© December 2023| IJIRT | Volume 10 Issue 7 | ISSN: 2349-6002

Analysis And Design of Primary School Building

Naga Subramanian G[1], Guneesdharan K[2] Sivaraman.V[3] Kandeeban.P[4]
[1]*Assistant Professor, Department of civil engineering, Peri Institute of Technology, Chennai*
[2,3,4]*B.E Student,Department of civil engineering Peri Institute of Technology, Chennai*

***Abstract*— The planning and design of the school building includes our project, which involves designing the proposed school building plan and planning the school in accordance with NBC 2005 criteria. followed by using STAADPRO software to assess whether or not the proposed school is stable. A fundamental comprehension of the engineer's surroundings and the behavior of a structure is essential for anybody overseeing the construction process. On the construction site, constructors must be able to answer a variety of technical queries, including structural ones that the design experts may not always address.**

Construction managers need to know this information because worker safety and the strength and stability of structures during construction are critical issues. A wide range of software applications are available for the many specializations within civil engineering. The majority of civil engineers work in specific areas within the field, including project and construction management, geotechnical, structural, transportation, and environmental engineering. Because of its advanced features, flexible modeling environment, and fluid data collaboration, STAAD, or STAAD.Pro, is the go-to tool for structural engineering professionals when designing virtually any type of structure, including culverts, petrochemical plants, tunnels, bridges, piles, and much more. STAAD.Pro allows structural engineers to analyze and design virtually any type of structure through its flexible modeling environment, advanced features and fluent data collaboration. Its wide use in the field of civil engineering makes it of an utter importance to learn.

Keywords—***School Building, NBC-2005, analysis, design, staad-pro.***

I. INTRODUCTION

Planning When thinking about planning of school from a constructors point of view certain factors need to be considered environmental factors, social factors and economical factors etc. My project involves analysis and design of PRIMARY SCHOOL BUILDING using very popular designing software STAAD Pro v8i.

The detailed assessment of the primary school building needs and associated capital and operational funding requirements for primary school facility to service.

This building comes under the category of educational in the higher educational sector, there form of construction is typically academic buildings consisting of offices, principal cabin, classrooms and laboratories, restrooms.

This school is having primary section. This buildings is G+2 having ground floor, first floor, second floor.

This education building is rectangular shaped, shows that the building is symmentrical and having good air circulation throughout the building.

1.1 Scope of the Study

- *Architectural Design:* To Planning and designing functional and aesthetically pleasing spaces for classrooms, laboratories, libraries, administrative offices, and recreational areas.
- *Structural Engineering:* Ensuring the structural integrity of the building to withstand environmental factors and provide a safe learning environment.
- *Safety:* To Adhering to building codes, safety standards, and accessibility requirements to ensure the well-being of students, staff, and visitors.
- *Educational Technology Integration:* To incoporating technology infrastructure to support modren teaching methods and educational tools.

1.2 Objectives

This school building is found technically good in every season, giving good environment for teaching. The objectives of school building construction include creating a safe and conducive learning environment, accommodating the educational needs of students, fostering a sense of community, complying with building codes and regulations, and ensuring sustainability and efficiency in design and construction.

- To Ensure the construction meets safety standards to provide a secure environment for students, staff, and visitors.

- To Design and construct classrooms, laboratories, and common areas to support effective teaching and learning.
- To Build with materials and system that ensure durability and ease of maintenance over the long term.

1.3 Design Concepts

There are three design philosophies to design reinforced concrete structures. They are ,

1.Working stress method,

2.Limit state method.

In the ‘working stress’ method it is seen that the permissible stresses for concrete and steel are not exceeded anywhere in the structure when it is subjected to the worst combination of working loads. A linear variation of stress from zero at the neutral axis to the maximum stress at the extreme fiber is assumed. Practically, the stress strain curve for concrete is not linear as it was assumed in the working stress method. So, in ‘ultimate load’ design an idealized form of actual stress strain diagram is used and the working loads are increased by multiplying them with the load factors. The basis for the ‘limit state’ method is that a structure with appropriate degrees of reliability should be able to withstand safely all loads that are liable to act on it throughout its life and it should also satisfy the serviceability requirements such as limitations on deflection and cracking. Limit state method is the most rational method of the three methods. It considers the actual behavior of the materials at failure and also it takes serviceability also into consideration. Therefore, a limit state method has been employed in this work.

