MYANMAR NATIONAL BUILDING CODE–2020

PART 5D – WATER SUPPLY, DRAINAGE AND SANITATION

Presented by

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YCDC

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MNBC 2020 – PART –5–D–Water Supply , Drainage and Sanitation

5D.5.5.11 Storm Water Drainage

5D.5.5.11.2 Design factors

(a) Soil and absorption

(b) Ground slope and time

(c) Intensity of rainfall

(d) Duration of rain

5D.5.5.11.2.1 Imperviousness $\frac{\textbf{runoff}}{\textbf{rainfall}}$

In the absence of such data, the following values may serve as a guide:

Type of area	**Imperviousness**
Commercial and industrial	70-90
Residential areas (high density)	60-75
Residential areas (low density)	35-60
Parks and underdeveloped areas	10-20

JICA (Technical Guideline/ Draft)

Table 4 Runoff Coefficient by Land Surface Cover

Area	Runoff Coefficient (%)
Commercial / Business Lots	90
Asphalt Concrete Roads	90
Residential Lots	80
Mixed Industrial Lots	70
Parks / Gardens/ Lawns	40
Natural Forest	30

Source: Yangon City Development Committee, Design of Main Streams Improvement and Outfall Structures (North Okkalapa, South Okkalapa, & Thingangyun Townships), Final Report, March 2018

Code of Practice in Drainage Design (YCDC) Draft

Runoff Coefficients for Urban Watersheds(TxDoT, hydraulic Design Manual, September 2019)

YCDC PROPOSAL

Type of drainage area	Runoff coefficient
Business:	
Downtown areas	0.70-0.95
Neighborhood areas	0.30-0.70
Residential:	
Single-family areas	0.30-0.50
Multi-units, detached	0.40-0.60
Multi-units, attached	0.60-0.75
Suburban	0.35-0.40
Apartment dwelling areas	0.30-0.70
Industrial:	
Light areas	0.30-0.80
Heavy areas	0.60-0.90
Parks, cemeteries	0.10-0.25
Playgrounds	0.30-0.40
Railroad yards	0.30-0.40
Lawns:	
Sandy soil, flat 2%	0.05-0.10
Sandy soil, average 2-7%	0.10-0.15
Sandy soil, steep 7%	0.15-0.20
Heavy soil, flat 2%	0.13-0.17
Heavy soil, average 2-7%	0.18-0.22
Heavy soil, steep 7%	0.25-0.35
Streets:	
Asphaltic	0.85-0.95
Concrete	0.90-0.95
Brick	0.70-0.85
Drives and walks	0.75-0.95
Roofs	0.75-0.95

5D.5.5.11.2.2 Terrain modeling

The planning of the area should ensure that:

a) All areas become self-draining by gravity with respect to the high flood level of the area or the drainage channels passing whichever is higher.

b) As far as possible, natural drainage pattern with respect to the whole area be maintained except when low lying areas need to be filled up for grading purposes.

c) The drainage in the area shall be planned in accordance with the natural slopes.

d) Levels of the main highway or road connecting to the property shall be determined to ensure proper drainage and protection of the site.

e) The formation levels of the entire area shall be prepared to determine proposed formation levels by preparing a terrain model which will show the proposed the site contours, ground and road levels and connections to all services including storm water disposal system.

JICA (Technical Guideline/ Draft)

3. Preparatory Survey for Rainwater Drainage Work

For planning the rainwater drainage work in the development area, the preparatory survey should be carried out to clarify the following.

(1) Locations of existing rainwater drainage including river, creek, open channel, and conduit and the rainwater drainage network formed by interconnections of these.

(2) The management boundary of existing rainwater drainage and the need for any adjustment with the boundary of the planned development area.

(3) Locations where rainwater runoff concentrating and flow conditions through existing drainage

(4) Size, structural feature, and flow capacity of existing rainwater drainage to be connected with the rainwater drainage work in the development area.

5. Rainwater Runoff Released from Development Area

> In the case of a rainfall intensity within the design scale of the rainwater drainage work, the peak of rainwater runoff released from the development area to the downstream should not exceed that estimated under the pre-development land use condition.

Supplemental Explanations:

The urban developments are likely to cause an increase of rainwater runoff when the natural features on the ground are changed into buildings and paved surfaces as shown in Figure 5. Then, the rainwater runoff peak is anticipated to increase and exceed the flow capacity of the existing drainage located downstream of the outfall from the development area. As a result, the area along the downstream of the outfall is threatened by the risk of flooding.

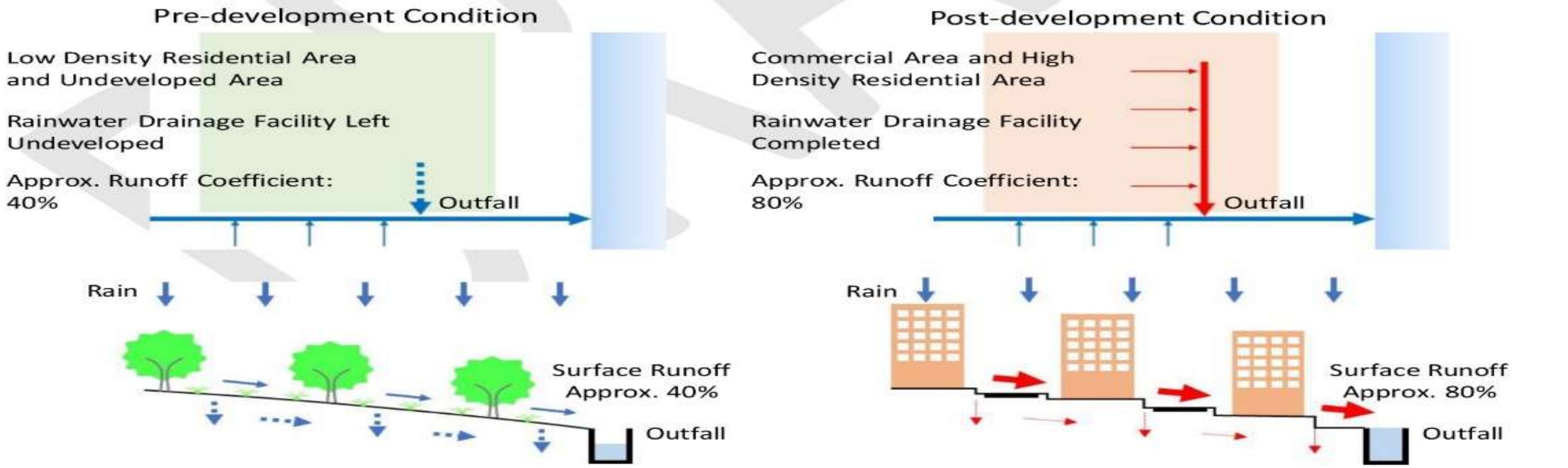


Figure 5 Image of Rainwater Runoff Peak Anticipated to Increase

Considering the situations above, introduction of the rainwater runoff control measures, including rainwater retention facility and/or rainwater infiltration facility, should be taken into consideration in order to alleviate a rapid increase of rainwater runoff released from the development area.

The peak of rainwater runoff released from the development area to the existing drainage located downstream should be regulated as shown in Figure 6 in order to minimize the risk of flooding in the existing drainage located downstream of the development area. Meanwhile, the rainwater runoff reduction measures are considered as optional for the development area less than 1 acre (0.405 ha) since an increase of rainwater runoff released from such a development area cause less impact on the existing drainage located downstream. It will be required to discuss with YCDC taking into consideration the surrounding condition of development area.

