	√	√
24	Eachchalampattu WTP	√	√	√	√	√	√
25	Seethawaka WTP		√	√	√	√	√

Appendix C-5: Chemical Dosage

No.	Water Treatment Plants	Alum (kg/day)		Lime (kg/day)		PACl (kg/day)	
		Avg.	Range	Avg.	Range	Avg.	Range
1	Ambatale WTP						
2	Biyagama WTP	1660					
3	Kalatuwawa WTP			800		375	
4	Labugama WTP						
5	Kandana WTP	800	550-1400	400	320-550		
6	Kethhena WTP			200	160-200	225	175-225
7	Paradeka WTP					40	30-50
8	Ulapane WTP						
9	Katugastota WTP			30		250	
10	Wakwella WTP	200	150-250	150	100-175		
11	Hallalla WTP	85	75-90	90	80-100		
12	Malimbada WTP	500	450-600	200	160-280		
13	Nadugala WTP	95	75-120	13	10-15		
14	Ambalantota/Hambantota	750					
15	RannaWTP	400	400-425				
16	Tangalle WTP	250	150-350	30	28-50		
17	Eluduwa WTP	150	80-250	10	5-15		
18	Ruhunupura WTP	7.5x175					
19	Kanthale WTP	400					
20	Pothuvil WTP						
21	Thirukkovil WTP	45	25-50				
22	Konduwattuwana			280	250-350	500	400-550

No.	Water Treatment Plants	Alum (kg/day)		Lime (kg/day)		PACl (kg/day)	
		Avg.	Range	Avg.	Range	Avg.	Range
23	Vavunathivu WTP	155	150-200	130	100-200		
24	Eachchalampattu WTP						
25	Seethawaka WTP	45	30-80	50	20-90		

Appendix C-6: Sludge Production & Characteristics

No.	Water Treatment Plants	Type		Quantity		Characteristics			
		Alum	Lime	Dry (kg/day)	Wet (m3/day)	% Solid	pH	TSS (mg/L)	TDS (mg/L)
1	Ambatale WTP	√							
2	Biyagama WTP	√					7.1	120.75	
3	Kalatuwawa WTP	√					6	210	15
4	Labugama WTP	√							
5	Kandana WTP	√		2135	125	23.25			
6	Kethhena WTP	√							
7	Paradeka WTP	√							
8	Ulapane WTP	√							
9	Katugastota WTP	√							
10	Wakwella WTP	√							
11	Hallalla WTP	√			59				
12	Malimbada WTP	√							
13	Nadugala WTP	√							
14	Ambalantota/Ham bantota	√							
15	RannaWTP	√							
16	Tangalle WTP	√							
17	Eluduwa WTP	√							
18	Ruhunupura WTP	√		100					
19	Kanthale WTP	√							
20	Pothuvil WTP	√							
21	Thirukkovil WTP	√		634					
22	Konduwattuwana	√		840	30	2.5-3.0	7.1	0.08	

No.	Water Treatment Plants	Type		Quantity		Characteristics			
		Alum	Lime	Dry (kg/day)	Wet (m3/day)	% Solid	pH	TSS (mg/L)	TDS (mg/L)
23	Vavunathivu WTP	√							
24	Eachchalampattu WTP	√							
25	Seethawaka WTP	√							

Appendix C-7: Sludge Removal & Discharge

No.	Water Treatment Plants	Removal			Basin Sludge Discharge to				
		Flushing	Continuous Mechanical Removal	Manual	Stream	Lake / Reservoir	Low ground	Sewer system	Impounding basin
1	Ambatale WTP	√			√				
2	Biyagama WTP		√				√		
3	Kalatuwawa WTP	√			√				
4	Labugama WTP	√			√				
5	Kandana WTP			√					√
6	Kethhena WTP			√					√
7	Paradeka WTP			√	□				√
8	Ulapane WTP			√	√				□
9	Katugastota WTP			√					√
10	Wakwella WTP			√	√				
11	Hallalla WTP			√	√				
12	Malimbada WTP			√					√
13	Nadugala WTP			√	√				
14	Ambalantota/Hambantota			√		√			
15	RannaWTP		√		√				
16	Tangalle WTP			√	√				
17	Eluduwa WTP			√	√				
18	Ruhunupura WTP			√					√
19	Kanthale WTP			√					√

No.	Water Treatment Plants	Removal			Basin Sludge Discharge to				
		Flushing	Continuous Mechanical Removal	Manual	Stream	Lake / Reservoir	Low ground	Sewer system	Impounding basin
20	Pothuvil WTP			√	√				
21	Thirukkovil WTP			√			√		
22	Konduwattuwana		√						√
23	Vavunathivu WTP		√						√
24	Eachchalampattu WTP			√					√
25	Seethawaka WTP			√				√	

Appendix C-8: Sludge Treatment

No.	Water Treatment Plants	Thickening			Wash water Recycle	Sludge Dewatering
		Gravity	Flotation	Centrifuge		
1	Ambatale WTP					
2	Biyagama WTP			√		√
3	Kalatuwawa WTP					
4	Labugama WTP					
5	Kandana WTP					√
6	Kethhena WTP					√
7	Paradeka WTP					√
8	Ulapane WTP					□
9	Katugastota WTP					√
10	Walwella WTP					
11	Hallalla WTP					
12	Malimbada WTP					√
13	Nadugala WTP					
14	Ambalantota/Hambantota					
15	RannaWTP					
16	Tangalle WTP					
17	Eluduwa WTP					
18	Ruhunupura WTP	√				√
19	Kanthale WTP				√	√
20	Pothuvil WTP	□			√	
21	Thirukkovil WTP	√				√
22	Konduwattuwana			√	√	√
23	Vavunathivu WTP					√
24	Eachchalampattu WTP					√
25	Seethawaka WTP	□				

Appendix C-9: Sludge Dewatering

No.	Water Treatment Plants	Method				
		Drying beds	Lagoons	Centrifuge	Gravity Thickner	Filter press
1	Ambatale WTP					
2	Biyagama WTP			√		
3	Kalatuwawa WTP					
4	Labugama WTP					
5	Kandana WTP		√			
6	Kethhena WTP	√				
7	Paradeka WTP	√				
8	Ulapane WTP					
9	Katugastota WTP		√			
10	Wakwella WTP					
11	Hallalla WTP					
12	Malimbada WTP		√			
13	Nadugala WTP					
14	Ambalantota/Hambantota					
15	RannaWTP					
16	Tangalle WTP					
17	Eluduwa WTP					
18	Ruhunupura WTP	√				
19	Kanthale WTP	√				
20	Pothuvil WTP	√				
21	Thirukkovil WTP	√			√	
22	Konduwattuwana	□		√		
23	Vavunathivu WTP	□	√			
24	Eachchalampattu WTP	√			√	
25	Seethawaka WTP					

Appendix C-10: Sludge Final Disposal

No.	Water Treatment Plants	Utilization for		Dispose to Land	
		land Reclamation	Filling Material	Open dump	Dedicated Land
1	Ambatale WTP				
2	Biyagama WTP		√	□	
3	Kalatuwawa WTP				
4	Labugama WTP				
5	Kandana WTP	√		□	
6	Kethhena WTP			√	
7	Paradeka WTP			√	
8	Ulapane WTP			□	
9	Katugastota WTP			√	
10	Wakwella WTP				
11	Hallalla WTP				
12	Malimbada WTP	√		□	
13	Nadugala WTP				
14	Ambalantota/Hambanto ta				
15	RannaWTP				
16	Tangalle WTP				
17	Eluduwa WTP				
18	Ruhunupura WTP			√	
19	Kanthale WTP			√	
20	Pothuvil WTP				
21	Thirukkovil WTP		√		
22	Konduwattuwana			√	□
23	Vavunathivu WTP			√	
24	Eachchalampattu WTP			√	
25	Seethawaka WTP			□	

