1. INTRODUCTION

1.1 Smart City Mission

The Smart City Mission has been launched in India with an objective to bridge the gap and to provide amenities to society in line with the vision of inclusive growth. The purpose of the Smart Cities Mission is to drive economic growth and improve the quality of life of people by enabling local area development and harnessing technology, especially technology that leads to Smart outcomes. Area based development will transform existing areas (retrofit and redevelop), including slums, into better planned ones, thereby improving liveability of the whole City. New areas (Greenfield) will be developed around cities to accommodate the expanding population in urban areas. Pan-city development is oriented towards application of selected Smart Solutions to the existing city-wide infrastructure. Application of Smart Solutions will involve the use of technology, information and data to make infrastructure and services better.

Patna has been selected among the 100 cities by the Ministry of Urban Development (Govt. of India) under SMART CITY MISSION through "Smart City Challenge" to transform it into a futuristic city.

The scope of Patna Smart City is to develop Patna and achieve international standards of core infrastructure such that a decent quality of life to its citizens, a clean and sustainable environment can be provided. The focus is on sustainable and inclusive development. Patna conducted one of the widest citizens' consultation and prepared the Area based Development and Pan City Initiatives for Smart City mission. Smart City Proposal (SCP) envisages making Patna a vibrant and responsive city by fulfilling the citizen's needs for reliable and efficient basic urban services and to provide a clean environment by adopting sustainable and green technologies. Smart Patna would be a solar city, an eco-friendly tourist destination and a hub for health, education and IT industry. As an inclusive city it would provide opportunities for the citizen's social and economic development and ensuring its viability through a continuous education process to cultivate the spirit of Smart City.

The strategic components of Area-based development in the Smart Cities Mission are city improvement (Retrofitting), city renewal (Redevelopment) and city extension (Greenfield development) plus a Pan-city initiative in which Smart Solutions are applied covering larger parts of the city.

- **Pan-City** initiative in which at least one Smart Solution is applied city-wide.
- Develop areas step-by-step – three models of **Area Based Developments**
    - City Improvement (Retrofitting),
    - City Renewal (Redevelopment),
    - City Extension (Greenfield)

1.2 Patna City

1.2.1 City Overview

Patna, the "capital city of Bihar State" situated 15 km along the confluence of the River Ganges. It lies mid-way between the humid West Bengal in the east and the sub humid Uttar Pradesh in the west which provides it with a transitional position in respect of climate, economy and culture. The city is located on the south bank of the river Ganga and it is an important administrative and educational centre. The city has a very long river line surrounded on three sides by rivers The Ganga, Sone, and Punpun. The river Gandak flows into the river Ganga making it a unique place having four largish rivers in its vicinity to the north of Patna.

As per census 2011 the population of Patna District is 58,38,465 (Male- 30,78,512 and Female- 27,59,953). The growth rate in the decade 2001-2011 was 23.73%. Overall Literacy rate is 70.68 % with male literacy rate of 78.48% and female literacy rate of 61.96%.

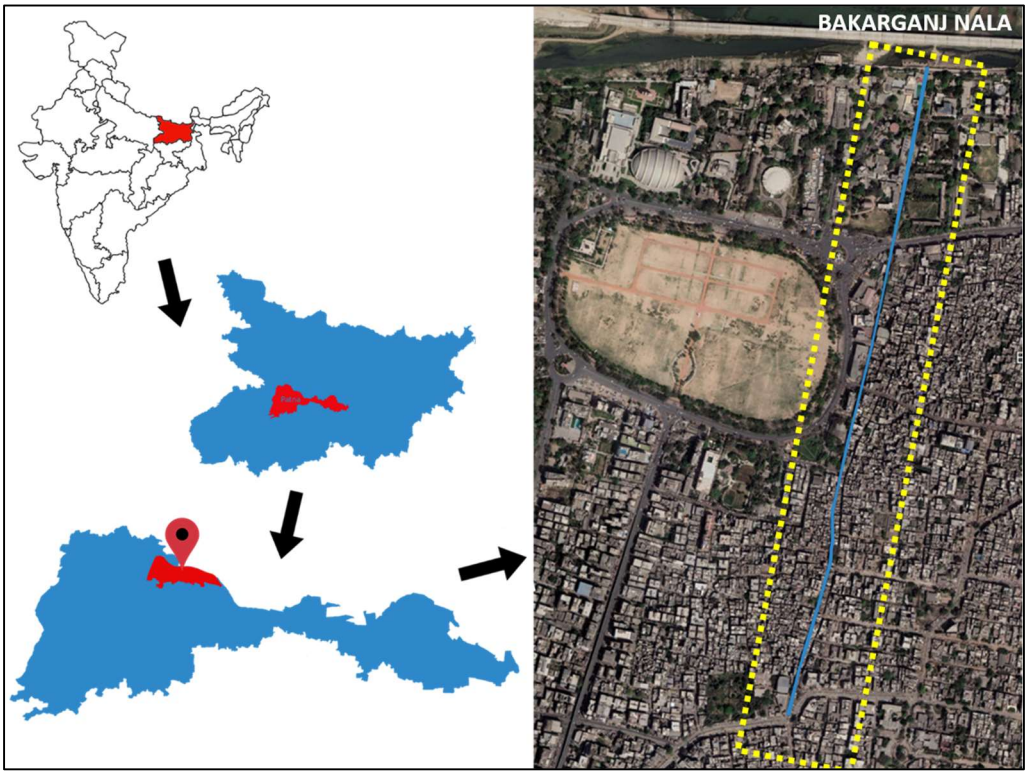


Figure 1-1: Project Location

1.2.2 Connectivity

Patna is situated in the eastern part of Bihar. Because of it being the capital city of Bihar, it is connected with most of the other city. Patna is a town in Bihar situated in the plains of southern side of river Ganga. The district comprises six sub-divisions. It is well connected by many means like Road, Railways and airways. It is having airport mainly comprising Patna Airport, Gaya Airport, many coming up in near future. National Highways No.19, 30, 83 & 98 passes through city limits. The Patna Railway Station has decent connectivity with other cities of the country.

1.2.3 Topography

Patna is on the Southern bank of the river Ganges in Eastern India. The total area of Patna is 250 km^2. Of this, the municipal area constitutes 109.218 km^2. The suburban area covers 140.782 km^2. The exact cartographic co-ordinates of Patna are 25.6°N 85.1°E. It has an average elevation of 53 m (174 ft.). A characteristic feature of the geography of Patna is its confluence of major rivers. During the British Raj, Patna was part of the Bengal Presidency. After Nalanda district was carved out of Patna district in 1976, Patna was puged of all hilly regions. It is an alluvial, flat expanse of land. The land in the district is too fertile and is almost entirely cultivated with no forest cover. Alluvial soil found here is ideal for cultivation of rice, sugarcane and other food grains. The area under cultivation is studded with mango orchards and other bamboo groves. In the field along the bank of river Ganges, weed such as ammannia, citriculari, hugrophile and sesbania grow. But palmyra, date palm and mango orchards are found near habitations. Dry stretches of shrubbery are sometimes seen in the villages far from the rivers. Trees commonly found are bel, siris, jack fruit and the red cotton tree. Patna is unique in having four large rivers in its vicinity. It is the largest riverine city in the world. The topography of Patna city is saucer shaped as per Patna city Development Plan prepared in 2006. The bridge over the river Ganges named Mahatma Gandhi Setu is 5575m long and is the longest river bridge in India. Patna comes under India's seismic zone-IV, indicating its vulnerability to major earthquakes, but earthquakes have not been common in recent history. Patna also falls in the risk zone for floods cyclones.

1.2.4 Climate and Rainfall

The climate of Patna is warm and temperate. The mean monthly average temperature here averages 26.0 °C. Precipitation here averages 931 mm. The summers here have a good deal of rainfall, while the winters have very little. The driest month is December, with 3 mm of rainfall. Most of the precipitation here falls in July, averaging 288 mm. The warmest month of the year is May, with an average temperature of 32.4 °C. January is the coldest month, with temperatures averaging 17.2 °C. The difference in precipitation between the driest month and the wettest month is 285 mm. And throughout the year, temperatures vary by 15.2°C. The monthly distribution of maximum, minimum and average temperature.

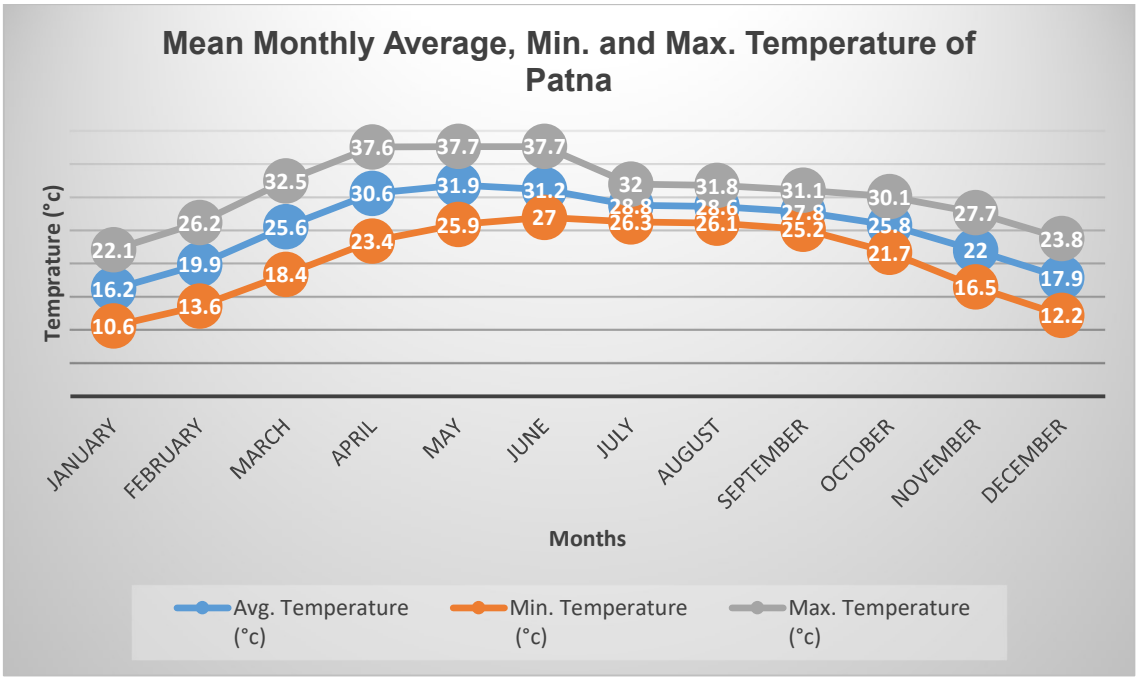


Figure 1-2: Mean Monthly Average, Min. and Max. Temperature of Patna

Source: https://en.climate-data.org/asia/india/bihar/patna

The difference in precipitation between the driest month and the wettest month is 317mm /12 inch. Throughout the year, temperatures vary by 15.7 °C.

1.2.5 Soil Strata

The most common soil in Patna is Gangetic alluvium of Indo-Gangetic plain region, Piedmont Swamp soil which is found in beside the plain of Ganga. Patna is situated at the bank of river Ganga hence its soil is mixed which is consist of clay soil, sand soil and loamy soil. The soil at the bank of river Ganga is mostly fertile in nature. The Indo-Gangetic plain in Patna consists of a thick alluvial mantle of drift origin in most part, The Siwalik and older tertiary rocks. The soil is mainly little young loam rejuvenated every year by constant deposition of silt, clay and sand brought by streams but mainly by floods in Bihar. The Agroclimatic zones of Bihar is shown in **Figure 1-3.**

Figure 1-3: Agro-Climatic Zones of Bihar

Source: Krishi.bih.nic.in

Based on soil characterization, rainfall, temperature and terrain, four main agro-climatic zones in Patna have been identified.

Zone-I, North Alluvial Plain,
Zone II, North East Alluvial Plain,
Zone-III A South East Alluvial Plain and
Zone-III B, South West Alluvial Plain

Table 1-1: Districts under each Agro-Climatic Zone

Sl. No	Agro-Climatic Zone	Districts
1	Agro-Climatic Zone-I (Northern West)	West Champaran, East Champaran, Siwan, Saran, Sitamarhi, Sheohar, Muzaffarpur, Vaishali, Madhubani, Darbhanga, Samastipur, Gopalganj and Begusarai
2	Agro-Climatic Zone-II (Northern East)	Purnea, Katihar, Saharsa, Supaul, Madhepura, Khagaria, Araria and Kishanganj.
3	Agro-Climatic Zone-IIIA (Southern East)	Sheikhpura, Munger, Jamui, Lakhisarai, Bhagalpur and Banka.
4	Agro-Climatic Zone-IIIB (Southern West)	Rohtas, Bhojpur, Buxar, Bhabhua, Arwal, **Patna**, Aurangabad, Gaya, Nalanda, Nawada and Jahanabad

Based on map Patna lies in Agro Climatic Zone III B.

