3. PROJECT PROPOSAL

The total length of the Serpentine drain is about 4.7 km from Airport Road to Planetarium where it further connects to mandiri drain. It is an Unlined open drain which is not continuous having no side walls with encroachments found on both sides.

Table 3-1: Details of Drain

Total Length	4.7 Km	**Serpentine Nala** - Starting from Patel Chowk near Patna Airport upto Planetarium near Income Tax Roundabout.
Open Drain	2.4 Km	
Close drain	2.3 Km	

The proposal broadly comprises of following activities:

a. **Construction of drain for the stretch of open Drain.**
b. **Construction of vehicular road for the stretch where drain will be covered covering ROW.**
c. **Redevelopment of side areas for Parking apart from the road surface.**

3.1 Encroachment removal and Utility Shifting – Serpentine Drain

Encroachments are found from Patel Chowk up to the Anne Marg Road which leads to Eco Park. The edges of Nala have been encroached and unplanned development of squatters has taken place along the edges. Some encroachment is found along the drain from Harding Park up to Planetarium. For overall development, these encroachments need to be removed.
There are many culverts over Serpentine Nala. Since a continuous drain is proposed to be constructed and made *pucca* therefore all the Nala crossings need to be demolished and reconstructed except those under major roads. The Chainage wise locations of existing culverts are mentioned in table below.

Tree to be cut

There are small trees in the entire stretch that are to be cut for drain construction. The Chainage wise locations of existing trees are mentioned in table below and also refer **Annexure 4** for details.

Electric poles, Light Poles, DTR Transformer and Phases

The Chainage wise locations of existing electrical fixtures are mentioned in table below and also refer **Annexure 4** for detail. There are 6 light poles, 3 DTR transformers.

Water supply lines

Water supply lines are found embedded in the depth in soil and shall be taken care of (shifted, removed, replaced) during the execution of the project.

Table 3-2: Details of Utility shifting – Serpentine Nala

	Nos.	Chainage
	Section 1- Ali Imam Path to Anne Marg	
Demolition of Culverts	1	Ch 0 +000
	1	Ch 0 +280
	1	Ch 0 +637
	Section 2- Mangal road to Beer Chand Patel Path	
	1	Ch 0 +180
	1	Ch 0 +210
	2	Ch 0 +600
	1	Ch 1 +000
	Section 3- Beer Chand Patel Path to Dak Banglow Rd	
	1	Ch 0 +000
	1	Ch 0 +400
	1	Ch 0 +540
	1	Ch 0 +580
	1	Ch 0 +620
	1	Ch 0 +640
	1	Ch 0 +660
Total Demolition	**15**	
Trees	**Nos.**	**Chainage**
	Section 1- Ali Imam Path to Anne Marg	
	2	Ch 0 +000
	2	Ch 0 +056
	1	Ch 0 +125
	1	Ch 0 +210
	2	Ch 0 +300
	1	Ch 0 +390
	1	Ch 0 +440
	1	Ch 0 +450
	1	Ch 0 +620
	1	Ch 0 +637
	Section 2- Mangal road to Beer Chand Patel Path	
	1	Ch 0 +055
	1	Ch 0 +130
	2	Ch 0 +350
	1	Ch 0 +600
	1	Ch 0 +750
	2	Ch 0 +800
	1	Ch 0 +810
	2	Ch 0 +830
	2	Ch 0 +840
	1	Ch 0 +860
	Section 3- Beer Chand Patel Path to Dak Banglow Rd	

	1	Ch 0 +050
	1	Ch 0 +190
	1	Ch 0 +251
	3	Ch 0 +325
	2	Ch 0 +351
	1	Ch 0 +400
	2	Ch 0 +455
	2	Ch 0 +540
	1	Ch 0 +560
	2	Ch 0 +600
Total Trees Cutting	**43**	
Electric Poles	**Section 1- Ali Imam Path to Anne Marg**	
	1	Ch 0 +300
	1	Ch 0 +325
	1	Ch 0 +350
	1	Ch 0 +380
	Section 2- Mangal road to Beer Chand Patel Path	
	2	Ch 0 +050
	3	Ch 0 +600
	Section 3- Beer Chand Patel Path to Dak Banglow Rd	
	3	Ch 0 +425
	1	Ch 0 +450
	1	Ch 0 +460
	1	Ch 0 +465
	1	Ch 0 +500
	1	Ch 0 +540
	1	Ch 0 +550
	1	Ch 0 +590
	1	Ch 0 +640
	1	Ch 0 +660
Total Electrical Poles Shifting	**21**	
Light Poles	**Section 1- Ali Imam Path to Anne Marg**	
	2	Ch 0 +000
	2	Ch 0 +637
	Section 2- Mangal road to Beer Chand Patel Path	
	1	Ch 0 +155
	Section 3- Beer Chand Patel Path to Dak Banglow Rd	
	1	Ch 0 +380
Total Light Poles	**6**	
DTR Transformer	**Section 1- Ali Imam Path to Anne Marg**	
	1	Ch 0 +265
	1	Ch 0 +290
	Section 3- Beer Chand Patel Path to Dak Banglow Rd	
	1	Ch 0 +400
Total DTR Transformers	**3**	

3.2 Construction of Drain

Construction of RCC Drain cast in-situ is proposed in the length where drain is open in nature, a silt trap provision, manholes screens at joining drains as well as in main drain are also made wherever required along the drainage line and same is shown in **Annexure 8: Proposed Drain Plan.**

The detailed Design and planning study of the Drainage system is dealt with in subsequent chapters.

3.3 Development of Vehicular Road

From the vehicular movement analysis, it was observed that 4 wheelers and 2 wheelers are getting merged on the main road from the perpendicular roads creating traffic jam on major roads. Since the Serpentine is parallel to this major city road, traffic movement will be allowed on the drain stretch.
Also, the minimum right of way proposed for nala would be 7.5m which is for LMV only considering the nature of proposed drain.

The proposed drain section would be covered single box drain with motor able road surface above it and on sides PCC road would be made so as to ensure total width of 7.5m road is achieved. After the road width 1.5m paver blocks on both sides will be laid while the rest of area would be levelled for parking and other activities as per available ROW.

