

GOVERNMENT OF THE PUNJAB
AGRICULTURE DEPARTMENT

MANUAL

Watercourse Design and Improvement with Precast Concrete Parabolic Segments (PCPS)



Directorate General Agriculture (Water Management)
Punjab, Lahore



**AGRICULTURE DEPARTMENT
GOVERNMENT OF THE PUNJAB**

MANUAL

Watercourse Design and Improvement
with
Precast Concrete Parabolic Segments (PCPS)

May 2018

TABLE OF CONTENTS

Sr. #	Description	Page #
1.	Table of figures	ii
2.	List of Annexes	ii
3.	1. Introduction	1
4.	Background	1
5.	Pre-cast Concrete Parabolic Segments (PCPS) Lining	2
6.	2. Design of PCPS LINED Watercourse	4
7.	Design Discharge	4
8.	Flow Velocity	4
9.	Free Board	4
10.	Design Formula	4
11.	Optimum Hydraulic Cross Section	5
12.	Watercourse Design in Parabolic Shape	6
13.	Preparing Cost Estimate	15
14.	3. Manufacturing/fabrication of PCPS	17
15.	Cement	17
16.	Sand and Gravel	18
17.	3.1.1 Testing Sand for Fineness Modulus (FM)	20
18.	Table-3.3 Calculation Sheet for Fineness Modulus of Sand	23
19.	Fineness Modulus	23
20.	3.1.2 Testing Sand for Silt Contents	23
21.	3.1.3 Testing Sand and Gravel for Gradation	24
22.	Table-3.4 Test Results of Grading during Sieve Analysis of Gravel	25
23.	3.1.4 Testing Sand and Gravel for Bulk Density	25
24.	Water	27
25.	Proportions for Concrete	27
26.	Batching of Concrete Ingredients	27
27.	Water-Cement Ratio	28
28.	Mixing Procedures	29
29.	Slump Test	31
30.	Placing Concrete (Filling of Molds)	32
31.	Mold Removal	35
32.	Curing	36
33.	Compressive Strength Testing of Cubes	40
34.	4. Construction of PCPS Watercourse	42
35.	General	42
36.	Laying Out Watercourse	44
37.	Preparation of Sand Bed	44
38.	Installation of PCPS	45
39.	Backfill	46

TABLE OF FIGURES

No.	Description	Page #
Figure-1.1	Schematic View of Typical Precast Parabolic Segment	3
Figure-2.1	Cross-sectional view of Precast Parabolic Lined Section	6
Figure-2.2	Design Work Sheet for Parabolic Shape Watercourse	8
Figure-2.3	Process of Enabling Macros in PCPS Design Work Sheet	9
Figure-2.4	Isometric view for Bend Structure	14
Figure-2.5	Isometric view for Drop Structures	14
Figure-2.6	Detail of Sand Bed Below Segment and Joint	16
Figure-3.1	Cubical/Angular Aggregates vs Flaky & Elongated Aggregates	20
Figure-3.2	Sampling Aggregate from Stockpile	21
Figure-3.3	Manual Sieving of Aggregates	22
Figure-3.4	Testing sand for silt contents	24
Figure-3.5	Apparatus for Testing Bulk Density	25
Figure-3.6	Bulk Densities Comparison	27
Figure-3.7	Use of measuring box for a batch of concrete	28
Figure-3.8	Pouring Material into the Mixing Machine	30
Figure-3.9	Concrete Ready for Placing in Molds	31
Figure-3.10	Procedure of Slump test and Slump Measurement	32
Figure-3.11	Mold Preparation for Concrete Placing for PCPS	33
Figure-3.12	Setting Molds on Vibrating Table	34
Figure-3.13	Fabrication of Precast Parabolic Lining Segment	35
Figure-3.14	Curing of Pre-cast Concrete Parabolic Segments (PCPSs)	37
Figure-3.15	A Typical Atmospheric Steam Curing Cycle	40
Figure-3.16	Compression Testing of Sample Cube	41
Figure-4.1	Pre-Cast Concrete Parabolic Segments (PCPS)	43
Figure-4.2	Sand Bed Specifications for PCPS Installation	45
Figure-4.3	Sand Bed Preparation for PCPS Installation	45
Figure-4.4a	Placing PCPS in Position	46
Figure-4.4b	Checking and Adjusting PCPS for being in Horizontal Position	47
Figure-4.5	PCPS Installation Using String line	47
Figure-4.6	Finished Back Earth Filling	48

TABLE OF ANNEXURES

Sr.#	Name	Page #
1	A – Watercourse Design Tables for PCP Lining	50
2	B – Drawings for Pre-cast Concrete Parabolic Segments (PCPSs)	87
3	C – Rate Assessment Sheet for PCPSs	99
4	D – Watercourse Cost Estimate Performa	103
5	E – Blucking of Sand	106

1. INTRODUCTION

Background

The standard lining executed under previous and ongoing OFWM projects has been a rectangular shaped double brick plastered lining (channel constructed by using double brick masonry walls (23 cm) and a brick masonry floor (07 cm) plastered inside and on top of the walls). This type of lining has been adopted since the inception of OFWM program for being durable and easy to construct. Moreover, the availability of construction material (bricks, cement and sand) at local level coupled with easily available appropriate skilled labour supported brick lining. Consequently, this type of brick lining was preferred even over other low cost lining alternatives.

The present scenario is comparatively less favorable for the traditional brick lining due to following reasons:

- i. The available capacity of kiln industry may not be sufficient to meet the heavy demand of bricks for construction of remaining watercourses/irrigation schemes. Besides, the government has also launched many other development projects, which are consuming a large quantity of bricks. Private sector development projects are the third major consumer of bricks.
- ii. Continuous rise in demand for bricks has created monopoly of the kiln owners. There is no price control and the kiln owners demand rates of their own choice. The prices of bricks, therefore, are increasing continuously.
- iii. Quality of the produce is dwindling day by day. Mineral coal is rarely used for firing of bricks. Dry raw wood, bushes, weeds and even rice husk are being used by most of the kiln owners which do not create uniform heat in the kiln chambers. As a result, bricks of poor strength (locally called as “pilla”) or over burnt bricks are produced.
- iv. The kilns are generally installed in areas having non-productive soils which are normally saline in nature. The bricks made of this soil do not give desired strength and plaster on such brick masonry crumbles away with the passage of time.
- v. Brick lining requires adequate curing which is not generally practiced by WUAs.

In these circumstances, there is a need to adopt an innovative approach in selecting alternate techniques for lining to overcome the multifarious problems being faced in the field. Following are the main factors required to be kept in view while making choice for a particular lining technology:

- Technical suitability
- Economical feasibility
- Acceptability by the farming community

A particular watercourse may be designed in different shapes. Cross sectional area (A) and wetted perimeter (P) vary with shape. Until now, most of the watercourses in Punjab are improved using double brick lining with rectangular cross section (shape). Besides this technology many other lining techniques/shapes have also been developed and tested for their technical suitability, economical feasibility and acceptability by the farmers. These lining options include:

- i) Brick lining with 11 cm thick walls in rectangular shape,
- ii) Brick linings with 07 & 11 cm thick walls in trapezoidal shapes with sharp corners,
- iii) Concrete lining in trapezoidal shape with sharp/round corners,
- iv) Concrete lining in triangular shape with sharp/round corners,
- v) Precast concrete lining in semi-circular shape and
- vi) Precast concrete lining in parabolic shape.

Among these, semi-circular shape is the most hydraulically efficient cross section. However, in watercourse construction, this shape may not be practicable with regard to construction and fabrication/installation issues and poor acceptability by farmers due to its greater top widths. The next hydraulically most optimum cross section is the parabolic shape.

Pre-cast Concrete Parabolic Segments (PCPS) Lining

A schematic view of a Pre-cast Concrete Parabolic Segment (PCPS) is shown in **Figure-1.1**.

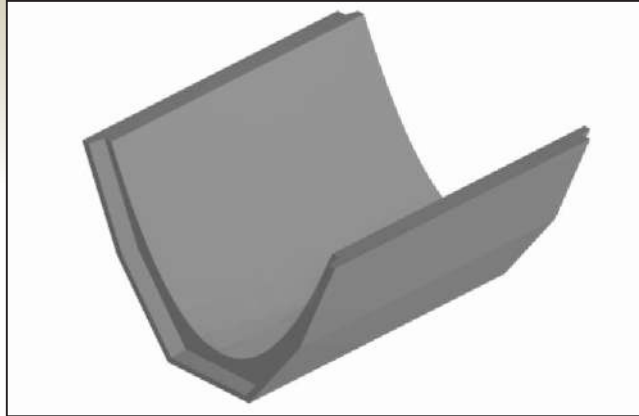


Figure-1.1 Schematic View of Typical Precast Parabolic Segment

In Punjab, PCPS lining technology is in practice since inception of the project “National Program for Improvement of Watercourses in Pakistan (NPIW)” during 2004-05 as an alternate lining technology to overcome different problems faced in the field with the brick lining. However, the use of this technology was limited due to inadequate fabrication of PCPSs confined in few districts of Punjab. Presently, donor agencies for water management projects in Pakistan have also found this lining technology most favorable due to its various advantages over brick lining given below and emphasized to line/improve all remaining un-improved watercourses with the PCPS lining technology.

- PCPS lining technology is hydraulically efficient than the rectangular brick lining.
- PCPS quality can be ensured in controlled environment at their manufacturing yards as compared with brick lining scattered on vast areas.
- Easy and speedy installation in the field as compared with brick lining technology.
- Curing of PCPS can be ensured in the yards while it is difficult to manage/ensure curing of brick lining at watercourse site.
- Involves less labor cost of installation than constructing a brick lined watercourse.
- PCPS lining has long life as compared with brick lining if properly maintained.
- PCPS lining can successfully be used in saline areas by using sulphate resistant cements while brick lining deteriorates in its early age in saline areas.

In Punjab, this lining option has also gained acceptability amongst farming community due to its various advantages mentioned above. To ensure the availability of PCPSs in all districts of Punjab, PCPS manufacturing yards have been established by private manufacturers all over the Punjab.

2. DESIGN OF PCPS LINED WATERCOURSE

This chapter includes basic criteria and hydraulic formulae involved in designing of PCPS lined watercourses.

Design Discharge

The design discharge of a watercourse is based on sanction discharge from Irrigation Department, calculated from outlet/mogha dimensions or discharge actually measured downstream mogha. The design discharge should also include additional water entering the watercourse from tubewell or any other source. Consideration, however, may also be given to the water losses while designing lower reaches or sections of the watercourse.

Flow Velocity

The design flow velocities in lined channel should be non-silting as well as non-erosive. The minimum design flow velocity may not be less than 0.15 m/s to avoid silting whereas, the maximum one should not exceed 2.5 m/s. Greater velocities may cause cavitations (formation of partial vacuum caused by swiftly moving water over a solid body) that causes pitting or wearing away of the lining material.

Free Board

Free board is the extra depth of lined channel above the designed water surface elevation to allow for most severe operating conditions. The minimum free board in parabolic/trapezoidal lined channel is recommended as 07 cm. However, depending upon design discharge and available slope, free board may vary from 07 cm to 10 cm.

Design Formula

The basic hydraulic formula for channel capacity or discharge is:

$$Q = A \times V \quad \text{----- (a)}$$

Manning's Formula for velocity is:

$$V = \frac{1}{n} R^{\frac{2}{3}} \sqrt{S} \text{ ----- (b)}$$

By combining these two formulae, channel capacity or quantity of flow can be determined by:

$$Q = \frac{1}{n} A R^{\frac{2}{3}} \sqrt{S} \text{ ----- (c)}$$

Where:

Q = Quantity of flow in cubic meters per second

V = Mean velocity in meters per second

A = Flow area in square meters

R = Hydraulic Radius in meters = A/P

P = Wetted perimeter in meters

S = Slope or energy gradient in meters drop per meter length

n = Roughness coefficient

The Manning's Roughness Coefficient (n) is the indicative of resistance or friction between water and the channel surface. In concrete channels, the value of 'n' vary from a minimum value of 0.012 to a maximum value of 0.018 with an average recommended value of 'n' as 0.014.

Optimum Hydraulic Cross Section

As indicated in equation (c) above, the discharge (Q) at a given cross section in a channel is not only dependent on the value of roughness coefficient (n), available longitudinal slope (S) and the cross sectional area (A), but also on its shape as expressed by its hydraulic radius (R). A deep & narrow channel and a wide & shallow one may both have the same cross sectional areas, but the hydraulic radius and consequently the discharge will be different. Therefore, a channel (x-sectional) shape is said to be hydraulically more efficient if it has higher hydraulic radius (R) and flow velocity (V) or lesser wetted perimeter (P) and flow area (A) for the same discharge (Q) and slope (S). Of all these cross sectional shapes, semi-circular ones have the greatest hydraulic radius and therefore, are the most hydraulically efficient cross sections. However, in watercourse construction, this shape may not be practicable with regard to construction and fabrication/installation issues and poor acceptability by farmers due to its greater top widths. The next most hydraulically efficient cross sections are parabolic ones. This design manual has been prepared for parabolic shapes as these have been found easier to fabricate and install, durable, less labour intensive and acceptable to farmers.

Watercourse Design in Parabolic Shape

Before starting with design, it is necessary to define the nomenclature of PCPS watercourse elements and dimensions which are illustrated in **Figure-2.1**.

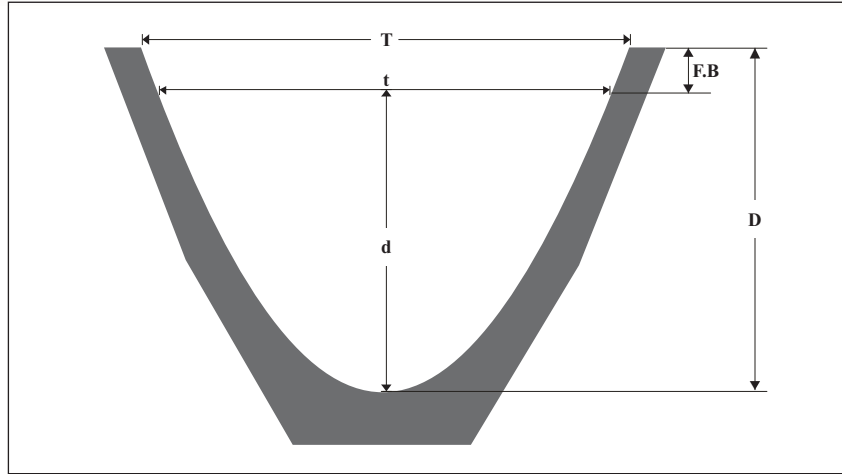


Figure-2.1 Cross-sectional view of Precast Parabolic Lined Section

Where,

T	=	Top width of watercourse
t	=	Flow width
d	=	Flow depth
D	=	Total depth of watercourse = d+FB
FB	=	Free board

As per Manning Equation:

$$V = \frac{1}{n} R^{\frac{2}{3}} \sqrt{S}$$

And formula for channel capacity or discharge is:

$$Q = A \times V$$

By combining these two formulae, channel capacity or quantity of flow can be determined by:

$$Q = \frac{1}{n} A R^{\frac{2}{3}} \sqrt{S} \quad \text{_____ (1)}$$

Equation-1 can be re-written as:

$$AR^{\frac{2}{3}} = \frac{Q \times n}{\sqrt{S}} \quad \text{_____ (2)}$$

In equation (2) above Q, S and “n” are known but area ‘A’ and hydraulic radius ‘R’ are required to be determined.

$$R = A/P$$

Flow Area (A) and Wetted Perimeter (P) for a parabolic shape watercourse can be calculated by the following Equations:

$$A = \frac{2}{3} \times t \times d$$

And,

$$P = \frac{1}{2} \sqrt{t^2 + 16d^2} + \frac{t^2}{8d} \ln \left[\frac{4d + \sqrt{t^2 + 16d^2}}{t} \right]$$

- Introducing A & P in **Equation-2** above and solving for t & d.
- Assume the value of “t” and calculate “d” accordingly.
- Velocity should be computed and then checked whether it falls within the permissible range or not.
- If the computations, do not meet the design requirement then re-examine for another value of “t” and proceed for new computations.

The Consultants have developed computer worksheet/spreadsheet to make the above complex calculations easier and time savings for preparation of watercourse design. Design worksheet developed (soft copy enclosed) for the purpose is shown as **Figure-2.2**; and procedure to use the same is given in the following section:

PUNJAB IRRIGATED-AGRICULTURE PRODUCTIVITY IMPROVEMENT PROJECT (PIPIP)
Project-Implementation Supervision Consultants (PSC)
Design Work Sheet for Parabolic Shaped Watercourse

A. Identification

1. Watercourse No.		4. Village	
2. Disty./Minor		5. Tehsil	
3. Field Team		6. District	

B. Design Requirement

Watercourse Section

Main
Branch

From (RD)	To (RD)	Length (m)

Hydraulic Data

Discharge (Q)	305 L/s
	0.305 cu.m
Roughness Coefficient (n)	0.014
Longitudinal Slope (S)	0.0004 m/m

SEGMENT SIZES AVAILABLE

Segment		Top Width (T)	Total Depth (D)	Free Board (FB)	Max. Flow Depth (d)	Flow Area (A)	Eq. Coefficient (a)
No.	Size (mmxmm)	(mm)	(mm)	(mm)	(mm)	(sq.m)	
1	360 x 225	360	225	70	155	0.054	0.008944
2	457 x 305	457	305	70	235	0.093	0.005842
3	600 x 360	600	360	70	290	0.144	0.004000
4	640 x 460	640	460	70	390	0.196	0.004492
5	675 x 480	675	480	70	410	0.216	0.004214
6	760 x 530	760	530	70	460	0.269	0.003670
6a	850 x 570	850	570	70	500	0.323	0.003156
7	920 x 610	920	610	70	540	0.374	0.002883
7a	1030 x 650	1030	650	70	580	0.446	0.002451
8	1144 x 686	1144	686	70	616	0.523	0.002097
9	1220 x 760	1220	760	70	690	0.618	0.002042

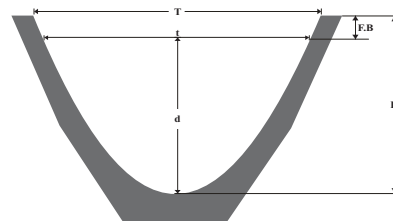
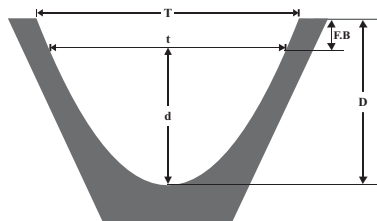
Select the Segment No. and Press "Ctrl p"

Segment No.	9
Constant "a"	0.002042
Max d	690 mm

Select when "P" and "P_cal" are almost equal

d	t	A	V	R	P	P_cal	Ratio (P_cal/P)
(mm)	(mm)	(sq.m)	(m/s)	(m)	(m)	(m)	
660.42	1137.27	0.501	0.609	0.278	1.798	1.798	1.00

Selected Flow Depth, d	660 mm
Max Allowed Flow Depth, Max d	690 mm
Difference	30 mm
Freeboard	100 mm
Check for FB, and Decide	FB is Sufficient. Select This Segment

**SEGMENT NO. 9****Figure-2.2 Design Work Sheet for Parabolic Shape Watercourse**

PCPL-Design Work Sheet_Revised 14-02-2018 - Microsoft Excel

Home Insert Page Layout Formulas Data Review View

Cut Copy Paste Format Painter Clipboard Font Alignment Number Styles

Security Warning Macros have been disabled. Options...

125 $f_x = 4 * E25 / (D25)^2$

PUNJAB IRRIGATED-AGRICULTURE PRODUCTIVITY IMPROVEMENT PROJECT (PIIP)
Project-Implementation Supervision Consultants (PSC)
 Design Work Sheet for Parabolic Shaped Watercourse

A. Identification

1. Watercourse No.

2. Disty./Minor

3. Field Team

4. Village

5. Tehsil

6. District

B. Design Requirement

Watercourse Section

From (RD)	To (RD)	Length (m)

Hydraulic Data

Discharge (Q) L/s

PCPL-Design Work Sheet_Revised 14-02-2018 - Microsoft Excel

Home Insert Page Layout Formulas Data Review View

Cut Copy Paste Format Painter Clipboard Font Alignment Number Styles

Security Warning Macros have been disabled. Options...

125 $f_x = 4 * E25 / (D25)^2$

PUNJAB IRRIGATED-AGRICULTURE PRODUCTIVITY IMPROVEMENT PROJECT (PIIP)
Project-Implementation Supervision Consultants (PSC)
 Design Work Sheet for Parabolic Shaped Watercourse

A. Identification

1. Watercourse No.

2. Disty./Minor

3. Field Team

4. Village

5. Tehsil

6. District

B. Design Requirement

Watercourse Section

From (RD)	To (RD)	Length (m)

Hydraulic Data

Discharge (Q) L/s

Microsoft Office Security Options

Security Alert - Macro

Macro

Macros have been disabled. Macros might contain viruses or other security hazards. Do not enable this content unless you trust the source of this file.

Warning: It is not possible to determine that this content came from a trustworthy source. You should leave this content disabled unless the content provides critical functionality and you trust its source.

[More information](#)

File Path: E:\Zia\WCD\PCPL-Design Work Sheet_Revised 14-02-2018.xlsm

☐ Help protect me from unknown content (recommended)

☒ Enable this content

[Open the Trust Center](#)

OK Cancel

Figure-2.3 Process of Enabling Macros in PCPL Design Work Sheet

- Open file “PCPL-Design Work Sheet” select “Options” tab and enable the macros as is illustrated in the following **Figure-2.3** and press “OK”:
- Fill Watercourse Identification information in Part “A”
- Input Data: In part B, enter the following:
 - Watercourse Section (Main or Branch)
 - Watercourse RD (from: to)
 - Design Discharge (Q), Manning’s Coefficient (n) and Longitudinal Slope (S)
- Select the Segment No. (from amongst the Segment Sizes Available as given in the Table) and Press “Ctrl P”
- Output Data:
 - Selected Flow Depth, d
 - Max Allowed Flow Depth, Max d
 - Difference (in the Selected Flow Depth and Max Allowed Flow Depth)
 - Free Board, FB
 - Check for FB, and decide (If the FB is sufficient, select the Segment Size, and if not, then select the next Segment Size and Press “Ctrl. P”
 - Repeat till the FB is sufficient and Segment Size is selected.

An alternate to computer worksheet, design tables are provided in **Annexure-A** for use in the field to select standard segment sizes (# 1 to 9), for a wide range of longitudinal slopes and discharges. A suitable segment amongst the given standard sizes can be selected depending upon available slope and design discharge.

The standard segment sizes (segments No. 1 to 9) have been designed and are being manufactured and used for lining of watercourses all over the Pakistan. Different segment sizes available with their hydraulic dimensions are given in **Table-2.1** and material requirement for fabrication of each segment size is given in **Table-2.2**. The drawings of each segment size are provided in **Annexure-B** (Figure- 1 to 11).

Table-2.1 Segment Sizes and their Hydraulic Dimensions

Segment Size (T x D)			Top Width	Depth	X-Sectional Area	Perimeter	Equation Coefficient
No.	Section (mm x mm)	Length (mm)	T (mm)	D (mm)	A (sq.m)	P (mm)	(a)
1	360 x 225	1220	360	225	0.054	593	0.006944
2	457 x 305	920	457	305	0.093	783	0.005842
3	600 x 360	920	600	360	0.144	966	0.004000
4	640 x 460	920	640	460	0.196	1150	0.004492
5	675 x 480	920	675	480	0.216	1204	0.004214
6	760 x 530	920	760	530	0.269	1339	0.003670
6a	850 x 570	920	850	570	0.323	1488	0.003156
7	920 x 610	920	920	610	0.374	1571	0.002883
7a	1030 x 650	920	1030	650	0.446	1735	0.002451
8	1144x 686	920	1144	686	0.523	1841	0.002097
9	1220 x 760	920	1220	760	0.618	2040	0.002042

Table-2.2 Material Estimate for Various PCPS Sizes

Segment Size (T x D)			Concrete Weight	Concrete Volume (Dry)	Quantities of Construction Material with Mix Ratio of 1 : 1 : 2		
			per seg	per seg.	Cement	Sand	Gravel
No.	Section (mm x mm)	Length (mm)	(kg.)	(cu.m)	(bags)	(cu.m)	(cu.m)
1	360 x 225	1220	87.19	0.0559	0.415	0.015	0.029
2	457 x 305	920	103.20	0.0662	0.491	0.017	0.035
3	600 x 360	920	123.51	0.0793	0.588	0.021	0.042
4	640 x 460	920	162.90	0.1045	0.775	0.027	0.055
5	675 x 480	920	173.66	0.1114	0.826	0.029	0.059
6	760 x 530	920	228.88	0.1469	1.089	0.039	0.077
6a	850 x 570	920	257.47	0.1652	1.225	0.043	0.087
7	920 x 610	920	286.47	0.1838	1.363	0.048	0.097
7a	1030 x 650	920	298.45	0.1915	1.420	0.050	0.101
8	1144x 686	920	309.37	0.1985	1.472	0.052	0.104
9	1220 x 760	920	394.47	0.2531	1.877	0.066	0.133

Note: Above quantities are based on concrete dry to wet ratio of 1.54, concrete density = 2400 Kg/m³ and include permissible wastages

Lining does not always follow straight alignments and uniform slopes. Field conditions/sanctioned routes may compel to commonly follow 45 or 90 degree turning of watercourse to any way (right or left). Similarly, extra head may need to be dissipated by providing drops/falls in the lining to avoid erosive velocities. Consultants has, accordingly, designed bends/drops in all available/newly added segments sizes. The design dimensions for bends and drops for each segment size are given in **Table-2.3 & 2.4**, respectively while drawings are shown in **Figure-2.4 & 2.5**. For segments 6 to 8, only 45 degree bend is feasible as the inner arc becomes so small that it may be broken/ damaged during transportation or handling during installation. For these segments 90 degree turn may be achieved by installing two bends of 45 degree. The material requirements for these designed bends are the same as those for the straight segments.

Table-2.3 Design Dimensions for 45 & 90 Degrees Bended Segments

Seg. No	Top Width, T (mm)	Total Depth, D (mm)	Bend (degree)	Centre Bottom (mm)		Outer Top (mm)		Inner Top (mm)	
				Bottom Radius (Rb)	Bottom Arc (Ab)	Top Outer Radius (Rto)	Top Outer Arc (Ato)	Top Inner Radius (Rti)	Top Inner Arc (Ati)
1	360	225	90	557	875	737	1158	377	592
	360	225	45	1115	875	1295	1016	935	734
2	457	305	90	557	875	786	1234	329	516
	457	305	45	1115	875	1343	1054	886	696
3	600	360	90	557	875	857	1346	257	404
	600	360	45	1115	875	1415	1111	815	640
4	640	460	90	557	875	877	1377	237	373
	640	460	45	1115	875	1435	1126	795	624
5	675	480	90	557	875	900	1413	215	337
	675	480	45	1115	875	1457	1144	772	606
6	760	530	45	1115	875	1495	1173	735	577
6a	850	570	45	1115	875	1540	1209	690	541
7	920	610	45	1115	875	1575	1236	655	514
7a	1030	650	45	1115	875	1630	1279	600	471
8	1144	686	45	1115	875	1687	1324	543	426

Table-2.4 Design Dimensions for Drop Structures

Seg. No	Top Width, T (mm)	Total Depth, D (mm)	Slope in Drop, Z	Lengths (mm)					
				Before Drop (b/d)	After Drop (a/d)	150 mm Drop		300 mm Drop	
						On Slope (l/s)	total	On Slope (l/s)	total
1	360	225	1.0	150	150	212	513	424	724
2	457	305	1.0	150	150	212	513	424	724
3	600	360	1.0	150	150	212	513	424	724
4	640	460	1.0	150	150	212	513	424	724
5	675	480	1.0	150	150	212	513	424	724
6	760	530	1.0	150	150	212	513	424	724
6a	850	570	1.0	150	150	212	513	424	724
7	920	610	1.0	150	150	212	513	424	724
7a	1030	650	1.0	150	150	212	513	424	724
8	1144	686	1.0	150	150	212	513	424	724

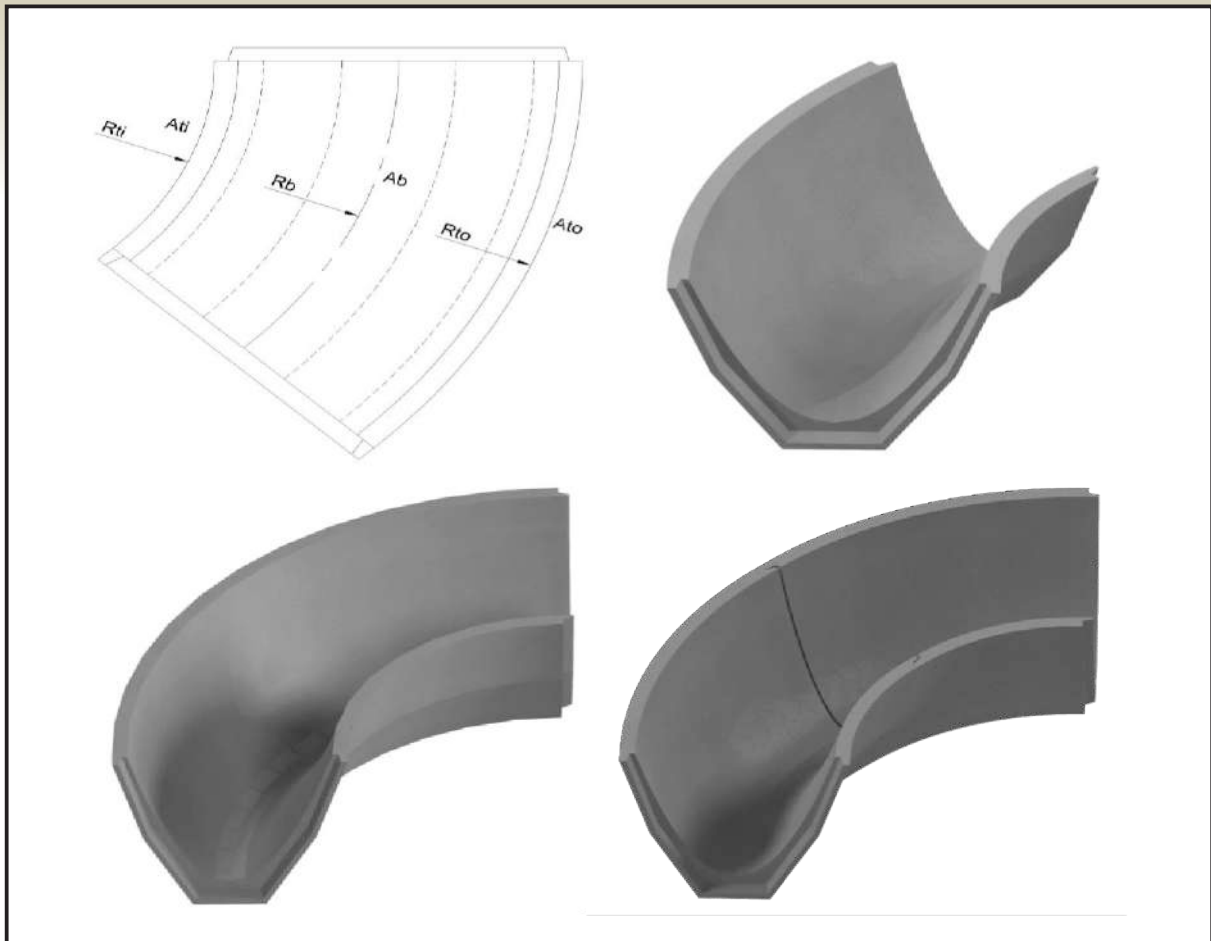


Figure-2.4 Isometric view for Bend Structure

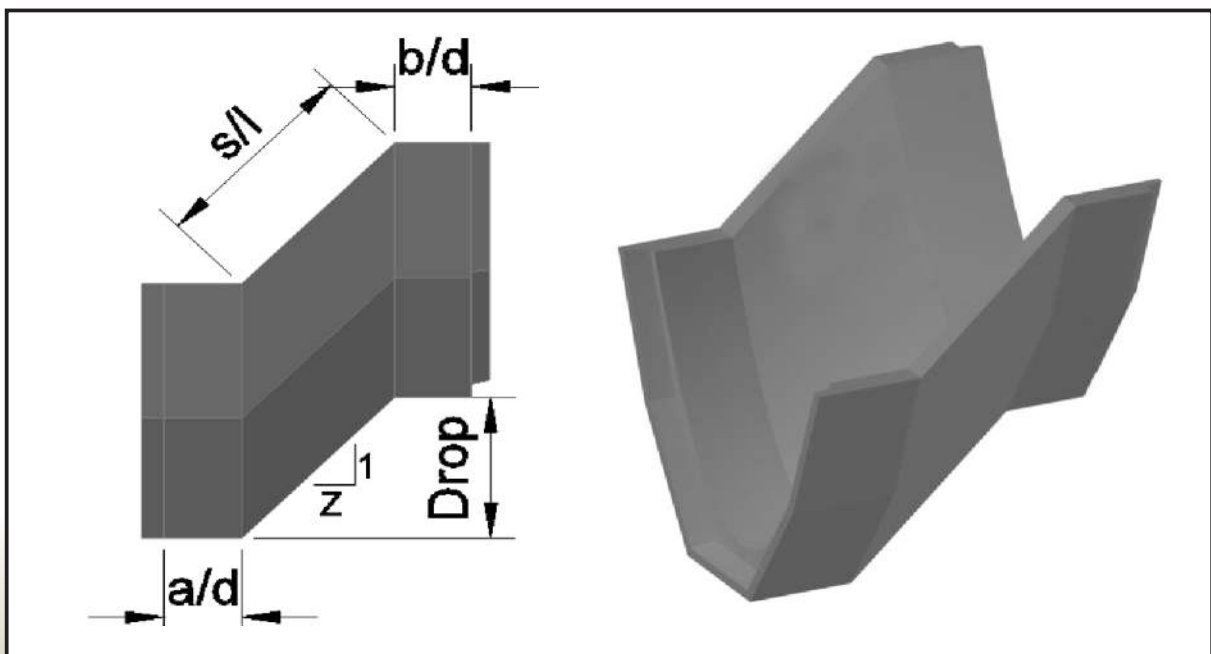


Figure-2.5 Isometric view for Drop Structures

Preparing Cost Estimate

To facilitate cost estimation/rate analysis for each fabricated segment size, a worksheet has also been developed, which is attached as an **Annexure-C**.

