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Project-1, CE462A

A. Plotting intensity duration frequency curves and fitting equation

Basic Statistical parameters of data, gumbel distribution & Log Normal distributions:

For Gumbel distribution:

$$a = \frac{\sigma_x}{\sqrt{(1.645)}}$$

$$b = \mu_x - 0.5772a$$

For Normal distribution:

$$\sigma_y = \sqrt{\left(ln\left(\frac{\sigma_x^2}{\mu_x^2} + 1\right)\right)}$$

$$\mu_y = ln(\mu_x) - \frac{\sigma_y^2}{2}$$

Average	2.017761	3.533283	6.054245	12.01511	13.85424	19.88133	30.86805	45.37955	60.77059
STD	0.199788	0.372713	0.563889	1.08842	1.434397	1.911273	3.136217	4.954618	6.313266
	Gumbel Distribution								
a	0.155771	0.290598	0.439653	0.84862	1.118372	1.490184	2.445249	3.863022	4.922335
b	1.92785	3.36555	5.800477	11.52529	13.20871	19.02119	29.45665	43.14981	57.92942
	Log Normal Distribution								
Mean	0.69711	1.256694	1.796441	2.482079	2.62326	2.985181	3.424587	3.809136	4.101739
STD	0.098773	0.105195	0.092938	0.090403	0.103259	0.095913	0.10134	0.108858	0.103608

⇨ Now, we conducted **Kolmogorov-smirnov** test for every time duration given in data.
To check best-fit distribution, we compared **KS stat** value with **KS stat critical** value. If

$$KS_{stat} < KS_{critical}$$

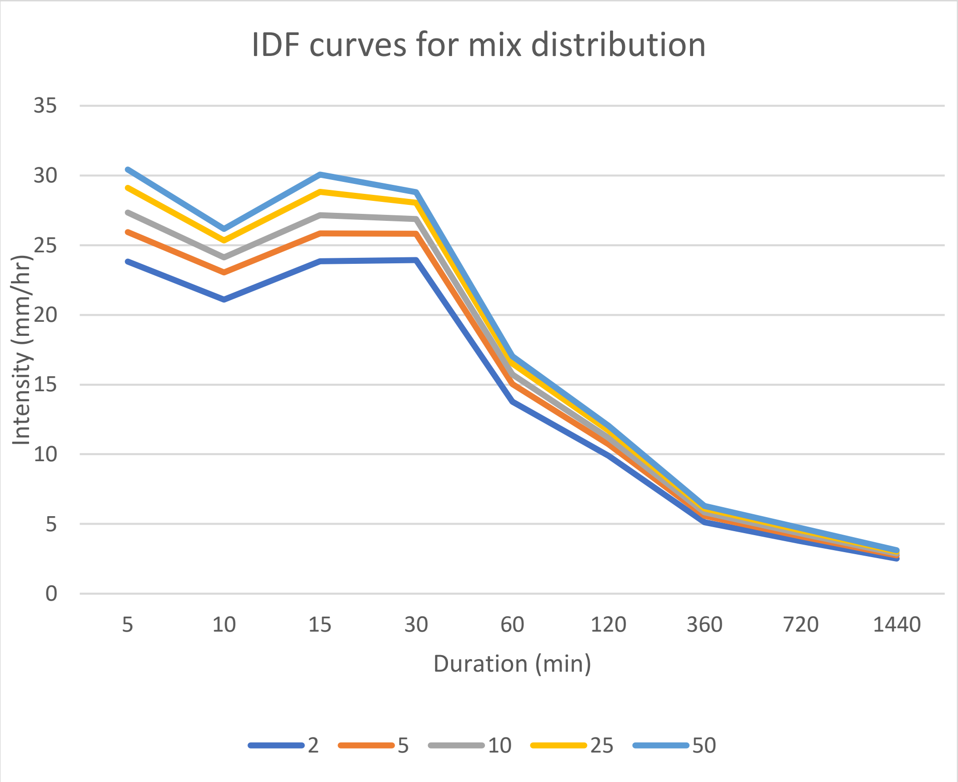
Then our distribution is a good fit.
Result: For every time duration, Above condition followed for both distribution!