4. DESIGN FOR DRAINAGE SYSTEM

4.1 Design Criteria for Drainage System

Design basics for drainage network are presented in the following sections.

4.1.1 Design Year

The design year for all the civil structures of drainage components is year 2021.

4.1.2 Estimation of Storm Runoff

The analysis of drainage system is usually based on testing the ability of the covered surface drains to appropriately handle peak flows without flooding roadways or scouring action due to high velocities. Rational method has been used for estimating peak flows, based on the size and runoff coefficient of watershed, and the intensity of the storm event. The proposed drain is sized such that the estimated runoff to be conveyed does not exceed design capacity of the drain.

The maximum runoff, which has to be carried in a drain, has been computed for a condition when the entire basin draining at that point becomes contributory to the flow. The time needed for this is known as the time of concentration (tc) with reference to the concerned section. The runoff beyond the time of concentration remains constant.

4.1.3 Rainfall- Runoff Intensity

The runoff reaching the storm water system has been estimated by the following expression:

$Q = 10\ C\ i\ A$

Where,

Q = is the runoff (m^3/hr)

C = is the coefficient of runoff;

I = is the critical intensity of rainfall (mm/hr)

A = is the area of drainage zone (hectares)

4.1.4 Storm Frequency

The selection of return period of the design-storm depends on several factors such as the importance of the facility being designed, the cost, the level of protection the drainage facility will provide, and the damages that would result from the failure of the facility. The suggested frequency of flooding in the different areas as per the CPHEEO Manual is as follows:

a. Residential areas

i. Peripheral areas twice a year
ii. Central and comparatively high-priced areas once in a year

b. Commercial and high-priced areas once in 2 years

As the project area is primarily urban area comprising residential areas, a flood frequency of once in 2 years has been considered for the design.

4.1.5 Intensity of Precipitation

Patna receives an average annual rainfall of about 931 mm. The intensity of precipitation has been calculated based on IDF curve for given time of concentration (tc), expressed in minutes and Gumbel's method has been used to compute the Rainfall intensity analysis and generation of IDF Curve.

4.1.6 Time of Concentration

Time of concentration (tc) is equal to inlet time (t_i) plus the time of flow in the drain (t_f). The inlet time is dependent on the distance of the farthest point in the drainage basin to the inlet manhole, the shape, characteristics and topography of the basin. The ti may generally vary from 5 to 30 minutes. The inlet time has been calculated by the following formula as described in **IRC SP-50 (2013).**

Inlet time (ti) Hours = $(0.87\ L^3/D)^{0.385}$

Where,

L = Farthest Point in the catchment in km

D = Difference in levels of the farthest point in the catchment & inlet point in, m

The catchment areas/ drainage zones have been demarcated based on the topographical details. Subsequently the time of concentration and discharge in the drains has been calculated, accordingly.

4.1.7 Co-Efficient of Runoff

The coefficient of runoff is dependent on land use and slope approaching for impervious ground covers, such as pavement. The percent imperviousness of the drainage can be assumed based on the master plan of the area. The following has been listed in the CPHEEO manual as a guide:

Duration t, minutes	10	20	30	45	60	75	90	100	120	135	150	180
Weighted average coefficient												
1.Sector concentrating in stated time												
a. Impervious	0.525	0.588	0.642	0.700	0.740	0.771	0.795	0.813	0.828	0.840	0.850	0.865
b. 60% impervious	0.365	0.427	0.477	0.531	0.569	0.598	0.662	0.641	0.656	0.670	0.682	0.701
c. 40% impervious	0.285	0.346	0.395	0.446	0.428	0.512	0.535	0.554	0.571	0.585	0.597	0.618
d. pervious	0.125	0.185	0.230	0.227	0.312	0.330	0.362	0.832	0.399	0.414	0.429	0.454
2. Rectangle (length=4*WIDTH) CONCENTRATING IN STATED TIME												

a. Impervious	0.550	0.648	0.711	0.768	0.808	0.837	0.856	0.869	0.879	0.887	0.892	0.903
b. 50% impervious	0.350	0.442	0.499	0.551	0.590	0.618	0.639	0.657	0.671	0.683	0.694	0.713
c. 30% impervious	0.269	0.360	0.414	0.646	0.502	0.530	0.552	0.572	0.588	0.601	0.614	0.636
d. pervious	0.149	0.236	0.287	0.334	0.371	0.398	0.422	0.445	0.463	0.479	0.495	0.522

The weighted average imperviousness of drainage basin for the flow concentrating at a point can be estimated as

I = [A1I1 + A2I2 ….]/ [A1 + A2 + ……]

Where,

A1, A2 = drainage areas tributary to the section under consideration

I1, I2 = imperviousness of the respective areas

I = weighted average imperviousness of the total drainage basin

From the previous experience of working in similar town, weighted average runoff co-efficient has been selected as 0.77 for the project area.

4.1.8 Tributary Area

A tributary area or catchment is the geographical area that “catches” the rainfall and directs it towards a common discharge point within the storm collection network.

For each length of storm drains, the drainage area has been indicated on the map and measured. The boundaries of each tributary are dependent on topography, land use, nature of development and shape of the drainage basin.

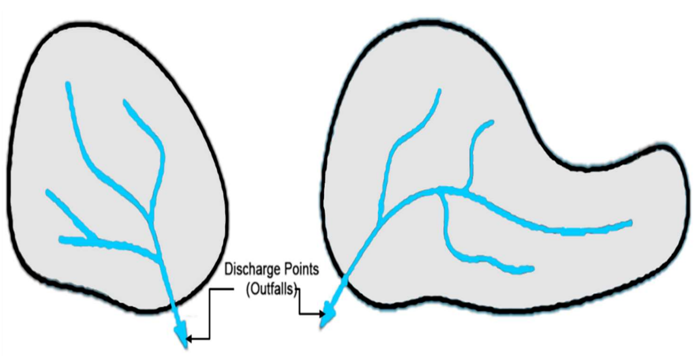


Figure 11: Discharge point Diagram

4.1.9 Material Selection

RCC drains have been proposed for drains throughout the length.