The quantities of sand required in bed for installation and that of cement & sand required for mortar to be placed in jointing for each segment size are given in **Table 2.5** while details of sand bed and joints are shown in **Figure-2.6**.

Table-2.5 Materials Required for Jointing and Sand Bed Preparation

Segment Size			Material Required Per Joint With Cement Sand Ratio of 1:3		Sand Required Per Segment for Bed Preparation
			Cement	Sand	
No.	Section (mm x mm)	Length (mm)	(bags)	(cu.m)	(cu.m)
1	360 x 225	1220	0.0022	0.00024	0.053
2	457 x 305	920	0.0037	0.00039	0.044
3	600 x 360	920	0.00445	0.00047	0.044
4	640 x 460	920	0.0062	0.00065	0.047
5	675 x 480	920	0.0065	0.00069	0.044
6	760 x 530	920	0.0089	0.00094	0.046
6a	850 x 570	920	0.0102	0.00108	0.048
7	920 x 610	920	0.0115	0.00121	0.049
7a	1030 x 650	920	0.0118	0.00124	0.050
8	1144x 686	920	0.0121	0.00128	0.051
9	1220 x 760	920	0.0125	0.00132	0.053

Note: Materials for jointing include permissible wastage

After detail estimation of materials, a sample cost estimate performa given in **Annexure-D** can be used to prepare cost estimates for watercourse improvement.

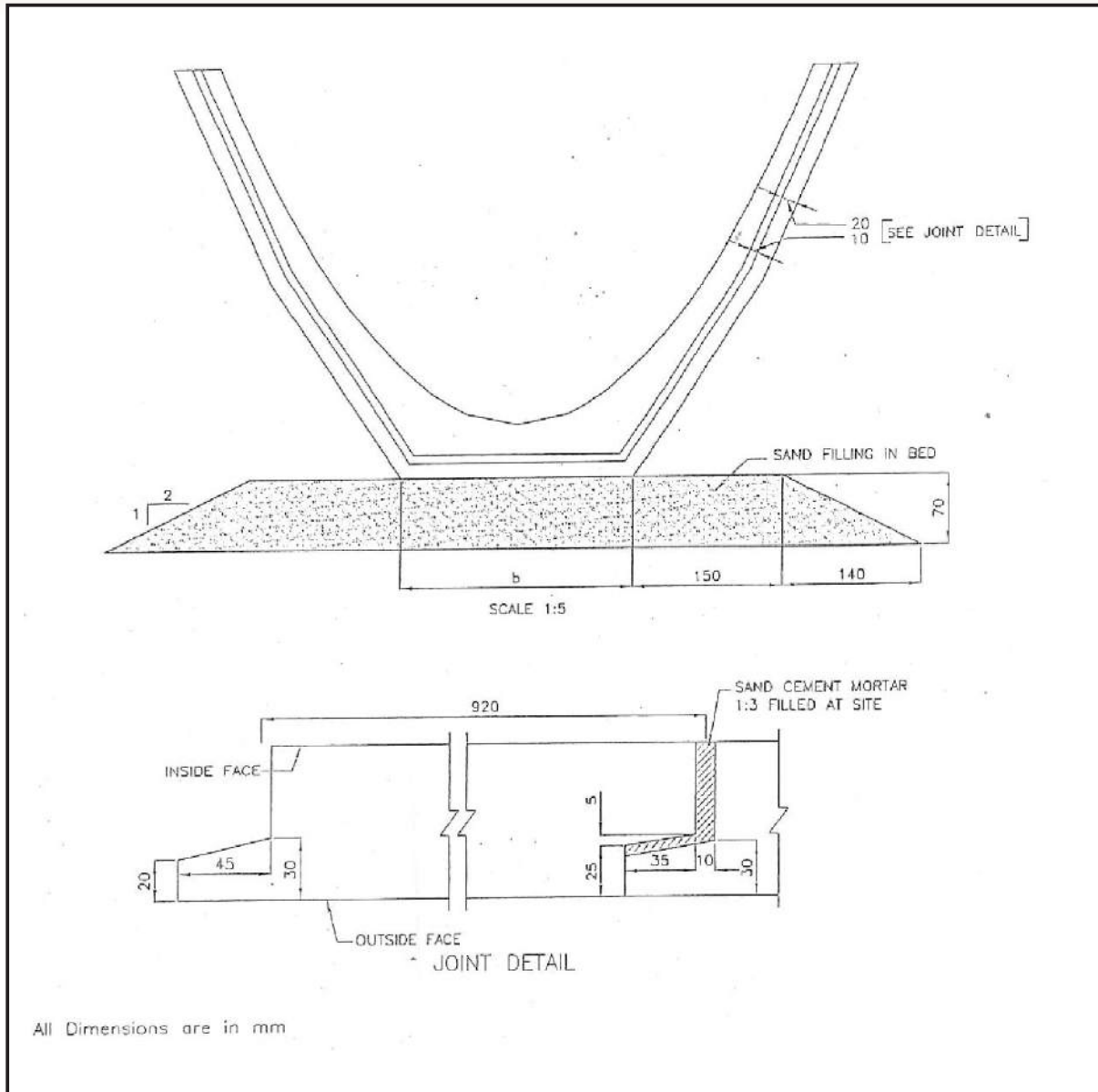


Figure-2.6 Detail of Sand Bed Below Segment and Joint

3. MANUFACTURING/FABRICATION OF PCPS

To achieve the desired quality in manufacturing/fabrication of Pre-cast Concrete Parabolic Segments (PCPS), it is essential that materials and manufacturing/fabrication procedures meet standard specifications. It is also essential that workmanship be carried out in a professional manner and that quality control during manufacturing/fabrication process be maintained at high standards. In this chapter, use of materials and procedures involved in manufacturing/fabrication of PCPSs are discussed in detail.

Cement

Cement shall be Ordinary Portland Cement (Type 1) supplied in 50 kg bags. It shall have been stored in a dry well ventilated place until used. The date of manufacturing must be shown on cement bags. It is important because the strength of cement reduces with age. Cement stored in a well-ventilated place can last for upto six months, however, it must be consumed within three months from the date of manufacturing.

The cement to be used in manufacturing/fabrication of PCPSs and in jointing during their installation shall have the following characteristics:

- i) The colour of the cement should be uniform. It should be grey colour with a light greenish shade. Pure cement shall not change its color on heat up.
- ii) The cement should feel smooth when touched or rubbed in between fingers. If it is felt rough, it indicates adulteration with sand.
- iii) Thrust your hand into the cement bag and it should give cool feeling. It indicates that no hydration reaction is taking place in the bag.
- iv) The cement should be free from any hard lumps. Such lumps are formed by the absorption of moisture from the atmosphere. Any bag of cement containing such lumps should be rejected.
- v) If a small quantity of cement is thrown in a bucket of water, the particles should float for some time before they sink.
- vi) The density (weight per unit volume) of Ordinary Portland cement shall be 1440 Kg/m^3 while for rapid hardening cement it shall be 1350 Kg/m^3 .
- vii) Its initial setting time should be 30 minutes and final 10 hours.

Sand and Gravel

Sand and gravel used in mortar for jointing and quality concrete must be clean and free of clay, silt and organic matter. The presence of these foreign materials will prevent the cement from binding the sand and gravel together and result in a weak and porous concrete.

- i) The sand shall be obtained from an approved source.
- ii) It shall be well graded. The whole of the sand shall pass through a No. 4 sieve (4.75 mm) and between 2 and 10 per cent shall pass through a No. 100 sieve (0.15 mm). The grading requirement for a good quality sand to be used in a concrete mix is given in **Table-3.1**.
- iii) It shall be clean and free from lumps, soft and flaky particles, shale, alkali organic matter, loam, mica and other harmful substances.
- iv) The sand shall be sharp, cubical, hard, dense and durable.
- v) For a good quality sand (fine aggregate), the Fineness Modulus (FM) should be between 2.3 and 3.1 (ASTM range for fine aggregates). Testing sand for FM is explained under section 3.2.1.
- vi) The maximum allowable silt and/or clay content in good quality sand should be 10%. Testing sand for silt and/or clay content is explained in section 3.2.2.
- vii) The recommended bulk density of sand and gravel is 1520 to 1680 Kg/m³ (95 to 105 lbs/ft³) for a normal weight concrete of density 2400 Kg/m³. Testing sand and gravel for bulk density is explained under section 3.2.4.

Table-3.1 ASTM Grading Requirements for Sand (Fine Aggregates)

Sieve Size	% Passing by Weight	
	Minimum	Maximum
4.75mm (No.4)	95	100
2.36mm (No.8)	80	100
1.18mm (No.16)	50	85
600µm (No.30)	25	60
300µm (No.50)	10	30
150µm (No.100)	2	10

Gravel must have the following characteristics for use in concrete works.

- i) Gravel must be hard, durable and reasonably well graded between the minimum and maximum sizes. The minimum and maximum sizes required in PCPS manufacturing are 3/8" (9.5mm) and 3/4" (19mm), respectively. The ASTM grading requirement for a 3/4" (19mm) down aggregate is given in **Table-3.2** while grading test for gravel is explained under section 3.2.3.
- ii) Gravel/crushed aggregate must be of angular and roughly cubical in shape. Flaky, elongated and round shaped gravel and light weight gravel having bulk density below the recommended values shall not be used in concrete (see **Figure-3.1**).
- iii) The bulk density of gravel must be within recommended range of 1520 to 1680 Kg/m³ (95 to 105 lbs/ft³) for a normal weight concrete of density 2400 Kg/m³. Testing gravel for bulk density is explained in under section 3.2.4.

Table-3.2 ASTM Grading Requirements For Gravel of 19mm (3/4") Down Aggregate Size

Sieve Size (mm)	% Passing by Weight	
	Minimum	Maximum
25 (1")	100	100
19 (3/4")	90	100
9.5 (3/8")	20	55
4.75 (3/16")	0	10
2.36 (3/32")	0	5

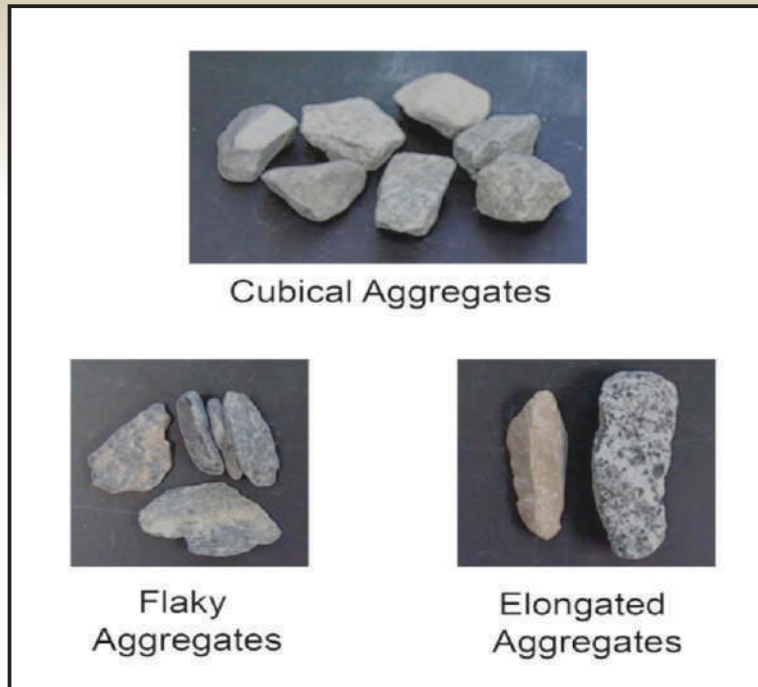


Figure-3.1 Cubical/Angular Aggregates vs Flaky & Elongated Aggregates

3.1.1 Testing Sand for Fineness Modulus (FM)

FM is the cumulative percentage retained on standard sieve 150 μ m or sieve No. 100 and above divided by 100. It is a single factor or an empirical number which is obtained from the results of sieve analysis. The information obtained from fineness modulus is helpful in the following ways;

- Fineness modulus tells us directly whether the material is well-graded or gap-graded.
- Fineness modulus gives us an overall idea whether the material is fine or coarse. Higher the value of FM, coarser will be the aggregate.
- It also indicates the surface area of the particles. The surface area of particle is inversely proportional to the FM. Greater the FM, lower will be the surface area. Lower the surface area of the aggregate, the required amount of fresh cement paste to cover the aggregate particles will be less and thus less water is required.
- Larger value of FM is preferred for sand (fine aggregates). For a good quality sand (fine aggregate), the FM should be between 2.3 and 3.1 (ASTM Range for fine aggregates).

3.1.1.1 Sampling of Aggregate (Sand & Gravel)

Getting a sample from a stockpile is not easy, and great care must be taken to obtain a truly representative sample. Segregation usually occurs when the material is stockpiled, because the coarse particles will roll to the base of the pile while the fine particles stay on top. Samples of

stockpiled sand and crushed aggregate must be taken at or near the base of the pile, at or near the middle of the pile, and at or near the top of the pile at several areas about the pile, as shown in **Figure-3.2**. Sample from stockpiles shall be taken as briefed in the following steps:

- 1) Insert a board into the pile just above the point of sampling to prevent segregation during sampling.
- 2) Dig a step into the pile, discarding the material.
- 3) Dig into the step and place one shovelful of the aggregate into the metal pail. Avoid loss of material.
- 4) Repeat steps 1 to 3 at each location, at several areas about the pile, obtaining equal quantities of material from each hole.
- 5) The aggregate sample is the total material from all holes combined and must meet the minimum original sample size requirement.

Note: The sample should be perfectly dry for sieve analysis because if there is some moisture content present, the particles will stick together and will not pass through the sieves.

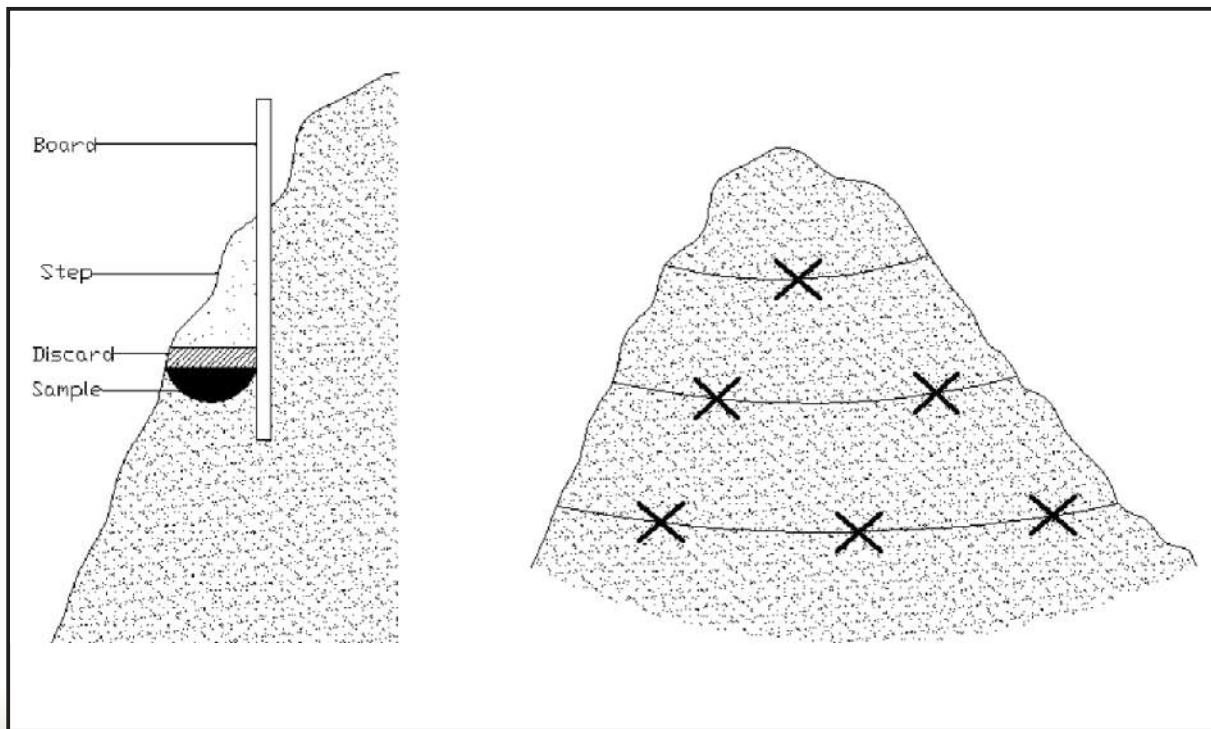


Figure-3.2 Sampling Aggregate from Stockpile

3.1.1.2 Procedure

- (i) Sieve the aggregate using the standard sieves (4.75 mm, 2.36 mm, 1.18 mm, 600 micron, 300 micron & 150 micron).
- (ii) Take a representative sample as explained above and weigh it after drying preferably in an oven.
- (iii) For manual shaking, pour the sample into the sieve which has the largest openings. Sieving is done by shaking the sieve by hands, the sample that goes through the sieve is collected on a tray for weighing as is shown in **Figure-3.3** below.
- (iv) Repeat the same procedure for other sieves.
- (v) Note down the weight of aggregate retained on each sieve.
- (vi) Calculate the percentage of weight of aggregate retained on each sieve.
- (vii) Find out the cumulative percentage of aggregate retained on each sieve.
- (viii) Sum-up the cumulative percentage of weight of aggregate retained on each sieve except the pan and divide the sum by 100.
- (ix) Record data as is given in **Table-3.3**.

$$FM = \sum \text{Cumulative \% retain on each Sieve} / 100$$



Figure-3.3 Manual Sieving of Aggregates

Table-3.3 Calculation Sheet for Fineness Modulus of Sand

Sieve of Size	Weight of Sand Retained	Percentage Retained	Cumulative Percentage of sand Retained	Cumulative Percentage Passing
(mm)	(g)	(%)	(%)	(%)
4.75 mm (No.4)	9	0.9	0.9	99.1
2.36 mm (No.8)	44	4.4	5.3	94.7
1.18 mm (No.16)	163	16.3	21.6	78.4
600 micron (No.30)	191	19.1	40.7	59.3
300 micron (No.50)	468	46.8	87.5	12.5
150 micron (No.100)	101	10.1	97.6	2.4
Pan	24	2.4	100	0
Total	1000	100	253.6	

Fineness Modulus **= (Sum of Cumulative % Retained except of Pan)/100**
= 253.6/100 = 2.536

Note: Only standard set of sieves mentioned above shall be used for sieve analysis and FM.

3.1.2 Testing Sand for Silt Contents

The silt test is carried out to determine the amount of silt, clay or other fine dust that may be present in a sand sample. The presence of such material in the sand used in concrete will reduce the strength of the hardened concrete if exceeds a permitted limit. The presence of the silt content in sand can be determined using the following methodology:

1. Take a 250 ml measuring cylinder.
2. Pour the damp sand (consolidated by shaking) until it reached the 200 ml mark.
3. Fill the cylinder with water and stir the sand well (the water shall be sufficient to submerge the sand completely) and wait till all the material settle down.
4. Note down the top surface of material i.e sand + sedimentation of silt 'X' (**Figure-3.4**).
5. Note down the top surface of sand layer only 'Y' (**Figure-3.4**).

6. Calculate the silt content as follows:

$$\text{Silt content} = (X - Y)/Y \times 100$$

7. Repeat the test for three different samples and then take the average value.

Note: The maximum allowable silt content in good quality sand is 10%. Sand containing more percentage of silt content shall be washed before using it in a concrete mix.



Figure-3.4 Testing sand for silt contents

3.1.3 Testing Sand and Gravel for Gradation

Sieve analysis of sample aggregate provides information for use in controlling gradation and checking compliance with specified grading requirements. Grading basically indicates the sizes of the aggregates and in which proportions they are present. There are minimum and maximum values of cumulative percent passing from each standard sieve as provided by ASTM which is given above in **Tables 3.1 & 3.2** for sand and gravel, respectively. Cumulative % passing from each sieve shall be within these limits, if not the sample is not properly graded.

Using the same procedure as is explained in calculating the Fineness Modulus for sand, perform the sieve analysis for gravel using standard sieves i.e, 25 mm, 19 mm, 9.5 mm, 4.75 mm & 2.36 mm. The test results of sieve analysis for sand are already shown above in **Table-3.3** while that of gravel are shown in **Table-3.4** below.

Table-3.4 Test Results of Grading during Sieve Analysis of Gravel

Sieve Sizes	Weight of Gravel Retained	Percentage Retained	Cumulative % Retained	Cumulative % Passing
(mm or inches)	(gm)	(%)	(%)	(%)
25 (1")	0	0	0	100
19 (3/4")	346	8.65	8.65	91.35
9.5 (3/8")	2840	71	79.65	20.35
4.75 (3/16")	798	19.95	99.6	0.4
2.36 (3/32")	4	0.1	99.7	0.3
Pan	12	0.3	100	0
Total	4000	100	287.6	

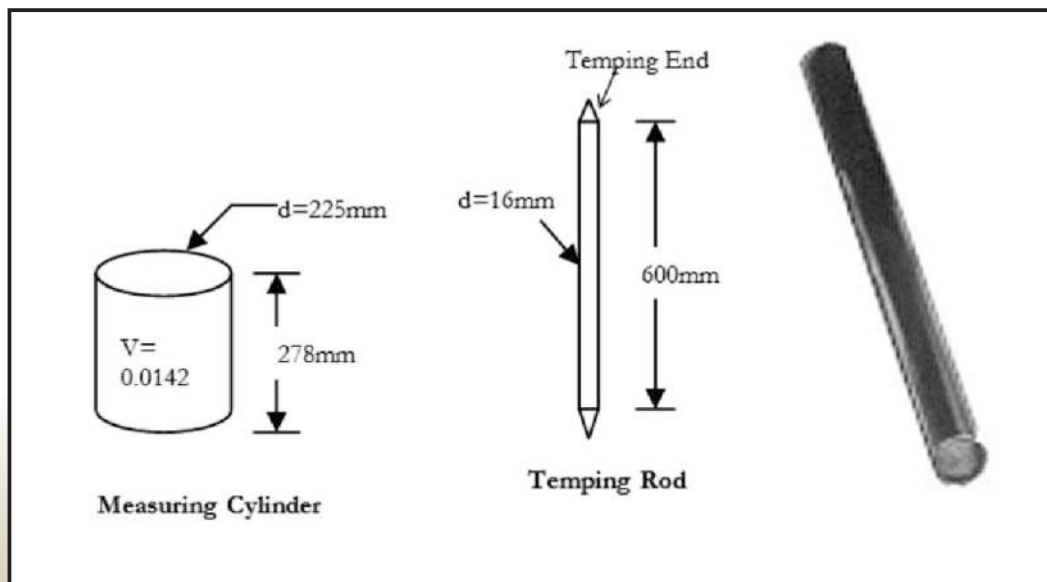
Note: Only standard set of sieves mentioned above shall be used for sieve analysis.

The minimum and maximum values of grading requirements for sand and gravel are already shown above in **Tables 3.1 & 3.2**, respectively.

3.1.4 Testing Sand and Gravel for Bulk Density

Bulk density is the weight of the unit volume of the aggregate (sand & gravel). The term volume includes the volume of the individual particles and the volume of the voids between the particles. Bulk density for sand and gravel ranges from 1520 to 1680 Kg/m³ for a normal weight concrete of density 2400 Kg/m³.

Figure-3.5 shows the apparatus for performing bulk density test.

**Figure-3.5 Apparatus for Testing Bulk Density**

3.1.4.1 Procedure for Loose Bulk Density

- (i) Take a measuring cylinder and note the weight (in Kgs) of empty measure (W).
- (ii) Compute the volume (in m³) of the cylinder by measuring dimensions of the cylinder (V).
- (iii) Fill the measuring cylinder with dried aggregates until it overflows from the container.
- (iv) Level the top surface of container by rolling a rod on it.
- (v) Take the Weight of aggregate filled cylinder (W₁).
- (vi) Calculate Loose Bulk Density (in Kg/m³) of the aggregate as follows:

$$\text{Loose Bulk Density} = (W_1 - W) / V$$

3.1.4.2 Procedure for Compacted Bulk Density

- (i) Fill the measure with aggregates sample for about one third height and tamp evenly with 25 strokes of the rounded end of the tamping rod.
- (ii) Add a similar quantity of aggregate as second layer and tamp it evenly with 25 strokes.
- (iii) Fill the measure with a third layer of aggregate up to over following and tamp it with 25 strokes
- (iv) Strike off the surplus aggregate using the tamping rod as a straight edge.
- (v) Take the weight of aggregate filled measure (W₂)
- (vi) Calculate Compacted Bulk Density (in Kg/m³) of the aggregate as follows:

$$\text{Compacted Bulk Density} = (W_2 - W) / V$$

Note: The aggregate sample must be dried before performing this test. The ratio of loose bulk density to the compacted bulk density should be between 0.87 to 0.96

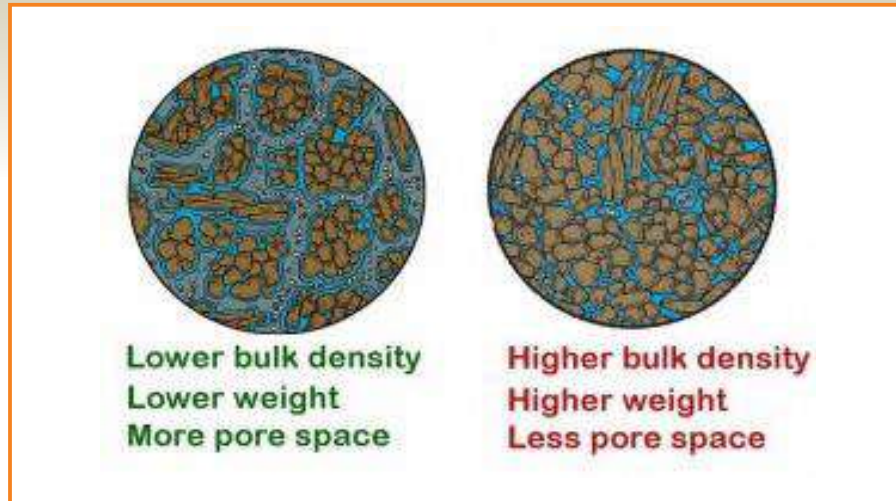


Figure-3.6 Bulk Densities Comparison

Water

Water plays a significant role in the mixing of concrete during manufacturing/fabrication of PCPSs. As the strength of concrete work is reduced if water containing impurities is used in mixing of concrete, therefore, water used for this purpose must be clean and free from silt, oil, salt, alkali, and acid. Generally, water fit to drink is suitable for this purpose.

Proportions for Concrete

The manufacturing of PCPSs requires the proportions/mix ratio of concrete ingredients i.e, cement, sand & gravel of 1:1:2. The required minimum 28 days cylindrical compressive strength for the recommended concrete mix is 4500 PSI (5610 PSI strength required for cubes).

Batching of Concrete Ingredients

Batching is the "process of weighing or volumetrically measuring and introducing into the mixer the ingredients for a batch of concrete". The ratio, 1:1:2 signifies proportions of the mix; one-part cement, to one part sand, to two parts gravel. For PCPS manufacturing the cement, sand and gravel will usually be measured out, or batched, in the correct proportions on a volumetric basis. See **Annexure-E** for discussion on the bulking of sand. This is best achieved using wooden or steel batching boxes as shown in **Figure-3.7**. These boxes measuring 0.33 x 0.33 x 0.33 m (or 13 x 13 x 13 inches) have a volume of 0.036 m³ (1.27 ft³) almost equal to one bag of cement. To

obtain a 1:1:2 mix, one 50 kg bag of cement should be mixed with 0.036 m^3 (one measuring box) of sand and 0.072 m^3 (two measuring box) of coarse aggregate.



Figure-3.7 Use of measuring box for a batch of concrete

Water-Cement Ratio

The water/cement ratio is a critical factor in quality concrete. This is the ratio of the weight of water in the mix (including water in the sand and gravel) to the weight of cement in the mix. Lowering the water content results in stronger concrete, but the amount of water must be enough to produce a workable mix. Excess water will cause shrinkage cracks and a weak porous concrete. The water-cement ratio needed for cement to complete its hydration process ranges from 0.22 to 0.25. The existence of additional water in the mixture is needed for ease of concrete placing and finishing (workability of concrete).

A water/cement ratio of 0.36 is recommended in a concrete mix for production of PCPS. In general 18 Kg “OR” 18 Liters water is to be used for 1 bag (50 kg) of cement (1 Kg=1Liter for liquid with density of 1 g/cm^3).

Note: All of the water shall not be added at once during concrete mixing. It shall be added sparingly until the desired workability is attained and then stopped adding more water.