1.2.6 Land Use Pattern

Land Use of Patna City

The land use based on Patna City Development Plan shown in **Figure-1-4,** it is estimated that major portion of the developed land is under residential use around 55%, followed by agriculture and related water bodies about 20%, transportation is about 11%), public & semi-public about 8%), industrial is about 2.0% and commercial is about 3.0%). The major land use deficiency is under recreational (existing 1.0 % and required 18-20%) as there are very less recreational places in the city. Recreational spaces like urban parks, gardens, and recreational open space stimulate commercial growth and promote inner-city revitalization. Open space boosts local economies by attracting tourists and supporting outdoor recreation.

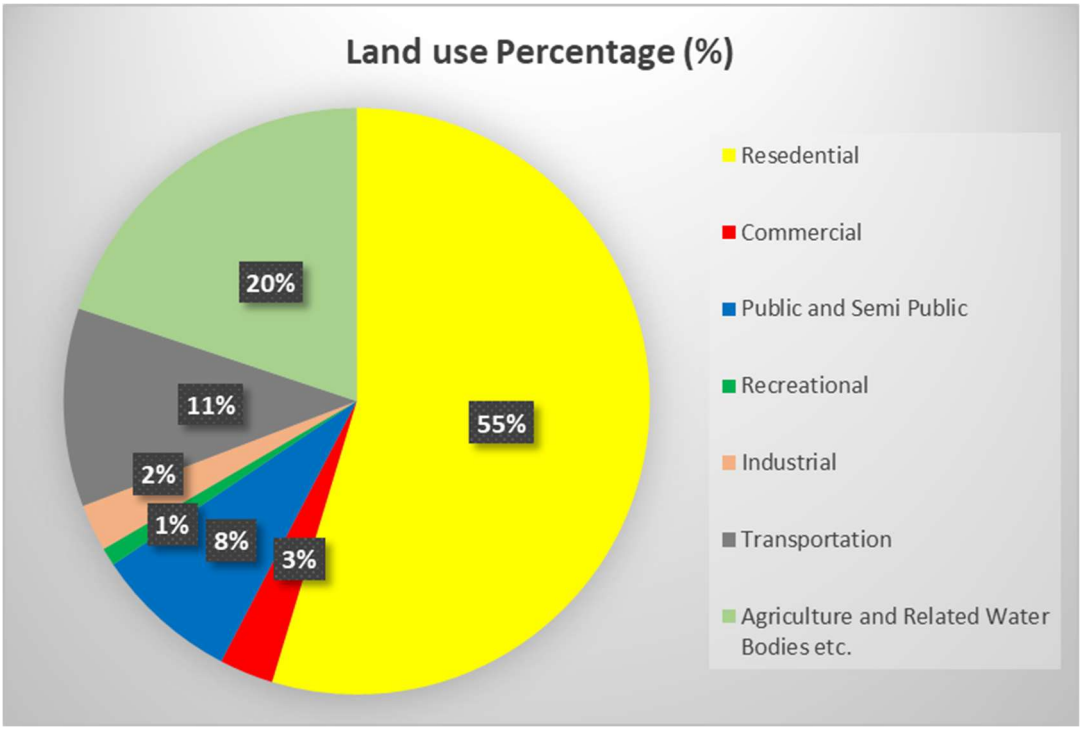


Figure 1-4: Land Use of Patna

Land Use of Current Project Area (Bakarganj Nala and adjoining area)

Bakarganj Nala is the main-city drainage line connecting Pirmohani (Uma Cinema) to the Ganga River at Anta Ghat with settlement on both sides of the drain. During site investigation it was found that from Uma Cinema to the Khetan market Road which leads to Gandhi Maidan, lot of encroachment were found with time, the edges of nala have been encroached and unplanned development of squatters have taken place along the edges some encroachment found from in the route from Ashok Rajpath upto SBI Bank.

The land use before Gandhi Maidan Police station is mixed on the east side and residential on the west side of the nala. It was observed that a slum area in a stretch of about 70 m just behind the traffic police station and a stretch of about 80 m behind the petrol pump are settled on the left side of Bakarganj nala. Near the end of the nala, there is a sabzi mandi covering 280m length of nala and the land use at the edge of it is of public and semi-public use. The nala is also surrounded by a commercial stretch of about 330 m.The Land use on either side of the Nala is presented in **Figure- 1.5.**

Figure 1-5: Land use around Bakarganj Nala

1.3 Necessity of Project

The requirement for the project is need of new drainage system in the area of Bakarganj Nala and its adjacent area. Due to heavy waterlogging in the area and dumping of solid waste into the drainage, the drainage becomes flooded in the rainy season. Also due to the open structure of drainage it causes health issues for the residence. Because of open nature of drainage its act as a breeding ground for mosquitos. Hence there is hazardous condition prevailing in the area. Therefore, construction of drainage is need of hour for the Bakarganj Nala.

The Bakarganj Nala is kachha in nature and also no lining from both side of Nala present currently, so the water exceeding in rainy season use to enter into the adjoining houses. Poor drainage results into losses – direct and indirect in the form of damaged roads and reduced serviceability. In spite of this, adequate priority for drainage system is rarely accorded, whether it is in the matter of planning, organization, find allocation or monitoring. It is necessary that due priority is given to this area of development and satisfactory arrangements ensure by way of proper design and planning.

The town has received very little attention on drainage front, which has given rise on ecological threat. There remains an apprehension of spread of epidemic all the time as the human infesto is finding its way in existing water courses. All the structural facilities like hospitals, banks, educational institution etc. are present here and there is urgent need of providing drainage system in town which will ensure hygienically safe scenario and health conducive habitat. Providing of drainage network in the town is all the more important because the slight rainfall / snow fall finds its way to existing compounds / houses of dwellers and everybody remains in threat of survival all the time.

Bakarganj Nala is the main-city drainage line connecting Pirmohani (Uma Cinema) to the Ganga River at Anta Ghat with settlement on both sides of the drain. A part of drain is pucca in construction and carries discharge of Wards -27, 28, 36, 37, 38, 39, 40, 42 and 43. During reconnaissance survey it was found that most of the length of Nala remains open from Pirmohani Chowk to Daldali road, after parking area of regent cinema upto Ashok raj path road, after Ashok Raj path upto JC road.

The households nearby this Nala having very thin strip about 1500 meter of pathway which leads the residence in difficulty in commuting towards adjoining road. Also, during site investigation, it was found that whole stretch of Nala is Kutcha i.e., is unlined.

The drain has converted into a dumping ground for solid wastes of the adjoining areas. The solid waste from households is directly dumped in the Nala. Some of point describes need for the development of Bakarganj Nala:

Removal of Encroachment: Along the 1440 m length of Nala stretch, with time the edges of Nala have been encroached and unplanned development of building have taken place along the edges. For overall development, these encroachments need to be removed. Some of the encroachment is above the Nala near Sabji mandi.

Construction of New Drainage: After detailed reconnaissance survey done by Rodic PMC Team, it was found that the drain is very old in nature. It has no lining present from both side of the Nala. The drain is open throughout and create an unhygienic atmosphere throughout, thus reconstruction and remodelling of construction of box drain is proposed.

2. EXISTING SCENARIO

2.1 Existing Drainage

Project Area i.e., Bakarganj Nala is located on the heart of the Patna City (Near Gandhi Maidan) near the bank of River Ganga. The high Flood recorded as recorded in 1984 and 1975 are 168.45 and 169.29 feet respectively. Overall topography depicted below (in the Digital Elevation model) reflects that storm water from the surrounding wards of Patna City i.e., Ward 27, 28, 36, 37, 38, 39, 40, 42 and 43 drains to the Bakarganj Nallah, either naturally of practice of pumping impounding water to this nallah.

2.2 Bakarganj Nala

The Rodic consultants conducted a detailed topographical survey and conditional assessment of Existing Bakarganj Nala, collected primary and secondary data from various sources, to understand and analyse situation of Bakarganj nala. The existing situation of the nala has been elaborated in subsequent paragraphs.

Bakarganj Nala starts from Rajendra Path and extends upto the Anta ghat. It is very old storm water drainage system of the city of 1440 m length. At present the Bakarganj nala is in very poor condition and unhygienic. A large stretch of nala is open which is blocked due to plastic bags and sewage. This causes overflow of nala, which produces foul smell and also provides a breeding ground for germs and mosquitoes. Currently in some areas, night soil generated from household is flushed into nala, which is causing fly nuisance and unhygienic conditions. The storm water combined with sullage water generated from surrounding areas of nala are directly disposed into River Ganga without any treatment. Discharging untreated raw sewage into water bodies is polluting river and surrounding environment.

The access to buildings along the nala is primarily from Daldali road and narrow pedestrian streets connecting buildings behind the local roads.

The maximum stretch of drain lining was found to be kutcha. The drain is pucca in construction from regent cinema to Mona cinema. Bakarganj Nala is open from Rajendra Path to Daldali road, Regent cinema upto the Ashok raj path road, and Ashok Raj path upto the JC road nala is open. Storm water drain at various points has become a dumping ground for all solid wastes of the adjoining areas. This is leading to deterioration in the condition of Nala day by day.

The major issues of the site are as below:

- Encroachment above and along the nala
- Garbage dumping leading to choking and foul smell
- Discharge of sewage in the drain

- Also, pumping of storm water impounding in nearby area during rains results in running overflow conditions.
- Being major drain in area, stagnation and dumping leads to bad health issues to residents
- Deterioration of overall environment.

There are around 12 existing nallah that are draining to Bakarganj Nala from the adjoining areas, bringing storm runoff and the garbage dumped in the residents from those areas, which needs to be screened out at entry to the Bakarganj Nala.

2.3 Conditional Assessment of Existing Nallah

As mentioned earlier, a conditional assessment survey was being conducted by the consultant to assess the true physical conditions on the ground.

Table 2-2-1: Survey Data of Bakarganj Nala as Per Existing Drainage

Sl. No.	Chainage		Length in (meter)	Width (Existing)	Culvert size	Remarks
	From	To	upto	Approx.	(L*W)	
1	0	50	50	(4,3.8,3.6,2.8)		
2	50	12	62	(2.8,2.7)		
3	62	15	77	(2.9,3.4,3.5)		
4	77	13	90	(3.4,2.3)		
5	90	20	110	(3,3.1,2.9)		
6	110	4	114	(4.1,4)	4.1*6.1	
7	114	50	164	(4.1,4,3.8)		
8	164	25	189	(4.2,4)		
9	189	25	214	(5.5,6)		
10	214	38	252	(4.3,4,4.5)		
11	252	4	256	(5,5.1)	4*5	
12	256	37	293	(6.2,6)		
13	293	4	297	(3.8,4)	3.8*6	
14	297	30	327	(5.2,5)		
15	327	3.5	330.5	(5,5.1)	3.5*5	
16	330.5	30	360.5	(5.6,5.5)		
17	360.5	4.5	365	(5.6,5.3)	4.5*5.6	
18	365	165	530	(5.2,5)		
19	530	3.5	533.5	(5.2,)	3.5*5.2	
20	533.5	30	563.5	(4,4.1)		
21	563.5	3.5	567	(4,4.1)	3.5*4	
22	567	20	587	(6.2,6)		
23	587	30	617	(5,4.0)		
24	617	20	637	(4.8, 5)		

25	637	15	652	(5,4.9)		
26	652	15	667	(5,4.9)		
27	667	20	687	(5.7,6)		
28	687	17	704	(6,6.2)		
29	704	12	716	(4.2,4)		
30	716	15	731	(5,4.9)		
31	731	23	754	(4.6,5)		
32	754	12	766	(6.6.1)	12*6	Road Udyog
33	766	30	796	(4.5,4.3)		
34	796	23	819	(4.7,5)		
35	819	38	857	(5.5,5.4)		
36	857	5	862	(5.5,5.5)	5*5.5	C9
37	862	7	869	(3.5.3.5)		
38	869	30	899	(4.5,4.4)		Regent theatre
39	899	30	929	(6.0,6.1)		
40	929	6	935	(6.5,6.5)		
41	935	6	941	(6.5,6.5)	6*6.5	C10
42	941	30	971	(5,5.1)		
43	971	30	1001	(5,5.1)		
44	1001	15	1016	(5,5.1)		
45	1016	50	1066	(5,5)		
46	1066	17.5	1083.5	(5.5,5.4)		
47	1083.5	22	1105.5	(6.5,6.5)	22*6.5	Ashok Raj path road
48	1105.5	10	1115.5	(6,5.5)		Open Drain
49	1115.5	42	1157.5	(5.5,5.5)		RCC Drain
50	1157.5	30	1187.5	(6,6)		
51	1187.5	30	1217.5	(6,6)		
52	1217.5	30	1247.5	(6,6)		
53	1247.5	30	1277.5	(6,6)		
54	1277.5	6.5	1284	(6,6)		
55	1284	50	1334	(5.6,5.5)		RCC Drain
56	1334	20	1354	(5.3,5.1)		RCC Drain upto veg. shop