Now, to compare between Log Normal and Gumbel distribution, we performed AIC/BIC test.
Smaller the value of AIC/BIC, better our distribution fits.

Result:
For $t_D = 5, 15\ min$, Gumbel Distribution is the best fit.
For $t_D =\ 10\ min, 30\ min, 60\ min, 1H, 2H, 6H, 12H, 24H,$ Log-Normal distribution is the best fit.

Now, calculate IDF data using distributions and get mix distribution.
For $t_D = 5, 15\ min$, Use Gumbel Distribution
For $t_D =\ 10\ min, 30\ min, 60\ min, 1H, 2H, 6H, 12H, 24H,$ Use Log-Normal distribution.

Plotted the data to obtain IDF curves.



Equation obtained after fitting our data (by minimizing sum of least squares is):

$$\boldsymbol{i_{D,T} = \frac{768.15T^{0.067}}{(D + 65.73)^{0.82}}}$$

B. Designing Storm water drainage system

Important Formule used:

1. Rational Formula

$$Q = C_{equivalent} iA/3.6$$

Where $C_{equivalent} = \sum C_j A_j \,/ \sum A_j$

3.6 = Conversion factor

Runoff coefficients for various types of area can be found here:

https://hello.iitk.ac.in/sites/default/files/ce462a2021/Table_Rational.jpg

2. Time of concentration using kinematic wave approximation

$$t_c = \frac{6.99}{i_e^{(2/5)}} \left(\frac{nL}{S_0}\right)^{(3/5)}$$

3. Required Diameter

$$d_r = \left(3.208 * \frac{nQ}{\sqrt{S_0}}\right)^{(3/8)}$$

4. Rainfall intensity formula (from part A)

$$i_{D,T} = \frac{768.15T^{0.067}}{(D + 65.73)^{0.82}}$$

5. Discharge for Uniform Triangular Gutter

$$Q = \frac{K_s}{n} S_x^{(5/3)} S_L^{(1/2)} T^{(8/3)}$$

6. Discharge for curb opening inlet

$$Q = \left(\frac{L_t (nS_x)^{(0.6)}}{K_o (S_L)^{(0.3)}}\right)^{(1/0.42)}$$

Procedure for designing pipeline:

1. Calculate $\sum C_i A_i$ for each basin.
2. Calculate inlet time for each basin, this will also be time of concentration for that basin = $t_{c,basin}$
3. If there are upstream pipelines, then time of concentration for upstream pipeline will be addition of inlet time of that pipeline and sewer flow time of that upstream pipeline = $t_{c,upstream\ pipe}$
4. Designing Duration will be:
$$max(t_{c,basin}, t_{c,upstream\ pipe})$$
5. Calculate design discharge through rational formula and required diameter of pipeline. Min diameter of pipeline should be $= \ 450mm$

Procedure for designing Gutter for basin

1. Calculate Rain intensity for each basin corresponding to its inlet time using IDF equation.
2. Calculate the Design Discharge from its inlet time.
3. Finally, design the discharge of curb which should be higher than design discharge (Assume no. of inlets =1).
4. Also calculate the spread of gutter corresponding to design discharge.

Results:

<u>Pipeline:</u>

Diameter used for each pipeline: **450mm.**

Assumed length = 500m, Slope = 0.003, for pipeline 41-51.

Pipeline	Length L(m)	Slope S	Design Discharge Qp, (m^3/sec)	Required Diameter (m)	Diameter used (m)
11 to 21	1000	0.002	0.032158653	0.283247234	0.45
21 to 31	400	0.0035	0.025506597	0.233805134	0.45
23 to 31	600	0.004	0.030863776	0.244922822	0.45
31 to 41	500	0.001	0.036060723	0.336713104	0.45
44 to 41	600	0.0032	0.031441862	0.257171052	0.45
54 to 41	700	0.0042	0.026983475	0.230767459	0.45
41 to 51	500	0.003	0.207620974	0.528309695	0.55

Manhole:

Manhole	Reduced level of the Manhole (m)	Upstream Crown Elevation (m)	Upstream Invert Elevation (m)	Downstream Crown Elevation (m)	Downstream Invert Elevation (m)
11	137.1	136.1	135.65	134.1	133.65
21	136.5	135.5	135.05	134.1	133.65
31	133.2	132.2	131.75	129.8	129.35
41	129.5	128.5	128.05	128	127.55
23	131.6	130.6	130.15	128.68	128.23
44	132.2	131.2	130.75	128.26	127.81
54	132.6	131.6	131.05	130.1	129.55

Gutter:

Assume No. of inlets = 1.

Basin	Assumed length of Curb Opening (m)	Design discharge of curb opening (m^3/s)	Design spread of gutter (m)
I	3	0.047488566	2.26472689
II	3	0.047488566	2.23009076
III	2	0.018085235	1.615789745
IV	3	0.047488566	2.245663791
V	3	0.047488566	2.120512537

C. Probable maximum 12-h precipitation with a return period of 500 years

For return period T = 500

$$F(k_m) = 1 - \frac{1}{T}$$

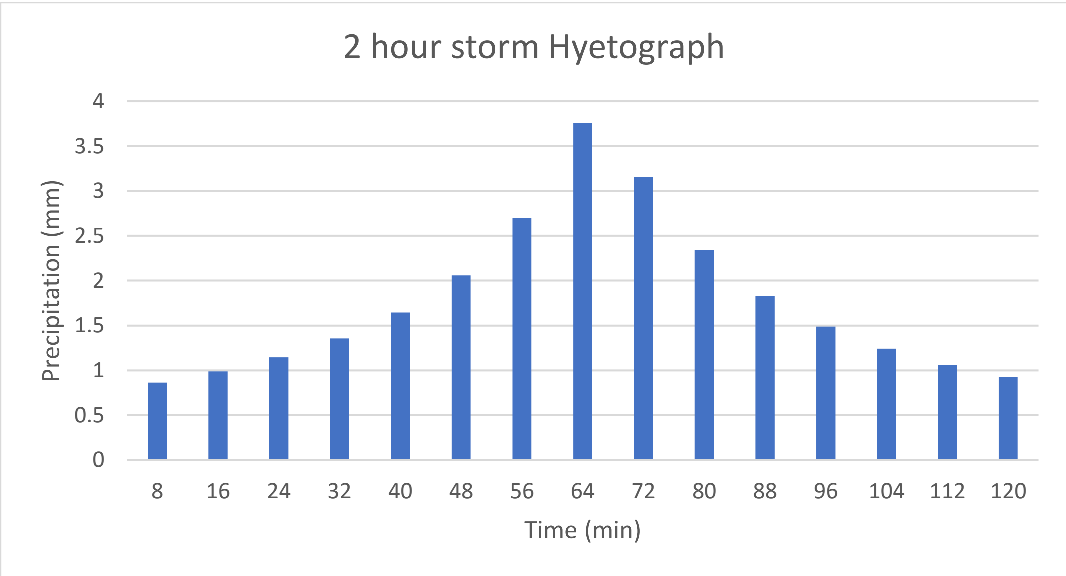
$$F(k_m) = exp\left(-\left[1 + \frac{0.13(k_m - 0.44)}{0.6}\right]^{-7.69}\right)$$

From this, calculate k_m (calculated using excel solver)

Probable maximum rainfall $= \boldsymbol{\mu_x + k_m\sigma_x}$

$$= \mathbf{75.9952\ mm}$$

D. Hyetograph for 2-hour storm for return period of 20 year



E. Adequacy of design

To check whether clogging will occur in part d, compare the peak discharge in part (d) for each basin with the designed discharge gutter can take.

Result:

Basin	Peak discharge of storm	Design discharge of curb opening
I	0.040476174	0.047488566
II	0.038094394	0.047488566
III	0.014719748	0.018085235
IV	0.037494642	0.047488566
V	0.03925005	0.047488566

⇨ For each basin, Peak discharge of storm < Designed discharge drainage system can take.
No clogging will occur.