Mixing Procedures

Mixing concrete is the complete blending of the materials which are required for the production of a homogeneous concrete. Concrete should be mixed thoroughly but not over mixed. The cement must come in contact with and surround all surfaces of the sand and gravel. The cement must fill the spaces (voids) between the sand and gravel particles – hence there is need for sand and gravel to be well graded to ensure that the voids are small.

Machine Mixing

A mixing machine shall be used for this purpose which will give the best distribution of the ingredients and a uniform appearance to the concrete. To maintain quality concrete, the mixer should not be loaded above its design capacity and should be operated at the design drum speed. The drum should be revolving when it is charged. No successful mixture can be achieved without the proper batching of all materials. Quality assurance, suitable arrangement of materials and equipment, and correct weighing of the materials are the essential steps that must be completed before any mixing takes place.

Step-1:

Measure the recommended water amount to be added to the mixer and pour half of the water into the mixer.

NOTE: water should be added to the mixer before the dry mix.

Step-2:

Turn the mixer on and add the dry mix into the mixer (place gravel first into the mixer followed by sand and then the cement). Allow the concrete to mix for about a minute and then add the remaining water as necessary.

Step-3:

Mix the concrete for about 3-5 minutes (but not less than two minutes), until a uniform workable consistency is achieved. If additional water is needed, add small amounts of water sparingly. Properly mixed concrete should look like thick oatmeal and should hold its shape when it is squeezed in a gloved hand.

NOTE: the more water added to the mix the weaker it becomes; adding one extra quart of water per 80 lb bag can reduce the strength of the concrete by up to 40%.

Step-4:

Keep the mixer running and dump the concrete into a wheelbarrow or on a desired place for filling of molds.



Figure-3.8 Pouring Material into the Mixing Machine



Figure-3.9 Concrete Ready for Placing in Molds

Slump Test

Slump Test is a useful test for the consistency (Consistency refers to the ease with which concrete flows) and strength of the concrete mix being used for manufacturing PCPSs. It is recommended that a slump cone be obtained and tests made and recorded for each batch of concrete used. Maximum 1" slump is recommended for the concrete mix of PCPSs. This test is carried out with a mold called slump cone having top diameter as 10cm, bottom diameter 20 cm and height as 30 cm. The test may be performed in the following steps:

- i. Place the slump mold on a smooth flat and non-absorbent surface.
- ii. Place the mixed concrete in the mold to about one-fourth of its height.
- iii. Compact the concrete 25 times with the help of a tamping rod uniformly all over the area.
- iv. Place the concrete in the mold about half of its height and compact it again.
- v. Place the concrete upto its three fourth height and then upto its top. Compact each layer 25 times with the help of tamping rod uniformly. For the second subsequent layers, the tamping rod should penetrate into underlying layers (see **Figure-3.10**).
- vi. Strike off the top surface of mold with a trowel or tamping rod so that the mould is filled to its top.

- vii. Remove the mould immediately, ensuring its movement in vertical direction.
- viii. When the settlement of concrete stops, measure the subsidence of the concrete in inches which is the required slump of the concrete.
- ix. The slump is measured by placing the cone just besides the slump concrete and the temping rod is placed over the cone so that it should also come over the area of slumped concrete.
- x. The decrease in height of concrete to that of mold is noted with scale. The allowable slump is 1 inch under PCPS works (see **Figure-3.10**).

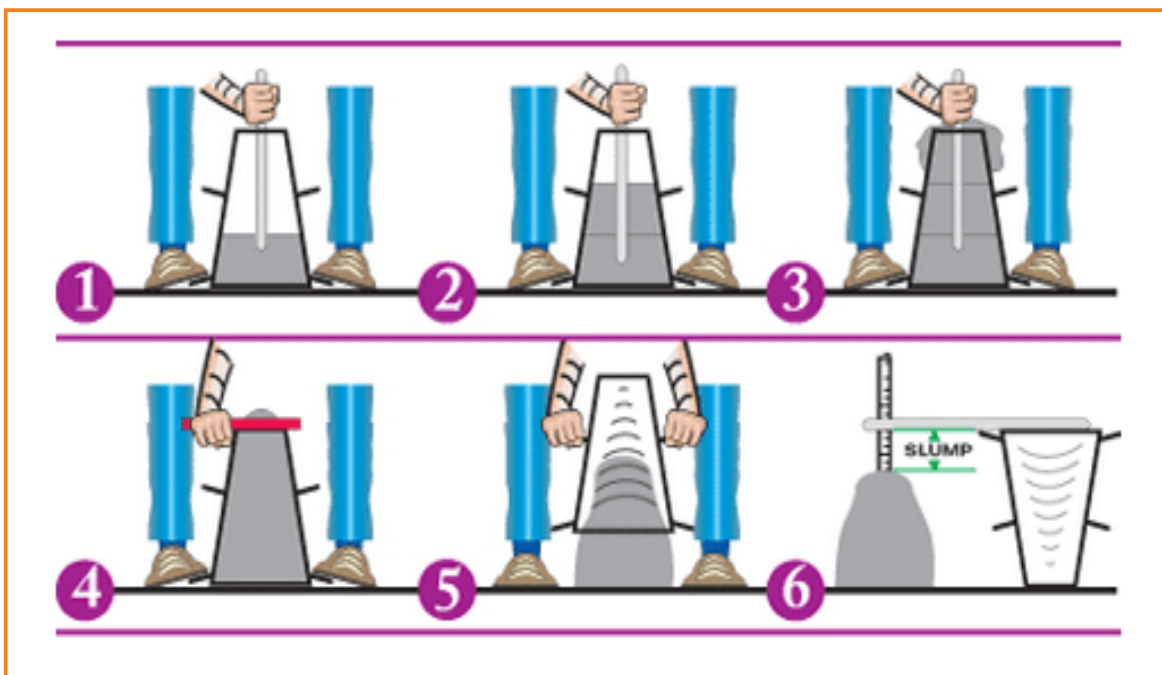


Figure-3.10 Procedure of Slump test and Slump Measurement

Placing Concrete (Filling of Molds)

PCPS molds treated with motor oil will facilitate removal from the set concrete (**Figure-3.11**). For best results, be sure to wipe most of the oil out of your molds prior to filling them with concrete and avoid puddling of the oil in low crevice of the mold which can introduce air bubble in the concrete.

Placing Concrete on Vibrating Table

The concrete for PCPS fabrication is placed in molds on vibrating table as explained below:

- Put the mold on to the table top then turn vibrating table on (**Figure-3.12**).

- Start filling your mold with concrete slowly in a manner to limit the flow and segregation of gravel and sand particles and allow the table to spread the mix into the mold (**Figure-3.13**).
- Vibration shall be done till the moisture come to the surface.
- Level the mix off using a trowel which gives a smooth and level base (**Figure-3.13**).
- The mold should then be left to set.

Note: Vibration shall be accomplished till the moisture come to the surface and over vibrating shall be avoided especially with only half of the concrete batch poured into the mold first, can certainly cause excess air.



Oiling of Mold



Assembling of Mold

Figure-3.11 Mold Preparation for Concrete Placing for PCPS



Concrete Placing on Vibrating Table



Figure-3.12 Setting Molds on Vibrating Table



Figure-3.13 Fabrication of Precast Parabolic Lining Segment

Representative samples of concrete shall also be taken and used for casting cubes of 6"x6"x6" or cylindrical specimens of 6" dia x 12" long for relative strength testing of the concrete placed. After cleaning the molds and applying oil, the concrete is poured in the cube mold in layers and tempered properly so as not to have any voids. Level the top surface and smoothen it with a trowel. Compression testing of sample cubes is explained under section 3.11.

Mold Removal

Molds may be removed when the concrete attains sufficient strength to support the dead load. Generally, good quality concrete under ideal conditions will attain strength of about 350 kg/cm² per day for the first 3 or 4 days; thereafter, the curing process slows down considerably. In case of PCPSs, as concrete is not subjected to appreciable bending or direct stresses, therefore, molds can be removed after attaining strength of 350 kg/cm² (500 psi) which can be attained after 24 to 36 hours depending upon the surrounding temperature.

If admixtures are used, curing time period may be reduced and minimum strength requirement for mold removal can be achieved earlier depending upon the dosage and type of admixture used. There are certain admixtures available in the market that claim to have gained 90% of specified strength in one day (24 hrs) with maximum water-cement ratio of 0.35.

Curing

Concrete does not dry (or set) as a result of the water evaporating from the mix, rather the water in the mix reacts chemically with the cement which enables it to harden. Excessive or rapid evaporation of water from the freshly placed concrete will result in weak concrete which in turn will shrink and crack. In order to prevent the water in the mix from evaporating, the concrete must be cured. Curing of concrete can be done by any of the following three methods:

- i) Water curing
- ii) Membrane curing
- iii) Steam curing

i) Water Curing

Out of three above mentioned curing methods, water curing is the best method of curing as it satisfies all the requirements of curing; namely,

- a) promotion of hydration,
- b) elimination of shrinkage, and
- c) absorption of the heat of hydration.

It is pointed out that even if the membrane method is adopted, it is desirable that a certain extent of water curing is done before the concrete is covered with membranes.

Water curing can be achieved by keeping the surface of the concrete wet for a period of five days, either by:

- continuously wetting it, the most often method of curing used for Pre-cast Concrete Parabolic Segments (PCPSs) which is done by placing PCPSs in curing ponds immediately after removing molds (**Figure-3.14**);
- covering PCPSs with hessian (canvas or jute bags) or other thick absorbent material and keeping this wet.



Figure-3.14 Curing of Pre-cast Concrete Parabolic Segments (PCPSs)

ii) Membrane Curing

Membrane curing is done by using the impermeable coating of the compounds known as curing compounds. It is laid on the surface of the concrete. Thus it allows for curing itself. As the coating is done, it helps to reduce the rate of heat of hydration, thus curing is done. However, the moisture content i.e. water added while preparation of mix also contributes to curing.

Admixtures can also be used in combination with curing compounds when there is a compelling need to reduce the curing time. The admixtures are added in order to reduce the water content in a mixture or to slow the setting rate of the concrete while retaining the flowing properties of a concrete mixture. Admixtures are used to modify the properties of concrete or mortar to make them more suitable to work by hand or for other purposes such as saving mechanical energy. The admixtures are able to accommodate water for more time i.e. retardation & use for the water curing. Admixture can be classified by function as follow:

- i) Air-entraining admixtures;
- ii) Water reducing or normal plasticizing admixtures;
- iii) Superplasticizers;
- iv) Accelerating admixtures;
- v) Retarding admixtures;

- vi) Hydration-control admixtures;
- vii) Corrosion inhibitors;
- viii) Shrinkage reducers;

The effectiveness of an admixture depends upon factors such as type, brand, and amount of cementing materials; water content; aggregate shape, gradation, and proportions; mixing time; slump; and temperature of the concrete. The major reasons for using admixtures are:

- To achieve certain properties of concrete (e.g, durability, water reduction without changing workability, high strength, accelerate the rate of strength development at early stages) more effectively than by other means.
- To maintain the quality of concrete during the stages of mixing, transporting, placing, and curing in adverse weather conditions.
- To overcome certain emergencies during concreting operations.
- To reduce the cost of concrete construction.

iii) Steam curing

Steam curing is a process for hardening concrete, cement, and mortar that involves exposure to warm steam. Materials subjected to this hardening technique tend to cure more uniformly and also much more quickly than those hardened via other processes. Steam curing is advantageous where early strength gain in concrete is important or where additional heat is required to accomplish hydration, as in cold weather. Two methods of steam curing are used: live steam at atmospheric pressure (for enclosed cast-in-place structures and large precast concrete units) and high-pressure steam in autoclaves (for small manufactured units). Only live steam at atmospheric pressure is mostly used.

Steam at atmospheric pressure

This is used for enclosed cast-in-place structures and large precast units. In the precast concrete industry, steam curing allows increased production by a more rapid turnover of molds and formwork.

In this method steam is introduced to precast segments enclosed under tarpaulins through pipes. Steam temperature in the enclosure should be kept at about 60°C (140°F) until the desired concrete strength has developed. Strength will not increase significantly if the maximum steam

temperature is raised from 60°C to 70°C (140°F to 160°F). Steam-curing temperatures above 70°C (160°F) should be avoided; they are uneconomical and may result in damage. It is recommended that the internal temperature of concrete not exceed 70°C (160°F) to avoid heat induced delayed expansion and undue reduction in ultimate strength.

During curing, the concrete is taken through a curing cycle consisting of the following stages

- an initial delay prior to steaming (The time delay between the mixing of the concrete and the beginning of steam curing.
- a period for increasing the temperature.
- a period for holding the maximum temperature constant.
- a period for cooling.

A typical atmospheric steam curing cycle/stages is shown in **Figure-3.15**.

With careful temperature selection, the strength of concrete after 3 days can exceed the 28-day strength of normally cured concrete. Besides the early strength gain, steam-cured concrete has reduced drying shrinkage and creep as compared to normally cured concrete.

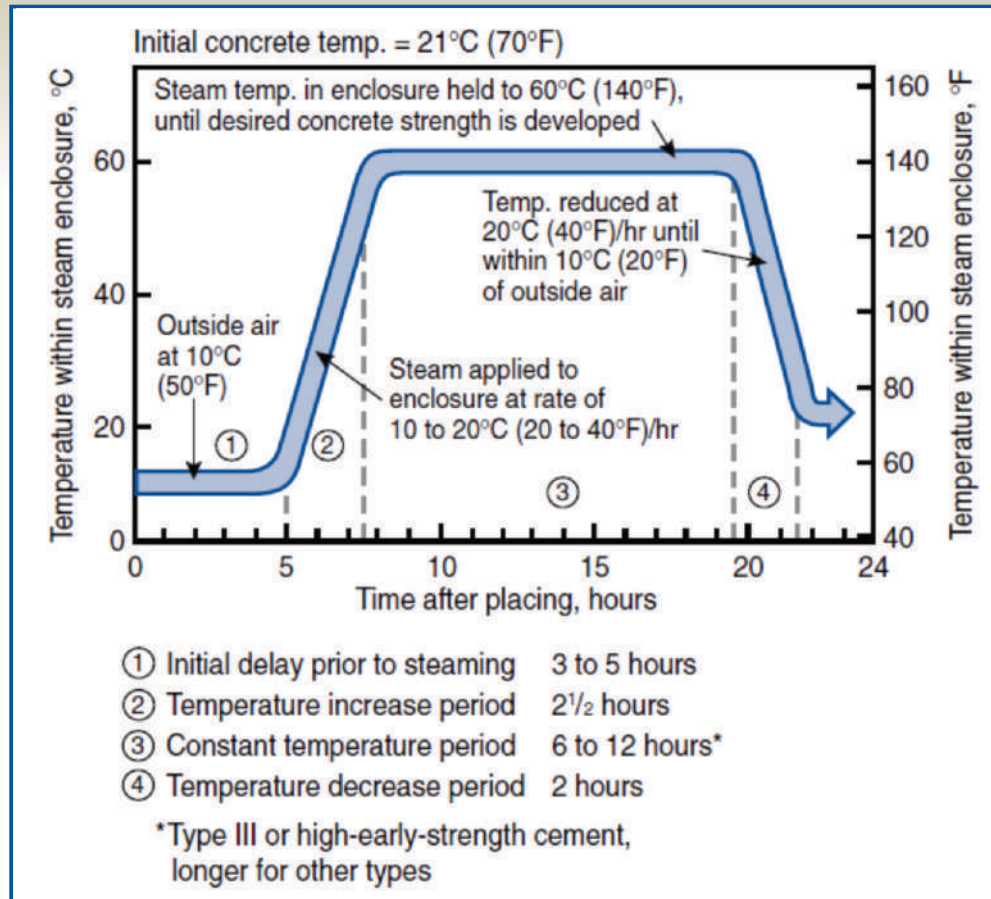


Figure-3.15 A Typical Atmospheric Steam Curing Cycle

The problem with steam cured cement is that in the long term, the cement may be weaker. Steam cured cement, concrete, and mortar products are stronger at the outset than traditionally cured products, but they are more likely to fracture, crumble, and develop other problems later in their useful lives. This may not be a concern in all situations, but it can become a serious issue in others. Variations in the temperature and humidity levels used during curing that change the length of time required will also vary the long-term strength of the product.

Compressive Strength Testing of Cubes

Before performing test, it must be ensured that the compressive strength testing machine is properly calibrated and the seal of the guage is intact. Compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of concrete material, and quality control during production of concrete etc. The strength testing procedure of cubes is briefed in the following steps;

- i. The specimen should be removed from the water 30 minutes prior to the testing.

- ii. The specimen should be in dry condition before conducting the testing.
- iii. Dimensions of sample cube to be tested shall be checked before performing test.
- iv. Clean the bearing surface of the testing machine.
- v. Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast i.e smooth surfaces of cube shall be kept between the bearing surfaces of machine (see **Figure-3.16**).
- vi. Align the axis of the specimen with the steel plate and do not use any packing.



Figure-3.16 Compression Testing of Sample Cube

- vii. Rotate the movable portion gently by hand so that it touches the top surface of the specimen.
- viii. Apply the load gradually without shock.
- ix. Record the maximum load and note any unusual features in the type of failure.

NOTE

Minimum three specimens should be tested. Average of three specimens gives the crushing strength of concrete. If strength of any specimen varies by more than 15 per cent of average strength, results of such specimen should be rejected.

CALCULATIONS

Size of the cube = 6"x6"x6"

Area of the specimen = 36 Sq.inches

Maximum load applied = 202500 lbs

Compressive strength = Maximum Load Applied/ Area of Specimen

$$= 202500/36 = 5625 \text{ lbs/in}^2$$

4. CONSTRUCTION OF PCPS WATERCOURSE

General

The construction stage of watercourse improvement is most important and rewarding, and it is also the most difficult. Various problems will arise daily to thwart the program, but careful planning beforehand will assure that many problems do not arise and those that do can be readily resolved. Without proper control of construction, watercourse improvement will not be successful nor sustainable.

At this point the designer has provided a design that best matches requirements and site conditions. It is now that construction must turn these designs into a functional, sustainable watercourse. Therefore, careful attention to details of construction is fully as important as the investigation, surveys and design. To achieve the desired quality in construction, three factors are essential:

- i) Materials and construction procedures must meet standard specifications;
- ii) Workmanship be carried out in a highly professional manner; and
- iii) Quality control of the construction process must be maintained at a high standard achieved through visual examination, measurement and testing.

Prior to commencing construction, the following pre-requisites must have been completed:

- 1) A complete design with specifications, estimates, drawings for work to be done.
- 2) A list of materials showing quantities of various items needed for construction.
- 3) The signatures and dates of design and sanction approvals obtained.
- 4) Arrangements made with the WUA for their required inputs and a scheduled date to begin construction.

Watercourse improvement means demolishing the old watercourse and rebuilding it according to specific design, dimensions and grades, with compacted earth fill and /or lining and construction of pertinent structures (turnouts, checks, drops).

Various methods may be used to accomplish the work. However, the quality of construction and grade dimensions are of primary importance. The way it is done (the construction procedure) is

secondary. For example; earth fill (loose earth) may be compacted with a hand tamper or a mechanical vibrating compactor or by passing tractor wheels uniformly across the pad. The primary concern is to obtain the proper amount of compaction, not how it was done.

Emphasis should be given to ensure quality of work at all stages of construction. Proper surveys are necessary to establish a base of measurement for construction personnel. Periodic inspections of construction work are needed to ensure a high quality finished product. The best and safest design is useless without timely measurement and tests to ensure adherence to design and specifications. Before construction begins, the centre line and right-of-way should be reaffirmed with the WUA and OFWM officials. The entire engineering plan should be reviewed with members of the WUA. It is much easier to move a check structure or to modify a drop structure on paper before the job starts than it is after construction begins. In this chapter, only construction of PCPS lined watercourse is discussed while construction of trapezoidal (earthen & lined) and rectangular brick lined watercourse have already been discussed in OFWM Field Manual Volume-IV (Watercourse Design and Improvement).

Depending upon varying design capacities and available longitudinal slopes, a series of Pre-cast Concrete Parabolic Segments (segments No. 1 to 9) have been designed and are being manufactured and used for lining of watercourses. A typical Pre-cast Concrete Parabolic Segment (PCPS) is shown in **Figure-4.1**.



Figure-4.1 Pre-Cast Concrete Parabolic Segments (PCPS)

The construction procedure and quality control measures essentially required during execution/construction of PCPS lining type of watercourses are briefly given below:

Laying Out Watercourse

- A PCPS lined watercourse is laid out in a similar manner to that of an earthen channel in which the centre line and right-of-way limits are staked.
- The berm stakes are set, on both sides of the centre line, at one half the channel top width (T) plus wall thickness plus an allowance for over excavation of about 200 mm to allow for ease in installation of PCPSs.
- The watercourse is then 'rough' excavated, using the berm stakes as a guide. Material excavated can be disposed of in nearby areas in an appropriate manner.
- The bed grade elevation stakes are set at the centerline at an elevation of the finished grade (the finished grade is the designed bed elevation, which should be equal to sub-grade elevation plus 7cm thick layer of sand bed plus thickness of the PCPS at the bottom).
- Frequently during construction operations stakes are accidentally hit, run over or even pulled up. Sometimes they are only stuck back in or near the location where they were. Since the stake may represent an elevation there is a chance for serious error to occur unless it is replaced at the correct location and/or elevation. Thus frequent checking is necessary to ensure adherence to the design.
- The bottom of the excavated section is then compacted. Continual checking should be made to ensure that proper procedures are followed. Walk the full length of the watercourse, in the bottom, and check for proper compaction.

Preparation of Sand Bed

- Bed formation and its proper compaction is necessary as if PCPSs are laid on poorly compacted pad, will settle down and will cause leakage of the joints.
- To facilitate the installation of PCPSs, about 07 cm thick layer of compacted sand is laid over a firm bed (of desired compaction) already prepared as shown in **Figure-4.2 & 4.3**.

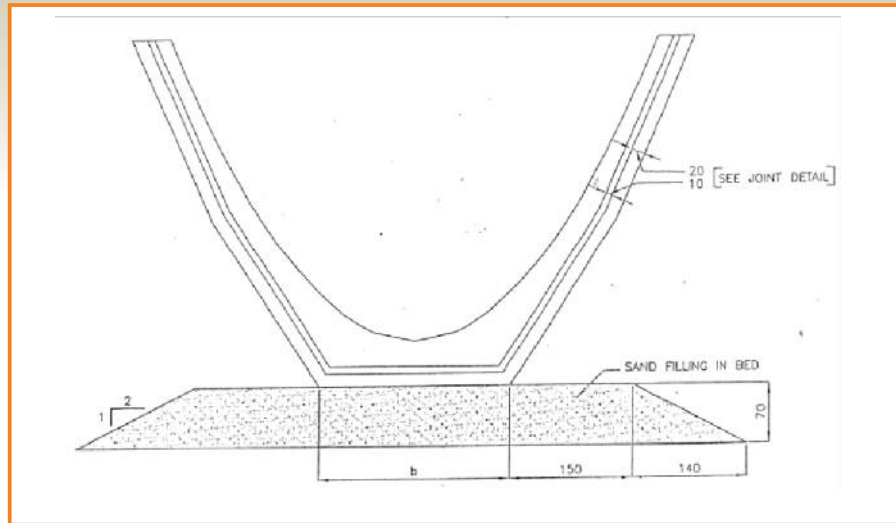


Figure-4.2 Sand Bed Specifications for PCPS Installation



Figure-4.3 Sand Bed Preparation for PCPS Installation

Installation of PCPS

- To start with, initially two corner PCPSs are installed/placed on sand bed (1st at the start and the 2nd at about 30 m distance along the length of watercourse) following proper alignment and ensuring designed longitudinal slope.
- Segments shall be checked by mason's hand level for their being in horizontal position (**Figure-4.4**) to ensure proper jointing of male and female ends of each segment.
- A string is then stretched between these two installed segments by using pegs, which is at an elevation equal to the designed bed elevation. This will ensure installation of the segments between these two with a proper longitudinal slope (**Figure-4.5**).
- Install/place the segments between the two corner segments using the stringline as a guide

and check each segment by mason's hand level for their being in horizontal position to ensure proper jointing of male and female ends of each segment.

- The joints are then filled with mortar of 1:3 cement-sand ratio and cured for a minimum period of seven days.

Note: Mortar shall be used within time limits of 30 minutes after addition of water. Any mortar which has not been used within permissible time shall not be used in jointing.

Backfill

Once all the segments have been installed and joined with proper mortar followed by curing, back earth filling along lining be completed to a minimum width of 600mm, compacted and dressed to the finished physical parameters as shown in **Figure-4.6**.



Figure-4.4a Placing PCPS in Position



Figure-4.4b Checking and Adjusting PCPS for being in Horizontal Position



Figure-4.5 PCPS Installation Using String line



Figure-4.6 Finished Back Earth Filling



ANNEXURES





ANNEXURE 'A'



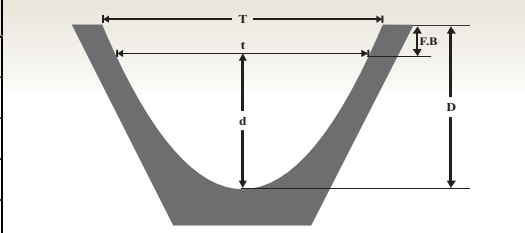
Annexure - A/I

Design Data for Parabolic Shaped Watercourse

SEGMENT NO. 1								
Top Width (T)		360 mm						
Total Depth (D)		225 mm						
Cross Sectional Area		0.054 sq.m						
Equation Co-efficient		0.006944						
Roughness Co-efficient.		0.014000						
Slope	Discharge	Flow Depth	Flow Width	Free Board	Flow Area	Velocity	Hydraulic Radius	Wetted Perimeter
(S)	(Q)	(d)	(t)	(FB)	(A)	(V)	(R)	(P)
(m/m)	(lps)	(mm)	(mm)	(mm)	(sq.m)	(m/s)	(m)	(m)
0.00020	5.00	151.20	295.11	74	0.030	0.168	0.068	0.438
0.00025	5.00	143.00	287.00	82	0.027	0.183	0.065	0.420
0.00030	5.00	136.70	280.61	88	0.026	0.196	0.063	0.407
0.00035	5.00	131.60	275.32	93	0.024	0.207	0.061	0.396
0.00040	5.00	127.30	270.79	98	0.023	0.218	0.059	0.387
0.00075	10.00	153.60	297.45	71	0.030	0.328	0.069	0.443
0.00080	10.00	151.20	295.11	74	0.030	0.336	0.068	0.438
0.00085	10.00	148.90	292.86	76	0.029	0.344	0.067	0.433
0.00090	10.00	146.71	290.70	78	0.028	0.352	0.066	0.428
0.00095	10.00	144.80	288.80	80	0.028	0.359	0.066	0.424
0.00100	10.00	143.00	287.00	82	0.027	0.365	0.065	0.420
0.00110	10.00	139.60	283.57	85	0.026	0.379	0.064	0.413
0.00120	10.00	136.70	280.61	88	0.026	0.391	0.063	0.407
0.00130	10.00	134.00	277.82	91	0.025	0.403	0.062	0.401
0.00140	10.00	131.60	275.32	93	0.024	0.414	0.061	0.396
0.00150	10.00	129.30	272.90	96	0.024	0.425	0.060	0.391
0.00160	10.00	127.30	270.79	98	0.023	0.435	0.059	0.387
0.00170	10.00	125.40	268.76	100	0.022	0.445	0.059	0.382
	15.00	153.40	297.25	72	0.030	0.493	0.069	0.443
0.00180	15.00	151.20	295.11	74	0.030	0.504	0.068	0.438
0.00190	15.00	149.10	293.06	76	0.029	0.515	0.067	0.433
0.00200	15.00	147.20	291.18	78	0.029	0.525	0.067	0.429

Annexure - A/II

Design Data for Parabolic Shaped Watercourse

SEGMENT NO. 2								
Top Width (T)		457 mm						
Total Depth (D)		305 mm						
Cross Sectional Area		0.093 sq.m						
Equation Co-efficient		0.005842						
Roughness Co-efficient.		0.014000						
Slope	Discharge	Flow Depth	Flow Width	Free Board	Flow Area	Velocity	Hydraulic Radius	Wetted Perimeter
(S) (m/m)	(Q) (lps)	(d) (mm)	(t) (mm)	(FB) (mm)	(A) (sq.m)	(V) (m/s)	(R) (m)	(P) (m)
0.00015	10.00	216.80	385.30	88	0.056	0.180	0.093	0.599
0.00025	15.00	233.80	400.12	71	0.062	0.241	0.098	0.635
0.00030	15.00	223.40	391.12	82	0.058	0.258	0.095	0.613
0.00035	15.00	214.90	383.61	90	0.055	0.273	0.092	0.595
0.00040	15.00	207.80	377.22	97	0.052	0.287	0.090	0.580
0.00045	20.00	233.20	399.60	72	0.062	0.322	0.098	0.634
0.00050	20.00	227.00	394.26	78	0.060	0.335	0.096	0.621
0.00055	20.00	221.60	389.54	83	0.058	0.348	0.094	0.609
0.00060	20.00	216.80	385.30	88	0.056	0.359	0.093	0.599
0.00065	20.00	212.50	381.46	93	0.054	0.370	0.092	0.590
0.00070	20.00	208.60	377.94	96	0.053	0.381	0.090	0.582
	25.00	233.40	399.78	72	0.062	0.402	0.098	0.634
0.00075	20.00	205.00	374.67	100	0.051	0.391	0.089	0.574
	25.00	229.40	396.34	76	0.061	0.412	0.097	0.626
0.00080	25.00	225.70	393.13	79	0.059	0.423	0.096	0.618
0.00085	25.00	222.30	390.15	83	0.058	0.432	0.095	0.611
0.00090	25.00	219.10	387.34	86	0.057	0.442	0.094	0.604
0.00095	25.00	216.05	384.63	89	0.055	0.451	0.093	0.597
0.00100	25.00	213.40	382.26	92	0.054	0.460	0.092	0.592
	30.00	233.80	400.12	71	0.062	0.481	0.098	0.635
0.00110	25.00	208.30	377.67	97	0.052	0.477	0.090	0.581
	30.00	228.30	395.38	77	0.060	0.499	0.097	0.623
0.00120	30.00	223.40	391.12	82	0.058	0.515	0.095	0.613
0.00130	30.00	218.85	387.11	86	0.056	0.531	0.094	0.603
0.00140	30.00	214.90	383.61	90	0.055	0.546	0.092	0.595
	35.00	232.10	398.66	73	0.062	0.567	0.098	0.631

0.00150	30.00	211.20	380.29	94	0.054	0.560	0.091	0.587
	35.00	228.20	395.30	77	0.060	0.582	0.096	0.623
0.00160	30.00	207.80	377.22	97	0.052	0.574	0.090	0.580
	35.00	224.50	392.08	81	0.059	0.596	0.095	0.615
0.00170	35.00	221.10	389.10	84	0.057	0.610	0.094	0.608
0.00180	35.00	218.00	386.36	87	0.056	0.623	0.093	0.602
	40.00	233.20	399.60	72	0.062	0.644	0.098	0.634
0.00190	35.00	215.00	383.69	90	0.055	0.636	0.092	0.595
	40.00	230.00	396.85	75	0.061	0.657	0.097	0.627
0.00200	35.00	212.20	381.19	93	0.054	0.649	0.092	0.589
	40.00	227.00	394.26	78	0.060	0.670	0.096	0.621