2. LITERATURE REVIEW

DINESH RANJAN.S,AISHWARYALAKSHMI.V “Design and Analysis of an Institutional Building” Analyzing and designing an institutional building is the project's goal. Using AUTO CADD 2010, a layout design of the proposed building is created. This is how calculations for bending moment, shear force, deflection, end moments, and foundation reactions are made in a lot of standard literature. STAAD.ProV8i was used to assess the structure. We are designing the whole structure using the limit state technique. In general, R.C.C. detailing must follow I.S. 13920.1993's ductile detailing code and SP 34. For the aforementioned load combinations, IS 456:2000 was followed in the design process. Therefore, the one-month training program provided for a sample exposure to different field approaches in the research and design of multistory structures.and also in various construction techniques used in the school.

Natasha Khalil on design and analysis of a building. The aim of the project is to analyze and design of an institutional building. A lay out plan of the proposed building is drawn by using AUTO CADD 2010.Using this so many standard books analysis of bending moment, shear force, deflection, end moments and foundation reactions are calculated. The structure was analyzed using STAAD.ProV8i. The method we are design the entire structure is limit state Method. The R.C.C. detailing in general shall be as per SP 34 and as per ductile detailing code I.S. 13920.1993. The design was carried as per IS 456:2000 for the above load combinations. As a result, the training, taken through a period of one month allowed to have sample exposure to various field practices in the analysis and design of multistoried buildings and also in various construction techniques used in the school.

Arjunsahu, AnuragVerma, Aryanpaul “Design and analysis of framed structure. There are several methods for analysis of different frames like cantilever method, portal method, and Matrix method. The present project deals with the design & analysis of an institutional building. The dead load & live loads are applied and the design for beams, columns, footing is obtained STAAD Pro

3.METHODOLOGY

3.1 School Plan

We are planning a school which will be made according to the NBC 2005 .The school is easily accessible. School will be constructed on plan terrain which will be well compacted

We plan to Provide an interior environment that is visually comfortable and stimulating by providing ample natural light and incorporating colors that stimulate or soothe, depending on the space function.Avoid glare and direct-beam sunlight. Design for diffuse, uniform daylight throughout classrooms.Select building elements on the basis of life-cycle cost analysis—Mirror the lifespan of projects and systems with the expected lifespan of the facility.

Specify materials and products that are easy to maintain (balance this with their impact on children's health and the environment). Use energy simulation and analysis tools to optimize energy performance (integrate day lighting systems, high-performance HVAC, energy-efficient building shell, and high-performance electric lighting) Cluster classrooms around common areas. Provide platform spaces for gathering, sitting, and presenting and alcoves for reading and studying. Use operable walls to increase the efficiency of large, multipurpose spaces. Accommodate technology upgrades. Make day lighting a priority, especially in classrooms. Day lighting is the controlled admission of natural light into a space. Use natural ventilation when possible. (This and day lighting also provide a connection to the outdoors.) Ensure superior indoor air quality.Connect the indoor environment to the outdoors by providing operable view windows in classrooms and easy access from classrooms to gardens and other outdoor areas that can be utilized in the curriculum.

We plan a school which will have 12 class room ,2 library ,1 computer labs ,1 Principal office, 1 office ,1 commitee room ,1 boys and 1 girls toilet on each floor which will be made according to CBSE norms which are :

- School should have a min. area of 2 acres including academic block & playground.

The Student teacher ratio should not exceed 30:1 and section teacher ratio must be 1:1.5. The minimum floor space should be at least 1 sq. mtr. per student. The number of student in the class should not be very large. The optimum number in a section of a class is 40.Class rooms- minimum size should be 500 sq. ft. There should be seperate labs for Maths,Physics,Chemistry,Bio & Computer with min. area of 600 sq. ft. Library – minimum size should be 14m*8m fully equipped and with reading room facility.The school should have adequate facilities for providing recreation activities and physical education.