The existing ROW has also been marked on Survey Drawing, attached as **Annexure- 14.1.**

Figure 2-1: Start of Nala at Pirmohani

Figure 2-2: Nala adjoining Building line

Figure 2-3: Encroachment above Nala near

Figure 2-4: No Access after Uma Cinema

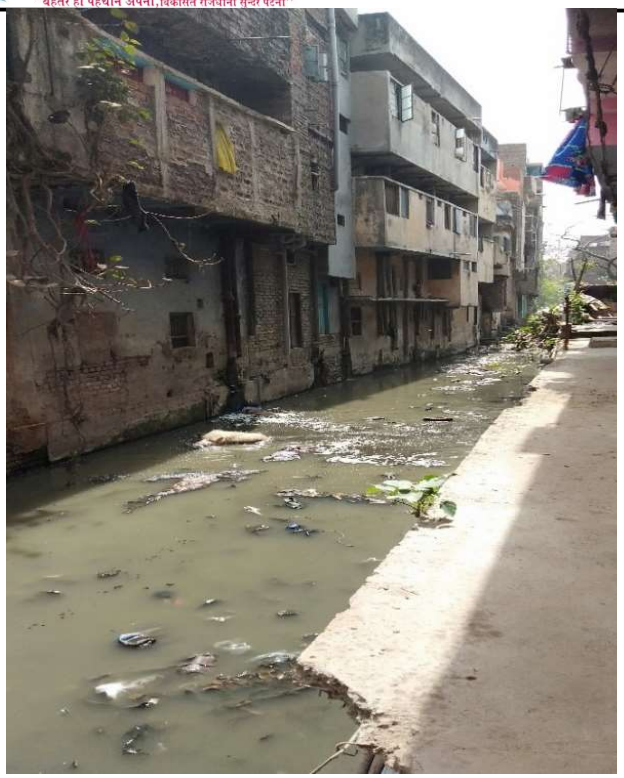


Figure 2-5: Discharge from household all along the Nala

Figure 2-6: Shiv Mandir boundary above Nala Beside(Gali no. 2)

gure 2-7: Blocked Nala Near B. M. Compound Gali

Figure 2-8: Cow Shed Encroachment Beside (B.M. Compound Gali)

Figure 2-9: Sewage Discharge in Bakarganj Nala

Figure 2-10: Encroachment on Bakarganj Nala (Behind Traffic Police Station Building)

Figure 2-11: Utility on ROW

Figure 2-12: Parking Behind Mona Cinema (On Nala)

Figure 2-13: Utility on ROW

2.4 Commercial Spaces around nala

2.4.1 Commercial Complexes

The link between Ashok Rajpath and Bakarganj comprise of several high-end commercial establishments like Regent Fun cinema, Mona cinema, KFC, Café Coffee Day, Mc Donalds, etc. The portion of nala in front of Regent Fun Cinema is already coved and used as access to the complex and parking. The Premiere Square is located adjacent to the nala. Although the frontage the Premiere Square is towards Gandhi Maidan Road, the portion of nala, which is at the back of this mall, has a good potential to be developed for public uses, such as pedestrian area with food stalls, sitting space etc. which would be used by the people who visit this commercial area.

Figure 2-14: Existing Commercial Establishments on one edge of the Nala (Nala is on the rear side of these buildings)

In addition to the above the market nearby the above mentioned area comprise of many top branded commercial shops like United Colors of Benetton, Monte Carlo, World of Titan, etc.

2.4.2 Sabzi Mandi

After the Ashok Raj Path crossing Sabzi Mandi starts which ends at Judges Court Road. The portion of nala is covered and used by the vendors selling vegetable. The length of stretch is 280m with width varying from 10.19 m to 20.07 m.

Figure 2-15: Vegetable Market above RCC Slab over Nala

Figure 2-16: Encroachment above Nala Beside nearby Plot Boundaries

3. PROJECT PROPOSAL

The total length of the drain is 1440 m out of which the drain design is proposed upto the existing sump house that is at chainage 1440 and all the other architectural proposals are made upto JC road i.e. a stretch of 1380m. The proposal broadly comprises of following activities:

a. **Construction of drain for the stretch of 1440m**
b. **Construction of vehicular road for a stretch of 1100m above nala**
c. **Redevelopment of existing sabzi mandi above nala of stretch of 280m**

3.1 Encroachment removal and Utility Shifting

Encroachments are found that from Pirmohani Chowk upto the Khetan market Road which leads to Gandhi Maidan. 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 Ashok Rajpath upto SBI Bank. For overall development, these encroachments need to be removed. The stretches with encroachment are:

a. Between culvert 1 (C1) and culvert 2 (C2).
b. Opposite of Culvert 3 (C3) cowshed and washroom encroachment found above the Nala. Here Nala width touches both side of the household having no pathway between culvert 3 (C3) (Shri Kuttir gali) to culvert 4 (C4) (B.M. compound gali).
c. Slum houses beside boundary wall of government building of Art Theater.
d. Beside Ashok Rajpath behind petrol pump encroachment on both sides of nala was found.
e. Along the Sales Tax boundary wall upto the J C road the drain is covered with RCC slab over which sabzi mandi is located. At the end of the J C wall Building structure was found above the nala. This stops access to the J C Road due to encroachment.
f. The detailed map over utility shifting electrical poles, transformer, water pipelines etc. has been considered.

The detailed map over encroachment is shown in **Annexure 3.2: Encroachment, demolition and Utility Shifting Map**

Condition of Culverts and adjoining drain

There are total 12 culverts over Bakarganj Nala. Since a continuous drain is proposed to be constructed and made *pucca* therefore all the 12 culvert crossings need to be demolished and reconstructed. The Chainage wise locations of existing culverts are mentioned in **Table 3.1** and also refer **Annexure 3.2.** for details. Adjoining , drainage near culvert are in good condition, hence no need of redevelopment of adjoining drain detail is shown in **Annexure 3.1.**

Tree to be cut

There are 21 trees up to stretch 1440 that are to be cut for drain construction. The Chainage wise locations of existing trees are mentioned in table below and also refer **Annexure 3.2.** 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 3.2** for detail. There are 3 light poles, 2 DTR transformers and 3 phases.

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 for provision for removing, providing and joining of ductile iron pipe has been taken in the Cost estimate.

Table -3-1: Chainage wise demolition, trees cutting and utility shifting

	Nos.	Chainage
Demolition of Culverts	1	Ch 0 +120
	1	Ch 0+ 260
	1	Ch 0+300
	1	Ch0+340
	1	Ch0+360 to Ch0+380
	1	Ch0+540
	1	Ch0+580
	1	Ch0+760 to Ch0+780
	1	Ch0+860 to Ch0+880
	1	Ch0+940 to Ch0+ 960
	1	Ch1+080 to Ch1+ 100
	1	Ch1+380 to Ch1+400
Total Demolition	**12**	
Trees	1	Ch0+280 to Ch0+300
	2	Ch0+360 to Ch0+380
	1	Ch0+740 to Ch0+760
	1	Ch0+800 to Ch0+820
	2	Ch0+920 to Ch0+940
	1	Ch0+980 to Ch1+1100
	2	Ch1+020 to Ch1+040
	1	Ch1+160 to Ch1+080
	1	Ch1+360 to Ch1+380
	2	Ch1+380 to Ch1+400
	7	Ch1+400 to Ch1+430
Total Trees Cutting	**21**	
Electric Poles	3	Ch 0 to Ch 0+20
	1	Ch 0+40 to Ch 0+60
	1	Ch 0+60 to Ch 0+80
	1	Ch 0+100 to Ch 0+120
	1	Ch 0+220 to Ch 0+240
	1	Ch 0+240 to Ch 0+260
	1	Ch 0+560 to Ch 0+ 580
	4	Ch 0+780 to Ch 0+800
	1	Ch 0+ 800 to Ch 0+820
	2	Ch 0+820 to Ch 0+ 840
	1	Ch 0+840 to Ch 0+ 860
	2	Ch 0+860 to Ch 0+ 880

	2	Ch 0+940 to Ch 0+960
	1	Ch 1+100 to Ch 1+ 1020
Total Electrical Poles Shifting	**24**	
Light Poles	1	Ch 0+900 to Ch 0+920
	1	Ch 0+960 to Ch 0+980
	1	Ch 0+980 to Ch 1000
Total Light Poles	**3**	
DTR Transformer	1	Ch 0 to Ch 0+20
	1	Ch 1+420 to Ch 1+430
Total DTR Transformers	**2**	
Two /Three Phases	2	Ch 0+100 to Ch 0+120
	1	Ch 300 to Ch 320
Total Phases	**3**	

3.2 Construction of Drain

Construction of RCC Drain cast/precast in-situ is proposed in the length of 1440 m, a silt trap provision, manholes screens at joining drains as well as in main drain (Bakarganj Drain)are also made wherever required along the drainage line and same is shown in **Annexure 3.1: Proposed Bakarganj 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 Daldali road from the perpendicular roads creating traffic jam on Daldali road. Since the Bakarganj nala is adjacent to this Daldali road, traffic movement will be allowed on the Bakarganj drain stretch. Also, the minimum right of way of nala is 3.5mwhich is very less for a 4-wheeler carriage way, the nala should be developed for traffic movement of 2-wheeleronly for a particular stretch as mentioned in **Figure 3.1.**

The total length of vehicular road is 1100m (Ch 0+0 to 1+100 m) with available ROW ranging between 3.50m to 25.27m. The stretch starts at railway station road near Pirmohani (Uma cinema) (ROW= 6.25m) and ends at Ashok Raj Path (ROW=14.60m) is shown in **Annexure 3.1: Proposed Bakarganj Drain Plan.**

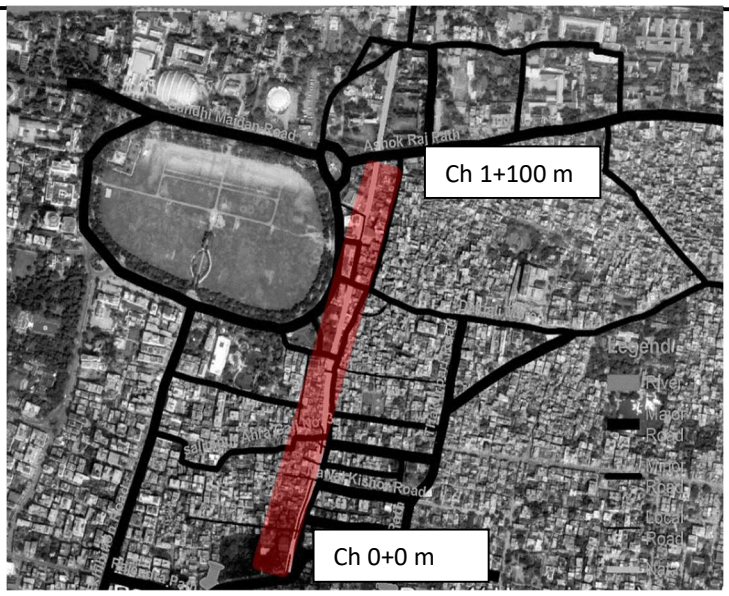


Figure 3-1: Stretch to be developed for vehicular movement

3.4 Redevelopment of Sabzi Mandi

The Existing sabzi mandi is situated exactly over the nala (from Ch- 1+100 m to Ch- 1+380 m) to which is predominantly being used as vegetable market. This sabzi mandi should be developed with proper design consideration. The length of stretch is 280m with ROW varying from10.19m to 21.08m. There are approximately 140 kachha vegetable shops in the area. The stretch of nala considered for redevelopment of existing sabzi mandi is shown in **Figure-3.2**. and also, **Annexure 3.1: Proposed Bakarganj Drain Plan.**

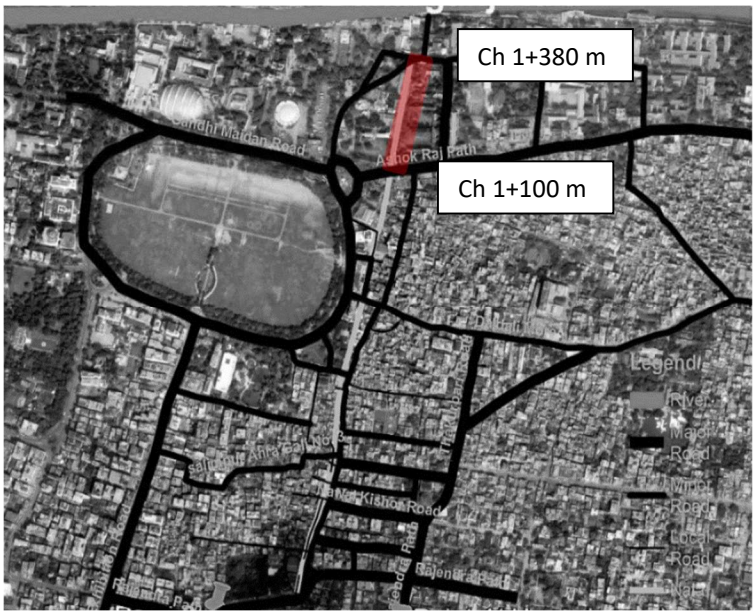


Figure 3-2: Stretch for Redevelopment of Sabzi Mandi

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 (m3/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

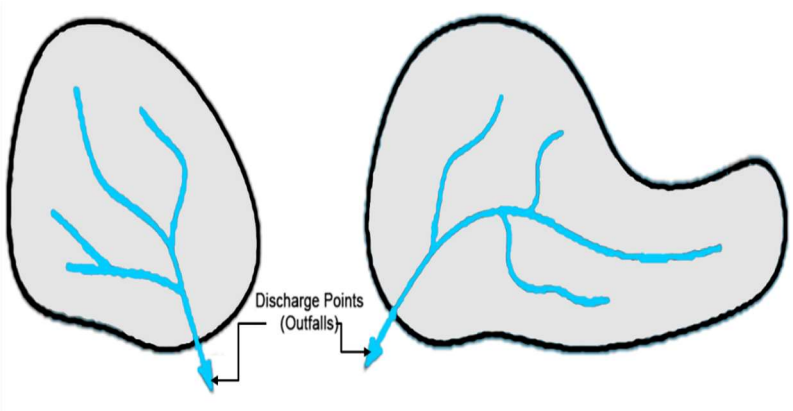
I = weighted average imperviousness of the total drainage basin

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.



