

Analysis and Design of a Shopping Complex

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ABSTRACT: In this project planning, analysis, structural design and Estimation 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 35070 sq. ft and the built area is around 19989 sq. ft.

KEYWORDS: AutoCAD and STAAD Pro

I. INTRODUCTION

This project deals with Analysis, Design and Estimation of a Shopping complex Building. Thanjavur was selected as smart city on 20th September 2016. It is one of the 11 smart cities in the state of Tamil Nadu. 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 shopping complex is going to be constructed in V.P.Garden which was in raja serfoji college road, Thanjavur.

II. SOIL TEST

It is proposed to construct a Shopping Complex Building at Thanjavur. 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 15.07.2021, 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

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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 through 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

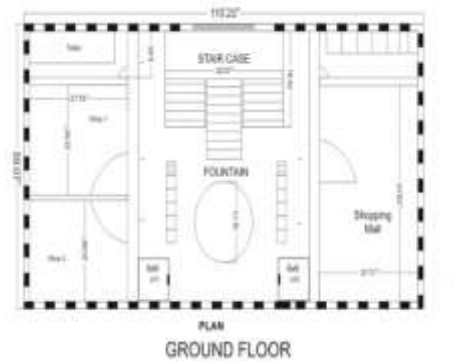
Mainly these 'N' values are used to assess the shear strength of different soil layers.

Non - Cohesive Layers:

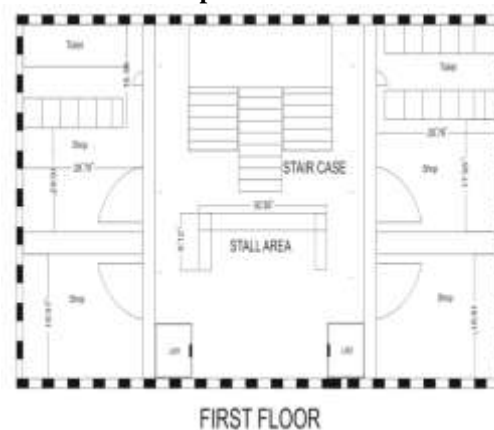
The sand layers towards depth are of residual type and suitable modifications are made to take care of the presence of plastic fines in the residual soil. Conventional method of estimating the angle of shearing resistance ϕ corresponding to the relative density and the grain size distribution as per 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

