KANDULA SRINIVASA REDDY MEMORIAL COLLEGE OF ENGINEERING
(AUTONOMOUS)

KADAPA-516003. AP

(Approved by AICTE, Affiliated to JNTUA, Ananthapuramu, Accredited by NAAC)

(An ISO 9001-2008 Certified Institution)

DEPARTMENT OF CIVIL ENGINEERING

CERTIFICATE COURSE

ON

"STORM WATER DRAINAGE SYSTEM DESIGN"

Resource Person:

Dr. T. Kiran Kumar, Professor, Dept. of CE, KSRMCE

Course Coordinator:

K. Pramod, Assistant Professor, Dept. of CE, KSRMCE

Duration:

19/09/2022 to 30/09/2022

K.S.R.M. COLLEGE OF ENGINEERING

(UGC-AUTONOMOUS)

Kadapa, Andhra Pradesh, India 516 003

Approved by AICTE, New Delhi & Affiliated to JNTUA, Ananthapuramu.

An ISO 14001:2004 & 9001: 2015 Certified Institution

KSNR

Date: 08.09.2022

To
The Principal,
K.S.R.M.College of Engineering,
Kadapa.

Respected Sir,

Sub: Permission to conduct a Certification course on **"Storm Water Drainage System Design"**–Reg.

It is being brought to your kind notice that, With reference to the cited, the Civil Engineering Department is planning to conduct a Certification course on "Storm Water Drainage System Design" for V & VII Sem B.Tech students from 19th to 30th September 2022 at 3 PM- 6 PM. In this regard I kindly request you to grant permission to conduct the certification course.

Thanking you Sir,

Forwarded to principal sir

Yours Faithfully
K.Pramod,
Assistant professor,
Dept. of CE

Permitted
V. S. S. Murthy

K.S.R.M. COLLEGE OF ENGINEERING
(UGC-AUTONOMOUS)
Kadapa, Andhra Pradesh, India – 516 003
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09-09-2022

Circular

All the V & VII Sem B. Tech students are here by informed that Department of Civil Engineering is going to conduct a Certification course on **"Storm Water Drainage System Design"** from 19th to 30th September 2022 at 3 pm to 6 pm in CE Seminar Hall.

In this connection, all the V & VII Sem B. Tech Civil Engineering students those who are interested to participate in the above programme are hereby directed to register their names with the link given below on or before 18th October 2022.

Registration link: https://forms.gle/SEAJ1gLTkWSYG8wQ8

Resource Person:
Dr. T. Kiran Kumar
Professor
Dept. of Civil Engineering
KSRMCE.

Coordinator:
Sri. K.Pramod,
Assistant Professor
Dept. of Civil Engineering
KSRMCE.

Head
Department of Civil Engineering
K.S.R.M. College of Engineering
(Autonomous)
KADAPA 516 003. (A.P.)

KSRM
COLLEGE OF ENGINEERING
(UGC-AUTONOMOUS)
Kadapa, Andhra Pradesh, India - 516 005
Approved by AICTE, New Delhi & Affiliated to JNTUA, Ananthapuramu

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ESTD: 1980

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DEPARTMENT OF CIVIL ENGINEERING

ICI

CEA

Certification Course
on

STORM WATER DRAINAGE SYSTEM DESIGN

Resource Person

Dr. T Kiran Kumar
Professor
Dept. of Civil Engineering, KSRMCE

starts

19-09-2022

oordinator: K Pramod, Asst. Professor, Dept. of CE

CE SEMINAR HALL

. N Amaranatha Reddy HOD	Prof. V S S Murthy Principal	Dr. K Chandra Obul Reddy Managing Director	Smt. K Rajeswari Correspondent Secretary, Treasurer	Sri K Madan Mohan Reddy Vice Chairman	Sri K Raja Mohan Reddy Chairman

ksrmceofficial www.ksrmce.ac.in 8143731980, 857697569

Certification Course on ***"STORM WATER DRAINAGE SYSTEM"***

For V and VII Sem Civil Engineering students

Resource Person: Dr.T.Kiran Kumar, Professor, Dept. of CE

* Required

1. Email *

2. Name of the Student (as per SSC) *

3. Roll Number *

4. Semester *

   Mark only one oval.

   ◯ V
   ◯ VII

5. Section *

   Mark only one oval.

   ◯ A
   ◯ B
   ◯ C

6. Interested in Certification course ? *

Mark only one oval.

( ) Yes

( ) No

7. Phone Number (preferably WhatsApp number)

____

K.S.R.M. COLLEGE OF ENGINEERING

(UGC-AUTONOMOUS)

Kadapa, Andhra Pradesh, India– 516 003

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Department of Civil Engineering

Name of the Event: Certification course on "Storm Water Drainage System Design"

List of Registrations

Sl.No.	Roll No.	Name of the student	Semester	Section	Branch
1	209Y1A0102	A.Jyoshika	V	A	C.E
2	209Y1A0105	B.Guru Suchitra	V	A	C.E
3	209y1a0116	Cherasalaudaykiran	V	A	C.E
4	209y1a0126	K.Sree Revathi	V	A	C.E
5	209Y1A0158	P. Lokanath	V	A	C.E
6	209y1a0171	Sette.Vamsi Krishna	V	B	C.E
7	209Y1A0175	Shaik Mahammad Jabeer	V	B	C.E
8	209y1a0189	U.Poojitha	V	B	C.E
9	209y1a0191	Velpula Anusha	V	B	C.E
10	209Y1A0194	Y.Anusha Lakshmi	V	B	C.E
11	219Y5A0101	Ajjugottu Rajitha	V	B	C.E
12	219y5a0103	Armala Madhu Sudhan Reddy	V	B	C.E
13	219y5a0104	B. Anitha	V	B	C.E
14	219Y5A0112	C. Nikileswara Sai Kumar	V	B	C.E
15	219y5a0114	Chinthakuntla Narendra Reddy	V	B	C.E
16	219Y5A0121	Gogula Avinash	V	C	C.E
17	219Y5A0126	Kamireddy Jaipal Reddy	V	C	C.E
18	219y5a0128	K Sai Kumar Naik	V	C	C.E
19	219y5a0130	Kethavaram Gangdhar	V	C	C.E
20	219y5a0131	K.Sree Kavya	V	C	C.E
21	219Y5A0133	Kummari Dastagiri	V	C	C.E
22	219Y5A0134	Subhash Kunchapu	V	C	C.E

23	219y5a0135	Kuruba Lavanya	V	C	C.E
24	219Y5A0137	Lodi Naveen	V	C	C.E
25	219y5a0142	Malishetty Gurulakshmi	V	C	C.E
26	219Y5A0145	Mekala Chennakeshavulu	V	C	C.E
27	219Y5A0147	N.Shiva Kishor	V	C	C.E
28	219y5a0148	N.Shankar	V	C	C.E
29	219Y5A0149	N.Malleswari Devi	V	C	C.E
30	219y5a0151	Palla Yogendra	V	C	C.E
31	219Y5A0152	Pasupuleti Sai Charan	V	C	C.E
32	219y5a0153	Pathan Rahamathullah Khan	V	C	C.E
33	219y5a0155	P.Lalappa	V	C	C.E
34	219y5a0156	P.Sunanda	V	C	C.E
35	219y5a0158	Rapuru Nikitha	V	C	C.E
36	219Y5A0159	Ratala Chandra Sekhar	V	C	C.E
37	219y5a0161	S. V. Sumalatha	V	C	C.E
38	219y5a0163	Shaik.Mahaboob Bee	V	C	C.E
39	219Y5A0165	Shaik Mohammed Zuber	V	C	C.E
40	219y5a0166	Shaik Nasar	V	C	C.E
41	219y5a0170	T.Hemanth Kumar	V	C	C.E
42	199Y1A0101	Boggiti Avinash Kumar	VII	A	C.E
43	199y1a0102	B.Sampurna Rani	VII	A	C.E
44	199Y1A0103	Byrisetty Suryanarayana	VII	A	C.E
45	199Y1A0106	C.Haritha	VII	A	C.E
46	199y1a0107	Dantham Arunkumar	VII	A	C.E
47	199Y1A0108	Dhamerla Anusha	VII	A	C.E
48	199y1a0115	Hachhulukatte Faheem	VII	A	C.E
49	199Y1A0116	Janapati Venkata Sai	VII	A	C.E
50	199y1a0119	K Vekrishna Yadav	VII	A	C.E
51	199Y1A0120	Kola Kejiya	VII	A	C.E
52	199Y1A0122	Kumbhagiri Nagarathna	VII	A	C.E
53	199y1a0127	Moram Yagna Priya	VII	A	C.E
54	199Y1A0136	Phatan Arfathulla Khan	VII	A	C.E
55	199Y1A0141	Ragi Divya	VII	A	C.E

56	199Y1A0143	Ravella Hima Bindu	VII	A	C.E
57	199Y1A0144	Sako Sadamini	VII	A	C.E
58	199Y1A0146	Salivemula.Mahammad	VII	A	C.E
59	199Y1A0147	Sandolla Sudharshan	VII	A	C.E
60	199Y1A0149	Savali Nagarjuna	VII	A	C.E
61	199Y1A0151	Shaik Babavazeeru	VII	A	C.E
62	199y1a0153	Shaik Imran	VII	A	C.E
63	199y1a0156	Shaik Muhammad Aatif	VII	A	C.E
64	199Y1A0145	Salindra Pavan Kumar Reddy	VII	A	C.E
65	199Y1A0157	Shaik Mustan	VII	B	C.E
66	199Y1A0158	Sirangi Kavitha	VII	B	C.E
67	199Y1A0159	S. Venkata Sai Pavan	VII	B	C.E
68	199Y1A0160	S Rajeshreddy	VII	B	C.E
69	199y1a0161	Suraboina Surendra	VII	B	C.E
70	199Y1A0162	Syed Mohammed Junaid	VII	B	C.E
71	199y1a0163	Syed Zareena Tasneem	VII	B	C.E
72	199Y1A0164	Thummala Anil Kumar Reddy	VII	B	C.E
73	199Y1A0166	U. V. Sai Yeshaswini	VII	B	C.E
74	199Y1A0167	Vadde Chandra Sekhar	VII	B	C.E
75	199Y1A0168	V. S. Fayaz Hussain	VII	B	C.E
76	199Y1A0170	Yambadi Prathyusha	VII	B	C.E
77	199y1a0172	Y. Bramhini	VII	B	C.E
78	199y1a0174	Y. Mounika	VII	B	C.E
79	209y5a0101	Amari Supraja	VII	B	C.E
80	209Y5A0102	Mahesh Amruthapuri	VII	B	C.E
81	209y5a0111	C Rupesh	VII	B	C.E
82	209Y5A0112	Chakali Upendra	VII	B	C.E
83	209Y5A0116	Derangula Sivanityam	VII	B	C.E
84	209Y5A0123	G.V.Chandana	VII	B	C.E
85	209y5a0125	Indla Chinna Prasad	VII	B	C.E
86	209Y5A0128	Jukuru Kalinga	VII	B	C.E
87	209Y5A0131	K Dharmateja	VII	B	C.E

88	209Y5A0133	Kondakind Bhanu Prasad	VII	B	C.E
89	209Y5A0134	Kondapuram Ramakrishna	VII	B	C.E
90	209Y5A0135	Kummara Mallikarjuna	VII	B	C.E
91	219Y5A0167	Shaik Thakkalla Yunus	VII	C	C.E
92	209Y5A0137	L. Dwarakanath Reddy	VII	C	C.E
93	209y5a0139	Maduru Venkata Naveen Kumar	VII	C	C.E
94	209Y5A0143	Matamkari Ganesh	VII	C	C.E
95	209y5a0155	P.Viswa Karthik	VII	C	C.E
96	209Y5A0161	P. Lalshmana	VII	C	C.E
97	209Y5A0165	Sai Pallavi Proddatur	VII	C	C.E
98	209Y5A0173	Shaik Sayyad Basha	VII	C	C.E
99	209Y5A0189	Yerragorla Naga Mahendra	VII	C	C.E

Coordinator

HOD, C.E

Head
Department of Civil Engineering
K.S.R.M. College of Engineering
(Autonomous)
KADAPA 516 003. (A.P.)

K.S.R.M. COLLEGE OF ENGINEERING

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Department of Civil Engineering

Certification course on "**Storm Water Drainage System Design**"

Date	Timing	Course Instructor	Topic to be covered
19/09/2022	3 PM to 6 PM	Dr. T. Kiran Kumar, Professor, Dept. of C.E, KSRMCE.	Introduction, Status of urban drainage systems in India.
20/09/2022	3 PM to 6 PM	Dr. T. Kiran Kumar, Professor, Dept. of C.E, KSRMCE.	Causes of urban flooding and Need for storm water drainage system.
21/09/2022	3 PM to 6 PM	Dr. T. Kiran Kumar, Professor, Dept. of C.E, KSRMCE.	Objectives of planning and investigation, Data collection
22/09/2022	3 PM to 6 PM	Dr. T. Kiran Kumar, Professor, Dept. of C.E, KSRMCE.	Survey and investigation, Permission, Environmental consideration
23/09/2022	3 PM to 6 PM	Dr. T. Kiran Kumar, Professor, Dept. of C.E, KSRMCE.	Hydraulic Design Of Strom Water Drainage System, Inlet locations, Manholes and is locations, Pumping of storm runoff, Outfall structure
24/09/2022	3 PM to 6 PM	Dr. T. Kiran Kumar, Professor, Dept. of C.E, KSRMCE.	Natural stream/river, Instructional arrangement and capacity building, DPR Preparation.
26/09/2022	3 PM to 6 PM	Dr. T. Kiran Kumar, Professor, Dept. of C.E, KSRMCE.	Rain Fall Analysis, Measurements of rainfall, Steps for rainfall analysis, Alternative method of rainfall analysis,
27/09/2022	3 PM to 6 PM	Dr. T. Kiran Kumar, Professor, Dept. of C.E, KSRMCE.	Runoff estimation, Estimation of runoff from rainfall, Methods of runoff Estimation.
28/09/2022	3 PM to 6 PM	Dr. T. Kiran Kumar, Professor, Dept. of C.E, KSRMCE.	Hydraulic Design Of Strom Water Drains Strom water Flows in conduits
29/09/2022	3 PM to 6 PM	Dr. T. Kiran Kumar, Professor, Dept. of C.E, KSRMCE.	Strom water Flows in conduits and Design for surface drainage.
30/09/2022	3 PM to 6 PM	Dr. T. Kiran Kumar, Professor, Dept. of C.E, KSRMCE.	Design for subsurface drainage and a brief revision.

Instructor:

Dr. T. Kiran Kumar, Professor, CED

Coordinator:

K. Pramod, Assist. Prof., CED

HOD, C.E

Head
Department of Civil Engineering
K.S.R.M. College of Engineering
(Autonomous)
KADAPA 516 003. (A.P.)

Syllabus for Certification Course
Course Name: Storm Water Drainage System Design

UNIT-1: INTRODUCTION

General, Status of urban drainage systems in India, Causes of urban flooding, Need for storm water drainage system.

UNIT-2: PROJECT PLANNING AND INVESTIGATION

Objectives of planning and investigation, Data collection, Survey and investigation, Permission, Environmental consideration

UNIT-3: HYDRAULIC DESIGN OF STROM WATER DRAINAGE SYSTEM

Inlet locations, Manholes and is locations, Pumping of storm runoff, Outfall structure, Natural stream/river, Instructional arrangement and capacity building, DPR Preparation

UNIT-4: RAIN FALL ANALYSIS

General, Measurements of rainfall, Steps for rainfall analysis, Alternative method of rainfall analysis, Runoff estimation, Estimation of runoff from rainfall, Methods of runoff Estimation.

UNIT-5: HYDRAULIC DESIGN OF STROM WATER DRAINS

Strom water Flows in channels & conduits, Design consideration for surface/ subsurface drainage.

Textbooks:

1. Stormwater Collection Systems Design Handbook:(McGraw-Hill Handbooks) 1st Edition by Larry W. Mays
2. Design of Urban Stormwater Controls: MOP 23 (2) (Wef Manual of Practice, 23)
3. Manual on storm water drainage system by CPHEEO

Department of Civil Engineering

Name of the Event: Certification course on "Storm Water Drainage System Design"

List of Participants

Sl.No.	Name of the Student	Roll Number	Sem	Section	Branch	Signature
1	A.Jyoshika	209Y1A0102	V	A	C.E	A.Jyoshika
2	B.Guru Suchitra	209Y1A0105	V	A	C.E	B.G.Suchitra
3	P. Lokanath	209Y1A0158	V	A	C.E	P.Lokanath
4	U.Poojitha	209y1a0189	V	B	C.E	U.Poojitha
5	Velpula Anusha	209y1a0191	V	B	C.E	V.Anusha
6	Y.Anusha Lakshmi	209Y1A0194	V	B	C.E	Y.Anusha
7	Ajjugottu Rajitha	219Y5A0101	V	B	C.E	A.Rajitha
8	B. Anitha	219y5a0104	V	B	C.E	B.Anitha
9	Chinthakuntla Narendra Reddy	219y5a0114	V	B	C.E	C.Narendra Reddy
10	Gogula Avinash	219Y5A0121	V	C	C.E	G.Avinash
11	Kamireddy Jaipal Reddy	219Y5A0126	V	C	C.E	K. Jaipal Reddy
12	Kethavaram Gangdhar	219y5a0130	V	C	C.E	K.Gangadhar.
13	K.Sree Kavya	219y5a0131	V	C	C.E	K.Sreekavya.
14	Kummari Dastagiri	219Y5A0133	V	C	C.E	K.Dastagiri
15	Subhash Kunchapu	219Y5A0134	V	C	C.E	K.Subhash.
16	Lodi Naveen	219Y5A0137	V	C	C.E	L.Naveen
17	Mekala Chennakeshavulu	219Y5A0145	V	C	C.E	M.chenna keshavulu
18	N.Shiva Kishor	219Y5A0147	V	C	C.E	N.Shiva Kishor
19	N.Shankar	219y5a0148	V	C	C.E	N.Shankar
20	N.Malleswari Devi	219Y5A0149	V	C	C.E	N. Malleswari Devi
21	Palla Yogendra	219y5a0151	V	C	C.E	P.Yogendra
22	Pasupuleti Sai Charan	219Y5A0152	V	C	C.E	P.SaiCharan
	Ratala Chandra Sekhar	219Y5A0159	V	C		R.Chandra.Sekhar

23	M.Harshavardhan	199Y1A0[illegible]	VII	A	C.E	[illegible]
24	Shaik.Mahaboob Bee	219y5a0163	V	C	C.E	S. Mahaboob Bee
25	Shaik Mohammed Zuber	219Y5A0165	V	C	C.E	Zuber
26	Shaik Nasar	219y5a0166	V	C	C.E	Nasar
27	Boggiti Avinash Kumar	199Y1A0101	VII	A	C.E	B. Avinash kumar
28	Byrisetty Suryanarayana	199Y1A0103	VII	A	C.E	[illegible]
29	C.Haritha	199Y1A0106	VII	A	C.E	C. Haritha
30	Dantham Arun kumar	199y1a0107	VII	A	C.E	[illegible]
31	Janapati Venkata Sai	199Y1A0116	VII	A	C.E	[illegible]
32	K Vckrishna Yadav	199y1a0119	VII	A	C.E	[illegible]
33	Kola Kejiya	199Y1A0120	VII	A	C.E	K. Kejiya
34	Kumbhagiri Nagarathna	199Y1A0122	VII	A	C.E	K. Nagarathna
35	Moram Yagna Priya	199y1a0127	VII	A	C.E	M. Yagna Priya
36	Ragi Divya	199Y1A0141	VII	A	C.E	R. Divya
37	Ravella Hima Bindu	199Y1A0143	VII	A	C.E	R. Hima Bindu
38	Sake Sadamini	199Y1A0144	VII	A	C.E	S. Sadamini
39	Salivemula.Mahammad	199Y1A0146	VII	A	C.E	S. Mahammad
40	Sandella Sudharshan	199Y1A0147	VII	A	C.E	S. Sudharshan
41	Savali Nagarjuna	199Y1A0149	VII	A	C.E	S. Nagarjuna
42	Shaik Imran	199y1a0153	VII	A	C.E	S. Imran
43	Shaik Muhammad Aatif	199y1a0156	VII	A	C.E	Aatif
44	Salindra Pavan Kumar Reddy	199Y1A0145	VII	A	C.E	S. Pavan [illegible]
45	Sirangi Kavitha	199Y1A0158	VII	B	C.E	S. Kavitha
46	S. Venkata Sai Pavan	199Y1A0159	VII	B	C.E	S.V. Sai Pavan
47	S Rajeshreddy	199Y1A0160	VII	B	C.E	S. Rajesh Reddy.
48	Syed Mohammed Junaid	199Y1A0162	VII	B	C.E	S. Junaid
49	Syed Zareena Tasneem	199y1a0163	VII	B	C.E	Zareena
50	Thummala Anil Kumar Reddy	199Y1A0164	VII	B	C.E	T. Anil [illegible]
51	U. V. Sai Yeshaswini	199Y1A0166	VII	B	C.E	U.V. Sai Yeshaswini
52	Vadde Chandra Sekhar	199Y1A0167	VII	B	C.E	V. Chandra Sekhar
53	V. S. Fayaz Hussain	199Y1A0168	VII	B	C.E	V.S Fayaz Hussain
54	Yambadi Prathyusha	199Y1A0170	VII	B	C.E	Y. Prathyusha

55	Y. Bramhini	199y1a0172	VII	B	C.E	
56	Amari Supraja	209y5a0101	VII	B	C.E	
57	C Rupesh	209y5a0111	VII	B	C.E	
58	Chakali Upendra	209Y5A0112	VII	B	C.E	
59	G.V.Chandana	209Y5A0123	VII	B	C.E	
60	K. Bhanu Prasad	209Y5A0133	VII	B	C.E	
61	L. Dwarakanath Reddy	209Y5A0137	VII	C	C.E	
62	Maduru Venkata Naveen Kumar	209y5a0139	VII	C	C.E	
63	Matamkari Ganesh	209Y5A0143	VII	C	C.E	
64	P.Viswa Karthik	209y5a0155	VII	C	C.E	
65	P. Lakshmana	209Y5A0161	VII	C	C.E	
66	Shaik Sayyad Basha	209Y5A0173	VII	C	C.E	
67	Yerragorla Naga Mahendra	209Y5A0189	VII	C	C.E	

Coordinator

HOD, C.E

Head
Department of Civil Engineering
K.S.R.M. College of Engineering
(Autonomous)
KADAPA 516 003. (A.P.)

