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Management Of Rain Water In Highway Through Different Drain Design With Loaded Wheel

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ABSTRACT: A drain is the drainage system component that collects runoff from inlets and transfers the runoff to a point where it is then drained into a stream, water source, or piped system. It is very significant that all highway roads must have a proper storm drainage design to avoid further problems such as, poor highway traffic due to flood on the main road, potholes causing accidents, and erosion on the road sub-grades.This research focuses on designing the storm water drainage system of Independence Drive in Chandikhole Bhadrak Highway.Its purpose is to provide a complete design of drainage system, including suitable ways to improve the current conditions of the road in terms of its drainage network. In order to designa better drainage network for the road, the drainage design is carried out in two phases as per the guidelines provided in IRC: SP-42; namely, Hydrologic analysis and Hydraulic analysis. Therefore, the research engaged the detailed design Calculation along with Strip Plan and Profile are given below. The design of RCC drain with wheel load are calculated for four heights 0.9m, 1.25m, 1.5m, 1.75m and 2 m. All the design are installed as per requirement of strom water management.

KEYWORDS: Drainage, subgrade, hydrologic, hydraulic, RCC, wheel load etc.

I. INTRODUCTION

The primary purpose of a road drainage system is to remove the water from the road and its surroundings. The road drainage system consists of two parts: dewatering and drainage. “Dewatering” means the removal of rainwater from the surface of the road. “Drainage” on the other hand covers all the different infrastructural elements to keep the road structure dry. “Dewatering” is further divided into two parts: runoff and dewatering. “Runoff” covers the waterflowing from the surface of the pavement via road shoulders and inner slopes to the ditches. “Dewatering” covers the collection and transport of water from the surface and structure of the road so that there will be no ponds on the road or in the ditches.

The general score of road drainage system is dependent on its “weakest link”. This means that if any of its elements is out of order, the whole system will not operate as planned and the road willbe damaged. On the other hand a well built and maintained road drainage system is a very sustainable investment policy. The main advantages of a good drainage system are: effective removal of rainwater out of the road surface and its surroundings, road structures that stay dry, good bearing capacity, and a road that is nice and safe to drive.

II. LITERATURE SURVEY

Season S Chen et. al. (2021) In this paper author improve the reliability of SuDS in such regions, we evaluate design factors based on the site-specific context and identify sizing criteria, filter media engineering, and vegetation selection, which are critical for regulating both quantity and quality. Continuous monitoring and pre-design modeling are necessary to deliver effective designguidelines based on the rainfall-runoff profiles. Innovative design measures including modification of filter media by biochar and selection of local vegetation can enhance stormwater treatment and minimize seasonal effects such as intensive flow and distinct wet/dry periods in subtropical climates.

Jim W. Hall et. al. (2021) This paper explores the response of a one hectare urban area to rainfallevents of varying magnitude under a range of different scenarios for the built environment (development density, SuDS type, residence type and SuDS deployment extent), using the Stormwater Management Model (SWMM). It finds that whilst increased development density leads to an increased peak runoff rate, in some cases lower SuDS deployment in higher density scenarios leads to lower runoff rates than higher deployment in a lower development density. The type of SuDS also has a considerable impact on runoff dynamics, with those constructed on existing infrastructure offering greater proportional reductions in runoff rates than those constructed on previously undeveloped land.

Joong Hoon Kim et. al. (2021) Author proposes a resilience-constrained optimal design model of urban drainage networks that minimizes total system cost while satisfying predefined levels of failure depth and duration. Failure (e.g., flooding) depth refers to the level of system performance degradation, whereas failure duration is the time taken for a system's recovery to its normal state.Optimal layout and pipe sizes are identified by the proposed model comprising the harmony search algorithm for optimization and the storm water management model (SWMM) for dynamichydrology–hydraulic simulations. The proposed model is demonstrated through the design of twogrid networks and an A-city drainage network. The obtained resilience-based design is compared to the least-cost design obtained with no resilience consideration according to optimized layout and pipe sizes and the resulting topological characteristics.

M. Eugoli et. al. (2021) In this paper, a new genetic algorithm (GA)–based methodology is developed to determine the optimal location of multiple FCDs in urban drainage networks, when assessing RTC performance through hydraulic analysis. The methodology is tested on a case studynetwork, where a high number of possible FCD location arrangements are tested and compared, and the RTC effectiveness in reducing combined sewer overflows has been evaluated over a range of design storm events. Results demonstrate the capability of the proposed method in selecting robust FCD placement strategies, for example when designing local RTC systems to meet specific performance criteria.