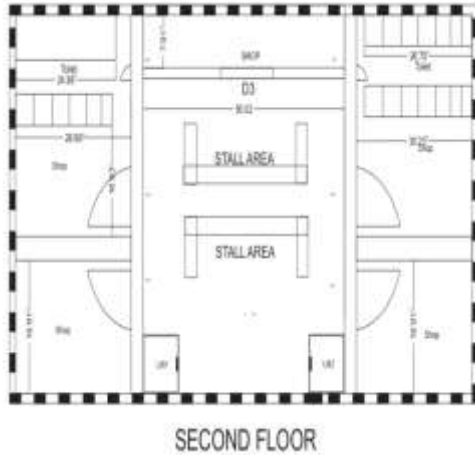
1) Ground Floor Plan



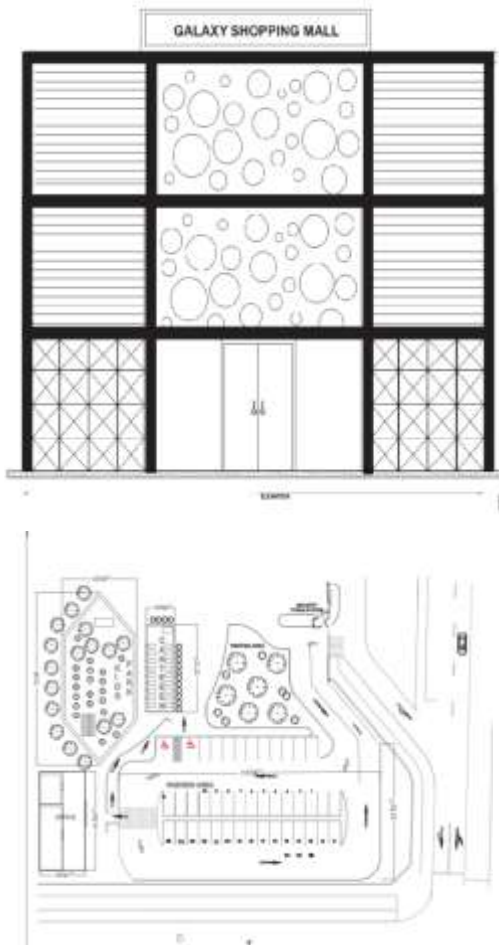
2) First floor plan



3) Second floor plan



4) Front elevation



Front portion of shopping mall

IV. 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

$$M_u = 0.138 f_c k b d^2$$

$$D = \sqrt{\frac{M_u}{0.138 f_c k b d^2}}$$

$$= \sqrt{\frac{1.5 \times 64.46 \times 10^3}{0.138 \times 20 \times 230}}$$

$$= 390 \text{mm} < 450 \text{mm}$$

Stirrups

Refer IS 456:2000 Page No: 48

$$S_v = (A_{st} \times 0.87 f_y) / (0.4 \times b)$$

$$= (2 \times 0.87 \times 415 \times 50.3) / (0.4 \times 230)$$

$$S_v = 394.529 \text{mm}^2$$

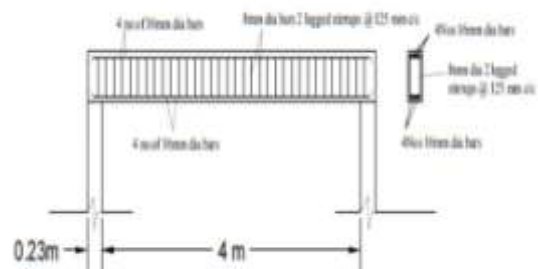
Provide 2 legged 8mm dia stirrups, spacing

$$\text{Spacing} = (A_{st} / a_{st}) \times 1000 = (\pi / 4 \times 8^2) / 394.54 \times 1000 = 127.40 \text{mm}$$

$$S = 125 \text{ mm}$$

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

$$\text{Effective length } l_{eff} = 0.65 \times l = 0.65 \times 3 = 1.95 \text{m}$$

Use M 25 & Fe 415

Check for slenderness ratio

$$\text{Slenderness ratio} = l_{eff} / \text{least dimension}$$

$$= 1.95/0.3$$

$$= 6.5 < 12 \text{ Hence it is short}$$

column

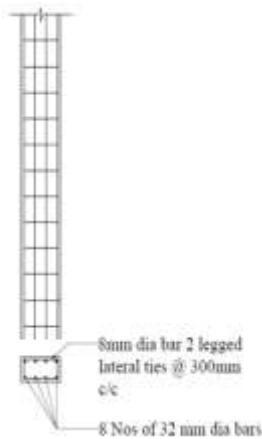
Check for minimum Eccentricity

$$e_{\min} = (l_{\text{eff}}/500) + (D/30)$$

$$= (1950/500) + (450/30)$$

$$e_{\min} = 18.9$$

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

$$\text{Width of two flight slab} = 3000 - 200$$

$$= 2800 \text{ mm}$$

$$\text{Width of each flight slab} = 2800/2$$

$$= 1400 \text{ mm}$$

$$\text{Horizontal going of each flight} = 4000 - (2 \times 1000)$$

$$= 2000 \text{ mm}$$

Provide the tread 250mm and rise 160mm for each steps.

Floor to floor height = 3000mm

$$\text{Landing to landing height} = 3000/2$$

$$= 1500 \text{ mm}$$

$$\text{Number of steps in each flight} = 1500/160$$

$$= 9.37 \text{ so we take}$$

it as 10 Nos

Effective span

The landing slabs span parallel with the risers (perpendicular to the flight direction),

$$\text{Effective span of flight slab} = 2 + (1.0/2) + (1.0/2)$$

$$= 3 \text{ m}$$

Depth required

For balanced section of M20 grade concrete, fe415 grade steel

$$M_u = 0.138 \times f_{ck} \times b d^2$$

$$17 \times 10^6 = 0.138 \times 20 \times 1000 \times d^2$$

Provide 10mm dia bar

Nominal cover 15mm

$$\text{Effective depth provided} = 150 - 15 - 10/2 = 130 \text{ mm}$$

$$= 130 >$$

78.4mm

Design of Pile Foundation

Data

Size of column: 230 x 450

Size of pile: 300 x 300

No. of piles: 2

$$\text{Ultimate load on each pile: } 3920.7/2 = 1960.35 \text{ kN}$$

Length of pile: 6m

Longitudinal Reinforcement

$$P_u = [0.4f_{ck} A_g + (0.67f_y - 0.4f_{ck}) A_{sc}]$$

$$1960.35 \times 10^3 = [0.4 \times 20 \times 300 \times 300 + (0.67 \times 415 - 0.4 \times 20) A_{sc}]$$

