CHAPTER 1

INTRODUCTION

1.1 GENERAL

A Store cum Godown Block Building is a structure designed to provide a combined storage and warehousing facility for goods, materials, and equipment. This type of building is typically used in industrial, commercial, or institutional settings. It ensures smooth functioning of these structures by providing;

- Adequate infrastructure such as loading/unloading areas
- Combines storage and store functions
- Accommodate various types of materials and equipment
- Secure environment for storing valuable or sensitive items

The proposed building is designed for the storage of dairy machineries, packing materials of ghee and milk products marketed by MRCMPU Ltd. Malabar Regional Co-operative Milk Producers' Union (MRCMPU) Limited is a Union of more than 1000 village level Dairy Co-operative Societies located at Kalleppuly in Palakkad. The building has to be designed as Steel-framed structural system composed of steel columns, beams, RCC slabs and other elements to support the loads and stresses imposed on the building. It is the composed of concrete based foundation with a steel based super structure. The construction typically consists of following phases; namely planning, analysis, design and estimation. Any engineering structure should satisfy the functional and structural needs, have a sufficient degree of performance, a reasonable cost and should be aesthetically attractive. The purpose of structural analysis and design is to enable the designers to design the structure with adequate strength, stiffness, and stability.

The planning of the proposed structure was carried out based on the requirements specified by MRCMPU Ltd. The project includes: Detailed drawings prepared using AutoCAD. Architectural drawings and 3D views developed using SketchUp. Estimation of costs using MS Excel. Structural analysis conducted using SAP2000 software. The limit state method was used for designing concrete structures in accordance with IS: 456-2000. Additionally, the design of beams and columns follows the criteria and provisions specified in IS: 800-2007 and SP-6.

1.2 OBJECTIVES

The primary objectives of this project are Planning, Analysis, Design, and Cost Estimation. Before commencing the work, the following requirements were identified based on the specifications provided by MRCMPU Ltd.

- To ensure the building can withstand various loads, including dead load, live load, and other imposed forces, without compromising structural integrity
- To prepare detailed architectural and structural drawings, develop 3D visualizations, estimate costs accurately, and conduct structural analysis to verify stability and strength

1.3 SCOPE

- Strength of steel approximately ten times that of concrete. Steel structures are having more life span, higher strength to weight ratio.
- Steel structures can be implemented fastly, eco-friendly material and steel structures can be easily dismantled and sold as scrap.
- Steel to be more economical than concrete structures for tall buildings and large span buildings and bridges.
- Steel structures can be easily repaired and retrofitted to carry higher loads.
- Improve and provide a better marketing for Palakkad dairy.
- Provide sufficient space for storage of raw materials.

1.4 CLIENT REQUIREMENTS

1.4.1 Ground Floor

- Godown and Store area -To receive and stock packing products (290-300 Sqm)
- Minimum Height of Godown - 3.00 m
- Office room - To accommodate 2 staffs (10.00 Sqm)
- Record room - To maintain the inward and outward data/registers
- Loading area - For the distribution of products (10-30 Sqm)
- Plinth Height - 1.10 m from ground level
- Canopy - To park 2 trucks at a time near to loading area
- Necessary Ramps - For loading and unloading materials
- Steel ladder - For easy access
- Sufficient windows for day light and ventilation

1.4.2 First Floor

- Store area - For arranging less weight materials (150 – 175 Sqm).
- Steel ladder - For easy access
- Minimum Room Height - 3.00 m
- Sufficient windows for day light and ventilation

1.4.3 Details of Proposed Site

- Client name : MRCMPU LTD
- Total land area : 10.73 Acres (43424.31 Sqm)
- Total area of Existing Buildings : 4960 Sqm
- Location : Palakkad, Kalleppully
- Municipality : Palakkad.
- District : Palakkad.

1.4.4 KMBR Requirements

Category of Building: Storage Building (Group H)

Table 1.1: KMBR Requirements

Description	Required as per KMBR	Provided at Site
Set back: Front	6.00 m	18.00 m
Back	3.00 m	10.00 m
Side	2.00 m	6.00 m
Coverage	70.00 %	11.42 %
Floor Space Index	3.00	0.144
Access width	7.00 m	15.00 m
Parking	1 No	15 Nos.

Table 1.1 shows the comparison between the KMBR required at the site and what is available at the site. The KMBR requirements are satisfied at the site; hence, the building permit shall be obtained from Palakkad Municipality.

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL

With the increasing requirements for building safety, environmental protection and efficiency, the traditional concrete structure can no longer meet the needs of people. Therefore, steel-structure buildings have gradually become an important form of construction. Compared to traditional concrete structures, steel structures have the advantages of excellent seismic performance, lightweight, and reusability. And among steel structures, assembled steel structures, as an emerging form of construction, have more advantages. The review of the following journals, to which we have referred, for analysing soil condition, structural stability, and foundation characteristics, and cost estimation, will contribute to the successful fulfilment of our project.