Department of Civil Engineering

Name of the Event: Certification course on "Storm Water Drainage System Design"

Daily Attendance 19/09/2022 to 30/09/2022

Sl.No.	Name of the Student	Roll Number	Sem	Sec	19/09	20/09	21/09	22/09	23/09	24/09	26/09	27/09	28/09	29/09	30/09
1	A.Jyoshika	209Y1A0102	V	A	A	A	A	1	1	A	A	A	1	A	1
2	B.Guru Suchitra	209Y1A0105	V	A	A	A	A	1	1	A	A	A	1	A	1
3	P. Lokanath	209Y1A0158	V	A	1	1	A	1	1	A	A	A	1	1	1
4	U.Poojitha	209y1a0189	V	B	1	1	A	1	1	A	A	1	1	1	A
5	V ANUSHA	209y1a0191	V	B	1	1	A	1	1	A	A	1	1	1	1
6	Y.Anusha Lakshmi	209Y1A0194	V	B	1	1	A	1	1	A	A	1	1	1	1
7	Ajjugottu Rajitha	219Y5A0101	V	B	A	1	A	1	1	A	A	1	1	A	1
8	B. Anitha	219y5a0104	V	B	A	1	A	1	1	A	A	1	1	A	1
9	C Narendra reddy	219y5a0114	V	B	1	1	A	1	1	A	A	1	1	1	1
10	GOGULA AVINASH	219Y5A0121	V	C	1	1	A	1	1	A	A	1	1	1	A
11	K. jaipal reddy	219Y5A0126	V	C	1	A	A	1	1	A	A	A	1	1	1
12	K. Gangdhar	219y5a0130	V	C	1	1	A	1	A	A	A	A	1	A	1
13	K.sree kavya	219y5a0131	V	C	A	1	A	1	1	A	A	1	1	A	1
14	KUMMARI DASTAGIRI	219Y5A0133	V	C	A	A	A	1	1	A	A	A	1	1	1
15	Subhash kunchapu	219Y5A0134	V	C	1	1	1	1	A	A	A	A	1	A	1
16	LODI NAVEEN	219Y5A0137	V	C	1	1	A	1	A	A	A	1	1	1	1
17	M. Chennakeshavulu	219Y5A0145	V	C	1	1	1	1	1	A	1	1	1	1	A
18	N.SHIVA KISHOR	219Y5A0147	V	C	1	1	1	A	1	A	A	1	1	1	1
19	N.shankar	219y5a0148	V	C	A	1	1	1	1	A	A	1	1	1	1
20	N.Malleswari devi	219Y5A0149	V	C	1	1	A	1	1	1	A	1	1	1	1
21	PALLA YOGENDRA	219y5a0151	V	C	1	1	1	1	1	1	A	1	1	1	A
22	P SAI CHARAN	219Y5A0152	V	C	1	1	A	1	A	A	A	A	1	A	1
23	R Chandra sekhar	219Y5A0159	V	C	1	1	A	1	1	1	A	1	1	1	1
24	Shaik.Mahaboob bee	219y5a0163	V	C	1	1	1	1	A	1	A	A	1	1	1
25	S Mohammed Zuber	219Y5A0165	V	C	1	1	1	A	A	A	A	1	1	1	1
26	Shaik Nasar	219y5a0166	V	C	1	1	1	1	A	1	A	1	1	1	1
27	B AVINASH KUMAR	199Y1A0101	VII	A	A	A	A	1	1	A	A	1	1	A	1
28	B Suryanarayana	199Y1A0103	VII	A	1	A	A	A	A	A	1	1	1	A	1
29	C.HARITHA	199Y1A0106	VII	A	1	1	1	A	A	A	1	1	1	A	1

31	Janapati venkata sai	199Y1A0116	VII	A	A	1	A	1	1	A	1	1	1	1	1
32	K Vekrishna Yadav	199y1a0119	VII	A	A	A	1	1	A	A	A	A	1	1	1
33	Kola Kejiya	199Y1A0120	VII	A	A	A	A	1	1	A	1	1	1	A	1
34	K NAGARATHNA	199Y1A0122	VII	A	1	1	A	1	A	A	1	1	1	A	1
35	M YAGNA PRIYA	199y1a0127	VII	A	1	1	A	1	1	A	1	1	1	A	1
36	RAGI DIVYA	199Y1A0141	VII	A	1	1	A	1	1	A	1	1	1	A	1
37	R HIMA BINDU	199Y1A0143	VII	A	1	1	1	1	1	A	1	1	1	1	1
38	SAKE SADAMINI	199Y1A0144	VII	A	1	A	A	1	1	A	1	1	1	A	1
39	S.MAHAMMAD	199Y1A0146	VII	A	1	1	1	1	1	A	1	1	1	A	1
40	S SUDHARSHAN	199Y1A0147	VII	A	A	A	1	1	1	A	1	A	1	1	1
41	S NAGARJUNA	199Y1A0149	VII	A	1	1	1	1	1	A	A	1	1	1	1
42	Shaik imran	199y1a0153	VII	A	1	1	A	A	1	1	A	A	1	1	1
43	S Muhammad Aatif	199y1a0156	VII	A	1	1	A	1	A	1	A	1	1	1	1
44	S. Pavan kumar reddy	199Y1A0145	VII	A	A	1	1	1	A	A	1	1	1	A	A
45	SIRANGI KAVITHA	199Y1A0158	VII	B	1	A	A	A	1	A	A	A	1	A	1
46	S. Venkata Sai Pavan	199Y1A0159	VII	B	1	1	A	1	1	A	A	1	1	1	1
47	S Rajesh Reddy	199Y1A0160	VII	B	1	A	1	A	1	1	1	1	1	1	1
48	S Mohammed Junaid	199Y1A0162	VII	B	1	1	1	1	1	A	A	1	1	1	1
49	Syed Zareena Tasneem	199y1a0163	VII	B	1	1	A	1	1	A	A	1	1	1	1
50	T. Anil kumar reddy	199Y1A0164	VII	B	1	1	A	1	1	A	A	1	1	1	1
51	U. V. Sai Yeshaswini	199Y1A0166	VII	B	1	1	1	1	1	A	A	1	1	A	1
52	V Chandra Sekhar	199Y1A0167	VII	B	1	A	1	A	1	1	1	1	1	1	1
53	V. S. Fayaz Hussain	199Y1A0168	VII	B	1	1	A	1	1	A	A	1	1	1	1
54	Y PRATHYUSHA	199Y1A0170	VII	B	1	1	A	A	1	A	A	1	1	A	1
55	Y. Bramhini	199y1a0172	VII	B	1	A	A	A	A	A	A	1	1	A	1
56	Amari supraja	209y5a0101	VII	B	A	A	A	A	1	A	1	1	1	A	1
57	C Rupesh	209y5a0111	VII	B	1	1	A	1	A	A	A	1	1	A	A
58	C. Upendra	209y5a0112	VII	B	1	1	1	1	1	1	1	1	1	1	1
59	G.v.chandana	209Y5A0123	VII	B	A	1	A	1	1	A	A	1	1	A	1
60	K. Bhanu Prasad	209Y5A0133	VII	B	A	A	A	1	1	A	A	1	1	A	1
61	L. Dwarakanath Reddy	209Y5A0137	VII	C	1	1	A	1	1	A	A	1	1	A	1
62	M. Venkata Naveen Kumar	209y5a0139	VII	C	1	1	A	A	1	1	A	1	1	A	1
63	M GANESH	209Y5A0143	VII	C	1	1	A	1	1	A	1	1	1	A	1

65	P. LALSHMANA	209Y5A0161	VII	C	1	1	A	1	1	A	1	1	1	1	1
66	S SAYYAD BASHA	209Y5A0173	VII	C	1	1	A	1	1	A	1	1	1	1	1
67	Y Naga Mahendra	209Y5A0189	VII	C	1	1	A	A	1	1	1	1	1	A	1

Coordinator

HoD

Head
Department of Civil Engineering
K.S.R.M. College of Engineering
(Autonomous)
KADAPA 516 003. (A.P.)

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ACTIVITY REPORT

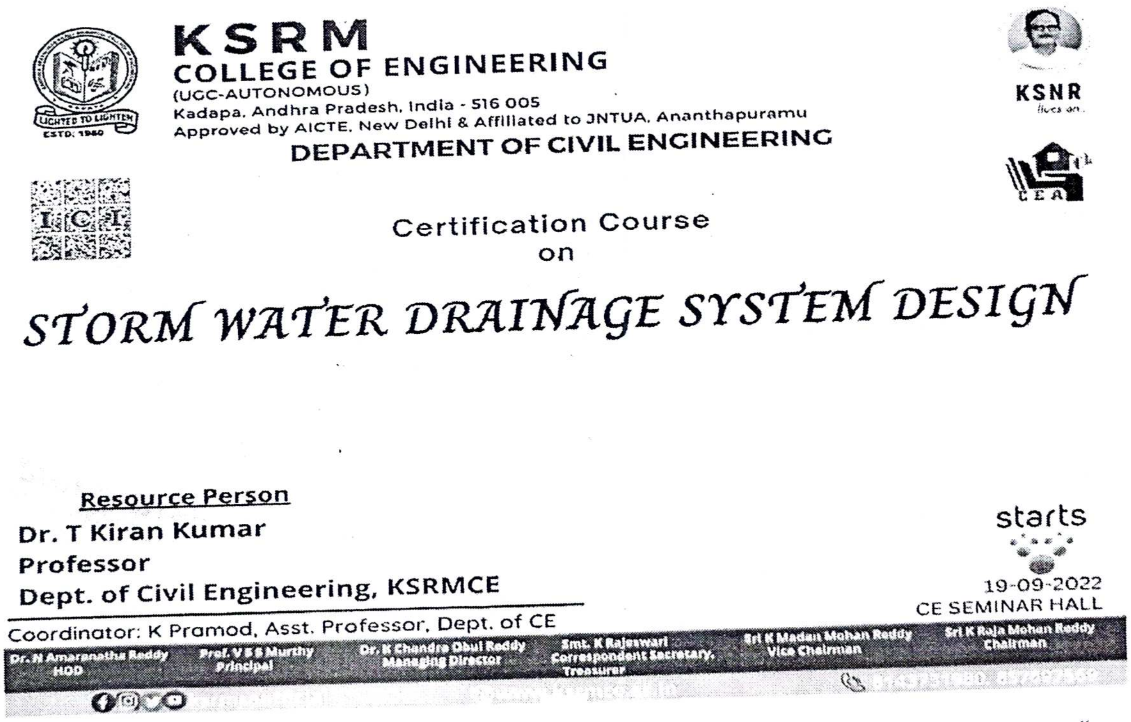
Certification Course

On

"Storm Water Drainage System Design"

19th September, 2022 to 30th September, 2022

Target Group	:	**V & VII SEM Students**
Details of Participants	:	**67 Students**
Co-Ordinator	:	**Sri. K. Pramod**
Organizing Department	:	**Civil Engineering**
Venue	:	**CE Seminar Hall**



Poster of the Event: Certification Course on "Storm Water Drainage System Design"

REPORT

Resource Person: Dr. T. Kiran Kumar, Professor, Dept. of C.E, KSRMCE.

The importance of Certification Course on REVIT: Storm water is that water originates during the precipitation. It may also be use to apply to water that originates with snow melt that enters the storm water system. If storm water does not soak in to the ground, it becomes surface runoff which either flows directly in the surface water ways or it channelled into storm drain lines which then after gets drained into that particular surface. Here the process to plan, design, construct and manage a proper drainage system can be taught.

The theme of the Certification Course:
The main theme of the present certification course was to enhance the knowledge on Storm water drainage system design to students and give exposure from skilled resource person. The main theme of this certification course is to expose the scope of Drainage system design to students and to enhance their knowledge.

The sequence of the Certification course :
The Certification course was arranges by Department of Civil Engineering for the B.Tech. V & VII Semester students. The venue was CE Seminar Hall, KSRMCE. The course was planned for Eleven days from 19th to 30th September, 2022. Each day Certification course was organized for three hours form 3 PM to 6 PM. All the sessions were hosted by Dr. T. Kiran Kumar, Sri. K. Pramod. A total of 67 students of Department of Civil Engineering were actively participated in the Certification course.

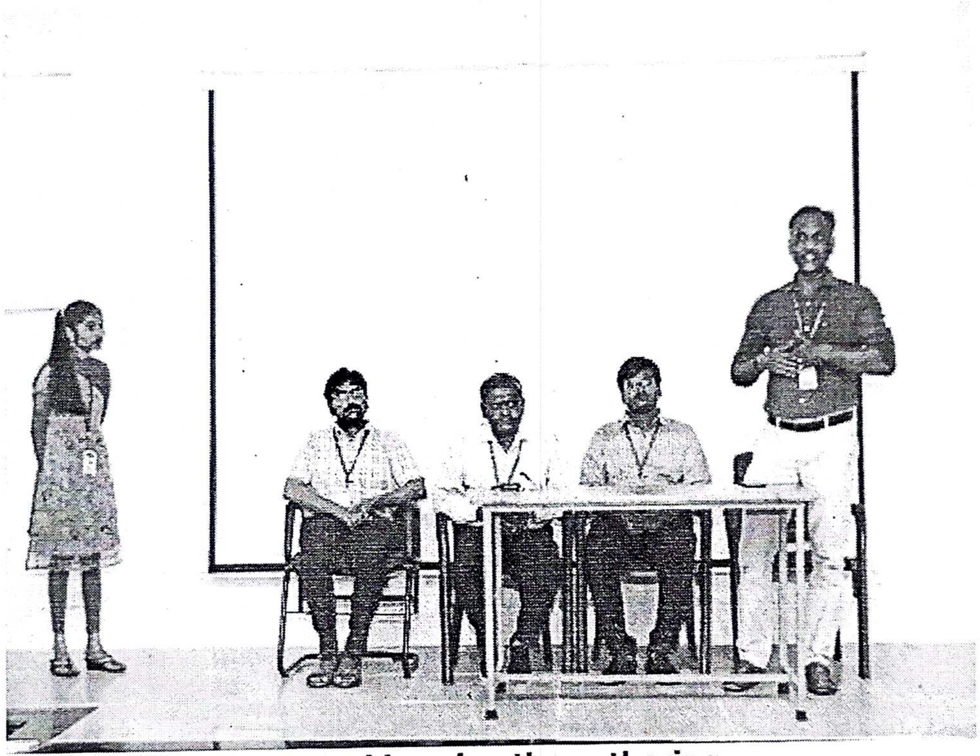
Welcome speech:
Sri. K. Pramod (Coordinator of the event), Assistant Professor, Department of Civil Engineering, KSRMCE expressed a very warm welcome to the HOD, Resource person and students of the Civil Engineering Department. Then the coordinator introduced the resource person to the gathering; the brief of their education and professional experiences was read for the audience.

HOD's words:
Dr. N. Amaranatha Reddy, HOD & Associate Professor of the Dept. of Civil Engineering, KSRMCE addressed the gathering by welcoming the Resource Person to the event. HOD shared about the resource person's dedication towards work and capabilities of his profession to the students and how he evolved to stand in this position by continuous improvement. Later he also shared a few problems he faced in his old days due to lack of proper drainage facilities in his village and wished students to concentrate in the certification course.

The detailed contents of the Certification Course:

Session 1 (3 PM to 6 PM, 19th September, 2022):

Resource Person explained the eleven days plan of action of this Certification course as per given schedule. Session one majorly concentrated on the introduction of the course, its importance, problems related to the drainage facilities facing in our surroundings as examples and the decisions taken the government authorities to solve those problems were discussed. The overview of the syllabus was explained by the resource person and plan of action to complete the syllabus and also explained about the final assessment test needed to be completed to get the participation certificate. Later unit 1 was started the Status of urban drainage systems in India was explained.



HoD addressing the gathering

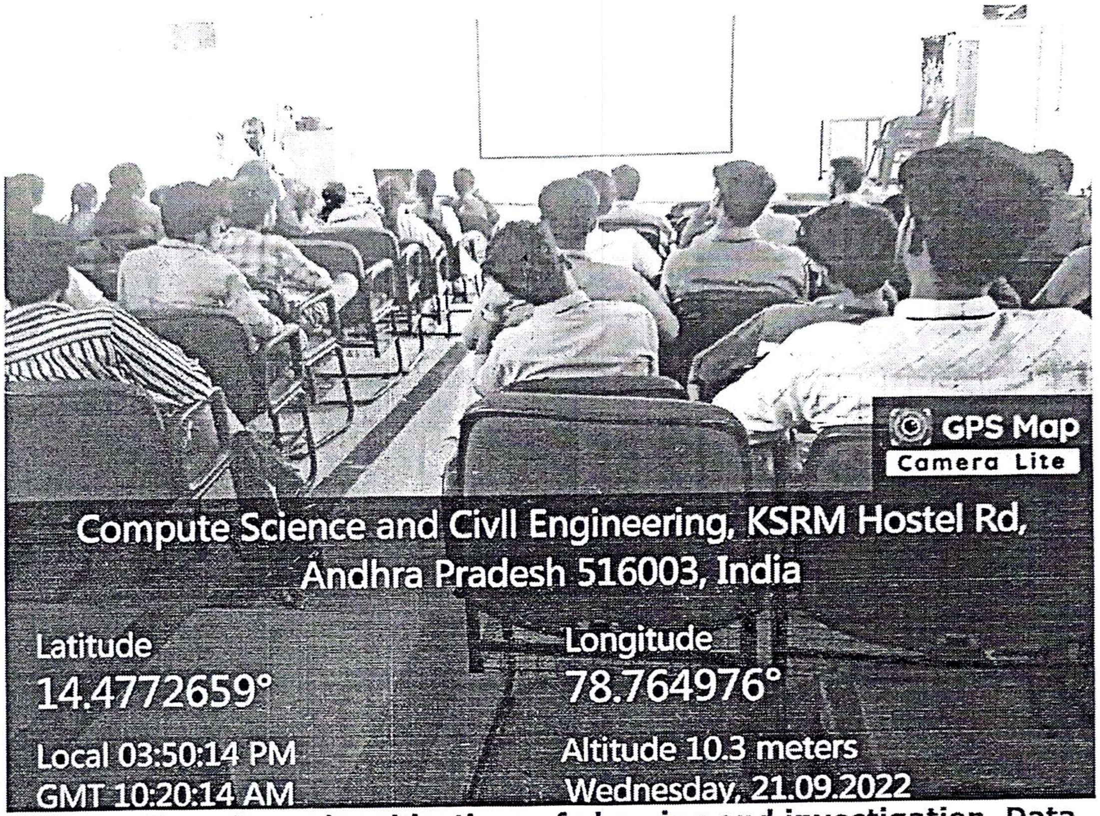
Session 2(3 PM to 6 PM, 20th September, 2022):

Session 2 started with the short revision of Status of urban drainage systems in India and later the resource person explained about the causes of urban flooding. He explanation that the main causes of the urban flooding was High intensity rainfall with higher frequencies. The unplanned urbanization causes considerable increase in impervious areas leading to enhanced surface runoff and frequent flooding, global climate change, Illegal disposal of construction and demolition waste/municipal solid waste coupled with poor maintenance of existing drainage system obstructs the groom runoff causing localized fluidity in the areas. Later the started the concepts of need for the storm water drainage system design.

