Planning and Designing of Three Story Commercial Building

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Abstract: **In this project planning, analysis, structural design have been done for a commercial building of shopping complex based on all Indian Standard Codes of practice. Detailing drawings pertaining to the structural design of shopping complex are presented. Analysis of the structure was done using STAAD.Pro V8i. All the structural members like slabs, beams, columns and footings are designed using Indian Standard Code IS 456-2000, IS-875.**

The structural components are designed by limit state method. Materials were used as specified by National Building Code. Concrete M20 grade and Fe415 steel bars were considered for all the design. The shopping complex is built with almost all the amenities required for the people to get entertained in their busy schedule. This structure is going to be designed with the view that all the entertainment facilities should be made available under one roof. The overall plot area of the mall is 31250 sq. ft and the built area is around 27089 sq. ft.

Keywords: AutoCAD and STAAD Pro

I. INTRODUCTION

This project deals with Analysis, Design and Estimation of a Shopping complex Building. Trivandrum was selected as smart city on 4th September 2019. It is one of the 02 smart cities in the state of Kerala. So we selected this project to provide excellent infrastructure and a good quality of life to its citizens. Shopping complex is a building designed for Entertaining the people, which consist of Retail shops and cluster of all other shops, including Food courts and super market. The main objectives is planning a shopping mall with proper ventilation and sunlight, Designing of all structural members based on limit state method of design, Designing of other miscellaneous structures like septic tank by working stress method and analysis work is done by STAAD Pro. The main scope is to Design of slab by using limit state method, Design of beam is done as per IS code, Design of dog-legged and Open wall staircase and Design of septic tank as per NBC requirements. The Commercial building is going to be constructed in Neyyattinkara which was in Trivandrum, Kerala.

II. SOILTEST

It is proposed to construct a Commercial building at Neyyattinkara. A detailed soil investigation was suggested for estimating the safe bearing capacity of the soil, so that suitable type of foundation can be decided for the proposed structure. The study carried out on 02.10.2024, This report presents complete investigation data and discusses the results to recommend the bearing capacity values at different depths for the proposed structure. Section 2 describes the soil profile and bore log details of one exploratory bore holes. Section 3 of this report gives the grain size distribution curves and its analysis. Section 4 of this report presents the calculated safe Bearing capacity values of soil at various depths. Section 5 of this report reviews the test results and the recommended safe bearing capacity values for design of foundation. Investigation was carried out in one location at the site through exploratory bore hole. Soil samples were collected from bore hole at different depths for conducting laboratory test. Standard Penetration test was conducted at regular intervals and „N‟ values were recorded. Undisturbed soil samples were collected and were preserved and transported to the laboratory for detailed identification tests. Based on the field and laboratory tests on the samples collected, the results are furnished in this report. An exploratory bore hole was advanced from the existing ground level using truck mounted rotary drilling techniques supplemented by Betonies mud circulation. This drilling procedure with mud circulation is found most suitable for making exploratory bore hole

An exploratory bore hole was advanced from the existing ground level using truck mounted rotary drilling techniques supplemented by Betonies mud circulation. This drilling procedure with mud circulation is found most suitable for making exploratory bore hole. The mud circulation was employed through the drill rods and letting it out though the side jets provided in the cutting tool thus preventing any disturbance at the bore hole bottom. Mud circulation was used to stabilize the sides and the bottom of the bore hole, and then to bring the soil cuts to the surface. It is important to note that the mud jet is not used to cut the soils as in the case of wash boring technique. Use of drilling mud will also help in preventing the disturbance to the soil at the bore hole bottom during drilling operations. Diameter of the bore hole is about 150mm. Bore hole was always kept full with the drilling mud so that a positive head is maintained in the bore hole thus preventing any disturbance to the soil within the test zone. The field tests included Standard penetration test, Disturbed and undisturbed soil sampling, identification of different soil layers, Ground water table observation, complete logging of the bore hole, etc. Laboratory investigation consisted of classification tests like grain size distribution analysis, determination of specific gravity etc. Unconfined Compression test and Direct shear was conducted on preserved soil samples. All the field and laboratory tests were conducted according to the procedures stipulated in relevant IS codes.

Review of Field and Laboratory Results Sub soil Profile

The original ground level in the presently investigated area was plain terrain.

Bore Hole 1

The soil below the existing ground level is filled up soil. This layer is extended up to 0.6m depth. Red laterite soil exists from 0.6m to 2m depth. Below which laterite soil with gravels mixed exist from 2m to 6m depth from the existing ground level. The soil stratification and its variation under present investigation are available in bore log details. The „N" value is progressively increasing towards depth, due to the soil stratification.