Annexure - A/III

Design Data for Parabolic Shaped Watercourse

SEGMENT NO. 3								
Top Width (T)		600 mm						
Total Depth (D)		360 mm						
Cross Sectional Area		0.144 sq.m						
Equation Co-efficient		0.004000						
Roughness Co-efficient.		0.014000						
Slope (S) (m/m)	Discharge (Q) (lps)	Flow Depth (d) (mm)	Flow Width (t) (mm)	Free Board (FB) (mm)	Flow Area (A) (sq.m)	Velocity (V) (m/s)	Hydraulic Radius (R) (m)	Wetted Perimeter (P) (m)
0.00015	20.00	270.15	519.76	90	0.094	0.214	0.121	0.776
0.00020	25.00	281.20	530.28	79	0.099	0.251	0.124	0.800
0.00025	25.00	266.00	515.75	94	0.091	0.273	0.119	0.768
0.00030	30.00	278.30	527.54	82	0.098	0.307	0.123	0.794
0.00035	30.00	267.90	517.59	92	0.092	0.325	0.120	0.772
	35.00	289.20	537.77	71	0.104	0.338	0.127	0.817
0.00040	35.00	279.80	528.96	80	0.099	0.355	0.124	0.797
0.00045	35.00	271.60	521.15	88	0.094	0.371	0.121	0.779
0.00050	35.00	264.60	514.39	95	0.091	0.386	0.119	0.765
	40.00	282.90	531.88	77	0.100	0.399	0.125	0.804
0.00055	40.00	276.20	525.55	84	0.097	0.413	0.123	0.789
0.00060	40.00	270.15	519.76	90	0.094	0.427	0.121	0.776
	45.00	286.60	535.35	73	0.102	0.440	0.126	0.811
0.00065	40.00	264.90	514.68	95	0.091	0.440	0.119	0.765
	45.00	280.90	530.00	79	0.099	0.453	0.124	0.799
0.00070	40.00	260.10	510.00	100	0.088	0.452	0.117	0.755
	45.00	275.85	525.21	84	0.097	0.466	0.122	0.789
0.00075	45.00	271.15	520.72	89	0.094	0.478	0.121	0.779
	50.00	285.80	534.60	74	0.102	0.491	0.126	0.810
0.00080	45.00	266.70	516.43	93	0.092	0.490	0.119	0.769
	50.00	281.20	530.28	79	0.099	0.503	0.124	0.800
0.00085	45.00	262.67	512.51	97	0.090	0.501	0.118	0.760
	50.00	276.91	526.22	83	0.097	0.515	0.123	0.791
0.00090	50.00	273.00	522.49	87	0.095	0.526	0.122	0.782
	55.00	286.30	535.07	74	0.102	0.539	0.126	0.811
0.00095	50.00	269.40	519.04	91	0.093	0.536	0.120	0.775
	55.00	282.50	531.51	78	0.100	0.549	0.125	0.803
0.00100	50.00	266.00	515.75	94	0.091	0.547	0.119	0.768
	55.00	278.90	528.11	81	0.098	0.560	0.123	0.795

0.00110	55.00	272.35	521.87	88	0.095	0.580	0.121	0.781
	60.00	284.40	533.29	76	0.101	0.593	0.125	0.807
0.00120	55.00	266.50	516.24	94	0.092	0.600	0.119	0.769
	60.00	278.30	527.54	82	0.098	0.613	0.123	0.794
	65.00	289.70	538.24	70	0.104	0.625	0.127	0.818
0.00130	55.00	261.20	511.08	99	0.089	0.618	0.118	0.757
	60.00	272.80	522.30	87	0.095	0.632	0.121	0.782
	65.00	283.95	532.87	76	0.101	0.644	0.125	0.806
0.00140	60.00	267.90	517.59	92	0.092	0.649	0.120	0.772
	65.00	278.75	527.97	81	0.098	0.662	0.123	0.795
	70.00	289.20	537.77	71	0.104	0.675	0.127	0.817
0.00150	60.00	263.15	512.98	97	0.090	0.667	0.118	0.761
	65.00	274.00	523.45	86	0.096	0.680	0.122	0.785
	70.00	284.20	533.10	76	0.101	0.693	0.125	0.806
0.00160	65.00	269.55	519.18	90	0.093	0.697	0.120	0.755
	70.00	279.80	528.96	80	0.099	0.709	0.124	0.797
	75.00	289.60	538.14	70	0.104	0.722	0.127	0.818
0.00170	65.00	265.50	515.27	95	0.091	0.713	0.119	0.766
	70.00	275.55	524.93	84	0.096	0.726	0.122	0.788
	75.00	285.20	534.04	75	0.102	0.739	0.126	0.808
0.00180	65.00	261.80	511.66	98	0.089	0.728	0.118	0.759
	70.00	271.70	521.25	88	0.094	0.741	0.121	0.788
	75.00	281.15	530.24	79	0.099	0.755	0.124	0.800
0.00190	70.00	268.00	517.69	92	0.092	0.757	0.120	0.772
	75.00	277.40	526.69	83	0.097	0.770	0.123	0.792
	80.00	286.50	535.26	74	0.102	0.783	0.126	0.811
0.00200	70.00	264.60	514.39	95	0.091	0.771	0.119	0.765
	75.00	273.80	523.26	86	0.096	0.785	0.122	0.784
	80.00	282.90	531.88	77	0.100	0.798	0.125	0.804

Annexure - A/IV

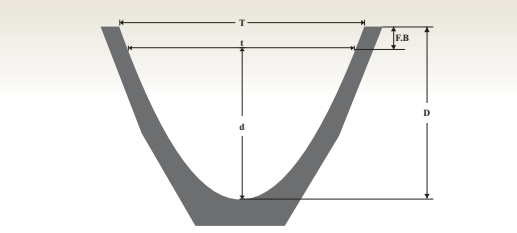
Design Data for Parabolic Shaped Watercourse

SEGMENT NO. 4								
Top Width (T)		640 mm						
Total Depth (D)		460 mm						
Cross Sectional Area		0.196 sq.m						
Equation Co-efficient		0.004492						
Roughness Co-efficient.		0.014000						
Slope (S) (m/m)	Discharge (Q) (lps)	Flow Depth (d) (mm)	Flow Width (t) (mm)	Free Board (FB) (mm)	Flow Area (A) (sq.m)	Velocity (V) (m/s)	Hydraulic Radius (R) (m)	Wetted Perimeter (P) (m)
0.00010	30.00	382.00	583.22	78	0.149	0.202	0.150	0.988
0.00015	35.00	372.70	576.08	87	0.143	0.245	0.148	0.969
0.00020	40.00	370.80	574.61	89	0.142	0.282	0.147	0.965
0.00025	45.00	372.00	575.54	88	0.143	0.315	0.147	0.968
0.00030	50.00	374.70	577.62	85	0.144	0.347	0.148	0.973
0.00035	50.00	360.30	566.41	100	0.136	0.368	0.144	0.943
	55.00	378.10	580.24	82	0.146	0.376	0.149	0.980
0.00040	55.00	365.50	570.49	95	0.139	0.396	0.146	0.954
	60.00	382.00	583.22	78	0.149	0.404	0.150	0.988
0.00045	60.00	370.80	574.61	89	0.142	0.422	0.147	0.965
	65.00	386.20	586.42	74	0.151	0.431	0.151	0.997
0.00050	60.00	361.00	566.96	99	0.136	0.440	0.144	0.945
	65.00	376.00	578.62	84	0.145	0.448	0.149	0.976
0.00055	65.00	367.00	571.66	93	0.140	0.465	0.146	0.957
	70.00	381.00	582.46	79	0.148	0.473	0.150	0.986
0.00060	70.00	372.70	576.08	87	0.143	0.489	0.148	0.969
	75.00	386.10	586.34	74	0.151	0.497	0.151	0.997
0.00065	70.00	365.20	570.25	95	0.139	0.504	0.146	0.953
	75.00	378.20	580.31	82	0.146	0.513	0.149	0.980
0.00070	75.00	371.20	574.92	89	0.142	0.527	0.147	0.966
	80.00	383.50	584.36	77	0.149	0.535	0.151	0.991
0.00075	75.00	364.70	569.86	95	0.139	0.541	0.146	0.952
	80.00	377.00	579.39	83	0.146	0.549	0.149	0.978
	85.00	388.80	588.39	71	0.153	0.557	0.152	1.003
0.00080	80.00	370.80	574.61	89	0.142	0.563	0.147	0.965
	85.00	382.40	583.53	78	0.149	0.571	0.150	0.989
0.00085	80.00	365.10	570.17	95	0.139	0.576	0.146	0.953
	85.00	376.60	579.08	83	0.145	0.585	0.149	0.977
	90.00	387.70	587.56	72	0.152	0.593	0.152	1.000
0.00090	85.00	371.20	574.92	89	0.142	0.597	0.147	0.966
	90.00	382.00	583.22	78	0.149	0.606	0.150	0.988

0.00095	85.00	366.00	570.88	94	0.139	0.610	0.146	0.955
	90.00	376.90	579.31	83	0.146	0.618	0.149	0.978
	95.00	387.40	587.33	73	0.152	0.626	0.152	1.000
0.00100	85.00	361.30	567.20	99	0.137	0.622	0.145	0.945
	90.00	372.00	575.54	88	0.143	0.631	0.147	0.968
	95.00	382.30	583.45	78	0.149	0.639	0.150	0.989
0.00110	90.00	363.10	568.61	97	0.138	0.654	0.145	0.949
	95.00	373.20	576.46	87	0.143	0.662	0.148	0.970
	100.00	383.00	583.98	77	0.149	0.671	0.151	0.990
0.00120	95.00	365.00	570.10	95	0.139	0.685	0.146	0.953
	100.00	374.70	577.62	85	0.144	0.693	0.148	0.973
	105.00	384.10	584.82	76	0.150	0.701	0.151	0.993
0.00130	100.00	367.10	571.73	93	0.140	0.715	0.146	0.957
	105.00	376.40	578.93	84	0.145	0.723	0.149	0.977
	110.00	385.30	585.73	75	0.150	0.731	0.151	0.995
0.00140	100.00	360.30	566.41	100	0.136	0.735	0.144	0.943
	105.00	369.30	573.44	91	0.141	0.744	0.147	0.962
	110.00	378.10	580.24	82	0.146	0.752	0.149	0.980
	115.00	386.80	586.87	73	0.151	0.760	0.152	0.998
0.00150	105.00	362.90	568.45	97	0.138	0.763	0.145	0.949
	110.00	371.60	575.23	88	0.143	0.772	0.147	0.967
	115.00	380.00	581.69	80	0.147	0.780	0.150	0.984
	120.00	388.40	588.09	72	0.152	0.788	0.152	1.002
0.00160	110.00	365.50	570.49	95	0.139	0.791	0.146	0.954
	115.00	373.80	576.93	86	0.144	0.800	0.148	0.971
	120.00	382.00	583.22	78	0.149	0.808	0.150	0.988
0.00170	110.00	360.00	566.18	100	0.136	0.810	0.144	0.943
	115.00	368.10	572.51	92	0.140	0.819	0.147	0.959
	120.00	376.20	578.78	84	0.145	0.827	0.149	0.976
	125.00	384.20	584.90	76	0.150	0.834	0.151	0.993
0.00180	115.00	362.80	568.37	97	0.137	0.837	0.145	0.948
	120.00	370.80	574.61	89	0.142	0.845	0.147	0.965
	125.00	378.70	580.70	81	0.147	0.853	0.149	0.982
	130.00	386.20	586.42	74	0.151	0.861	0.151	0.997
0.00190	120.00	365.80	570.72	94	0.139	0.862	0.146	0.955
	125.00	373.50	576.70	87	0.144	0.870	0.148	0.971
	130.00	380.90	582.38	79	0.148	0.879	0.150	0.986
	135.00	388.40	588.09	72	0.152	0.887	0.152	1.002
0.00200	120.00	361.00	566.96	99	0.136	0.879	0.144	0.945
	125.00	368.50	572.82	92	0.141	0.888	0.147	0.960
	130.00	376.00	578.62	84	0.145	0.896	0.149	0.976
	135.00	383.30	584.21	77	0.149	0.904	0.151	0.991

Annexure - A/V

Design Data for Parabolic Shaped Watercourse

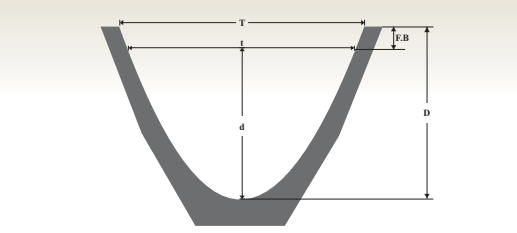
SEGMENT NO. 5								
Top Width (T)		675 mm						
Total Depth (D)		480 mm						
Cross Sectional Area		0.216 sq.m						
Equation Co-efficient		0.004214						
Roughness Co-efficient.		0.014000						
Slope (S) (m/m)	Discharge (Q) (lps)	Flow Depth (d) (mm)	Flow Width (t) (mm)	Free Board (FB) (mm)	Flow Area (A) (sq.m)	Velocity (V) (m/s)	Hydraulic Radius (R) (m)	Wetted Perimeter (P) (m)
0.00010	35.00	404.00	619.26	76	0.167	0.210	0.159	1.047
0.00015	40.00	390.00	608.44	90	0.158	0.253	0.155	1.018
0.00020	45.00	384.88	604.43	95	0.155	0.290	0.154	1.007
	50.00	406.00	620.79	74	0.168	0.298	0.160	1.051
0.00025	50.00	383.70	603.50	96	0.154	0.324	0.154	1.005
	55.00	402.70	618.26	77	0.166	0.331	0.159	1.044
0.00030	55.00	384.40	604.05	96	0.155	0.355	0.154	1.006
	60.00	401.90	617.65	78	0.165	0.363	0.159	1.043
0.00035	60.00	386.50	605.70	94	0.156	0.384	0.154	1.011
	65.00	402.50	618.11	78	0.166	0.392	0.159	1.044
0.00040	65.00	389.00	607.66	91	0.158	0.412	0.155	1.016
	70.00	404.00	619.26	76	0.167	0.420	0.159	1.047
0.00045	70.00	392.00	609.99	88	0.159	0.439	0.156	1.022
	75.00	406.00	620.79	74	0.168	0.446	0.160	1.051
0.00050	70.00	381.70	601.93	98	0.153	0.457	0.153	1.001
	75.00	395.30	612.56	85	0.161	0.465	0.157	1.029
	80.00	408.50	622.70	72	0.170	0.472	0.161	1.056
0.00055	75.00	385.80	605.15	94	0.156	0.482	0.154	1.009
	80.00	398.70	615.19	81	0.164	0.489	0.158	1.036
0.00060	80.00	390.00	608.44	90	0.158	0.506	0.155	1.018
	85.00	402.20	617.88	78	0.166	0.513	0.159	1.043
0.00065	80.00	382.10	602.24	98	0.153	0.521	0.153	1.001
	85.00	394.20	611.70	86	0.161	0.529	0.156	1.027
	90.00	405.80	620.64	74	0.168	0.536	0.160	1.051
0.00070	85.00	386.70	605.86	93	0.156	0.544	0.155	1.011
	90.00	398.20	614.80	82	0.163	0.551	0.158	1.035
	95.00	409.20	623.23	71	0.170	0.559	0.161	1.058

0.00075	85.00	380.00	600.59	100	0.152	0.559	0.153	0.997
	90.00	391.20	609.37	89	0.159	0.566	0.156	1.020
	95.00	402.10	617.80	78	0.166	0.574	0.159	1.043
0.00080	90.00	384.85	604.41	95	0.155	0.580	0.154	1.007
	95.00	395.50	612.71	85	0.162	0.588	0.157	1.029
	100.00	406.00	620.79	74	0.168	0.595	0.160	1.051
0.00085	95.00	389.50	608.05	91	0.158	0.602	0.155	1.017
	100.00	399.80	616.03	80	0.164	0.609	0.158	1.038
	105.00	409.80	623.69	70	0.170	0.616	0.161	1.059
0.00090	95.00	383.90	603.66	96	0.154	0.615	0.154	1.005
	100.00	394.00	611.55	86	0.161	0.623	0.157	1.026
	105.00	404.00	619.26	76	0.167	0.630	0.159	1.047
0.00095	100.00	388.70	607.42	91	0.157	0.635	0.155	1.015
	105.00	398.40	614.95	82	0.163	0.643	0.158	1.035
	110.00	407.90	622.24	72	0.169	0.650	0.160	1.055
0.00100	100.00	383.70	603.50	96	0.154	0.648	0.154	1.005
	105.00	393.20	610.93	87	0.160	0.656	0.156	1.024
	110.00	402.70	618.26	77	0.166	0.663	0.159	1.044
0.00110	105.00	383.90	603.66	96	0.154	0.680	0.154	1.005
	110.00	393.00	610.77	87	0.160	0.687	0.156	1.024
	115.00	402.00	617.73	78	0.166	0.695	0.159	1.043
0.00120	110.00	384.40	604.05	96	0.155	0.711	0.154	1.006
	115.00	393.15	610.89	87	0.160	0.718	0.156	1.024
	120.00	401.80	617.57	78	0.165	0.725	0.159	1.042
0.00130	115.00	385.30	604.76	95	0.155	0.740	0.154	1.008
	120.00	393.65	611.28	86	0.160	0.748	0.157	1.025
	125.00	402.00	617.73	78	0.166	0.755	0.159	1.043
	130.00	410.00	623.84	70	0.171	0.762	0.161	1.059
0.00140	120.00	386.40	605.62	94	0.156	0.769	0.154	1.010
	125.00	394.50	611.94	86	0.161	0.777	0.157	1.027
	130.00	402.50	618.11	78	0.166	0.784	0.159	1.044
0.00150	125.00	387.60	606.56	92	0.157	0.798	0.155	1.013
	130.00	395.40	612.63	85	0.161	0.805	0.157	0.157
	135.00	403.10	618.57	77	0.166	0.812	0.159	1.045
0.00160	125.00	381.40	601.69	99	0.153	0.817	0.153	1.000
	130.00	389.00	607.66	91	0.158	0.825	0.155	1.016
	135.00	396.60	613.56	83	0.162	0.832	0.157	1.032
	140.00	404.00	619.26	76	0.167	0.839	0.159	1.047
0.00170	130.00	383.00	602.95	97	0.154	0.844	0.154	1.003
	135.00	390.50	608.83	90	0.158	0.852	0.156	1.019
	140.00	397.80	614.49	82	0.163	0.859	0.158	1.034
	145.00	404.90	619.95	75	0.167	0.866	0.160	1.049

0.00180	135.00	384.80	604.37	95	0.155	0.871	0.154	1.007
	140.00	392.00	609.99	88	0.159	0.878	0.156	1.022
	145.00	399.10	615.49	81	0.164	0.885	0.158	1.037
	150.00	406.00	620.79	74	0.168	0.893	0.160	1.051
0.00190	140.00	386.70	605.86	93	0.156	0.896	0.154	1.011
	145.00	393.60	611.24	86	0.160	0.904	0.156	1.025
	150.00	400.50	616.57	80	0.165	0.911	0.158	1.040
	155.00	407.30	621.79	73	0.169	0.918	0.160	1.054
0.00200	140.00	381.70	601.93	98	0.153	0.914	0.153	1.001
	145.00	388.60	607.34	91	0.157	0.922	0.155	1.015
	150.00	395.35	612.60	85	0.161	0.929	0.157	1.029
	155.00	402.00	617.73	78	0.166	0.936	0.159	1.043
	160.00	408.60	622.78	71	0.170	0.943	0.160	1.057

Annexure - A/VI

Design Data for Parabolic Shaped Watercourse

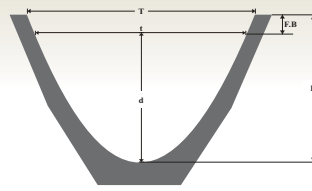
SEGMENT NO. 6								
Top Width (T)		760 mm						
Total Depth (D)		530 mm						
Cross Sectional Area		0.269 sq.m						
Equation Co-efficient		0.003670						
Roughness Co-efficient.		0.014000						
Slope (S) (m/m)	Discharge (Q) (lps)	Flow Depth (d) (mm)	Flow Width (t) (mm)	Free Board (FB) (mm)	Flow Area (A) (sq.m)	Velocity (V) (m/s)	Hydraulic Radius (R) (m)	Wetted Perimeter (P) (m)
0.00010	45.00	437.00	690.11	93	0.201	0.224	0.175	1.146
0.00015	55.00	436.50	689.71	94	0.201	0.274	0.175	1.145
	60.00	456.20	705.10	74	0.214	0.280	0.181	1.186
0.00020	65.00	441.70	693.81	88	0.204	0.318	0.177	1.156
	70.00	458.60	706.96	71	0.216	0.324	0.182	1.191
0.00025	70.00	433.40	687.26	97	0.199	0.353	0.174	1.139
	75.00	448.90	699.44	81	0.209	0.358	0.179	1.171
0.00030	80.00	442.80	694.67	87	0.205	0.390	0.177	1.158
	85.00	456.70	705.49	73	0.215	0.396	0.181	1.187
0.00035	85.00	439.20	691.84	91	0.203	0.420	0.176	1.151
	90.00	452.00	701.85	78	0.211	0.426	0.180	1.177
0.00040	90.00	437.00	690.11	93	0.201	0.448	0.175	1.146
	95.00	449.10	699.60	81	0.209	0.454	0.179	1.171
0.00045	95.00	435.90	689.24	94	0.200	0.474	0.175	1.144
	100.00	447.40	698.27	83	0.208	0.480	0.178	1.168
	105.00	458.60	706.96	71	0.216	0.486	0.182	1.191
0.00050	100.00	435.60	689.00	94	0.200	0.500	0.175	1.143
	105.00	446.50	697.57	84	0.208	0.506	0.178	1.166
	110.00	457.20	705.88	73	0.215	0.511	0.181	1.188
0.00055	105.00	435.90	689.24	94	0.200	0.524	0.175	1.144
	110.00	446.30	697.41	84	0.208	0.530	0.178	1.166
	115.00	456.50	705.34	74	0.215	0.536	0.181	1.187
0.00060	110.00	436.50	689.71	94	0.201	0.548	0.175	1.145
	115.00	446.50	697.57	84	0.208	0.554	0.178	1.166
	120.00	456.20	705.10	74	0.214	0.560	0.181	1.186
0.00065	115.00	437.50	690.50	93	0.201	0.571	0.176	1.147
	120.00	447.10	698.04	83	0.208	0.577	0.178	1.167
	125.00	456.50	705.34	74	0.215	0.582	0.181	1.187

0.00070	120.00	438.80	691.53	91	0.202	0.593	0.176	1.150
	125.00	447.90	698.66	82	0.209	0.599	0.179	1.169
	130.00	457.00	705.72	73	0.215	0.605	0.181	1.188
0.00075	120.00	431.10	685.43	99	0.197	0.609	0.174	1.134
	125.00	440.20	692.63	90	0.203	0.615	0.176	1.153
	130.00	449.00	699.52	81	0.209	0.621	0.179	1.171
	135.00	457.70	706.26	72	0.216	0.626	0.181	1.189
0.00080	125.00	433.00	686.94	97	0.198	0.630	0.174	1.138
	130.00	441.70	693.81	88	0.204	0.636	0.177	1.156
0.00080	135.00	450.30	700.53	80	0.210	0.642	0.179	1.174
	140.00	458.60	706.96	71	0.216	0.648	0.182	1.191
0.00085	130.00	435.00	688.53	95	0.200	0.651	0.175	1.142
	135.00	443.30	695.06	87	0.205	0.657	0.177	1.159
	140.00	451.70	701.62	78	0.211	0.663	0.179	1.177
	145.00	459.80	707.88	70	0.217	0.668	0.182	1.194
0.00090	135.00	437.00	690.11	93	0.201	0.671	0.175	1.146
	140.00	445.10	696.47	85	0.207	0.677	0.178	1.163
	145.00	453.20	702.78	77	0.212	0.683	0.180	1.180
0.00095	135.00	431.10	685.43	99	0.197	0.685	0.174	1.134
	140.00	439.00	691.68	91	0.202	0.692	0.176	1.150
	145.00	447.00	697.96	83	0.208	0.697	0.178	1.167
	150.00	454.70	703.94	75	0.213	0.703	0.180	1.183
0.00100	140.00	433.30	687.18	97	0.199	0.705	0.174	1.138
	145.00	441.20	693.42	89	0.204	0.711	0.177	1.155
	150.00	448.90	699.44	81	0.209	0.717	0.179	1.171
	155.00	456.30	705.18	74	0.215	0.723	0.181	1.186
0.00110	145.00	430.70	685.11	99	0.197	0.737	0.174	1.133
	150.00	438.10	690.97	92	0.202	0.743	0.176	1.148
	155.00	445.50	696.79	85	0.207	0.749	0.178	1.164
	160.00	452.70	702.39	77	0.212	0.755	0.180	1.179
	165.00	459.90	707.96	70	0.217	0.760	0.182	1.194
0.00120	155.00	435.80	689.16	94	0.200	0.774	0.175	1.144
	160.00	442.80	694.67	87	0.205	0.780	0.177	1.158
	165.00	449.80	700.14	80	0.210	0.786	0.179	1.173
	170.00	456.70	705.49	73	0.215	0.791	0.181	1.187
0.00130	160.00	433.90	687.65	96	0.199	0.804	0.175	1.140
	165.00	440.70	693.02	89	0.204	0.810	0.177	1.154
	170.00	447.50	698.35	83	0.208	0.816	0.178	1.168
	175.00	454.10	703.48	76	0.213	0.822	0.180	1.182

0.00140	165.00	432.50	686.54	98	0.198	0.834	0.174	1.137
	170.00	439.20	691.84	91	0.203	0.839	0.176	1.151
	175.00	445.60	696.86	84	0.207	0.845	0.178	1.164
	180.00	452.00	701.85	78	0.211	0.851	0.180	1.177
	185.00	458.30	706.73	72	0.216	0.857	0.182	1.190
0.00150	170.00	431.40	685.67	99	0.197	0.862	0.174	1.134
	175.00	437.90	690.82	92	0.202	0.868	0.176	1.148
	180.00	444.20	695.77	86	0.206	0.874	0.177	1.161
	185.00	450.40	700.61	80	0.210	0.879	0.179	1.174
	190.00	456.60	705.41	73	0.215	0.885	0.181	1.187
0.00160	175.00	430.80	685.19	99	0.197	0.889	0.174	1.133
	180.00	437.00	690.11	93	0.201	0.895	0.175	1.146
	185.00	443.10	694.91	87	0.205	0.901	0.177	1.159
	190.00	449.10	699.60	81	0.209	0.907	0.179	1.171
	195.00	455.10	704.25	75	0.214	0.913	0.181	1.184
0.00170	180.00	430.30	684.80	100	0.196	0.916	0.174	1.132
	185.00	436.40	689.63	94	0.201	0.922	0.175	1.145
	190.00	442.30	694.28	88	0.205	0.928	0.177	1.157
	195.00	448.10	698.82	82	0.209	0.934	0.179	1.169
	200.00	454.00	703.40	76	0.213	0.939	0.180	1.182
	205.00	459.80	707.88	70	0.217	0.945	0.182	1.194
0.00180	185.00	430.10	684.64	100	0.196	0.942	0.173	1.132
	190.00	435.90	689.24	94	0.200	0.949	0.175	1.144
	195.00	441.70	693.81	88	0.204	0.954	0.177	1.156
	200.00	447.40	698.27	83	0.208	0.960	0.178	1.168
	205.00	453.00	702.63	77	0.212	0.966	0.180	1.179
	210.00	458.60	706.96	71	0.216	0.972	0.182	1.191
0.00190	190.00	430.00	684.56	100	0.196	0.968	0.173	1.132
	195.00	435.80	689.16	94	0.200	0.974	0.175	1.144
	200.00	441.30	693.49	89	0.204	0.980	0.177	1.155
	205.00	446.90	697.88	83	0.208	0.986	0.178	1.167
	210.00	452.40	702.16	78	0.212	0.992	0.180	1.178
	215.00	457.90	706.42	72	0.216	0.997	0.181	1.190
0.00200	195.00	430.10	684.64	100	0.196	0.993	0.173	1.132
	200.00	435.60	689.00	94	0.200	1.000	0.175	1.143
	205.00	441.10	693.34	89	0.204	1.005	0.177	1.155
	210.00	446.50	697.57	84	0.208	1.011	0.178	1.166
	215.00	451.90	701.77	78	0.211	1.017	0.180	1.177
	220.00	457.20	705.88	73	0.215	1.023	0.181	1.188

Annexure - A/VII

Design Data for Parabolic Shaped Watercourse

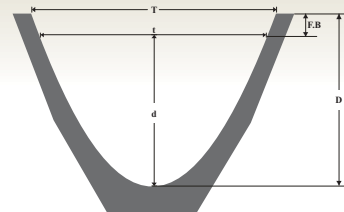
SEGMENT NO. 6a								
Top Width (T)			850	mm				
Total Depth (D)			570	mm				
Cross Sectional Area			0.323	sq.m				
Equation Co-efficient			0.003156					
Roughness Co-efficient.			0.014000					
Slope (S) (m/m)	Discharge (Q) (lps)	Flow Depth (d) (mm)	Flow Width (t) (mm)	Free Board (FB) (mm)	Flow Area (A) (sq.m)	Velocity (V) (m/s)	Hydraulic Radius (R) (m)	Wetted Perimeter (P) (m)
0.00010	60.00	479.45	779.53	91	0.249	0.241	0.196	1.273
	65.00	499.30	795.50	71	0.265	0.245	0.201	1.314
0.00015	75.00	484.43	783.57	86	0.253	0.296	0.197	1.283
	80.00	500.54	796.49	69	0.266	0.301	0.202	1.317
0.00020	85.00	479.87	779.87	90	0.249	0.341	0.196	1.274
	90.00	493.97	791.25	76	0.261	0.345	0.200	1.303
0.00025	95.00	479.79	779.81	90	0.249	0.381	0.196	1.274
	100.00	492.42	790.00	78	0.259	0.386	0.199	1.300
0.00030	100.00	470.20	771.98	100	0.242	0.413	0.193	1.254
	105.00	481.96	781.57	88	0.251	0.418	0.196	1.278
	110.00	493.46	790.83	77	0.260	0.423	0.200	1.302
0.00035	110.00	474.56	775.55	95	0.245	0.448	0.194	1.263
	115.00	485.36	784.32	85	0.254	0.453	0.197	1.285
	120.00	495.95	792.83	74	0.262	0.458	0.201	1.307
0.00040	115.00	469.24	771.18	101	0.241	0.477	0.193	1.252
	120.00	479.45	779.53	91	0.249	0.482	0.196	1.273
	125.00	489.47	787.63	81	0.257	0.486	0.199	1.294
	130.00	499.30	795.50	71	0.265	0.491	0.201	1.314
0.00045	125.00	475.09	775.97	95	0.246	0.509	0.194	1.264
	130.00	484.61	783.72	85	0.253	0.513	0.197	1.284
	135.00	493.97	791.25	76	0.261	0.518	0.200	1.303
0.00050	130.00	471.86	773.34	98	0.243	0.534	0.194	1.257
	135.00	480.96	780.76	89	0.250	0.539	0.196	1.276
	140.00	489.90	787.98	80	0.257	0.544	0.199	1.295
	145.00	498.70	795.02	71	0.264	0.549	0.201	1.313
0.00055	135.00	469.50	771.40	100	0.241	0.559	0.193	1.252
	140.00	478.22	778.53	92	0.248	0.564	0.195	1.270
	145.00	486.80	785.48	83	0.255	0.569	0.198	1.288
	150.00	495.23	792.26	75	0.262	0.573	0.200	1.306
0.00060	145.00	476.19	776.87	94	0.247	0.588	0.195	1.266
	150.00	484.43	783.57	86	0.253	0.593	0.197	1.283
	155.00	492.55	790.11	77	0.259	0.597	0.200	1.300
	160.00	500.54	796.49	69	0.266	0.602	0.202	1.317
0.00065	150.00	474.72	775.67	95	0.245	0.611	0.194	1.263
	155.00	482.66	782.14	87	0.252	0.616	0.197	1.280
	160.00	490.49	788.45	80	0.258	0.621	0.199	1.296
	165.00	498.20	794.63	72	0.264	0.625	0.201	1.312