Appendix D - Test Results of Burnt Clay Bricks

Characteristics of Raw Materials

Table D.1: Observation & Results of Moisture Content

Material	Sample No.	Weight of can (g)	Weight of wet soil +can (g)	Weight of dry soil + can (g)	Moisture Content (%)	Avg. Moisture Content (%)
WTP Sludge 1 Kethhena	1	53.144	60.247	57.889	22.258	**33.61**
	2	63.542	84.273	77.226	22.823	
	3	68.236	89.581	82.398	22.799	
WTP Sludge 2 Kandana	1	57.244	84.669	76.584	20.819	**29.69**
	2	53.5121	75.237	68.752	20.728	
	3	68.236	100.187	90.682	20.828	
Clay	1	98.994	111.478	109.258	17.783	**17.88**
	2	105.236	120.024	117.362	17.995	
	3	93.563	112.024	108.723	17.876	

Table D.2: Observation & Results of Volatile Organic Content

Material	Sample No.	Weight of can (g)	Weight of wet soil +can (g)	Weight of dry soil + can 110C (g)	Weight of dry soil + can 550C (g)	Volatile Organic Content (%)	Avg. Volatile Organic Content (%)
WTP Sludge 1 Kethhena	1	10.480	15.687	14.498	13.580	22.847	**22.83**
	2	10.500	16.050	14.780	13.804	22.804	
	3	10.450	15.550	14.383	13.485	22.832	
WTP Sludge 2 Kandana	1	10.460	15.450	14.440	13.540	22.613	**22.70**
	2	10.510	16.200	15.055	14.024	22.684	
	3	10.480	15.620	14.580	13.645	22.805	

Table D.3: Results of Sieve Analysis

Water Treatment Plant Sludge (Kethhena)						
Sieve size (mm)	**Sieve weight (g)**	**Mass + sieve (g)**	**Mass in each sieve (g)**	**Cumulative mass retained (g)**	**Cumulative retained (%By mass)**	**Passing (% By mass)**
3.35	546	546	0	0	0	100
2.36	527	527	0	0	0	100
2	376	377	1	1	0.1	99.9
1.18	366	400	34	35	3.5	96.5
0.6	471	820	349	384	38.4	61.6
0.425	303	700	397	781	78.1	21.9
0.3	299	395	96	877	87.7	12.3
0.212	281	380	99	976	97.6	2.4
0.15	278	280	2	978	97.8	2.2
0.075	402	417	15	993	99.3	0.7
pan	462	466	4	997	99.7	0.3
Water Treatment Plant Sludge (Kandana)						
Sieve size (mm)	**Sieve weight (g)**	**Mass + sieve (g)**	**Mass in each sieve (g)**	**Cumulative mass retained (g)**	**Cumulative retained (%By mass)**	**Passing (% By mass)**
3.35	546	546	0	0	0	100
2.36	527	527	0	0	0	100
2	376	378	2	2	0.2	99.8
1.18	366	382	16	18	1.8	98.2
0.6	471	845	374	392	39.2	60.8
0.425	303	755	452	844	84.4	15.6
0.3	299	390	91	935	93.5	6.5
0.212	281	320	39	974	97.4	2.6
0.15	278	288	10	984	98.4	1.6
0.075	402	410	8	992	99.2	0.8
pan	462	465	3	995	99.5	0.5

Characteristics of Clay- Sludge Mix

Table D.4: Observations & Results of Moisture Content

Mix Proportion Sludge: Clay		Sample No.	Weight of can (g)	Weight of wet soil +can (g)	Weight of dry soil + can (g)	Moisture Content (%)	Avg. Moisture Content (%)
Sludge 1 Kethhena WTP	10:90	1	56.235	67.317	64.214	28.002	**28.01**
		2	63.236	75.632	72.165	27.969	
		3	55.332	68.235	64.616	28.048	
	20:80	1	85.191	93.400	90.958	29.749	**30.26**
		2	48.171	62.356	57.995	30.744	
		3	63.235	71.585	69.056	30.287	
	30:70	1	53.652	62.225	59.472	32.112	**31.78**
		2	56.236	68.456	64.652	31.129	
		3	48.710	60.125	56.462	32.089	
Sludge 2 Kandana WTP	10:90	1	48.710	59.590	56.543	28.002	**28.22**
		2	53.652	63.253	60.542	28.238	
		3	56.235	68.256	64.841	28.409	
	20:80	1	55.331	65.320	62.363	29.604	**29.68**
		2	63.236	73.524	70.486	29.530	
		3	53.651	65.368	61.865	29.897	
	30:70	1	55.623	73.658	67.985	31.456	**31.32**
		2	63.235	76.235	72.185	31.154	
		3	53.651	62.130	59.472	31.348	
Control	0:100	1	63.235	76.546	73.045	26.302	**26.85**
		2	56.236	67.259	64.362	26.281	
		3	53.651	65.231	61.992	27.971	

Table D.5: Dimension of Bricks

Mix 1 of Kethhena WTP Sludge																				
No	**Length**					**Width**							**Height**							
	L1	L2	L3	L4	Avg	W1	W2	W3	W4	W5	W6	**Avg**	H1	H2	H3	H4	H5	H6	**Avg**
1-1	194	195	194	194	**194**	96	96	96	95	96	96	**96**	57	57	56	57	57	57	**57**
1-2	194	194	193	194	**194**	96	95	96	96	95	96	**96**	57	57	57	58	57	57	**57**
1-3	193	194	194	194	**194**	96	96	96	96	96	96	**96**	57	57	57	57	58	57	**57**
1-4	194	194	194	194	**194**	96	95	96	96	95	96	**96**	57	58	57	57	57	57	**57**
1-5	195	194	194	194	**194**	96	96	96	96	96	96	**96**	57	57	57	57	57	57	**57**
1-6	194	195	193	194	**194**	96	96	96	96	96	96	**96**	56	57	57	57	57	57	**57**
1-7	194	195	194	194	**194**	96	96	96	96	96	96	**96**	57	58	57	57	57	58	**57**
1-8	193	194	194	195	**194**	95	96	96	96	96	96	**96**	57	57	57	58	57	57	**57**
1-9	194	194	194	194	**194**	96	95	96	96	95	96	**96**	57	57	57	58	57	57	**57**
1-10	194	194	193	194	**194**	96	96	96	96	96	96	**96**	58	56	57	57	58	57	**57**
	194	**194**	**194**	**194**	**194**	**96**	**96**	**96**	**96**	**96**	**96**	**96**	**57**	**57**	**57**	**57**	**57**	**57**	**57**