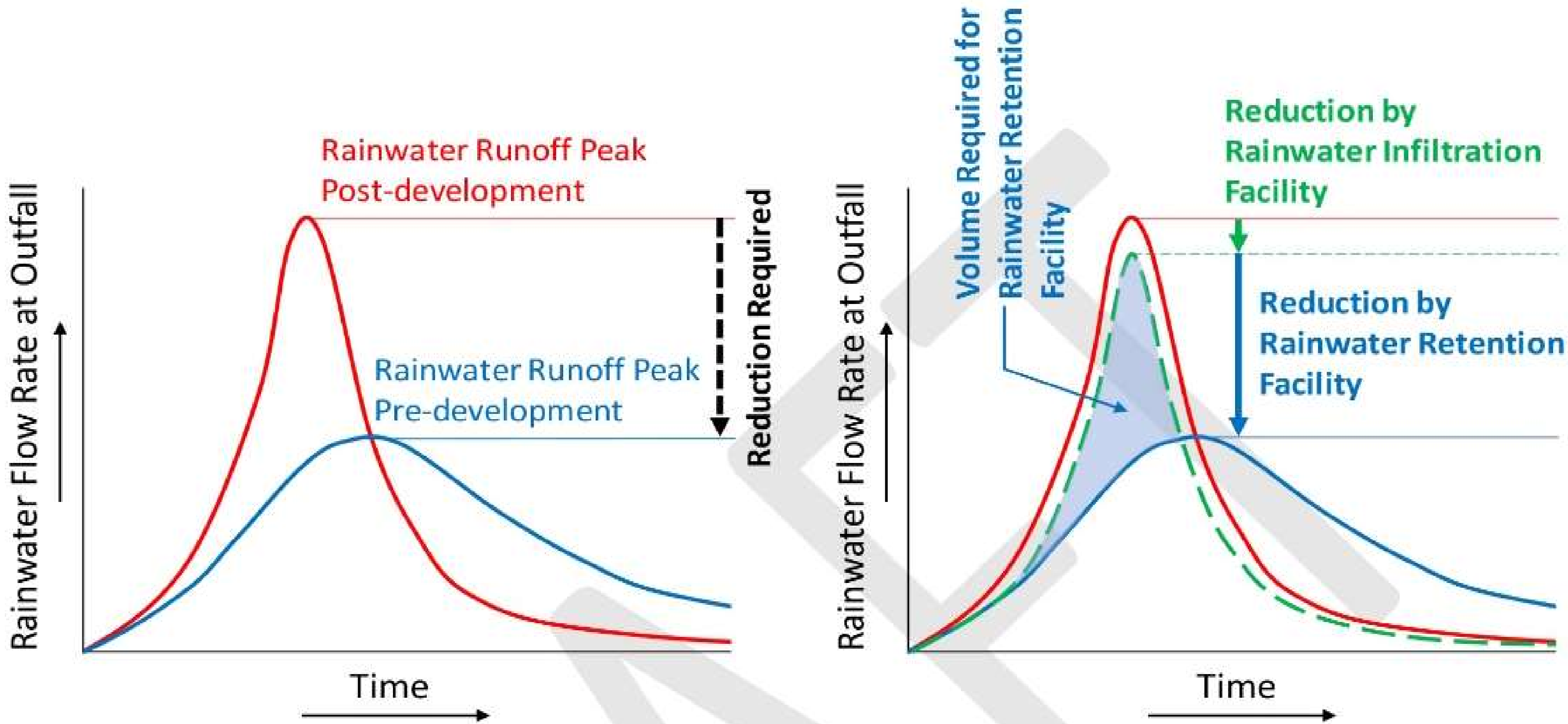
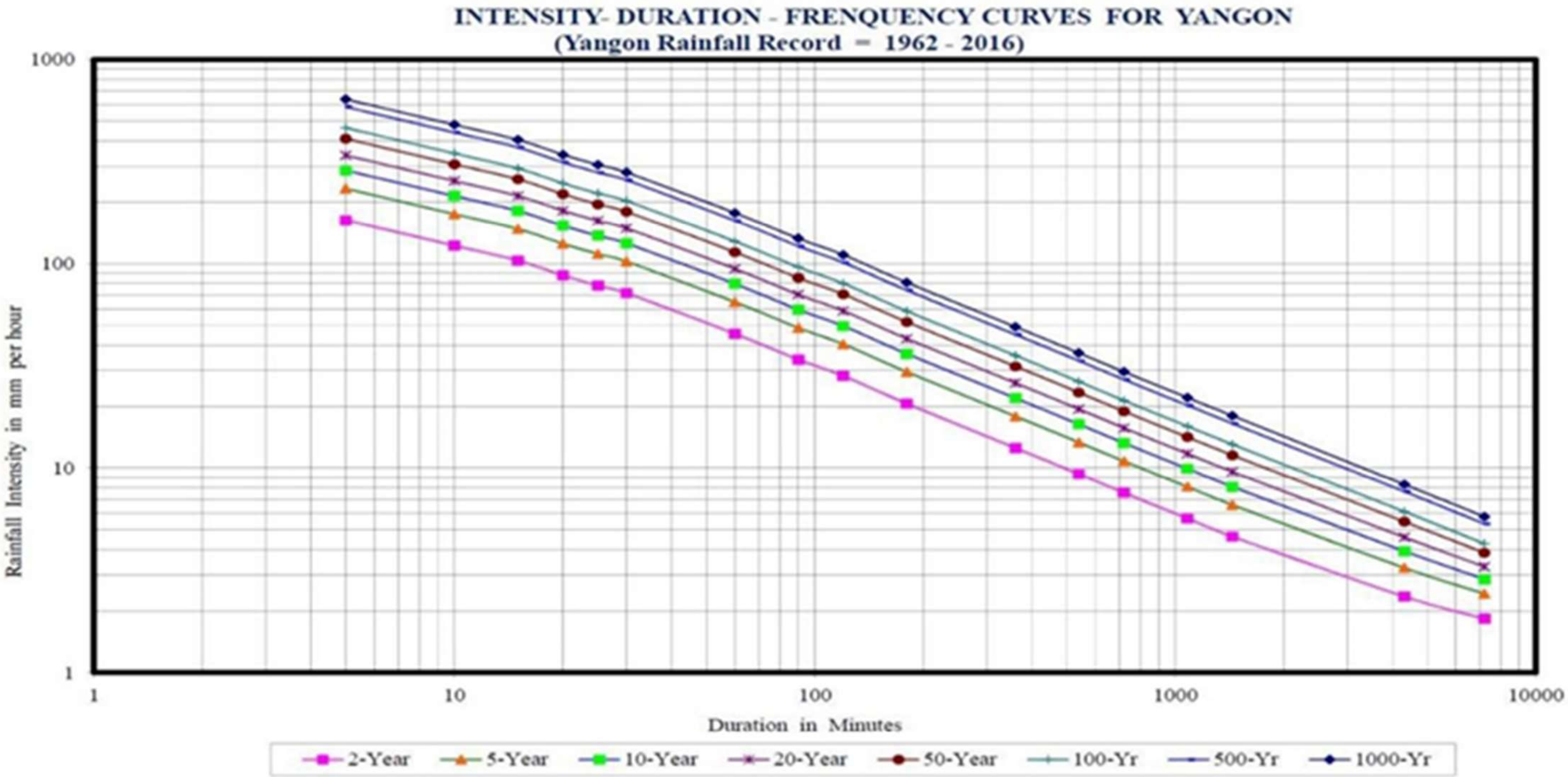


Figure 6 Image of Rainwater Runoff Peak to be Regulated

5D.5.5.11.2.3 Design frequency

If data are not available use rainfall intensity as (3-5) in/hr.