Ground Water Table

Ground water was not encountered during the investigation up to 6m depth.

Shear Strength

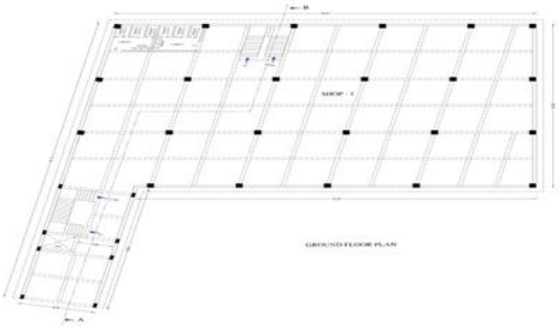
Standard Penetration test blow counts „N" is measured at different levels in the borehole Mainly these „N" values are used to assess the shear strength of different soil layers.

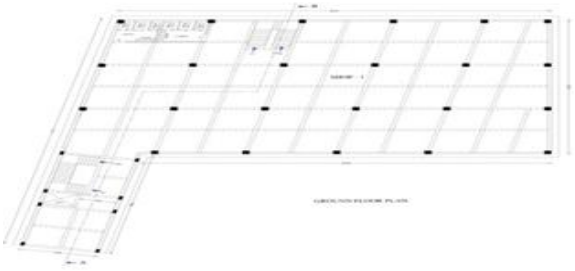
Non - Cohesive Layers:

The sand layers towards depth are of residual type and suitable modifications are made to take care of the presence of plastic fines in the residual soil. Conventional method of estimating the angle of shearing resistance φ corresponding to the relative density and the grain size distribution as per the classification suggested by Peck and suitably modified by the R.K. Hough to account for the influence of grain size distribution is adopted here.

III. PLANNING

1) Grou





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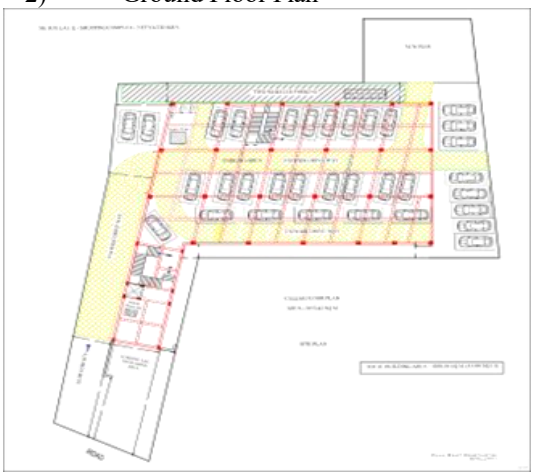
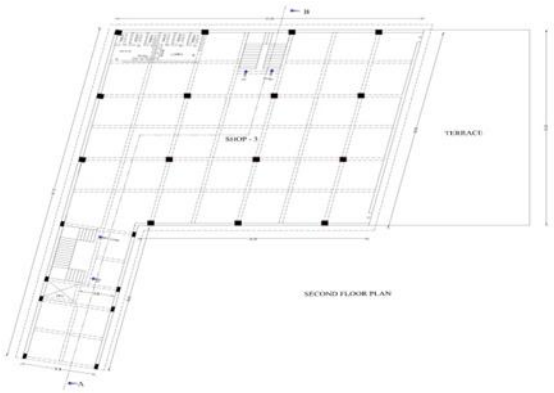
IV. PLANNING

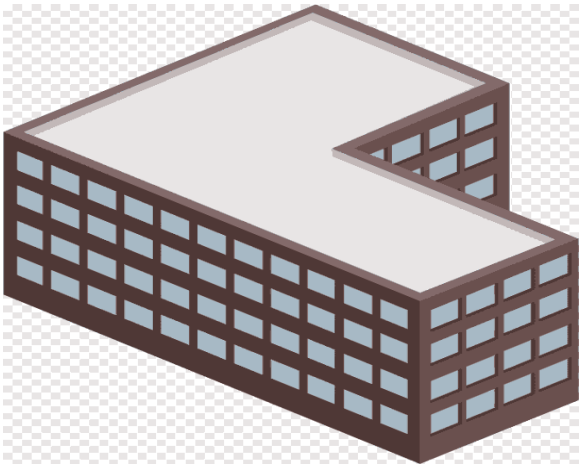
2) Ground Floor Plan



3) First floor plan



4) Second floor plan



5) Front elevation

V. STRUCTURAL DESIGN

Design of beam:

Assumption:

Assume Beam size = 230mm×450mm

Bending moment :(From Moment Distribution Method):