Dr. Rambabu Palaka et. al. (2021) In this study, the Central Zone of town covering 4 Wards (13, 14, 15, and 8 Partly) is considered for investigation and design of stormwater drainage systems. The entire zone is completely urbanized, and frequent inundation is observed during moderate to heavy rainfall events due to congested and improper drainage disposal system. The study is carriedout in five phases viz. Mapping of Road Network, Obtaining Elevations, Mapping Drainage Network, Computation of Peak Discharge, and Design of Stormwater Drainage System. In this study, EPA-SWMM Software is used to build a Hydraulic and Hydrologic Model to analyze the existing drainage system and re-design the stormwater drains to safely discharge flood water without causing inundation in low-lying areas. To validate the results, Manning's Flow Equation is used to compute the flow carrying capacity of drainage channels.

Michael Gormley et. al. (2021) This paper assesses the limitations of applying current building drainage system design guides when applied to the case of tall buildings. Primarily, the assessments used in this research are based on codes from Europe, the USA and Australia/New Zealand as representative of the most common approaches and from which many other codes and standards are derived. The numerical simulation model, AIRNET, was used as the analysis tool. Our findings confirm that current design guides, which have been out of date for a number of decades, are now in urgent need of updating as code-compliant systems have been shown to be susceptible to water-trap seal depletion, a risk to cross-transmission of disease, which is a major public health concern, particularly in view of the current COVID-19 pandemic.

Martina Zele et. al. (2020) This study aims to assess the effect of changing the runoff coeffcient due to urban growth on the design of a storm water drainage system. The hydrological models Hyfran, Storm CAD and GIS are used to analyze different runoff coeffcients. This study examines three zones in Dammam in the Kingdom of Saudi Arabia (KSA). The data developed from the models for the current case studies are used to develop an empirical equation to predict the max discharge for other catchments. The discharge is a function of the return period, runoff coeffcient, drainage density, longest path, rainfall intensity and catchment area. To validate the developed equation, we use it to estimate the discharge in a real case study in South Korea. A comparison between the measured discharge and estimated discharge shows that the empirical equation is capable of predicting the maximum discharge for different catchments with high accuracy. Then,the validation of the models is carried out to determine the effect of the runoff coeffcient on the design of a storm water drainage system in a case study in KSA. The results show that an increasingrunoff coeffcient due to urban growth increases the outfall discharge and velocity of storm water drainage systems, as well as affecting the cost of construction and decreasing the lag time.

Anil R Chinchmalatpure et. al. (2020) In this paper author works on SSD system installed at a village with 30 m drain spacing and average 1.2 m drain depth was found effective in amelioratingthe water lagged saline vertisols in the area. The system resulted in the soil salinity up to 0.9 m depth from initial level of 1.2 – 7.3 dS m^{-1} and the soil of entire projet area become non saline.

Clifford Jr. Mespuk et. al. (2020) The research engaged a survey to obtain information about thestate of the Independence Drive drainage system and the effect of poor drainage on road users, including the surrounding environment. Based on the survey findings, the research focuses on providing solutions to the drainage problem encountered along the Independence Drive using bothsurvey and GIS data, processing of the data using spatial survey and geographical information tool and providing the appropriate drainage design output.

Shuchi Mishra et. al. (2020) Detailed Project Report for Storm Water Drainage Scheme is preparedto facilitate an implementable plan for the area. This paper presents a novel design of stormwaterdrainage system for a city. The objectives of preparing scheme are to identify all flood-prone areasin the catchment of draining areas, assessment of water flooding in the area affecting the stakeholders and details of all feasible storm water systems to address the issues.

Ruozhou Lin et. al. (2020) This paper proposes an efficient optimization framework for UDS design, where an engineering-based design method (EBDM) is developed to generate approximate solutions to initialize the MOEA's search, thereby greatly enhancing the optimization efficiency. To improve the solution practicality, two ideas have been implemented in the proposed optimization method (PM): (i) the variability of peak depths across pipes is minimized and (ii) a constraint is introduced to ensure that sizes of pipes in the downstream direction are no smaller than their corresponding upstream diameters. Two real-world UDSs of different size are used to demonstrate the effectiveness of the PM. Results show that (i) the proposed EBDM is effective in producing initial solutions that are very close to the final solutions identified by the optimization methods, (ii) the minimization of the variability of peak depths in pipes is practically meaningful as it can facilitate to identify solutions with great ability in handling future uncertainties (e.g., rainfall variability), and (iii) the PM significantly improves optimization efficiency and solution practicality compared to the traditional optimization approach, with benefits being more prominentfor larger UDSs.