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

Sl.No.	Start Node	Stop Node	Span (m)	Avg Depth (m)
1	CB-1	CB-2	2.8	2.26
2	CB-2	CB-3	2.8	2.91
3	CB-3	CB-4	2.8	2.84
4	CB-4	CB-5	2.8	2.94
5	CB-5	CB-6	2.8	2.93
6	CB-6	CB-7	2.8	3.05
7	CB-7	CB-8	2.8	3.26
8	CB-8	CB-9	2.8	3.27
9	CB-9	CB-10	2.8	3.06
10	CB-10	CB-11	2.8	3.10
11	CB-11	CB-12	2.8	3.13
12	CB-12	CB-13	2.8	3.14
13	CB-13	CB-14	2.8	3.30
14	CB-14	CB-15	2.8	3.05
15	CB-15	CB-16	2.8	3.09
16	CB-16	CB-17	3.5	3.14
17	CB-17	CB-18	3.5	3.15
18	CB-18	CB-19	3.5	3.41
19	CB-19	CB-20	3.5	3.38
20	CB-20	CB-21	3.5	3.26
21	CB-21	CB-22	3.5	3.17
22	CB-22	CB-23	3.5	3.22
23	CB-23	CB-24	3.5	3.26
24	CB-24	CB-25	3.5	3.15
25	CB-25	CB-26	3.5	3.04
26	CB-26	CB-27	3.5	2.88
27	CB-27	CB-28	3.5	2.69
28	CB-28	CB-29	3.5	2.56
29	CB-29	CB-30	3.5	2.80
30	CB-30	CB-31	3.5	2.92
31	CB-31	CB-32	3.5	3.06
32	CB-32	CB-33	3.5	3.86
33	CB-33	O-1	3.5	4.38

The hydraulic design statement of Bakarganj drain is shown in **Annexure: 5.1: 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 AND HYDROLOGY

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, consultant establish that Ward topographical in details (both surveyed and documents) and establish that total area of 1.75 Sq.Km comprising Ward 37, Part of Ward 27, 28, 36, 38, 39, 40, 41, 42 and 43 naturally draining to the Bakarganj Nallah as shown in the figure below.

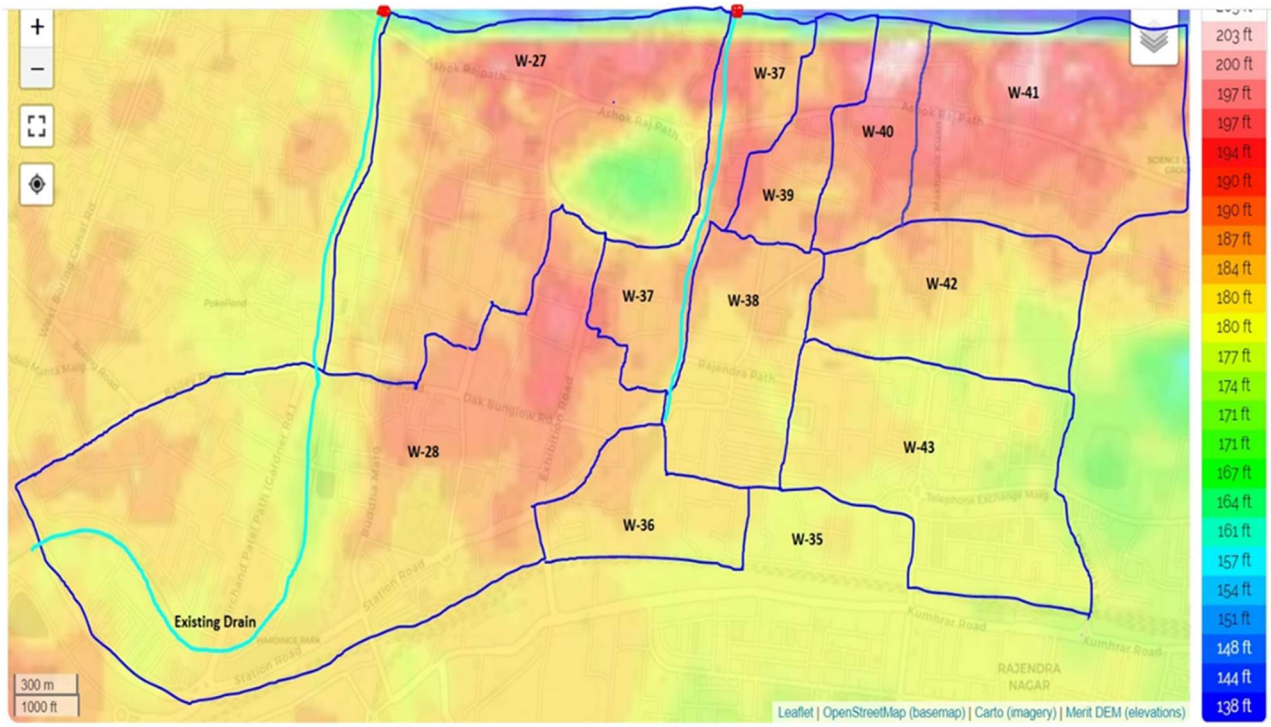


Figure 5-1: Digital Elevation Area of Project Area

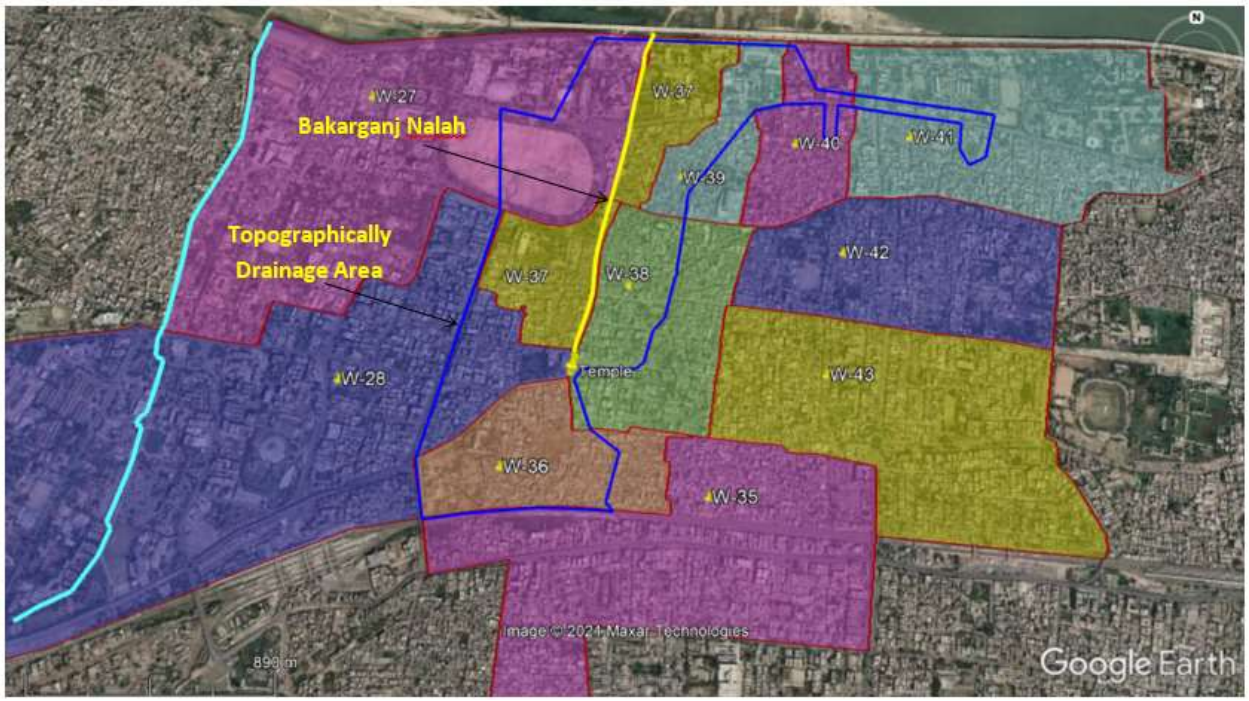
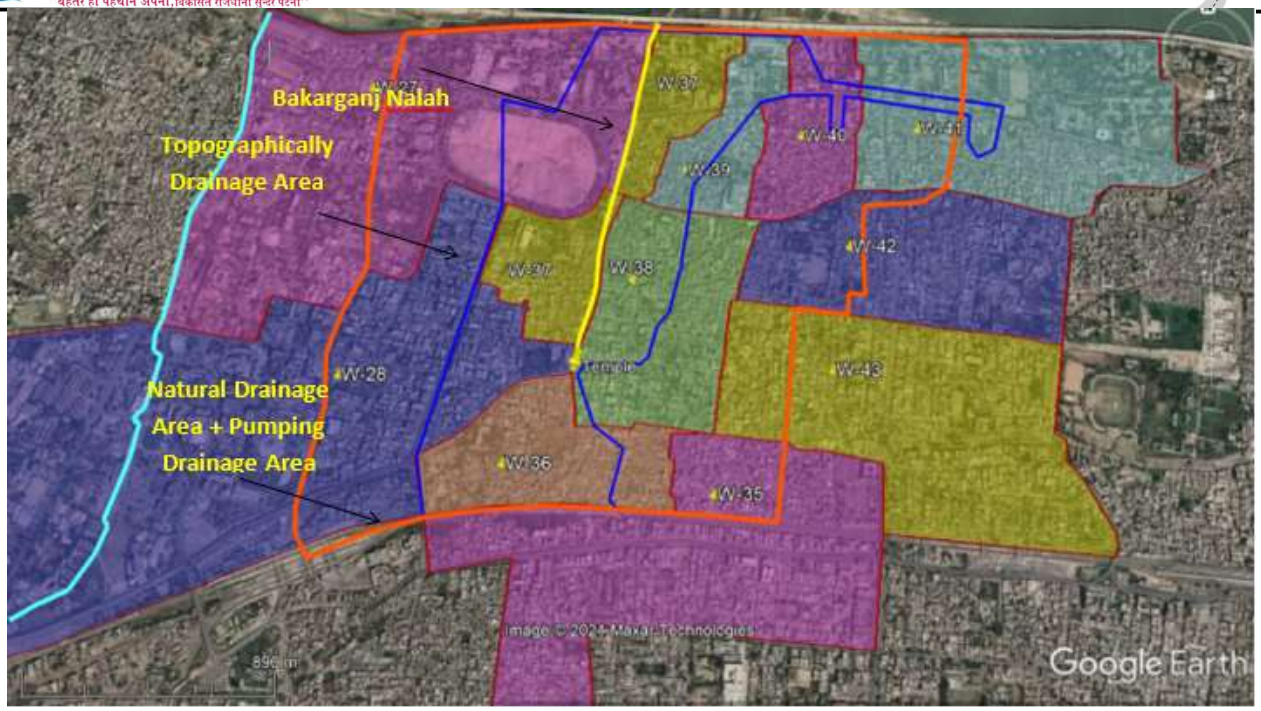


Figure 5.2 : Ward 37, Part of Ward 27, 28, 36, 38, 39, 40, 41, 42 and 43 draining naturally to the Bakarganj Nallah.