4.1.10 Size of Drains

The sections of drain shown in **Table-4.1** are considered in the drainage design:

Table 4-4-1: Sections of Drains

Serpentine Drain				
Sl.No.	**Drain**	**Start Node**	**Stop Node**	**Span**
1	D-1	CB-1	CB-2	4500
2	D-2	CB-2	CB-3	4500
3	D-3	CB-3	CB-4	4500
4	D-4	CB-4	CB-5	4500
5	D-5	CB-5	CB-6	4500
6	D-6	CB-6	CB-7	4500
7	D-7	DB-1	DB-2	4500
8	D-8	DB-2	DB-3	5000
9	D-9	DB-3	DB-4	5000
10	D-10	DB-4	DB-5	5000
11	D-11	DB-5	DB-6	5000
12	D-12	DB-6	DB-7	5000
13	D-13	EB-1	EB-2	5000
14	D-14	EB-2	EB-3	5000
15	D-15	EB-3	EB-4	5000
16	D-16	EB-4	EB-5	5000
17	D-17	EB-5	EB-6	5000
18	D-18	EB-7	EB-8	5000
19	D-19	EB-8	EB-9	5000
20	D-20	EB-9	EB-10	5000

The hydraulic design statement of Serpentine Drain is shown in **Annexure: 3: Hydraulic Design Statement**

4.1.11 Minimum Free Board

Minimum freeboard depends on size of the drain and has been ensured as per IRC SP: 50.

Table 4-2: Drain Sizes

Sl. No.	Drain Size	Free Board
1	Upto 300 mm bed width	10 cm
2	Beyond 300 mm bed width and upto 900 mm bed width	15 cm
3	Beyond 900 mm bed width and upto 1500 mm bed width	30 cm

4.1.12 Hydraulic Design of Drainage System

The hydraulic design of drains has been done on in spread sheet which is based on Manning's formula.

Manning's Formula,

$V = [(1/n)] \times [R^{2/3} S^{1/2}]$

and

$Q = A \times [(1/n)] \times [R^{2/3} S^{1/2}]$

Where,

Q = Discharge (m3/sec)

S = Slope of hydraulic gradient (hf/l)

A = Area of the section (m2)

R = Hydraulic radius (m) = A/P

V = Velocity (m/s)

n = Manning's coefficient of roughness

4.1.13 Minimum and Maximum Velocities

Generally, the minimum design velocity has been considered as 0.6 m/s to avoid siltation and the maximum design velocity has been limited to 3.0 m/s to avoid erosion/ scouring.

4.1.14 Manning's Coefficient

The value of Manning's coefficient for RCC drains with steel forms has been considered as 0.013 (CPHEEO Manual, 2013).

5. PLANNING OF NEW DRAINAGE SYSTEM

5.1 Planning of Drainage Network

The planning of the drainage system has been carried out has been done in line with CPHEEO manual on storm water drainage system and the experience on the storm drainage projects. The planning of drainage system has been done on the basis of physical topographical survey and data gathered.

Based on the Digital Elevation model (provided below), topographical survey carried out and the other topographical report from the existing or in planning drainage plan made available by the department. The catchment covers most of the major drains named as Anandpuri, Shivpuri, Boring Canal, Serpentine, Mandiri and Bakarganj Nala. Northern boundary of the catchment is shared by River Ganga, Southern boundary is shared by Baily Road and Railway line, Western boundary by Kurjee Drain and Eastern boundary by Bakarganj Drain. The four major drains directly discharge into River Ganga which are Anandpuri Drain via Rajapul new DPS at Rajapur, Boring Canal via Rajpul old DPS at Rajapur, Mandiri Drain via Mandiri DPS at Bans Ghat, Bakarganj drain Via Bakarganj DPS at Anta Ghat.