Explaining about the causes of urban flooding, Need for storm water drainage system.

Session 3 (3 PM to 6 PM, 21st September, 2022):

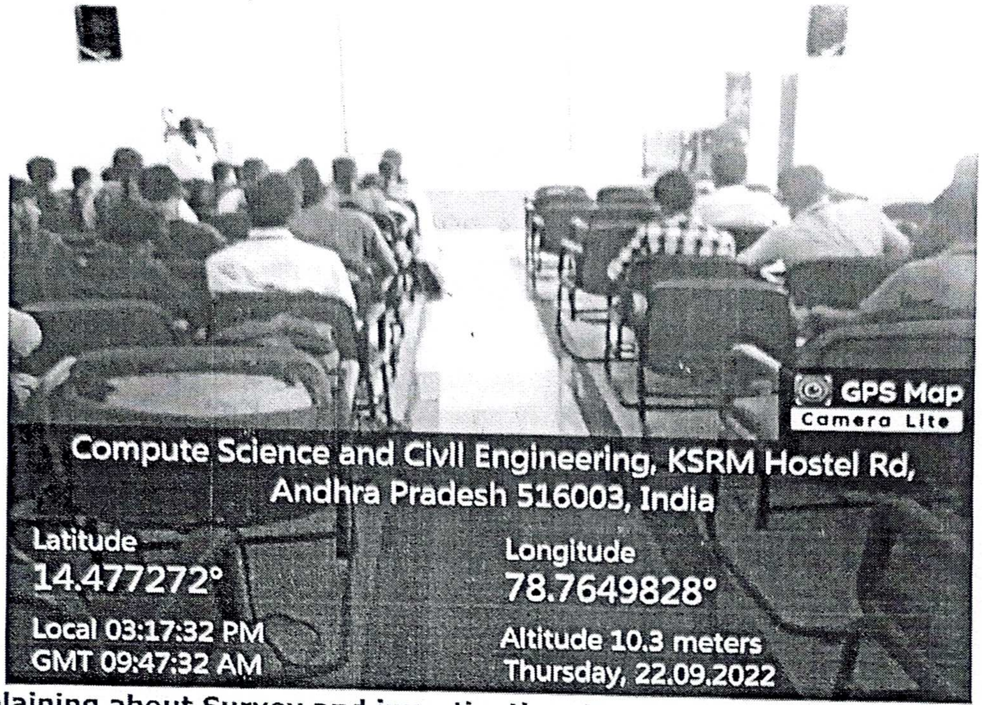
The session 3 was started with the discussion on previous session. The trainer clarified the doubts on previous session asked by the students. In this session the resource person completed the topics like the Objectives of planning and investigation, Data collection. He said that identification and marking of probable drainage zones, direction of gradients and selection of disposal points, Preparation of topographical layout of collection and conveyance, Identification of locations for pumping stations, finding a Strategy for rainwater storage and its recharge to ground water, Strategy for prevention of solid waste and C & D waste into storm water ways. Strategy for arresting pollutants with urban runoff from entering into water bodies Conserving the aesthetic, public safety and other social concerns of recreational open space and landscape to preserve the ecological nature of water ways were the man objectives of planning. Later he discussed about the data collection. The type of data required here is physical, rainfall, waterway characteristics.



Explanation about the objectives of planning and investigation, Data collection

Session 4 (3 PM to 6 PM, 22nd September, 2022):

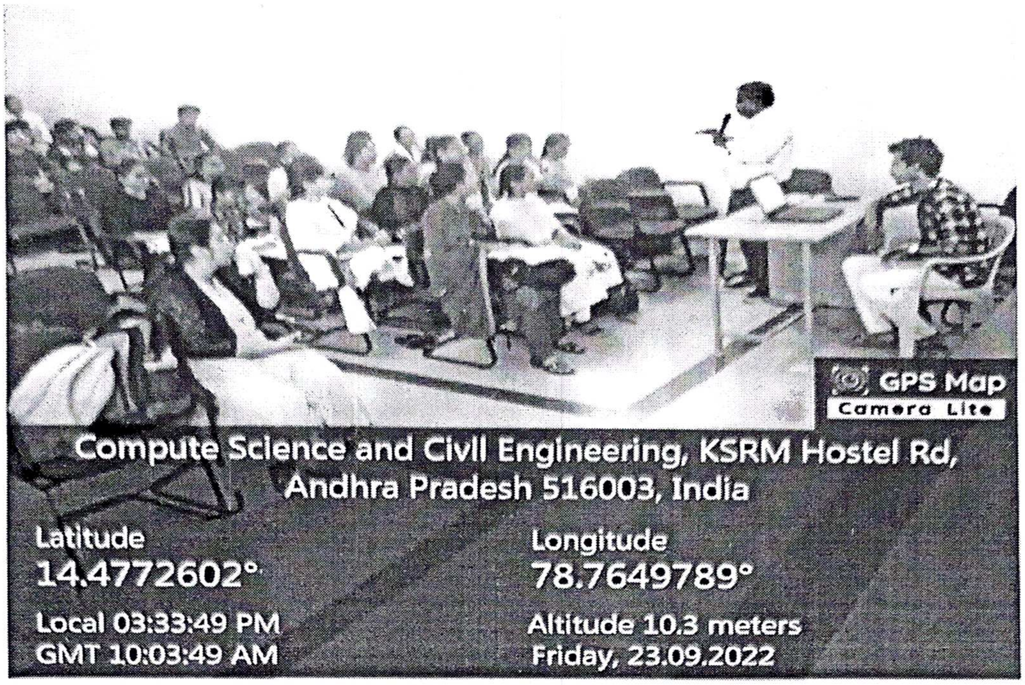
The session started with revision of previous session. The trainer clarified the doubts on previous session asked by the students. This session is mainly concentrated on Survey and investigation, Permission, Environmental consideration that are required in the storm water design system. He explained that the Topographical maps, contour maps and different types of maps and drawings that are needed to study prior to the design. Later he explained about the Environmental considerations to be done by doing an EIA study to the locality by considering the surface water, ground water, coastal water and the landscape of the locality. Later he also discussed about the various permissions and clearance that are required to be taken prior to starting the construction. Resource person clarified a few doubts that are raised by the students at the end.



Explaining about Survey and investigation, Permission and Environmental consideration

Session 5 (3 PM to 6 PM, 23rd September, 2022):

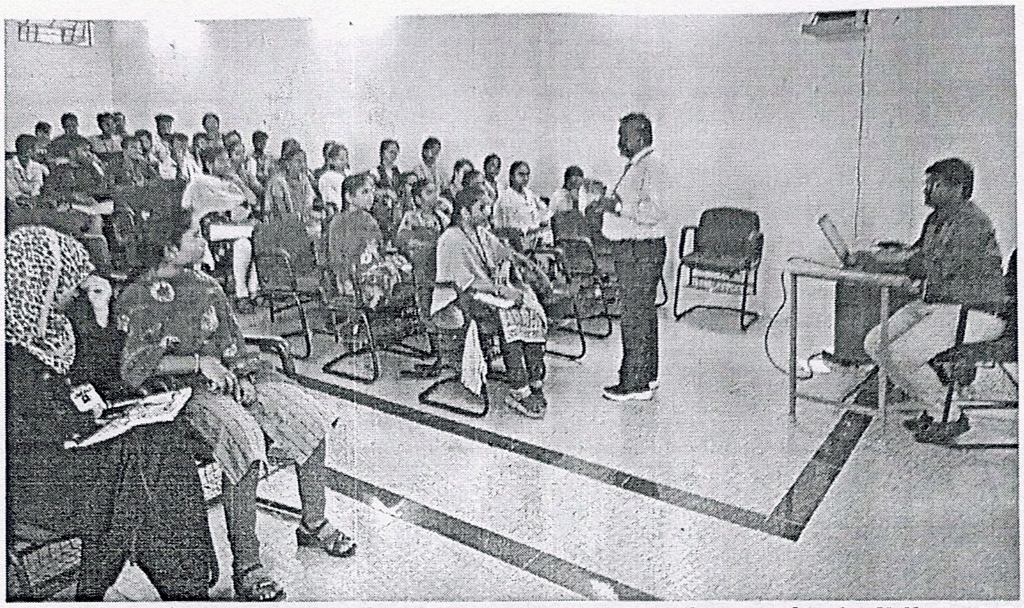
The session started by explanation about the different types of sewer appurtenances that are used in the water drainage system mainly the resource person explains about the inlets and their types and locations, manholes and their functions in sewer lines, catch pits and how it is differ from the inlets, also slight design parameters and where it is to be installed compulsory. Later he also discussed about the various pumping devices that were used along the storm water drainage arrangements. He explained about the outfall structures that an ocean outfall may be conveyed several miles offshore, to discharge by nozzles at the end of a spreader or T-shaped structure. Outfalls may also be constructed as an outfall tunnel or subsea tunnel and discharge effluent to the ocean via one or more marine risers with nozzles.



Explaining about inlet locations, Manholes and is locations, Pumping of storm runoff, Outfall structure

Session 6 (3 PM to 6 PM, 24th September, 2022):

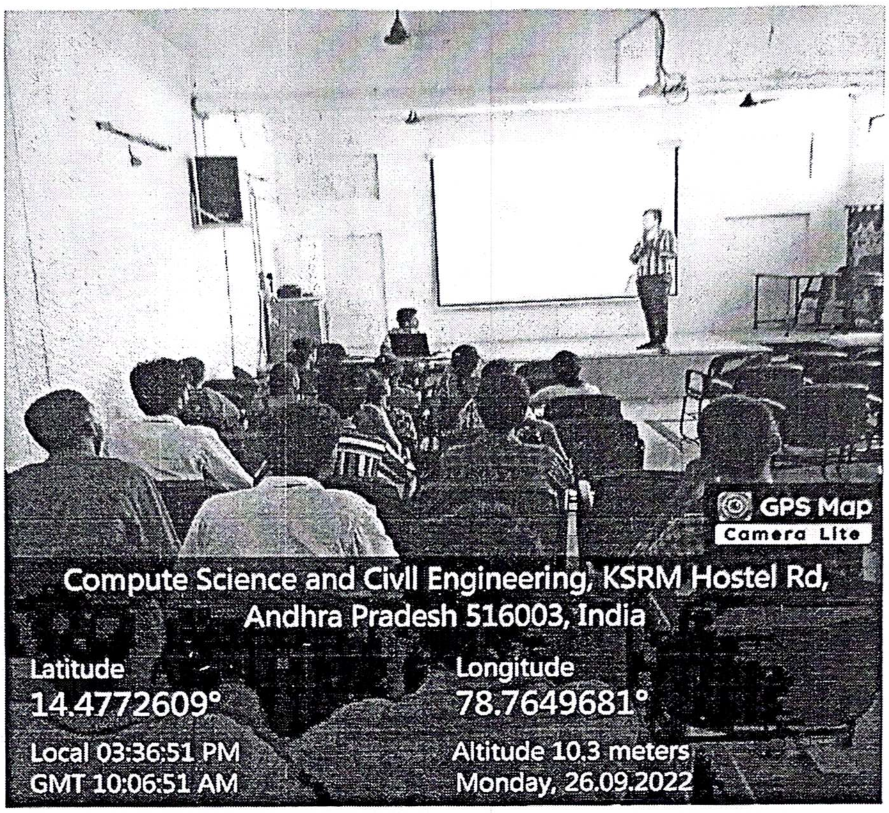
The session started with revision of previous session. The trainer clarified the doubts on previous session asked by the students. This session is mainly concentrated on Natural stream/river, Instructional arrangement and capacity building, DPR Preparation. He explained that the creation of storm water drain infrastructure is one aspect but its periodic maintenance is the key to provide the desired level of services on a sustainable basis. An efficient organization is very important for planning, design, and sustainable operation and maintenance of SWD infrastructure. Therefore, measures must be taken for institutional strengthening and internal capacity building so that the efforts made can be sustained over a period of time and the system put in place can be well managed. Institutional strengthening can be done by adequately decentralizing the administration, delegating adequate powers at the decentralized level, inducting professionals into the administration and providing adequate training to the existing staff. Later he also explained about the DPR Preparation also.



Explaining about Instructional arrangement and capacity building, DPR Preparation.

Session 7 (3 PM to 6 PM, 26th September, 2022):

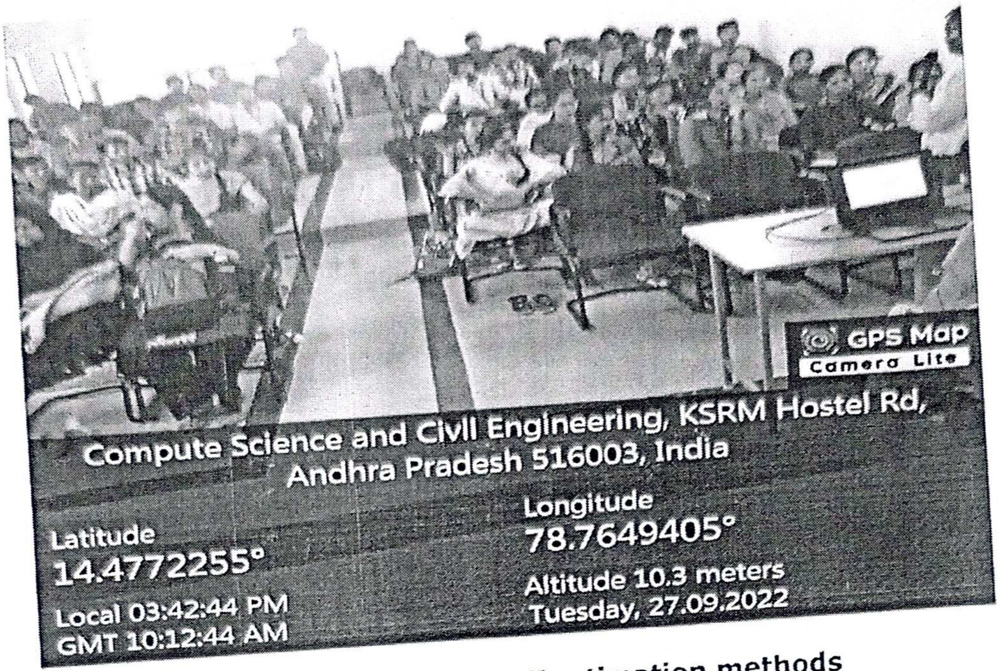
The session started by explanation about how rainfall in any particular area can be analysis by using different types of rain gauges, he also explained clearly about the functions, principles, advantages, disadvantages and limitations of various recording and non recording types of rain gauges with the help of images. He explained about the simon's type non-recording rain gauge and float type, tipping bucket type and weighing type recording type of rain gauges and the suitability of each ran gauge based on the type of locations. Later he moved to rainfall estimation methods, he discussed about different methods like the Rational Method, Time Area Method, Unit Hydrograph Method, Rainfall- Runoff process simulation. In which rational method is the widely used method in designing the storm water drainage system design.



Explaining about Rain Fall Analysis, Rain Fall Estimation

Session 8 (3 PM to 6 PM, 27th September, 2022):

The session started with revision of previous session. The trainer clarified the doubts on previous session asked by the students. This session is mainly concentrated on Runoff estimation, Estimation of runoff from rainfall, Methods of runoff Estimation. Resource person clearly explained about the runoff, causes of runoff and the factors which affects the rate of runoff. Later he explained about the methods to estimate the runoff by using Infiltration indices. Initially he explained about what is an infiltration indices and later he also discussed about the phi-index and w-index concepts, he take a few numerical examples to make the students understand about how to estimate the runoff by using those methods.



Explaining about Runoff estimation methods

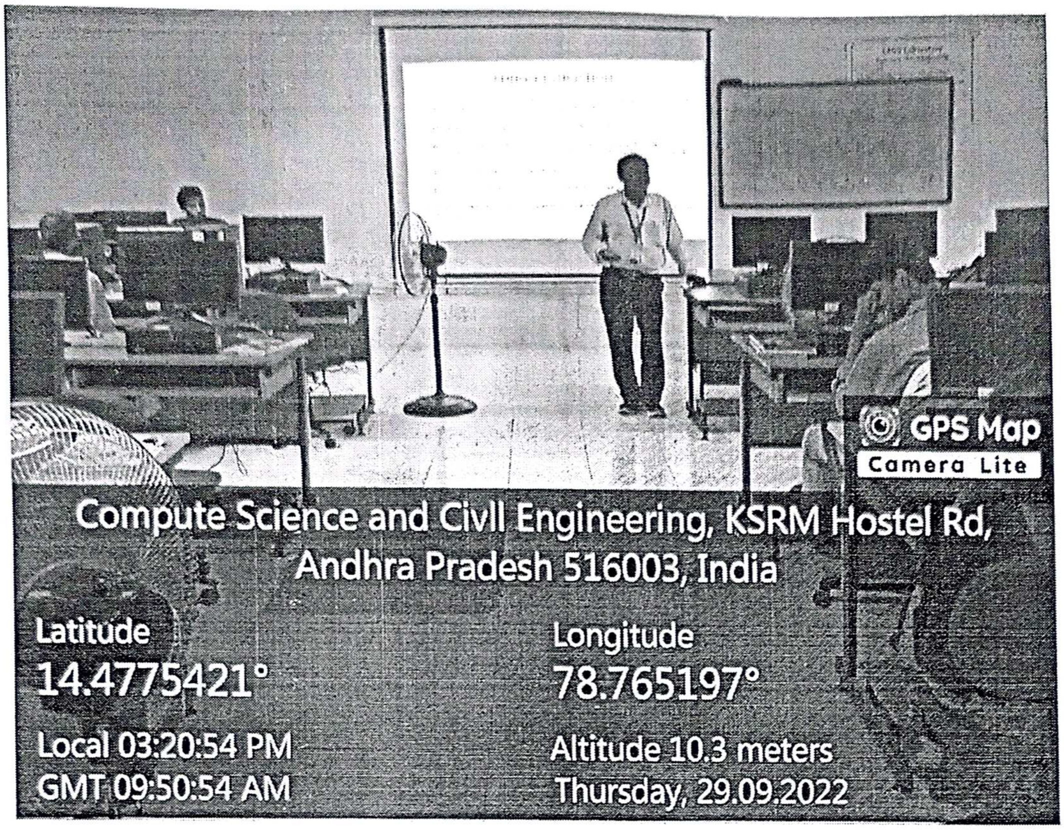
Session 9 (3 PM to 6 PM, 28th September, 2022):

This session concentrated on revision of all the contents which are practiced in previous session. And also concentrated on new topics i.e., Hydraulic Design Of Strom Water Drains Strom water Flows in conduits. In this session the resource person mainly concentrated on the derivations for proportionate depth, proportionate velocity and proportionate discharge for various depth of sewers like when the depth is i)full condition, ii)half full condition, iii)partial full conditions. Few numerical examples were also discussed in the session to built a practical exposure to design problems. Later he also discussed about the different conditions of storm water flow in the conduits.