- Computer Lab and Math Lab. No minimum size is prescribed, however the school should have separate provision for each. The computer lab should have 10 computers or computer student ratio of 1:20.

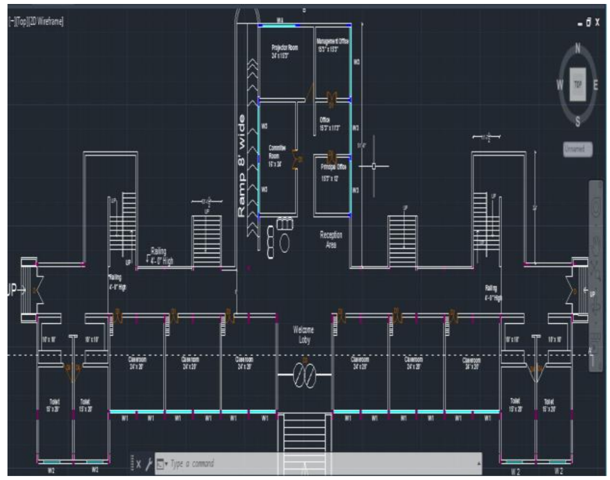

Fig3.1 School Building-Plan

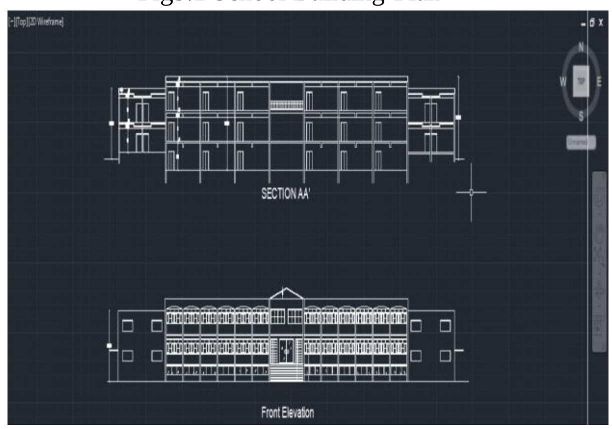

Fig3.2 School Building-Section, Elevation

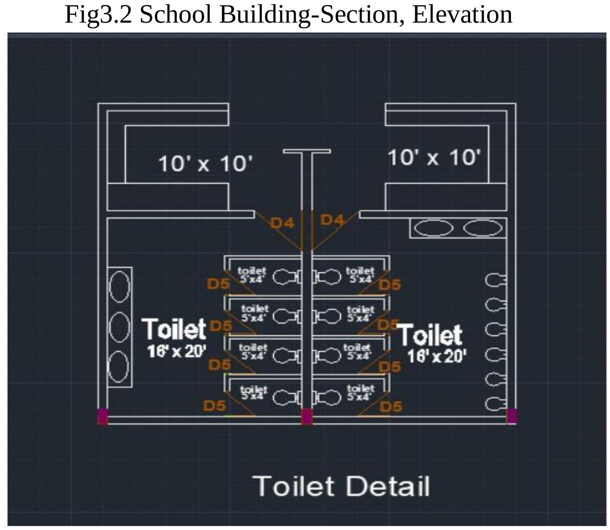

Fig.3.3 School Building-Toilet Detail

3.2Preliminary design of slab

Design parameters

Size = 7.5 m × 6.25 m

Grade of concrete,

fck = 20 N/ mm2

Grade of steel, fy = 415 N/ mm2
Condition Ly/Lx = 7500/6250= 1.24 < 2
Therefore it is a two way slab.
Effective depth As per clause 24 of *IS 456 – 2000*
Span / depth = 0.8×40
Assuming Pt = 0.4
fs = 0.58 × fy= 0.58 × 415
= 240 N/mm2
From figure 4 of IS 456 - 2000
Modification factor for tension reinforcement
= 1.3 d =6250/ (32 × 1.25)
= 160 mm
Overall depth
Nominal cover mild exposure from Table 16,
D =150+20 + (12/2)
D = 186 mm ~ 150mm
Therefore provide a slab thickness of 150 mm.