Positive bending moment at mid span (M_u) = 64.46kN-m

Negative bending moment at mid span (M_u) = 64.46kN-m

Depth required:

Refer IS code 456:2000 pages No: 96 M u =0.138f ck bd ^{2}

$$D = \sqrt{\frac{Mu}{0.138fckbd^2}}$$

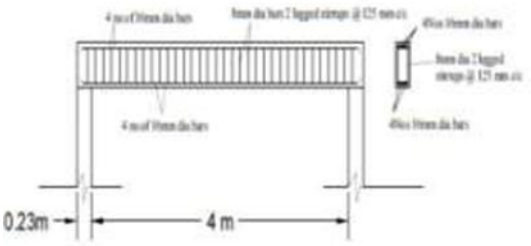
$$= \sqrt{\frac{1.5x64.46x10^3}{0.138x30x230}}$$

= 390mm<450mm Stirrups

Refer IS 456:2000 Page No: 48 $S_v = (A_{st} \times 0.87f_y)/ (0.4 \times b)$

= (2 x 0.87 x 415 x 50.3)/ (0.4 x 230) S_v = 394.529mm^2
Provide 2 legged 8mm dia stirrups, spacing Spacing = (A_{st}/a_{st}) x 1000= ((π/4 x 8^2)/394.54) x 1000 =127.40mm
S = 125 mm
Provide 2 legged 8mm dia stirrups, spacing @ 125 mm c/c

Beam reinforcement detail



Column Design
Assumption
Column size = 450mm x 300mm
Unsupported length = 3m
Effective length l eff = 0.65 x l = 0.65 x 3 = 1.95m

5. Parking Area plan
Use M 25 & Fe 415
Check for slenderness ratio
Slenderness ratio = l_{eff} / least dimension
= 1.95/0.3
= 6.5 < 12Hence it is short column

Check for minimum Eccentricity e
min = (l_{eff} /500) + (D/30)
= (1950/500) + (450/30)
e min = 18.9

Column reinforcement detail

Design of staircase

Allowing a clear gap of 200mm between the flight slab,
Assume the width of landing also as 1000mm, Breadth of staircase = 3000mm
Width of two flight slab = 3000-200
= 2800mm
Width of each flight slab = 2800/2
=1400mm
Horizontal going of each flight = 4000-(2 x 1000)
= 2000mm
Provide the tread 250mm and rise 160mm for each steps.
Floor to floor height = 3000mm Landing to landing height = 3000/2
= 1500mm
Number of steps in each flight = 1500/160
= 9.37 so we take it as 10 Nos

Effective span
The landing slabs span parallel with the risers (perpendicular to the flight direction),
Effective span of flight slab = 2+ (1.0/2) +(1.0/2)
= 3m

Depth required
For balanced section of M20 grade concrete, fe415 grade steel
Effective depth provided = 150-15-10/2 = 130mm
= 130 >
78.4mm

Mu = 0.138 x f_{ck} x bd²
17x10.6 = 0.138x20x1000xd2
Provide 10mm d2bar
Nominal cover 15mm
Design of Pile Foundation Data
Size of column: 230 x 450
Size of pile: 300 x 300 No. of piles: 2
Ultimate load on each pile: 3920.7/2 = 1960.35kN
Length of pile: 6m Longitudinal Reinforcement
P_u = [0.4f ck A_g + (0.67f $_y$ -0.4f $_{ck}$) A_{sc}] 1960.35 x10^3 = [0.4 x 20 x 300 x 300 + (0.67 x 415 – 0.4 x 20) A_{sc}]
= 4593mm ^{2}
A_{sc} minimum = 1.25% of cross section of piles
= (1.25 x 300 x 300) /100
= 1125mm ^{2}
Provide 4 bars of 20mm dia (A_{sc} = 4593mm ^{2}) with clear cover of 50 mm

Design of Septic tank
Design a septic tank for 900 persons with average daily flow of 120 L / head / day. Provide 6 separate tank for each 150 persons with average daily flow of 120 L / head / day.