Explanation about Hydraulic Design Of Strom Water Drains

Session 10 (3 PM to 6 PM, 29th September, 2022):

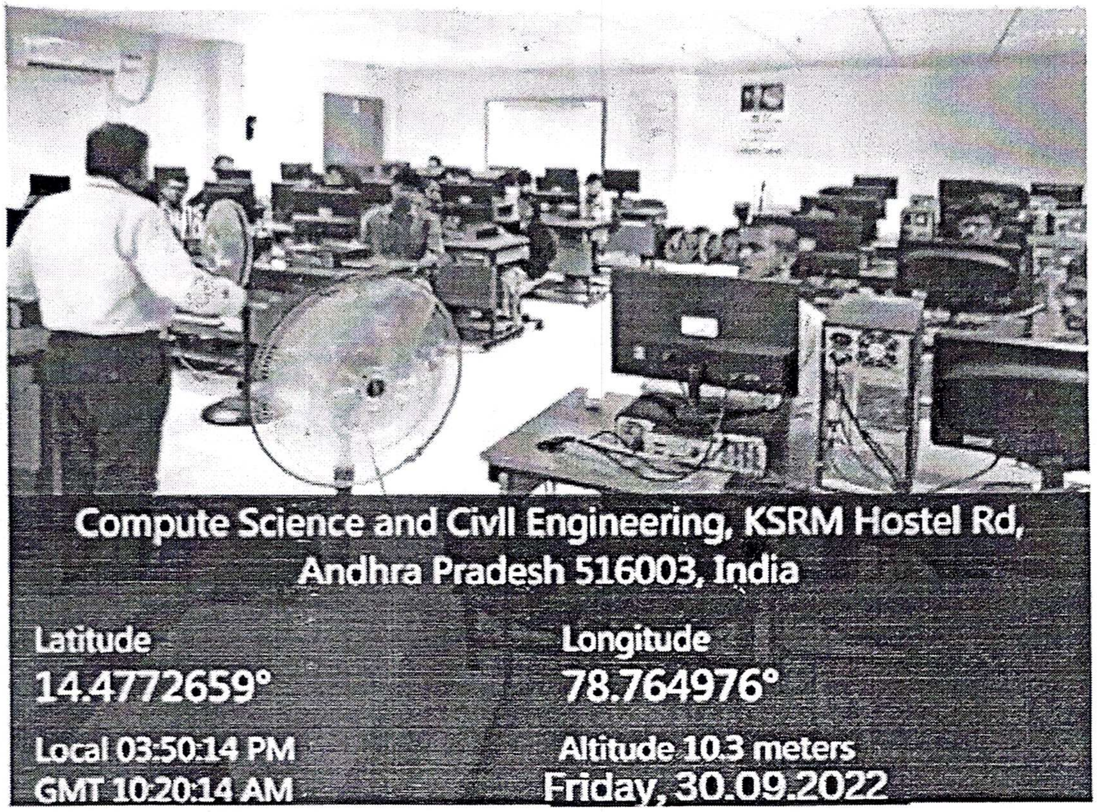
The session started with revision of previous session. Resource person clarified the doubts raised by the students related to previous session. This session is mainly concentrated on Strom water Flows in conduits and Design for surface drainage. He explained that the Storm water conduits are designed for a specific capacity that depends on the upstream conditions and downstream controls. Conduits flowing full operate at, or near, that capacity. Measuring discharge in a full-flowing conduit with a weir is not recommended because weirs reduce the capacity of the conduit and the relationship between discharge and the water surface elevation is not well established without a critical depth. Area-velocity probes, however, can measure discharge without causing significant obstruction in conditions that provide adequate depth over the probe. Later he focused on the design of surface drainage system also.



Explaining about Strom water Flows in conduits and Design for surface drainage.

Session 11 (3 PM to 6 PM, 30th September, 2022):

This session concentrated on revision of all the contents which are discussed in previous session. He concentrated on new topic design of subsurface drainage system. He explained that Pipe drainage is probably the most widely used subsurface drainage method worldwide. Pipe drainage projects can vary widely in scope and size. A project may be a single farm, or it may cover several hectares of land. He discussed about the most important considerations that lead to a designed spatial arrangement of a subsurface drainage system in an area. These considerations involve the choice between a singular system and a composite system, the location and alignment of drains, subsurface drainage in rice fields as a special case, and the use of multiple small pumping stations. A brief explanation on singular and composite drainage systems is discussed.



Explanation about the design for subsurface drainage

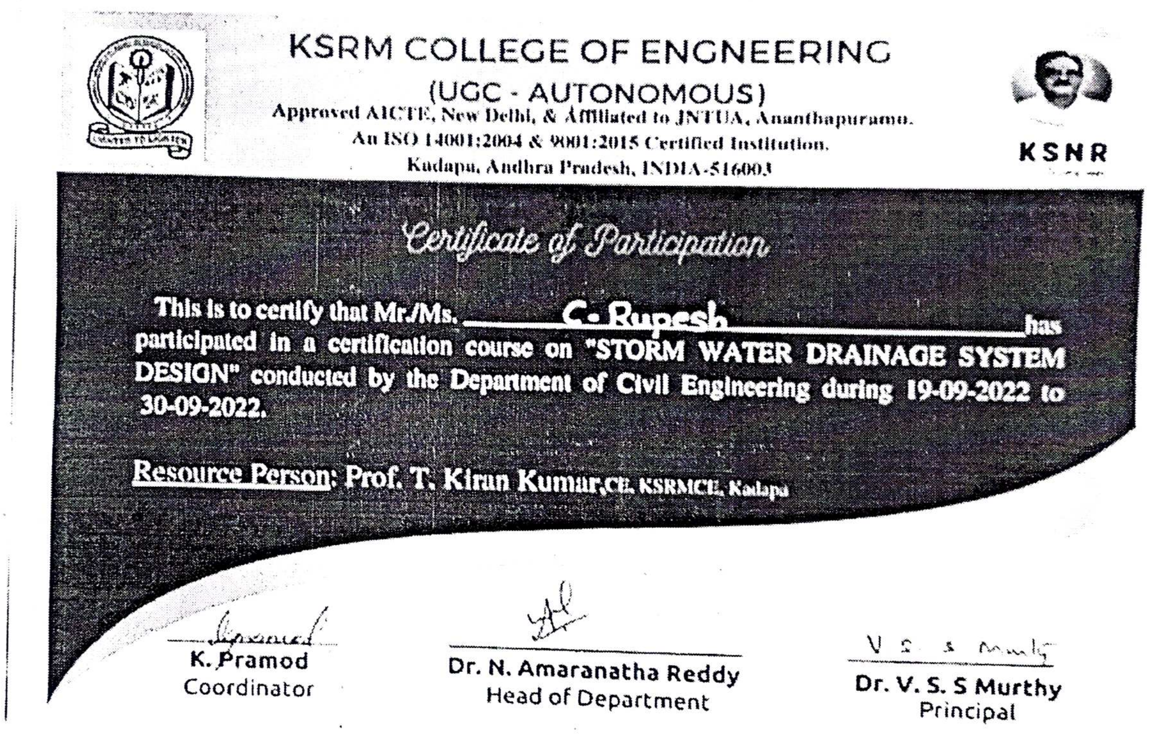
Final Assessment Test (1 PM to 2 PM, 3rd November, 2022):

Offline based final assessment for the certification course is conducted with a 50 questions consisting of 45 multiple choice questions and 5 fill in the blank questions. The questions were related to the course only. The exam was conducted for one hour, all the students took the exam, the answer sheets were evaluated and the top 3 ranks (got for 5 students) were given a Certificate of Merit by HoD sir during validation programme.

Final Assessment

HOD's words at end of the Event:
At the end of the workshop, Dr. N. Amaranatha Reddy, HOD, Dept. of Civil Engineering, KSRMCE expressed his regard to the resource person for sharing his knowledge with the students. HOD whished the resource person to conduct more courses like this in future.

Vote of thanks:
Sri. K. Pramod (Coordinator of the event) delivered vote of thanks by thanking the students for their participation, HOD & KSRMCE Management for giving the opportunity to organize such events.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Certificate of Participation

This is to certify that Mr./Ms. C. Rupesh has participated in a certification course on "STORM WATER DRAINAGE SYSTEM DESIGN" conducted by the Department of Civil Engineering during 19-09-2022 to 30-09-2022.

Resource Person: Prof. T. Kiran Kumar,CE, KSRMCE, Kadapa

K. Pramod
Coordinator

Dr. N. Amaranatha Reddy
Head of Department

Dr. V. S. S Murthy
Principal

Certificate of Participation

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This is to certify that Mr./Ms. G.V. Chandana has participated in a certification course on "STORM WATER DRAINAGE SYSTEM DESIGN" conducted by the Department of Civil Engineering during 19-09-2022 to 30-09-2022.

Resource Person: Prof. T. Kiran Kumar,CE, KSRMCE, Kadapa

K. Pramod	Dr. N. Amaranatha Reddy	Dr. V. S. S Murthy
Coordinator	Head of Department	Principal

Certificate of Participation

Coordinator	HOD	V. S. S. Murthy Principal

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Certificate of Participation

This is to certify that Mr./Ms. A.Jyoshika - 209Y1A0102 has participated in a certification course on "STORM WATER DRAINAGE SYSTEM DESIGN" conducted by the Department of Civil Engineering during 19-09-2022 to 30-09-2022.

<u>Resource Person</u>: Prof. T. Kiran Kumar, CE, KSRMCE, Kadapa

K. Pramod	Dr. N. Amaranatha Reddy	Dr. V. S. S Murthy
Coordinator	Head of Department	Principal

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This is to certify that Mr./Ms. B.Guru Suchitra - 209Y1A0105 has participated in a certification course on "STORM WATER DRAINAGE SYSTEM DESIGN" conducted by the Department of Civil Engineering during 19-09-2022 to 30-09-2022.

Resource Person: Prof. T. Kiran Kumar, CE, KSRMCE, Kadapa

K. Pramod	Dr. N. Amaranatha Reddy	Dr. V. S. S Murthy
Coordinator	Head of Department	Principal

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BINDU

Certificate of Participation

This is to certify that Mr./Ms. R. Hima Bindu - 199Y1A0143 has participated in a certification course on "STORM WATER DRAINAGE SYSTEM DESIGN" conducted by the Department of Civil Engineering during 19-09-2022 to 30-09-2022.

Resource Person: Prof. T. Kiran Kumar, CE, KSRMCE, Kadapa

K. Pramod
Coordinator

Dr. N. Amaranatha Reddy
Head of Department

V. S. S. Murthy
Dr. V. S. S Murthy
Principal

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This is to certify that Mr./Ms. P. lakshmana has participated in a certification course on "STORM WATER DRAINAGE SYSTEM DESIGN" conducted by the Department of Civil Engineering during 19-09-2022 to 30-09-2022.

Resource Person: Prof. T. Kiran Kumar, CE, KSRMCE, Kadapa

K. Pramod	Dr. N. Amaranatha Reddy	Dr. V. S. S Murthy
Coordinator	Head of Department	Principal

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DEPARTMENT OF CIVIL ENGINEERING

Certificate course Feedback Form

Your feedback is crucial to ensure we meet your educational needs. We would appreciate it if you could take a few minutes to share your opinions with us so we can serve you better.

Course Title : Stoom water drainage System Design

Resource Person(s) : Dr. T. Kiran Kumar

Date(s) of the course : 19-09-2022 to 30-09-2022

Name of the Student : B. Avinash kumar

Roll No. : 199Y1A0101

S. No.	Item Description	RATING (Please Tick the relevant)		
		LOW	MODERATE	HIGH
1	The content was Clear & Understandable			✓
2	The program was well-paced within the allotted time		✓	
3	The instructor was a good communicator			✓
4	The material was presented in an organized manner			✓
5	The instructor was knowledgeable about the topic		✗	✓
6	I would be interested in attending a follow-up, more advanced workshop on this same subject/any other			✓
7	Given the topic, was this workshop	Too Short	Right Length	Too Long
8	In your opinion, was this workshop	Introductory	Intermediate	Advanced
	Please Rate the following	**LOW**	**MODERATE**	**HIGH**
	a) Visuals		✓	
	b) Acoustics		✓	
	c) Meeting space/Venue			✓
	d) Handouts		✓	
	e) The Overall Program			✓
9	What did you most appreciate/enjoy/think was best about the course? Any suggestions for improvement?			

Please return this form to the instructor or organizer at the end of the course. Thank you.

B. Avinash Kumar

Signature of the Student

K.S.R.M. COLLEGE OF ENGINEERING

(UGC-AUTONOMOUS)

Kadapa, Andhra Pradesh, India - 516 005

Approved by AICTE, New Delhi & Affiliated to JNTUA, Ananthapuramu

An ISO 14001:2004 & 9001: 2015 Certified Institution

DEPARTMENT OF CIVIL ENGINEERING

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Certificate course Feedback Form

Your feedback is crucial to ensure we meet your educational needs. We would appreciate it if you could take a few minutes to share your opinions with us so we can serve you better.

Course Title : Storm water drainage system design

Resource Person(s) : Dr.T.Kiran kumar.

Date(s) of the course : 19-09-2022 to 30-09-2022

Name of the Student : M.Yagna Priya

Roll No. : 1994 1A0127

S. No.	Item Description	RATING (Please Tick the relevant)		
		LOW	MODERATE	HIGH
1	The content was Clear & Understandable			✓
2	The program was well-paced within the allotted time			✓
3	The instructor was a good communicator			✓
4	The material was presented in an organized manner			✓
5	The instructor was knowledgeable about the topic			
6	I would be interested in attending a follow-up, more advanced workshop on this same subject/any other		✓	
7	Given the topic, was this workshop	Too Short	Right Length	Too Long
8	In your opinion, was this workshop	Introductory	Intermediate	Advanced
	Please Rate the following	LOW	MODERATE	HIGH
	a) Visuals		✓	
	b) Acoustics		✓	
	c) Meeting space/Venue		✓	
	d) Handouts			✓
	e) The Overall Program			✓
9	What did you most appreciate/enjoy/think was best about the course? Any suggestions for improvement?			

Please return this form to the instructor or organizer at the end of the course. Thank you.

M.Yagna Priya

Signature of the Student

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Certificate course Feedback Form

Your feedback is crucial to ensure we meet your educational needs. We would appreciate it if you could take a few minutes to share your opinions with us so we can serve you better.

Course Title : Storm water drainage system Design

Resource Person(s) : Dr. T. Kiran Kumar sir prof, Dept of CE

Date(s) of the course : 19 - 9-22 to 30 - 9-22

Name of the Student : S. Mahammad

Roll No. : 199Y1A0146

S. No.	Item Description	RATING (Please Tick the relevant)		
		LOW	MODERATE	HIGH
1	The content was Clear & Understandable			✓
2	The program was well-paced within the allotted time			✓
3	The instructor was a good communicator			✓
4	The material was presented in an organized manner			✓
5	The instructor was knowledgeable about the topic			✓
6	I would be interested in attending a follow-up, more advanced workshop on this same subject/any other			
7	Given the topic, was this workshop	Too Short	Right Length ✓	Too Long
8	In your opinion, was this workshop	Introductory	Intermediate	Advanced ✓
	Please Rate the following	LOW	MODERATE	HIGH
	a) Visuals			✓
	b) Acoustics			✓
	c) Meeting space/Venue			✓
	d) Handouts			✓
	e) The Overall Program			✓
9	What did you most appreciate/enjoy/think was best about the course? Any suggestions for improvement?			

Please return this form to the instructor or organizer at the end of the course. Thank you.

S. Mahammad

Signature of the Student

K.S.R.M. COLLEGE OF ENGINEERING (AUTONOMOUS), KADAPA-516003
DEPARTMENT OF CIVIL ENGINEERING
Certificate Course on Storm Water Drainage System Design
Marks Award List

S.No	Roll Number	Name of the Student	Marks Obtained
1	209Y1A0102	A.Jyoshika	14
2	209Y1A0105	B.Guru Suchitra	17
3	209Y1A0158	P. Lokanath	10
4	209y1a0189	U.Poojitha	11
5	209y1a0191	Velpula Anusha	18
6	209Y1A0194	Y.Anusha Lakshmi	11
7	219Y5A0101	Ajjugottu Rajitha	17
8	219y5a0104	B. Anitha	17
9	219y5a0114	Chinthakuntla Narendra Reddy	19
10	219Y5A0121	Gogula Avinash	10
11	219Y5A0126	Kamireddy Jaipal Reddy	17
12	219y5a0130	Kethavaram Gangdhar	11
13	219y5a0131	K.Sree Kavya	13
14	219Y5A0133	Kummari Dastagiri	14
15	219Y5A0134	Subhash Kunchapu	10
16	219Y5A0137	Lodi Naveen	9
17	219Y5A0145	Mekala Chennakeshavulu	15
18	219Y5A0147	N.Shiva Kishor	18
19	219y5a0148	N.Shankar	15
20	219Y5A0149	N.Malleswari Devi	19
21	219y5a0151	Palla Yogendra	14
22	219Y5A0152	Pasupuleti Sai Charan	13
23	219Y5A0159	Ratala Chandra Sekhar	13
24	219y5a0163	Shaik.Mahaboob Bee	18
25	219Y5A0165	Shaik Mohammed Zuber	6
26	219y5a0166	Shaik Nasar	16

27	199Y1A0101	Boggiti Avinash Kumar	15
28	199Y1A0103	Byrisetty Suryanarayana	14
29	199Y1A0106	C.Haritha	11
30	199y1a0107	Dantham Arun kumar	12
31	199Y1A0116	Janapati Venkata Sai	12
32	199y1a0119	K Vekrishna Yadav	10
33	199Y1A0120	Kola Kejiya	13
34	199Y1A0122	Kumbhagiri Nagarathna	5
35	199y1a0127	Moram Yagna Priya	10
36	199Y1A0141	Ragi Divya	12
37	199Y1A0143	Ravella Hima Bindu	10
38	199Y1A0144	Sake Sadamini	17
39	199Y1A0146	Salivemula.Mahammad	13
40	199Y1A0147	Sandella Sudharshan	14
41	199Y1A0149	Savali Nagarjuna	15
42	199y1a0153	Shaik Imran	11
43	199y1a0156	Shaik Muhammad Aatif	18
44	199Y1A0145	Salindra Pavan Kumar Reddy	18
45	199Y1A0158	Sirangi Kavitha	10
46	199Y1A0159	S. Venkata Sai Pavan	14
47	199Y1A0160	S Rajeshreddy	11
48	199Y1A0162	Syed Mohammed Junaid	17
49	199y1a0163	Syed Zareena Tasneem	12
50	199Y1A0164	Thummala Anil Kumar Reddy	7
51	199Y1A0166	U. V. Sai Yeshaswini	15
52	199Y1A0167	Vadde Chandra Sekhar	15
53	199Y1A0168	V. S. Fayaz Hussain	18
54	199Y1A0170	Yambadi Prathyusha	5
55	199y1a0172	Y. Bramhini	15
56	209y5a0101	Amari Supraja	17
57	209y5a0111	C Rupesh	12

58	209Y5A0112	Chakali Upendra	12
59	209Y5A0123	G.V.Chandana	19
60	209Y5A0133	K. Bhanu Prasad	17
61	209Y5A0137	L. Dwarakanath Reddy	6
62	209y5a0139	Maduru Venkata Naveen Kumar	12
63	209Y5A0143	Matamkari Ganesh	13
64	209y5a0155	P.Viswa Karthik	14
65	209Y5A0161	P. Lakshmana	12
66	209Y5A0173	Shaik Sayyad Basha	14
67	209Y5A0189	Yerragorla Naga Mahendra	13

Coordinator

HoD

Head
Department of Civil Engineering
K.S.R.M. College of Engineering
(Autonomous)
KADAPA - 516 003. (A.P.)

11/20

K.S.R.M. COLLEGE OF ENGINEERING (AUTONOMOUS), KADAPA-516003
DEPARTMENT OF CIVIL ENGINEERING
Certificate Course on Storm Water Drainage System Design
Assessment Test

Name of the Student: U. Poojitha. **Reg. Number:** 209120189

Time: 20 Min **(Objective Questions)** **Max. Marks: 20**

Note: Answer the following Questions and each question carries **one** mark.