$$= 4593 \text{ mm}^2$$

$$A_{sc} \text{ minimum} = 1.25\% \text{ of cross section of piles}$$

$$= (1.25 \times 300 \times 300) / 100$$

$$= 1125 \text{ mm}^2$$

Provide 4 bars of 20mm dia ($A_{sc} = 4593 \text{ mm}^2$) 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

$$\text{Total quantity of sewage produced} = 150 \times 120$$

$$= 18000$$

$$= 18 \text{ m}^3 / \text{day}$$

$$\text{Capacity of tank required} = 18 \times 18 / 24$$

$$= 13.5 \text{ m}^3$$

Space required for storage for sludge = 0.0708 m³ / capita

$$\text{Space required for 150 person} = 0.0708 \times 150$$

$$= 10.62 \text{ m}^3$$

$$\text{Say } 11 \text{ m}^3$$

$$\text{Area of tank} = 7.8 \times 2.6$$

$$= 20.28 > 20 \text{ m}^2$$

Hence ok

Assume free board = 0.5 m
 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
 $S_v = 0.87 A_{sv} f_y / 0.4b$
 = $(0.87 \times 100.53 \times 415) / (0.4 \times 230)$
 = 394.5 mm
 $S_{v \max} = 0.75 \times 180$
 = 135 mm

Hence provide 8mm dia 2-legged stirrups at 135 mm c/c.

Design of Sunshade

Data

Projection of sunshade = 0.6 m
 Width of opening = 1.5 m
 Live load = 0.45 kN/m²
 Materials: M20, Fe-415 HYSD bars
 Depth Required
 As per IS: 456-2000,

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

$P t = 100 A_{st} / bd$
 = $100 \times 153 / (1500 \times 60)$
 = 0.17 N/mm²
 Shear stress $\tau_v = V_u / bd$
 = $1.43 \times 1000 / (1500 \times 60)$
 = 0.016 N/mm²
 $\tau_v < \tau_c$ Hence sunshade is safe against shear forces

5. Analysis by STAAD.Pro

Structure Type - SPACE FRAME

Number of Nodes 384 Highest Node 400

Number of Elements 804 Highest Beam 849

Number of Basic Load Cases 4

Number of Combination Load Cases 1

Included in this printout are data for:

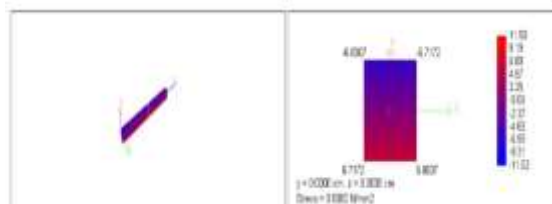
All The Whole Structure

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

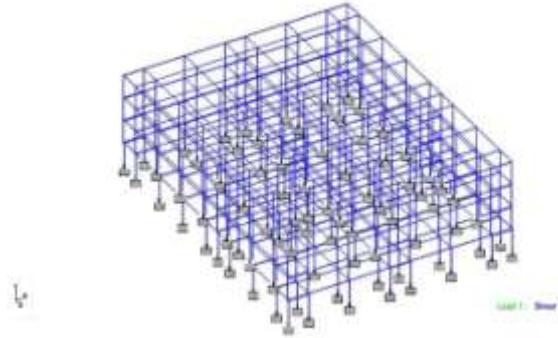
Included in this printout are results for load cases

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

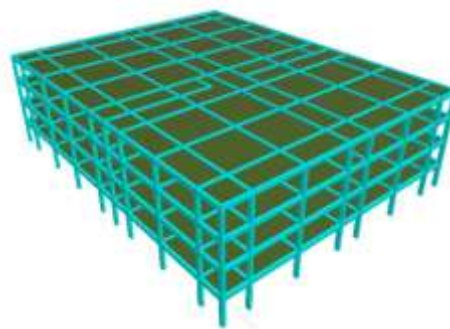
3D Beam stress view



Bending Moment along Z axis



Rendering view



Speciality 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.

V. CONCLUSION

The proposed Shopping Mall Building is planned to be constructed in V. P. Garden, Raja Serfoji College Road, Thanjavur. 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 us to understand concepts of design of slab, beam, column and footing we gained knowledge in software's like STAAD.Pro and AutoCAD and some codal provisions.

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