Guru Chythanya Guptha et. al. (2020) In this paper, a case study to evaluate the effectiveness of implementing SuDS is demonstrated for Gurugram region using Storm Water Management Model (SWMM). The comparative analysis with conventional methods revealed that introducing SuDS has reduced the peak runoff by around 20% on the higher intensity of rainfall and even control the urban flooding by minimising the flooding volume at the junctions by millions of litres and storing it within the catchment area.

Manaye Teshome Sewnet et. al. (2020) This paper presents a critical review on stormwater drainage and urban flood based on 78 selected journal papers published over the period of 1990 to2018. The review focus on pluvial flooding to relate urban stormwater drainage management and urban flood disaster management and to show the links between the two. The methods taken to manage urban stormwater drainage and urban flooding as well as the complexity of achieving a comprehensive urban flood disaster management are evaluated and discussed. To better understand the concepts behind urban flood and improve the urban flood risk management strategies, recommendation of future research directions is also provided.

Waterman Sulistyana Bargawa et. al. (2019) The purpose of the study is to analyse statistically the parameters of the mine drainage system, and to design the mine drainage system; including open drain, sump, and settling pond. The research tools used include the calculation of runoff water discharge that requires statistical analysis for rainfall data processing and the determination of catchment area (CA). The open channel dimension and settling pond design is based on the sump volume calculation. The research area has high rainfall clased for the particle to settle is 30.38 minutes. The percsification, solid percent 2.66 % with settling rate 0.0027 m/s; the time requirentage of theoretically suctioned particle is 83 %, and the settling pond maintenance time that has 4 compartments is 15, 16, 19, and 23 days.

Satish Taji et. al. (2017) In this paper, the performance analysis of part of existing drainage network is carried out for combined system by using SWMM, which is one of the most widely used urban flood planning and management model. Various hydrologic data for this analysis (slope, sub-catchments, percentage of imperviousness, etc.) are obtained using the GIS. The resultof SWMM shows that, the existing system is not capable to cater the storm water and flooding is occurred during heavy rainfall. Thus, the design of new drainage system for collecting the storm water has been proposed. The design has been done by using EPA SWMM which consists of trial and error iterative method.

Emily Bock et. al. (2016)In this paper author improving drainage of agricultural fields can be achieved by three primary means: (1) installing subsurface, artificial “tile” (perforated pipe) drains at some depth below the soil surface; (2) surface ditching; and/or (3) land shaping (usually used with either ditching or subsurface drainage). Both the subsurface tile drainage and ditch-type systems function to lower the water table in the soil below the crop’s root zone, while land shapingprevents water ponding on soils with very low infiltration capacity by building a crown or convexsurface to direct surface flow from the field. These practices are usually used in combination; tile lines and/or surface-shaped fields need to drain to a ditch. Selection of a drainage system dependsin part on the drainage problem that exists and the particular soil characteristics causing the problem.

III. METHODOLOGY

The drainage design is carried out in two phases as per the guidelines provided in IRC: SP-42. References were also made from IRC: SP-13.

- Hydrologic analysis
- Hydraulic analysis

3.1 Hydrologic Analysis

Hydrologic analysis is very important step prior to the hydraulic design of the drainage system. This analysis is necessary to determine the magnitude of the flow and the duration for which it would last. Factors which affect the run-off are size and shape of drainage area, slope of ground,land use characteristics, surface property etc.

3.2 Estimation of Peak Run-off

A number of methods are in use for the calculation of Peak Run-Off. The method widely used due to its simplicity is the "Rational Method". The Rational method empirical formula is most widely used to calculate rain run-off applicable to small catchment area (Area not exceeding 50Km^2). The Peak Run-Off rate given by the formulae is:

$Q=0.028*P*A*I_C$

Q = Design peak runoff rate in cum/sec

P = Coefficient of run-off for catchment.

A = Area of catchment in hectares

I_C= Critical intensity of rainfall in cm per hour or the selected frequency and the duration.

3.3 Coefficient of Runoff- P

Coefficient of run-off (P) is the portion of precipitation that makes its way to the drain. Its value depends on a large number of factors such as permeability of the surface, type of ground cover, shape and size of catchment area, the topography, the geology, initial state of wetness and duration of storm. The value of "P" commonly adopted in the Rational Formula is given in Table1.