JICA (Technical Guideline/ Draft)



Source: Yangon City Development Committee, Design of Main Streams Improvement and Outfall Structures (North Okkalapa, South Okkalapa, & Thingangyun Townships), Final Report, March 2018

Figure 10 Rainfall IDF in Yangon City

JICA (Technical Guideline/ Draft)

Table 5 Rainfall IDF in Yangon City

Duration (min)	ARI / Rainfall Intensity (mm/hour)		
	2-year	5-year	10-year
5	163.4	233.6	286.6
10	122.6	175.2	214.9
15	103.5	147.9	181.5
30	71.7	102.5	125.8
60	45.4	64.9	79.6
120	28.2	40.4	49.5
180	20.7	29.5	36.2
360	12.6	17.9	22.0
720	7.6	10.8	13.3
1440	4.6	6.6	8.1

Source: Yangon City Development Committee, Design of Main Streams Improvement and Outfall Structures (North Okkalapa, South Okkalapa, & Thingangyun Townships), Final Report, March 2018

Design Scale of Rainwater Drainage Work

The design scale of the rainwater drainage work in the development area should be given with due consideration of the following.

- Located in Urbanization Area (UA): 10-year Return Period
- Located in Guided Urbanization Area (GUA): 10-year Return Period
- Pump Drainage Required: 10-year Return Period

Code of Practice in Drainage Design (YCDC) Draft

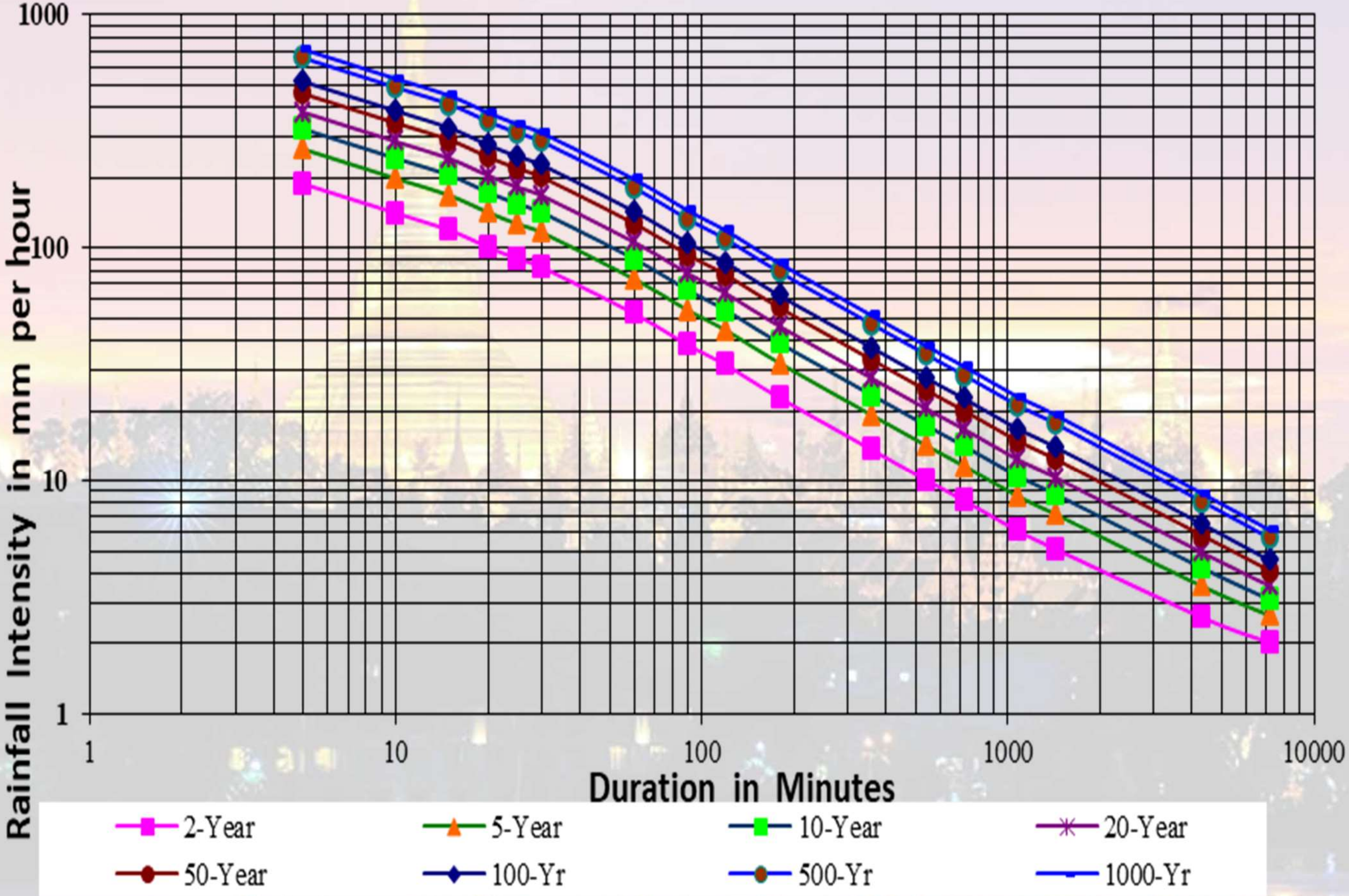
Design Frequency Return Period

The return periods (T) adopted for the design of drainage systems in YANGON CITY shall be as follows.

Flood zone	Usage	Proposed Area /Catchment area	Drainage type	Return period
Low	Residential Mixed used Industrial Office & School		Inhouse drain Public drain Box culvert	
Medium				
High				

Code of Practice in Drainage Design (YCDC) Draft

The intensity –Duration– Frequency (IDF) curves



5D.5.5.11.2.3

Design Frequency (Suggestions)

Storm water drainage system for an urbanized area is planned on the basis of the design frequency of the storm which shall be determined by the designer. Frequency is the period in which the selected design intensity recurs in a given period of time in years. If Intensity Duration Frequency Curve (IDF) is not available , use Rainfall intensity as (3-5) in/hr.

However if any specification regard with rainfall intensity recommended by Local Authorities such as YCDC , NCDC , MCDC , need to follow their guide lines or code of practice.