0.00070	155.00	473.69	774.84	96	0.245	0.633	0.194	1.261
	160.00	481.37	781.09	89	0.251	0.638	0.196	1.277
	165.00	488.93	787.20	81	0.257	0.643	0.198	1.293
	170.00	496.38	793.18	74	0.262	0.648	0.201	1.308
0.00075	160.00	473.03	774.30	97	0.244	0.655	0.194	1.259
	165.00	480.46	780.35	90	0.250	0.660	0.196	1.275
	170.00	487.78	786.27	82	0.256	0.665	0.198	1.290
	175.00	495.00	792.07	75	0.261	0.670	0.200	1.305
0.00080	165.00	472.68	774.00	97	0.244	0.677	0.194	1.259
	170.00	479.87	779.87	90	0.249	0.681	0.196	1.274
	175.00	486.97	785.62	83	0.255	0.686	0.198	1.289
0.00080	180.00	493.97	791.25	76	0.261	0.691	0.200	1.303
	185.00	500.88	796.76	69	0.266	0.695	0.202	1.318
0.00085	170.00	472.57	773.91	97	0.244	0.697	0.194	1.259
	175.00	479.55	779.61	90	0.249	0.702	0.196	1.273
	180.00	486.44	785.19	84	0.255	0.707	0.198	1.288
	185.00	493.24	790.66	77	0.260	0.712	0.200	1.302
	190.00	499.96	796.03	70	0.265	0.716	0.202	1.316
0.00090	175.00	472.66	773.99	97	0.244	0.718	0.194	1.259
	180.00	479.45	779.53	91	0.249	0.722	0.196	1.273
	185.00	486.15	784.96	84	0.254	0.727	0.198	1.287
	190.00	492.77	790.28	77	0.260	0.732	0.200	1.301
	195.00	499.30	795.50	71	0.265	0.736	0.201	1.314
0.00095	180.00	472.94	774.22	97	0.244	0.737	0.194	1.259
	185.00	479.54	779.60	90	0.249	0.742	0.196	1.273
	190.00	486.06	784.89	84	0.254	0.747	0.198	1.287
	195.00	492.50	790.07	77	0.259	0.752	0.200	1.300
	200.00	498.86	795.16	71	0.264	0.756	0.201	1.313
0.00100	185.00	473.36	774.56	97	0.244	0.757	0.194	1.260
	190.00	479.79	779.81	90	0.249	0.762	0.196	1.274
	195.00	486.14	784.95	84	0.254	0.767	0.198	1.287
	200.00	492.42	790.00	78	0.259	0.771	0.199	1.300
	205.00	498.62	794.96	71	0.264	0.776	0.201	1.313
0.00110	195.00	474.55	775.54	95	0.245	0.795	0.194	1.263
	200.00	480.67	780.52	89	0.250	0.800	0.196	1.275
	205.00	486.72	785.42	83	0.255	0.804	0.198	1.288
	210.00	492.70	790.23	77	0.260	0.809	0.200	1.301
	215.00	498.62	794.96	71	0.264	0.814	0.201	1.313
0.00120	200.00	470.20	771.98	100	0.242	0.826	0.193	1.254
	205.00	476.12	776.82	94	0.247	0.831	0.195	1.266
	210.00	481.96	781.57	88	0.251	0.836	0.196	1.278
	215.00	487.74	786.24	82	0.256	0.841	0.198	1.290
	220.00	493.46	790.83	77	0.260	0.846	0.200	1.302
	225.00	499.11	795.35	71	0.265	0.850	0.201	1.314
0.00130	210.00	472.30	773.69	98	0.244	0.862	0.194	1.258
	215.00	477.95	778.31	92	0.248	0.867	0.195	1.270
	220.00	483.55	782.86	86	0.252	0.872	0.197	1.281
	225.00	489.09	787.33	81	0.257	0.876	0.199	1.293
	230.00	494.57	791.72	75	0.261	0.881	0.200	1.304
	235.00	499.99	796.05	70	0.265	0.886	0.202	1.316

0.00140	215.00	469.08	771.05	101	0.241	0.892	0.193	1.251
	220.00	474.56	775.55	95	0.245	0.897	0.194	1.263
	225.00	479.99	779.97	90	0.250	0.901	0.196	1.274
	230.00	485.36	784.32	85	0.254	0.906	0.197	1.285
	235.00	490.68	788.61	79	0.258	0.911	0.199	1.296
	240.00	495.95	792.83	74	0.262	0.916	0.201	1.307
0.00150	225.00	471.68	773.19	98	0.243	0.925	0.193	1.257
	230.00	476.96	777.50	93	0.247	0.930	0.195	1.268
	235.00	482.18	781.75	88	0.251	0.935	0.197	1.279
	240.00	487.35	785.93	83	0.255	0.940	0.198	1.289
	245.00	492.47	790.04	78	0.259	0.945	0.200	1.300
	250.00	497.54	794.10	72	0.263	0.949	0.201	1.311
0.00160	230.00	469.24	771.18	101	0.241	0.953	0.193	1.252
	235.00	474.37	775.39	96	0.245	0.958	0.194	1.262
	240.00	479.45	779.53	91	0.249	0.963	0.196	1.273
	245.00	484.48	783.61	86	0.253	0.968	0.197	1.283
	250.00	489.47	787.63	81	0.257	0.973	0.199	1.294
0.00160	255.00	494.41	791.60	76	0.261	0.977	0.200	1.304
	260.00	499.30	795.50	71	0.265	0.982	0.201	1.314
0.00170	240.00	472.15	773.57	98	0.243	0.986	0.194	1.258
	245.00	477.10	777.62	93	0.247	0.991	0.195	1.268
	250.00	482.01	781.61	88	0.251	0.995	0.196	1.278
	255.00	486.87	785.54	83	0.255	1.000	0.198	1.288
	260.00	491.68	789.41	78	0.259	1.005	0.199	1.298
	265.00	496.45	793.23	74	0.263	1.009	0.201	1.308
0.00180	245.00	470.25	772.02	100	0.242	1.012	0.193	1.254
	250.00	475.09	775.97	95	0.246	1.017	0.194	1.264
	255.00	479.87	779.87	90	0.249	1.022	0.196	1.274
	260.00	484.61	783.72	85	0.253	1.027	0.197	1.284
	265.00	489.31	787.51	81	0.257	1.032	0.199	1.294
	270.00	493.97	791.25	76	0.261	1.036	0.200	1.303
	275.00	498.59	794.94	71	0.264	1.041	0.201	1.313
0.00190	255.00	473.35	774.56	97	0.244	1.043	0.194	1.260
	260.00	478.03	778.37	92	0.248	1.048	0.195	1.270
	265.00	482.66	782.13	87	0.252	1.053	0.197	1.280
	270.00	487.25	785.85	83	0.255	1.058	0.198	1.289
	275.00	491.80	789.51	78	0.259	1.062	0.199	1.299
	280.00	496.31	793.12	74	0.262	1.067	0.201	1.308
	285.00	500.79	796.69	69	0.266	1.071	0.202	1.317
0.00200	260.00	471.86	773.34	98	0.243	1.069	0.194	1.257
	265.00	476.43	777.07	94	0.247	1.074	0.195	1.267
	270.00	480.96	780.76	89	0.250	1.079	0.196	1.276
	275.00	485.45	784.39	85	0.254	1.083	0.197	1.285
	280.00	489.90	787.98	80	0.257	1.088	0.199	1.295
	285.00	494.32	791.53	76	0.261	1.093	0.200	1.304
	290.00	498.70	795.02	71	0.264	1.097	0.201	1.313

Annexure - A/VIII

Design Data for Parabolic Shaped Watercourse

SEGMENT NO. 7								
Top Width (T)		920 mm						
Total Depth (D)		610 mm						
Cross Sectional Area		0.374 sq.m						
Equation Co-efficient		0.002883						
Roughness Co-efficient.		0.014000						
Slope (S) (m/m)	Discharge (Q) (lps)	Flow Depth (d) (mm)	Flow Width (t) (mm)	Free Board (FB) (mm)	Flow Area (A) (sq.m)	Velocity (V) (m/s)	Hydraulic Radius (R) (m)	Wetted Perimeter (P) (m)
0.00010	75.00	520.00	849.42	90	0.294	0.255	0.213	1.383
	80.00	537.41	863.52	73	0.309	0.259	0.218	1.420
0.00015	90.00	514.70	845.08	95	0.290	0.310	0.211	1.372
	95.00	529.00	856.74	81	0.302	0.314	0.215	1.402
0.00020	105.00	517.50	847.38	93	0.292	0.359	0.212	1.379
	110.00	529.80	857.39	80	0.303	0.363	0.216	1.404
0.00025	115.00	512.10	842.95	98	0.288	0.400	0.210	1.367
	120.00	523.20	852.03	87	0.297	0.404	0.214	1.390
	125.00	534.10	860.86	76	0.307	0.408	0.217	1.413
0.00030	125.00	510.00	841.22	100	0.286	0.437	0.210	1.362
	130.00	520.30	849.67	90	0.295	0.441	0.213	1.384
	135.00	530.30	857.80	80	0.303	0.445	0.216	1.405
0.00035	135.00	510.00	841.22	100	0.286	0.472	0.210	1.362
	140.00	519.40	848.93	91	0.294	0.476	0.213	0.138
	145.00	528.70	856.50	81	0.302	0.480	0.215	0.140
	150.00	538.00	864.00	72	0.310	0.484	0.218	1.421
0.00040	145.00	511.20	842.21	99	0.287	0.505	0.210	1.365
	150.00	520.00	849.42	90	0.294	0.509	0.213	1.383
	155.00	528.70	856.50	81	0.302	0.513	0.215	1.401
	160.00	537.40	863.52	73	0.309	0.517	0.218	1.420
0.00045	155.00	513.20	843.85	97	0.289	0.537	0.211	1.369
	160.00	521.60	850.73	88	0.296	0.541	0.213	1.387
	165.00	529.80	857.39	80	0.303	0.545	0.216	1.404
	170.00	537.70	863.76	72	0.310	0.549	0.218	1.420
0.00050	165.00	515.70	845.90	94	0.291	0.567	0.212	1.374
	170.00	523.60	852.36	86	0.298	0.571	0.214	1.391
	175.00	531.40	858.68	79	0.304	0.575	0.216	1.407
	180.00	539.00	864.80	71	0.311	0.579	0.218	1.423

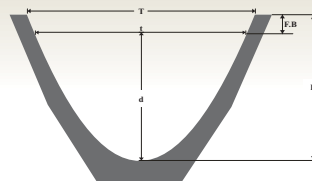
0.00055	170.00	511.20	842.21	99	0.287	0.592	0.210	1.365
	175.00	518.60	848.28	91	0.293	0.597	0.213	1.380
	180.00	526.10	854.39	84	0.300	0.601	0.215	1.396
	185.00	533.60	860.46	76	0.306	0.604	0.217	1.412
0.00060	180.00	514.70	845.08	95	0.290	0.621	0.211	1.372
	185.00	521.90	850.97	88	0.296	0.625	0.213	1.387
	190.00	529.00	856.74	81	0.302	0.629	0.215	1.402
	195.00	536.00	862.39	74	0.308	0.633	0.218	1.417
0.00065	185.00	511.50	842.45	99	0.287	0.644	0.210	1.366
	190.00	518.40	848.12	92	0.293	0.648	0.212	1.380
	195.00	525.20	853.66	85	0.299	0.652	0.214	1.394
	200.00	532.00	859.17	78	0.305	0.656	0.216	1.408
	205.00	538.70	864.56	71	0.310	0.660	0.218	1.422
0.00070	195.00	515.50	845.74	95	0.291	0.671	0.212	1.374
	200.00	522.00	851.06	88	0.296	0.675	0.214	1.387
	205.00	528.60	856.42	81	0.302	0.679	0.215	1.401
	210.00	535.20	861.75	75	0.307	0.683	0.217	1.415
0.00075	200.00	513.10	843.77	97	0.289	0.693	0.211	1.369
	205.00	519.50	849.02	91	0.294	0.697	0.213	1.382
	210.00	525.80	854.15	84	0.299	0.701	0.215	1.395
	215.00	532.20	859.33	78	0.305	0.705	0.216	1.409
	220.00	538.50	864.40	72	0.310	0.709	0.218	1.422
0.00080	205.00	511.20	842.21	99	0.287	0.714	0.210	1.365
	210.00	517.40	847.30	93	0.292	0.719	0.212	1.378
	215.00	523.60	852.36	86	0.298	0.723	0.214	1.391
	220.00	529.80	857.39	80	0.303	0.726	0.216	1.404
	225.00	535.80	862.23	74	0.308	0.731	0.217	1.416
0.00085	215.00	515.60	845.82	94	0.291	0.739	0.212	1.374
	220.00	521.70	850.81	88	0.296	0.743	0.213	1.387
	225.00	527.60	855.61	82	0.301	0.748	0.215	1.399
	230.00	533.50	860.38	77	0.306	0.752	0.217	1.411
	235.00	539.40	865.12	71	0.311	0.755	0.218	1.424
0.00090	220.00	514.20	844.67	96	0.290	0.760	0.211	1.371
	225.00	520.00	849.42	90	0.294	0.764	0.213	1.383
	230.00	525.80	854.15	84	0.299	0.768	0.215	1.395
	235.00	531.70	858.93	78	0.304	0.772	0.216	1.408
	240.00	537.40	863.52	73	0.309	0.776	0.218	1.420

0.00095	225.00	513.00	843.69	97	0.289	0.780	0.211	1.369
	230.00	518.80	848.44	91	0.293	0.784	0.212	1.381
	235.00	524.30	852.93	86	0.298	0.788	0.214	1.392
	240.00	530.00	857.55	80	0.303	0.792	0.216	1.404
	245.00	535.60	862.07	74	0.308	0.796	0.217	1.416
0.00100	230.00	512.10	842.95	98	0.288	0.799	0.210	1.367
	235.00	517.60	847.46	92	0.292	0.804	0.212	1.378
	240.00	523.20	852.03	87	0.297	0.808	0.214	1.390
	245.00	528.60	856.42	81	0.302	0.812	0.215	1.401
	250.00	534.10	860.86	76	0.307	0.816	0.217	1.413
	255.00	539.50	865.20	71	0.311	0.819	0.219	1.424
0.00110	240.00	510.70	841.79	99	0.287	0.837	0.210	1.364
	245.00	516.05	846.19	94	0.291	0.842	0.212	1.375
	250.00	521.40	850.57	89	0.296	0.846	0.213	1.386
	255.00	526.60	854.80	83	0.300	0.850	0.215	1.397
	260.00	531.80	859.01	78	0.305	0.854	0.216	1.408
0.00110	265.00	537.00	863.20	73	0.309	0.858	0.218	1.419
0.00120	250.00	510.00	841.22	100	0.286	0.874	0.210	1.362
	255.00	515.10	845.41	95	0.290	0.878	0.212	1.373
	260.00	520.30	849.67	90	0.295	0.882	0.213	1.384
	265.00	525.20	853.66	85	0.299	0.887	0.214	1.394
	270.00	530.30	857.80	80	0.303	0.890	0.216	1.405
	275.00	535.20	861.75	75	0.307	0.894	0.217	1.415
0.00130	265.00	514.70	845.08	95	0.290	0.914	0.211	1.372
	270.00	519.60	849.10	90	0.294	0.918	0.213	1.382
	275.00	524.50	853.09	86	0.298	0.922	0.214	1.393
	280.00	529.30	856.99	81	0.302	0.926	0.216	1.403
	285.00	534.10	860.86	76	0.307	0.930	0.217	1.413
	290.00	538.80	864.64	71	0.311	0.934	0.218	1.423
0.00140	275.00	514.70	845.08	95	0.290	0.948	0.211	1.372
	280.00	519.40	848.93	91	0.294	0.953	0.213	1.382
	285.00	524.10	852.77	86	0.298	0.957	0.214	1.392
	290.00	528.80	856.58	81	0.302	0.960	0.215	1.402
	295.00	533.30	860.22	77	0.306	0.965	0.217	1.411
	300.00	538.00	864.00	72	0.310	0.968	0.218	1.421
0.00150	280.00	510.40	841.55	100	0.286	0.978	0.210	1.363
	285.00	515.10	845.41	95	0.290	0.982	0.211	1.373
	290.00	519.60	849.10	90	0.294	0.986	0.213	1.382
	295.00	524.10	852.77	86	0.298	0.990	0.214	1.392
	300.00	528.60	856.42	81	0.302	0.994	0.215	1.401
	305.00	533.00	859.98	77	0.306	0.998	0.217	1.410
	310.00	537.50	863.60	73	0.309	1.002	0.218	1.420

0.00160	290.00	511.20	842.21	99	0.287	1.010	0.210	1.365
	295.00	515.60	845.82	94	0.291	1.015	0.212	1.374
	300.00	520.00	849.42	90	0.294	1.019	0.213	1.383
	305.00	524.50	853.09	86	0.298	1.022	0.214	1.393
	310.00	528.80	856.58	81	0.302	1.027	0.215	1.402
	315.00	533.00	859.98	77	0.306	1.031	0.217	1.410
	320.00	537.40	863.52	73	0.309	1.034	0.218	1.420
0.00170	300.00	512.10	842.95	98	0.288	1.042	0.211	1.367
	305.00	516.40	846.48	94	0.291	1.047	0.212	1.376
	310.00	520.70	850.00	89	0.295	1.051	0.213	1.385
	315.00	525.00	853.50	85	0.299	1.054	0.214	1.394
	320.00	529.10	856.82	81	0.302	1.059	0.216	1.402
	325.00	533.30	860.22	77	0.306	1.063	0.217	1.411
	330.00	537.50	863.60	73	0.309	1.066	0.218	1.420
0.00180	310.00	513.20	843.85	97	0.289	1.074	0.211	1.369
	315.00	517.40	847.30	93	0.292	1.078	0.212	1.378
	320.00	521.50	850.65	89	0.296	1.082	0.213	1.386
	325.00	525.60	853.99	84	0.299	1.086	0.215	1.395
	330.00	529.80	857.39	80	0.303	1.090	0.216	1.404
	335.00	533.80	860.62	76	0.306	1.094	0.217	1.412
0.00180	340.00	537.70	863.76	72	0.310	1.098	0.218	1.420
0.00190	315.00	510.40	841.55	100	0.286	1.100	0.210	1.363
	320.00	514.50	844.92	96	0.290	1.104	0.211	1.372
	325.00	518.50	848.20	92	0.293	1.108	0.212	1.380
	330.00	522.60	851.55	87	0.297	1.112	0.214	1.389
	335.00	526.50	854.72	84	0.300	1.117	0.215	1.397
	340.00	530.50	857.96	80	0.303	1.121	0.216	1.405
	345.00	534.50	861.19	76	0.307	1.124	0.217	1.414
	350.00	538.40	864.32	72	0.310	1.128	0.218	1.422
0.00200	325.00	511.80	842.70	98	0.288	1.130	0.210	1.366
	330.00	515.70	845.90	94	0.291	1.135	0.212	1.374
	335.00	519.80	849.26	90	0.294	1.138	0.213	1.383
	340.00	523.60	852.36	86	0.298	1.143	0.214	1.391
	345.00	527.50	855.53	83	0.301	1.147	0.215	1.399
	350.00	531.40	858.68	79	0.304	1.151	0.216	1.407
	355.00	535.20	861.75	75	0.307	1.155	0.217	1.415
	360.00	539.00	864.80	71	0.311	1.158	0.218	1.423

Annexure - A/IX

Design Data for Parabolic Shaped Watercourse

SEGMENT NO. 7a								
Top Width (T)		1030		mm				
Total Depth (D)		650		mm				
Cross Sectional Area		0.446		sq.m				
Equation Co-efficient		0.002451						
Roughness Co-efficient.		0.014000						
Slope (S) (m/m)	Discharge (Q) (lps)	Flow Depth (d) (mm)	Flow Width (t) (mm)	Free Board (FB) (mm)	Flow Area (A) (sq.m)	Velocity (V) (m/s)	Hydraulic Radius (R) (m)	Wetted Perimeter (P) (m)
0.00010	95.00	553.94	950.85	96	0.351	0.271	0.233	1.506
	100.00	568.45	963.23	82	0.365	0.274	0.238	1.537
0.00015	115.00	550.69	948.06	99	0.348	0.330	0.232	1.500
	120.00	562.63	958.28	87	0.359	0.334	0.236	1.525
	125.00	574.34	968.20	76	0.371	0.337	0.239	1.549
0.00020	135.00	555.29	952.01	95	0.352	0.383	0.234	1.509
	140.00	565.56	960.77	84	0.362	0.386	0.237	1.531
	145.00	575.67	969.32	74	0.372	0.390	0.240	1.552
0.00025	150.00	553.56	950.52	96	0.351	0.428	0.233	1.506
	155.00	562.78	958.41	87	0.360	0.431	0.236	1.525
	160.00	571.86	966.11	78	0.368	0.434	0.239	1.544
	165.00	580.82	973.64	69	0.377	0.438	0.241	1.563
0.00030	165.00	554.71	951.51	95	0.352	0.469	0.233	1.508
	170.00	563.12	958.70	87	0.360	0.472	0.236	1.526
	175.00	571.42	965.73	79	0.368	0.476	0.238	1.543
	180.00	579.60	972.62	70	0.376	0.479	0.241	1.560
0.00035	175.00	549.64	947.15	100	0.347	0.504	0.232	1.497
	180.00	557.50	953.90	93	0.355	0.508	0.234	1.514
	185.00	565.25	960.51	85	0.362	0.511	0.237	1.530
	190.00	572.91	966.99	77	0.369	0.514	0.239	1.546
	195.00	580.47	973.35	70	0.377	0.518	0.241	1.562
0.00040	190.00	553.94	950.85	96	0.351	0.541	0.233	1.506
	195.00	561.24	957.10	89	0.358	0.545	0.235	1.522
	200.00	568.45	963.23	82	0.365	0.548	0.238	1.537
	205.00	575.58	969.24	74	0.372	0.551	0.240	1.552
0.00045	200.00	551.83	949.03	98	0.349	0.573	0.232	1.502
	205.00	558.73	954.96	91	0.356	0.576	0.235	1.516
	210.00	565.56	960.77	84	0.362	0.580	0.237	1.531
	215.00	572.32	966.49	78	0.369	0.583	0.239	1.545
	220.00	579.00	972.12	71	0.375	0.586	0.241	1.559
0.00050	210.00	550.75	948.10	99	0.348	0.603	0.232	1.500
	215.00	557.31	953.74	93	0.354	0.607	0.234	1.513
	220.00	563.81	959.28	86	0.361	0.610	0.236	1.527
	225.00	570.24	964.74	80	0.367	0.613	0.238	1.541
	230.00	576.60	970.10	73	0.373	0.617	0.240	1.554
0.00055	220.00	550.43	947.83	100	0.348	0.633	0.232	1.499
	225.00	556.70	953.21	93	0.354	0.636	0.234	1.512
	230.00	562.90	958.51	87	0.360	0.639	0.236	1.525
	235.00	569.04	963.72	81	0.366	0.643	0.238	1.538
	240.00	575.12	968.85	75	0.371	0.646	0.240	1.551

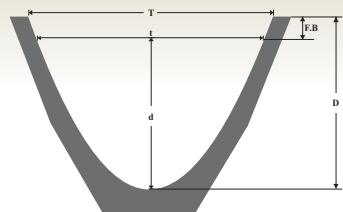
0.00060	230.00	550.69	948.06	99	0.348	0.661	0.232	1.500
	235.00	556.69	953.21	93	0.354	0.664	0.234	1.512
	240.00	562.63	958.28	87	0.359	0.668	0.236	1.525
	245.00	568.51	963.28	81	0.365	0.671	0.238	1.537
	250.00	574.34	968.20	76	0.371	0.674	0.239	1.549
	255.00	580.11	973.05	70	0.376	0.678	0.241	1.561
0.00065	240.00	551.40	948.67	99	0.349	0.688	0.232	1.501
	245.00	557.16	953.61	93	0.354	0.692	0.234	1.513
0.00065	250.00	562.86	958.47	87	0.360	0.695	0.236	1.525
	255.00	568.51	963.27	81	0.365	0.698	0.238	1.537
	260.00	574.11	968.00	76	0.370	0.702	0.239	1.549
	265.00	579.65	972.67	70	0.376	0.705	0.241	1.560
0.00070	250.00	552.45	949.57	98	0.350	0.715	0.233	1.503
	255.00	557.99	954.32	92	0.355	0.718	0.234	1.515
	260.00	563.47	959.00	87	0.360	0.722	0.236	1.526
	265.00	568.91	963.62	81	0.365	0.725	0.238	1.538
	270.00	574.30	968.17	76	0.371	0.728	0.239	1.549
	275.00	579.65	972.66	70	0.376	0.732	0.241	1.560
0.00075	260.00	553.76	950.70	96	0.351	0.741	0.233	1.506
	265.00	559.10	955.27	91	0.356	0.744	0.235	1.517
	270.00	564.40	959.78	86	0.361	0.748	0.236	1.528
	275.00	569.64	964.23	80	0.366	0.751	0.238	1.539
	280.00	574.85	968.63	75	0.371	0.754	0.239	1.550
	285.00	580.01	972.96	70	0.376	0.758	0.241	1.561
0.00080	265.00	550.09	947.54	100	0.347	0.763	0.232	1.498
	270.00	555.29	952.01	95	0.352	0.766	0.234	1.509
	275.00	560.45	956.42	90	0.357	0.770	0.235	1.520
	280.00	565.56	960.77	84	0.362	0.773	0.237	1.531
	285.00	570.64	965.07	79	0.367	0.776	0.238	1.541
	290.00	575.67	969.32	74	0.372	0.780	0.240	1.552
	295.00	580.66	973.51	69	0.377	0.783	0.241	1.562
0.00085	275.00	551.95	949.14	98	0.349	0.787	0.232	1.502
	280.00	556.99	953.46	93	0.354	0.791	0.234	1.513
	285.00	561.98	957.72	88	0.359	0.794	0.236	1.523
	290.00	566.93	961.93	83	0.364	0.798	0.237	1.534
	295.00	571.84	966.09	78	0.368	0.801	0.239	1.544
	300.00	576.71	970.20	73	0.373	0.804	0.240	1.554
0.00090	280.00	549.03	946.62	101	0.346	0.808	0.232	1.496
	285.00	553.94	950.85	96	0.351	0.812	0.233	1.506
	290.00	558.82	955.03	91	0.356	0.815	0.235	1.517
	295.00	563.66	959.15	86	0.360	0.818	0.236	1.527
	300.00	568.45	963.23	82	0.365	0.822	0.238	1.537
	305.00	573.21	967.25	77	0.370	0.825	0.239	1.547
	310.00	577.94	971.23	72	0.374	0.828	0.240	1.557
0.00095	290.00	551.26	948.54	99	0.349	0.832	0.232	1.501
	295.00	556.03	952.64	94	0.353	0.835	0.234	1.511
	300.00	560.76	956.68	89	0.358	0.839	0.235	1.521
	305.00	565.45	960.68	85	0.362	0.842	0.237	1.531
	310.00	570.11	964.62	80	0.367	0.846	0.238	1.540
	315.00	574.73	968.53	75	0.371	0.849	0.239	1.550
	320.00	579.31	972.38	71	0.376	0.852	0.241	1.560

0.00100	300.00	553.56	950.52	96	0.351	0.855	0.233	1.506
	305.00	558.19	954.49	92	0.355	0.859	0.234	1.515
	310.00	562.78	958.41	87	0.360	0.862	0.236	1.525
	315.00	567.34	962.28	83	0.364	0.865	0.237	1.535
	320.00	571.86	966.11	78	0.368	0.869	0.239	1.544
	325.00	576.36	969.90	74	0.373	0.872	0.240	1.553
	330.00	580.82	973.64	69	0.377	0.875	0.241	1.563
0.00110	310.00	549.43	946.97	101	0.347	0.894	0.232	1.497
	315.00	553.87	950.79	96	0.351	0.897	0.233	1.506
	320.00	558.28	954.57	92	0.355	0.901	0.234	1.516
	325.00	562.67	958.31	87	0.359	0.904	0.236	1.525
	330.00	567.01	962.01	83	0.364	0.907	0.237	1.534
	335.00	571.33	965.66	79	0.368	0.911	0.238	1.543
0.00110	340.00	575.62	969.28	74	0.372	0.914	0.240	1.552
	345.00	579.88	972.86	70	0.376	0.917	0.241	1.561
0.00120	325.00	550.46	947.86	100	0.348	0.934	0.232	1.499
	330.00	554.71	951.51	95	0.352	0.938	0.233	1.508
	335.00	558.93	955.13	91	0.356	0.941	0.235	1.517
	340.00	563.12	958.70	87	0.360	0.945	0.236	1.526
	345.00	567.28	962.23	83	0.364	0.948	0.237	1.534
	350.00	571.42	965.73	79	0.368	0.951	0.238	1.543
	355.00	575.52	969.20	74	0.372	0.955	0.240	1.552
0.00130	360.00	579.60	972.62	70	0.376	0.958	0.241	1.560
	340.00	551.88	949.08	98	0.349	0.974	0.232	1.502
	345.00	555.95	952.58	94	0.353	0.977	0.234	1.511
	350.00	560.00	956.04	90	0.357	0.981	0.235	1.519
	355.00	564.02	959.46	86	0.361	0.984	0.236	1.528
	360.00	568.01	962.85	82	0.365	0.987	0.237	1.536
	365.00	571.98	966.21	78	0.368	0.991	0.239	1.544
	370.00	575.92	969.53	74	0.372	0.994	0.240	1.553
0.00140	375.00	579.83	972.82	70	0.376	0.997	0.241	1.561
	350.00	549.64	947.15	100	0.347	1.008	0.232	1.497
	355.00	553.58	950.54	96	0.351	1.012	0.233	1.506
	360.00	557.50	953.90	93	0.355	1.015	0.234	1.514
	365.00	561.39	957.22	89	0.358	1.019	0.235	1.522
	370.00	565.25	960.51	85	0.362	1.022	0.237	1.530
	375.00	569.09	963.77	81	0.366	1.026	0.238	1.538
	380.00	572.91	966.99	77	0.369	1.029	0.239	1.546
	385.00	576.70	970.19	73	0.373	1.032	0.240	1.554
0.00150	390.00	580.47	973.35	70	0.377	1.035	0.241	1.562
	365.00	551.71	948.94	98	0.349	1.046	0.232	1.502
	370.00	555.51	952.19	94	0.353	1.049	0.234	1.510
	375.00	559.28	955.42	91	0.356	1.053	0.235	1.518
	380.00	563.03	958.62	87	0.360	1.056	0.236	1.525
	385.00	566.75	961.78	83	0.363	1.059	0.237	1.533
	390.00	570.45	964.92	80	0.367	1.063	0.238	1.541
	395.00	574.13	968.02	76	0.371	1.066	0.239	1.549
0.00150	400.00	577.79	971.10	72	0.374	1.069	0.240	1.556