Mix 2 of Kethhena WTP Sludge																		
No	**Length**					**Width**							**Height**					
	L1	L2	L3	L4	Avg	W1	W2	W3	W4	W5	W6	**Avg**	H1	H2	H3	H4	H5	H6	**Avg**
2-1	191	191	191	192	**191**	94	94	94	94	95	94	**94**	56	57	56	56	57	56	**56**
2-2	191	191	191	191	**191**	94	94	94	94	94	94	**94**	56	56	56	57	56	57	**56**
2-3	191	191	192	192	**192**	95	94	94	95	94	95	**95**	56	56	57	56	57	56	**56**
2-4	192	192	191	192	**192**	94	94	95	94	94	94	**94**	57	56	57	56	55	56	**56**
2-5	191	192	191	191	**191**	94	94	94	94	95	95	**94**	57	55	56	56	56	57	**56**
2-6	191	191	190	191	**191**	94	95	95	95	94	94	**95**	56	56	56	57	56	57	**56**
2-7	190	191	190	191	**191**	95	94	94	94	94	94	**94**	56	56	57	56	57	55	**56**
2-8	190	191	191	190	**191**	94	94	94	94	94	94	**94**	56	57	56	57	56	55	**56**
2-9	191	190	190	190	**190**	95	95	94	94	94	94	**94**	56	57	56	55	57	56	**56**
2-10	190	190	191	191	**191**	94	94	95	94	94	94	**94**	55	56	57	56	57	56	**56**
	191	**191**	**191**	**191**	**191**	**95**	**94**	**94**	**94**	**94**	**94**	**94**	**56**	**56**	**56**	**56**	**56**	**56**	**56**

Mix 3 of Kethhena WTP Sludge

No	Length					Width							Height						
	L1	L2	L3	L4	Avg	W1	W2	W3	W4	W5	W6	**Avg**	H1	H2	H3	H4	H5	H6	**Avg**
3-1	188	189	188	189	**189**	93	94	93	94	93	93	**93**	56	55	55	56	55	55	**55**
3-2	189	188	189	188	**189**	94	93	93	94	93	93	**93**	55	55	55	56	56	55	**55**
3-3	188	189	188	189	**189**	93	94	93	93	94	93	**93**	56	55	55	56	55	55	**55**
3-4	189	188	189	188	**189**	93	93	94	93	93	94	**93**	55	56	56	55	55	55	**55**
3-5	188	189	188	189	**189**	93	93	94	93	93	94	**93**	55	56	55	55	55	56	**55**
3-6	189	188	188	189	**189**	94	93	93	94	93	93	**93**	55	55	55	55	55	56	**55**
3-7	188	189	189	188	**189**	94	93	93	93	94	93	**93**	56	55	56	55	55	55	**55**
3-8	188	189	188	189	**189**	93	93	93	94	94	93	**93**	55	55	55	56	56	55	**55**
3-9	189	188	189	188	**189**	93	94	94	93	93	94	**94**	55	55	55	55	55	55	**55**
3-10	189	188	189	189	**189**	93	94	93	93	93	94	**93**	55	56	56	55	55	55	**55**
	189	**189**	**189**	**189**	**189**	**93**	**93**	**93**	**93**	**93**	**93**	**93**	**55**	**55**	**55**	**55**	**55**	**55**	**55**

Mix 1 of Kandana WTP Sludge																			
No	**Length**					**Width**							**Height**						
	L1	L2	L3	L4	Avg	W1	W2	W3	W4	W5	W6	**Avg**	H1	H2	H3	H4	H5	H6	**Avg**
1-1	192	192	193	193	**193**	96	96	96	97	96	96	**96**	57	57	57	57	58	57	**57**
1-2	192	193	192	192	**192**	96	96	97	96	95	96	**96**	57	57	57	57	56	57	**57**
1-3	192	192	192	192	**192**	96	97	96	96	96	96	**96**	57	57	57	56	57	56	**57**
1-4	192	192	192	193	**192**	96	95	96	97	96	96	**96**	57	57	58	57	57	57	**57**
1-5	193	193	193	192	**193**	97	96	96	96	95	96	**96**	58	57	57	57	57	57	**57**
1-6	192	192	192	192	**192**	96	96	95	96	96	96	**96**	57	57	57	57	57	57	**57**
1-7	192	192	192	192	**192**	96	96	96	96	96	95	**96**	57	57	57	58	57	57	**57**
1-8	193	192	193	192	**193**	96	96	96	96	97	96	**96**	57	57	57	57	57	58	**57**
1-9	192	192	192	192	**192**	95	96	96	96	96	97	**96**	57	57	57	57	57	57	**57**
1-10	192	192	192	192	**192**	96	96	96	95	96	96	**96**	57	57	57	58	57	57	**57**
	192	**192**	**192**	**192**	**192**	**96**	**96**	**96**	**96**	**96**	**96**	**96**	**57**	**57**	**57**	**57**	**57**	**57**	**57**

Mix 2 of Kandana WTP Sludge

No	Length					Width							Height						
	L1	L2	L3	L4	Avg	W1	W2	W3	W4	W5	W6	**Avg**	H1	H2	H3	H4	H5	H6	**Avg**
2-1	190	189	190	190	**190**	94	95	93	94	94	93	**94**	56	57	56	56	56	57	**56**
2-2	190	190	189	190	**190**	94	94	94	93	94	94	**94**	57	56	56	56	56	56	**56**
2-3	190	190	190	189	**190**	94	94	94	95	93	94	**94**	56	56	56	57	56	56	**56**
2-4	189	190	190	190	**190**	93	94	94	94	94	95	**94**	57	56	56	56	57	56	**56**
2-5	190	189	190	190	**190**	94	93	94	94	94	94	**94**	56	56	57	56	56	57	**56**
2-6	190	190	189	190	**190**	94	93	93	94	94	94	**94**	57	56	56	56	56	56	**56**
2-7	190	190	190	189	**190**	94	94	94	93	93	94	**94**	56	57	56	57	56	56	**56**
2-8	189	190	190	189	**190**	93	94	94	94	94	94	**94**	57	56	56	56	56	56	**56**
2-9	190	189	190	190	**190**	94	94	94	94	94	93	**94**	56	56	56	56	57	56	**56**
2-10	190	190	189	190	**190**	94	93	94	94	94	94	**94**	57	56	57	56	56	56	**56**
	190	**190**	**190**	**190**	**190**	**94**	**94**	**94**	**94**	**94**	**94**	**94**	**57**	**56**	**56**	**56**	**56**	**56**	**56**

Mix 3 of Kandana WTP Sludge																			
No	**Length**					**Width**							**Height**						
	L1	L2	L3	L4	Avg	W1	W2	W3	W4	W5	W6	**Avg**	H1	H2	H3	H4	H5	H6	**Avg**
3-1	188	189	189	188	**189**	93	93	93	92	93	92	**93**	56	56	56	56	56	56	**56**
3-2	189	188	189	188	**189**	93	92	93	93	92	93	**93**	56	56	57	56	56	57	**56**
3-3	189	188	188	189	**189**	93	93	93	93	94	93	**93**	56	56	56	57	56	56	**56**
3-4	188	189	189	188	**189**	93	93	92	93	93	92	**93**	57	56	56	56	57	56	**56**
3-5	189	188	188	189	**189**	92	93	93	94	93	93	**93**	56	57	56	56	56	56	**56**
3-6	188	188	188	189	**188**	93	92	93	93	93	93	**93**	57	56	57	56	56	56	**56**
3-7	188	189	189	188	**189**	93	93	93	92	92	93	**93**	56	56	56	56	56	57	**56**
3-8	189	188	188	188	**188**	93	93	93	93	93	94	**93**	57	56	56	56	56	56	**56**
3-9	188	189	188	189	**189**	94	93	94	93	93	93	**93**	56	56	56	57	56	56	**56**
3-10	189	188	189	188	**189**	93	93	92	92	93	93	**93**	57	56	56	56	56	56	**56**
	189	**188**	**189**	**188**	**188**	**93**	**93**	**93**	**93**	**93**	**93**	**93**	**56**	**56**	**56**	**56**	**56**	**56**	**56**