3.3 Preliminary design of beam

Design parameter Grade of concrete,
fck = 20 N/mm2
Grade of steel, fy = 415 N/mm2
Load calculation Loads on floor slab
Self-weight of slab = 25 × 0.15= 3.75 kN/m2
Floor finish = 1 kN/m2
Live load = 2 kN/m2
Total load = 6.75 kN/m2
Assume, beam dimensions of 300 mm × 450 mm.

3.4 Preliminary design of column

For column C30
Load calculation
Dead load of slab FFS17 = 17 kN
Dead load of beam = (25×0.3×0.3×7.5)
= 16.87 kN
Wall load = 20×0.3×4.5×7.5= 202.5kN
Total load = 236.37 kN
Dead load of slab FFS17 = 17 kN
Dead load of beam = (25×0.3×0.3×6.25) = 14.06 kN
Wall load = 20×0.3×0.3×6.25= 123.75 kN
Total factored load = 157.62 kN
Self-weight of column = 25×0.3×0.45×4.5×1.5
= 22.78 kN
Total Load on column 3C = Load on F1+ Load on F2+self-weight of column = 349.03 kN
Total storey = 2
Hence, Pu = 349.03x2 =698.06 kN

3.4.1Dimension Calculations

Assuming 2 % of steel,
Asc = 0.98 Ag
From IS 456- 2000 clause 39.3,
Pu = 0.4 × fck × Asc + 0.67 × fy × Ast 698.06× 10^3
= 0.4 × 20 × 0.98 Ag + 0.67 × 415 × 0.02Ag
Ag = 52090.14 mm2
Assuming, width = 300 mm,
Depth = 52090.14 / 300
= 173 mm ~ 450 mm
Therefore provide 300 mm × 450 mm size columns.

4.ANALYSIS

The model was created using the coordinate data for the points and the element connectivity table and suitable cross- sectional properties were assigned to the elements created. The boundary condition was stimulated in the model by fixing the three lowermost nodes of the modelled structure. The loads calculated above are applied at appropriate nodes and the stress parameters, deformation of the structure under the effect of the applied load is studied.