If Intensity Duration Frequency Curve (IDF) is available ,

Area Served by Drainage System	Return Period(T)
Catchment of less than 100 acre	
Box Culvert	5 years
Main Drain	5 years
Catchment of 100 to 500 acre	
Box Culvert	10 years
Main Drain	10 years
Catchment of 500 to 1000 acre	
Box Culvert	20 years
Main Drain	20year
Catchment of more than 1000 acre	
Box Culvert	50 years
Main Drain	25 years
Airport runway or any area as specified by the Board	100 years

5D.5.5.11.2.4 Time of Concentration

Inlet Time + flow Time = Time of Concentration

Inlet Time → 5 min to 30 min

Highly developed/ impervious surface → 3 min or lower

Low time of concentration → Higher intensity

JICA (Technical Guideline/ Draft)

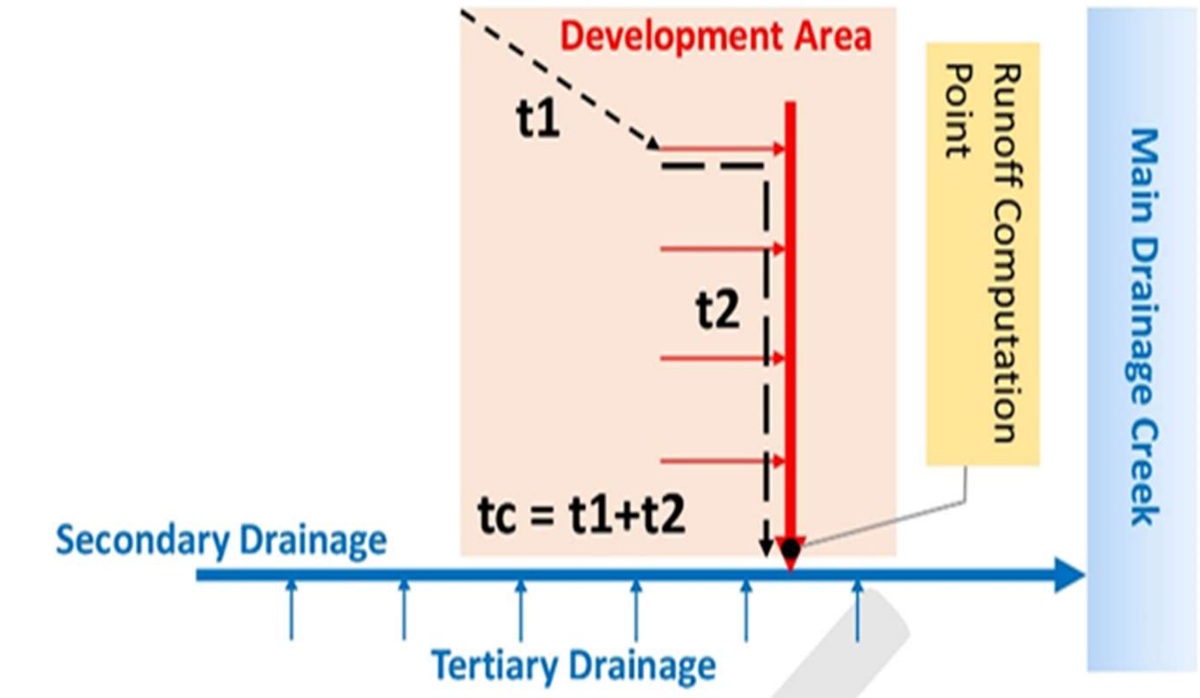


Figure 8 Image of Time of Rainwater Runoff Concentration in Development Area

T_c = Overland flow Time(t_1)+Drain flow Time (t_2)

t_1 = 5 min (minimum)

For moderately populated

Sub-catchments → t_1 = 10 min

t_2 = $l/v_{/60}$

L = length of drainage segment (m)

V = Velocity

PUB 2018 7th Edition ⟶ Overland flow Time = 5 min to 15 min

The overland flow time (to) varies from 5minutes to 15minutes, depending on the overland travel distance, land topography and characteristics. The drain flow time (td) shall be estimated from the hydraulic properties of the drainage channel.(PUB 2018 7th EDITION)

10. Hydraulic Calculation for Design of Rainwater Drainage Work

Size (or flow capacity) of drainage channel or conduit is designed by using the Manning's Equation.

$$Q = A \times V = A \times 1/n \times R^{2/3} \times i^{1/2}$$

where,
Q = Peak flow rate of rainwater runoff (m^3/s)
A = Flow area inside drainage channel or conduit (m^2)
V = Flow velocity inside drainage channel or conduit (m/s)
n = Manning's roughness coefficient
R = Hydraulic radius (= A/S) (m)
S = Wetted perimeter inside drainage channel or conduit (m)
i = Slope of drainage channel or conduit

Supplemental Explanations:

The peak flow rate of rainwater runoff is computed by the Rational Method described in Section 6. Design Flow for Rainwater Drainage Work. Then the rainwater drainage channel or conduit is sized through hydraulic calculation by using the Manning's Equation

YCDC's design document prepared in 2018 describes the following Manning's roughness coefficient (n) and design flow velocity (V) and these are considered as acceptable. In addition, it is recommended to refer to other references describing these values corresponding to various cross-sectional shapes and materials of the rainwater drainage.

Manning's Roughness:

Lined Drains or Culverts	= 0.014
Rubble Drains	= 0.020
Earth Drains	= 0.035

Flow Velocity:

Minimum Self Clean Velocity	= 0.75 m/s
Maximum Velocity: Lined Drains and Culverts	= 4.0 m/s
Maximum Velocity: Earth Drains	= 1.2 m/s

Roughness Coefficient

The value of the roughness coefficient (n) depends on the drain's flow surface and is given below:

Boundary Condition	Roughness Coefficient (n)
Unplasticised Polyvinyl Chloride (UPVC)	0.0125
Concrete	0.0150
Brick	0.0170
Earth	0.0270
Earth with stones and weed	0.0350
Gravel	0.0300

Note: Where there are different flow surfaces within a drain section equivalent, roughness coefficient may be used.

Table : Manning's Roughness Coefficients for Open Channels

Type of Channel	Manning's n
B. Excavated or dredged channels	
1. Earth, straight and uniform	0.016-0.020
a. Clean, recently completed	0.016-0.020
b. Clean, after weathering	0.018-0.025
c. Gravel, uniform section, clean	0.022-0.030
d. With short grass, few weeds	0.022-0.033
2. Earth, winding and sluggish	
a. No vegetation	0.023-0.030
b. Grass, some weeds	0.025-0.033
c. Deep weeds or aquatic plants in deep channels	0.030-0.040
d. Earth bottom and rubble sides	0.028-0.035
e. Stony bottom and weedy banks	0.025-0.040
f. Cobble bottom and clean sides	0.030-0.050
g. Winding, sluggish, stony bottom, weedy banks	0.025-0.040
h. Dense weeds as high as flow depth	0.050-0.120
3. Dragline-excavated or dredged	
a. No vegetation	0.025-0.033
b. Light brush on banks	0.035-0.060