Manufacturer Original Clay (Control Sample)																				
No	**Length**					**Width**							**Height**							
	L1	L2	L3	L4	Avg	W1	W2	W3	W4	W5	W6	**Avg**	H1	H2	H3	H4	H5	H6	**Avg**
1	195	195	196	196	**196**	96	97	96	96	96	97	**96**	57	58	57	58	57	57	**57**
2	195	196	196	195	**196**	96	96	96	97	97	96	**96**	57	58	57	57	57	57	**57**
3	195	196	195	196	**196**	97	96	97	96	96	96	**96**	57	57	57	57	58	57	**57**
4	196	195	195	196	**196**	96	96	96	96	96	96	**96**	58	57	57	57	57	57	**57**
5	196	195	195	195	**195**	96	96	95	96	96	97	**96**	57	58	57	57	58	57	**57**
6	195	195	196	195	**195**	96	97	96	96	96	95	**96**	57	57	58	57	57	58	**57**
7	195	195	196	195	**195**	96	97	97	96	96	96	**96**	58	57	58	57	57	57	**57**
8	195	196	195	195	**195**	97	96	96	97	96	96	**96**	57	57	57	58	57	57	**57**
9	195	196	196	196	**196**	96	96	96	97	96	97	**96**	57	57	57	57	57	57	**57**
10	196	196	195	196	**196**	97	96	96	96	97	96	**96**	58	57	57	57	57	58	**57**
	195	**196**	**196**	**196**	**195**	**96**	**96**	**96**	**96**	**96**	**96**	**96**	**57**	**57**	**57**	**57**	**57**	**57**	**57**

Compressive Strength Results

Table D.6: Observations & Results of Moisture Content

	Mix	No	Avg. Length (mm)	Avg. width (mm)	Area (mm2)	Failure Load (Ton)	Compressive Strength (N/mm2)	Avg. Compressive Strength (N/mm2)
Kethhena WTP Sludge	**Mix 1** Clay: Sludge 90:10	1-1	195	94	18330	4.70	2.52	**2.87**
		1-2	194	94	18236	5.10	2.74	
		1-3	194	96	18624	6.14	3.23	
		1-4	198	96	19008	5.78	2.98	
		1-5	194	94	18236	4.96	2.67	
		1-6	197	97	19109	6.16	3.16	
		1-7	194	94	18236	5.36	2.88	
		1-8	196	93	18228	4.74	2.55	
		1-9	194	95	18430	5.40	2.87	
		1-10	195	97	18915	6.06	3.14	
	Mix 2 Clay: Sludge 80:20	2-1	193	94	18142	4.36	2.36	**2.49**
		2-2	193	95	18335	5.24	2.80	
		2-3	190	95	18050	5.06	2.75	
		2-4	190	93	17670	4.32	2.40	
		2-5	193	93	17949	4.18	2.28	
		2-6	193	94	18142	4.08	2.21	
		2-7	190	94	17860	4.86	2.67	
		2-8	190	94	17860	4.40	2.42	
		2-9	190	95	18050	4.76	2.59	
		2-10	190	93	17670	4.46	2.48	
	Mix 3 Clay: Sludge 70:30	3-1	189	94	17766	3.16	1.74	**1.91**
		3-2	190	94	17860	3.60	1.98	
		3-3	187	93	17391	2.90	1.64	
		3-4	188	95	17860	3.50	1.92	
		3-5	188	94	17672	3.70	2.05	
		3-6	187	93	17391	3.40	1.92	
		3-7	188	94	17672	3.36	1.87	
		3-8	190	94	17860	3.58	1.97	
		3-9	190	93	17670	3.64	2.02	
		3-10	189	93	17577	3.60	2.01	

	Mix	No	Avg. Length (mm)	Avg. width (mm)	Area (mm2)	Failure Load (Ton)	Compressive Strength (N/mm2)	Avg. Compressive Strength (N/mm2)
Kandana WTP Sludge	**Mix 1** Clay: Sludge 90:10	1-1	194	98	19012	5.5	2.84	**2.76**
		1-2	192	95	18240	5.1	2.74	
		1-3	192	95	18240	5.0	2.69	
		1-4	190	95	18050	4.9	2.66	
		1-5	191	93	17763	4.5	2.49	
		1-6	192	96	18432	5.3	2.82	
		1-7	190	95	18050	5.2	2.83	
		1-8	194	98	19012	5.6	2.89	
		1-9	195	96	18720	5.4	2.83	
		1-10	192	97	18624	5.3	2.79	
	Mix 2 Clay: Sludge 80:20	2-1	188	93	17484	3.9	2.19	**2.24**
		2-2	189	94	17766	4.3	2.37	
		2-3	191	95	18145	4.5	2.43	
		2-4	188	92	17296	3.4	1.93	
		2-5	188	92	17296	3.7	2.10	
		2-6	190	95	18050	4.4	2.39	
		2-7	192	96	18432	4.6	2.45	
		2-8	192	95	18240	4.2	2.26	
		2-9	192	96	18432	4.3	2.29	
		2-10	188	92	17296	3.5	1.99	
	Mix 3 Clay: Sludge 70:30	3-1	186	93	17298	3.1	1.76	**1.85**
		3-2	190	94	17860	3.7	2.03	
		3-3	186	91	16926	2.8	1.62	
		3-4	191	94	17954	3.9	2.13	
		3-5	188	93	17484	3.3	1.85	
		3-6	190	94	17860	3.6	1.98	
		3-7	189	93	17577	3.4	1.90	
		3-8	187	93	17391	3.0	1.69	
		3-9	189	93	17577	3.2	1.79	
		3-10	186	92	17112	3.0	1.72	

	Mix	No	Avg. Length (mm)	Avg. width (mm)	Area (mm2)	Failure Load (Ton)	Compressive Strength (N/mm2)	Avg. Compressive Strength (N/mm2)
ManufacturerOriginal Bricks	Clay: Sludge 100:00	1	196	94	18424	8.1	4.31	**4.23**
		2	195	97	18915	8.3	4.30	
		3	198	97	19206	8.6	4.39	
		4	195	96	18720	8.2	4.30	
		5	195	97	18915	8.5	4.41	
		6	195	96	18720	7.9	4.14	
		7	197	94	18518	7.8	4.13	
		8	193	96	18528	8.3	4.39	
		9	195	97	18915	7.7	3.99	
		10	193	96	18528	7.4	3.92	