Fig.4.1 School Building-Stair case

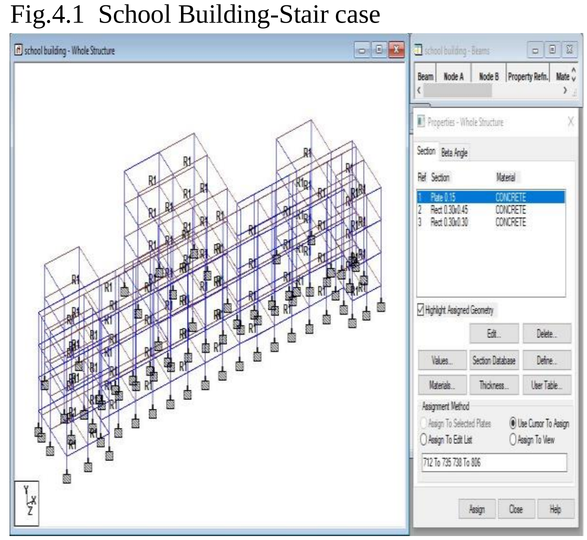

Fig4.2 School Building Whole structure -Staadpro

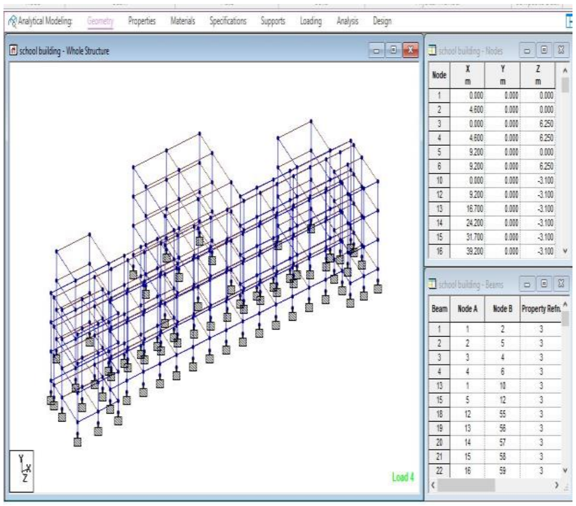

Fig4.3 School Building Analysis-Staadpro

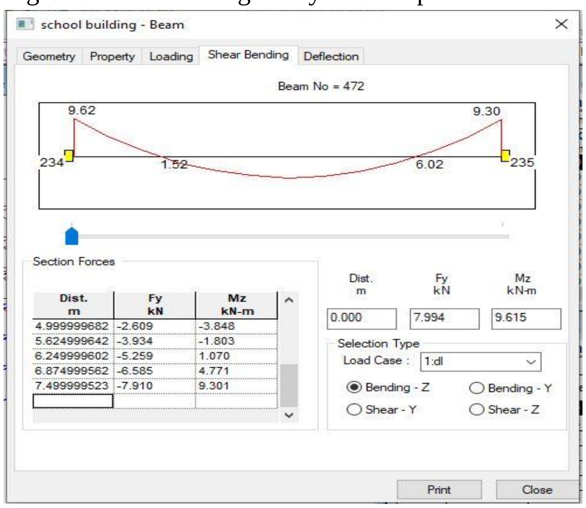

Fig4.3 School Building Analysis-Beam

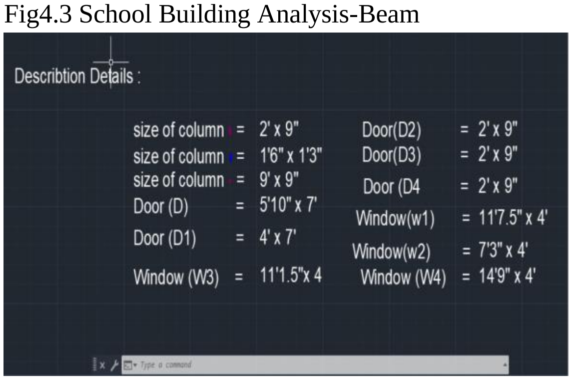

Fig4.3 School Building Description

V.DETAILED DESIGN

5.1 DESIGN OF SLAB

Edge condition = Two edge discontinues
Slab number = slab no. 4
Size of slab = 7.5× 6.25m
Use M20 grade of concrete and Fe 415 steel.

Effective depth
Side ratio = Ly / Lx
=7.5 / 6.25= 1.2 <2
Hence the slab is to be designed as a two way slab.
As per clause 23.2.1 of IS 456 – 2000,
For continuous slabs
Span / depth = 40×0.8 =32
Assuming Pt = 0.4
fs = 0.58 × fy
= 0.58 × 415
= 240 N/mm2
From figure 4 of IS 456- 2000
Modification factor for tension reinforcement = 1.3 d
=6250/ (32 × 1.3)
d = 253.9mm
Nominal cover mild exposure from table 16
Overall depth D = 253.9+ 20 + (12/2)
D =280 mm

Therefore provide a 150mm depth slab.
Effective span (lx)
Effective span = Clear span + Effective depth
Le = 6.25 + 0.30 = 6.5m
Effective span = Clear span + Slab thickness

Le = 6.23 + 0.13
= 6.36 m (Take the least Le value.)

Design loads
Self- weight of slab = 0.15× 25
=3.75 kN/m2
Live load = 3 kN/m2
Assume floor finish = 1kN/m2
Total load =7.75 kN/m2
Factored load = 7.75 × 1.5
= 11.625 kN/m2
Ultimate design moment and shear force
From table 26 of IS 456 – 2000,
Bending moment coefficients for ly / lx = 1.23 are obtained.
αx
Negative moment = 0.071
Positive moment = 0.053
αy
Negative moment = 0
Positive moment = 0.043
a) Moment along shorter span
Mx = αx wu lx 2 (NEGATIVE) 42