1	What is the primary purpose of a stormwater drainage system?				[A]	✗
	A) To supply drinking water	B) To transport wastewater	C) To manage and control rainwater runoff	D) To irrigate farmland		
2	What is a detention basin in stormwater management?				[C]	✗
	A) A facility to treat wastewater	B) A facility to collect and store stormwater for later use	C) A system to pump water from low areas to high areas	D) A facility to generate electricity from stormwater flow		
3	Which stormwater management method allows rainwater to infiltrate the ground and recharge groundwater?				[A]	✗
	A) Detention basins	B) Retention ponds	C) Infiltration systems	D) Stormwater pipes		
4	What is a "100-year storm event" in stormwater design?				[B]	✗
	A) A storm that occurs once every 100 days	B) A storm that occurs every 100 years	C) A storm with a 1% chance of occurring in any given year	D) A storm with the highest intensity rainfall		
5	Which stormwater management practice focuses on reducing runoff by creating green spaces and using permeable surfaces?				[A]	✗
	A) Detention basins	B) Infiltration systems	C) Low-impact development (LID)	D) Stormwater pipes		
6	What is the purpose of a "swale" in stormwater design?				[C]	✗
	A) To transport wastewater	B) To manage stormwater runoff	C) To create a natural swimming pool	D) To generate electricity from stormwater flow		
7	What is the goal of stormwater quality management within a drainage system?				[C]	✓
	A) To increase the flow rate of stormwater	B) To reduce the peak discharge of stormwater	C) To improve the quality of stormwater runoff	D) To promote groundwater infiltration		
8	What is a "biofiltration" system in stormwater management?				[D]	✓
	A) A system to collect stormwater for reuse	B) A system to treat wastewater	C) A system to reduce stormwater flow velocity	D) A system that uses vegetation to filter and treat stormwater runoff		
9	Which factor is considered in designing the size of stormwater pipes and channels?				[D]	✓
	A) Distance to the ocean	B) Average wind speed	C) Average temperature	D) Peak flow rate during storms		
10	What is the purpose of a "perforated pipe" in a stormwater drainage system?				[C]	✓
	A) To carry wastewater	B) To carry drinking water	C) To collect and transport stormwater	D) To generate electricity from stormwater flow		

11	What is the concept of "first flush" in stormwater management?				
	A) The first rainfall event of the year	B) The first step in building a stormwater pond	C) The initial runoff that carries pollutants from surfaces	D) The beginning of a stormwater pipe network	[D]
12	What does a "swirl separator" do in stormwater management?				
	A) Separates stormwater from wastewater	B) Generates energy from stormwater flow	C) Removes debris and sediments from stormwater	D) Transports stormwater to treatment plants	[A]
13	What does the term "hydraulic design" refer to in stormwater systems?				
	A) Designing the aesthetic appearance of stormwater structures	B) Designing stormwater ponds for recreational use	C) Designing stormwater systems to control water flow and pressure	D) Designing stormwater systems to generate electricity	[B]
14	What is the purpose of a "check dam" in a stormwater drainage system?				
	A) To control floodwaters	B) To generate electricity from stormwater flow	C) To filter stormwater runoff	D) To slow down stormwater flow and reduce erosion	[D]
15	What is the role of "swirl control devices" in stormwater management?				
	A) To control wind patterns during storms	B) To remove debris from stormwater flow	C) To prevent stormwater from entering sewer systems	D) To reduce the velocity of stormwater flow and improve pollutant removal	[D]
16	Which type of stormwater management practice involves creating depressions to temporarily store stormwater?				
	A) Swales	B) Detention basins	C) Infiltration systems	D) Filtration systems	[B]
17	What is "erosion control" in stormwater management?				
	A) A method to increase the flow of stormwater	B) A method to remove pollutants from stormwater	C) A method to prevent soil erosion due to stormwater runoff	D) A method to generate electricity from stormwater flow	[C]
18	What is the primary function of "stormwater treatment devices"?				
	A) To collect stormwater for reuse	B) To generate electricity from stormwater flow	C) To slow down stormwater flow	D) To remove pollutants and sediments from stormwater	[D]
19	What is a "rain garden" in stormwater management?				
	A) A garden that only grows during rainy seasons	B) A garden with special plants that require less water	C) A garden designed to capture and treat stormwater runoff	D) A garden used to collect rainwater for irrigation	[C]
20	Which of the following is an example of a "best management practice" (BMP) for stormwater management?				
	A) Building taller structures to minimize runoff	B) Diverting stormwater into nearby rivers	C) Discharging untreated stormwater directly into oceans	D) Installing rain barrels to collect and store rainwater	[D]

18/20

K.S.R.M. COLLEGE OF ENGINEERING (AUTONOMOUS), KADAPA-516003
DEPARTMENT OF CIVIL ENGINEERING
Certificate Course on Storm Water Drainage System Design
Assessment Test

Name of the Student: V. Anusha **Reg. Number:** 2097IA0191

Time: 20 Min **(Objective Questions)** **Max. Marks: 20**

Note: Answer the following Questions and each question carries **one** mark.

1	What is the primary purpose of a stormwater drainage system?				[C] ✓
	A) To supply drinking water	B) To transport wastewater	C) To manage and control rainwater runoff	D) To irrigate farmland	
2	What is a detention basin in stormwater management?				[B] ✓
	A) A facility to treat wastewater	B) A facility to collect and store stormwater for later use	C) A system to pump water from low areas to high areas	D) A facility to generate electricity from stormwater flow	
3	Which stormwater management method allows rainwater to infiltrate the ground and recharge groundwater?				[C] ✓
	A) Detention basins	B) Retention ponds	C) Infiltration systems	D) Stormwater pipes	
4	What is a "100-year storm event" in stormwater design?				[C] ✓
	A) A storm that occurs once every 100 days	B) A storm that occurs every 100 years	C) A storm with a 1% chance of occurring in any given year	D) A storm with the highest intensity rainfall	
5	Which stormwater management practice focuses on reducing runoff by creating green spaces and using permeable surfaces?				[C] ✓
	A) Detention basins	B) Infiltration systems	C) Low-impact development (LID)	D) Stormwater pipes	
6	What is the purpose of a "swale" in stormwater design?				[B] ✓
	A) To transport wastewater	B) To manage stormwater runoff	C) To create a natural swimming pool	D) To generate electricity from stormwater flow	
7	What is the goal of stormwater quality management within a drainage system?				[C] ✓
	A) To increase the flow rate of stormwater	B) To reduce the peak discharge of stormwater	C) To improve the quality of stormwater runoff	D) To promote groundwater infiltration	
8	What is a "biofiltration" system in stormwater management?				[D] ✓
	A) A system to collect stormwater for reuse	B) A system to treat wastewater	C) A system to reduce stormwater flow velocity	D) A system that uses vegetation to filter and treat stormwater runoff	
9	Which factor is considered in designing the size of stormwater pipes and channels?				[D] ✓
	A) Distance to the ocean	B) Average wind speed	C) Average temperature	D) Peak flow rate during storms	
10	What is the purpose of a "perforated pipe" in a stormwater drainage system?				[B] ✗
	A) To carry wastewater	B) To carry drinking water	C) To collect and transport stormwater	D) To generate electricity from stormwater flow	

11	What is the concept of "first flush" in stormwater management?				[C] ✓
	A) The first rainfall event of the year	B) The first step in building a stormwater pond	C) The initial runoff that carries pollutants from surfaces	D) The beginning of a stormwater pipe network	
12	What does a "swirl separator" do in stormwater management?				[C] ✓
	A) Separates stormwater from wastewater	B) Generates energy from stormwater flow	C) Removes debris and sediments from stormwater	D) Transports stormwater to treatment plants	
13	What does the term "hydraulic design" refer to in stormwater systems?				[C] ✓
	A) Designing the aesthetic appearance of stormwater structures	B) Designing stormwater ponds for recreational use	C) Designing stormwater systems to control water flow and pressure	D) Designing stormwater systems to generate electricity	
14	What is the purpose of a "check dam" in a stormwater drainage system?				[D] ✓
	A) To control floodwaters	B) To generate electricity from stormwater flow	C) To filter stormwater runoff	D) To slow down stormwater flow and reduce erosion	
15	What is the role of "swirl control devices" in stormwater management?				[D] ✓
	A) To control wind patterns during storms	B) To remove debris from stormwater flow	C) To prevent stormwater from entering sewer systems	D) To reduce the velocity of stormwater flow and improve pollutant removal	
16	Which type of stormwater management practice involves creating depressions to temporarily store stormwater?				[C] ✗
	A) Swales	B) Detention basins	C) Infiltration systems	D) Filtration systems	
17	What is "erosion control" in stormwater management?				[C] ✓
	A) A method to increase the flow of stormwater	B) A method to remove pollutants from stormwater	C) A method to prevent soil erosion due to stormwater runoff	D) A method to generate electricity from stormwater flow	
18	What is the primary function of "stormwater treatment devices"?				[D] ✓
	A) To collect stormwater for reuse	B) To generate electricity from stormwater flow	C) To slow down stormwater flow	D) To remove pollutants and sediments from stormwater	
19	What is a "rain garden" in stormwater management?				[C] ✓
	A) A garden that only grows during rainy seasons	B) A garden with special plants that require less water	C) A garden designed to capture and treat stormwater runoff	D) A garden used to collect rainwater for irrigation	
20	Which of the following is an example of a "best management practice" (BMP) for stormwater management?				[D] ✓
	A) Building taller structures to minimize runoff	B) Diverting stormwater into nearby rivers	C) Discharging untreated stormwater directly into oceans	D) Installing rain barrels to collect and store rainwater	

10/20

K.S.R.M. COLLEGE OF ENGINEERING (AUTONOMOUS), KADAPA-516003
DEPARTMENT OF CIVIL ENGINEERING
Certificate Course on Storm Water Drainage System Design
Assessment Test

Name of the Student: P. Lokanath **Reg. Number:** 20991A0158

Time: 20 Min **(Objective Questions)** **Max. Marks: 20**

Note: Answer the following Questions and each question carries **one** mark.

1	What is the primary purpose of a stormwater drainage system?				
	A) To supply drinking water	B) To transport wastewater	C) To manage and control rainwater runoff	D) To irrigate farmland	[C] ✓
2	What is a detention basin in stormwater management?				
	A) A facility to treat wastewater	B) A facility to collect and store stormwater for later use	C) A system to pump water from low areas to high areas	D) A facility to generate electricity from stormwater flow	[C] ✗
3	Which stormwater management method allows rainwater to infiltrate the ground and recharge groundwater?				
	A) Detention basins	B) Retention ponds	C) Infiltration systems	D) Stormwater pipes	[C] ✓
4	What is a "100-year storm event" in stormwater design?				
	A) A storm that occurs once every 100 days	B) A storm that occurs every 100 years	C) A storm with a 1% chance of occurring in any given year	D) A storm with the highest intensity rainfall	[D] ✗
5	Which stormwater management practice focuses on reducing runoff by creating green spaces and using permeable surfaces?				
	A) Detention basins	B) Infiltration systems	C) Low-impact development (LID)	D) Stormwater pipes	[B] ✗
6	What is the purpose of a "swale" in stormwater design?				
	A) To transport wastewater	B) To manage stormwater runoff	C) To create a natural swimming pool	D) To generate electricity from stormwater flow	[C] ✗
7	What is the goal of stormwater quality management within a drainage system?				
	A) To increase the flow rate of stormwater	B) To reduce the peak discharge of stormwater	C) To improve the quality of stormwater runoff	D) To promote groundwater infiltration	[A] ✗
8	What is a "biofiltration" system in stormwater management?				
	A) A system to collect stormwater for reuse	B) A system to treat wastewater	C) A system to reduce stormwater flow velocity	D) A system that uses vegetation to filter and treat stormwater runoff	[B] ✗
9	Which factor is considered in designing the size of stormwater pipes and channels?				
	A) Distance to the ocean	B) Average wind speed	C) Average temperature	D) Peak flow rate during storms	[A] ✓
10	What is the purpose of a "perforated pipe" in a stormwater drainage system?				
	A) To carry wastewater	B) To carry drinking water	C) To collect and transport stormwater	D) To generate electricity from stormwater flow	[C] ✓

11	What is the concept of "first flush" in stormwater management?				
	A) The first rainfall event of the year	B) The first step in building a stormwater pond	C) The initial runoff that carries pollutants from surfaces	D) The beginning of a stormwater pipe network	[B] ✗
12	What does a "swirl separator" do in stormwater management?				
	A) Separates stormwater from wastewater	B) Generates energy from stormwater flow	C) Removes debris and sediments from stormwater	D) Transports stormwater to treatment plants	[C] ✓
13	What does the term "hydraulic design" refer to in stormwater systems?				
	A) Designing the aesthetic appearance of stormwater structures	B) Designing stormwater ponds for recreational use	C) Designing stormwater systems to control water flow and pressure	D) Designing stormwater systems to generate electricity	[D] ✗
14	What is the purpose of a "check dam" in a stormwater drainage system?				
	A) To control floodwaters	B) To generate electricity from stormwater flow	C) To filter stormwater runoff	D) To slow down stormwater flow and reduce erosion	[C] ✗
15	What is the role of "swirl control devices" in stormwater management?				
	A) To control wind patterns during storms	B) To remove debris from stormwater flow	C) To prevent stormwater from entering sewer systems	D) To reduce the velocity of stormwater flow and improve pollutant removal	[D] ✗
16	Which type of stormwater management practice involves creating depressions to temporarily store stormwater?				
	A) Swales	B) Detention basins	C) Infiltration systems	D) Filtration systems	[B] ✓
17	What is "erosion control" in stormwater management?				
	A) A method to increase the flow of stormwater	B) A method to remove pollutants from stormwater	C) A method to prevent soil erosion due to stormwater runoff	D) A method to generate electricity from stormwater flow	[C] ✓
18	What is the primary function of "stormwater treatment devices"?				
	A) To collect stormwater for reuse	B) To generate electricity from stormwater flow	C) To slow down stormwater flow	D) To remove pollutants and sediments from stormwater	[D] ✓
19	What is a "rain garden" in stormwater management?				
	A) A garden that only grows during rainy seasons	B) A garden with special plants that require less water	C) A garden designed to capture and treat stormwater runoff	D) A garden used to collect rainwater for irrigation	[C] ✓
20	Which of the following is an example of a "best management practice" (BMP) for stormwater management?				
	A) Building taller structures to minimize runoff	B) Diverting stormwater into nearby rivers	C) Discharging untreated stormwater directly into oceans	D) Installing rain barrels to collect and store rainwater	[D] ✓

14/20

K.S.R.M. COLLEGE OF ENGINEERING (AUTONOMOUS), KADAPA-516003
DEPARTMENT OF CIVIL ENGINEERING
Certificate Course on Storm Water Drainage System Design
Assessment Test

Name of the Student: A. Jyoshika **Reg. Number:** 20941A0102

Time: 20 Min **(Objective Questions)** **Max. Marks: 20**

Note: Answer the following Questions and each question carries **one** mark.

1	What is the primary purpose of a stormwater drainage system?					
	A) To supply drinking water	B) To transport wastewater	C) To manage and control rainwater runoff	D) To irrigate farmland	[A]	X
2	What is a detention basin in stormwater management?					
	A) A facility to treat wastewater	B) A facility to collect and store stormwater for later use	C) A system to pump water from low areas to high areas	D) A facility to generate electricity from stormwater flow	[C]	X
3	Which stormwater management method allows rainwater to infiltrate the ground and recharge groundwater?					
	A) Detention basins	B) Retention ponds	C) Infiltration systems	D) Stormwater pipes	[A]	X
4	What is a "100-year storm event" in stormwater design?					
	A) A storm that occurs once every 100 days	B) A storm that occurs every 100 years	C) A storm with a 1% chance of occurring in any given year	D) A storm with the highest intensity rainfall	[A]	X
5	Which stormwater management practice focuses on reducing runoff by creating green spaces and using permeable surfaces?					
	A) Detention basins	B) Infiltration systems	C) Low-impact development (LID)	D) Stormwater pipes	[C]	✓
6	What is the purpose of a "swale" in stormwater design?					
	A) To transport wastewater	B) To manage stormwater runoff	C) To create a natural swimming pool	D) To generate electricity from stormwater flow	[B]	✓
7	What is the goal of stormwater quality management within a drainage system?					
	A) To increase the flow rate of stormwater	B) To reduce the peak discharge of stormwater	C) To improve the quality of stormwater runoff	D) To promote groundwater infiltration	[C]	✓
8	What is a "biofiltration" system in stormwater management?					
	A) A system to collect stormwater for reuse	B) A system to treat wastewater	C) A system to reduce stormwater flow velocity	D) A system that uses vegetation to filter and treat stormwater runoff	[A]	X
9	Which factor is considered in designing the size of stormwater pipes and channels?					
	A) Distance to the ocean	B) Average wind speed	C) Average temperature	D) Peak flow rate during storms	[A]	X
10	What is the purpose of a "perforated pipe" in a stormwater drainage system?					
	A) To carry wastewater	B) To carry drinking water	C) To collect and transport stormwater	D) To generate electricity from stormwater flow	[C]	

11	What is the concept of "first flush" in stormwater management?				[C]
	A) The first rainfall event of the year	B) The first step in building a stormwater pond	C) The initial runoff that carries pollutants from surfaces	D) The beginning of a stormwater pipe network	
12	What does a "swirl separator" do in stormwater management?				[C]
	A) Separates stormwater from wastewater	B) Generates energy from stormwater flow	C) Removes debris and sediments from stormwater	D) Transports stormwater to treatment plants	
13	What does the term "hydraulic design" refer to in stormwater systems?				[C]
	A) Designing the aesthetic appearance of stormwater structures	B) Designing stormwater ponds for recreational use	C) Designing stormwater systems to control water flow and pressure	D) Designing stormwater systems to generate electricity	
14	What is the purpose of a "check dam" in a stormwater drainage system?				[D]
	A) To control floodwaters	B) To generate electricity from stormwater flow	C) To filter stormwater runoff	D) To slow down stormwater flow and reduce erosion	
15	What is the role of "swirl control devices" in stormwater management?				[D]
	A) To control wind patterns during storms	B) To remove debris from stormwater flow	C) To prevent stormwater from entering sewer systems	D) To reduce the velocity of stormwater flow and improve pollutant removal	
16	Which type of stormwater management practice involves creating depressions to temporarily store stormwater?				[B]
	A) Swales	B) Detention basins	C) Infiltration systems	D) Filtration systems	
17	What is "erosion control" in stormwater management?				[C]
	A) A method to increase the flow of stormwater	B) A method to remove pollutants from stormwater	C) A method to prevent soil erosion due to stormwater runoff	D) A method to generate electricity from stormwater flow	
18	What is the primary function of "stormwater treatment devices"?				[D]
	A) To collect stormwater for reuse	B) To generate electricity from stormwater flow	C) To slow down stormwater flow	D) To remove pollutants and sediments from stormwater	
19	What is a "rain garden" in stormwater management?				[C]
	A) A garden that only grows during rainy seasons	B) A garden with special plants that require less water	C) A garden designed to capture and treat stormwater runoff	D) A garden used to collect rainwater for irrigation	
20	Which of the following is an example of a "best management practice" (BMP) for stormwater management?				[D]
	A) Building taller structures to minimize runoff	B) Diverting stormwater into nearby rivers	C) Discharging untreated stormwater directly into oceans	D) Installing rain barrels to collect and store rainwater	

17/20

K.S.R.M. COLLEGE OF ENGINEERING (AUTONOMOUS), KADAPA-516003
DEPARTMENT OF CIVIL ENGINEERING
Certificate Course on Storm Water Drainage System Design
Assessment Test

Name of the Student: R. Guru Suchitra **Reg. Number:** 209Y1A0105

Time: 20 Min **(Objective Questions)** **Max. Marks: 20**

Note: Answer the following Questions and each question carries **one** mark.