2.2 LITERATURE REVIEW

Shengfei et. al (2023) with the increasing requirements for building safety, environmental protection and efficiency, the traditional concrete structure can no longer meet the needs of people. Therefore, steel-structure buildings have gradually become an important form of construction. Compared to traditional concrete structures, steel structures have the advantages of excellent seismic performance, lightweight, and reusability. And among steel structures, assembled steel structures, as an emerging form of construction, have more advantages. The assembled steel structure is a building system in which prefabricated steel beams, columns, connectors and other components in the factory are assembled on-site. It can not only greatly shorten the construction cycle and reduce the construction cost.

Suchita et. al (2023) Steel concrete composite structure can be built instead of RC structures to get the maximum benefit from steel and concrete and produce efficient and economical structures. It depends on the character of the building and the material used, and according to these characteristics, the type of material can be chosen to achieve the best result. A composite structure occurs when two heterogeneous materials are effectively bonded together so that they function together as a single element in the structure. Composite construction is a new technique that is often used to save construction costs and save money on construction.

AradhanaRao. et. al (2019) Estimation is the scientific way of working out the approximate cost of an engineering project before execution of the work. It is totally different from calculation of the exact cost after completion of the project. Estimation requires a thorough Knowledge of the construction procedures and cost of materials &labor in addition to the skill, experience, foresight and good judgment. An estimate of the cost of a construction job is the probable cost of that job as computed from plans and specifications. For a good estimate the, actual cost of the proposed work after completion should not differ by more than 5 to 10 % from its approximate cost estimate, provided there are no unusual, unforeseen circumstances. Estimation is used for framing the tenders for the works and to check contractor's work during and after the execution for the purpose of making payments to the contractor.

Rajeshwari et. al (2017) SAP2000 stands for STRUCTURAL ANALYSIS PROGRAMMING. SAP2000 is commonly used to analyze concrete structures, steel structures, parking garages, skyscrapers, low and high raise buildings, and portal frame design of multi-storey R.C.C residential building of '3' story's. Modeling of 3- storey's R.C.C. framed building is done by using the SAP2000 software for analysis. Post analysis of the structure, maximum shear forces, bending moments, and maximum member displacement are computed. The structural elements are designed manually by using IS456 & SP16.

Fathi et. al (2016) The design of isolated column footing is accomplished through the application of geotechnical and structural analysis concepts. So that, the input research into isolated column footings comes from two different disciplines, geotechnical and structural. This may be one of the main causes that attributed to the limited research input to the subject. Therefore, the structural design of isolated column footings is based on empirical rules and the calculations of bending moments (BM) and shearing forces (SF) induced in a footing are based on the rules of beam theory, which is questionable. Also experimental research on isolated column footings is scarce, due to the difficulties involved in the setup of the laboratory models and the cost of experiments.

CHAPTER 3

METHODOLOGY

3.1 GENERAL

The project has been divided in to different stages for doing and analysing the work progress. The following Fig.3.1 shows the methodology of the project

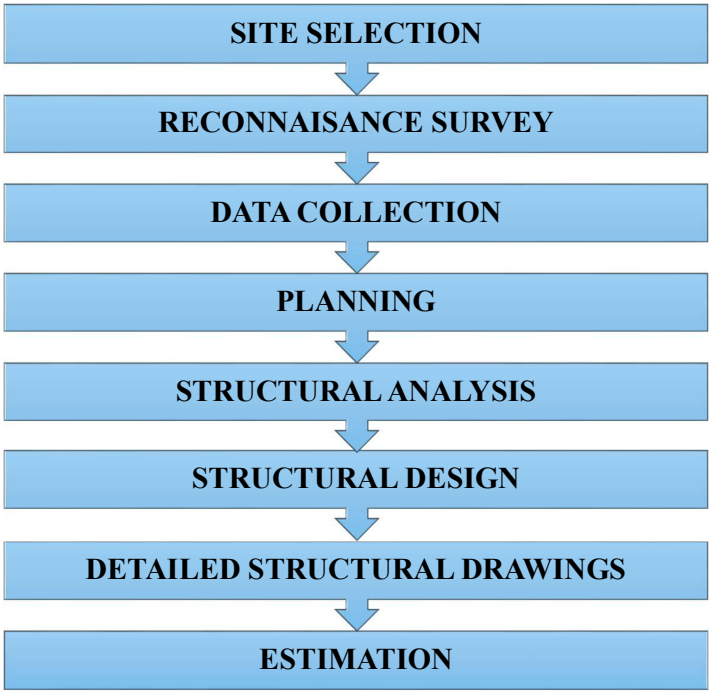

Fig.3.1 Proposed Methodology

The chapter proposes structured methodologies for the design of a Store cum Godown Building for MRCMPU Ltd at Palakkad. We have studied about the design of structures and foundations from the literature review to get an idea for doing this project. In the initial stage, site selection and reconnaissance are done, through which we can collect general ideas and get clear measurements and levels while doing the Total station survey. Then, in the next phase, the planning of the building is done. The structure of the building is analysed and designed manually based on Indian standard Codes and specifications. SAP2000 and AutoCAD software are used for structural analysis and detailed drawing respectively.