0.00160	375.00	550.26	947.68	100	0.348	1.079	0.232	1.499
	380.00	553.94	950.85	96	0.351	1.082	0.233	1.506
	385.00	557.60	953.99	92	0.355	1.086	0.234	1.514
	390.00	561.24	957.10	89	0.358	1.089	0.235	1.522
	395.00	564.86	960.17	85	0.362	1.092	0.236	1.529
	400.00	568.45	963.23	82	0.365	1.096	0.238	1.537
	405.00	572.03	966.25	78	0.368	1.099	0.239	1.544
	410.00	575.58	969.24	74	0.372	1.102	0.240	1.552
	415.00	579.11	972.21	71	0.375	1.106	0.241	1.559
0.00170	385.00	549.15	946.73	101	0.347	1.111	0.232	1.496
	390.00	552.73	949.81	97	0.350	1.114	0.233	1.504
	395.00	556.29	952.87	94	0.353	1.118	0.234	1.511
	400.00	559.83	955.89	90	0.357	1.121	0.235	1.519
	405.00	563.35	958.89	87	0.360	1.125	0.236	1.526
	410.00	566.84	961.86	83	0.363	1.128	0.237	1.533
	415.00	570.32	964.81	80	0.367	1.131	0.238	1.541
	420.00	573.78	967.73	76	0.370	1.135	0.239	1.548
	425.00	577.21	970.62	73	0.374	1.138	0.240	1.555
0.00180	430.00	580.63	973.49	69	0.377	1.141	0.241	1.562
	400.00	551.83	949.03	98	0.349	1.146	0.232	1.502
0.00180	405.00	555.29	952.01	95	0.352	1.149	0.234	1.509
	410.00	558.73	954.96	91	0.356	1.153	0.235	1.516
	415.00	562.16	957.88	88	0.359	1.156	0.236	1.524
	420.00	565.56	960.77	84	0.362	1.159	0.237	1.531
	425.00	568.95	963.65	81	0.366	1.163	0.238	1.538
	430.00	572.32	966.49	78	0.369	1.166	0.239	1.545
	435.00	575.67	969.32	74	0.372	1.169	0.240	1.552
0.00190	440.00	579.00	972.12	71	0.375	1.173	0.241	1.559
	410.00	551.18	948.47	99	0.349	1.176	0.232	1.501
	415.00	554.55	951.37	95	0.352	1.180	0.233	1.508
	420.00	557.91	954.25	92	0.355	1.183	0.234	1.515
	425.00	561.25	957.10	89	0.358	1.187	0.235	1.522
	430.00	564.57	959.93	85	0.361	1.190	0.236	1.529
	435.00	567.87	962.73	82	0.364	1.194	0.237	1.536
	440.00	571.15	965.51	79	0.368	1.197	0.238	1.543
	445.00	574.42	968.26	76	0.371	1.200	0.239	1.549
0.00200	450.00	577.67	971.00	72	0.374	1.203	0.240	1.556
	455.00	580.90	973.71	69	0.377	1.207	0.241	1.563
	420.00	550.75	948.10	99	0.348	1.207	0.232	1.500
	425.00	554.04	950.93	96	0.351	1.210	0.233	1.507
	430.00	557.31	953.74	93	0.354	1.213	0.234	1.513
	435.00	560.57	956.52	89	0.357	1.217	0.235	1.520
	440.00	563.81	959.28	86	0.361	1.220	0.236	1.527
	445.00	567.03	962.02	83	0.364	1.224	0.237	1.534
	450.00	570.24	964.74	80	0.367	1.227	0.238	1.541
0.00200	455.00	573.43	967.43	77	0.370	1.230	0.239	1.547
	460.00	576.60	970.10	73	0.373	1.234	0.240	1.554
	465.00	579.75	972.75	70	0.376	1.237	0.241	1.561

Annexure - A/X

Design Data for Parabolic Shaped Watercourse

SEGMENT NO. 8								
Top Width (T)		1144 mm						
Total Depth (D)		686 mm						
Cross Sectional Area		0.523 sq.m						
Equation Co-efficient		0.002097						
Roughness Co-efficient.		0.014000						
Slope	Discharge	Flow Depth	Flow Width	Free Board	Flow Area	Velocity	Hydraulic Radius	Wetted Perimeter
(S) (m/m)	(Q) (lps)	(d) (mm)	(t) (mm)	(FB) (mm)	(A) (sq.m)	(V) (m/s)	(R) (m)	(P) (m)
0.00010	120.00	590.70	1061.57	95	0.418	0.255	0.255	1.641
	125.00	603.00	1072.56	83	0.431	0.290	0.259	1.667
	130.00	614.90	1083.09	71	0.444	0.293	0.262	1.692
0.00015	145.00	586.70	1057.97	99	0.414	0.350	0.254	1.632
	150.00	596.80	1067.03	89	0.425	0.353	0.257	1.654
	155.00	606.70	1075.85	79	0.435	0.356	0.260	1.675
0.00020	170.00	591.20	1062.02	95	0.419	0.406	0.255	1.642
	175.00	599.50	1069.71	86	0.428	0.409	0.258	1.660
	180.00	608.40	1077.35	78	0.437	0.412	0.260	1.678
0.00025	190.00	591.10	1061.93	95	0.418	0.454	0.255	1.642
	195.00	598.85	1068.87	87	0.427	0.457	0.257	1.658
	200.00	606.50	1075.67	80	0.435	0.460	0.260	1.674
	205.00	614.10	1082.39	72	0.443	0.463	0.262	1.690
0.00030	205.00	586.60	1057.88	99	0.414	0.496	0.253	1.632
	210.00	593.70	1064.26	92	0.421	0.499	0.256	1.647
	215.00	600.80	1070.60	85	0.429	0.501	0.258	1.662
	220.00	607.80	1076.82	78	0.436	0.504	0.260	1.677
	225.00	614.60	1082.83	71	0.444	0.507	0.262	1.691
0.00035	225.00	591.30	1062.11	95	0.419	0.537	0.255	1.642
	230.00	597.90	1068.02	88	0.426	0.540	0.257	1.656
	235.00	604.40	1073.81	82	0.433	0.543	0.259	1.670
	240.00	610.80	1079.48	75	0.440	0.546	0.261	1.683
0.00040	240.00	590.70	1061.00	95	0.418	0.574	0.255	1.641
	245.00	596.90	1067.12	89	0.425	0.577	0.257	1.654
	250.00	603.00	1072.56	83	0.431	0.580	0.259	1.667
	255.00	608.90	1077.80	77	0.438	0.583	0.261	1.679
	260.00	614.90	1083.09	71	0.444	0.586	0.262	1.692
0.00045	255.00	591.20	1062.02	95	0.419	0.609	0.255	1.642
	260.00	597.00	1067.21	89	0.425	0.612	0.257	1.654
	265.00	602.70	1072.30	83	0.431	0.615	0.259	1.666
	270.00	608.40	1077.35	78	0.437	0.618	0.260	1.678
	275.00	614.00	1082.30	72	0.443	0.621	0.262	1.690

0.00050	265.00	587.00	1058.24	99	0.414	0.640	0.254	1.633
	270.00	592.60	1063.27	93	0.420	0.643	0.255	1.645
	275.00	598.00	1068.11	88	0.426	0.646	0.257	1.656
	280.00	603.50	1073.01	83	0.432	0.649	0.259	1.668
	285.00	608.80	1077.71	77	0.437	0.652	0.261	1.679
	290.00	614.10	1082.39	72	0.443	0.654	0.262	1.690
0.00055	280.00	589.10	1060.13	97	0.416	0.673	0.254	1.637
	285.00	594.50	1064.98	92	0.422	0.675	0.256	1.649
	290.00	599.70	1069.62	86	0.428	0.678	0.258	1.660
	295.00	604.90	1074.25	81	0.433	0.681	0.259	1.671
	300.00	610.00	1078.77	76	0.439	0.684	0.261	1.682
	305.00	615.00	1083.18	71	0.444	0.687	0.263	1.692
0.00060	290.00	586.80	1058.06	99	0.414	0.701	0.253	1.633
	295.00	591.75	1062.51	94	0.419	0.704	0.255	1.643
	300.00	596.80	1067.03	89	0.425	0.707	0.257	1.654
	305.00	601.70	1071.41	84	0.430	0.710	0.258	1.664
	310.00	606.70	1075.85	79	0.435	0.712	0.260	1.675
	315.00	611.60	1080.18	74	0.440	0.715	0.261	1.685
0.00065	305.00	589.80	1060.76	96	0.417	0.731	0.254	1.639
	310.00	594.60	1065.07	91	0.422	0.734	0.256	1.649
	315.00	599.40	1069.36	87	0.427	0.737	0.258	1.659
	320.00	604.10	1073.54	82	0.432	0.740	0.259	1.669
	325.00	608.90	1077.80	77	0.438	0.743	0.261	1.679
	330.00	613.60	1081.95	72	0.443	0.746	0.262	1.689
0.00070	315.00	588.40	1059.50	98	0.416	0.758	0.254	1.636
	320.00	593.05	1063.68	93	0.421	0.761	0.255	1.646
	325.00	597.60	1067.75	88	0.425	0.764	0.257	1.655
	330.00	6022.00	1071.85	84	0.430	0.767	0.259	1.665
	335.00	606.80	1075.94	79	0.435	0.770	0.260	1.675
	340.00	611.40	1080.01	75	0.440	0.772	0.261	1.685
	345.00	615.90	1083.97	70	0.445	0.775	0.263	1.694
0.00075	325.00	587.40	1058.60	99	0.415	0.784	0.254	1.634
	330.00	592.00	1062.73	94	0.419	0.787	0.255	1.644
	335.00	596.40	1066.68	90	0.424	0.790	0.257	1.653
	340.00	600.80	1070.60	85	0.429	0.793	0.258	1.662
	345.00	605.20	1074.52	81	0.434	0.796	0.259	1.671
	350.00	609.70	1078.50	76	0.438	0.798	0.261	1.681
	355.00	614.00	1082.30	72	0.443	0.801	0.262	1.690

0.00080	335.00	586.90	1058.15	99	0.414	0.809	0.253	1.633
	340.00	591.20	1062.02	95	0.419	0.812	0.255	1.642
	345.00	595.50	1065.87	91	0.423	0.815	0.256	1.651
	350.00	599.80	1069.71	86	0.428	0.818	0.258	1.660
	355.00	604.10	1073.54	82	0.432	0.821	0.259	1.669
	360.00	608.40	1077.35	78	0.437	0.824	0.260	1.678
	365.00	612.60	1081.07	73	0.442	0.827	0.262	1.687
0.00085	345.00	586.55	1057.83	99	0.414	0.834	0.253	1.632
	350.00	590.80	1061.66	95	0.418	0.837	0.255	1.641
	355.00	595.00	1065.42	91	0.423	0.840	0.256	1.650
	360.00	599.20	1069.18	87	0.427	0.843	0.258	1.659
	365.00	603.40	1072.92	83	0.432	0.846	0.259	1.668
	370.00	607.50	1076.56	79	0.436	0.849	0.260	1.676
0.00085	375.00	611.60	1080.18	74	0.440	0.851	0.261	1.685
	380.00	615.80	1083.89	70	0.445	0.854	0.263	1.694
0.00090	355.00	586.55	1057.83	99	0.414	0.858	0.253	1.632
	360.00	590.70	1061.57	95	0.418	0.861.000	0.255	1.641
	365.00	594.70	1065.16	91	0.422	0.864	0.256	1.649
	370.00	598.90	1068.91	87	0.427	0.867	0.257	1.658
	375.00	603.00	1072.56	83	0.431	0.870	0.259	1.667
	380.00	606.90	1076.03	79	0.435	0.873	0.260	1.675
	385.00	611.00	1079.65	75	0.440	0.875	0.261	1.684
	390.00	614.90	1083.09	71	0.444	0.878	0.262	1.692
0.00095	365.00	586.70	1057.97	99	0.414	0.882	0.254	1.632
	370.00	590.80	1061.66	95	0.418	0.885	0.255	1.641
	375.00	594.80	1065.24	91	0.422	0.888	0.256	1.650
	380.00	598.80	1068.82	87	0.427	0.891	0.257	1.658
	385.00	602.70	1072.30	83	0.431	0.894	0.259	1.666
	390.00	606.70	1075.85	79	0.435	0.896	0.260	1.675
	395.00	610.50	1079.21	76	0.439	0.899	0.261	1.683
	400.00	614.40	1082.65	72	0.443	0.902	0.262	1.691
0.00100	375.00	587.15	1058.37	99	0.414	0.905	0.254	1.633
	380.00	591.10	1061.93	95	0.418	0.908	0.255	1.642
	385.00	595.00	1065.42	91	0.423	0.911	0.256	1.650
	390.00	598.85	1068.87	87	0.427	0.914	0.257	1.658
	395.00	602.70	1072.30	83	0.431	0.917	0.259	1.666
	400.00	606.50	1075.67	80	0.435	0.920	0.260	1.674
	405.00	610.30	1079.04	76	0.439	0.923	0.261	1.682
	410.00	614.10	1082.39	72	0.443	0.925	0.262	1.690

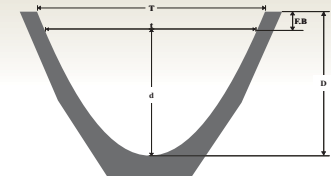
0.00110	395.00	588.40	1059.50	98	0.416	0.950	0.254	1.636
	400.00	592.20	1062.91	94	0.420	0.953	0.255	1.644
	405.00	595.90	1066.23	90	0.424	0.956	0.256	1.652
	410.00	599.50	1069.45	87	0.427	0.959	0.258	1.659
	415.00	603.20	1072.74	83	0.431	0.962	0.259	1.667
	420.00	606.90	1076.03	79	0.435	0.965	0.260	1.675
	425.00	610.50	1079.21	76	0.439	0.968	0.261	1.683
	430.00	614.10	1082.39	72	0.443	0.970	0.262	1.690
0.00120	410.00	586.60	1057.88	99	0.414	0.991	0.253	1.632
	415.00	590.20	1061.12	96	0.418	0.994	0.255	1.640
	420.00	593.70	1064.26	92	0.421	0.997	0.256	1.647
	425.00	597.30	1067.48	89	0.425	1.000	0.257	1.655
	430.00	600.80	1070.60	85	0.429	1.003	0.258	1.662
	435.00	604.30	1073.72	82	0.433	1.006	0.259	1.670
	440.00	607.80	1076.82	78	0.436	1.008	0.260	1.677
	445.00	611.20	1079.83	75	0.440	1.011	0.261	1.684
	450.00	614.60	1082.83	71	0.444	1.014	0.262	1.691
0.00130	430.00	588.90	1059.95	97	0.416	1.033	0.254	1.637
	435.00	592.30	1063.00	94	0.420	1.036	0.255	1.644
0.00130	440.00	595.70	1066.05	90	0.423	1.039	0.256	1.651
	445.00	599.00	1069.00	87	0.427	1.042	0.258	1.658
	450.00	602.50	1072.12	84	0.431	1.045	0.258	1.666
	455.00	605.80	1075.05	80	0.434	1.048	0.260	1.673
	460.00	609.20	1078.06	77	0.438	1.051	0.261	1.680
	465.00	612.50	1080.98	74	0.441	1.053	0.262	1.687
	470.00	615.80	1083.89	70	0.445	1.056	0.263	1.694
0.00140	445.00	588.00	1059.14	98	0.415	1.072	0.254	1.635
	450.00	591.30	1062.11	95	0.419	1.075	0.255	1.642
	455.00	594.60	1065.07	91	0.422	1.078	0.256	1.649
	460.00	597.90	1068.02	88	0.426	1.081	0.257	1.656
	465.00	601.20	1070.96	85	0.429	1.083	0.258	1.663
	470.00	604.40	1073.81	82	0.433	1.086	0.259	1.670
	475.00	607.55	1076.60	78	0.436	1.189	0.260	1.676
	480.00	610.80	1079.48	75	0.440	1.092	0.261	1.683
	485.00	614.00	1082.30	72	0.443	1.095	0.262	1.690

0.00150	460.00	587.60	1058.78	98	0.415	1.109	0.254	1.634
	465.00	590.80	1061.66	95	0.418	1.112	0.225	1.641
	470.00	594.00	1064.53	92	0.422	1.115	0.256	1.648
	475.00	597.10	1067.30	89	0.425	1.118	0.257	1.654
	480.00	600.30	1070.16	86	0.428	1.121	0.258	1.661
	485.00	603.50	1073.01	83	0.432	1.123	0.259	1.668
	490.00	606.50	1075.67	80	0.435	1.127	0.260	1.674
	495.00	609.70	1078.50	76	0.438	1.129	0.261	1.681
	500.00	612.70	1081.15	73	0.442	1.132	0.262	1.687
	505.00	615.90	1083.97	70	0.445	1.135	0.263	1.694
0.00160	475.00	587.60	1058.78	98	0.415	1.145	0.254	1.634
	480.00	590.70	1061.57	95	0.418	1.148	0.255	1.641
	485.00	593.70	1064.26	92	0.421	1.151	0.256	1.647
	490.00	596.90	1067.12	89	0.425	1.154	0.257	1.654
	495.00	600.00	1069.89	86	0.428	1.157	0.258	1.661
	500.00	603.00	1072.56	83	0.431	1.160	0.259	1.667
	505.00	605.90	1075.14	80	0.434	1.163	0.260	1.673
	510.00	608.90	1077.80	77	0.438	1.166	0.261	1.679
	515.00	612.00	1080.54	74	0.441	1.168	0.261	1.686
	520.00	614.90	1083.09	71	0.444	1.171	0.262	1.692
0.00170	490.00	587.80	1058.96	98	0.415	1.181	0.254	1.635
	495.00	590.80	1061.66	95	0.418	1.184	0.255	1.641
	500.00	593.80	1064.35	92	0.421	1.187	0.256	1.647
	505.00	596.80	1067.03	89	0.425	1.190	0.257	1.654
	510.00	599.75	1069.67	86	0.428	1.192	0.258	1.660
	515.00	602.70	1072.30	83	0.431	1.195	0.259	1.666
	520.00	605.60	1074.87	80	0.434	1.198	0.260	1.672
	525.00	608.50	1077.44	78	0.437	1.201	0.260	1.678
	530.00	611.50	1080.10	75	0.440	1.204	0.261	1.685
0.00170	535.00	614.40	1082.65	70	0.443	1.206	0.262	1.691
0.00180	505.00	588.30	1059.41	98	0.415	1.215	0.254	1.636
	510.00	591.20	1062.02	95	0.419	1.218	0.255	1.642
	515.00	594.10	1064.62	92	0.422	1.221	0.256	1.648
	520.00	597.00	1067.21	89	0.425	1.224	0.257	1.654
	525.00	599.80	1069.71	86	0.428	1.227	0.258	1.660
	530.00	602.70	1072.30	83	0.431	1.230	0.259	1.666
	535.00	605.60	1074.87	80	0.434	1.233	0.259	1.672
	540.00	608.40	1077.35	78	0.437	1.236	0.260	1.678
	545.00	611.20	1079.83	75	0.440	1.239	0.261	1.684
	550.00	614.00	1082.30	72	0.443	1.241	0.262	1.690

0.00190	515.00	586.10	1057.43	100	0.413	1.246	0.253	1.631
	520.00	588.90	1059.95	97	0.416	1.250	0.254	1.637
	525.00	591.80	1062.56	94	0.419	1.252	0.255	1.643
	530.00	594.60	1065.07	91	0.422	1.255	0.256	1.649
	535.00	597.40	1067.57	89	0.425	1.258	0.257	1.655
	540.00	600.20	1070.07	86	0.428	1.261	0.258	1.661
	545.00	603.00	1072.56	83	0.431	1.264	0.259	1.667
	550.00	605.80	1075.05	80	0.434	1.267	0.260	1.673
	555.00	608.50	1077.44	78	0.437	1.270	0.260	1.678
	560.00	611.25	1079.87	75	0.440	1.273	0.261	1.684
0.00200	565.00	614.00	1082.30	72	0.443	1.275	0.262	1.690
	530.00	587.00	1058.24	99	0.414	1.280	0.254	1.633
	535.00	589.80	1060.76	96	0.417	1.283	0.254	1.639
	540.00	592.60	1063.27	93	0.420	1.286	0.255	1.645
	545.00	595.30	1065.69	91	0.423	1.289	0.256	1.651
	550.00	598.00	1068.11	88	0.426	1.292	0.257	1.656
	555.00	600.70	1070.52	85	0.429	1.295	0.258	1.662
	560.00	603.50	1073.01	83	0.432	1.297	0.259	1.668
	565.00	606.10	1075.32	80	0.434	1.300	0.260	1.673
	570.00	608.80	1077.71	77	0.437	1.303	0.261	1.679
	575.00	611.50	1080.10	75	0.440	1.306	0.261	1.685
	580.00	614.10	1082.39	72	0.443	1.309	0.262	1.690

Annexure - A/XI

Design Data for Parabolic Shaped Watercourse

SEGMENT NO. 9								
Top Width (T)			1220	mm				
Total Depth (D)			760	mm				
Cross Sectional Area			0.618	sq.m				
Equation Co-efficient			0.002042					
Roughness Co-efficient.			0.014000					
Slope (S) (m/m)	Discharge (Q) (lps)	Flow Depth (d) (mm)	Flow Width (t) (mm)	Free Board (FB) (mm)	Flow Area (A) (sq.m)	Velocity (V) (m/s)	Hydraulic Radius (R) (m)	Wetted Perimeter (P) (m)
0.00010	155.00	665.80	1142.02	94	0.507	0.306	0.280	1.810
	160.00	676.54	1151.19	83	0.519	0.308	0.283	1.832
	165.00	687.12	1160.16	73	0.531	0.310	0.287	1.855
0.00015	185.00	657.10	1134.54	103	0.497	0.372	0.278	1.791
	190.00	665.99	1142.18	94	0.507	0.375	0.280	1.809
	195.00	674.76	1149.68	85	0.517	0.377	0.283	1.828
	200.00	683.43	1157.04	77	0.527	0.379	0.286	1.846
0.00020	215.00	659.32	1136.45	101	0.500	0.430	0.278	1.796
	220.00	667.00	1143.05	93	0.508	0.433	0.280	1.812
	225.00	674.59	1149.53	85	0.517	0.435	0.283	1.828
	230.00	682.10	1155.92	78	0.526	0.438	0.285	1.844
	235.00	689.54	1162.20	70	0.534	0.440	0.287	1.859
0.00025	240.00	658.77	1135.98	101	0.499	0.481	0.278	1.795
	245.00	665.65	1141.89	94	0.507	0.483	0.280	1.809
	250.00	672.47	1147.73	88	0.515	0.486	0.282	1.823
	255.00	679.22	1153.47	81	0.522	0.488	0.284	1.838
	260.00	685.91	1159.14	74	0.530	0.491	0.286	1.852
0.00030	265.00	661.49	1138.32	99	0.502	0.528	0.279	1.801
	270.00	667.74	1143.68	92	0.509	0.530	0.281	1.814
	275.00	673.93	1148.97	86	0.516	0.533	0.283	1.827
	280.00	680.07	1154.19	80	0.523	0.535	0.284	1.840
	285.00	686.16	1159.35	74	0.530	0.537	0.286	1.853
0.00035	285.00	659.99	1137.03	100	0.500	0.570	0.278	1.797
	290.00	665.79	1142.02	94	0.507	0.572	0.280	1.810
	295.00	671.55	1146.94	88	0.513	0.575	0.282	1.822
	300.00	677.27	1151.81	83	0.520	0.577	0.284	1.834
	305.00	682.93	1156.62	77	0.527	0.579	0.285	1.845
	310.00	688.56	1161.37	71	0.533	0.581	0.287	1.857
0.00040	305.00	660.34	1137.33	100	0.501	0.609	0.278	1.798
	310.00	665.78	1142.00	94	0.507	0.612	0.280	1.810
	315.00	671.17	1146.62	89	0.513	0.614	0.282	1.821
	320.00	676.30	1150.99	84	0.519	0.617	0.284	1.830
	325.00	681.67	1155.55	78	0.525	0.619	0.285	1.842
	330.00	686.98	1160.04	73	0.531	0.621	0.287	1.853

0.00045	320.00	656.74	1134.22	103	0.497	0.644	0.277	1.791
	325.00	661.88	1138.66	98	0.502	0.647	0.279	1.801
	330.00	666.99	1143.04	93	0.508	0.649	0.280	1.812
	335.00	672.06	1147.38	88	0.514	0.652	0.282	1.823
	340.00	677.10	1151.67	83	0.520	0.654	0.284	1.833
	345.00	682.10	1155.91	78	0.526	0.656	0.285	1.844
	350.00	687.06	1160.11	73	0.531	0.659	0.287	1.854
0.00050	340.00	659.38	1136.51	101	0.500	0.681	0.278	1.796
	345.00	664.25	1140.69	96	0.505	0.683	0.280	1.806
	350.00	669.22	1144.95	91	0.511	0.685	0.281	1.818
	355.00	673.96	1149.00	86	0.516	0.688	0.282	1.827
	360.00	678.69	1153.02	81	0.522	0.690	0.284	1.837
	365.00	683.40	1157.02	77	0.527	0.692	0.285	1.847
	370.00	688.10	1160.99	72	0.533	0.695	0.287	1.856
0.00055	355.00	657.93	1135.25	102	0.498	0.713	0.278	1.793
	360.00	662.57	1139.25	97	0.503	0.715	0.279	1.803
	365.00	667.19	1143.21	93	0.508	0.718	0.281	1.813
	370.00	671.77	1147.13	88	0.514	0.720	0.282	1.822
	375.00	676.33	1151.01	84	0.519	0.723	0.283	1.832
	380.00	680.86	1154.86	79	0.524	0.725	0.285	1.841
	385.00	685.36	1158.67	75	0.529	0.727	0.286	1.851
0.00060	390.00	689.83	1162.45	70	0.535	0.730	0.287	1.860
	370.00	657.34	1134.74	103	0.497	0.744	0.277	1.793
	375.00	661.73	1138.52	98	0.502	0.747	0.279	1.802
	380.00	666.12	1142.29	94	0.507	0.749	0.280	1.811
	385.00	670.50	1146.04	90	0.512	0.752	0.282	1.820
	390.00	674.86	1149.77	85	0.517	0.754	0.283	1.829
	395.00	679.21	1153.46	81	0.522	0.756	0.284	1.838
0.00065	400.00	683.40	1157.01	77	0.527	0.759	0.286	1.846
	405.00	687.76	1160.70	72	0.532	0.761	0.287	1.855
	385.00	657.17	1134.59	103	0.497	0.775	0.277	1.792
	390.00	661.53	1138.36	98	0.502	0.777	0.279	1.802
	395.00	665.64	1141.89	94	0.507	0.780	0.280	1.809
	400.00	669.88	1145.52	90	0.512	0.782	0.281	1.818
	405.00	674.09	1149.11	86	0.516	0.784	0.283	1.827
0.00070	410.00	678.38	1152.76	82	0.521	0.786	0.284	1.837
	415.00	682.34	1156.12	78	0.526	0.789	0.285	1.844
	420.00	686.42	1159.57	74	0.531	0.792	0.287	1.852
	400.00	657.60	1134.96	102	0.498	0.804	0.277	1.793
	405.00	661.75	1138.54	98	0.502	0.806	0.279	1.802
	410.00	665.88	1142.09	94	0.507	0.809	0.280	1.811
	415.00	669.99	1145.61	90	0.512	0.811	0.281	1.820
0.00070	420.00	673.85	1148.90	86	0.516	0.814	0.283	1.827
	425.00	677.88	1152.34	82	0.521	0.816	0.284	1.835
	430.00	681.89	1155.74	78	0.525	0.818	0.285	1.844
	435.00	685.88	1159.12	74	0.530	0.821	0.286	1.852
	440.00	689.85	1162.46	70	0.535	0.823	0.287	1.860

0.00075	415.00	658.26	1135.53	102	0.498	0.833	0.278	1.794
	420.00	662.43	1139.13	98	0.503	0.835	0.279	1.804
	425.00	666.31	1142.46	94	0.507	0.837	0.280	1.812
	430.00	670.20	1145.79	90	0.512	0.840	0.281	1.819
	435.00	674.08	1149.10	86	0.516	0.842	0.283	1.827
	440.00	677.96	1152.40	82	0.521	0.845	0.284	1.835
	445.00	681.83	1155.68	78	0.525	0.847	0.285	1.843
	450.00	685.68	1158.94	74	0.530	0.849	0.286	1.851
	455.00	689.36	1162.05	71	0.534	0.852	0.287	1.858
0.00080	425.00	655.51	1133.16	104	0.495	0.858	0.277	1.788
	430.00	659.37	1136.49	101	0.500	0.861	0.278	1.796
	435.00	663.20	1139.79	97	0.504	0.863	0.279	1.804
	440.00	667.02	1143.07	93	0.508	0.866	0.280	1.812
	445.00	670.83	1146.32	89	0.513	0.868	0.282	1.820
	450.00	674.61	1149.55	85	0.517	0.870	0.283	1.828
	455.00	678.38	1152.76	82	0.521	0.873	0.284	1.836
	460.00	681.94	1155.78	78	0.525	0.875	0.285	1.842
	465.00	685.75	1159.00	74	0.530	0.878	0.286	1.851
0.00085	470.00	689.52	1162.18	70	0.534	0.880	0.287	1.859
	440.00	656.88	1134.35	103	0.497	0.886	0.277	1.791
	445.00	660.62	1137.57	99	0.501	0.888	0.279	1.799
	450.00	664.32	1140.75	96	0.505	0.891	0.280	1.806
	455.00	668.09	1143.98	92	0.510	0.893	0.281	1.814
	460.00	671.78	1147.14	88	0.514	0.895	0.282	1.822
	465.00	675.47	1150.28	85	0.518	0.898	0.283	1.830
	470.00	679.14	1153.41	81	0.522	0.900	0.284	1.838
	475.00	682.81	1156.51	77	0.526	0.902	0.285	1.846
0.00085	480.00	686.47	1159.61	74	0.531	0.904	0.286	1.854
	485.00	690.14	1162.71	70	0.535	0.907	0.287	1.862
0.00090	455.00	658.48	1135.73	102	0.499	0.913	0.278	1.794
	460.00	662.15	1138.89	98	0.503	0.915	0.279	1.802
	465.00	665.78	1142.00	94	0.507	0.917	0.280	1.810
	470.00	669.38	1145.09	91	0.511	0.920	0.281	1.817
	475.00	673.03	1148.20	87	0.515	0.922	0.282	1.825
	480.00	676.64	1151.28	83	0.519	0.924	0.283	1.833
	485.00	680.08	1154.21	80	0.523	0.927	0.284	1.840
	490.00	683.58	1157.17	76	0.527	0.929	0.286	1.847
	495.00	686.99	1160.05	73	0.531	0.932	0.287	1.853
0.00095	465.00	656.81	1134.28	103	0.497	0.936	0.277	1.791
	470.00	660.34	1137.33	100	0.501	0.939	0.278	1.798
	475.00	664.08	1140.54	96	0.505	0.941	0.279	1.808
	480.00	667.45	1143.44	93	0.509	0.943	0.281	1.814
	485.00	670.87	1146.36	89	0.513	0.946	0.282	1.820
	490.00	674.35	1149.33	86	0.517	0.948	0.283	1.828
	495.00	677.81	1152.27	82	0.521	0.951	0.284	1.835
	500.00	681.28	1155.22	79	0.525	0.953	0.285	1.842
	505.00	684.73	1158.14	75	0.529	0.955	0.286	1.850
	510.00	688.27	1161.13	72	0.533	0.957	0.287	1.858