1	What is the primary purpose of a stormwater drainage system?				
	A) To supply drinking water	B) To transport wastewater	C) To manage and control rainwater runoff	D) To irrigate farmland	[C] ✓
2	What is a detention basin in stormwater management?				
	A) A facility to treat wastewater	B) A facility to collect and store stormwater for later use	C) A system to pump water from low areas to high areas	D) A facility to generate electricity from stormwater flow	[B] ✓
3	Which stormwater management method allows rainwater to infiltrate the ground and recharge groundwater?				
	A) Detention basins	B) Retention ponds	C) Infiltration systems	D) Stormwater pipes	[C] ✓
4	What is a "100-year storm event" in stormwater design?				
	A) A storm that occurs once every 100 days	B) A storm that occurs every 100 years	C) A storm with a 1% chance of occurring in any given year	D) A storm with the highest intensity rainfall	[C] ✓
5	Which stormwater management practice focuses on reducing runoff by creating green spaces and using permeable surfaces?				
	A) Detention basins	B) Infiltration systems	C) Low-impact development (LID)	D) Stormwater pipes	[A] ✗
6	What is the purpose of a "swale" in stormwater design?				
	A) To transport wastewater	B) To manage stormwater runoff	C) To create a natural swimming pool	D) To generate electricity from stormwater flow	[B] ✓
7	What is the goal of stormwater quality management within a drainage system?				
	A) To increase the flow rate of stormwater	B) To reduce the peak discharge of stormwater	C) To improve the quality of stormwater runoff	D) To promote groundwater infiltration	[C] ✓
8	What is a "biofiltration" system in stormwater management?				
	A) A system to collect stormwater for reuse	B) A system to treat wastewater	C) A system to reduce stormwater flow velocity	D) A system that uses vegetation to filter and treat stormwater runoff	[C] ✗
9	Which factor is considered in designing the size of stormwater pipes and channels?				
	A) Distance to the ocean	B) Average wind speed	C) Average temperature	D) Peak flow rate during storms	[D] ✓
10	What is the purpose of a "perforated pipe" in a stormwater drainage system?				
	A) To carry wastewater	B) To carry drinking water	C) To collect and transport stormwater	D) To generate electricity from stormwater flow	[B] ✗

11	What is the concept of "first flush" in stormwater management?				[C]
	A) The first rainfall event of the year	B) The first step in building a stormwater pond	C) The initial runoff that carries pollutants from surfaces	D) The beginning of a stormwater pipe network	
12	What does a "swirl separator" do in stormwater management?				[C]
	A) Separates stormwater from wastewater	B) Generates energy from stormwater flow	C) Removes debris and sediments from stormwater	D) Transports stormwater to treatment plants	
13	What does the term "hydraulic design" refer to in stormwater systems?				[C]
	A) Designing the aesthetic appearance of stormwater structures	B) Designing stormwater ponds for recreational use	C) Designing stormwater systems to control water flow and pressure	D) Designing stormwater systems to generate electricity	
14	What is the purpose of a "check dam" in a stormwater drainage system?				[D]
	A) To control floodwaters	B) To generate electricity from stormwater flow	C) To filter stormwater runoff	D) To slow down stormwater flow and reduce erosion	
15	What is the role of "swirl control devices" in stormwater management?				[D]
	A) To control wind patterns during storms	B) To remove debris from stormwater flow	C) To prevent stormwater from entering sewer systems	D) To reduce the velocity of stormwater flow and improve pollutant removal	
16	Which type of stormwater management practice involves creating depressions to temporarily store stormwater?				[B]
	A) Swales	B) Detention basins	C) Infiltration systems	D) Filtration systems	
17	What is "erosion control" in stormwater management?				[C]
	A) A method to increase the flow of stormwater	B) A method to remove pollutants from stormwater	C) A method to prevent soil erosion due to stormwater runoff	D) A method to generate electricity from stormwater flow	
18	What is the primary function of "stormwater treatment devices"?				[D]
	A) To collect stormwater for reuse	B) To generate electricity from stormwater flow	C) To slow down stormwater flow	D) To remove pollutants and sediments from stormwater	
19	What is a "rain garden" in stormwater management?				[C]
	A) A garden that only grows during rainy seasons	B) A garden with special plants that require less water	C) A garden designed to capture and treat stormwater runoff	D) A garden used to collect rainwater for irrigation	
20	Which of the following is an example of a "best management practice" (BMP) for stormwater management?				[D]
	A) Building taller structures to minimize runoff	B) Diverting stormwater into nearby rivers	C) Discharging untreated stormwater directly into oceans	D) Installing rain barrels to collect and store rainwater	

Chapter 12
STORM DRAINAGE SYSTEMS

12.1 OVERVIEW

12.1.1 Introduction

This Chapter provides guidance on all elements of storm drainage design: system planning, pavement drainage, gutter flow calculations, inlet spacing, pipe sizing and hydraulic grade line calculations. The quality of the final in-place system usually reflects the attention provided to every aspect of the design and to the construction and maintenance of the facility.

The design of a drainage system should address the needs of the traveling public and those of the local community through which it passes. The drainage system for a roadway traversing an urban area is more complex than for roadways traversing sparsely settled rural areas. This is due to:

- the wide roadway sections, flat grades (both in longitudinal and transverse directions), shallow water courses and absence of side channels;
- the more costly property damage that may occur from ponding of water or from flow of water through built-up areas; and
- the roadway section must carry traffic but also act as a channel to convey the water to a disposal point. Unless proper precautions are taken, this flow of water along the roadway may interfere with or possibly halt the passage of highway traffic.

12.1.2 Inadequate Drainage

The most serious effects of an inadequate storm drainage system are:

- damage to adjacent property, resulting from water overflowing the roadway curbs and entering such property;
- risk and delay to traffic caused by excessive ponding in sags or excessive spread along the roadway; and
- weakening of the base and subgrade due to saturation from frequent ponding of long duration.

12.1.3 General Design Guidelines

A storm drain is defined as that portion of the storm drainage system that receives runoff from inlets and conveys the runoff to some point where it is then discharged into a channel, water body or piped system. A storm drain may be a closed-conduit, open-conduit or some combination of the two. They may be designed with consideration for future development, if appropriate. A higher design frequency (or return interval) should be used for storm drain systems located in a major sag vertical curve to decrease the depth of ponding on the roadway and bridges and potential inundation of adjacent property. Where feasible, the storm drains should be designed to avoid existing utilities. Attention should be provided to the storm drain outfalls to ensure that the potential for erosion is minimized. Drainage system design should be coordinated with the proposed staging of large construction projects to maintain an outlet throughout the construction project.

This Chapter discusses SDDOT design guidelines for storm drainage design and analysis, which are based on HEC 22 (Reference (1)). For additional guidance, refer to the AASHTO *Highway Drainage Guidelines*, Chapter 9 (Reference (2)).

12.1.4 Detention Storage

The reduction of peak flows can be achieved by the storage of runoff in detention basins, storm drainage pipes, swales and channels, and other detention storage facilities. These should be considered where existing downstream conveyance facilities are inadequate to accommodate peak-flow rates from highway storm drainage facilities. In many locations, the SDDOT, local highway agencies and/or developers are not permitted to increase runoff when compared to existing conditions, thus necessitating detention storage facilities. A dditional benefits may include the reduction of downstream pipe sizes and the improvement of water quality by removing sediment and/or pollutants. See Chapter 13 "Storage Facilities" for a discussion on det ention storage.

12.4 GENERAL DESIGN APPROACH

12.4.1 Design Process

The design of a storm drainage system is a process that evolves as a project develops. The primary elements of this process are listed below in a general sequence by which they may be implemented:

- coordinate with other agencies (see Section 4.2);
- collect data (see Chapter 5 "Data Collection");
- prepare preliminary layout;
- determine inlet location and spacing (see Section 12.10);
- plan layout of storm drainage system:
    - locate main outfall,
    - determine direction of flow,
    - locate existing utilities,
    - locate connecting mains, and
    - locate manholes;
- size the pipes (see Section 12.12) and manholes (see Section 12.11);
- review hydraulic grade line (see Section 12.13);
- prepare the plan; and
- provide documentation (see Chapter 6 "Documentation of Hydraulic Studies").

12.4.2 Location and Size Guidelines

Storm drain pipes should not decrease in size in a downstream direction regardless of the available pipe gradient.

Locate the storm drain to avoid conflicts with utilities, foundations or other obstacles. Coordination with utility owners during the design phase is necessary to determine if an adjustment to the utilities or the storm drainage system is required. The location of the storm drain may affect construction activities and phasing. The storm drain should be located to minimize traffic disruption during construction. Minimizing the depth of the storm drain may produce a significant cost savings. Dual trunklines along each side of the roadway may be used in some cases where it is difficult or more costly to install laterals. Temporary drainage measures may be needed to avoid increases in flood hazards during construction.

12.4.3 Outfall Guidelines

The outfall of the storm drainage system is a key component that should accommodate the hydraulic demands and physical characteristics of the system. The identification of an appropriate system outfall includes the following considerations:

- the availability of the channel and associated right-of-way or easement,
- the profile of the existing or proposed channel or conduit,
- the flow characteristics under flood conditions, and
- the land use and soil type through the area of the channel.

Whether the outfall is enclosed in a conduit or is an open channel, the design flows should be conveyed without causing significant risk to the highway and surrounding property.

Because the outfall must be available for the life of the system, SDDOT should have access to all parts of the outfall for maintenance and to ensure adequate operation of the drainage system. This may require that a drainage easement be purchased through private property.

12.4.4 Contributing Drainage Areas

In previous upstream developed areas, the contributing drainage area will generally be limited to approximately one block either direction of the State Highway for determining drop inlet locations and pipe sizing of the storm sewer system. Any additional contributing drainage area beyond this distance can be designed into the State Highway storm drainage system, however by agreement the Local Governing Agency will be required to reimburse the State for any additional cost to upsize the storm drainage system along the State Highway.

In circumstances where upstream drainage areas are either undeveloped or has a natural water course that approaches the State Highway, the drainage will be accommodated based on proper year design storm according to Figure 7.6-A.

12.4.5 Pipe Length Measurements

When pipe is installed between drop inlet and/or manholes requires that a section be cut, the pipe will be measured from the structure inside wall to inside wall and payment of pipe shall be rounded up to the nearest two feet in all cases.

12.5 HYDROLOGY

12.5.1 Introduction

Chapter 7 "Hydrology" discusses SDDOT's practices with respect to hydrology. This Section discusses the application of the Department's hydrologic practices specifically to storm drainage systems.

12.5.2 Design Frequency

Figure 7.6-A summarizes SDDOT practices for selecting the design frequency for various drainage appurtenances. The following applies to storm drainage systems:

- The typical design frequency is 10 years.
- If a storm drain provides the outlet for a cross drain, then the design frequency of the cross drain should be used for the storm drainage system downstream from the cross drain inlet.
- If local drainage facilities and practices have provided storm drains of lesser standard, to which the highway system should connect, provide special consideration to whether it is realistic to design the highway system to a higher standard than available outlets.
- For major sag points on Interstate, US and State highways, the design frequency should be 50 years where water can pond 2 ft deep or more on the travel lane and where projected 2-way ADT is greater than 5000.
- With storm drainage systems a risk analysis can be made to see if a five-year storm would be the more appropriate storm design frequency. Also, check with local officials to see if local ordinances require different frequencies to be designed for or analyzed.

12.5.3 Review Frequency

The typical review frequency is 100 years when it is determined that larger storm event flows should be evaluated.

Review of larger storm events should be evaluated for critical areas where flow or ponding of water can cause property damage or risk and delay of traffic. This includes review of the flow pathways where surface water not collected by the storm drainage system will be carried and outlet in a major drainage way. Section 7.6.2.3 and Section 12.1.1 through Section 12.1.3 include discussion concerning this.

12.5.4 Rational Method

12.5.4.1 Introduction

The Rational Method is the most common method used for the design of storm drains when the peak-flow rate is desired. Its use should be limited to systems with drainage areas of 200 ac or less. Drainage systems involving detention storage and pumping stations require the development of a runoff hydrograph.

Section 7.13 discusses SDDOT's application of the Rational Method, which involves:

- the selection of a runoff coefficient (see Section 7.13.5),
- the time of concentration (see Section 7.13.6), and
- the rainfall intensity (see Section 7.13.7).

Of the variables in the Rational Method, only the time of concentration requires elaboration specifically for its application to storm drainage systems. See the following Section.

12.5.4.2 Time of Concentration

12.5.4.2.1 Introduction

The time of concentration is defined as the time required for water to travel from the most hydraulically distant point of the watershed to the point of the storm drainage system under consideration. The designer is usually concerned with two different times of concentration — one for inlet spacing and the other for pipe sizing. There is a major difference between the two times, as discussed in the following Sections.

12.5.4.2.2 Inlet Spacing

The time of concentration (t_c) for inlet spacing is the time for water to flow from the hydraulically most distant point of the drainage area to the first upstream inlet, which is known as the inlet time. Usually, this is the sum of the time required for water to move across the pavement or overland in back of the curb to the gutter, plus the time required for flow to move through the length of gutter to the inlet. For pavement drainage, when the total time of concentration to the upstream inlet is less than five minutes, a minimum t_c of five minutes should be used to estimate the intensity of rainfall. The time of concentration for the second downstream inlet and each succeeding inlet should be determined independently, the same as the first inlet. For a constant roadway grade and relatively uniform contributing drainage area, the time of concentration for each succeeding inlet should also be constant.

12.5.4.2.3 Pipe Sizing

The time of concentration for pipe sizing is defined as the time required for water to travel from the most hydraulically distant point of the watershed to the point of the storm drainage system under consideration. In these applications, time of concentration generally consists of two components:

- the time to flow to the inlet, which can consist of sheet flow, shallow concentrated flow and channel or gutter flow segments, and
- the time to flow through the storm drain to the point under consideration.

However, some NRCS Curve Number methods combine segments into a single lag time that is then empirically related to an overland time of concentration.

The sheet flow time of concentration segment is typically developed using the kinematic wave approach. The NRCS velocity equation provides a means to compute sheet flow and shallow concentrated flow travel time segments (see Section 7.13.6.4). Channel and storm drain times of concentration can be developed using Manning's equation or the HEC 22 (Reference (1)) triangular gutter approach.

12.5.4.2.4 Summary

To summarize, the time of concentration for any point on a storm drain is the inlet time for the inlet at the upper end of the line plus the time of flow through the storm drain from the upper end of the storm drain to the point in question. In general, where there is more than one source of runoff to a given point in the storm drainage system, the longest t_c is used to estimate the intensity (i).

12.6 ROADWAY GEOMETRICS

12.6.1 Introduction

This Section discusses the role of roadway geometrics on pavement drainage applicable to the hydraulic design of storm drainage systems. Where applicable, the discussion extracts information from or references the *SDDOT Road Design Manual* (Reference (3)). This Section does not discuss the following pavement drainage considerations:

1. Bridge Decks. Chapter 14 "Bridge Hydraulics" presents SDDOT practices for bridge deck drainage.
2. Roadside Channels. On roadway sections with open drainage and roadside channels, see Chapter 9 "Roadside Channels" for SDDOT practices.
3. Fill Slopes. Fill slopes should be designed to prevent erosion. In some cases, shoulder gutter and/or curbs may be necessary to channel drainage away from fill slopes especially susceptible to erosion. Chapter 7 "Cross Sections" of the *SDDOT Road Design Manual* (Reference (3)) presents SDDOT practices on the design of fill slopes.

Roadway geometric features that impact gutter, inlet and pavement drainage for storm drainage systems include:

- roadway width and cross slope,
- vertical alignment,
- curb and gutter sections, and
- presence of median barriers.

The pavement width, cross slope and profile control the time it takes for stormwater to drain to the gutter section. The gutter cross section and longitudinal slope control the quantity of flow that can be carried in the gutter section. Each of these is discussed in the following Sections.

12.6.2 Roadway Cross Section

12.6.2.1 Width

In general, the wider the roadway width (i.e., traveled way plus shoulder/curb offset width), the greater the quantity of water that can be accommodated by the curb and gutter storm drainage system. See Chapter 7 "Cross Sections" of the *SDDOT Road Design Manual* (Reference (3)) for SDDOT roadway width criteria.

12.6.2.2 Cross Slope

The pavement cross slope is a compromise between the need for reasonably steep cross slopes for drainage and relatively flat cross slopes for driver comfort. The *AASHTO Green Book* (Reference (4)) notes that cross slopes of 2% have little effect on driver effort in steering, especially with power steering, or on friction demand for vehicular stability.

Chapter 7 "Cross Sections" of the *SDDOT Road Design Manual* (Reference (3)) presents the Department's typical practice for cross slopes. SDDOT has adopted the following typical cross slopes on tangent sections of highways:

- Portland Cement Concrete: 2%
- Asphalt Concrete: 2%
- Other Asphalt Surfacing: 2%
- Gravel: 3%

12.6.3 Vertical Alignment

12.6.3.1 Longitudinal Slope

A minimum longitudinal gradient is more important for a curbed pavement than for an uncurbed pavement because of the impact on the spread of stormwater against the curb.

Desirable longitudinal gutter grades should not be less than 0.5% for curbed pavements with an absolute minimum of 0.3% allowed on high-type pavements adequately crowned. Minimum grades can be maintained in very flat terrain by use of a rolling profile.

12.6.3.2 Vertical Curves

Chapter 6 "Vertical Alignment" of the *SDDOT Road Design Manual* (Reference (3)) presents SDDOT's practices for the design of crest and sag vertical curves. However, on curbed roadways, drainage considerations become important. The following presents SDDOT practices:

1. Sag Vertical Curves. On curbed facilities, sag vertical curves should be sufficiently "sharp" to prevent inadequate drainage near the bottom of the vertical curve. This can be achieved by designing the sag vertical curve to provide a minimum longitudinal gradient of 0.3% at the two points 50 ft from the bottom. This yields a maximum value of K = 167 for the vertical curve, which is typically called the drainage maximum.

See Section 12.10.8 for SDDOT practices on the use of flanking inlets at sag vertical curves.

2. Crest Vertical Curves. Drainage considerations are not as critical on crest vertical curves as sag vertical curves. However, good design practice is to design crest vertical curves based on a maximum K = 167.

12.6.4 Curb and Gutter

Curbing at the outside edge of pavements is used extensively on urban highways and streets. Curbs serve several purposes, including containing the surface runoff within the roadway and away from adjacent properties, preventing erosion, providing pavement delineation and enabling the orderly development of property adjacent to the roadway. See the *SDDOT Standard Plates* for typical curb and gutter sections used by the Department.

A curb and gutter forms a triangular channel that can be an efficient hydraulic conveyance facility to transport runoff of a lesser magnitude than the design flow without interruption to traffic. When a design storm flow occurs, there is a "spread" or widening of the conveyed water surface. The water spread includes, not only the gutter width, but also parking lanes or shoulders and portions of the traveled way. This is the width the designer is most concerned with in curb and gutter flow, and limiting this width becomes a critical design criterion. Section 12.7.3 discusses the allowable water spread.

12.6.5 Medians

Medians are commonly used to separate opposing lanes of traffic on divided highways. It is preferable to slope median areas and inside shoulders to a center depression to prevent drainage from the median area from running across the traveled pavement. The following applies to surface drainage considerations on facilities with medians that are not depressed:

1. Flush Medians. Flush medians consist of a relatively flat paved area separating the traffic lanes with only painted stripes on the pavement. Flush medians should be either slightly crowned to avoid ponding of water in the median area or slightly depressed (with median drains) to avoid carrying all surface drainage across the travel lanes.

2. Curbed Medians. Curbed, raised medians are most commonly used on lower-speed urban arterials. The roadway is typically crowned to transport a portion of the pavement drainage to the outside and a portion to the median, which then requires a collection and conveyance system for the median drainage.

12.8 GUTTER FLOW CALCULATIONS

12.8.1 Introduction

Gutter flow calculations are necessary to relate the quantity of flow (Q) in the curbed channel to the spread of water on the shoulder, parking lane or traveled way section. This Section discusses uniform cross slope roadways and composite gutter sections. Composite gutter sections have a greater hydraulic capacity and are therefore preferred. Figure 12.8-A presents schematics of typical gutter sections. Section 12.8.4 provides an example problem for the composite gutter commonly used by SDDOT. The uniform gutter computations are provided in Section 12.8.3. If one of the alternative sections illustrated in Figure 12.8-A are proposed, see HEC 22 (Reference (1)) for procedures for calculating spread.