From the reconnaissance survey of project area by the consultant's teams, it is found that water impounded during monsoon season from the Ward 27, 28, 35, 36, 38, 39, 40, 41, 42 and 43 is pumped to the Bakarganj Nalla, which increases the overall drainage in the Bakarganj Area to 2.87 Sq.Km.



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

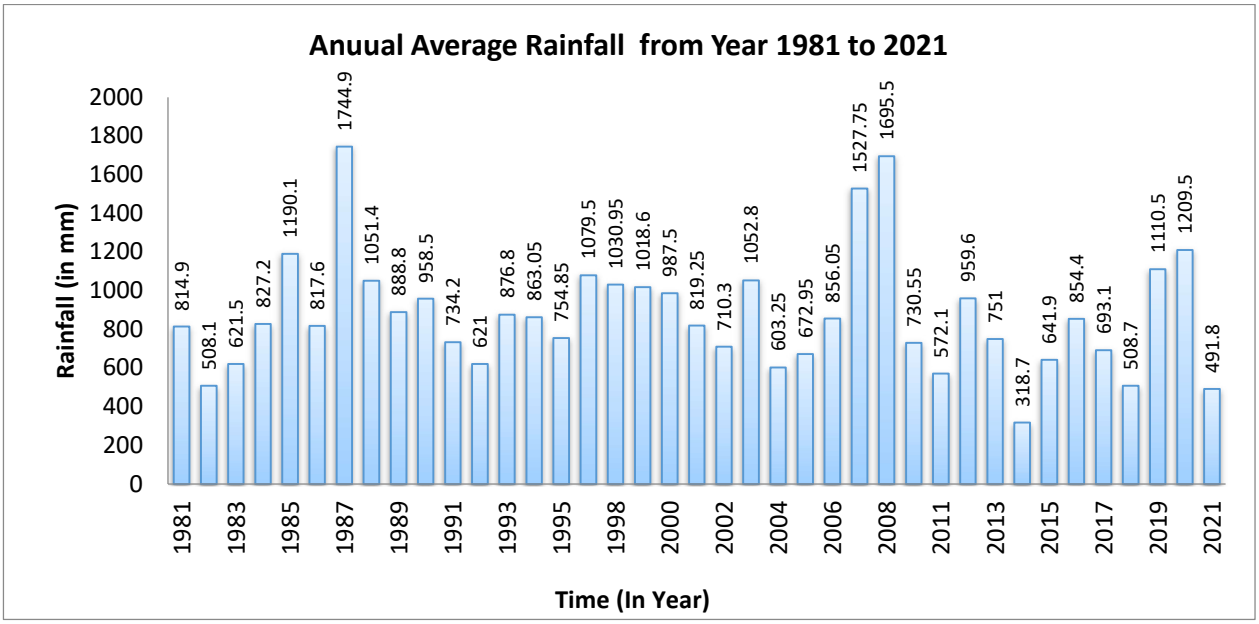


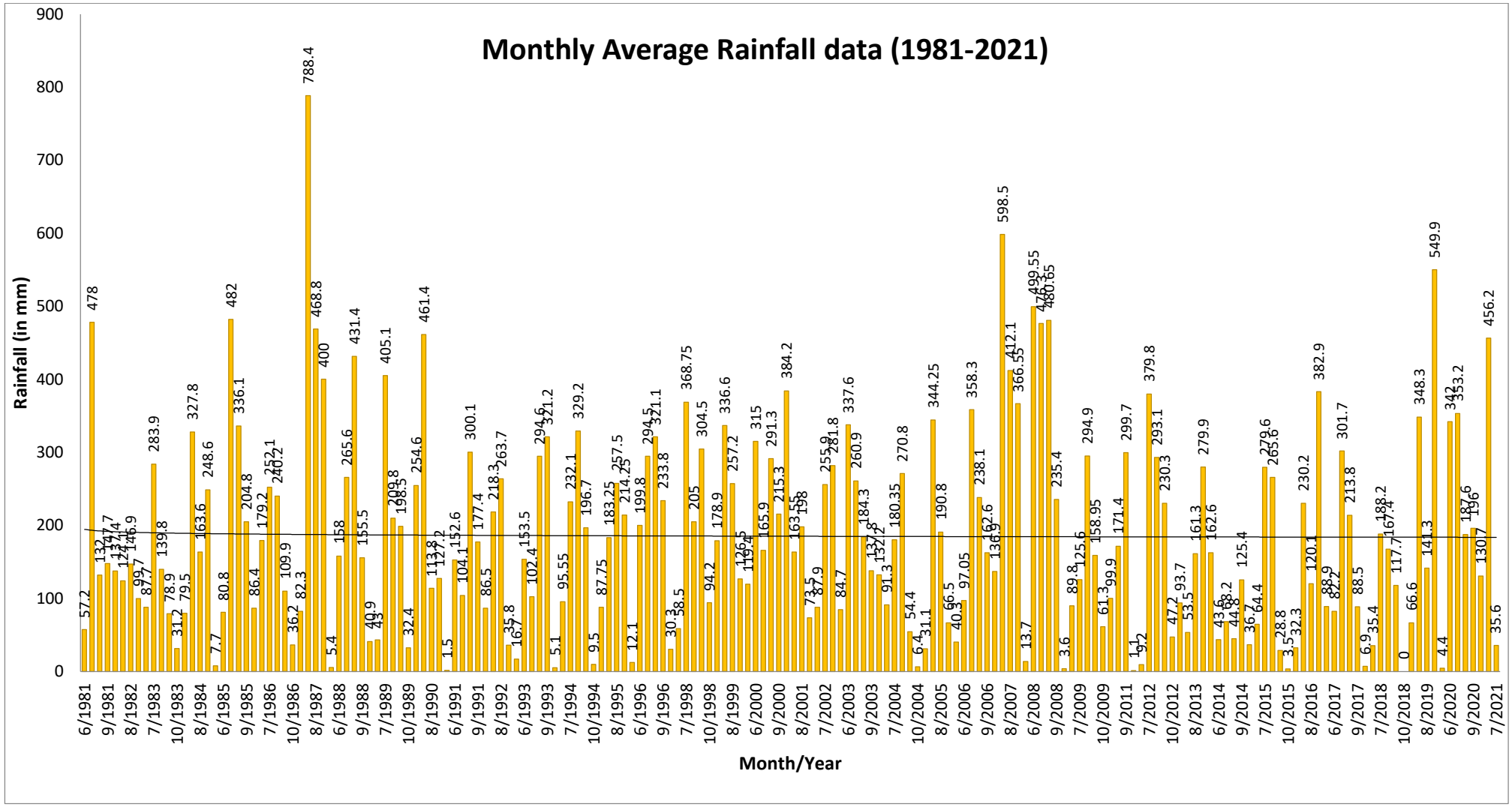
Figure 5-2: Represents computed annual rainfall for the year 1981 to 2009.

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.

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 more than 400mm rainfall.											

Graphical presentation of the data is provided below:


Monthly Average Rainfall data (1981-2021)
Rainfall (in mm)
Month/Year
0
100
200
300
400
500
600
700
800
900
6/1981
9/1981
8/1982
7/1983
10/1983
8/1984
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6/2017
9/2017
7/2018
10/2018
8/2019
6/2020
9/2020
7/2021

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 5-2: 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

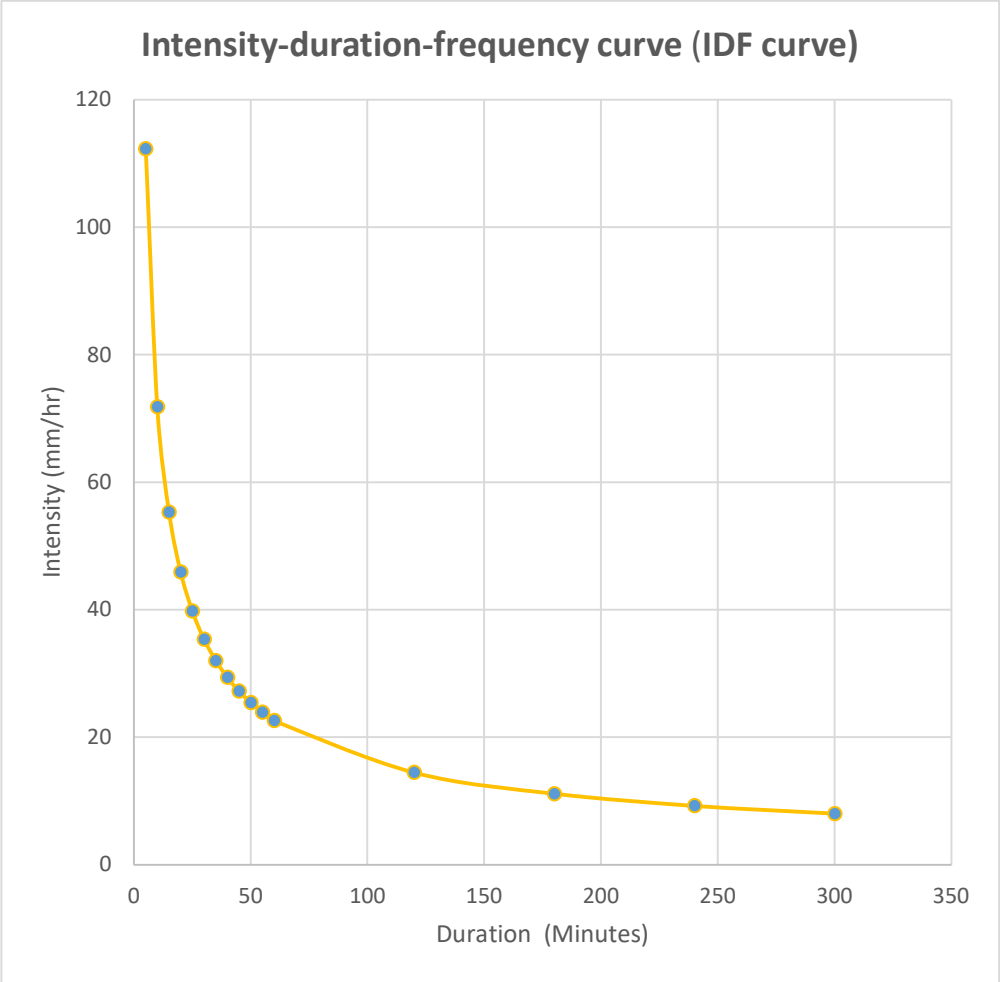


Figure 5-3: Intensity duration Curve

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 and Pre-cast RCC Drain has been recommended for the Bakarganj drainage system. The exact construction approach is provided under **Chapter 11.**

5.4 Recommendation

Following are the recommendations for effective implementation of drainage system:

a. Residents need to be encouraged to take sewer connections and not to dispose in the drains. This will keep the quality of storm water below stipulated norms especially during the lean flows periods.
b. Solid waste dumping should be stopped to prevent the blockages and overall health of environments.
c. The drainage system needs to be cleaned thoroughly and regularly. Regular maintenance of the drainage system is the main key to evacuate storm water as this enhances the efficiency of the system. Provision of adequately trained staff will go a long way in proper operation and maintenance of the system.
d. Interconnection of tributary drains with Bakarganj Nala should be through the intercepting chambers with coarse screens (Manual) to eliminate the garbage dumped in the drains.
e. Silting Traps at every 30 m across the drain section in the Bakarganj Nala is to be provided to check silt. Manhole opening has been proposed near to bring out the trapped silts during operation and maintenance.
f. A proper solid waste management system needs to be implemented in order to prevent dumping of garbage into drains. This will help in avoiding blockage of drains and flooding in surrounding areas. In order to check the dumped garbage, it is proposed to have Coarse screens (mechanical) at every 500 m in the drains especially where space for cleaning and motorable access available.
g. A library/ repository may be established to store the maps of the existing and proposed drainage system. This will facilitate the operation and maintenance and future planning of the various components of the system.
h. For operation and maintenance of the system, well trained staff is essential. Training of staff in modern methods of O & M is, therefore, recommended.
i. Drain cleaning equipment using airjets and or water jets should be made a part of the drain development proposal.
j. As the drain will also carry water by pumping from adjoining areas, it should ensure that no water than considered catchment area should be pumped to the project area. This may ensure no flooding situation in the drain and catchment area.
k. As the scope of work is limited to the drain work, no pumping station changes suggested in the report. However, it is established that existing pumps have the capacities 5040 cum/hr and 4320 cum/hr. Total 9360 cum/hr is on the lower side, whereas pump capacities requirement is high. It is suggested to upgrade the pump capacities to maximum designed discharge. In case, pump house structure is required to be modified, it is to be considered for the overall effective system. It is recommended that three pumps of equal capacities may be designed and installed to meet the requirements. At present only two pumps are installed

and one opening is vacant. Electro-mechanical changes required may be revised suiting the requirement.

l. Residents may be sensitized for operational troubles due to dumping of the garbage in the open drains.

m. Maintenance is an important aspect for the success of any system. Therefore the department should review and revise the operation practices and policies to improve on the system and overall environment of the project areas.