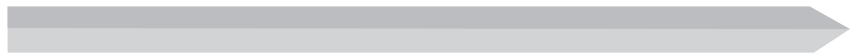
0.00100	480.00	658.85	1136.04	101	0.499	0.962	0.278	1.795
	485.00	662.26	1138.98	98	0.503	0.964	0.279	1.802
	490.00	665.91	1142.11	94	0.507	0.966	0.280	1.812
	495.00	669.15	1144.89	91	0.511	0.969	0.281	1.817
	500.00	672.33	1147.61	88	0.514	0.972	0.282	1.822
	505.00	675.96	1150.70	84	0.519	0.974	0.283	1.832
	510.00	679.26	1153.50	81	0.522	0.976	0.284	1.838
	515.00	682.61	1156.35	77	0.526	0.979	0.285	1.845
	520.00	686.13	1159.32	74	0.530	0.981	0.286	1.854
	525.00	689.45	1162.13	71	0.534	0.983	0.287	1.861
0.00110	500.00	656.49	1134.01	104	0.496	1.007	0.277	1.790
	505.00	659.80	1136.86	100	0.500	1.010	0.278	1.797
	510.00	663.09	1139.70	97	0.504	1.012	0.279	1.804
	515.00	666.37	1142.51	94	0.508	1.015	0.280	1.811
	520.00	669.63	1145.30	90	0.511	1.017	0.281	1.818
	525.00	672.87	1148.07	87	0.515	1.019	0.282	1.824
	530.00	676.10	1150.82	84	0.519	1.022	0.283	1.831
	535.00	679.31	1153.55	81	0.522	1.024	0.284	1.838
	540.00	682.69	1156.42	77	0.526	1.026	0.285	1.847
	545.00	685.68	1158.94	74	0.530	1.029	0.286	1.851
0.00120	550.00	688.83	1161.60	71	0.533	1.031	0.287	1.858
	525.00	658.30	1135.57	102	0.498	1.053	0.278	1.794
	530.00	661.45	1138.29	99	0.502	1.056	0.279	1.801
	535.00	664.59	1140.98	95	0.506	1.058	0.280	1.807
	540.00	667.71	1143.66	92	0.509	1.061	0.281	1.814
	545.00	670.82	1146.32	89	0.513	1.063	0.282	1.820
	550.00	673.92	1148.96	86	0.516	1.065	0.283	1.827
	555.00	677.00	1151.59	83	0.520	1.068	0.283	1.833
	560.00	680.07	1154.20	80	0.523	1.070	0.284	1.840
	565.00	683.13	1156.79	77	0.527	1.072	0.285	1.846
0.00130	570.00	686.18	1159.37	74	0.530	1.075	0.286	1.853
	575.00	689.21	1161.92	71	0.534	1.077	0.287	1.859
	545.00	657.41	1134.80	103	0.497	1.096	0.278	1.792
	550.00	660.44	1137.42	100	0.501	1.098	0.278	1.798
	555.00	663.46	1140.01	97	0.504	1.101	0.279	1.805
	560.00	666.46	1142.58	94	0.508	1.103	0.280	1.811
	565.00	669.45	1145.14	91	0.511	1.106	0.281	1.817
0.00130	570.00	672.42	1147.69	88	0.514	1.108	0.282	1.823
	575.00	675.38	1150.21	85	0.518	1.110	0.283	1.830
	580.00	678.33	1152.72	82	0.521	1.113	0.284	1.836
	585.00	681.27	1155.21	79	0.525	1.115	0.285	1.842
	590.00	684.19	1157.69	76	0.528	1.117	0.286	1.848
0.00130	595.00	687.10	1160.15	73	0.531	1.120	0.287	1.854
	600.00	690.00	1162.59	70	0.535	1.122	0.288	1.860

0.00140	565.00	657.09	1134.52	103	0.497	1.137	0.277	1.791
	570.00	660.01	1137.05	100	0.500	1.139	0.278	1.798
	575.00	662.93	1139.55	97	0.504	1.142	0.279	1.804
	580.00	665.84	1142.05	94	0.507	1.144	0.280	1.810
	585.00	668.74	1144.54	91	0.510	1.146	0.281	1.816
	590.00	671.63	1147.01	88	0.514	1.149	0.282	1.822
	595.00	674.52	1149.47	85	0.517	1.151	0.283	1.829
	600.00	677.40	1151.93	83	0.520	1.153	0.283	1.835
	605.00	680.29	1154.38	80	0.524	1.156	0.284	1.841
	610.00	683.17	1156.82	77	0.527	1.158	0.285	1.848
	615.00	685.78	1159.03	74	0.530	1.161	0.286	1.852
	620.00	688.59	1161.40	71	0.533	1.163	0.287	1.858
0.00150	585.00	657.22	1134.64	103	0.497	1.177	0.277	1.792
	590.00	660.03	1137.06	100	0.500	1.179	0.278	1.798
	595.00	662.83	1139.47	97	0.504	1.182	0.279	1.804
	600.00	665.62	1141.87	94	0.507	1.184	0.280	1.809
	605.00	668.41	1144.25	92	0.510	1.187	0.281	1.815
	610.00	670.99	1146.46	89	0.513	1.189	0.282	1.819
	615.00	673.82	1148.88	86	0.516	1.192	0.283	1.826
	620.00	676.62	1151.27	83	0.519	1.194	0.284	1.832
	625.00	679.40	1153.63	81	0.523	1.196	0.284	1.838
	630.00	682.16	1155.96	78	0.526	1.198	0.285	1.844
	635.00	684.90	1158.28	75	0.529	1.201	0.286	1.850
	640.00	687.62	1160.58	72	0.532	1.203	0.287	1.855
0.00160	645.00	690.33	1162.87	70	0.535	1.205	0.288	1.861
	605.00	657.64	1135.00	102	0.498	1.216	0.278	1.793
	610.00	660.36	1137.35	100	0.501	1.218	0.278	1.798
	615.00	663.12	1139.72	97	0.504	1.221	0.279	1.804
	620.00	665.85	1142.07	94	0.507	1.223	0.280	1.810
	625.00	668.52	1144.35	91	0.510	1.225	0.281	1.816
	630.00	671.18	1146.63	89	0.513	1.228	0.282	1.821
	635.00	673.75	1148.82	86	0.516	1.231	0.283	1.826
	640.00	676.55	1151.20	83	0.519	1.233	0.283	1.832
	645.00	679.19	1153.45	81	0.522	1.235	0.284	1.838
	650.00	681.94	1155.78	78	0.525	1.237	0.285	1.844
	655.00	684.48	1157.93	76	0.528	1.240	0.286	1.849
0.00170	660.00	687.13	1160.17	73	0.531	1.242	0.287	1.855
	665.00	689.74	1162.37	70	0.534	1.244	0.287	1.860
	620.00	655.80	1133.42	104	0.496	1.251	0.277	1.790
	625.00	658.57	1135.81	101	0.499	1.253	0.278	1.796
	630.00	661.15	1138.03	99	0.502	1.256	0.278	1.801
	635.00	663.63	1140.16	96	0.504	1.259	0.279	1.805
	640.00	666.44	1142.57	94	0.508	1.261	0.280	1.812
	645.00	668.93	1144.70	91	0.510	1.264	0.281	1.817
	650.00	671.50	1146.90	88	0.513	1.266	0.282	1.822
	655.00	674.11	1149.12	86	0.516	1.268	0.283	1.827
	660.00	676.76	1151.38	83	0.519	1.271	0.283	1.833
	665.00	679.26	1153.51	81	0.522	1.273	0.284	1.838
0.00170	670.00	682.04	1155.87	78	0.526	1.275	0.285	1.845
	675.00	684.51	1157.96	75	0.528	1.277	0.286	1.850
	680.00	687.01	1160.07	73	0.531	1.280	0.286	1.855
	685.00	689.52	1162.19	70	0.534	1.282	0.287	1.860

0.00180	640.00	656.87	1134.34	103	0.497	1.288	0.277	1.792
	645.00	659.33	1136.46	101	0.500	1.291	0.278	1.796
	650.00	661.94	1138.70	98	0.502	1.294	0.279	1.802
0.00180	655.00	664.64	1141.02	95	0.506	1.296	0.280	1.809
	660.00	667.00	1143.05	93	0.508	1.299	0.280	1.812
	665.00	669.53	1145.22	90	0.511	1.301	0.281	1.817
	670.00	672.06	1147.38	88	0.514	1.303	0.282	1.823
	675.00	674.54	1149.49	85	0.517	1.306	0.283	1.827
	680.00	677.32	1151.86	83	0.520	1.307	0.283	1.835
	685.00	679.63	1153.82	80	0.523	1.310	0.284	1.839
	690.00	682.07	1155.89	78	0.526	1.313	0.285	1.843
	695.00	684.55	1157.99	75	0.528	1.315	0.286	1.849
	700.00	687.19	1160.22	73	0.532	1.317	0.286	1.855
0.00190	705.00	689.65	1162.29	70	0.534	1.319	0.287	1.860
	660.00	657.96	1135.27	102	0.498	1.325	0.278	1.793
	665.00	660.46	1137.43	100	0.501	1.328	0.279	1.798
	670.00	662.96	1139.58	97	0.504	1.330	0.279	1.803
	675.00	665.44	1141.71	95	0.506	1.333	0.280	1.809
	680.00	667.92	1143.84	92	0.509	1.335	0.281	1.814
	685.00	670.39	1145.95	90	0.512	1.337	0.282	1.819
	690.00	672.85	1148.05	87	0.515	1.340	0.282	1.824
	695.00	675.30	1150.14	85	0.518	1.342	0.283	1.829
	700.00	677.75	1152.22	82	0.521	1.345	0.284	1.834
	705.00	680.19	1154.29	80	0.523	1.347	0.285	1.840
	710.00	682.61	1156.35	77	0.526	1.349	0.285	1.845
	715.00	685.03	1158.40	75	0.529	1.352	0.286	1.850
	720.00	687.45	1160.44	73	0.532	1.354	0.287	1.855
	725.00	689.86	1162.47	70	0.535	1.356	0.287	1.860
0.00200	675.00	656.93	1134.39	103	0.497	1.359	0.277	1.791
	680.00	659.38	1136.50	101	0.500	1.361	0.278	1.796
	685.00	661.81	1138.60	98	0.502	1.364	0.279	1.801
	690.00	664.24	1140.68	96	0.505	1.366	0.280	1.806
	695.00	666.66	1142.76	93	0.508	1.368	0.280	1.811
	700.00	669.07	1144.82	91	0.511	1.371	0.281	1.817
	705.00	671.48	1146.88	89	0.513	1.373	0.282	1.822
	710.00	673.87	1148.92	86	0.516	1.376	0.283	1.827
	715.00	676.26	1150.96	84	0.519	1.378	0.283	1.832
	720.00	678.64	1152.98	81	0.522	1.380	0.284	1.837
	725.00	681.01	1154.99	79	0.524	1.383	0.285	1.842
	730.00	683.37	1156.99	77	0.527	1.385	0.285	1.846
	735.00	685.73	1158.99	74	0.530	1.387	0.286	1.851
	740.00	688.08	1160.97	72	0.533	1.390	0.287	1.856
	745.00	690.42	1162.94	70	0.535	1.392	0.288	1.861

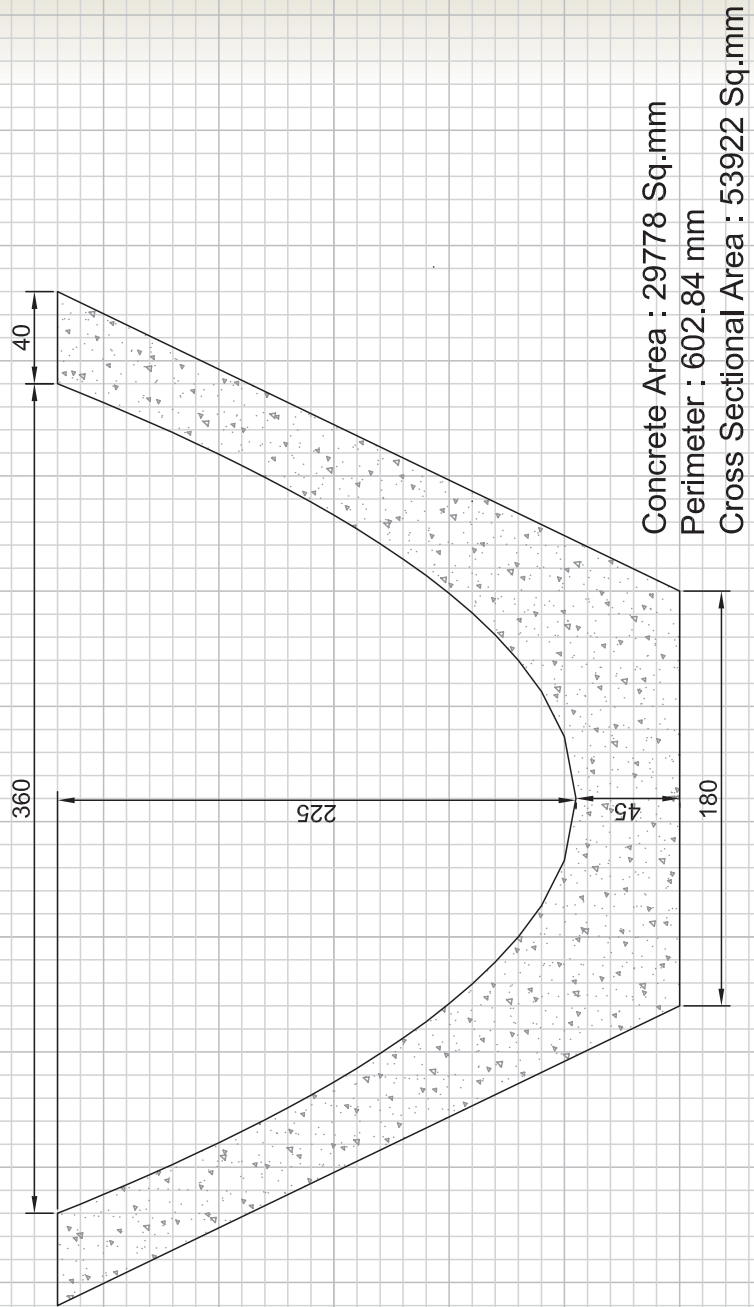


ANNEXURE 'B'



SEGMENT NO. 1

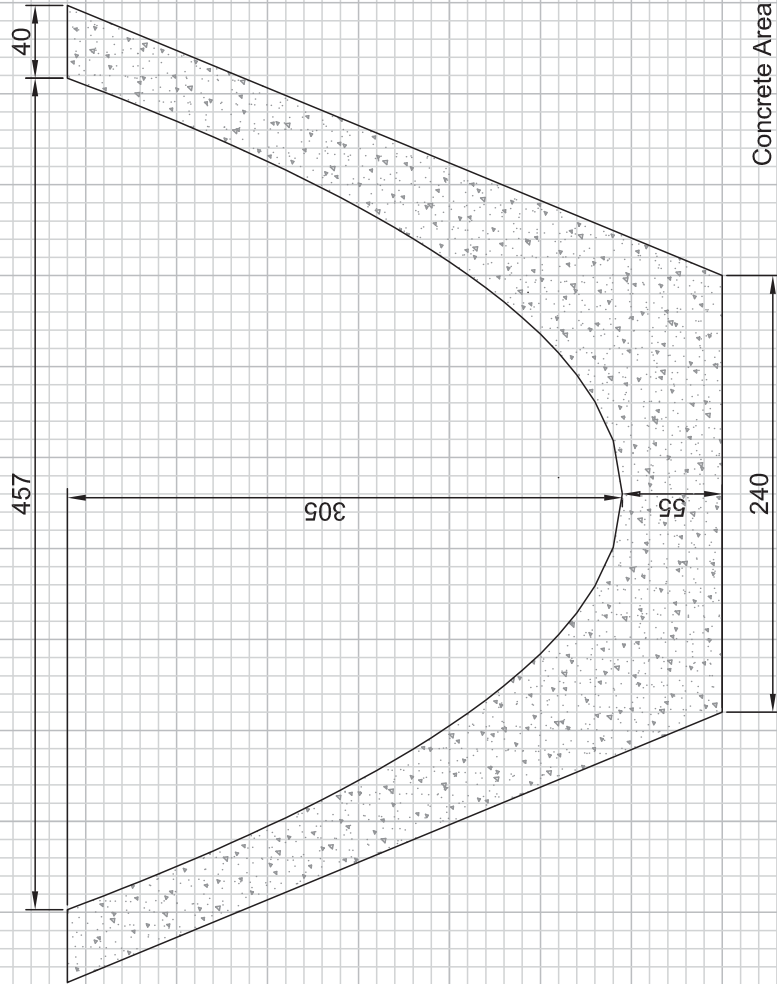
Annexure-B/i



Note:
 All dimensions are in mm

Annexure-B/ii

SEGMENT NO. 2

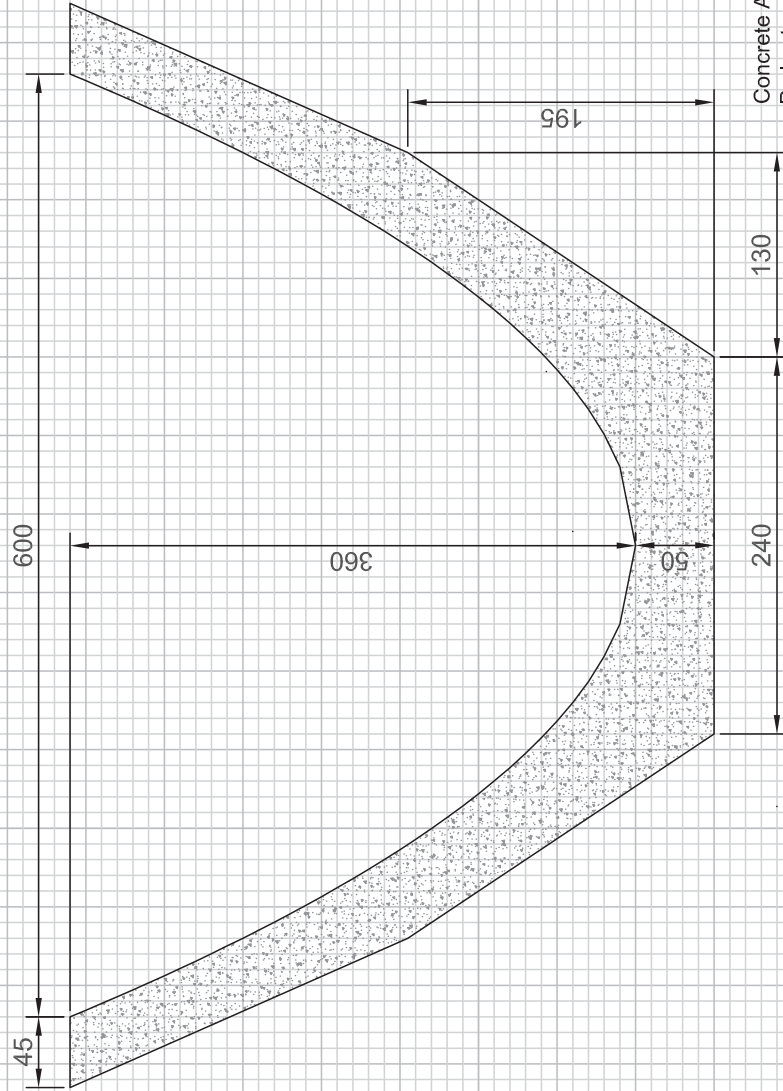


Concrete Area : 47025.50 Sq.mm
Perimeter : 797.23 mm
Cross Sectional Area : 92834.50 Sq.mm

Note:
All dimensions are in mm

Annexure-B/iii

SEGMENT NO. 3

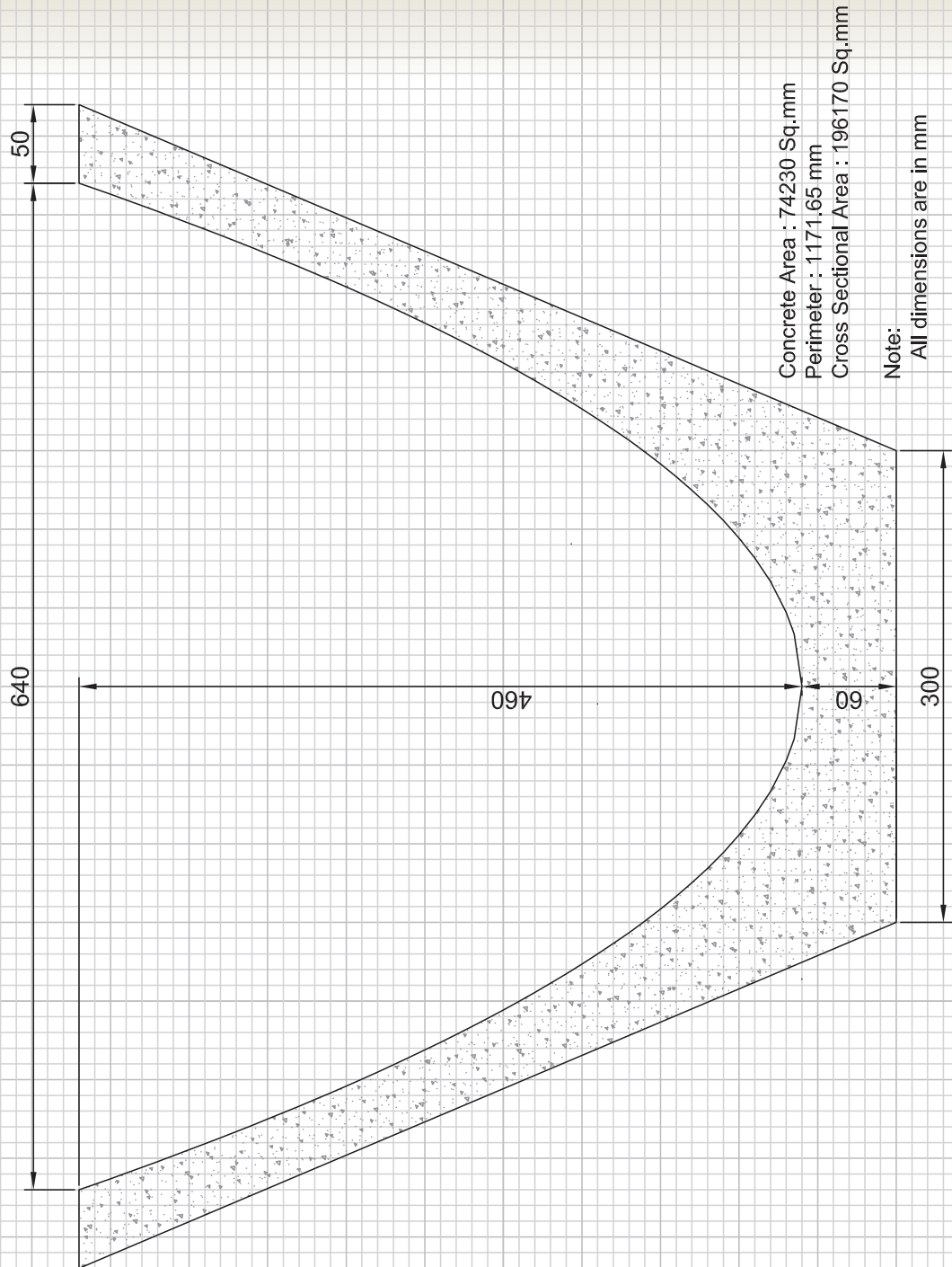


Concrete Area : 56279.39 Sq.mm
Perimeter : 980.48 mm
Cross Sectional Area : 143799.05 Sq.mm

Note:
All dimensions are in mm

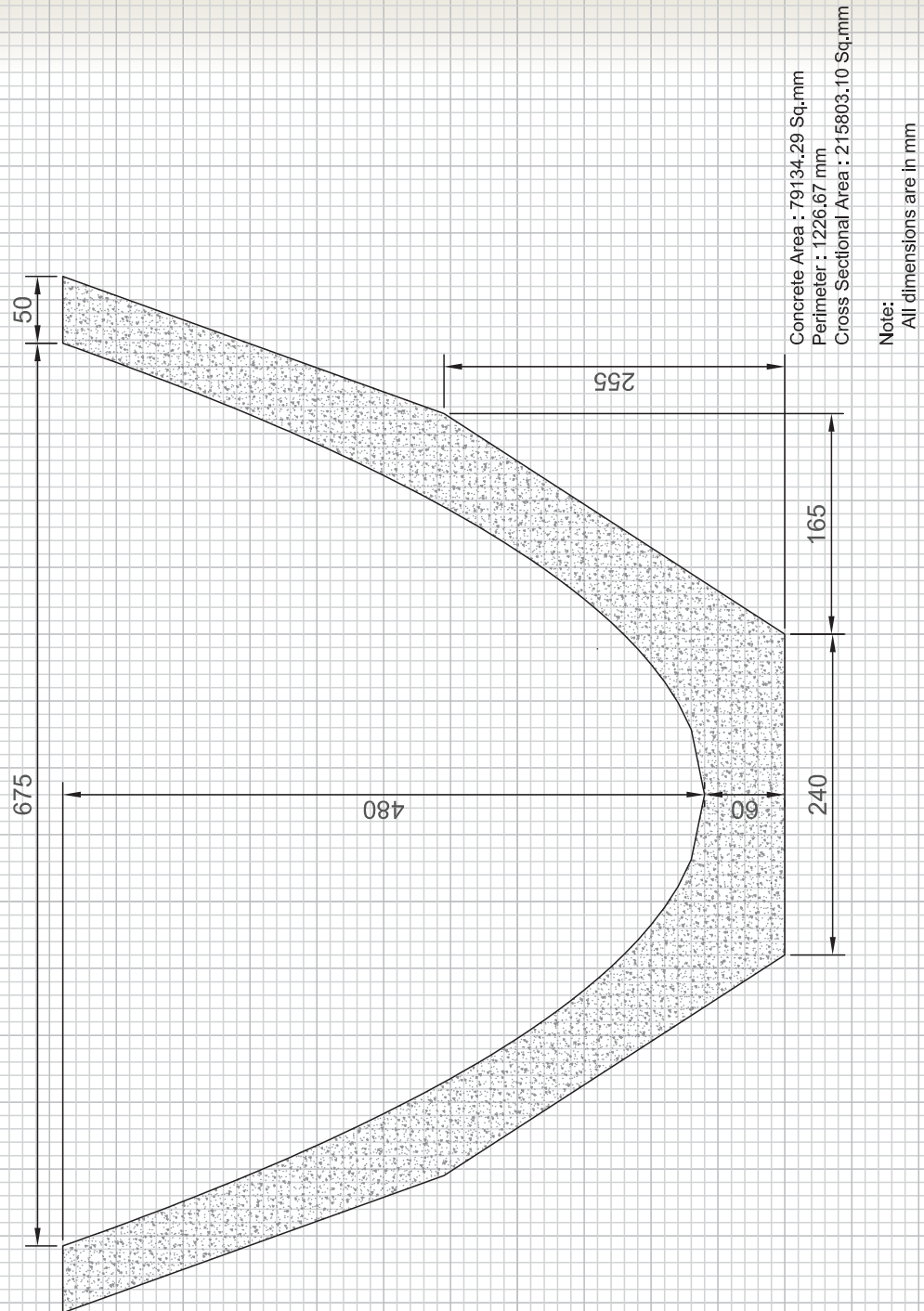
Annexure-B/iv

SEGMENT NO. 4



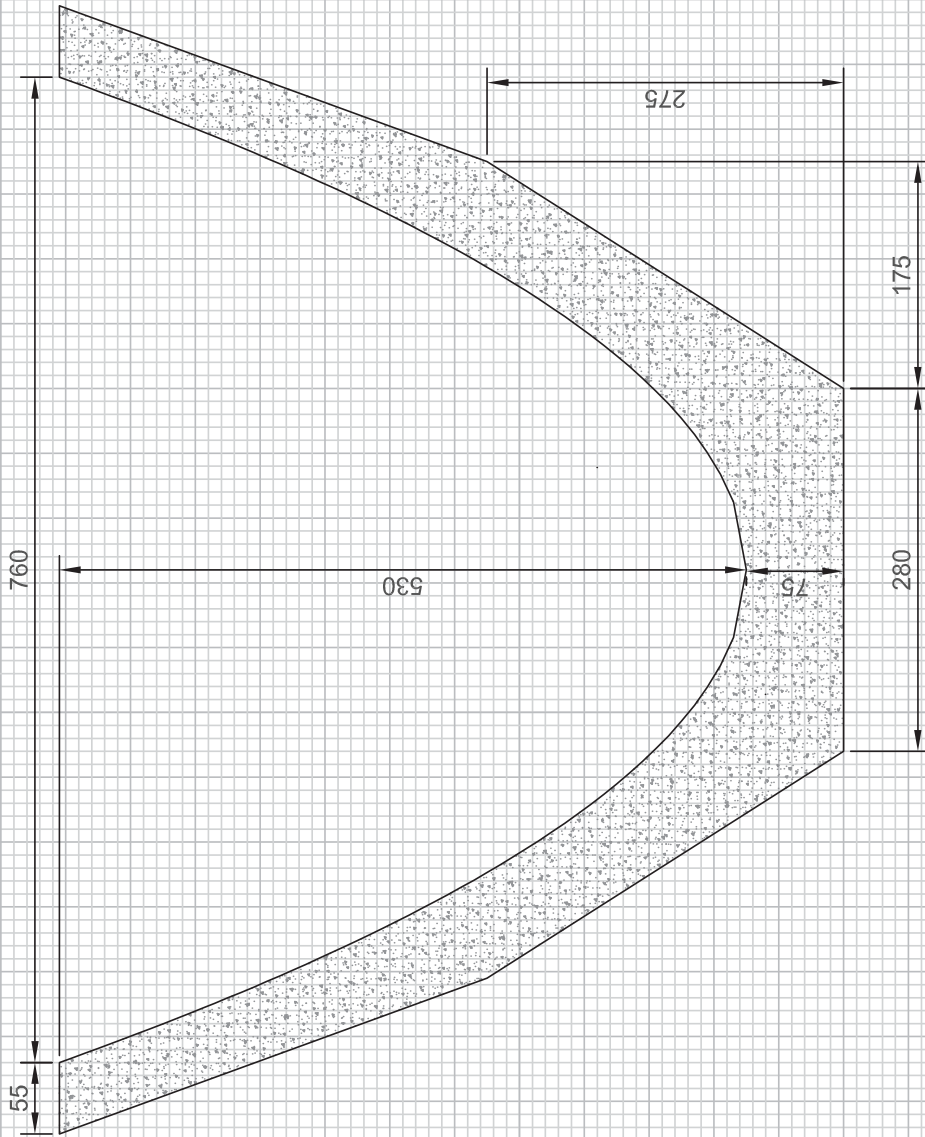
Annexure-B/v

SEGMENT NO. 5



Annexure-B/vi

SEGMENT NO. 6

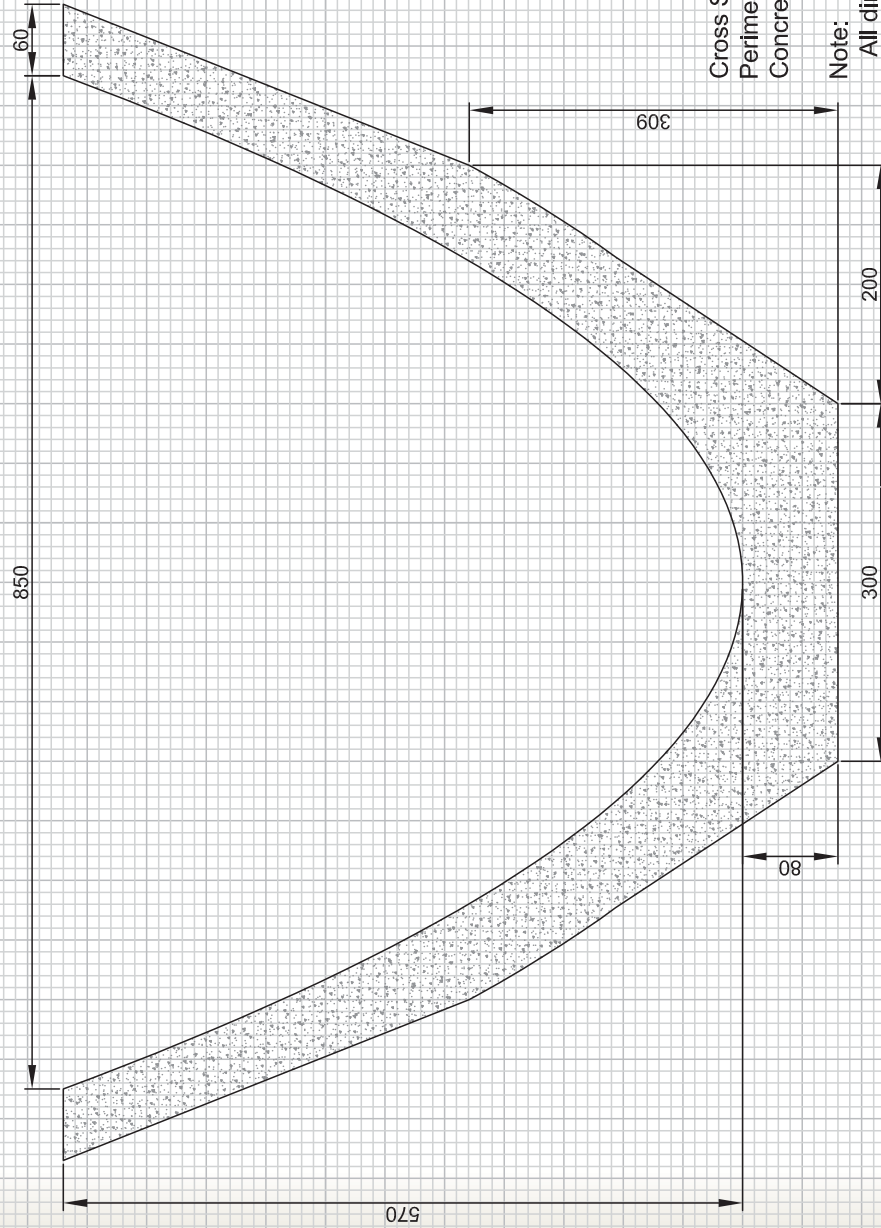


Concrete Area : 104295.70 Sq.mm
 Perimeter : 1363.76 mm
 Cross Sectional Area : 268335.45 Sq.mm