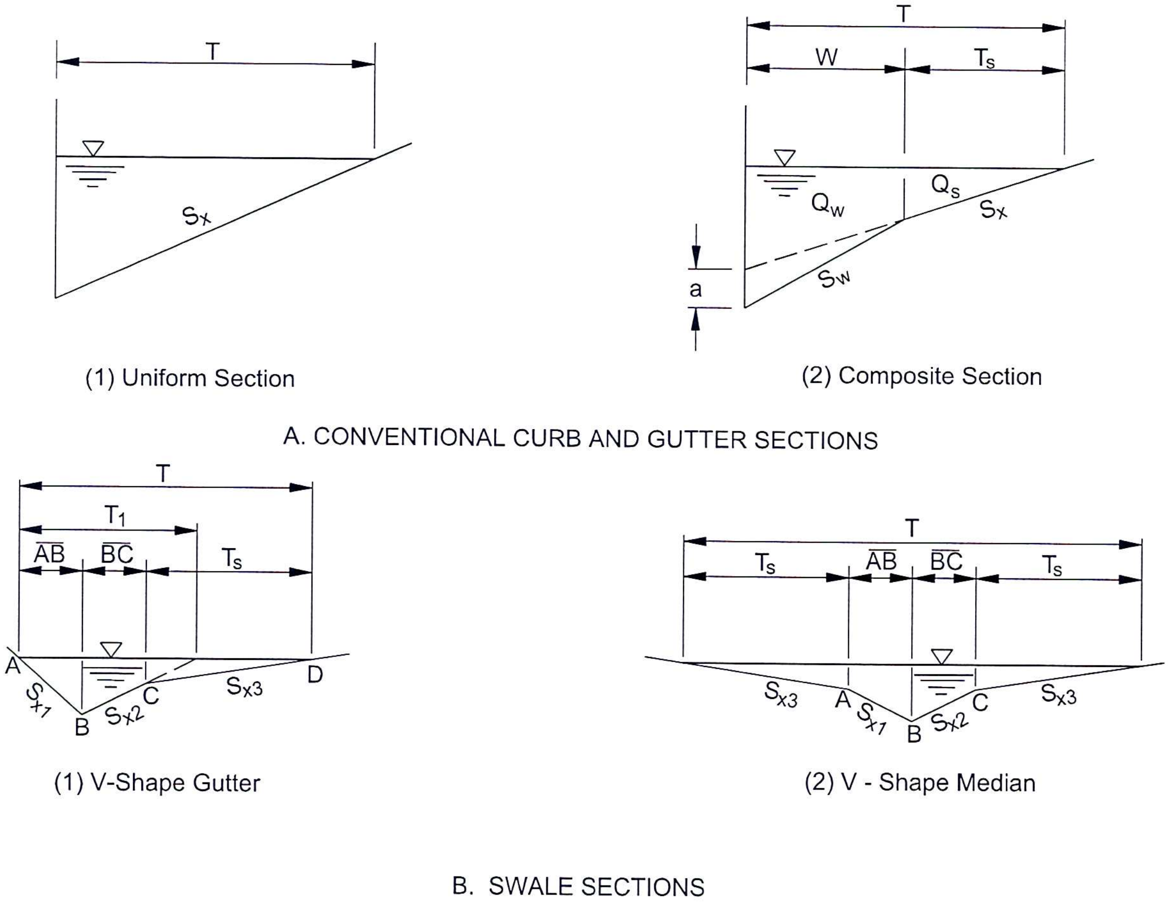


Figure 12.8-A — TYPICAL CURB AND GUTTER SECTIONS

12.8.2 Capacity Relationship

A modification of Manning's equation can be used for computing flow in triangular channels:

$$Q = \frac{K_u}{n} S_x^{1.67} S_L^{0.5} T^{2.67} \quad \text{(Equation 12.1)}$$

or in terms of T:

$$T = \left(\frac{Qn}{K_u S_x^{1.67} S_L^{0.5}} \right)^{0.375} \quad \text{(Equation 12.2)}$$

where:

Q = flow rate, cfs
K_u = 0.56
n = Manning's coefficient (see Figure 12.8-B)
S_x = cross slope, ft/ft
S_L = longitudinal slope, ft/ft
T = width of flow (spread), ft

Type of Gutter or Pavement	Manning's n
Concrete Gutter, troweled finish	0.012
Asphalt Pavement:	
Smooth texture	0.013
Rough texture	0.016
Concrete Gutter, Asphalt Pavement	
Smooth	0.013
Rough	0.015
Concrete Pavement	
Float finish	0.014
Broom finish	0.016

Note: For gutters with small longitudinal slope, where sediment may accumulate, increase above n values by 0.02.

Note: The n value is 0.015 for SDDOT typical gutter with pavement. This is based on SDDOT typical pavements being rough texture asphalt or broom finished concrete with troweled finish concrete gutter.

Figure 12.8-B — MANNING'S n FOR GUTTERS
(after HDS 3, Table 1 (Reference (5)))

12.8.3 Uniform Cross Slope Procedure

Example 12.8-1 illustrates the analysis of roadways and g utters with uniform cross slope using the above equations. The equations can also be solved using FHWA Hydraulic Toolbox; see Section 18.2.4.

Example 12.8-1

Given: Gutter section illustrated in Figure 12.8-A (sketch A(1))

S_L = 0.01 ft/ft
S_x = 0.02 ft/ft
n = 0.016

Find: (1) Spread at a flow of 1.8 cfs
(2) Gutter flow at a spread of 8.0 ft

Solution (1):

Step 1 Compute spread, T, using Equation 12.2:

$$T = \left[(Q\,n) / \left(K_u\, S_x^{1.67}\, S_L^{0.5}\right)\right]^{0.375}$$
$$T = \left[(1.8)(0.016) / \left\{(0.56)(0.02)^{1.67}(0.01)^{0.5}\right\}\right]^{0.375}$$
$$T = 9.0 \text{ ft}$$

Solution (2):

Step 1 Using Equation 12.1 with T = 8.0 ft and the information given above, determine Qn:

$$Qn = K_u\, S_x^{1.67}\, S_L^{0.5}\, T^{2.67}$$
$$Qn = (0.56)(0.02)^{1.67}(0.01)^{0.5}(8.0)^{2.67}$$
$$Qn = 0.021 \text{ cfs}$$

Step 2 Compute Q from Qn determined in Step 1:

$$Q = Qn / n$$
$$Q = 0.021 / 0.016$$
$$Q = 1.3 \text{ cfs}$$

12.8.4 Composite Gutter Section Procedure

The design of a composite gutter section requires the consideration of flow in the depressed segment of the gutter, Q_W. The equations provided below can be used to determine the flow in a width of gutter in a composite cross section, W, less than the total spread, T. The procedure for analyzing composite gutter sections is demonstrated in Example 12.8-2.

$$E_o = 1 / \left\{ 1 + \frac{S_w / S_x}{\left[1 + \frac{S_w / S_x}{\frac{T}{W} - 1} \right]^{2.67} - 1} \right\} \quad \text{(Equation 12.3)}$$

$$Q_w = Q - Q_s \quad \text{(Equation 12.4)}$$

$$Q = \frac{Q_s}{(1 - E_o)} \quad \text{(Equation 12.5)}$$

where:

Q_W = flow rate in the depressed section of the gutter, cfs

Q = gutter flow rate, cfs

Q_s = flow capacity of the gutter section above the depressed section, cfs

E_o = ratio of flow in a chosen width (usually the width of a grate) to total gutter flow (Q_W/Q)

S_W = $S_X + a/W$, ft/ft (see Figure 12.8-A, sketch (A(2))

Example 12.8-2

Given: SDDOT Type B Curb and Gutter
Gutter section illustrated in Figure 12.8-A (sketch A(2))
(*Note: The 2-in sloping section at the curb is not included*).

S_L = 0.01 ft/ft
S_x = 0.02 ft/ft
S_w = 0.05 ft/ft
W = 2 ft
n = 0.016

Find: (1) Gutter flow at a spread (T) = 8.0 ft
(2) Spread (T) at a gutter flow (Q) = 2 cfs

Solution (1):

Step 1 Using the cross slope of the depressed gutter (S_w = 0.05), compute "a" and the width of spread from the junction of the gutter and the road to the limit of the spread, T_s:

S_w = 0.05 = a/W + S_x = a/2 + 0.02 (a = 0.72 in)
T_s = T – W = 8.0 – 2.0
T_s = 6.0 ft

Step 2 From Equation 12.1 (using T_s):

$Q_s n = K_u S_x^{1.67} S_L^{0.5} T_s^{2.67}$
$Q_s n = (0.56)(0.02)^{1.67}(0.01)^{0.5}(6.0)^{2.67}$
$Q_s n$ = 0.0097 cfs
Q_s = $(Q_s n)/n$ = 0.0097/0.016
Q_s = 0.61 cfs

Step 3 Determine the gutter flow, Q, using Equations 12.3 and 12.5:

T/W = 8.0/2 = 4. 0
S_w/S_x = 0.05/0.02 = 2.5
$E_o = 1 / \{1 + [(S_w/S_x)/((1 + (S_w/S_x)/(T/W - 1))^{2.67} - 1)]\}$
$E_o = 1 / \{1 + [2.5 / ((1 + (2.5) / (4.0 - 1))^{2.67} - 1)]\}$
E_o = 0.618
$Q = Q_s/(1 - E_o)$
Q = 0.61/(1 – 0.618)
Q = 1.6 cfs

Solution (2):

Because the spread cannot be determined by a direct solution, an iterative approach should be used. This approach is provided in HEC 22 (Reference (1)), Section 4.3.2.2. If the FHWA Hydraulic Toolbox (Version 1.0) is used to determine the spread for a given discharge, the results are:

Q = 2.0 cfs
T = 8.8 ft
E_o = 0.573
Area of flow = 0.834 sq ft
Depth at curb = 2.83 in with a = 0.72 in

The distribution of the flow is:

$Q_w = E_o (Q) = 0.573 (2.0) = 1.15$ cfs
$Q_s = Q - Q_w = 2.0 - 1.15 = 0.85$ cfs
$T_s = T - W = 8.8 - 2 = 6.8$ ft

12.9 INLETS

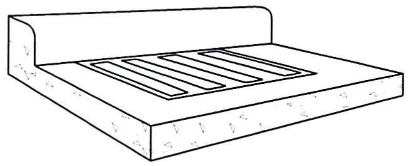
12.9.1 <u>General</u>

Inlets are drainage structures used to collect surface water through a grate, a curb opening or a combination of both (see inlet types figure) and convey it to storm drains or to culverts. This Section discusses the various types of inlets used by SDDOT and recommends guidelines on the use of each type.

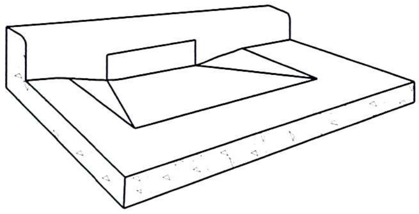
Drainage inlets are sized and located to limit the spread of water on the roadway to allowable widths for the design storm as specified in <u>Section 12.7.3</u>. Grate inlets and the depression of curb opening inlets should be located outside the through traffic lanes to minimize the shifting of vehicles attempting to avoid them. All grate inlets should be bicycle safe (like the Type B grate) where used on roadways that allow bicycle travel.

12.9.2 <u>Types</u>

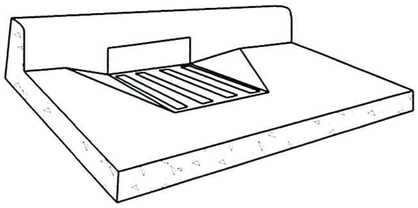
Inlets used for the drainage of highway pavements can be divided into four major classes. See the <u>*SDDOT Standard Plates*</u> for those grates used by the Department.



Grate Inlet



Curb-Opening Inlet



Combination Inlet

Inlet Types

12.9.2.1 Grate Inlets

These inlets consist of an opening in the gutter covered by one or more grates. They are best suited for use on continuous grades. Grate inlets have more capacity on steeper grades when compared to curb opening inlets. Because they are susceptible to clogging with debris, the use of standard grate inlets at sag points should be limited to minor sag point locations without debris potential. Special-design (oversize) grate inlets can be used at major sag points if sufficient capacity is provided for clogging. Otherwise, flanking inlets are needed.

SDDOT uses the following grate inlets:

1. <u>Type A Frame and Grate</u>. This is typically used on bridge approach slabs.

2. <u>Type C Frame and Grate</u>. This is typically used as a yard drain behind the curb and gutter.

3. <u>Type E Frame and Grate</u>. This is typically used with a valley-type gutter.

4. Types L, M and N Median Drains. These are used in depressed medians and roadside ditches.

12.9.2.2 Curb-Opening Inlets

These inlets provide openings in the curb covered by a top slab. Curb-opening inlets are preferred at sag points because they can convey large quantities of water and debris. They may also be a viable alternative to grates in many locations where grates may be hazardous for pedestrians or bicyclists. They are generally not the first choice for use on continuous grades because of their poor hydraulic capacity. However curb opening inlets have more capacity on flatter grades when compared to grate inlets.

The SDDOT curb-opening inlet is designated as a Type S Reinforced Concrete Drop Inlet. SDDOT typical practice is to use the Type S inlet at sag locations.

12.9.2.3 Combination Inlets

Various types of combination inlets are in use. Curb-opening and grate combinations are common, some with the curb opening upstream of the grate and some with the curb opening adjacent to the grate. The gutter grade, cross slope and proximity of the inlets to each other are significant factors when selecting this type of inlet. Combination inlets may be desirable in sags because they can provide additional capacity in the event of plugging.

The SDDOT Type B Frame and Grate is the Department's combination curb-opening and grate inlet. The grate uses 45° tilted bars sloped in the direction of flow to increase hydraulic capacity. The Type B is the most commonly used inlet by SDDOT, especially on continuous grades.

12.9.2.4 Slotted Drain Inlets

These inlets consist of a slotted opening with bars perpendicular to the opening. Slotted inlets function as weirs because the flow usually enters perpendicular to the slot. They can be used to intercept sheet flow, collect gutter flow with or without curbs, modify existing systems to accommodate roadway widening or increased runoff, and reduce ponding depth and spread at grate inlets.

The *SDDOT Standard Plates* do not include any slotted drains; they are designed on a case-by-case basis. Slotted corrugated metal pipes may be used in median crossovers and, at times, in curb and gutter sections where large volumes of water need to be picked up. Slotted reinforced concrete pipe may be used as a median drain. HEC 22 (Reference (1)) contains design guidance.

12.9.3 Drop Inlets

A drop inlet provides a base for the drainage grate. Basically, the drop inlet represents the below-pavement structure (or basin) to collect the storm drainage from the inlets and to convey the drainage to the underground piping system.

Drop inlets also act as manholes by providing access to the underground piping system for maintenance and inspection. Drop inlets should be designed to follow the same location and spacing requirements as manholes in Section 12.11, in addition to the inlet location, spacing and capacity requirements in Section 12.10.

Precast drop inlet collars should be provided on drop inlets where the grate is placed within or adjacent to paved surfaces, including PCC pavement and asphalt concrete pavement. The collar allows movement of the pavement without affecting the drop inlet structure. SDDOT has developed standard precast drop inlet collars.

SDDOT has also developed drop inlet covers where inlets and access to the piping system are not needed. Use of these may be rare as it is desirable to provide access to the piping system.

Sumps in drop inlets may be provided when requested by the City and where the City is responsible for maintenance of the storm drainage system. The sumps are created by constructing the drop inlet floor 1 ft below the pipe flowline elevation. Sumps are provided to collect debris.

12.10 INLET LOCATION, SPACING AND CAPACITY

12.10.1 General

12.10.1.1 Location

There are a number of locations where inlets may be necessary without regard to contributing drainage area. These locations should be marked on the plans prior to any hydraulic computations regarding discharge, water spread, inlet capacity or bypass. Examples of such locations are:

- Inlets should be placed on the upstream side of bridge approaches.
- Inlets should be placed at all low points in the gutter grade.
- Inlets should be placed upstream of intersecting streets.
- Inlets should be placed on the upstream side of a driveway entrance, curb-cut ramp or pedestrian crosswalk even if the hydraulic analysis places the inlet further down grade or within the feature.
- Inlets should be placed upstream of median breaks.
- Inlets should be placed to capture flow from intersecting streets before it reaches the major highway.
- Flanking inlets in sag vertical curves are standard practice. See Section 12.10.8.
- Inlets should be placed to prevent water from sheeting across the highway (i.e., place the inlet before the superelevation transition begins).
- Inlets should not be located in the path where pedestrians walk.
- Inlets connected by pips should have a maximum spacing according to the manhole spacing requirements in Section 12.11.2 to limit pipe lengths for maintenance puposes.

12.10.1.2 Spacing Process

Locate inlets from the crest and work downgrade to the sag points. The location of the first inlet from the crest can be found by determining the length of pavement and the area in back of the curb sloping toward the roadway that will generate the design runoff. The design runoff can be computed as the maximum allowable flow in the curbed channel that will meet the design frequency and allowable water spread. Where the contributing drainage area consists of a strip of land parallel to and including a portion of the highway, the location of the first inlet can be calculated as follows:

$$L = \frac{43{,}560\,Q_t}{CiW}$$ (Equation 12.6)

where:

L	=	distance from the crest, ft
Q_t	=	maximum allowable flow, cfs
C	=	composite runoff coefficient for contributing drainage area
W	=	width of contributing drainage area, ft
i	=	rainfall intensity for design frequency, in/hour

Equation 12.6 is an alternate form of the Rational Equation. If the drainage area contributing to the first inlet from the crest is irregular in shape, trial and error may be necessary to match a design flow with the maximum allowable flow.

To space successive downgrade inlets, it is necessary to compute the amount of flow that will be intercepted by the inlet (Q_i) and subtract it from the total gutter flow to compute the bypass. The bypass from the first inlet is added to the computed flow to the second inlet, the total of which must be less than the maximum allowable flow dictated by the allowable water spread. Figure 12.10-E (see Section 12.10.9) is an inlet spacing computation sheet that can be used to record the spacing calculations. However, inlet calculations are usually accomplished with software.

FHWA has investigated the inlet interception capacity of all types of grate inlets, slotted drain inlets, curb-opening inlets and combination inlets. HEC 22 (Reference (1)) or the FHWA Hydraulic Toolbox (see Section 18.2.4) may be used to analyze the flow in gutters and the interception capacity of all types of inlets on continuous grades and sags. Both uniform and composite cross slopes can be analyzed.

12.10.2 Grate Inlets on Grade

The capacity of a grate inlet depends upon its geometry, cross slope, longitudinal slope, total gutter flow, depth of flow and pavement roughness. The depth of water next to the curb is the major factor in the interception capacity of both gutter inlets and curb-opening inlets. At low velocities, all of the water flowing in the section of gutter occupied by the grate (frontal flow), is intercepted by grate inlets and a small portion of the flow along the length of the grate (side flow) is intercepted. On steep longitudinal slopes, a portion of the frontal flow may tend to splash over the end of the grate for some grates.

The ratio of frontal flow to total gutter flow, E_o, for a straight cross slope is given by the following equation:

$$E_o = Q_w / Q = 1 - (1 - W/T)^{2.67}$$ (Equation 12.7)

where:

Q = total gutter flow, cfs
Q_w = flow in width W, cfs
W = width of depressed gutter or grate, ft
T = total spread of water in the gutter, ft

The ratio of side flow, Q_s, to total gutter flow is:

$$Q_s/Q = 1 - Q_w/Q = 1 - E_o \qquad \text{(Equation 12.8)}$$

The ratio of frontal flow intercepted to total frontal flow, R_f, is expressed by the following equation:

$$R_f = 1 - 0.09\,(V - V_o) \qquad \text{(Equation 12.9)}$$

where:

V = velocity of flow in the gutter, fps
V_o = gutter velocity where splash-over first occurs, fps

This ratio is equivalent to frontal-flow interception efficiency. Figure 12.10-A (from HEC 22, Chart 5) provides a solution of Equation 12.9 that incorporates grate length, bar configuration and gutter velocity at which splash-over occurs. The gutter velocity needed to use Figure 12.10-A is total gutter flow divided by the area of flow. Figure 12.10-A shows that parallel bar grates are the most efficient grates on steep slopes but are not bicycle safe. The grates tested in a FHWA research study are described in HEC 22 (Reference (1)).

The equations provided in Figure 12.10-B can be used to determine splash-over velocities (V_o) for various grate configurations. Equation 12.10 can then be used to compute the portion of frontal flow intercepted by the grate.