Table : Manning's Roughness Coefficients for Open Channels

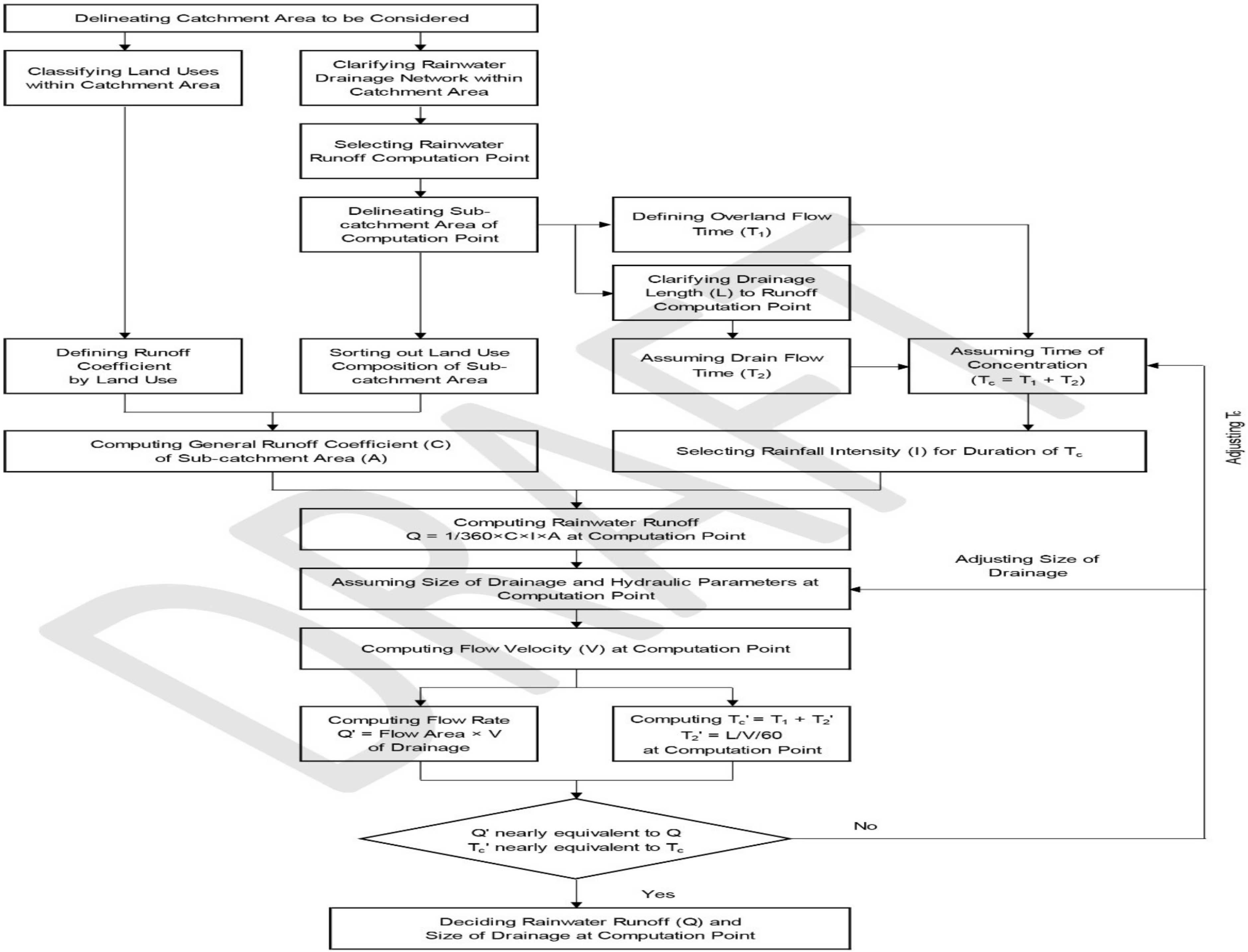
Type of Channel	Manning's n
4. Rock cuts	
a. Smooth and uniform	0.025-0.040
b. Jagged and irregular	0.035-0.050
5. Unmaintained channels	
a. Dense weeds, high as flow depth	0.050-0.120
b. Clean bottom, brush on sides	0.040-0.080
c. Clean bottom, brush on sides, highest stage	0.045-0.110
d. Dense brush, high stage	0.080-0.140
C. Lined channels	
1. Asphalt	0.013-0.016
2. Brick (in cement mortar)	0.012-0.018
3. Concrete	
a. Trowel finish	0.011-0.015
b. Float finish	0.013-0.016
c. Unfinished	0.014-0.020
d. Gunite, regular	0.016-0.023
d. Gunite, regular	0.016-0.023
e. Gunite, wavy	0.018-0.025
4. Riprap (n-value depends on rock size)	0.020-0.035
5. Vegetal lining	0.030-0.500

Table : Manning's Roughness Coefficients for Closed Conduits (ASCE 1982, FHWA 2001)

Material	Manning's n
Asbestos-cement pipe	0.011-0.015
Brick	0.013-0.017
Cast iron pipe	
Cement-lined & seal coated	0.011-0.015
Concrete (monolithic)	
Smooth forms	0.012-0.014
Rough forms	0.015-0.017
Concrete pipe	0.011-0.015
Box (smooth)	0.012-0.015
Corrugated-metal pipe -- (2-1/2 in. x 1/2 in. corrugations)	
Plain	0.022-0.026
Paved invert	0.018-0.022
Spun asphalt lined	0.011-0.015
Plastic pipe (smooth)	0.011-0.015
Corrugated-metal pipe -- (2-2/3 in. by 1/2 in. annular)	0.022-0.027
Corrugated-metal pipe -- (2-2/3 in. by 1/2 in. helical)	0.011-0.023
Corrugated-metal pipe -- (6 in. by 1 in. helical)	0.022-0.025
Corrugated-metal pipe -- (5 in. by 1 in. helical)	0.025–0.026
Corrugated-metal pipe -- (3 in. by 1 in. helical)	0.027–0.028
Corrugated-metal pipe -- (6 in. by 2 in. structural plate)	0.033–0.035
Corrugated-metal pipe -- (9 in. by 2-1/2 in. structural plate)	0.033–0.037
Corrugated polyethylene	0.010–0.013
Smooth	0.009-0.015
Corrugated	0.018–0.025
Spiral rib metal pipe (smooth)	0.012-0.013
Vitrified clay	
Pipes	0.011-0.015
Liner plates	0.013-0.017
Polyvinyl chloride (PVC) (smooth)	0.009-0.011

Table note: Manning's n for corrugated pipes is a function of the corrugation size, pipe size, and whether the corrugations are annular or helical (see USGS 1993).

Flowchart of the Rational Method
(Draft Technical Guidelines for Design of Rainwater Drainage Work in Development Area by JICA)



5D.5.5.11.2.5 Natural infiltration

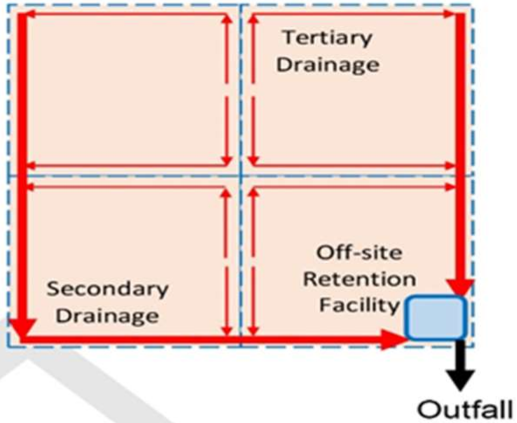
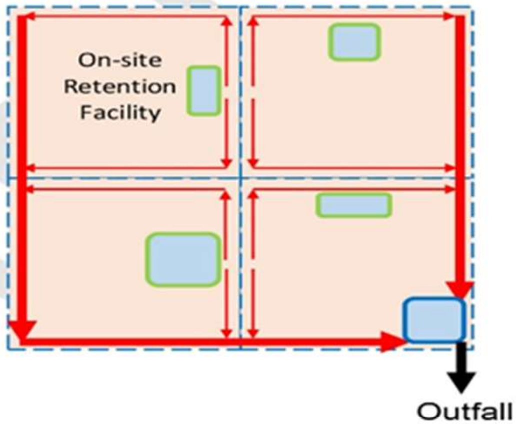
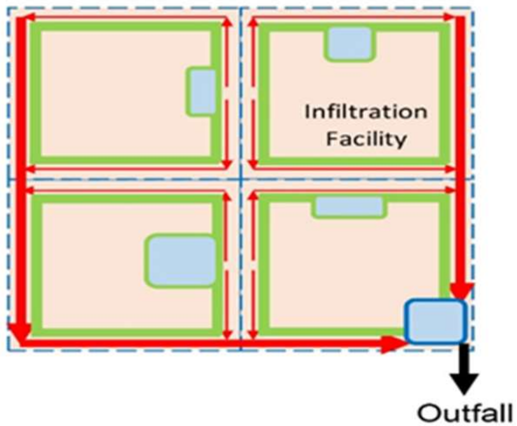
Reduce Runoff ground water to be recharge.