5.5 Proposed Drainage system

River Ganga is the main outfall for the Bakarganj Nala. 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 Bakarganj drain is shown in **Annexure: 5.1.**and L-section is shown in **Annexure 5.2** Starting width of the proposed box drain is 2.8 m and maximum 3.5 m near outfall. The only Outfall is proposed to discharge into the pumping station just before the river ganga.

5.6 Improvement in Drainage System

To improve hydraulic carrying capacity, drain covers will be provided which will prevent disposal of solid waste into drain. Field visits reveal that the existing drains are heavily silted because garbage is routinely thrown into these channels often packed in polythene bags. This causes a formidable problem as the polythene slows down the disintegration of the degradable material packed inside. Desilting of existing drains are proposed. Thus, most of the main drains are in a bad shape at present and hence required redevelopment of the same.

5.7 Sewage Disposal System

Scope of the project is limited to development of the Bakarganj Nala from Pirmohani road to J.C. road. The existing sump house near Anta Ghat will continue. Sewage from Sump house is discharged in the river Ganga. The pumping capacity of the sump house must be such that it could handle the incoming flow from the proposed bakarganj drain. Since Namami Gange project is under execution in Patna City therefore, it is recommended to discharge sewage after treating in sewage treatment plant proposed in Namami Gange project.

Land Ownership

The Consultant team did a reconnaissance survey and gathered few cadastral map from Department of Revenue & Land Reforms department along the Bakarganj nalla and visited the site along with Amin (Patna Nagar Nigam). We managed to procure few kahtiyani information from Patna Municipal Cororation and get it validated with Amin and conculded that majority of land falls under government property i.e. Patna Municipal corporation, hence we presume that there will be no construction issue in whole strectch of Bakarganj drain.

The Land ownership map is shown in **Annexure 5.3** and the detail of Khatiyani is given in **Annexure 5.4.**

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 PQC thickness of 250 mm is recommended and stipulates that rigid pavement shall rest on DLC of 100 mm, resting on a 170 mm thick GSB drainage layer.

Accordingly, the following pavement composition has been adopted for the pavement.

a. 250 mm thick Pavement Quality Concrete (PQC) over,
b. 100 mm of Dry Lean Concrete (DLC)
c. 170 mm thick Granular Sub-base (GSB) drainage layer over
d. 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.

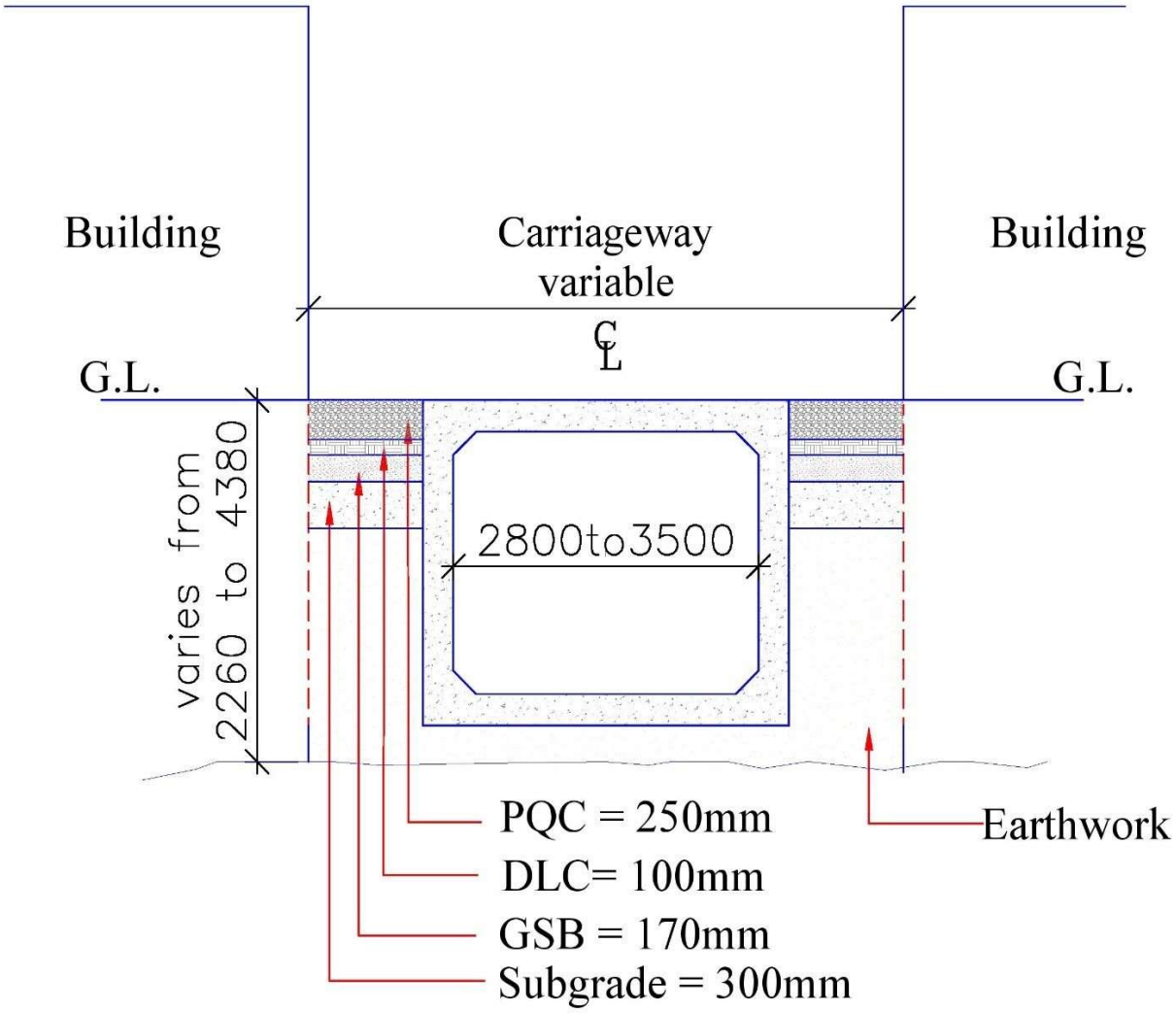


Figure 6-1: Typical Cross-section of Pavement

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 boggie 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 Annexure : B-3.

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 7.1** and Reinforcement details is shown in **Annexure 7.2.**

8. DESIGN OF VEHICULAR ROAD

The construction of vehicular road is proposed to start from railway station road (Rajendra Path) near Uma cinema and end at Ashok Raj Path

a. Total length of Road:1100m
b. Min. ROW available:3.5m
c. Max. ROW available: 25.27m

Elements proposed:

- Rigid Pavement
- Carriageway of width 3.4m and 4.1m
- Streetlight
- Dustbin

The existing scenario and the proposed interventions could be visualised through the **Figure 7.1** and **Figure7.2**as shown below:

Figure 7-1: Existing condition of Bakarganj Drain

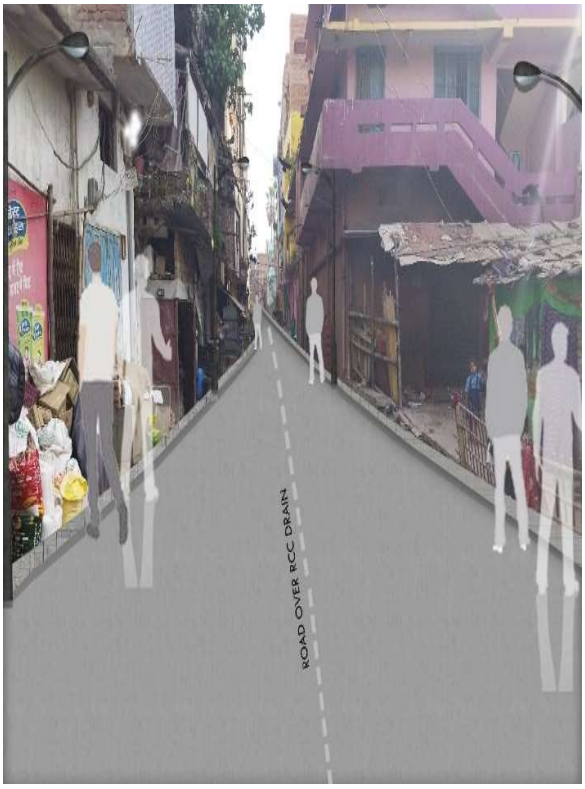


Figure 7-2: Proposal along Bakarganj Drain

Refer Annexure3.1: Proposed Bakarganj Drain Plan and for detailed drawings Refer **Annexure 8.1:** Architectural Drawing and **Annexure 8.2** for Traffic Movement Plan.

9. DESIGN OF SABZI MANDI

The existing sabzi mandi is semi-permanent market over Bakarganj Nala. All types of vegetables are sold here. A reconnaissance survey was carried out on this market with the objective to know the ground reality in context of vegetable market. The survey basically involved observation of pedestrian and traffic flow, buying, selling, loading, unloading, handling etc. it also involved visual assessment of environmental aspects such as cleanliness, waste generation and drainage. The existing market is not functioning efficiently and need to be planned.

Firstly the sabzi mandi is proposed to be pedestrian only, and to obstruct the access of vehicle bollards ad boom barrier have been placed at the entry of the market. The loading and unloading of vegetables will be allowed inside the market only during a fixed hour. The number of shops proposed for sabzi mandi is 146 of size 4.32 sq.m. each. The size of shop is taken with reference to literature study of fruit and vegetable market, Mohali which is designed by Ar. Sarabjit Singh Bahga. Focus is also given to the basic services in the sabzi mandi, such as public toilet, drinking water fountain, waste collection bin, electrical pole and green sitting space designed for sellers and customers. The two-wheeler parking is proposed at the ends of the sabzi mandi for vegetable sellers. The existing situation of Sabzi Mandi is shown **Figure 10.1.**

Figure 9-1: Existing condition of Sabzi Mandi

The detail drawing is shown in **Annexure 3.1: Proposed Bakarganj Drain Plan** and for detailed drawings Refer **Annexure 8.1:Architectural Drawing.**

Total length of Road:280m

a. Min. ROW available:10.19m
b. Max. ROW available: 21.08m
c. Elements proposed:
    - Parking
    - Vegetable shops
    - Streetlights
    - Sitting benches
    - Dustbins (primary and secondary collection bins)
    - Public Toilet
    - Metal Bollards and Barriers
    - Trees and shrubs

10. COMPONENT WISE DETAILS FOR ARCHITECTURAL WORKS

This section explains about various design elements that will be implemented as part of developing Bakarganj Drain:

10.1 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.

10.2 Traffic Crossings

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

10.2.1 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 10-1: Road marking

10.2.2 Pedestrian and two-wheeler crossings

The road of length 1100m is proposed for two-wheeler movement and Sabzi Mandi on a stretch of 280m is demarcated as no-vehicle zone. Bollard is proposed with height 0.5 to 0.7m from ground level with a setback of at least 0.15m from the edge of the kerb. The spacing between two bollards must be minimum 1m to disallow four wheelers to pass through the vehicular zone. The pedestrian crossing from designated parking spaces at the entry and exit of sabzi mandi should have bollards at a spacing of 0.6m.The barrier should be identifiable with reflective tapes.

Figure 10-2: Bollard

10.2.3 Wheelchair crossing in Sabzi Mandi

In no-vehicle zone which is sabzi mandi, proper consideration is given for wheelchair entrances. At specified locations, the metal barrier should be designed for easy movement of wheelchairs, while stopping the crossing of two-wheelers.

10.3 Street Furniture

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

10.3.1 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 10-3: Dustbin at every 100m interval

igure10-4: Secondary collection bin for wet and dry waste

10.3.2 Public Benches

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

Figure 10-5: Public Bench

10.3.3 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 10-6: Traffic signs

10.3.4 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 10-7: Example of RCC tree guard to prevent soil erosion

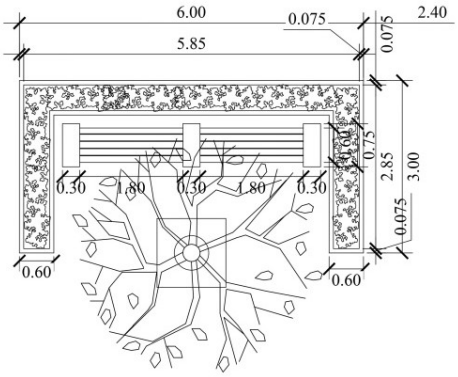


Figure 10-8: Proposed tree guard near sitting space

10.4 Electrical Components

10.4.1 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 10-9: Street light poles with single arm bracket & decorative light poles

10.4.2 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 10-10: 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.