The ratio of side flow intercepted to total side flow, R_s, or side-flow interception efficiency, is expressed by:

$$R_s = 1 / [1 + (0.15V^{1.8}/S_xL^{2.3})] \qquad \text{(Equation 12.10)}$$

where:

V = velocity of flow in gutter, fps
L = length of the grate, ft
S_x = cross slope, ft/ft

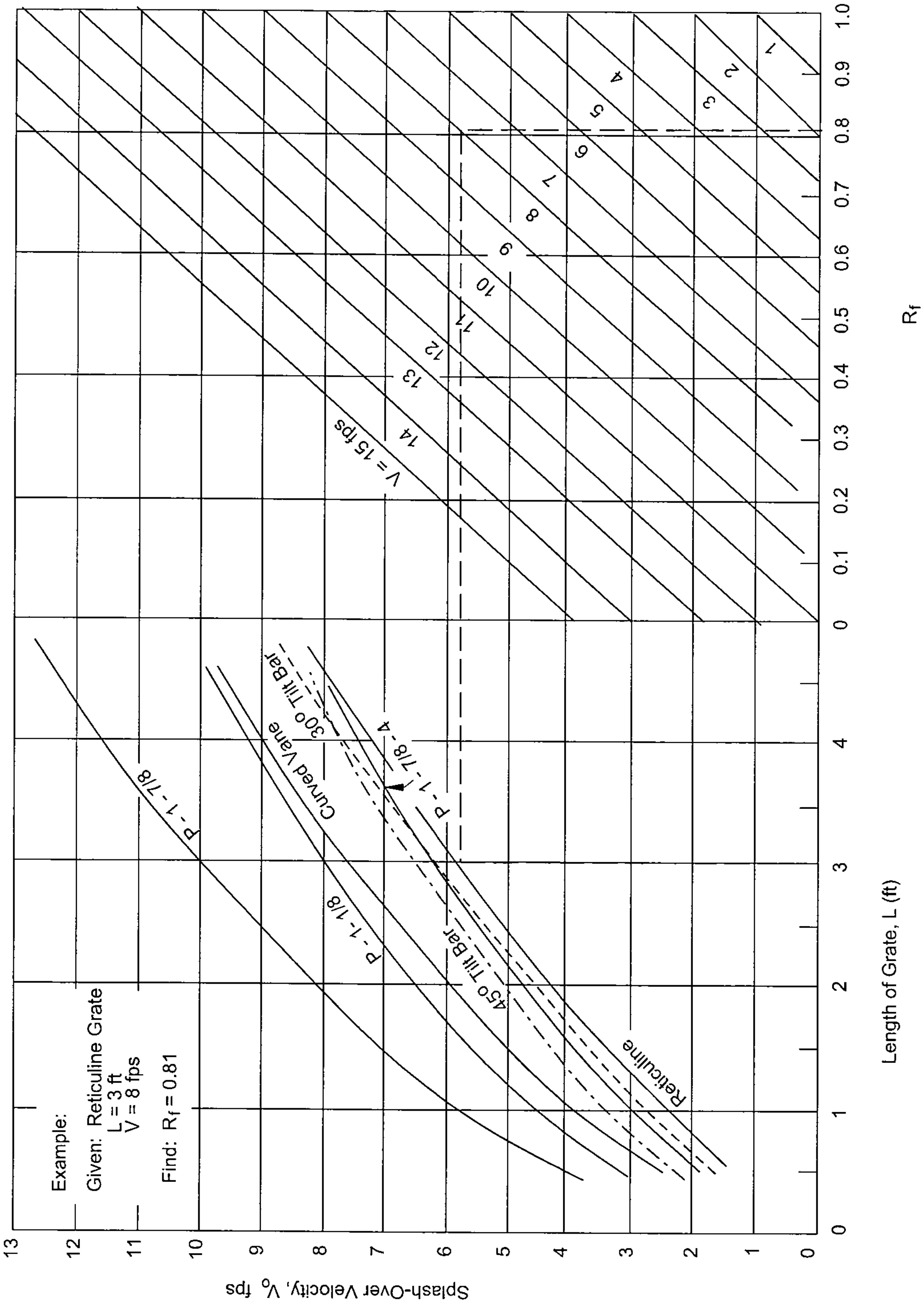


Figure 12.10-A — GRATE INLET FRONTAL-FLOW INTERCEPTION EFFICIENCY (Reference (1))

Grate Configuration	Typical Bar Spacing (in)	Splash-over Velocity Equation
Parallel Bars (P-1⅞)	2.0	$V_o = 2.218 + 4.031L - 0.649L^2 + 0.056L^3$
Parallel Bars (P-1⅛)	1.2	$V_o = 1.762 + 3.117L - 0.451L^2 + 0.033L^3$
Curved Vane	4.5	$V_o = 1.381 + 2.78L - 0.300L^2 + 0.020L^3$
45° Tilt Bar	4.0	$V_o = 0.988 + 2.625L - 0.359L^2 + 0.029L^3$
Parallel Bars with Transverse Rods (P-1⅞-4)	2.0 Parallel/ 4.0 Transverse	$V_o = 0.735 + 2.437L - 0.265L^2 + 0.018L^3$
30° Tilt Bar	4.0	$V_o = 0.505 + 2.344L - 0.200L^2 + 0.014L^3$
Reticuline	N/A	$V_o = 0.030 + 2.278L - 0.179L^2 + 0.010L^3$

Figure 12.10-B — SPASH-OVER VELOCITY EQUATIONS

The efficiency, E, of a grate is expressed as:

$$E = R_f E_o + R_s(1 - E_o) \qquad \text{(Equation 12.11)}$$

The interception capacity of a grate inlet on grade is equal to the efficiency of the grate multiplied by the total gutter flow:

$$Q_i = EQ = Q[R_f E_o + R_s(1 - E_o)] \qquad \text{(Equation 12.12)}$$

Example 12.10-1

Given: Given the gutter section from Example 12.8-2:

T = 8.0 ft S_L = 0.01 ft/ft
W = 2.0 ft S_x = 0.02 ft/ft
n = 0.016 S_w = 0.05 ft/ft (continuous gutter depression, a = 0.72 in)

Find: The interception capacity of a SDDOT Type B Frame and Grate. The grate has outside dimensions of 17.75 in (1.5 ft) by 35.5 in (3 ft) and has 11 tilted bars. The titled bars are 2-in high and at a 45-degree angle to vertical. (Note: Although this is a combination inlet, the grate provides all of the capacity and the curb opening provides for debris).

Solution: From Example 12.8-2:

E_o = 0.618
Q = 1.6 cfs

Step 1 Compute the average gutter velocity:

$V = Q/A = 1.6/A$
$A = 0.5T^2S_x + 0.5aW$
$A = 0.5(8.0)^2\,(0.02) + 0.5(0.06)(2.0) = 0.64 + 0.06$
$A = 0.70$ sq ft
$V = 1.6/0.70 = 2.29$ fps

Step 2 Determine the frontal flow efficiency using Figure 12.10-A:

$R_f = 1.0$

Step 3 Determine the side flow efficiency using Equation 12.10:

$R_s = 1/[1 + (0.15\,V^{1.8}) / (S_x\,L^{2.3})]$
$R_s = 1/[1 + (0.15)\,(2.29)^{1.8} / [(0.02)\,(3.0)^{2.3}]$
$R_s = 0.27$

Step 4 Compute the interception capacity using Equation 12.12. (Because the Type B grate is only 18-in wide, replace E_o with $E_o = E_o(A'_w / A_w)$ where A_w is the area of flow over the 2-ft gutter and A'_w is the area of flow over the grate):

$E'_o = E_o(A'_w / A_w) = 0.618(0.27/0.34) = 0.491$
$Q_i = Q[R_f\,E_o + R_s\,(1 - E_o)]$
$= (1.6)[(1.0)(0.491) + (0.27)(1 - 0.491)] = 1.6\,(0.491 + 0.137)$
$= 1.6(0.628) = 1.00$ cfs
$E = Q_i/Q = 1.00/1.6 = 0.625$ or 63%

The calculations show that the Type B inlet is 63% efficient and captures 1.0 cfs while 0.60 cfs is bypassed. The FHWA Hydraulic Toolbox (Version 1.0) gives similar results.

12.10.3 Grate Inlets In Sag

Although curb-opening inlets are generally preferred to grate inlets at a sag, grate inlets can be used successfully. For minor sag points where debris potential is limited, grate inlets without a curb-opening inlet can be utilized. An example of a minor sag point might be on a ramp as it joins a mainline. Curb-opening inlets in addition to a grate are preferred at sag points where debris is likely, such as on a city street (see Section 12.10.7). For major sag points, such as on divided high-speed highways, a curb-opening inlet is preferable to a grate inlet because of its hydraulic capacity and debrishandling capabilities. When grates are used, it is good practice to assume that half the grate is clogged with debris.

Where significant ponding can occur, in locations such as underpasses and in sag vertical curves in depressed sections, it is good engineering practice to place a minimum of one flanking inlet on each side of the sag point inlet. The flanking inlets should be placed so that they will limit spread on low-gradient approaches to the low point and act in relief of the inlet at the low point if it should become clogged or if the allowable spread is exceeded. Section 12.10.8 presents a further discussion and methodology.

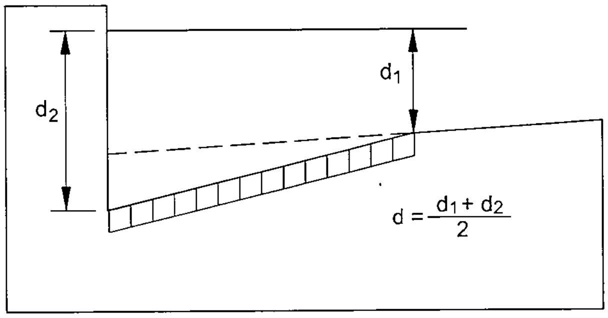
A grate inlet in a sag operates as a weir up to depths dependent on the size of the grate and as an orifice at greater depths. Grates of larger dimension will operate as weirs to greater depths than smaller grates.

The capacity of a grate inlet operating as a weir is:

$$Q_i = C_w P d^{1.5} \quad \text{(Equation 12.13)}$$

where:

P = perimeter of grate excluding bar widths and side against curb, ft
C_w = 3.0, weir coefficient
d = average depth across the grate ($0.5(d_1 + d_2)$), ft (see sketch below)



The capacity of a grate inlet operating as an orifice is:

$$Q_i = C_o A_g (2gd)^{0.5} \quad \text{(Equation 12.14)}$$

where:

C_o = 0.67, orifice coefficient
A_g = clear opening area of the grate, sq ft
g = 32.2 ft/sec^2

The use of Equation 12.14 requires the clear area of opening of the grate, which is obtained by multiplying the total area by the opening ratios given in the following table (from HEC 22 (Reference (1))):

Grate	Opening Ratio	SDDOT Inlet
P-1⅞-4	0.8	
P-1⅞	0.9	
P-1⅛	0.6	
Reticuline	0.8	Types C, D, E, L & M
Curved vane	0.35	
Tilt-bar	0.34	Type B

Example 12.10-2

Given: Given the gutter section from Example 12.8-2:

$T = 8.0$ ft $\quad S_L = 0.010$ ft/ft

$S_x = 0.02$ ft/ft

$n = 0.016 \quad S_w = 0.05$ ft/ft (continuous gutter depression, a = 0.72 in)

Find: The capacity of a SDDOT Type B Frame and Grate in a sump. The grate has outside dimensions of 17.75 in (1.5 ft) by 35.5 in (3 ft) and has 11 tilted bars. The tilted bars are 2-in high and at a 45-degree angle to vertical. (Note: Although this is a combination inlet, only the grate capacity will be assessed).

Solution: From Example 12.8-2:

$E_o = 0.618$

$Q = 1.6$ cfs

Solution:

Step 1 Determine the required grate perimeter:

Depth at curb, d_2:

$d_2 = TS_x + a = (8)(0.02) + 0.72/12 = 0.16 + 0.06$

$d_2 = 0.22$ ft

Average depth over grate:

$d = d_2 - ((\text{grate width})/2)S_w$

$d = 0.22 - (1.5/2)(0.05)$

$d = 0.18$ ft with no clogging

d = 0.20 ft with 50% clogging (assume that the upper half is clogged so that only 25% of the 1.5-ft width is subtracted to determine average depth)

From Equation 12.13:

$P = Q_i / [C_w d^{1.5}]$
$P = (1.6)/[(3.0)(0.20)^{1.5}]$
$P = 5.96$ ft (use 6 ft)

Assuming 50% clogging along the grate length (i.e., width is reduced by 50%):

$P_{effective} = 6.0 = (0.5)(2)W + L$
if W = 1.5 ft, then L = 4.5 ft

The Type B Grate is a 1.5 ft by 3 ft grate:

$P_{effective} = (0.5)(1.5)(2.0) + (3)$
$P_{effective} = 4.5$ ft (one grate)
$P_{effective} = 7.5$ ft (2 grates) > 6 ft needed, OK

Step 2 Check depth of flow at curb using Equation 12.13 using two grates:

$d = [Q/(C_w P)]^{0.67}$
$d = [1.6/(3.0)(7.5)]^{0.67}$
d = 0.17 ft or 2 in
Therefore, OK.

Step 3 Check depth of flow assuming orifice flow, Equation 12.14:

$A_g = 0.75(3)(0.34) = 0.765$ sq ft (clogged area is further reduced by opening ratio)

$Q_i = C_o A_g (2gd)^{0.5} = 0.67(0.765)(64.4d)^{0.5} = 1.6$ cfs

d = 0.15 ft (1 grate)

d = 0.04 ft (2 grates)

Because these depths are lower than those in Step 2, orifice flow does not occur.

Designing a simple stormwater drainage system

In this annexe we present a method to estimate how much stormwater a catchment area will produce, and how a drain can be sized to remove this water.
This method can be used to design a simple drainage system, or to determine whether a proposed drainage system is realistic.

Materials needed:

- A map of the catchment area with gradient lines, or a study of the catchment area from which it is possible to calculate its gradients and boundaries
- Ruler
- Paper with gridlines
- A calculator with the option 'y to the power x' (y^x)
- Preferably the IDF-curves (intensity-duration-frequency curves) of the zone studied

Analysis of the catchment area

First the catchment area with its boundaries will have to be identified on the map. A catchment area is the entire surface that will discharge its stormwater to one point (the discharge point). As water always flows from high to low, it is possible to identify the catchment area on a map with the aid of the gradient lines. Once the catchment area is identified, its surface must be estimated. This can be done by transferring the contours of a catchment area on paper with gridlines, and counting the grids.

Now the average gradient in the catchment area has to be identified. This can be done on the map with the aid of the gradient lines and the horizontal distances. Figure A6.1 shows how to determine the gradient in a terrain. Usually the average gradient of the terrain can be taken.

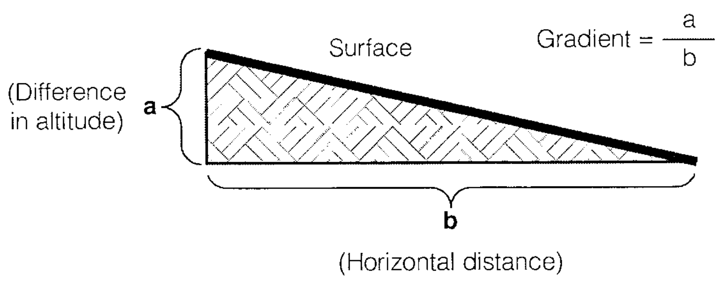


Figure A6.1. The gradient of a terrain

The next step is to assess the surface of the terrain. This information is needed to determine the runoff coefficient of the area. The runoff coefficient is that part of the rainwater which becomes stormwater; a runoff coefficient of 0.8 means that 80% of the rainfall will turn into stormwater. The runoff coefficient depends on the type of terrain, and its slope. Future changes in the terrain must be anticipated in the design of the drainage system to avoid problems at a later date. If no other values are available, the values from table A6.1 can be used.

Table A6.1. Runoff coefficients of different types of terrain (these values are approximate figures assuming a low soil permeability) (adapted from 49)**.**

Terrain type	*Runoff coefficient*	
	Gradient < 0.05 (flat terrain)	***Gradient > 0.05 (steep terrain)***
Forest and pastures	0.4	0.6
Cultivated land	0.6	0.8
Residential areas and light industry	0.7	0.8
Dense construction and heavy industry	1.0	1.0

Determining the rainfall intensity for which the system is designed

If no local IDF-curves (intensity-duration-frequency curve) are available, a rainfall intensity of 100 mm per hour can be assumed (this value is for tropical countries, with catchment areas smaller than 150 ha) [17]. If no IDF curves can be found, the reader can skip directly to the section *Calculating the amount of water the catchment area will produce*

If the IDF curves of the area can be obtained, these should be used. IDF curves show the rainfall intensity (in mm per hour) against the duration of the rains (in minutes) for specific return periods. Several curves from different return periods may be presented in one graph. A curve with a return period of 1 year will show the worst storm that will on average occur every year, a curve with a return period of 2 years is the worst storm that can be expected in a 2 year period, and so on.

To know which value to take from the IDF curve, the time of concentration has to be calculated. The time of concentration is the time the water needs to flow from the furthest point in the catchment area to the point where it will leave the area (the discharge point). The time of concentration is determined with the formula [49]:

$$T_{con} = 0.02 \times (L_{max})^{0.77} \times (S_{av})^{-0.383}$$

T_{con} : the time of concentration (in minutes)
L_{max} : the maximum length of flow in the catchment (in metres)
S_{av}: the average gradient of the catchment area

> If the furthest point of our catchment area is at a distance of 500 metres from the discharge point, and the difference in altitude between this point and the discharge point is 10 metres, than the time of concentration would be around ($0.02 \times (500)^{0.77} \times (10/500)^{-0.383}$ =) 11 minutes.

The curve with the appropriate return period is chosen (for residential areas often the curve with a 2 year return period [39]).

We look for the rainfall intensity on the chosen curve, at the duration of a storm equal to the time of concentration which we calculated.

Calculating the amount of water the catchment area will produce

The amount of stormwater the catchment will produce can be determined with the formula [adapted from 49]:

$$Q_{des} = 2.8 \times C \times i \times A$$

Q_{des} : the design peak runoff rate, or the maximum flow of stormwater the system will be designed for (in litres per second)
C : the runoff coefficient (see table F.1)
i : the rainfall intensity at the time of concentration read from the chosen IDF curve; if no IDF curves are available, a value of 100 mm/h can be taken (in mm/h)
A : the surface area of the catchment area (in ha (10,000 m^2))

> Thus, if our catchment area would be a residential area, with a surface of 12 ha, a gradient of 0.02, and a rainfall intensity of 100 mm/h, than the design peak runoff rate would be around ($2.8 \times 0.7 \times 100 \times 12$ =) 2350 litres per second.

It should be remembered that this figure is not a fixed value. Every once in a while storms will occur which produce more water than the drainage system can deal with (normally, on average, periods just above the return period). The larger the capacity of the system (the longer the return period the system is designed for) the less often it will overflow, and the higher its costs.

Sizing a drain to cope with the design peak runoff rate

With the design peak runoff rate known, we will have to plan where the drains will be installed. A drainage system must be planned together with other structures like roads and buildings to assure they are all adapted to one another.

Unlined drains are at risk of erosion, and should therefore have a relatively low gradient to control the velocity of the stormwater. Gradients in unlined drains should probably not exceed 0.005 (1 metre drop in 200 metres horizontal distance). In less stable soil unlined drains should be made with a slope less steep than 1/2 (see figure A6.2), in more cohesive material a steeper slope could be used [17].

The size of the drain can be calculated with the formula [17]:

$$Q = 1000 \times \left(\frac{A \times (R)^{0.67} \times (S)^{0.5}}{N} \right)$$

Q : the capacity of discharge of the drain (in l/s)
A : the cross section of the flow (in m^2)
R : the hydraulic radius of the drain (see figure F.3, in m)
S : the gradient of the drain
N : Manning's roughness coefficient: for earth drains, 0.025; brick drains,

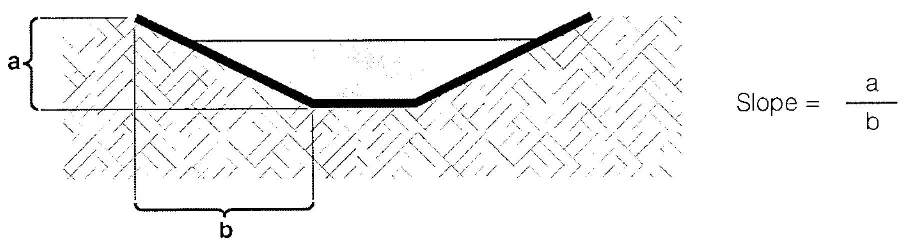


Figure A6.2. Section of an unlined drain in less stable soil

the hydraulic radius is the surface area of the cross section of the flow/the total length of the contact between water and drain;

Hydraulic radius = (a x b) / (a + b + c)

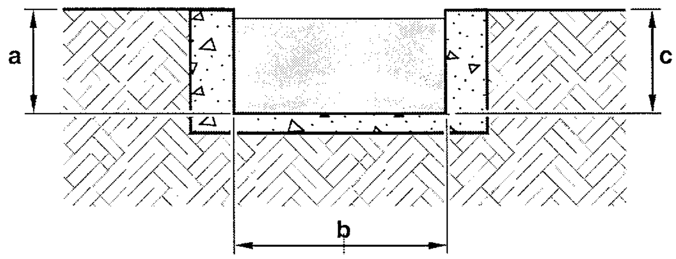


Figure A6.3. The hydraulic radius

A completely filled, rectangular, smooth concrete drain of 1.5 m by 0.7 m, with a gradient of 0.005, can in ideal circumstances discharge around (1000 x ((1.5 x 0.7) x $((1.5 \times 0.7/(1.5 + 0.7 + 0.7))^{0.67} \times (0.005)^{0.5}) / 0.015)$ = 2500 litres per second.

This calculation will probably have to be repeated a number of times to find the adequate size of drain [17].

Some reserve will be needed so that the drain is not completely filled with water, and because the calculated discharge rate does not take into account deposited solids, and lack of maintenance, which will usually reduce the efficiency of the system [39].