Water Absorption

Table D.7: Observations & Results of Moisture Content

	Mix	No	Oven dried Weight (g)	Weight after immersion (g)	Absorption (Percentage)	Avg. Absorption (Percentage)
Kethhena WTP Sludge	**Mix 1** Clay: Sludge 90:10	1-1	1400.7	1729.2	23.45	**23.59**
		1-2	1450.2	1784.1	23.02	
		1-3	1411.6	1749.3	23.92	
		1-4	1401.1	1722.7	22.95	
		1-5	1378.9	1712.2	24.17	
		1-6	1385.2	1718.0	24.03	
	Mix 2 Clay: Sludge 80:20	2-1	1277.0	1605.5	25.72	**25.42**
		2-2	1261.0	1593.3	26.35	
		2-3	1302.0	1635.2	25.59	
		2-4	1343.5	1673.9	24.59	
		2-5	1273.2	1599.0	25.59	
		2-6	1277.0	1591.9	24.66	
	Mix 3 Clay: Sludge 70:30	3-1	1097.3	1451.5	32.28	**26.30**
		3-2	1108.1	1463.5	32.07	
		3-3	1133.6	1481.1	30.65	
		3-4	1186.1	1538.5	29.71	
		3-5	1162.5	1518.5	30.62	
		3-6	1176.4	1514.4	28.73	

	Mix	No	Oven dried Weight (g)	Weight after immersion (g)	Absorption (Percentage)	Avg. Absorption (Percentage)
Kandana WTP Sludge	**Mix 1** Clay: Sludge 90:10	1-1	1387.3	1705.2	22.92	**23.11**
		1-2	1444.0	1766.4	22.33	
		1-3	1453.1	1798.2	23.75	
		1-4	1445.4	1784.0	23.43	
		1-5	1444.5	1778.0	23.09	
		1-6	1371.6	1688.8	23.13	
	Mix 2 Clay: Sludge 80:20	2-1	1283.8	1608.3	25.28	**25.36**
		2-2	1276.2	1600.4	25.40	
		2-3	1270.1	1595.0	25.58	
		2-4	1267.0	1586.0	25.18	
		2-5	1306.3	1635.9	25.23	
		2-6	1281.4	1607.8	25.47	
	Mix 3 Clay: Sludge 70:30	3-1	1107.6	1448.0	30.73	**30.29**
		3-2	1142.7	1485.0	29.96	
		3-3	1124.3	1466.7	30.45	
		3-4	1140.4	1477.7	29.58	
		3-5	1112.4	1444.0	29.81	
		3-6	1108.2	1454.4	31.24	

	Mix	No	Oven dried Weight (g)	Weight after immersion (g)	Absorption (Percentage)	Avg. Absorption (Percentage)
Manufacturer Original Clay	Clay: Sludge 100:00	1	1504.6	1811.0	20.36	**20.22**
		2	1603.7	1926.7	20.14	
		3	1563.0	1874.1	19.90	
		4	1527.9	1849.3	21.04	
		5	1572.3	1893.4	20.42	
		6	1579.0	1886.6	19.48	

Appendix E - Test Results of Cement Mortar

Table E.1: Observation & Results of Moisture Content

Material	Sample No.	Weight of can (g)	Weight of wet soil +can (g)	Weight of dry soil + can (g)	Moisture Content (%)	Avg. Moisture Content (%)
WTP Sludge Kandana	1	23.670	38.393	36.361	13.80	13.67
	2	53.512	72.737	70.152	13.45	
	3	68.236	96.587	92.682	13.77	

Table E.2: Data and Result of Sieve Analysis Test for Sand

Sieve size (mm)	Sieve weight (g)	Mass + Sieve (g)	Mass in each Sieve (g)	Cumulative Mass Retained (g)	Cumulative Retained (%By mass)	Passing (% By mass)
4.250	1500.0	1524.3	24.3	24.3	1.62	100.00
2.800	577.9	630.4	52.5	76.8	5.12	94.88
1.180	508.2	846.8	338.6	415.4	27.69	72.31
0.850	483.1	714.3	231.2	646.6	43.11	56.89
0.600	468.5	750.4	281.9	928.5	61.90	38.10
0.300	432.1	857.6	425.5	1354.0	90.27	9.73
0.150	405.6	525.2	119.6	1473.6	98.24	1.76
pan	542.5	568.5	26.0	1499.6	99.97	0.03

Table E.3: Observation and Calculation of SpecificGravityTest

Material	Trial No	W_1	W_2	W_3	W_4	(W_2-W_1)	$(W_4-W_1) - (W_3-W_2)$	Specific gravity
Sand	1	26.553	77.185	107.773	76.314	50.632	19.173	2.64
	2	24.675	75.474	105.285	73.624	50.799	19.138	2.65
	3	26.599	77.313	107.795	76.202	50.714	19.121	2.65
	Average							**2.65**
WTP Sludge	1	24.677	46.355	82.979	74.745	21.678	13.444	1.61
	2	26.552	48.256	84.659	76.328	21.704	13.373	1.62
	3	26.597	48.321	84.853	76.521	21.724	13.392	1.62
	Average							**1.62**

Calculation

Specific gravity = $(W_2-W_1) / \{(W_4-W_1) - (W_3-W_2)\}$

Where

Weight of specific gravity bottle - W_1 (g)

Weight of specific gravity bottle and one third of aggregate - W_2 (g)

Weight of specific gravity bottle, one-third of aggregate and water - W_3 (g)

Weight of specific gravity bottle and water - W_4 (g)

Table E.4: Observation &Results of Flow Table Test of Mortar

Mix number	0.5		0.7		0.9		1.1		1.3		1.5	
	X (mm)	Y (mm)	X (mm)	Y (mm)	X (mm)	Y (mm)	X (mm)	Y (mm)	X (mm)	Y (mm)	X (mm)	Y (mm)
1-1	210	210	200	160	180	155	120	130	165	160	175	175
1-2	200	200	190	200	200	185	120	130	160	150	175	175
2-1	185	160	120	190	115	125	170	160	190	180	200	210
2-2	165	165	140	180	115	120	150	155	185	185	210	210
3-1	210	210	155	165	120	125	150	140	175	160	170	185
3-2	210	190	170	165	125	125	170	150	155	170	185	195
4-1	170	160	160	180	130	140	160	155	190	185	205	195
4-2	200	160	160	160	125	130	160	155	190	195	205	200

Table E.4: Flow Value of Mortar

Mix	Water to Cement Ratio					
	0.5	**0.7**	**0.9**	**1.1**	**1.3**	**1.5**
1	205.0	187.5	180.0	125.0	158.8	175.0
2	168.8	157.5	118.8	158.8	185.0	207.5
3	205.0	163.8	123.8	152.5	165.0	183.8
4	172.5	165.0	131.3	157.5	190.0	201.3

Table E.5: Flow Percentage of Mortar

Mix	Water to Cement Ratio					
	0.5	**0.7**	**0.9**	**1.1**	**1.3**	**1.5**
1	192.9	167.9	**157.1**	**78.6**	**126.8**	**150.0**
2	141.1	**125.0**	**69.6**	**126.8**	164.3	196.4
3	192.9	**133.9**	**76.8**	**117.9**	135.7	162.5
4	146.4	**135.7**	**87.5**	**125.0**	171.4	187.5

Table E.6: Observation & Results of Compressive Strength Tests of Mortar at 7days