Data
No. of people = 150

Sewage/ capita/day = 120 litres Cleaning interval = 2 years Detention period = 18 hours

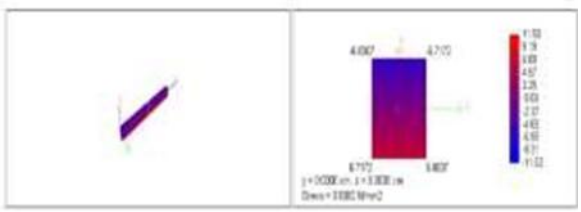
Design
Total quantity of sewage produced = 150 x120
= 18000
= 18 m^3 /day
Capacity of tank required = 18 x 18 / 24
= 13.5 m 3
Space required for storage for sludge = 0.0708 m 3/ capita
Space required for 150 person = 0.0708 x 150
= 10.62 m^3
Say 11 m^3

Area of tank = 7.8 x 2.6
= 20.28 > 20 m^2
Hence ok
Assume free board = 0.5m
Total depth of tank = 1.7 + .5
= 2.2 m
Size of tank = 7.8 x 2.6 x 2.2 m

Design of lintel Data
Clear Span = 1.5 m Wall thickness = 0.23 m
Span = 1.5+0.15+0.15
= 1.8 m

Use 8 mm 2-legged stirrups $S_v = 0.87 A_{sv} f_y /0.4b$
= (0.87x100.53x415)/(0.4x230)
= 394.5 mm
$S_{v\,max}$ = 0.75x180
= 135 mm

Span/depth = 10 Depth = 600/10
= 60 mm
Assume 10 mm dia bars and 20 mm clear cover.
Overall depth = 60 + 20 + (10/2)
= 85 mm
Check for Shear
$P_t = 100 A_{st} /bd$
= 100 x 153/ (1500 x 60)
= 0.17 N/mm^2
Shear stress $\tau_v = V_u /bd$ = 1.43 x 1000/ (1500 x 60)
= 0.016 N/mm 2
$\tau_v < \tau_c$ Hence sunshade is safe against shear forces



5. Analysis by STAAD.Pro
Structure Type - SPACE FRAME
Hence provide 8mm dia 2-legged stirrups at 135 mm c/c.
Number of Nodes 384 Highest Node 400

Design of Sunshade
Data
Projection of sunshade = 0.6 m
Width of opening = 1.5 m
Live load = 0.45 kN/m^2
Materials: M20, Fe-415 HYSD bars
Depth Required
As per IS: 456-2000,

Number of Basic Load Cases 4
Number of Combination Load Cases 1
Included in this printout are data for:

All The Whole Structure

Prop	Section	Area (cm^2)	I_{yy} (cm^4)	I_{zz} (cm^4)	J (cm^4)	Material
1	Rect 0.45x0.23	1.04E3	45.6E3	175E3	124E3	Concrete
2	Rect 0.45x0.23	1.04E3	45.6E3	175E3	124E3	Concrete

Included in this printout are results for load cases

Type	L/C	Name
Primary	1	Load case 1 sw
Primary	2	Load case 2 Floor
Primary	3	Load case 3 wall
Primary	4	Load case4 wind
Combination	5	Combination load

3D Beam stress view

Specialty of this project

Car parking system in the shopping complex is planned to be constructed as Digital car parking which was installed sensor in the car parking that detect and give a declaration that whether there is space in the car parking area or not, if there is a space then it will allot you a respective parking slot number. As the city authorities take crucial steps to achieve their smart city vision, it‟s also transforming various traditional infrastructures including that of traditional parking. In many cities, traditional parking is now being evolved into digital parking as universities, city garages, shopping malls, and airports already embracing this technology. So we adopted this concept in our project. As of now, the digital parking has rendered positive results by improving quality of life for many several residents. Even stats are in favour of digital parking. Digital parking payment solution leverages real-time information that enables users to get the list of unreserved and reserved parking spots. The main objective behind employing digital parking payment solution is to assimilate automation in the parking lifecycle.

Digital parking ensures that there‟s no wastage of time when a user is searching for a parking spot. A cashless parking payment solution is a payment system that doesn‟t require any physical money for making transactions pertaining to parking. It‟s a quick and foolproof way to make mobile money payments for parking. Digital parking involves payments via credit card, debit card, and e-wallet. This makes digital parking easier and convenient for users where they can make payments on the spot without the hassles of keeping cash.

Digital parking system enables you to monetize a free parking space. Moreover, you can offer a stress-free experience to your users which motivate them to park their car for a longer time.

The users already know that they can easily top-up their parking session at any time. This stress-free approach results in boosting your parking revenue.

VI. CONCLUSION

The proposed Commercial Building is planned to be constructed in Neyyattinkara which was in Trivandrum, Kerala. In this building detailed plan on design are prepared as per standard specification. We have designed the building according to IS 456:2000 and we have used the limit state concept for the members. By this project the objective of entertaining the people under one roof is met with the inclusion of all the amenities and requirements. The attempt of this project made me to understand concept of design of slab, beam, column and footing we gained knowledge in software's like STAAD Pro and AutoCAD and some codal provisions.

REFERENCE

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