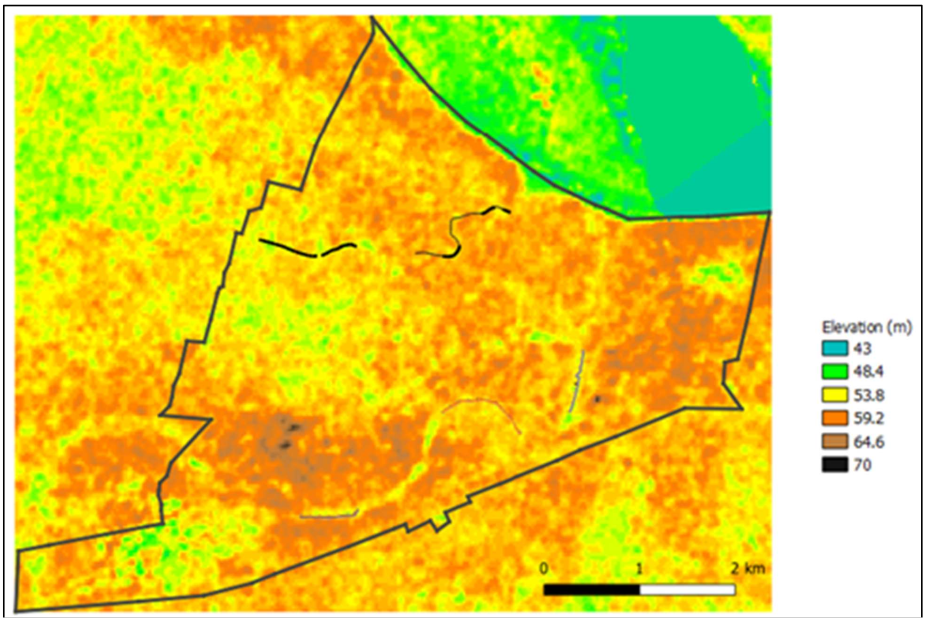


Figure 5-2: Digital Elevation Area of Project Area

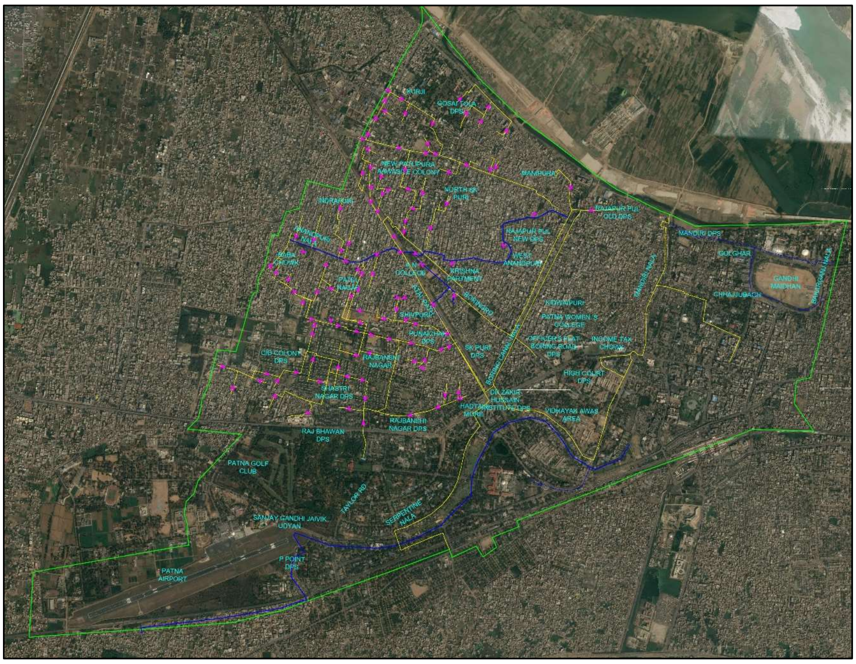


Figure 5.2: Drainage flow directions

From the reconnaissance survey of project area by the consultant's teams, it is found that water impounded during monsoon season, the above-mentioned drainage gets flooded.

5.2 Hydro-metrological Study

The first step involved in the design of drains is the estimation of the rate of surface runoff. The peak runoff at any given point has been calculated using the following rational formula as per Manual on Sewerage and Sewage Treatment (2013) from CPHEEO.

Analysis of rainfall data develops the Intensity Duration Frequency (IDF) curve for the storm of design return period. The IDF relationship comprises the estimates of rainfall intensities of different durations and recurrence intervals. As per CPHEEO Manual, empirical relationship for the estimation of rainfall intensity can be expressed by a suitable mathematical formula. One of the commonly used equations is:

$$i = a/t_n$$

Where, a and n are constants

By applying the logarithmic conversion, it is possible to convert the equation into a linear equation.

This analysis is organized according to the following sub-sections:

a. Obtaining Rainfall data (preferably for more than 25 years);

b. Type & extent of Rainfall data;
c. Sorting of Rainfall occurrence;
d. Development of IDF curves; and
e. Conclusion (final intensity selection for designing of drain sections)

Obtaining Rainfall data: Rainfall data has been collected from Indian Meteorological Department (IMD) for Patna for a period of 28 years (from 1981 to 2009) is adopted for designing the drains. Also, Daily Rainfall Data from 2011 to 2021 is being collected from concerned departments.

Table 5-5-1: Computed Annual Rainfall Data for 1981 to 2009

Year	Annual Rainfall (mm)	Year	Annual Rainfall (mm)
1981	814.9	2001	819.25
1982	508.1	2002	710.3
1983	621.5	2003	1052.8
1984	827.2	2004	603.25
1985	1190.1	2005	672.95
1986	817.6	2006	856.05
1987	**1744.9**	2007	**1527.75**
1988	**1051.4**	2008	**1695.5**
1989	888.8	2009	730.55
1990	958.5	2011	572.1
1991	734.2	2012	959.6
1992	621.0	2013	751
1993	876.8	2014	318.7
1994	863.1	2015	641.9
1995	754.9	2016	854.4
1996	1079.5	2017	693.1
1997	-	2018	508.7
1998	1031.0	2019	**1110.5**
1999	1018.6	2020	**1209.5**
2000	987.5	2021	491.8

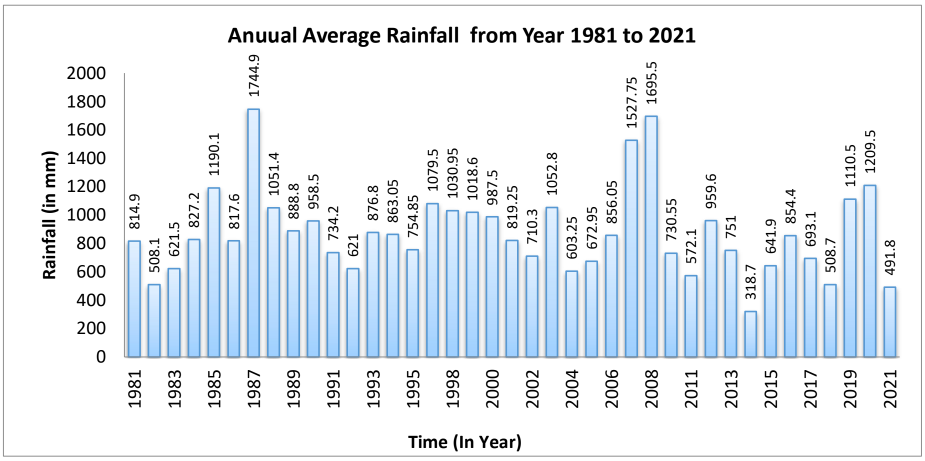


Figure 5-3: Represents computed annual rainfall for the year 1981 to 2009.