= 0.071 × 11.625 × 6.36
= 33.38 kNm
Mx = αx wu lx 2 (POSITIVE)
= 0.053 × 11.625 ×6.36
= 24.92 kNm
b) Moment along longer span
My = αy wu lx 2 (NEGATIVE)
Ay = 0
My = αy wu lx 2 (POSITIVE)
= 0.043 ×11.625× 6.36^2
=20.21 kNm
Shear force Calculation
Vu = wu lx /2
=(11.625×6.36)/2 =36.9 kN
Check for depth
Mu limit = 0.138 × fck × b × d
As per IS 456 2000 Annex C
33.38 ×10^6 = 0.138 × 20 × 1000 × d 2
d = 72.90 mm < 100 mm
So it is safe.
Reinforcement of shorter span
Mu = 0.87 fy Ast d (1- Ast fy/ fck b d)
14.67 × 106 = 0.87 × 415 × Ast × 130 [1- (Ast × 415) / (20 × 1000 × 130)]
Ast (Max) =5935.7 mm2
Ast (Min) =329.97 mm2
Ast =329.97 mm2
No of bars = Ast/ ast
= 329.97/ 113.09
= 2.97 ~ 4 No's
Spacing should be the least of 43
1. [ast / Ast] × 1000 = [π/4 × 122 / 329.97] × 1000 =342.72 mm
2. 3d = 3 × 130
= 390mm
3. 300mm
Therefore provide 4 N0's 12mm dia bars @ 300mm spacing.

Check for shear
τv = Vu / bd
= 23.70 × 10 3 / (1000 × 130) = 0.18 N/mm2
Refer 73, table 19,
τc =100 × Ast/ b d
= 100× 329.97 / 1000 × 130
= 0.25
Hence, τc = 0.25 N /mm2 and
k=1.3
τck = 0.325 N /mm2
τv < τck
Hence safe.
Torsional reinforcement
Length = 1/5 th of shorter span
= 1/5 × 4.23
= 846 mm2
75% of Ast = 0.846 × 329.97
= 279.15 mm2
No of bars = Ast/ ast
= 329.97/ 50.26
= 6.56 ~ 8 N0's
Spacing = [[(π/4) × 8 2]/ 250] × 1000
= 180.06 mm
Ly = (5230)/8
= 653.75mm
Lx = (4230)/8
= 528.75mm.
Provide 8 No's of 8 mm dia bars at 300 mm c-c spacing.
Provide 4 No's of 12mm dia bars at 300 mm c-c spacing.
Provide 8 No's of 8 mm dia bars at 300 mm c-c spacing.
Thickness of slab = 130 mm.

5.2DESIGN OF STAIRCASE AT GROUND FLOOR
Height of each flight = 3.6/2 = 1.8m
Assume rise as 150mm
Assume tread as 250mm
Number of rise= 1.8/0.15 = 12
Number of tread = 12-1 = 11
Length of each flight = 11 × 250 = 2750mm
Width of landing = 1500mm
Assume bearing of landing wall= 160mm
Effective span = 2750 + 1500 + 160/2
= 4250mm
Thickness of waist slab
= 40×4.23 or 50× 4.25
= 170 or 212.5 ~ 200 mm
Load calculation
Dead load at waist slab,
W' = 0.2 × 25 = 5 kN/m
Load per square meter on plane = (W'√ (R2 + T2)) / T
= [5√ (0.1502+ 0.2502)]
= 5.83 kN/m
Load on steps = ½ × 0.15 × 25 × 20
= 1.875 kN/m