Mix	W/C ratio	Cube No	Avg. Length (mm)	Avg. width (mm)	Area (mm2)	Failure Load (kN)	Compressive Strength (N/mm2)	Avg. Compressive Strength (N/mm2)
Mix 1 Sand: Sludge 100: 0	1.1	1-1	70	70	4900	16.1	3.29	3.16
		1-2	71	70	4970	14.9	3.00	
		1-3	70	70	4900	15.6	3.18	
	1.3	1-1	70	70	4900	13.9	2.84	2.82
		1-2	70	70	4900	13.2	2.69	
		1-3	70	71	4970	14.5	2.92	
	1.5	1-1	71	70	4970	14.0	2.82	2.78
		1-2	70	71	4970	13.3	2.68	
		1-3	70	70	4900	14.0	2.86	
Mix 2 Sand: Sludge 90:10	0.7	2-1	70	71	4970	32.0	6.44	6.26
		2-2	70	70	4900	34.8	7.10	
		2-3	70	70	4900	25.7	5.24	
	0.9	2-1	71	70	4970	28.4	5.71	5.96
		2-2	70	70	4900	29.7	6.06	
		2-3	70	71	4970	30.4	6.12	
	1.1	2-1	71	70	4970	13.9	2.80	2.67
		2-2	70	70	4900	13.2	2.69	
		2-3	70	70	4900	12.4	2.53	
Mix 3 Sand: Sludge 80:20	0.7	3-1	70	71	4970	26.8	5.39	5.78
		3-2	71	70	4970	30.0	6.04	
		3-3	70	70	4900	28.9	5.90	
	0.9	3-1	70	70	4900	23.3	4.76	4.86
		3-2	70	71	4970	24.1	4.85	
		3-3	70	70	4900	24.4	4.98	
	1.1	3-1	70	71	4970	12.1	2.43	2.54
		3-2	70	70	4900	13.6	2.78	
		3-3	70	70	4900	11.8	2.41	

Mix	W/C ratio	Cube No	Avg. Length (mm)	Avg. width (mm)	Area (mm2)	Failure Load (kN)	Compressive Strength (N/mm2)	Avg. Compressive Strength (N/mm2)
Mix 4 Sand: Sludge 70:30	0.7	4-1	70	70	4900	25.5	5.20	5.01
		4-2	70	70	4900	23.2	4.73	
		4-3	70	71	4970	25.3	5.09	
	0.9	4-1	70	70	4900	16.9	3.45	3.56
		4-2	71	70	4970	14.5	2.92	
		4-3	70	71	4970	21.5	4.33	
	1.1	4-1	70	70	4900	7.0	1.43	1.57
		4-2	70	70	4900	8.1	1.65	
		4-3	70	71	4970	8.1	1.63	

Table E.7: Observation & Results of Compressive Strength Tests of Mortar at 14days

Mix	W/C ratio	Cube No	Avg. Length (mm)	Avg. width (mm)	Area (mm2)	Failure Load (kN)	Compressive Strength (N/mm2)	Avg. Compressive Strength (N/mm2)
Mix 1 Sand: Sludge 100: 0	1.1	1-1	70	70	4900	22.9	4.67	4.66
		1-2	71	70	4970	22.5	4.53	
		1-3	70	70	4900	23.4	4.78	
	1.3	1-1	70	70	4900	20.9	4.27	4.26
		1-2	71	70	4970	21.5	4.33	
		1-3	70	70	4900	20.5	4.18	
	1.5	1-1	70	70	4900	16.6	3.39	3.39
		1-2	71	70	4970	17.3	3.48	
		1-3	70	71	4970	16.4	3.30	
Mix 2 Sand: Sludge 90:10	0.7	2-1	70	70	4900	38.1	7.78	7.61
		2-2	70	70	4900	41.5	8.47	
		2-3	71	70	4970	32.8	6.60	
	0.9	2-1	70	70	4900	30.2	6.16	6.37
		2-2	70	70	4900	31.7	6.47	
		2-3	71	70	4970	32.2	6.48	
	1.1	2-1	71	70	4970	14.5	2.92	3.03
		2-2	70	70	4900	15.3	3.12	
		2-3	70	70	4900	15.0	3.06	
Mix 3 Sand: Sludge 80:20	0.7	3-1	70	70	4900	31.5	6.43	6.87
		3-2	70	70	4900	36.8	7.51	
		3-3	71	70	4970	33.1	6.66	
	0.9	3-1	70	70	4900	26.8	5.47	5.75
		3-2	70	70	4900	28.3	5.78	
		3-3	71	70	4970	29.8	6.00	
	1.1	3-1	70	70	4900	14.2	2.90	2.83
		3-2	71	70	4970	14.1	2.84	
		3-3	70	70	4900	13.5	2.76	

Mix	W/C ratio	Cube No	Avg. Length (mm)	Avg. width (mm)	Area (mm2)	Failure Load (kN)	Compressive Strength (N/mm2)	Avg. Compressive Strength (N/mm2)
Mix 4 Sand: Sludge 70:30	0.7	4-1	70	70	4900	27.8	5.67	5.40
		4-2	71	70	4970	24.8	4.99	
		4-3	70	70	4900	27.2	5.55	
	0.9	4-1	70	70	4900	18.4	3.76	3.91
		4-2	71	70	4970	17.0	3.42	
		4-3	70	71	4970	22.6	4.55	
	1.1	4-1	70	70	4900	9.1	1.86	2.17
		4-2	70	70	4900	10.6	2.16	
		4-3	71	70	4970	12.4	2.49	

Table E.8: Observation & Results of Compressive Strength Tests of Mortar at 28days

Mix	W/C ratio	Cube No	Avg. Length (mm)	Avg. width (mm)	Area (mm2)	Failure Load (kN)	Compressive Strength (N/mm2)	Avg. Compressive Strength (N/mm2)
Mix 1 Sand: Sludge 100: 0	1.1	1-1	70	70	4900	30.6	6.24	7.18
		1-2	71	70	4970	35.9	7.22	
		1-3	70	70	4900	39.5	8.06	
	1.3	1-1	70	70	4900	33.8	6.90	6.53
		1-2	70	70	4900	30.3	6.18	
		1-3	70	71	4970	32.3	6.50	
	1.5	1-1	71	70	4970	25.9	5.21	5.88
		1-2	70	71	4970	32.6	6.56	
		1-3	70	70	4900	28.8	5.88	
Mix 2 Sand: Sludge 90:10	0.7	2-1	70	70	4900	46.5	9.49	9.72
		2-2	71	70	4970	53.7	10.80	
		2-3	70	70	4900	43.5	8.88	
	0.9	2-1	70	70	4900	35.6	7.27	6.91
		2-2	70	70	4900	33.4	6.82	
		2-3	70	71	4970	33.1	6.66	
	1.1	2-1	71	70	4970	26.6	5.35	6.46
		2-2	70	71	4970	35.6	7.16	
		2-3	70	70	4900	33.6	6.86	
Mix 3 Sand: Sludge 80:20	0.7	3-1	70	70	4900	47.0	9.59	8.71
		3-2	71	70	4970	39.9	8.03	
		3-3	70	70	4900	41.7	8.51	
	0.9	3-1	70	70	4900	34.4	7.02	6.96
		3-2	70	70	4900	32.2	6.57	
		3-3	70	71	4970	36.2	7.28	
	1.1	3-1	71	70	4970	15.5	3.12	3.61
		3-2	70	71	4970	18.9	3.80	
		3-3	70	70	4900	19.1	3.90	