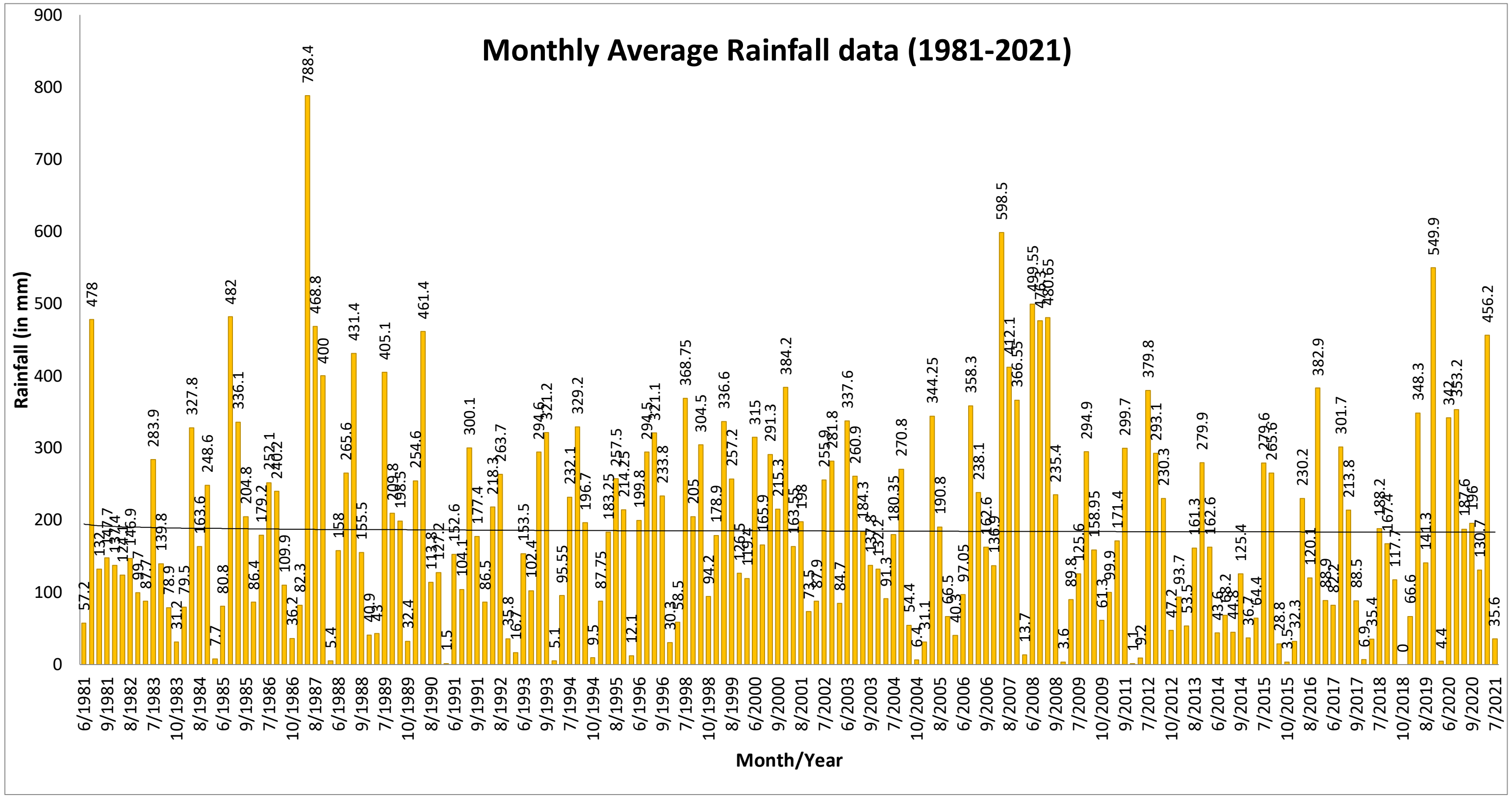
It is evident from the above data, the maximum rainfall was received i.e., 1744.9 mm in 1987, followed by 1695.5 mm in Year 2008, 1527.75 mm in Year 2007. In year 2019 and 2020, rainfall received was 1110.5 mm and 1209.5 mm.

Monthly Rainfall data collected is presented below. The trend shows that year 2007 received more rainfall than year 2019, in which flooding occurred in the project Nallah and nearby area.

Mon/yrs	Rainfall (In mm)	Mon/yrs	Rainfall (In mm)	Mon/yrs	Rainfall (In mm)	Mon/yrs	Rainfall (In mm)	Mon/yrs	Rainfall (In mm)	Mon/yrs	Rainfall (In mm)
6/1981	57.2	**9/1987**	**400.0**	6/1994	95.6	8/2001	198.0	**7/2008**	**476.3**	9/2015	28.8
7/1981	**478.0**	10/1987	5.4	7/1994	232.1	10/2001	73.5	**8/2008**	**480.7**	10/2015	3.5
8/1981	132.0	6/1988	158.0	8/1994	329.2	6/2002	87.9	9/2008	235.4	6/2016	32.3
9/1981	147.7	7/1988	265.6	9/1994	196.7	7/2002	255.9	10/2008	3.6	7/2016	230.2
6/1982	137.4	**8/1988**	**431.4**	10/1994	9.5	8/2002	281.8	6/2009	89.8	8/2016	120.1
7/1982	124.1	9/1988	155.5	6/1995	87.8	10/2002	84.7	7/2009	125.6	9/2016	382.9
8/1982	146.9	10/1988	40.9	7/1995	183.3	6/2003	337.6	8/2009	294.9	10/2016	88.9
9/1982	99.7	6/1989	43.0	8/1995	257.5	7/2003	260.9	9/2009	159.0	6/2017	82.2
6/1983	87.7	**7/1989**	**405.1**	9/1995	214.3	8/2003	184.3	10/2009	61.3	7/2017	301.7
7/1983	283.9	8/1989	209.8	10/1995	12.1	9/2003	137.8	7/2011	99.9	8/2017	213.8
8/1983	139.8	9/1989	198.5	6/1996	199.8	10/2003	132.2	8/2011	171.4	9/2017	88.5
9/1983	78.9	10/1989	32.4	7/1996	294.5	6/2004	91.3	9/2011	299.7	10/2017	6.9
10/1983	31.2	6/1990	254.6	8/1996	321.1	7/2004	180.4	10/2011	1.1	6/2018	35.4
6/1984	79.5	**7/1990**	**461.4**	9/1996	233.8	8/2004	270.8	6/2012	9.2	7/2018	188.2