(a) Use of Brick paved open jointed storm water drains.

(b) Providing bore holes in the storm water drains.

(c) Using paving tiles with open joints which enable water to percolates as it flows on it.

Table 8 Rainwater Control Measures

Classification	Image
Off-site Retention Facility Rainwater runoff is collected through open channels and conduits in the development area and is regulated by rainwater retention pond located at the downstream end for alleviating the peak of rainwater runoff released from the development area.	
On-site Retention Facility Open spaces (e.g. car parking, green park, sports field) and rooftop/underground of buildings in the development area are used as temporary rainwater storage for delaying time of rainwater runoff concentration into channel or conduit nearby.	
Infiltration Facility Infiltration facilities (e.g. permeable gully, permeable trench, permeable pavement) increase an infiltration rate of rainwater into the ground and reduce rainwater runoff discharging into channels and conduits.	

5D.5.5.11.4/5 Discharging into a watercourse and public storm water drain

- To discharge surface water to a nearby road side drain, stream, watercourse.
- Outfall protected against floating debris by a screen.
- Rainfall intensity 2 in/hr → not drainage design

JICA (Technical Guideline/ Draft)

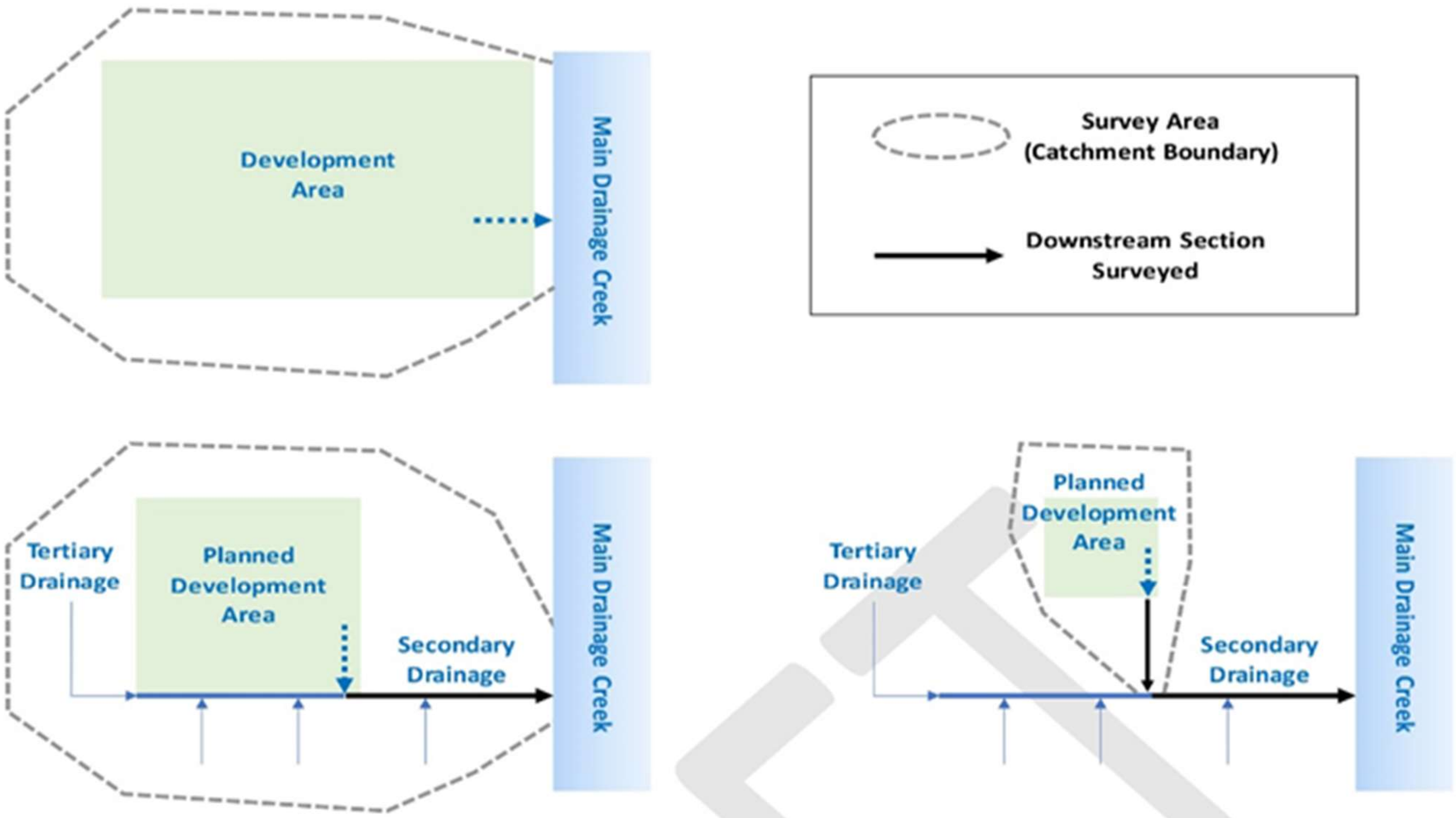


Figure 4 Image of Preparatory Survey Area

5D.5.5.11.6 Rain– water pipes for roof drainage

- Sufficient number of rain–water pipes of adequate size so arranged.
- Carried away from the building without causing dampness in any part of the walls or foundations.
- Fixed to the outside of the external walls.
- Not street drain within 100 ft from the boundary directly into the kerb drain, through outlet across the foot path.
- Not discharge into any soil pipe, ventilating pipe. Into a sewer gully trap.
- Rain–water pipes constructed of cast iron, pvc, asbestos cement, galvanized sheet, securely fixed.
- Quality of rainwater entering ⟶ Rainfall intensity
  ⟶ Time of concentration
- A bell mouth inlet area = 1.5 to 2 times of rain–water pipe area.
- Cast iron pipe (roughness coefficient (n) = (0013)

$$RA = 0.084 \times d^{5/2} / I$$

where,

d = pipe diameter ,mm

I = Intensity of Rainfall (mm/hr)

RA= Roof area (m2)

Table 26 Sizing of Rain-Water Pipes for Roof Drainage
(Clause 5.5.11.6.8)

Dia of Pipe (mm)	Average Rate of Rainfall (mm / hour)					
	50	75	100	125	150	200
	Roof Area (m^2)					
50	29.70	19.80	14.85	11.88	9.90	7.42
65	57.23	38.15	28.61	22.89	19.08	14.31
75	81.84	54.56	40.92	32.74	27.28	20.46
100	168.00	112.00	84.00	67.20	56.00	42.00
125	293.48	195.66	146.74	117.39	97.83	73.37
150	462.95	308.64	231.48	185.18	154.32	115.74

NOTE – For rain-water pipes of other materials, the roof areas shall be multiplied by (0.013/coefficient of roughness of surface of that material).

5D.5.5.11.6 Rain– water pipes for roof drainage

- Strom water discharge in a suitable drain to a watercourse change in direction or gradient pucca masonry drain.