Table 1: Value of Co-efficient of Run-off for Drainage Design

SL. No.	Description of surface	Coefficient of surface
1	Steep, bare rock and water tight pavement surfaces	0.9
2	Rock, Steep but wooded	0.8
3	Plateaus, lightly covered	0.7
4	Clayey soils, stiff and bare	0.6
5	Clayey soils, lightly covered	0.5
6	Loam lightly cultivated or covered	0.4
7	Loam lightly largely cultivated	0.3
8	Sandy soil, light growth	0.2
9	Sandy soil covered, heavy brush	0.1

3.4 Catchment Area (Ha)-A

For the purpose of design, the design drain catchment section is taken between two CD structures and again sub divided into 10m interval for arriving at the drainage depth at each 10minterval. Proposed road surface with levels is input to the model to calculate the catchment area.

3.5 Design Storm & Critical Rainfall Intensity (Cm/hr)-IC

The primary component in designing the drainage system is the design storm viz rainfall value for a specified duration and return period. Design storms forms one of the primary components of the drainage design, which is rainfall value for a specified duration and return period. As the extents of drainage system for the roads are small, even intense rainfall of short durations may cause heavy flows. IRC: SP: 42 recommend that the storm duration chosen for design purposes is equal to "Time of Concentration (TC)", which is detailed separately. Maximum recorded 24 hour rainfall data was obtained from the Flood estimation report for Mahanadi Subzone 3(d) by Central water commission published in 1987.The maximum rainfall of depth (24 hour) recorded for 50 year return period in Region for zone 3(d) is 320 mm.

As per IRC-SP-42 -2014, National Highway & State Highway shall be designed for 10-year return period.

Further, 24-Hour rainfall data for 100 Year return period is considered as 50 Year Return periods on a conservative side and converted to 24-Hour rainfall data for 10 Year return period as perthe conversion factor given at Page no. 131 of IRC-SP-42-2014.

24-Hour Rainfall of 10-Year return period = 24-Hour Rainfall of 50-Year return period X 0.67 (Conversion Factor)

24-Hour Rainfall of 10-Year return period=320 x 0.67 = 214.4 mm

Further, 24-Hour Rainfall of 10-Year return period converted to 1 hour rainfall of 10-Year returnperiod by using Conversation ratio given in below graph.

For 1 hour take conversion ratio value = 0.38,

Hence, 1-hour maximum rainfall= Conversion ratio x Max.24-hour rainfall = 0.38 x 214.4

= 81.472mm

3.7 Hydraulic Design:

Hydraulic design involves the design of the drain section for the design discharge calculated by the hydrologic analysis. Drains are designed based on the principle of flow through open Channels. Capacity of the drain (discharge through the channel) is calculated using the using Manning's Equation

$Q = A \times V$

$V = 1/n(R^{2/3} S^{1/2})$

Where

Q = Discharge through the drain in cum/secV= Mean Velocity of flow

n = Manning's constant

R= Hydraulic mean radius which is area of flow cross section divided by the wetted perimeter

S = Gradient of drain Bed

A= Area of flow cross section in m^2.

IV. Design Procedure

Depth of side drain is decided by considering both hydrologic and hydraulic analysis with the condition that Discharge through the channel (q) should always be greater than the maximum quantity of Runoff (Q) for the catchment area under consideration.

Step 1: Location for the proposed drains was identified from the plan and profile and with reference to the CA.

Step 2: Length of the drain is taken as the distance between the start point of drain and the culvert at which the storm water is discharged. Each section is further divided into 10m interval for hydrologic and hydraulic analysis

Step 3: The peak run off rate in cum/sec is calculated between the elements by the empirical formulae suggested for rational method. The Area between the elements is calculated as the catchment area. The critical intensity of rainfall will be derived from the maximum recorded 1hour rainfall as mentioned in 2.1.1.3

Step 4: Assume a suitable section with 0.45m depth

Step 5: The Longitudinal gradient of the drain is taken as the road gradient if the road is in falling gradient otherwise a gradient of 1 in 333 is considered.

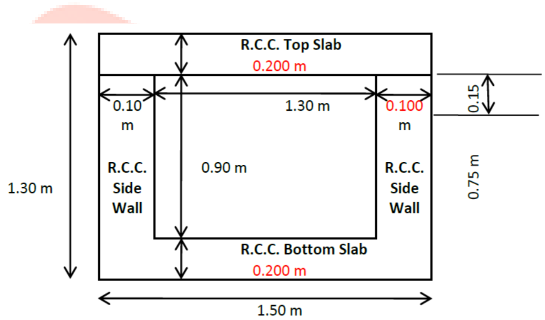
Step 6: The Invert Level of the drain is calculated from the road top level by deducting the assumed depth of drain for the U/S. Then the Invert level at the D/S side of the drain section shall be calculated by deducting the drop (Calculated from Length and Slope).