7/1984	327.8	8/1990	113.8	10/1996	30.3	9/2004	54.4	7/2012	379.8	8/2018	167.4
8/1984	163.6	9/1990	127.2	6/1998	58.5	10/2004	6.4	8/2012	293.1	9/2018	117.7
9/1984	248.6	10/1990	1.5	7/1998	368.8	6/2005	31.1	9/2012	230.3	10/2018	0.0
10/1984	7.7	6/1991	152.6	8/1998	205.0	7/2005	344.3	10/2012	47.2	6/2019	66.6
6/1985	80.8	7/1991	104.1	9/1998	304.5	8/2005	190.8	6/2013	93.7	7/2019	348.3
7/1985	**482.0**	8/1991	300.1	10/1998	94.2	9/2005	66.5	7/2013	53.5	8/2019	141.3
8/1985	336.1	9/1991	177.4	6/1999	178.9	10/2005	40.3	8/2013	161.3	**9/2019**	**549.9**
9/1985	204.8	6/1992	86.5	7/1999	336.6	6/2006	97.1	9/2013	279.9	10/2019	4.4
10/1985	86.4	7/1992	218.3	8/1999	257.2	7/2006	358.3	10/2013	162.6	6/2020	342.0
6/1986	179.2	8/1992	263.7	9/1999	126.5	8/2006	238.1	6/2014	43.6	7/2020	353.2
7/1986	252.1	9/1992	35.8	10/1999	119.4	9/2006	162.6	7/2014	68.2	8/2020	187.6
8/1986	240.2	10/1992	16.7	6/2000	315.0	6/2007	136.9	8/2014	44.8	9/2020	196.0
9/1986	109.9	6/1993	153.5	7/2000	165.9	**7/2007**	**598.5**	9/2014	125.4	10/2020	130.7
10/1986	36.2	7/1993	102.4	8/2000	291.3	**8/2007**	**412.1**	10/2014	36.7	**6/2021**	**456.2**
6/1987	82.3	8/1993	294.6	9/2000	215.3	9/2007	366.6	6/2015	64.4	7/2021	35.6
7/1987	788.4	9/1993	321.2	6/2001	384.2	10/2007	13.7	7/2015	279.6		
8/1987	**468.8**	10/1993	5.1	7/2001	163.6	**6/2008**	**499.6**	8/2015	265.6		
6/1981	57.2	**9/1987**	**400.0**	6/1994	95.6	8/2001	198.0	7/2008	476.3		
7/1981	478.0	10/1987	5.4	7/1994	232.1	10/2001	73.5	8/2008	480.7		
8/1981	132.0	6/1988	158.0	8/1994	329.2	6/2002	87.9	9/2008	235.4		

Note: Highlighted are the months received 400 mm rainfall.


Monthly Average Rainfall data (1981-2021)
Rainfall (in mm)
Month/Year
0
100
200
300
400
500
600
700
800
900

Type & extent of Rainfall data: The rainfall data collected presents continuous (15 minutes) rainfall recorded by automatic Rain-Gauge Station. The data includes total rainfall (mm), total duration of rainfall, rainfall intensity and number of events. Detailed rainfall data is enclosed in report.

Sorting of Rainfall occurrence: Sorting of rainfall occurrences of storm of a particular intensity or greater for certain duration was done and stepped-up line was drawn for storm of a particular frequency. The time-intensity relationship was found by interpolation from this stepped-up line for once-in two-year return period. These values of intensity and duration are plotted to get the trend line equation of the form $i = a/t_n$. This equation is adopted to develop IDF Curve.

Development of IDF curves: Based on the relationship derived above, the values of intensity were determined for different duration (Table 5.1). This is used to prepare intensity-duration-frequency curve (Table 5-2).

Table 5-5-2: Intensity of Rainfall (Once in two-year Return period)

Duration (Minute)	Intensity (mm/hr)
5	112.32
10	71.83
15	55.3
20	45.93
25	39.77
30	35.36
35	32.02
40	29.37
45	27.22
50	25.44
55	23.92
60	22.61
120	14.46
180	11.13
240	9.25
300	8.01

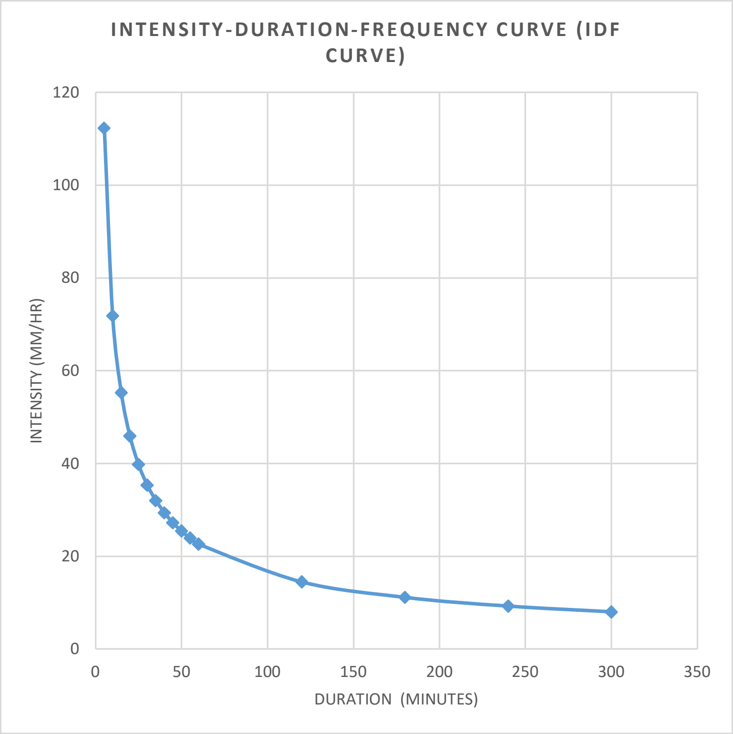


Figure 5-4: Intensity duration Curve

Conclusion (final intensity selection for designing of drain sections): The design intensity in the rational formula to calculate runoff is selected from the IDF Curve for given time of concentration (tc), expressed in minutes. Time of concentration is equal to the time required for rainwater to flow from the most remote point of the drainage basin to the point under consideration for which the runoff is estimated. At any node on the drain, the time of concentration (tc) is equal to inlet time (ti) plus the time of flow (tf) in the drain.

t_c = inlet time + time of flow in the drain

$t_c = t_i + t_f$;

where,

t_c = time of concentration

t_i = inlet time and

t_f = time of flow

5.3 Types of Drain

A cast in-situ RCC Drain has been recommended for the Serpentine drainage system.