Mix	W/C ratio	Cube No	Avg. Length (mm)	Avg. width (mm)	Area (mm2)	Failure Load (kN)	Compressive Strength (N/mm2)	Avg. Compressive Strength (N/mm2)
Mix 4 Sand: Sludge 70:30	0.7	4-1	70	70	4900	31.3	6.39	6.17
		4-2	71	70	4970	30.6	6.16	
		4-3	70	70	4900	29.2	5.96	
	0.9	4-1	70	70	4900	17.3	3.53	4.32
		4-2	70	70	4900	21.4	4.37	
		4-3	70	71	4970	25.2	5.07	
	1.1	4-1	71	70	4970	15.0	3.02	3.10
		4-2	70	71	4970	19.0	3.82	
		4-3	70	70	4900	12.0	2.45	

Appendix F - Test Results of Concrete Paving Blocks

Table F.1: Observation & Calculation of Moisture Content

Material	Trial No	Weight of can (g)	Weight of wet soil + can (g)	Weight of dry soil + can (g)	Moisture Content (%)	Avg. Moisture Content (%)
WT PSludge	1	20.980	29.459	27.466	23.51	23.87
	2	57.244	72.737	69.044	23.84	
	3	57.240	81.669	75.737	24.28	
Bottom Ash	1	53.948	61.747	60.171	20.21	20.61
	2	56.22	76.65	72.43	20.66	
	3	75.477	88.351	85.65	20.98	

Table F.2: Observation & Calculation of Specific Gravity

Material	Trial No	W_1	W_2	W_3	W_4	(W_2-W_1)	$(W_4-W_1) - (W_3-W_2)$	Specific gravity
Sand	1	26.553	77.185	107.773	76.314	50.632	19.173	2.64
	2	24.675	75.474	105.285	73.624	50.799	19.138	2.65
	3	26.599	77.313	107.795	76.202	50.714	19.121	2.65
								2.65
WT PSludge	1	24.777	37.783	77.726	74.745	13.006	10.025	1.30
	2	26.598	40.346	80.254	76.952	13.748	10.446	1.32
	3	24.68	37.856	77.668	74.736	13.176	10.244	1.29
								1.
Bottom Ash	1	26.599	37.028	79.971	76.275	10.429	6.733	1.55
	2	24.78	35.126	77.956	74.256	10.346	6.646	1.56
	3	26.534	35.524	78.836	75.632	8.99	5.786	1.55
								1.55
Coarse Aggregate	1	24.62	60.389	96.342	76.293	35.769	15.72	2.28
	2	26.595	62.429	97.231	77.325	35.834	15.928	2.25
	3	26.583	61.89	95.856	76.293	35.307	15.744	2.24
	Average							**2.26**

Specific gravity = $(W_2-W_1)/((W_4-W_1)-(W_3-W_2))$

Where

Weight of specific gravity bottle - W_1 (g)

Weight of specific gravity bottle and one third of aggregate - W_2 (g)

Weight of specific gravity bottle, one-third of aggregate and water- W_3 (g)

Weight of specific gravity bottle and water - W_4 (g)

Table F.3: Data and Result of Sieve Analysis Test

Sand						
Sieve size (mm)	**Sieve weight (g)**	**Mass + sieve (g)**	**Mass in each sieve (g)**	**Cumulative mass retained (g)**	**Cumulative retained (%By mass)**	**Passing (% By mass)**
4.250	1500.0	1524.3	24.3	24.3	1.62	100.00
2.800	577.9	630.4	52.5	76.8	5.12	94.88
1.180	508.2	846.8	338.6	415.4	27.69	72.31
0.850	483.1	714.3	231.2	646.6	43.11	56.89
0.600	468.5	750.4	281.9	928.5	61.90	38.10
0.300	432.1	857.6	425.5	1354.0	90.27	9.73
0.150	405.6	525.2	119.6	1473.6	98.24	1.76
pan	542.5	568.5	26.0	1499.6	99.97	0.03
Water Treatment Plant Sludge (Kethhena)						
Sieve size (mm)	**Sieve weight (g)**	**Mass + sieve (g)**	**Mass in each sieve (g)**	**Cumulative mass retained (g)**	**Cumulative retained (%By mass)**	**Passing (% By mass)**
3.35	546	546	0	0	0	100
2.36	527	527	0	0	0	100
2	376	377	1	1	0.1	99.9
1.18	366	400	34	35	3.5	96.5
0.6	471	820	349	384	38.4	61.6
0.425	303	700	397	781	78.1	21.9
0.3	299	395	96	877	87.7	12.3
0.212	281	380	99	976	97.6	2.4
0.15	278	280	2	978	97.8	2.2
0.075	402	417	15	993	99.3	0.7
pan	462	466	4	997	99.7	0.3

Bottom Ash						
Sieve size (mm)	**Sieve weight (g)**	**Mass + sieve (g)**	**Mass in each sieve (g)**	**Cumulative mass retained (g)**	**Cumulative retained (%By mass)**	**Passing (% By mass)**
3.35	545	546	1	0	0	100
2.36	528	625	97	97	9.7	90.3
2	376	416	40	137	13.7	86.3
1.18	365	442	77	214	21.4	78.6
0.6	470	582	112	326	32.6	67.4
0.425	304	342	38	364	36.4	63.6
0.3	300	348	48	412	41.2	58.8
0.212	281	385	104	516	51.6	48.4
0.15	277	513	236	752	75.2	24.8
0.075	401	503	102	854	85.4	14.6
pan	462	606	144	998	99.8	0.2

Table F.4: Compressive Strength of Concrete Paving Block at 7 days

Mix	No	Weight of the shape (g)	Weight of the rect. (g)	Area (mm2)	Failure Load (kN)	Compressive Strength (N/mm2)	Avg. Compressive Strength (N/mm2)
Mix 1	1-1	5.2	4.3	24190	1153.5	56.30	53.00
	1-2	5.2	4.3	24190	871.5	42.50	
	1-3	5.5	4.3	25580	1244.8	57.40	
Mix 2	2-1	5.4	4.3	25120	732.5	34.40	40.00
	2-2	5.2	4.3	24190	858.5	41.90	
	2-3	5.4	4.3	25120	907.0	42.60	
Mix 3	3-1	5.4	4.3	25120	596.3	28.00	28.00
	3-2	5.3	4.3	24650	584.3	28.00	
	3-3	5.5	4.3	25580	596.6	27.50	
Mix 4	4-1	5.4	4.3	25120	428.8	20.10	20.00
	4-2	5.3	4.3	24650	387.2	18.50	
	4-3	5.4	4.3	25120	397.6	18.70	
Mix 5	5-1	5.0	4.0	25000	428.8	20.20	18.00
	5-2	5.0	4.0	25000	357.7	16.90	
	5-3	5.0	4.0	25000	346.9	16.40	
Mix 6	6-1	5.3	4.3	24650	689.4	33.00	31.00
	6-2	5.5	4.3	25580	637.2	29.40	
	6-3	5.4	4.3	25120	631.8	29.70	
Mix 7	7-1	5.3	4.3	24650	569.3	27.30	28.00
	7-2	5.3	4.3	24650	597.8	28.60	
	7-3	5.9	4.3	27440	624.3	26.80	
Mix 8	8-1	5.3	4.3	24650	416.3	19.90	22.00
	8-2	5.4	4.3	25120	549.3	25.80	
	8-3	5.4	4.3	25120	380.4	17.90	
Mix 9	9-1	5.3	4.3	24650	410.5	19.70	20.00
	9-2	5.4	4.3	25120	380.7	17.90	
	9-3	5.4	4.3	25120	420.6	19.80	