Note:
 All dimensions are in mm

Annexure-B/vii

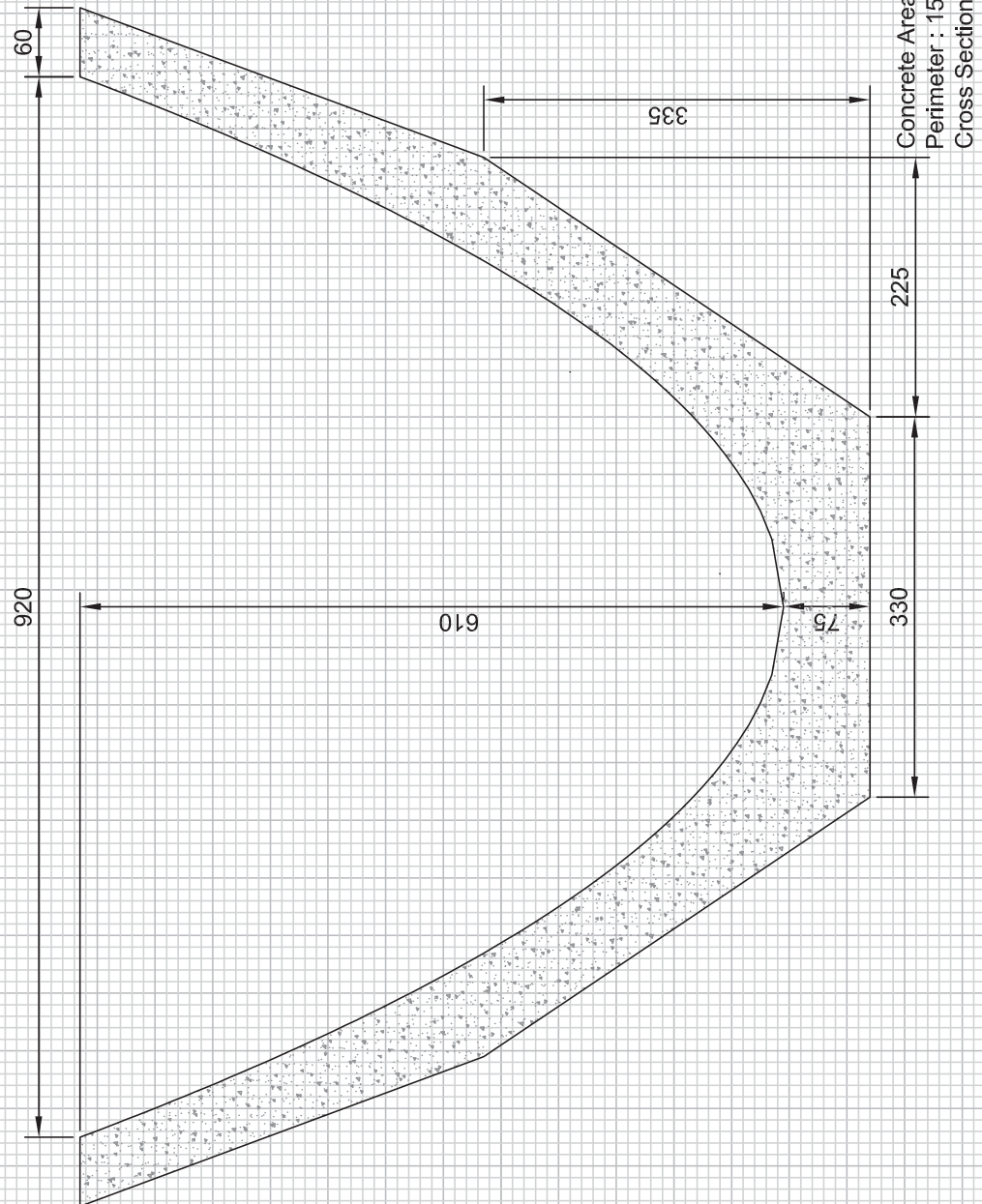
SEGMENT NO. 6a



Cross Sectional Area = 322985 sq.mm
Perimeter = 1488 mm
Concrete Area = 117323 sq.mm

Note:
All dimensions are in mm

SEGMENT NO. 7

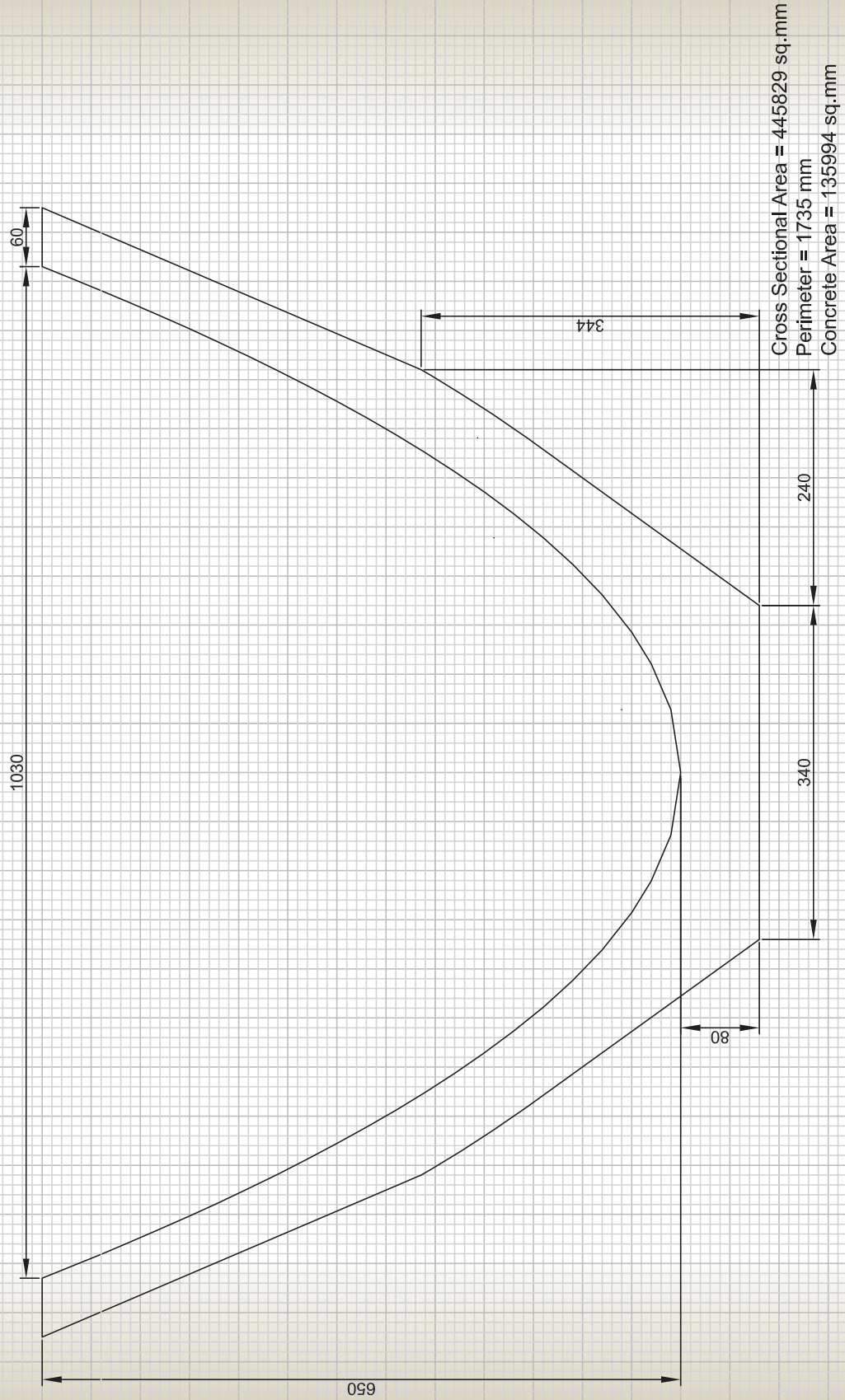


Note:

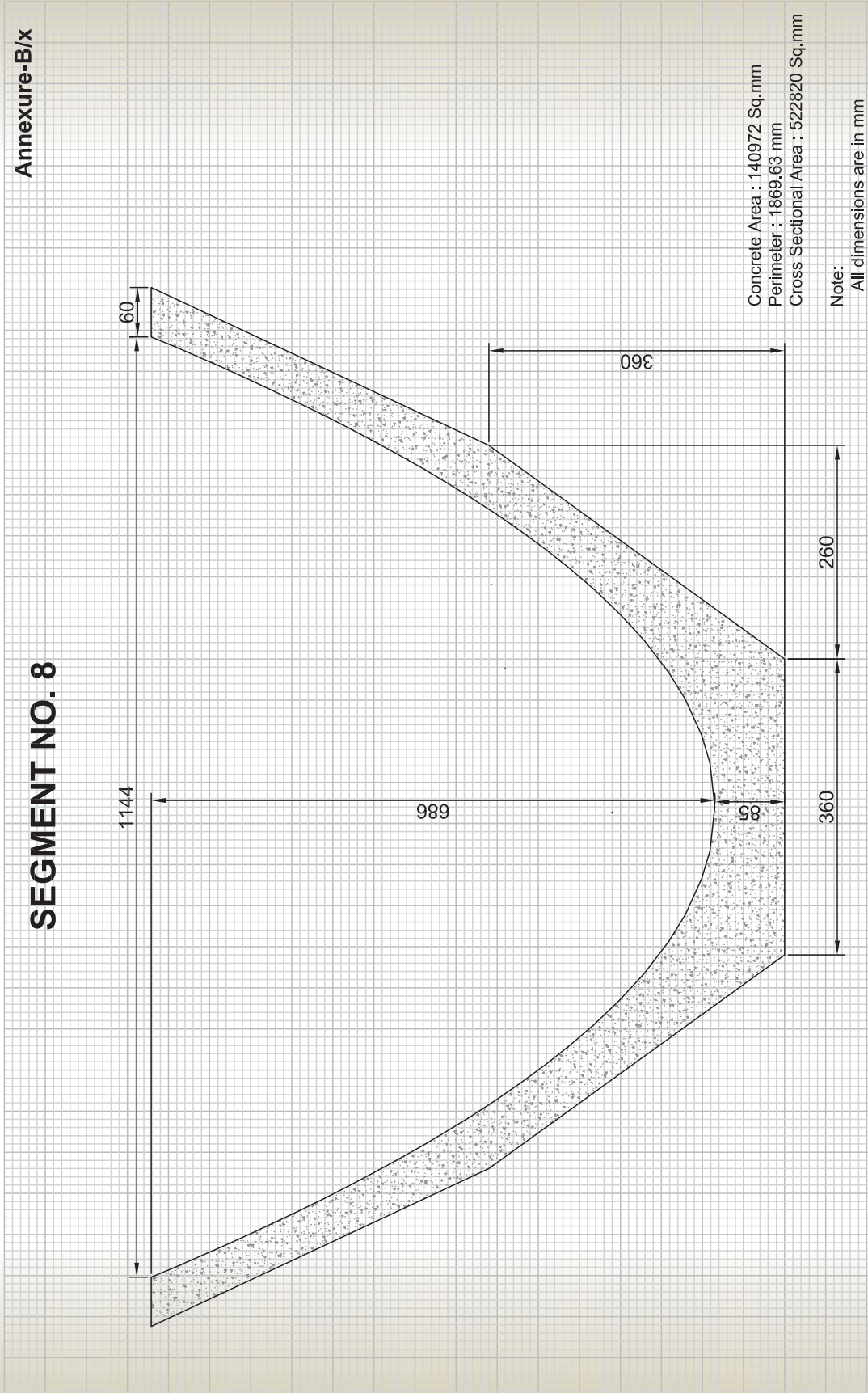
All dimensions are in mm

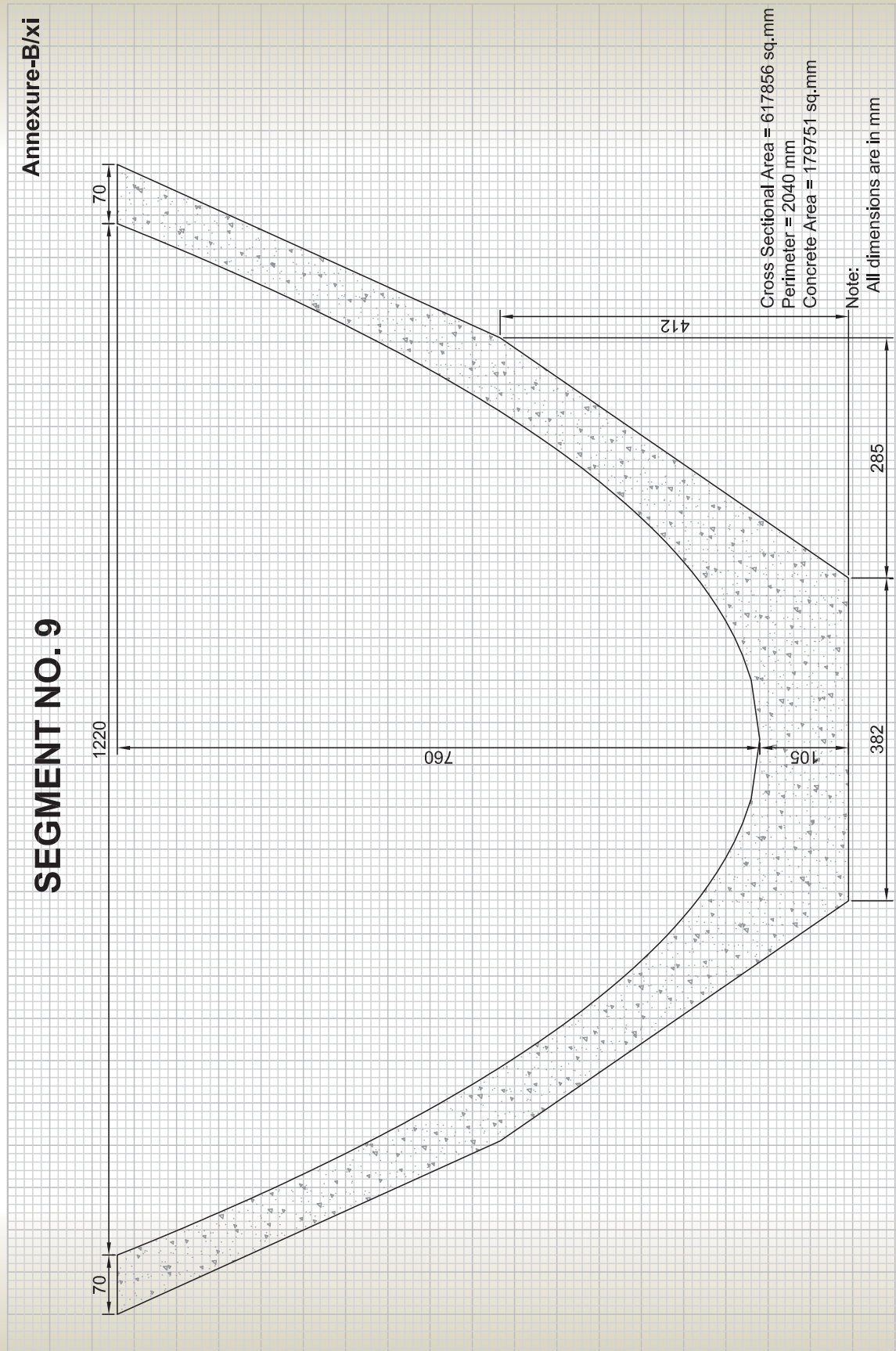
Annexure-B/ix

SEGMENT NO. 7a



Note:
All dimensions are in mm







ANNEXURE 'C'



PROJECT- IMPLEMENTATION SUPERVISION CONSULTANTS (PSC)

CONCRETE MIX, MATERIAL AND COST ESTIMATES OF DIFFERENT PCP SEGMENTS

A. Concrete Mixing Ratio

Materials for one cu. m Concrete			
Cement		Gravel	
cu.m.	Bags	cu.m.	cft
0.385	13.60	10.88	13.60

B. Unit Prices of Materials (Rs/Unit)

Cement	Sand *	Gravel *
Bags	cu.m.	cu.m.
510.00	1,059.000	2,472.00

* (Give rates Either in cu.m. OR cft)

Sand *	Gravel *
cft	cft
30.00	70.00

1,059.45 2,472.05

C. Estiamtes for Materials and Cost of Different Segments

Seg. No.	Size (T x D)		Wet Volume		Materials				Cost			
	cm	in	cu.m	cft	Cement	Sand	Gravel		Cement	Sand	Gravel	Total
1	36 x 22.5	14 x 9	0.0363	1.28	0.395	0.014	0.015	0.52	0.029	1.04	16	73
2	45.7 x 30.5	18 x 12	0.0430	1.52	0.468	0.017	0.017	0.61	0.035	1.23	18	86
3	60 x 36	24 x 14	0.0515	1.82	0.560	0.020	0.021	0.73	0.042	1.47	22	103
4	64 x 46	24 x 18	0.0679	2.40	0.738	0.026	0.027	0.97	0.055	1.94	29	136
5	67.5 x 48	26.6 x 19	0.0724	2.56	0.787	0.028	0.029	1.03	0.059	2.07	31	145
6	76 x 53	30 x 21	0.0954	3.37	1.037	0.037	0.039	1.36	0.077	2.72	41	191
6(a)	85 x 57	33.5 x 22.4	0.1073	3.79	1.167	0.041	0.043	1.53	0.087	3.06	46	214
7	92 x 61	36 x 24	0.1194	4.22	1.298	0.046	0.048	1.70	0.097	3.41	51	239
7(a)	103 x 65	40.6 x 25.6	0.1244	4.39	1.353	0.048	0.050	1.78	0.101	3.55	53	249
8	114.4 x 68.6	45 x 27	0.1289	4.55	1.402	0.050	0.052	1.84	0.104	3.68	55	258
9	122 x 76	48 x 29.9	0.1644	5.80	1.788	0.063	0.066	2.35	0.133	4.69	70	329

PROJECT- IMPLEMENTATION SUPERVISION CONSULTANTS (PSC)

Truck Capacity and Transport Cost including Loading/Unloading

Cost of Truck Load/unload upto 50 km within District* **8,000 Rs/Truck**

Cost of Truck Load Beyond 50 km within District **10,000 Rs/Truck**

S. No.	Particulars	Unit	Truck Capacity and Segment Transport Cost for Different Sizes (T x D cm)										
			1	2	3	4	5	6	6(a)	7	7(a)	8	9
			36 x 22.5	45.7 x 30.5	60 x 36	64 x 46	67.5 x 48	76 x 53	85 x 57	92 x 61	103 x 65	114.4 x 68.6	122 x 76
1	Truck Capacity	No/Truck	85	75	60	55	50	44	44	25	25	22	18
2	Transport Cost within 50 km	Rs/Segment	94	107	133	145	160	182	182	320	320	364	444
	Transport Cost beyond 50 km	Rs/Segment	118	133	167	182	200	227	227	400	400	455	556
3	Additional Transport per Km	Rs/Segment	0.47	0.53	0.67	0.73	0.80	0.91	0.91	1.60	1.60	1.82	2.22

* Cost of Truck shall include carriage and loading/unloading

**PROJECT- IMPLEMENTATION SUPERVISION CONSULTANTS (PSC)
PCPL SEGMENT COST ANALYSIS**

S. No.	Particulars	Unit	Segment Cost for Different Sizes (T x D cm)											
		Segment No.	1	2	3	4	5	6	6(a)	7	7(a)	8	9	
		Segment Size	36 x 22.5	45.7 x 30.5	60 x 36	64 x 46	67.5 x 48	76 x 53	85 x 57	92 x 61	103 x 65	114.4 x 68.6	122 x 76	
a) Material														
	Total Material Cost	Rs/Segment	290	343	410	541	577	760	855	952	992	1,028	1,311	
b) Labour														
	Labour cost (Skilled/un-skilled) from fabrication to finished PCPS including curling	Rs/Segment	78.0	92.3	110.5	145.7	155.3	204.7	230.3	256.2	266.9	276.7	352.8	
	Total Cost of PCPS Construction (a+b):	Rs/Segment	368	435	521	687	732	965	1,086	1,208	1,259	1,305	1,663	
c) Overhead & Profit														
	Overhead & Profit @ 25%	25%	92	109	130	172	183	241	271	302	315	326	416	
	Ex-Factory Cost of PCPS (a+b+c)	Rs/Segment	460	544	651	859	915	1,206	1,357	1,510	1,573	1,631	2,079	
d) Transportation														
	Transportation Cost upto 50 km in District	Rs/Segment	94	107	133	145	160	182	182	182	320	320	364	444
	Additional Carriage for No. of 0 km beyond 50 Km within District	Rs/Segment	-	-	-	-	-	-	-	-	-	-	-	
	Total Cost of Transportation	Rs/Segment	94	107	133	145	160	182	182	320	320	364	444	
	Total Cost of PCPS at Site (a+b+c+d)	Rs/Segment	554	651	784	1,004	1,075	1,388	1,539	1,830	1,893	1,994	2,524	
e) Taxes														
1	Sales Tax @17%	17%	94	111	133	171	183	236	262	311	322	339	429	
2	Further Tax @ 2%	2%	11	13	16	20	22	28	31	37	38	40	50	
	Total Taxes	19%	105	124	149	191	204	264	292	348	360	379	480	
	Total Cost at Site inclusive of Taxes	Rs/Segment	659	774	933	1,195	1,280	1,652	1,831	2,178	2,253	2,373	3,003	

Note: Please put actual number of Km beyond 50 km in cell "D17" to calculate & self incorporation of the same for additional carriage beyond 50 Km.



ANNEXURE ‘D’



COST ESTIMATES OF WATERCOURSE CONSTRUCTION

Project Name _____ **WC Improvement Type (Regular/Additional)** _____

Watercourse No. _____ Village/Chak No. _____ Minor/Disty. _____

DDO Office _____ Tehsil _____ District _____

Total Length (T.L) _____ Planned Earth. Impr'tment _____ Percent of T.L _____

Previous Lining (If any) _____ Planned Lining _____ Percent of T.L _____

Brick Lining Dimension:

Section-I

Total Depth (D) _____ Wall Thickness (T_w) _____

Floor Width (W_f) _____ Floor Thickness (T_f) _____ Unit Volume _____

Section-II

Total Depth (D) _____ Wall Thickness (T_w) _____

Floor Width (W_f) _____ Floor Thickness (T_f) _____ Unit Volume _____

PCPS Lining Dimension:

Section-I, Segment Size #

Total Depth (D) _____ Top Width (T) _____ No. of Segments _____

Section-II, Segment Size #

Total Depth (D) _____ Top Width (T) _____ No. of Segments _____

Description of Works:

Sr. No.	Particulars	Units	Length/ Quantity	Unit Volume	Brick Work (m^3)	Concrete Work (m^3)	No. of PCPS / RCC Slabs
1	i) Brick or PCPS Lining	m					
	ii) Brick or PCPS Lining	m					
2	i) Nakkas (_____ inch dia.)	No.					
	ii) Nakkas (_____ inch dia.)	No.					
3	Culverts	No.					
4	Buffalow Wallows	No.					
5	Drop	No.					
6	Other Structures (_____)	No.					
Total							

Estimated Materials and Cost of Watercourse Construction

Sr. No.	Description of Items	Unit	Quantity	Unit Rate (Rs.)	Total Cost
1	Bricks @ 500 Nos. per m ³ masonry volume	Nos.			
2	i) Cement @ 1.873 bags per m ³ masonry volume (1:4 mortar mix)	Bags			
	ii) Cement for PCPS jointing @ _____ bags/joint (1:3 mortar mix)	Bags			
	iii) Cement for any other concrete work	Bags			
3	Total Cement	Bags			
	i) Sand @ 0.26 m ³ per m ³ masonry volume (1:4 mortar mix)	cu.m			
	ii) Sand for PCPS jointing @ _____ m ³ per joint (1:3 mortar mix)	cu.m			
	iii) Sand for bed preparation for PCPS installation @ _____ m ³ /seg.	cu.m			
4	iv) Sand used in any other concrete work	cu.m			
	Total Sand	cu.m			
4	Gravel used in concrete work	cu.m			
5	i) Pre-cast Concrete Parabolic Segments (PCPS) size # _____	Nos.			
	ii) Pre-cast Concrete Parabolic Segments (PCPS) size# _____	Nos.			
6	i) Nakkas (_____ inch dia.)	Nos.			
	ii) Nakkas (_____ inch dia.)	Nos.			
7	Reinforcement used in concrete work	Kg.			
Total Cost of Material					

Overall Cost of Watercourse Improvement

A	Total Cost of Material/Civil Work	_____ %
B1	Cost of Mason/semi-skilled labor (including bed excavation & back earth filling)	_____ %
B2	Cost of un-skilled labor (including earthen improvement & alternate watercourse)	_____ %
B	Total Cost of Labor (B1+B2)	_____ %
C	Total Cost of Watercourse Improvement (A+B)	_____ %

Name of Supervisor _____ Name of Chairman WUA _____

Signature _____ Signature _____

Stamp _____ Stamp _____

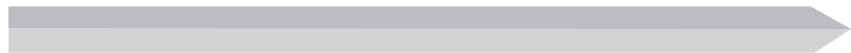
Name of DDO/DO _____ Name of Field Engineer _____

Signature _____ Signature _____

Stamp _____ Stamp _____



ANNEXURE 'E'



Annexure-E

Bulking of Sand

When using the volumetric method of proportioning, you should check the sand for bulking. Bulking of sand occurs when it is damp and is shovelled or moved, surface moisture holds the particles apart, causing an increase in volume known as bulking. Figure-1 shows that the amount of bulking varies with the moisture content and the grading: fine sands bulk more than coarse sand for a given amount of moisture. Most sand is delivered in damp conditions, therefore, the actual volume of sand is less if volumetric proportioning is used and an adjustment factor is needed. Since the bulking of sand returns to zero percent as it becomes saturated, a simple field test can be run to compute an adjustment factor. Use a straight sided container, fill it level full with sand in field condition. Then add water to bring it to a saturated condition, making sure it is completely saturated. The amount of settlement of the sand will indicate the bulking can be found by the following formula.

$$(a - b) / b \times 100 = \% \text{ bulking}$$

a = original depth of sand in container at field condition

b = depth of sand in container in saturated condition

The adjustment factor is, $(100 + \% \text{ bulking}) / 100$

Example:

Depth of container full of sand at field condition = 25 cm

Depth of saturated sand in container = 20 cm

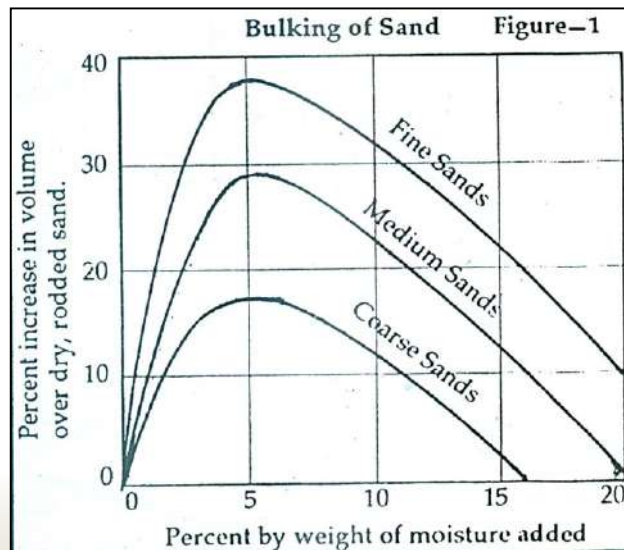
Cement sand ratio = 1:3 (dry sand)

$$\% \text{ bulking} = (25-20) / 20 \times 100 = 25\%$$

$$\text{Adjustment factor} = (100 + 25) / 100 = 1.25$$

$$\text{Corrected sand proportion} = 3 \times 1.25 = 3.75$$

$$\text{Corrected cement-sand (moist) ratio} = 1 : 3.75$$



Bulking of Sand. Surface moisture in fine aggregate causes considerable bulking, the amount of bulking varying with the amount of moisture and the aggregate grading.

OFWM



LASER Land Leveling



Watercourse Improvement



Sprinkler Irrigation



Drip Irrigation



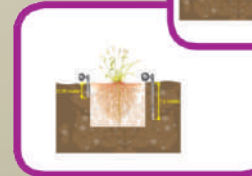
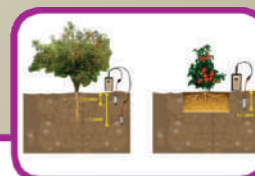
Storage Pond



Solar Coupled HEIS



Training/Human Resource Development



Soil Moisture Meter

Directorate General Agriculture (Water Management)
Punjab, Lahore

Agriculture House, 1st Floor, 21-Davis Road, Lahore

Tel: 042-99200703, 99200713

E-mail: pipipwm@gmail.com, Website: www.ofwm.agripunjab.gov.pk