5D.5.5.12 Rain Water Harvesting

5D.5.5.12.2 Artificial ground water recharge

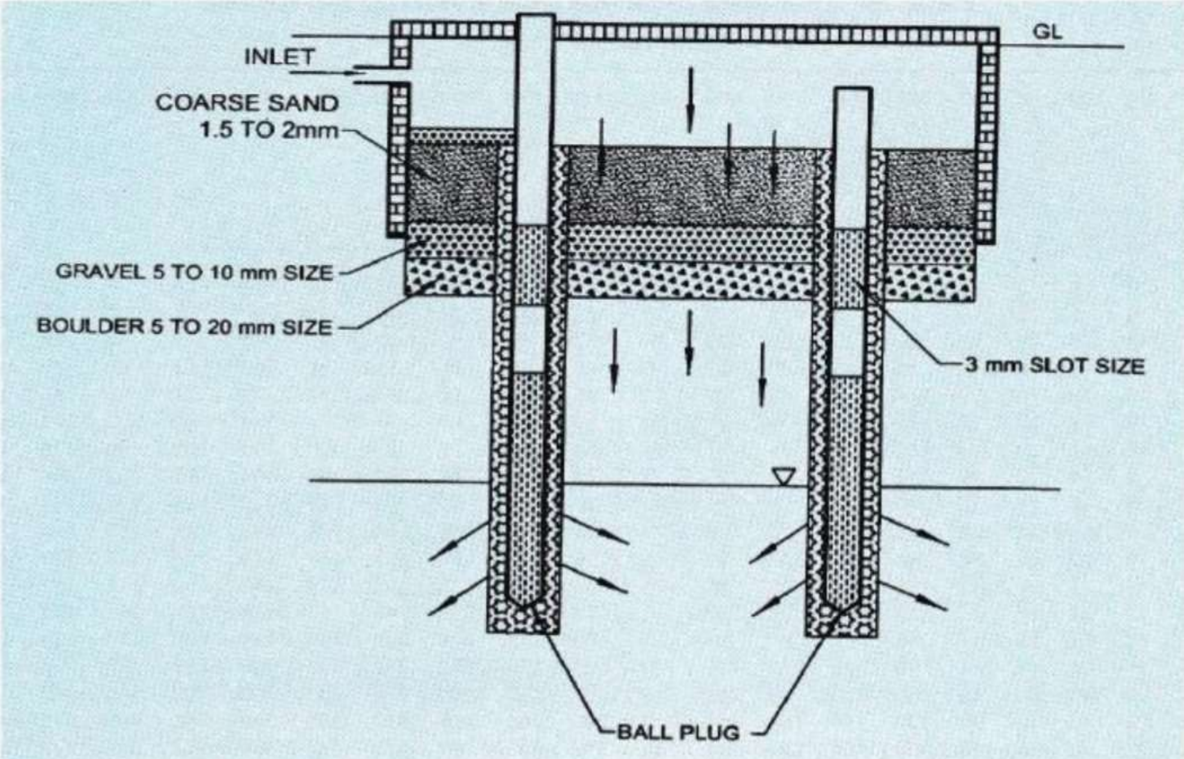


FIG. 18 ARTIFICIAL GROUND WATER RECHARGE STRUCTURE

In planning and designing the ground water recharge structures following should be taken into consideration:

a) Annual rainfall (for estimating approx rainwater recharge per year).
b) Peak intensity and duration of each storm.
c) Type of soil and sub-soil conditions and their permeability factor.
d) Ground slopes and runoff which cannot be caught.
e) Location of recharge structures and its overflow outfall.
f) Rainwater measuring devices for finding the flow of water in the system.

5D.5.5.12.3 Roof top rain–water harvesting

- Collect through roof gutters and down take pipes.
- First rainfall not collect (dust, soot, leaves,……)
- Water tank capacity should be enough.
- Water tank located in well protected area not exposed any hazards.
- Using chlorine residual chlorine ≃ 1 mg/L (1ppm)

Table 27 Rainwater Available from Roof Top Harvesting
(Clause 5.5.12.13.1)

Rain Fall (inch)	**3**	**6**	**9**	**12**	**15**	**18**	**21**	**24**	**27**	**30**	**33**	**36**	**39**	**42**	**45**	**48**	**51**	**54**	**57**	**60**
Roof Top Area (ft^2)	**Harvested Water from Roof Tops (x 10^3 ft^3) (80 percent of gross precipitation)**																			
100	0.02	0.04	0.06	0.08	0.1	0.12	0.14	0.16	0.18	0.2	0.22	0.24	0.26	0.28	0.3	0.32	0.34	0.36	0.38	0.4
200	0.04	0.08	0.12	0.16	0.2	0.24	0.28	0.32	0.36	0.4	0.44	0.48	0.52	0.56	0.6	0.64	0.68	0.72	0.76	0.8
300	0.06	0.12	0.18	0.24	0.3	0.36	0.42	0.48	0.54	0.6	0.66	0.72	0.78	0.84	0.9	0.96	1.02	1.08	1.14	1.2
400	0.08	0.16	0.24	0.32	0.4	0.48	0.56	0.64	0.72	0.8	0.88	0.96	1.04	1.12	1.2	1.28	1.36	1.44	1.52	1.6
500	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2
600	0.12	0.24	0.36	0.48	0.6	0.72	0.84	0.96	1.08	1.2	1.32	1.44	1.56	1.68	1.8	1.92	2.04	2.16	2.28	2.4
700	0.14	0.28	0.42	0.56	0.7	0.84	0.98	1.12	1.26	1.4	1.54	1.68	1.82	1.96	2.1	2.24	2.38	2.52	2.66	2.8
800	0.16	0.32	0.48	0.64	0.8	0.96	1.12	1.28	1.44	1.6	1.76	1.92	2.08	2.24	2.4	2.56	2.72	2.88	3.04	3.2
900	0.18	0.36	0.54	0.72	0.9	1.08	1.26	1.44	1.62	1.8	1.98	2.16	2.34	2.52	2.7	2.88	3.06	3.24	3.42	3.6
1000	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2	2.2	2.4	2.6	2.8	3	3.2	3.4	3.6	3.8	4
1100	0.22	0.44	0.66	0.88	1.1	1.32	1.54	1.76	1.98	2.2	2.42	2.64	2.86	3.08	3.3	3.52	3.74	3.96	4.18	4.4
1200	0.24	0.48	0.72	0.96	1.2	1.44	1.68	1.92	2.16	2.4	2.64	2.88	3.12	3.36	3.6	3.84	4.08	4.32	4.56	4.8
1300	0.26	0.52	0.78	1.04	1.3	1.56	1.82	2.08	2.34	2.6	2.86	3.12	3.38	3.64	3.9	4.16	4.42	4.68	4.94	5.2
1400	0.28	0.56	0.84	1.12	1.4	1.68	1.96	2.24	2.52	2.8	3.08	3.36	3.64	3.92	4.2	4.48	4.76	5.04	5.32	5.6
1500	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3	3.3	3.6	3.9	4.2	4.5	4.8	5.1	5.4	5.7	6
2000	0.4	0.8	1.2	1.6	2	2.4	2.8	3.2	3.6	4	4.4	4.8	5.2	5.6	6	6.4	6.8	7.2	7.6	8
2500	0.5	1	1.5	2.0	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
3000	0.6	1.2	1.8	2.4	3	3.6	4.2	4.8	5.4	6	6.6	7.2	7.8	8.4	9	9.6	10.2	10.8	11.4	12
4000	0.8	1.6	2.4	3.2	4	4.8	5.6	6.4	7.2	8	8.8	9.6	10.4	11.2	12	12.8	13.6	14.4	15.2	16
5000	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
10000	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
20000	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80
30000	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120

5D.5.5.12.4 Care to take in rain–water harvesting

Water conservation technique discussed above shall be constructed with due care taking following precautions:

(a) No sewage or waste should be admitted into the system.