Floor finish = 0.1 kN/m
Live load = 2.5 kN/m
Total load = 10.305 kN/m
Ultimate load, Wu = 10.305 × 1.5
= 15.460 kN/m 52
Bending moment
M = Wl2 /8
M = (15.460 × 4.252)/8
= 34.90 kNm
Check for depth
Mu Limits = 0.138 fck bd2
34.90 × 106 = 0.138 ×1000 × 20 × d 2
d = 112.45mm ~ 113mm <130mm
Hence, provide 150mm as a thickness of waist slab.
Calculation of main reinforcement
Assume, M20 grade concrete and Fe415 grade steel.
d = 150- 20-10/2 = 125mm
Mu = 0.87 fyAs d (1- Ast fy / b d fck)
34.90 × 10^6 = 0.87 × 415 × Ast × 125 [1- ((Ast × 415)/
(1000 × 125 × 20))]
34.90 × 10^6 = 45.13 × 103Ast (1- 1.66× 10-4)
Ast = 911mm2
Spacing = (ast / Ast) × 1000
= [(π/4 × 122)/ 911] × 1000
= 125 mm
Therefore provide a 12mm dia rod of 300mm c/c spacing.
Calculation of distributary reinforcement
Ast min = (0.12/100) × 1000 × 150 = 180mm2
Spacing = [(π/4 × 8 2)/180] ×1000
= 279mm ~ 280 mm
Therefore provide an 8mm dia rod of 300mm c/c spacing.

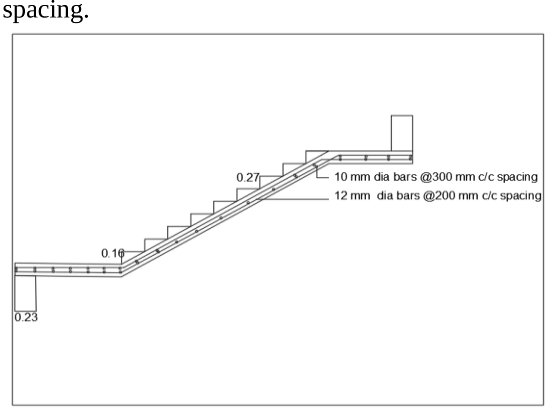

Fig.5.1StaircaseDetail

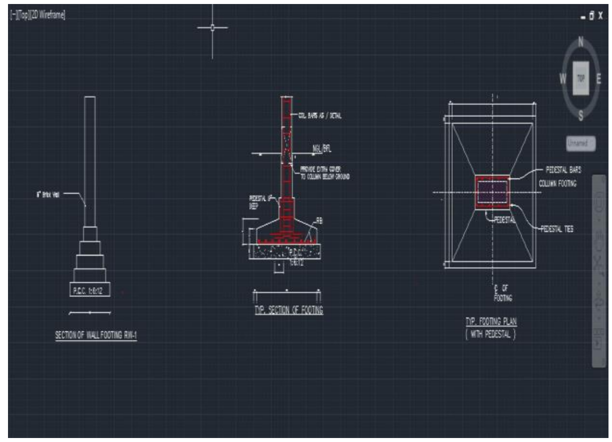

Fig.5.2Foundation Detail

6. RESULTS &CONCLUSIONS

The planning of the building is done using AUTOCAD and the same is analyzed for all the load combinations such as dead load and live load and wind load with respective Indian Standard codes IS 456 2000 and IS 875-2000 (Part 1-2) using STAAD Pro. The design forces as per the STAAD Pro results are considered for the design of the structure such as beam, column, slab and staircase.It has been shown that the members chosen are safe to carry the expected design loads..

REFERENCE

1. Bijaya Nepal1 & Prof. Dr. Ramkrishna Maharjan (2015),"Effect of School's Physical Facilities on Learning and Outcomes of Students in Nepal" Volume 01, Issue 06.
2. Mohsen Ghasemi Ariani & Fatemeh Mirdad (2016) "The Effect of School Design on Student Performance" Vol. 9, No. 1.
3.Dinesh Ranjan.S, Aishwarya Lakshmi.V(2017) "Design and Analysis of an Institutional Building" Volume 1, Issue2.
4. Natasha Khalil(2015) on" design and analysis of a school building" Volume 1,Issue 2.
5. Krishna Raju, N. (2004), 'Structural Design and Drawing Reinforced Concrete and Steel', CBS Publisher & Distributors Pvt. Ltd., New Delhi.
6.. Punmia.B.C(1980), 'Reinforced Concrete Structures', Laxmi Publications, New Delhi.
7. IS 456 – 2000, 'Plain and Reinforced Concrete Code of Practice', Bureau of Indian Standards, New Delhi