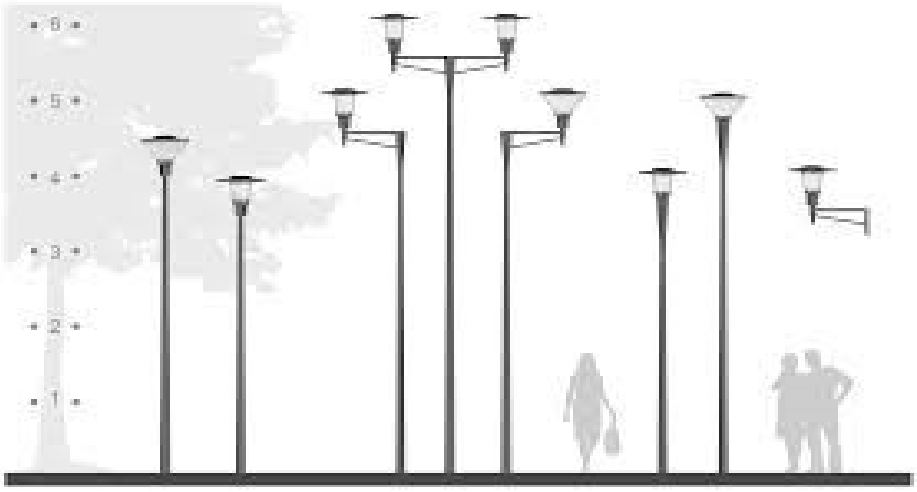


Figure 10-11: Decorative pole design by Philips, Design Type- City Charm

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 10-12: Octagonal / Conical Street light pole design by Philips

10.4.3 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

11. CONSTRUCTION PLANNING SCHEDULE

11.1 Considerations for Construction

The drainage system of Bakarganj covers about 1.44 km (1440 m) in the city of Patna. The overall project is split into five parts. The construction schedule prepared is based upon the conceptual design and existing concepts.

The schedule will be revised to reflect changes to the design and drawing. The first part is precast box drain section. The other three parts are of cast in situ RCC which involve the construction of RCC drains, culverts, road and the final part involves the construction of shops, washrooms, and landscape works.

The 1440 m sections are divided as shown below:

- Part 1: Ch 0+00 to Ch 0+80 (precast)
- Part 2: Ch: 0+80 to Ch: 0+750 (cast in situ)
- Part 3: Ch: 0+750 to Ch: 1+100 (cast in situ)
- Part 4: Ch:1+100 to Ch: 1+440 (cast in situ)
- Part 5: Ch:0+00 to Ch: 1+440 (construction of shops, washrooms, and landscape works)

The entire section of Nala cannot be closed simultaneously as it will lead to an overflow of wastewater, traffic jams, and confusion among people.

The prepared schedule is based on the data collected and observation from previous projects and on a few assumptions which are listed below:

1. The contractor selected for construction of the project must have strong labour and materials to meet the schedule.
2. Identifying encroachments & removing them, marking the number of trees to be felled & removing the trees, Electrical poles to be shifted, water supply pipelines to be relocated. Their duration is not considered in the schedule.
3. These activities involve obtaining NOC and authorization from various departments.
4. Blocking pipelines, removing debris, dewatering sewage and surveying are initial actions that must be taken.
5. The excavation and cleaning of a 100 m stretch can be done in 2 to 3 days, by deploying JCB which can work on shifts of 12 to 18 hours. Based on quantity, the number of JCB can be deployed by the Contractor.
6. PCC can be done in 2-3 days considering the use of pressurized pumps and working a 24-hour shift.
7. The concreting of the drain can be planned on both sides in a 100 m stretch, which saves time, since a 24-hour shift is included in this schedule.
8. A 24-hour shift is considered, which reduces the duration and makes it an efficient process.

9. For the deck slab, a 50 m stretch will include the activities listed below and their duration, respectively:
    - 3 days for formwork, prop fixing, and haunching,
    - 4 days for reinforcement,
    - 2 days for casting (and initiating formwork of next 50m stretch)
    - 21 days for curing 50m
    - and 3 days for de-shuttering

Calculation of days for 1440 m stretch		
Activity	**Stretch**	**Duration**
Excavation and site preparation including PCC	For 50m	2
Formwork to casting	For 50 m	9
Total till casting	For 50 m	11 days
Total till casting	For 1440 m	317 days
Other independent activities like pavement base, paver block shall run simultaneously		

10. Expansion joint as per design to be provided
11. Proper vibrators to be used during concreting
12. Proper safety measures to be adopted for laborer and equipments
13. Proper safety of adjacent buildings to be ensured
14. The site to be made safe for visitors and residents of the area
15. Proper care to be taken while demolishing the existing structures, road etc.
16. The demolished stuff of the existing road, structure to be carried away and dumped in a proper place as per instructions of site engineer

11.2 Construction Approach- Redevelopment of Bakarganj Nala

Part 1: Ch 0+00 to Ch 0+80

Access Route:

a. At the beginning of the nala (Ch:0+00 to Ch 0+80), an access road of minimum 1.8m and maximum width of 3 m is available for carrying the construction work and storing material. (as shown in construction schedule plan)
b. Vehicles such as JCBs and Concrete Mixer Dumpers can be accessed from the available access road.

Execution work:

a. Blocking of inlet pipelines that transport wastewater into the sewer
b. Cleaning and dewatering the residual sewage.
c. An access ramp need to be made for allowing the digger to access the stretch further down. The material for ramp made could be excavated from the available access road on the sides of the drain.

d. After suitable compaction or PCC installation, the excavated material can be used as a base layer.
e. To complete the below-mentioned exercise, several activities must take place at the same time: Coordination between multiple corporation departments, suppliers, and contractors is required.
f. In the case of a precast Box culvert, the trailer can reach the starting location, following which the Precast culvert can be installed using a vehicle-mounted crane.
g. The Precast culvert will not be able to be stored because the only ROW available in this stretch is only 4m.
h. It is not cost effective because it can only be utilized for a short distance, increasing the cost of crane hire, transportation, and so on.

Recommendation: Pre-Cast Drain

Timing:

a. Excavation, formwork, and reinforcement can be done during regular work hours or 24 hours a day.
b. It is possible to consider mass concreting at night.

Hindrances:

1. On the job site, there are some obstacles such as the crane's turning radius, overhead cables, restricted working area, and the crane's minimum distance covered.
2. Two electrical poles and one distribution transformer must be removed and replaced, resulting in a power outage in this section, which includes both residential and business buildings.
3. During the construction time, the ten commercial shops existing at the site along the length should be closed; however, temporary access can also be provided to keep it open.
4. During construction, all of the culverts/crossing over the drain that connects the Daldali and Gandhi Maidan Road must be blocked and demolished, leaving no way for people to travel. Alternative routes must be identified for the diverting the public movement.
5. This drain is connected to two drainage lines that run in opposite directions and must be closed during construction. Alternative channels for streamlining the flow to consider
6. Dewatering can only begin until all existing debris in the sewage has been removed.
7. The building projections acting as a hindrance to the construction work must be demolished.
8. People should be given warnings and shall be fined for throwing their household waste into the drain.

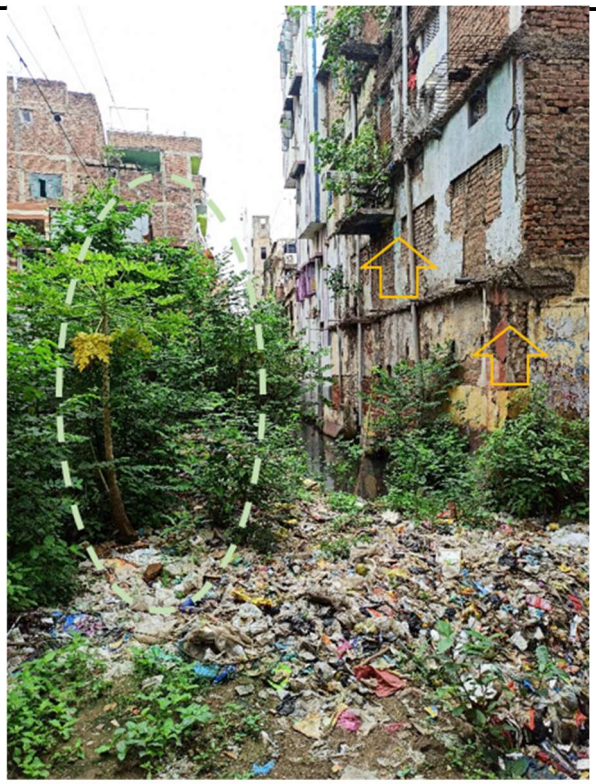
Legends:

	Hindrances to be replaced
	Existing Space available, Street entry or exits
	Existing Trees, grown up plants which will act as Hindrances
	Existing structure hindrances
	Existing Debris over the Drain

The above-mentioned points are shown in illustrations, with essential details highlighted:

Point No :1,2,4

Point No :3



Point No :7,8,9

Part 2: Ch: 0+80 to Ch: 0+750

Access Route:

- The access road in this section is narrow and does not have sufficient width, thus access to various vehicles such as JCBs and Concrete Mixer Dumpers is not possible.

Execution work:

a. Blockage of the inlet pipeline from adjacent buildings, as well as the continuation of the preceding stretch, which transports wastewater to the drain.
b. Dewatering the residual sewage and cleaning up the debris
c. After sufficient compaction of the excavated material, it can be used as a base layer and PCC is laid,
d. The bars can be cut at a different location (e.g. storage of material in between Ch:0+00 to Ch:0+80), then transported and installed on respective sites with minor adjustments.
e. The formwork from the previous section can be kept in the freshly built culvert's sidewalls or on top. The formwork may then further be moved to the second section and installed.
f. Each part of the culvert will be completed in sequential order, such as the raft, sidewalls, and top slab.
g. After the first culvert (C1) (near Ch: 0+120 of section 2) is completed, concrete mixer Dumper/trucks (RMC) can use this newly available space for the remaining construction part of the section 2.

h. Making provision for a Concrete pump with the pipe system allows for the transfer of concrete from the truck to the erected formworks.
i. Site mix is ruled out due to a lack of storage space and the risk of obstructing total access to the casting location if placed above the newly constructed culverts.
j. Concrete from the dumper can also be transferred using short trucks and JCBs.

Recommendation: Cast-in-Situ Drain

Timing:

- Excavation, formwork, and reinforcing can all be done during regular working hours.
- It is possible to consider mass concreting at night.
- The adjacent roads to the drain is found to have high traffic volume during the daytime thus the construction vehicle or any heavy vehicles shall be allowed during the night and on public holidays for their easy movement.

Hindrances:

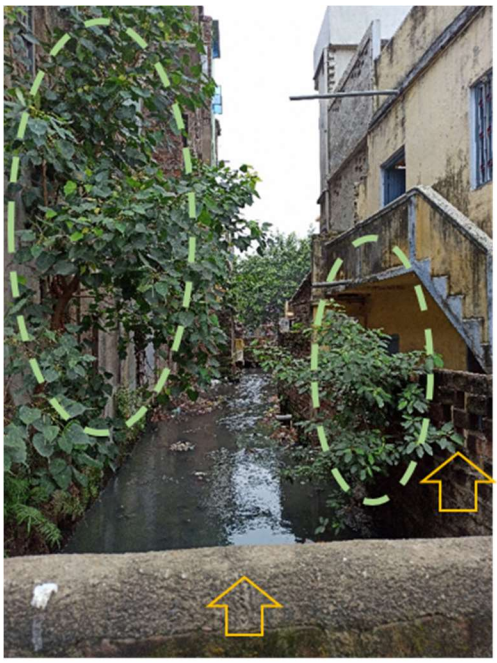
1. During construction, all of the culverts/crossing over the drain that connects the Daldali and Gandhi Maidan Road must be blocked and demolished, leaving no way for people to travel. Alternative routes must be identified for the diverting the public movement.
2. If moving materials via the Daldali road is a consideration, concreting can only be done at night.
3. Many cables and Eb lines (overhead electrical line) cross through and it should be removed, hence there are height limits.
4. Since the width of the Daldali road is narrow, one side should be used for entering and the other side should be utilized solely for the exit.
5. Unloading of items for market stores might also take place at night, which should be regulated or made available outside of casting time.
6. During construction, seven trees (i.e. near Ch: 0+282, Ch: 0+380, Ch: 0+758, Ch: 0+1025, Ch: 0+1035, Ch: 0+1170 , Ch: 0+1362, Ch: 0+1385 and Ch: 0+1485) must be taken down along this stretch, and they must be replanted during landscape work.
7. Cowshed Encroachments to be removed from culvert 3 (C3) (Ch: 0+300)
8. During the construction time, drainage lines must be closed. Alternative channels for streamlining the flow should be investigated.
9. Dewatering can only begin until all existing debris in the sewage has been removed.
10. Some dwellings' chajas must be demolished.
11. People should be given warnings and shall be fined for throwing their household waste into the drain.