(b) No waste water from areas likely to have oil, grease or other pollutants should be connected to the system.

(c) Each structure/well shall have an inlet chamber with a silt trap to prevent any silt from finding its way into the sub–soil water.

(d) The wells should be terminated at least 16 feet 6 inches above the natural static sub–soil water at its highest level so that the incoming flow through the natural ground condition and prevents contamination hazards.

(e) No recharge structure or a well shall be used for drawing water for any purpose.

5D.5.5.13 Sub-soil Water Drainage

5D. 5.5.13.1 General

Sub-soil water is that portion of the rainfall which is absorbed into the ground.

The drainage of sub-soil water may be necessary for the following reasons:

(a) to avoid surface flooding;

(b) to alleviate or to avoid causing dampness in the building, especially in the cellars;

(c) to reduce the humidity in the immediate vicinity of the building; and

(d) to increase the workability of the soil.

5D. 5.5.13.2 Depth of water table

- Vary with the season.
- The amount of rainfall.
- Level of drainage channels.
- Obtained by boreholes or trial pits
- Direction of sub-soil water is inclination of land surface.
- Main lines of sub-soil drains follow the natural falls.

5D. 5.5.13.3 Precautions

- Must not communicate directly with sewage pipe.

5D.5.5.13.4 Systems of sub-soil drainage

a) ***Natural*** — The pipes are laid to follow the natural depressions or valleys of the site; branches discharge into the main as tributaries do into a river.
b) ***Herringbone*** — The system consists of a number of drains into which discharges from both sides smaller subsidiary branch drains parallel to each other, but an angle to the mains forming a series of herringbone pattern. Normally these branch drains should not exceed 30 m in length.
c) ***Grid*** — A main or mains drain is laid to the boundaries if the site into which subsidiary branches discharge from one side only.

d) ***Fan-Shaper***—The drains are laid converging to a single outlet at one point on the boundary of a site, without the use of main or collecting drains.
e) ***Moat or cut-off system*** — This system consists of drains laid on one or more sides of a building to intercept the flow of subsoil water and carry it away, thereby protecting the foundations of a building.

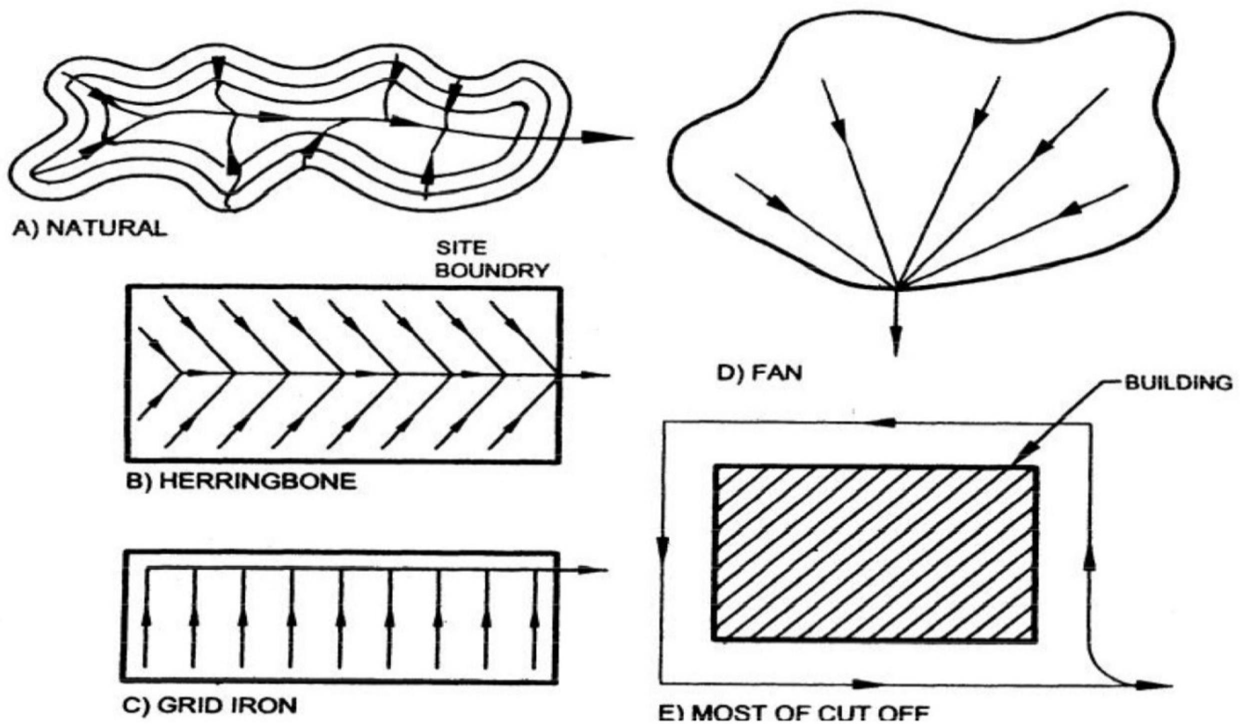


FIG. 19 DETAILS OF DRAINAGE SYSTEM

The choice of one or more of these systems will naturally depend on the local conditions of the site. For building sites, the mains shall be not less than 3 inches in diameter and the branches not less than 2½ inches in diameter but normal practice tends towards the use of 4 inches and 3 inches respectively. The pipes shall generally be laid at 2 feet to 3 feet depth, or to such a depth to which it is desirable to lower the water- table and the gradients are determined rather by the fall of the land than by considerations of self-cleansing velocity. The connection of the subsidiary drain to the main drain is best made by means of a clay ware or concrete junction pipe. The outlet of a sub-soil system may discharge into a soak away or through a catch pit into the nearest ditch or watercourse. Where these are not available, the sub-soil drains may be connected, with the approval of the Authority, through an intercepting trap to the surface water drainage system,

NOTE — Care shall be taken that there is no backflow from sub-surface drains during heavy rains.

5D.5.5.13.4 Design of drainage pipes

5D.5.5.3.5.1 Estimation of maximum flow of sewer

Maximum discharge flow– The maximum rate of discharge flow shall be taken as thrice the average rate, allowance being made in addition for any exception peak discharges. A good average rule is to allow for a flow of liquid wastes form buildings at the rate of **3 liters per minute per 10 persons.**

5D.5.7 Construction Relating to Conveyance of Rain or Storm Water

5D.5.7.1 Roof Gutters → any material of suitable thickness, junctions and joints shall be water tight.

5D.5.7.2 Rain Water Pipe → standard [9–1(32)]

5D.5.7.3 Sub–soil Drain Pipes

5D.5.7.3.1 Field drain pipes

- Plain cylindrical glazed pipes, concrete porous pipes.
- Unsuitable where sub–soil water carries sulphates / acidic.
- Enough at the bottom to permit laying the pipes, proper lines and gradients.
- To prevent the infiltration of silt, cover the pipes with clinker, brick ballast, brush–wood, straw.
- To prevent penetration by roots, socket pipes with cement or bitumen joints.

Thank You for Your Attention