Step 7: A Freeboard of 15cm is considered in the design. The available area of drain section is calculated and the maximum permissible discharge is estimated using Manning's equation. The maximum discharge permissible through the drain section shall be kept more than the Cumulative runoff estimated for the stretch under consideration.

V. RESULT AND CALCULATIONS

5.1 DESIGN OF RCC DRAIN WITH WHEEL LOAD FOR 0.9 m Ht.

5.1.1 DATA:



1 Live load on footpath/drain = 17.03 t/m^2 2
Density of concrete = 2.5 t/m^3
3 Density of soil retain by side wall g =2.1 t/m^3
4 Density of Granular Material = 2.3 t/m^3
5 Angle of internal friction-1 (ϕ) = 42 °
6 Angle of internal friction-2 (ϕ) = 30 °
7 Grade of concrete = M 30
8 Grade of steel = Fe 500
9 Clear Cover to reinforcement = 40 mm
10 Clear Cover for bott slab = 50 mm

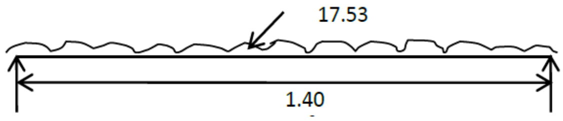
5.1.2 DESIGN COMBINATION FACTORS:

STRUCTURAL STRENGT	SERVICEABILITY LIMIT
Dead Load=1.35	Dead Load= 1.00
Live Load = 1.50	Live Load =1.00
Earth Pressure=1.50	Earth Pres =1.00
Live Load = 1.20	Live Load = 0.80

5.1.3 DESIGN CALCULATIONS:

A. TOP SLAB:

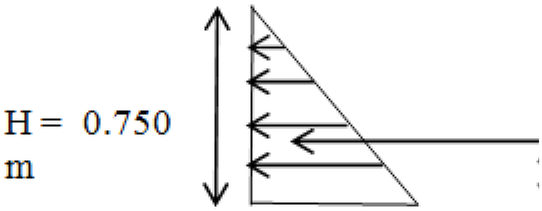
C/C span of top slab = 1.40 m
Self wt. of top slab per m width =0.50 T/m^2
Live Load on Footpath = 17.03 T/m^2
Total load on top slab (DL+Footpath)=17.53 T/m^2



Bending moment (M) due to DL, wL2/8 = 0.12 Tm
Bending moment (M) due to LL, wL2/8 = 4.17 Tm
Factored Bending moment (M) = 6.423 Tm

B. SIDE WALL:

I EARTH PRESSURE + LIVE LOAD SURCHARGE: (SERVICE ROAD SIDE)



p= 0.585 T/m^2

Angle δ =	2/3 x (ϕ) - 1	=	22.5 °
Angle δ =	2/3 x (ϕ) – 2	=	20 °
Active earth pressure (ka) - 1		=	0.183
Active earth pressure (ka) – 2		=	0.297

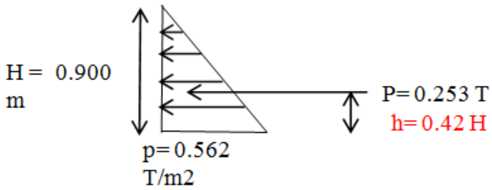
Earth Pressure :

	Ht.	k_a	Intensity	Force	Lever Arm	Moment
Granular	0.540	0.183	0.227	0.061	0.437	0.0268
Overburden			0.227	0.048	0.105	0.0050
Earth	0.21	0.297	0.131	0.014	0.088	0.0012
					Total =	0.0330

Live Load Surcharge : 1.2 m Ht.

	Ht.	k_a	Intensity	Force	Lever Arm	Moment
	0.750	0.297	0.749	0.562	0.375	0.2107
					Total	0.2107

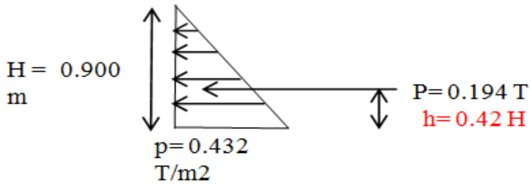
EARTH PRESSURE: (EMBANKMENT SIDE)



Earth Pressure :

	Ht.	k_a	Intensity	Force	Lever Arm	Moment
Earth	0.900	0.297	0.562	0.253	0.378	0.096

MIN FLUID PRESSURE:



Min Fluid Pressure :

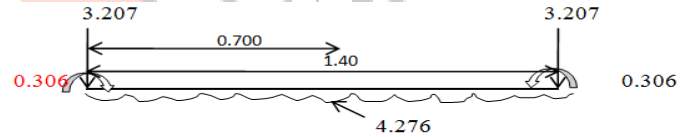
	Ht.	Intensity	Force	Lever Arm	Moment
Fluid pres.	0.900	0.432	0.194	0.378	0.073

Maximum Bending moment (M) = 0.306 T-m Factored Bending moment (M) = 0.396 T-m

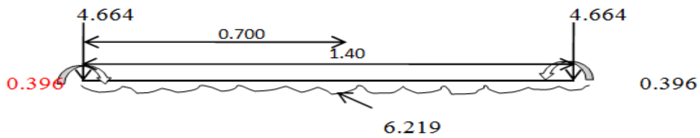
C. BOTTOM SLAB:

i TOP SLAB + FOOTPATH LOAD + SIDE WALLS + BOTT SLAB :

	Unfactored	Factored
Dead load of top slab =	0.750 T	1.013 T
Dispersed LL on bottom slab =	4.464 T	6.696 T
Dead load of side wall =	0.450 T	0.608 T
Dead load of bottom slab =	0.750 T	1.013 T
Total load on bottom slab =	6.414 T	9.329 T
Uplift load intensity =	4.276 T/m	6.219 T/m



Unfactored Forces Diagram



Factored Forces Diagram

Taking moment about centre line (factored forces)

= 4.66446 x 0.7 - 0.396 - 6.219 x 0.75 x 0.75 / 2

= 3.265 - 0.396 - 1.74917410714286

= 1.120T-m

Taking moment at support (factored forces)

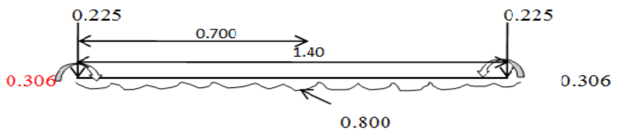
= -0.396 - 6.21928571428572 x 0.05 x 0.05 / 2

=-0.404T-m

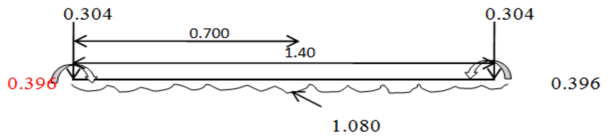
SIDE WALLS + BOTT SLAB :

	Unfactored	factored
Dead load of side wall =	0.450T	0.608 T
Dead load of bottom slab =	0.750 T	1.013 T
Total load on bottm slab =	1.200 T	1.620 T

Uplift load intensity = 0.800 T/m 1.080 T/m



Unfactored Force Diagram



factored Force Diagram

Taking moment about centre line (factored forces)

= 0.304 x 0.7 - 0.396 - 1.080 x 0.75 x 0.75 / 2

= 0.213 - 0.396 - 0.30375

= -0.487 T-m

Taking moment at support (factored forces)

= -0.396 - 1.08 x 0.05 x 0.05 / 2

= -0.398 Tm

Maximum bending moment = 0.487 Tm

DESIGN CONSTANTS:

Fck = M 30N/mm^2 = 3058.931 t/m^2

Fyk = Fe 500 N/mm^2 = 50982.19 t/m^2

Width = 1.00 m

Rumax = 0.133 x

fck = 3.99 N/mm^2 = 406.84 t/m^2

Fctm = 2.5 N/mm^2 = 254.91 t

5.1 Flexural Design

DESCRIPTION	UNIT	CLAUSE/ REFERENCE	TOP SLAB	SIDE WALL	BOTTOM SLAB
Mu	t-m		6.423	0.396	0.487
Dreq	m	SQRT(M/(Rumax x b))	0.126	0.031	0.035
Dprov	m		0.160	0.050	0.150
Ast req	mm^2	(For Design Moment)	1012.26	190.91	73.87
Asmin1	mm^2	(Cl. 16.5.1.1, IRC:112-2011) = 0.26 x fctm x bt x d / fyk	207.99	65.00	194.99
Asmin2	mm^2	(Cl. 16.5.1.1, IRC:112-2011) = 0.0013 x b x d	207.99	65.00	194.99
Asmin3	mm^2	(Cl. 16.5.1.1, IRC:112-2011) Kc x K x fctm x Act/□s	205.96	115.41	233.36
Astmin	mm^2		207.99	115.41	233.36
Ast Already Prov.	mm^2		0.00	0.00	0.00
Ast req	mm^2		1012.26	190.91	233.36
Dia of Bar	mm		12	8	8
Extra Bar	mm		-	-	-
Spacing Req.	mm		111.73	263.30	215.40
Spacing Prov.	mm		100	200	200
Ast prov	mm^2		1130.97	251.33	251.33
Total Ast prov	mm^2		1130.97	251.33	251.33
pt prov			0.0071	0.0050	0.0017
Astmax	mm^2	= 0.025 x D x B	5000	2500	5000
Ast,dist Req	mm^2		226	50	50
Dia of Bar	Mm		8	8	8
Spacing Req.	Mm		222	1000	1000
Spacing Prov.	Mm		200	200	200
Ast Prov	mm^2		251	251	251