Table F.5: Compressive Strength of Concrete Paving Block at 14 days

Mix	No	Weight of the shape	Weight of the rect.	Area (mm2)	Failure Load (kN)	Compressive Strength (N/mm2)	Avg. Compressive Strength
Mix 1	1-1	4.9	4.3	22790	1098.9	56.90	61.00
	1-2	4.8	4.3	22330	1280.0	67.60	
	1-3	5.1	4.3	23720	1158.5	57.60	
Mix 2	2-1	5.0	4.3	23260	927.7	47.10	50.00
	2-2	4.7	4.3	21860	962.3	51.90	
	2-3	4.8	4.3	22330	924.1	48.80	
Mix 3	3-1	5.1	4.3	23720	729.1	36.30	37.00
	3-2	5.0	4.3	23260	675.6	34.30	
	3-3	5.0	4.3	23260	791.2	40.10	
Mix 4	4-1	5.0	4.3	23260	601.4	30.50	29.00
	4-2	5.1	4.3	23720	578.7	28.80	
	4-3	5.1	4.3	23720	538.3	26.80	
Mix 5	5-1	5.0	4.3	23260	565.1	28.70	27.00
	5-2	4.9	4.3	22790	518.9	26.90	
	5-3	5.1	4.3	23720	484.2	24.10	
Mix 6	6-1	5.0	4.3	23260	996.3	50.50	49.00
	6-2	5.1	4.3	22720	920.0	47.80	
	6-3	4.9	4.3	22790	885.0	45.80	
Mix 7	7-1	5.0	4.3	23260	663.7	33.70	39.00
	7-2	4.9	4.3	22790	782.8	40.50	
	7-3	5.1	4.3	23720	842.7	41.90	
Mix 8	8-1	5.0	4.3	23260	556.2	28.20	32.00
	8-2	5.0	4.3	23260	657.2	33.30	
	8-3	4.9	4.3	22790	630.2	32.60	
Mix 9	9-1	5.0	4.3	23260	580.0	29.40	28.00
	9-2	5.1	4.3	23720	510.5	25.40	
	9-3	5.0	4.3	23260	565.6	28.70	

Table F.6: Compressive Strength of Concrete Paving Block at 28 days

Mix	No	Weight of the shape (g)	Weight of the rect. (g)	Area (mm2)	Failure Load (kN)	Compressive Strength (N/mm2)	Avg. Compressive Strength (N/mm2)
Mix 1	1-1	5.2	4.3	24190	1406.8	68.60	70.00
	1-2	5.2	4.3	24190	1476.6	72.00	
	1-3	5.5	4.3	25580	1456.5	67.20	
Mix 2	2-1	5.4	4.3	25120	1190.7	55.90	56.00
	2-2	5.2	4.3	24190	1123.0	54.80	
	2-3	5.4	4.3	25120	1191.0	55.90	
Mix 3	3-1	5.4	4.3	25120	973.2	45.70	45.00
	3-2	5.3	4.3	24650	976.0	46.70	
	3-3	5.5	4.3	25580	910.2	42.00	
Mix 4	4-1	5.4	4.3	25120	655.4	30.80	34.00
	4-2	5.3	4.3	24650	730.1	35.00	
	4-3	5.4	4.3	25120	735.6	34.60	
Mix 5	5-1	5.0	4.0	25000	655.8	31.00	32.00
	5-2	5.0	4.0	25000	622.0	29.40	
	5-3	5.0	4.0	25000	696.9	32.90	
Mix 6	6-1	5.0	4.0	25000	1155.5	54.50	54.00
	6-2	5.0	4.0	25000	1122.4	53.00	
	6-3	4.9	4.0	24500	1096.9	52.80	
Mix 7	7-1	5.1	4.0	25500	909.5	42.10	46.00
	7-2	5.0	4.0	25000	996.9	47.10	
	7-3	5.0	4.0	25000	971.4	45.90	
Mix 8	8-1	4.9	4.0	24500	747.5	36.00	37.00
	8-2	5.0	4.0	25000	774.5	36.60	
	8-3	5.0	4.0	25000	752.3	35.50	
Mix 9	9-1	4.9	4.0	24500	735.2	35.40	34.00
	9-2	5.0	4.0	25000	710.5	33.50	
	9-3	5.0	4.0	25000	680.0	32.10	

Table F.7: Unpolished Slip Resistance Value of Paving Block

Mix	No	USRV – (Unpolished Slip Resistance for Paving Blocks)					Average of each	Avg. USRV
Mix 1	1-1	95	90	90	90	90	91	90
	1-2	90	90	90	95	90	91	
	1-3	90	85	90	90	90	89	
Mix 2	2-1	90	85	90	85	85	87	86
	2-2	85	90	85	85	85	86	
	2-3	85	85	85	80	85	84	
Mix 3	3-1	80	80	85	85	85	83	80
	3-2	75	80	80	85	80	80	
	3-3	80	75	75	80	80	78	
Mix 4	4-1	80	80	80	75	80	79	78
	4-2	80	75	75	80	75	77	
	4-3	75	80	80	80	75	78	
Mix 5	5-1	75	75	80	75	70	75	76
	5-2	80	80	80	75	70	77	
	5-3	75	80	80	80	70	77	
Mix 6	6-1	75	75	75	75	75	75	75
	6-2	75	75	75	70	75	74	
	6-3	80	75	75	70	75	75	
Mix 7	7-1	75	70	70	70	75	72	72
	7-2	70	75	75	70	70	72	
	7-3	75	75	70	75	70	73	
Mix 8	8-1	65	65	70	70	70	68	68
	8-2	70	70	65	65	70	68	
	8-3	65	70	70	65	70	68	
Mix 9	9-1	65	60	60	65	65	63	63
	9-2	60	65	65	65	60	63	
	9-3	65	65	65	60	65	64	

Table F.8 : Water Absorption of Paving Block

Mix	No	Dry Weight (kg)	Wet Weight (kg)	Water Absorption (%)	Avg. Water Absorption (%)
Mix 1	1-1	4803.4	4991.4	3.91	4.06
	1-2	4787.9	4996.5	4.36	
	1-3	4811.0	4999.0	3.91	
Mix 2	2-1	4718.2	4952.6	4.97	4.93
	2-2	4696.1	4912.6	4.61	
	2-3	4727.7	4973.9	5.21	
Mix 3	3-1	4639.0	4877.5	5.14	5.22
	3-2	4664.0	4909.8	5.27	
	3-3	4663.0	4907.8	5.25	
Mix 4	4-1	4395.0	4560.0	3.75	6.23
	4-2	4488.0	4782.0	6.55	
	4-3	4490.0	4867.0	8.40	
Mix 5	5-1	4062.2	4451.0	9.57	9.41
	5-2	4013.7	4386.0	9.27	
	5-3	4133.9	4522.0	9.39	
Mix 6	6-1	4642.0	4964.0	6.94	6.48
	6-2	4686.7	4952.0	5.66	
	6-3	4363.0	4662.0	6.85	
Mix 7	7-1	4563.0	4913.0	7.67	6.77
	7-2	4684.0	4961.0	5.91	
	7-3	4634.0	4945.0	6.71	
Mix 8	8-1	4356.0	4733.0	8.65	8.48
	8-2	4437.0	4784.0	7.82	
	8-3	4388.0	4781.0	8.96	
Mix 9	9-1	4022.0	4451.0	10.67	10.51
	9-2	3974.0	4386.0	10.37	
	9-3	4093.0	4522.0	10.48	