5.4 Proposed Drainage system

River Ganga is the ultimate outfall for the Serpentine Nala. Serpentine nallah joins Mandiri nallah and finally discharged into river Ganga.

The main drain has been planned and design in the line with guidelines stipulated in the CPHEEO manual on storm water and the design norms defined above. The hydraulic design statement of Serpentine drain is shown in **Annexure: 3** and L-section is shown in **Annexure 7**. The starting clear width of the Serpentine Drain proposed box drain at start point is 4.0 m and maximum 5.0 m at the end.

6. DESIGN PARAMETERS FOR PAVEMENT

The primary objective of the design of pavement is to determine the optimum combination of pavement material and its thickness.

Pavement for minor roads of cities that carries low volume of traffic. Since the pavement is to be constructed along the RCC drain of 2.8 m to 3.5 m and as per IRC 58: 2015 the proposed road traffic is less than 450 CVPD (Commercial Vehicles per Day) then IRC: SP:62-2014 may be used for the design of the same.

6.1 Factors Governing Design

Following are the major factors which govern the thickness of pavement and its components based on IRC: SP: 62-2014.

a. **Wheel Load:** Heavy vehicles are not expected on the project road.
b. **Tyre Pressure:** Tyre Pressure of 0.8 MPa is considered.
c. **Design Period:** Concrete pavements designed and constructed as per the guidelines will have a design life of 20 years or higher.
d. **Design Traffic:** Since large volume of traffic is not expected on the proposed stretch. So, for traffic less than 50 CVPD, only wheel load stresses for a load of 50 kN on dual wheel has been considered for thickness estimation.
e. **Subgrade:** As per IRC: SP: 62-2014 minimum Design CBR of 4 % is considered.
f. **Subbase:** good quality compacted foundation layer provided below a concrete pavement is commonly termed as subbase. It must be of good quality so as not to undergo large settlement under repeated wheel load to prevent cracking of slabs.

6.2 Pavement Design

The design for rigid pavement has been done as per the IRC Guidelines "Guidelines for the Design and Construction of Pavement for Low Volume Roads".

Minimum Cement Concrete Pavement thickness of 300 mm is recommended and stipulates that rigid pavement shall rest on PCC of 100 mm, resting compacted earth layer. Accordingly, the following pavement composition has been adopted for the pavement.

a. 300 mm thick Cement Concrete Pavement over,
b. 100 mm of PCC
c. Granular material in subgrade, having a minimum 4-days soaked CBR 4 %

As per IRC: SP: 62-2014 for Low volume roads there is no need for a longitudinal joint.

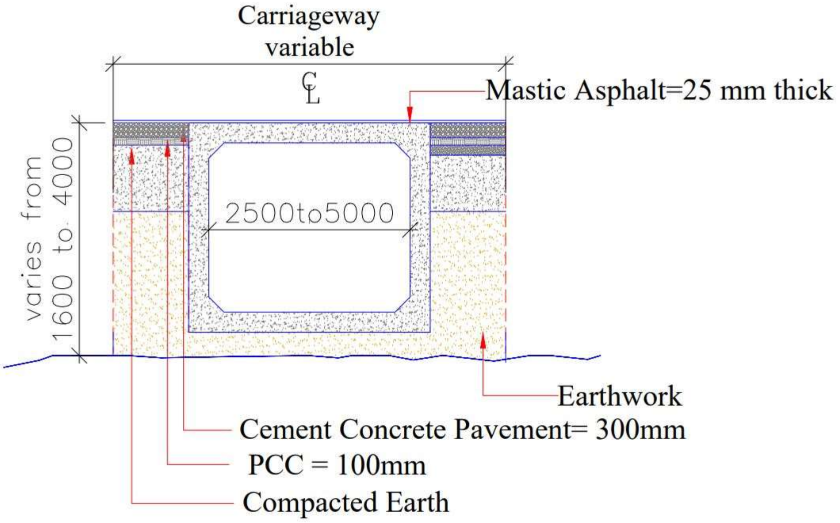


Figure 6-2: Typical Cross-section of Pavement for Serpentine Nallah

7. STRUCTURAL ANALYSIS OVER STAD-PRO

7.1 Introduction

The Single Cell RCC drain is meant for Vehicular Load. The box drain shall be made with single cell RCC box type structure. In the design of structure, clear cover is considered as 40 mm for top slab & inner surface of webs and clear cover is considered as 75 mm for bottom slab & outer sides of walls. This design note deals with design of the single cell RCC box structure.

7.2 Design Philosophy

The analysis of box structure has been done considering a slice of unit meter width. The box has been analysed for its self-weight, superimposed dead load, earth pressure and other applicable loads using STAAD-Pro. One case of earth pressure for Dry condition are considered separately. In one case, earth pressure at rest with dry density of earth is considered to produce maximum earth pressure Hence following cases of earth pressure are considered:

Coefficient of Earth Pressure as 0.50 when soil at rest & Density of Earth as 2.0 t/m3 for Dry condition and 2.2 t/m3 for Saturated Condition.

Analysis for 40-ton bogie load has been done using STAAD Pro. Live Load positions are identified for maximum bending moments at different sections and corresponding load intensities per metre width are evaluated as per effective width method as explained in IRC:112-2011

The partial safety factors for different load combinations considered for the analysis are as per IRC: 6 - 2014 Annex B as per Table: 3.2, Table: 3.3 and Table 3.4 for ULS, SLS and Base Pressure, respectively.

All the loads (except Vehicular live load) including the associated effects of Vehicular Live load have been combined in excel sheet manually according to partial safety factors mentioned above and run in STAAD. The vehicles have been run in STAAD in separate file with impact factor. Results are extracted from both the STAAD files and clubbed manually as per respective partial safety factor.

All the sections have been designed for ULS (ultimate Limit State) and the same have been checked for Stresses and Crack width for SLS (Serviceability Limit State) as per provision of IRC: 112 - 2011 (including ERRATA and latest amendments).

The Structural Design is shown in **Annexure 5** with Reinforcement details.