5.1.5 STRESS CHECK (SLS - RARE CHECK):

CALCULATION OF CREEP:

Age of Loading = 7 days

Atomespheric Condition = Dry 50 %

Ac = 1000 x 200 = 200000 mm^2

u = 2 x 1000 + 2 x 200 = 2400 mm

Notional Size h = 166.67 mm

Design service life of Drain = 10 yrs

= 3650 days

Creep Co-efficient

φ(t,t0) = φ0 x βc(t, t0)

= 3.463

φ0 = φRH x β(fcm) x β(t0) = 3.599

(For fcm <= 45) Fcm = 40 Mpa

β(fcm) = 18.78 / √fcm = 2.969

β(t0) = 1 / (0.1 + t0^0.2) = 0.635

(t -t0) 0.3 βH = 1.5 [1 + (1.2 x RH/100)^18] x h0 + 250

βH + (t - t0) = 500.03 (For fcm <= 45)

=> Ec,eff = Ecm / (1 + φ (t,t0)) = 6945.77 N/mm^2 Ecm = 31000 Mpa

RARE COMBINATIONS:

Allow. Stresses in Concrete = 14.40Mpa

Steel = 300 Mpa

Modulus of Elasticity for Steel = 200000 Mpa

For Long Term, Ec,eff = 6945.77 Mpa

For Short Term, Ec = 31000.00 Mpa

m = 28.795 (Long term)

MEMBER	BM	Depth	d eff	Ast	N/A X	M . I $_{Cr}$	Stress in Concrete	Stress in Steel	CHECK
	T - m	mm	mm	mm^2	mm	mm^4	Mpa	Mpa	
Top Slab	4.29	200	159.99	1130.97	74.58	375860754	8.512	281	OK
Side Wall	0.26	100	50	251.33	20.62	9169237.2	5.940	244	OK
Bottom Slab	0.37	200	150	251.33	39.92	10889345 7	1.370	109	OK

m = 6.4516 (Short term)

MEMBER	BM	Depth	d eff	Ast	N/A x	M . I Cr	Stress in Concrete	Stress in Steel	CHECK
	T - m	mm	mm	mm^2	mm	mm^4	Mpa	Mpa	
Top Slab	4.29	200	159.99	1130.97	41.57	126274245	14.123	260	OK
Side Wall	0.26	100	50	251.33	11.22	2909353.4	10.187	227	OK
Bottom Slab	0.37	200	150	251.33	20.49	30062718	2.548	104	OK

5.1.6 CRACK WIDTH CHECK (SECTION-12):

m = 6.4516

MEMBER	Cover	BM	Depth	d eff	Ast	N/A x	ρp,eff = As / Ac,eff	Srmax = 3.4C+0.17φ /ρp,eff	σsc
	mm	mm	mm	mm	mm2	mm			t/m2
Top Slab	40	4.29	200	159.99	1130.97	41.57	0.0214158	231.25664	25956.434
Side Wall	40	0.10	100	50	251.33	11.22	0.0084928	296.13581	8221.1261
Bottom Slab	50	0.37	200	150	251.33	20.49	0.0042003	493.78891	10388.674

MEMBER	(εsm-εcm)= σsc - kt(fct,eff/ρp.eff)*(1+αe ρp.eff)/Es	0.6*σsc/Es	Wk Sr,max * (εsm-εcm)	CHECK
Top Slab	0.000940656	0.0007637	0.218	OK
Side Wall	-0.000373104	0.0002419	0.072	OK
Bottom Slab	-0.001018896	0.0003057	0.151	OK