The above-mentioned points are show in illustrations, with essential details highlighted:

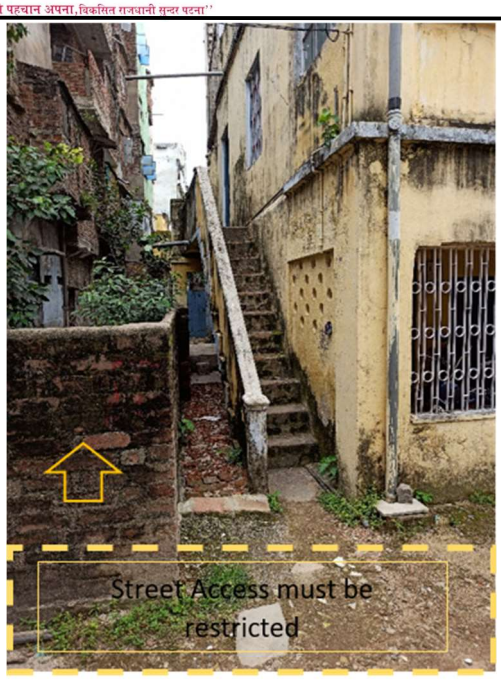
Point No :1,10

Point No :9,11

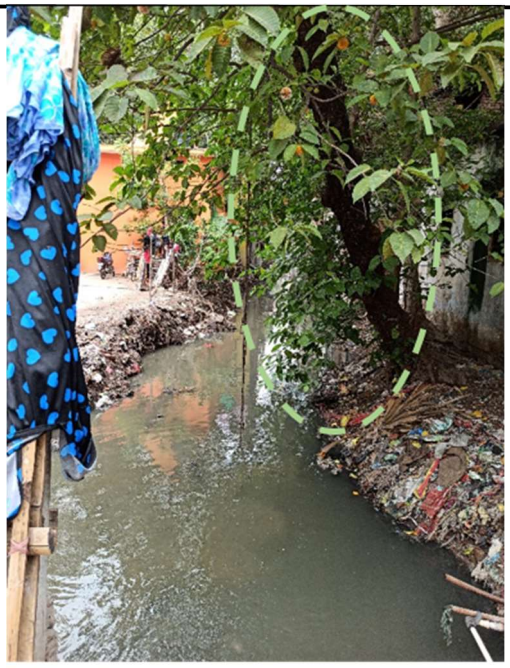
Point No :1,8



Point No :6,8



Point No :1,8



Point No :6,8

Point No :1,9

Point No :1,6,8

Point No: 2,3,4,5

Part 3: Ch: 0+750 to Ch: 1+100

Access Route:

a. The Bakarganj road (at Ch: 0+950) is a primary road where a culvert (C10) must be installed. It is necessary to demolish the present road.
b. This route connects a large number of traffic to the adjacent roads and the surrounding neighboring areas.
c. For shipping, lifting, and constructing, there exist an access road of varying width i.e., 2.5 m wide CC road which runs parallel to the drain from Bakarganj Road upto regent cinema hall.
d. A Street with bookstalls along the road could also provide access to the stretches of section 3.

e. Access to the stretch after this is also possible through the Regent cinema hall's front gate.
f. All of the above place's lead to a main road with designated pathways for transport vehicles, JCBs, and concrete mixers.
g. A designated crane route will be constructed that will lead to precast access.

Execution work:

k. Excavation can be done without difficulty.
l. If traffic and mobility are restricted, the reinforcement bars can be cut and stored on the job site.
m. If traffic and mobility are restricted, the formwork should be stored preferably on site.
n. Each section of the culvert will be completed in order, such as the raft, sidewalls, and top slab.
o. Concrete mixer Dumper/trucks (RMC) can use the available permitted access routes.
p. Concrete can be poured directly or moved through a pipe system.

Recommendation: Cast-in-Situ Drain

Timing:

a. Excavation, formwork, and reinforcing can be done during the day or at night, depending on the constraints.
b. It is possible to consider mass concreting at night.

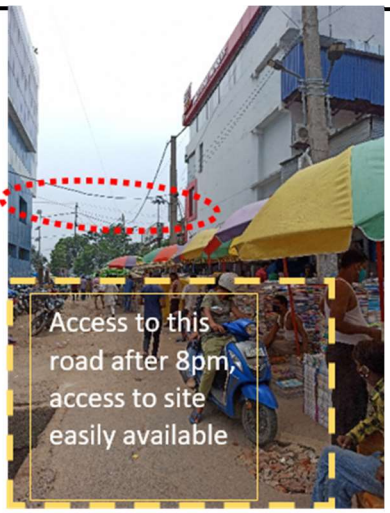
Hindrances:

1. During construction, the main route connecting to the market road must be removed, preventing people from travelling. Alternative routes must be found and diverted.
2. Many cables and Eb lines (overhead electrical lines) cross through, which must be changed during development of access routes, resulting in height limits.
3. During the construction time, drainage lines must be closed. Alternative channels for streamlining the flow should be investigated.
4. Dewatering can only begin until all existing debris in the sewage has been removed.
5. After 8 p.m., the bookstall closes, limiting the use of that particular road near the Regent Theatre.
6. After that, the slab of the parking lot behind the Mona Cinema (near Ch:0+960) will be demolished. This will limit access to commercial establishments in the area.
7. The encroachments of squatter's huts, near Ch: 1+180 upto Ch: 1+380 must be removed.
8. People should be given warnings and shall be fined for throwing their household waste into the drain.
9. During construction, a total of eight trees must be taken down along this stretch, and they must be replanted during landscape work.

The above-mentioned points are shown in illustrations, with essential details highlighted:

Point No: 2,9

Point No: 1,2



Point No: 1,2,5

Point No: 6,7

Point No: 8,9

Part 4: 1+100 to Ch: 1+440

Access Route:

h. Part 4 (at Ch1+100) is an area where Sabji Mandi begins. And accessed by Ashok Raj Path an JC Road.

i. This route connects a large number of traffic to the adjacent roads and the surrounding neighboring areas.

Execution work:

j. It is required to demolish the present road and existing Kutcha shops.

q. Excavation can be done without difficulty.

r. If traffic and mobility are restricted, the reinforcement bars can be cut and stored on the job site.

s. If traffic and mobility are restricted, the formwork can be stored preferably on site.

t. Each section of the culvert will be completed in order, such as the raft, sidewalls, and top slab.

u. Concrete mixer Dumper/trucks (RMC) can use the available permitted access routes.

v. Concrete can be poured directly or moved through a pipe system

Hindrances:

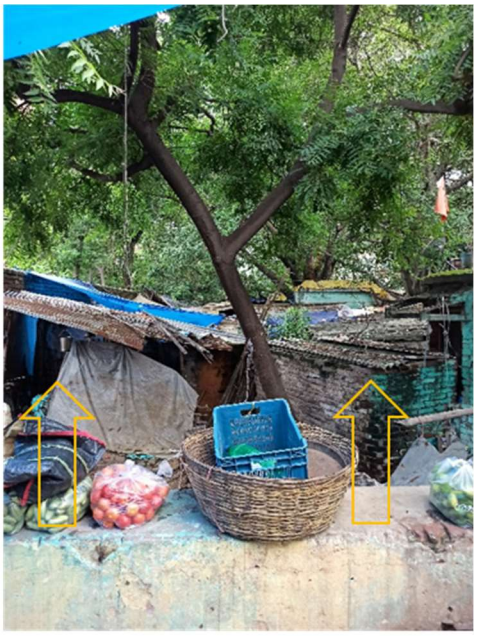
1. Sabzi mandi shall be closed for the time being, and a new location for their operation should be provided.
2. Throughout the Sabzi mandi, the present RCC Slab will be demolished.
3. During the construction time, drainage lines must be closed. Alternative channels for streamlining the flow should be investigated.
4. Dewatering can only begin until all existing debris in the sewage has been removed.
5. Encroachments in front of the sump house road, which goes to the sabzi mandi, must be removed.
6. People should be given warnings and shall be fined for throwing their household waste into the drain.

Recommendation: Cast-in-Situ Drain

Timing:

- As there are numbers of structures such as shops and toilet building, excavation, formwork, and reinforcement can be done on a 24-hour shift calendar.
- It is possible to consider mass concreting at night.


Point No :2,3



Point No :6,7

Technology (Applicable throughout the stretch)

- Techno craft formworks are prefabricated, which increases the efficiency of the formwork activity and is cost effective.
- LDPE Sheets can be put on the base to avoid seepage and act as a waterproof material.

Safety (Applicable throughout the stretch)

- The contractor must exercise extreme caution when excavating and using other mechanical equipment.
- The structure of most of the buildings is fragile because they are ancient and poorly maintained. Any collision between this equipment and the building wall will result in a mishap.

11.3 Consideration for Installing Pre-cast installation

The preceding schedule should only be used as a guideline. Pre-cast in distinct portions will shorten the project's length.

When precast is chosen, these are the methods, activities, and precautions to be followed.

1. **Unloading:**

   Care should be taken when unloading boxes to ensure that no workers are in the path of the box when it is moved. The box should be handled according to the manufacturer's instructions. To handle box culvert sections, only use lifting equipment that have been certified by the manufacturer. To avoid damage, the package should be lifted rather than dragged.
   If the lifting device has the potential to chip the box, padding between the box and the lifting mechanism should be supplied. When lifting holes are supplied in a box, the lifting device should pass through the wall and distribute the weight along the box's inside wall.

2. **As per the current scenario:**
   A crane with stabilizer's should be used to install the box directly from the truck trailer to the final place. Be mindful that some crawlers without outriggers, such as backhoes, may lack the stability or mobility required to properly line up the units.
   1. Site preparation
   2. Excavation
   3. PCC
   4. Raft
   5. Box alignment:

   The first box pieces must be installed correctly since they determine the line and slope of the subsequent boxes. Future connections may be harmed if these are incorrect.

   6. Placement of Boxes

Closest to the outlet, boxes should be put at the end of the line of box sections. The bell end should point upstream, while the spigot or tongue should point downstream. Loads from construction equipment transferred to a box section before, during, or after fill placement, either directly or through the fill, shall not be more than the loads assumed in the design, unless otherwise allowed by the owner.

7. BOX PLACEMENT

Boxes should be placed at the end of the line of box sections closest to the outlet. The spigot or tongue should point downstream, while the bell end should point upstream. Loads from construction equipment transferred to a box section before, during, or after fill placement, either directly or through the fill, shall not be more than the loads assumed in the design, unless otherwise allowed by the owner.

Using digging machinery to force boxes into place should be avoided since it may cause cracking, which may necessitate on-site repairs. It's also not a good idea to drop or drag the portion across gravel or stones. To ensure that the levelling course and the sidewalls of the excavation area are not damaged, an appropriate base for construction equipment should be present.

8. JOINTING

Jointing is vital for preventing soil fines and water from migrating between box sections and their surroundings. Various materials and methods for sealing the seams may be employed depending on the purpose of the box culvert.

9. CONNECTING THE BOXES

Chains or winches should be used to link boxes together. It is forbidden for installation machinery to come into direct touch with the box parts. To avoid spalling, use sufficient cushion material between the box part and the machine. Check that the grade is right, the joint surface is clear of all bedding material, and the joint sealant is correctly deposited before installing the box culvert in its final placement. While the box is being positioned, a worker should be able to guide the crane operator.

The worker in the alignment position should tell the crane operator to lower the box until the top slab of the new box section is about two feet higher than the prior box's top slab. The box should be lowered until the sides of the boxes are flush and the installed box's spigot end aligns with the bell end of the receiving section. Despite the fact that the box is in the correct location, the crane must maintain the section's weight. The joint must now be secured.

Winches or come-a-longs can be used to accomplish this. Install one end of the come-a-long or winch at the far end of the installed portions and the other end over the outer end of the following piece, being careful not to spall each surface.

This is best accomplished using a pair of winches or come-alongs, one on each side. Tighten the chains gradually until the box section is snug against the previous box. This winching should be done in a consistent manner.

If the joint is not within the maximum permissible joint opening, the crane should gently elevate the portion on top while the winches tighten the chains. Remove the portion and re-screw the bedding if this does not solve the open joint.

Check the sections for dimensional tolerances that will allow the joint to return home. When the box is in the proper position, the crane can progressively lower the box until the bedding material bears the entire weight of the box, at which point the crane can be detached. The chains are kept in place until the crane is disengaged, at which point they are let go.

10. COMPLETION

The lift holes should be filled according to the manufacturer's instructions after the boxes have been linked together.

11. BACKFILL
12. INSPECTION