8. COMPONENT WISE DETAILS FOR ARCHITECTURAL WORKS

This section explains about various design elements that will be implemented as part of developing the Drains.

8.1 Kerb

Barrier Type kerb as per IRC 86:1983, It is used at the edge of corner of the footpath. Semi-barrier type kerb could also be used in the planter.

8.2 Traffic Crossings

Crossing is proposed to facilitate cross movement of pedestrians and vehicles from one end to another.

8.2.1 Road Marking

Marking on the road including vehicle lane marking, painting of kerbs, road edge line, etc. shall be done as per prevailing IRC 35:1997 guidelines and standards.

Figure 8-1: Road marking

8.3 Street Furniture

The elements covered under street furniture include public seating, waste bins, traffic signs, public toilet etc. are explained below.

8.3.1 Dust Bin

It should be provided at 100-meter interval to keep the area clean and hygienic. Bins design segregating dry and wet waste should be adopted.

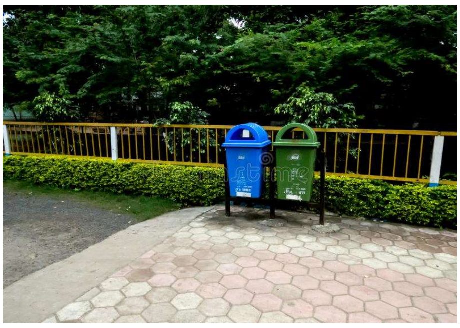


Figure 8-2: Dustbin at every 100m interval

;ure8-3: Secondary collection bin for wet and dry waste

8.3.2 Public Benches

Benches of cement concrete are proposed wherever required over for easy installation and long life.

Figure 8-4: Public Bench

8.3.3 Traffic Sign

All traffic signs to be as per IRC 67:2001 Code for Road Signs. Pole should be in black and white strips.

Figure 8-5: Traffic signs

8.3.4 Tree Grates

The grates to be placed in a manner to protect soil erosion and wash off. It is to be installed at the same level with the pavement around a tree that allows the soil underneath to stay uncompact and the pedestrians to walk without stepping on the soil. Tree pits are to be left for the roots to breath. Appropriate tree grates shall be used for the protection of urban trees. These tree guard may be of RCC, or industry manufactured grates made up of metal.

Figure 8-6: Example of RCC tree guard to prevent soil erosion

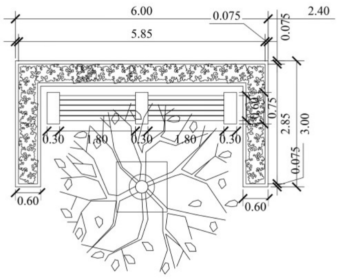


Figure 8-7: Proposed tree guard near sitting space

8.4 Electrical Components

8.4.1 Electric Boxes

Variety of options as junction electric boxes of streetlights attached in electrical poles is available in market in form of decorative architectural lights to modern looking simple lights LED based lights are preferred. For lights poles between footpath and planter/parking, the poles of height about 4-6 metres meter can be installed as shown below. For regular carriageway light poles of length 8-12 meter spaced at about 20 meters apart can be installed as per the given area.

Figure 8-8: Street light poles with single arm bracket & decorative light poles

8.4.2 Streetlights

Streetlight poles are the backbone of street lighting, and their use case extends from providing adequate lighting to the beautification of urban spaces. Today, designers choose streetlight poles design that blends with the modern city landscapes to provide a more homogenous and distinguished look. Streetlight poles design affects the lighting output, and there are other parameters like mounting height, spacing, outreach, drag coefficient and pole geometry, which influence the choice of the poles. Today several types of streetlight poles are available as- swaged poles, decorative poles, and octagonal poles in a wide range of mounting heights. Our **streetlight poles** design meets the IS2712: Part II specification.

Types of Poles.

a. Swaged Poles/ Tubular Poles-These are the most popular street-lighting poles even today. The entire range of these poles meets with the Indian standards confirming to IS2712: Part II.

Figure 8-9: Hot Dipped Galvanized Swaged / Tubular Poles Design by Philips

b. Decorative Poles-These are the favorite of all designers. These are present in wide varieties of customized options to suit particular design creations.

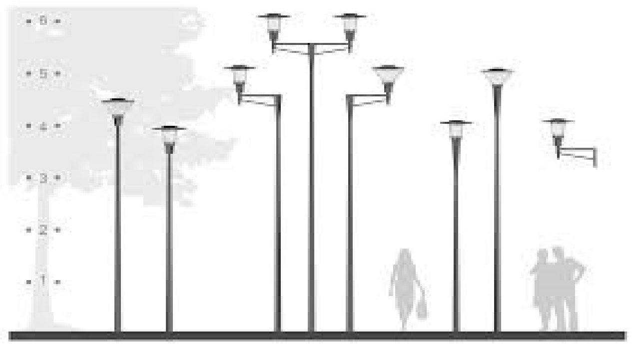


Figure 8-10: Decorative pole design by Philips, Design Type- City Charm

c. Octagonal Poles / Conical Poles
Modern octagonal poles are sleek, elegant and aesthetic. They provide a low maintenance, long life solutions for street-lighting applications.

Figure 8-11: Octagonal / Conical Street light pole design by Philips

8.4.3 Poles General Specification

Table 10-1: Standard specification for octagonal/tubular poles

Sl. No.	Height (meter)	Dia. (A/F) mm.		Thickness (mm)	Base Plate (mm)	P.C.D. Mm.	Foundation Bolt Details		
		TD	BD		OD.X Thk.		Dia. (mm)	Length (mm)	No of Bolts
1	3	70	130	3	200 * 12	200	16	450	4
2	4	70	130	3	200 * 12	200	16	450	4
3	5	70	130	3	220 * 12	220	16	600	4
4	6	70	130	3	220 * 12	220	20	600	4
5	7	70	135	3	225 * 16	225	20	700	4
6	8	70	135	3	225 * 16	225	20	700	4
7	9	70	155	3	260 * 16	260	24	750	4
8	11	70	210	3	320 * 20	320	24	750	4
9	12	70	230	3	325 * 20	325	24	750	4