5.1.7 SHEAR CHECK

A. TOP SLAB:

Ved = 0.506 t
= 4965 N
dprov = 160 mm
Ast prov = 1130.970 mm^2
Pt prov = 0.007 x 100 %
K =1 + sqrt (200/d) = 2.000 OK
σcp = Ned / Ac = 0.00 < 0.2 fcd
ρ1 = Asl / (bw d) = 0.0071 <= 0.02
= 0.0071
Vmin = 0.031 x K^1.5 x fck^0.5
= 0.031 x 2^1.5 x SQRT(30) = 0.480

Vrd.c = *0.12 x K x (80 x ρ1 x fck)^0.33 + 0.15 x σcp+ x bw x d
= (0.12 x 2 x (80 x 0.00707 x 30)^0.33 + 0.15 x 0) x 1 x 1000 x159.994
= 97745 N
= 9.970 t

Vrd.c min = (vmin + 0.15 x σcp) x bw x d
Vrd.c min =(0.48+0.150x 1000 x 159.994
. = 76797 N
Vrd.c min = 97745 N
= 9.97 t > 0.506 t OK

B. SIDE WALL:

Ved = 0.858 t
= 8419 N
Dprov = 50 mm
Ast prov = 251.330 mm^2
Pt prov = 0.005 x 100 %
K = 1 + sqrt (200/d) = 2.000
= 2.00 (d in mm) OK
σcp = Ned / Ac = 0.00 < 0.2 fcd
ρ1 = Asl / (bw d) = 0.0050
Vmin = 0.031 x K^1.5 x fck^0.5 = 0.031 x 2^1.5 x SQRT(30) = 0.480

Vrd.c = *0.12 x K x (80 x ρ1 x fck)^0.33 + 0.15 x σcp+ x bw x d
=(0.12 x 2 x (80 x 0.00503 x 30)^0.33 + 0.15 x 0) x 1 x 1000 x 50
= 27300 N
= 2.785 t
Vrd.c min = (vmin + 0.15 x σcp) x bw x d
Vrd.c min =(0.48 + 0.15 x 0) x 1000 x 50
= 24000 N
Vrd.c min =27300 N
= 2.78 t > 0.858 t OK

C. BOTTOM SLAB:

Ved = 4.664 t
= 45746 N
dprov = 150 mm
Ast prov = 251.330 mm^2
Pt prov = 0.002 x 100 %
K = 1 + sqrt (200/d) = 2.000 <= 2.00 (d in mm) OK
σcp = Ned / Ac = 0.00 < 0.2 fcd
ρ1 = Asl / (bw d) = 0.0017 <= 0.02
= 0.0017
Vmin = 0.031 x K^1.5 x fck^0.5 = 0.031 x 2^1.5 x SQRT(30)
= 0.480
Vrd.c = *0.12 x K x (80 x ρ1 x fck)^0.33 + 0.15 x σcp+ x bw x d (CL. 10.3.2, IRC:112-2011)
= (0.12 x 2 x (80 x 0.00168 x 30)^0.33 + 0.15 x 0) x 1 x 1000 x 149.996
= 57031 N
= 5.817 t
Vrd.c min = (vmin + 0.15 x σcp) x bw x d (CL. 10.3.2, IRC:112-2011)
Vrd.c min = (0.48 + 0.15 x 0) x 1000 x 149.996 = 71998 N
Vrd.c min = 71998 N
= 7.34 t > 4.664 t OK

5.1.8 BEARING CAPACITY CALCULATIONS:

Self-weight of Top Slab (per meter)= 0.75 T

Self-weight External Wall (per meter) =0.23 T

Self-weight Bottom Slab (per meter)= 0.75 T

Total Load P (DL, per meter) = 1.73 T

Total Area, A = 1.50 m^2

Pressure at the base, P/A (Due to DL)=1.15 T/m^2

Pressure at the base, P/A (Due to dispersed LL) = 2.60 T/m^2

Total Base Pressure, DL+LL = 3.75 T/m^2

In the following manner, following designs are accomplished;

1. **Design Of Rcc Drain With Wheel Load For 1.75 m Ht.**
2. **Design Of Rcc Drain With Wheel Load For 1.5 m Ht.**
3. **Design Of Rcc Drain With Wheel Load For 1.75 m Ht.**
4. **Design Of Rcc Drain With Wheel Load For 2 m Ht**

VI. CONCLUSION

1. The complete design of RCC drain with wheel load are calculated for four heights 0.9m, 1.25m, 1.5m, 1.75m and 2 m.
2. The designs are well tested mathematically for all types of load, pressure and external factors.
3. All the design are installed as per requirement of strom water management.
4. New drainage system larger and more expensive than current system.
5. Spots with flooding occurring for a minimum time.

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