CHAPTER 4

DATA COLLECTION AND PLANNING

4.1 APPROVAL FOR CONSTRUCTION ACTIVITY

When a building needs to be constructed anywhere in Kerala, building permit, approved plan and other drawings related to that building will have to be obtained from concerned local authority like Corporation/Municipality/ Panchayath as the case may be as per the list of approvals or sanctions required for the construction.

- Building Permit: A builder should submit building plan, service plan, site plan, Parking plan and other utility plan etc. signed by a registered Engineer/ Architect/Supervisor, before starting the construction activities.
- Basic Amenities: The Builder should get approval from concerned authorities for electricity, water for potable and non-potable use. The building should comply with building rules for this purpose.
- No Objection Certificate (NOC): NOC from the pollution control board on this project is essential for the approval for sewer or water supply.
- No objection Certificate: NOC from fire department of the project is essential to meet safety regulations.
- Completion Certificate: Completion certificate is mandatory for building constructed before occupied. Issuing of completion certificate will ensure the constructed building is as per approved plan.

4.2 DEFINITIONS OF VARIOUS TERMS RELATED TO BUILDING

1. Access: means a clear approach to a plot or a building;
2. Alteration: means a structural change, such as an addition to the area or height
3. Approved plan: means the set of drawings and statements submitted under these rules for obtaining development permit or building permit and duly approved by the Secretary
4. Balcony: means a horizontal projection, including a hand rail, or balustrade to serve as passage or sitting out place;
5. Building line: means the line up to which the plinth of a building adjoining a street or an extension of a street or a future street may lawfully extend. It includes the lines prescribed, if any, in any town planning scheme in force in the area beyond which no

portion of the building may extend except as prescribed in these rules. The building line may change from time to time as decided by the authority.

6. Built- up area: means the total area covered by the building at all floor levels. It shall also include area of mezzanine floor, galleries, barsati and pent house at terrace level;
7. Category –I: Village Panchayath means a Village Panchayath notified as Category I Village Panchayat by the Government under sub-rule (5) of rule 3;
8. Category –II Village Panchayath means a Village Panchayath notified as Category-II Village Panchayath by the Government under sub-rule (5) of rule 3;
9. Cladding: means those components of a building which are exposed to the outdoor and indoor environment and are intended to provide protection against wind, vapour and heat;
10. Corridor: means an exit serving as a passageway communicating with separate rooms or with different parts of a building or with different buildings;
11. Covered area: means the ground area covered by the building and is synonymous to area of the building foot print. It shall include covered parking. It does not include the spaces covered by:-
    (i) Garden, rockery, well and well structures, plant, nursery, water tank, swimming pool (if uncovered), platform around a tree, tank, fountain bench and like:
    (ii) drainage, culvert, conduit, catch pit, gully pit, drainage chamber, gutter and the like:
    (iii) Flight of steps and ramps all open to sky, cantilevered car porch, compound wall, gate, slide, swing, areas covered by sunshade and the like.
    (iv) storeys fully below the ground level
12. Coverage: means the percentage of covered area with respect to the plot area.
13. Drainage: means the removal of any liquid by a system constructed for the purpose;
14. Exit: means a passage, channel or means of egress from any building, storey or floor to a street or other open space of safety;
15. External wall: means an outer wall of a building; it also means a wall abutting on an interior open space of any building;
16. Floor space index (F.S.I.): means the quotient obtained by dividing the total built up area by the area of the plot (This word is synonymous with FAR)

$$\text{FAR} = \frac{\text{Total Floor Area}}{\text{Plot area}}$$

17. Frontage means side or part of a side of a plot which abuts a street;

18. front yard: means an open space extending laterally along the front side (main entrance side of ground floor) of a building and forming part of the plot; Note:

    Where more than one entrances to a building are provided at the ground floor, the entrance giving access to the major portion of the ground floor shall be considered as the main entrance;

19. Ground floor: means (i) the lowest floor of a building in the case of the building without basement floor(s) and; (ii) the floor above the uppermost basement floor, in the case of building with basement floor(s).
20. Height of building: means the vertical distance measured from the average proposed ground level contiguous to the building;
    (i) in the case of flat roofs, to the highest point of the flat roof;
    (ii) in the case of pitched roofs and gabled roofs, to the midpoint between the eves level and the ridge;
    (iii) in the case of domed roofs, to the highest point of the dome; provided that architectural features appurtenant roof structures like staircase tower, overhead tanks, air-conditioning plant rooms, lift rooms, cellular telecommunication equipment, tower structures, chimneys, rooftop helipad, open swimming pools, parapet walls and similar roof structures other than pent houses shall not be included in the height of the building. Note: - for arriving at the average proposed ground level, the average of the lowest proposed ground level and the highest proposed ground level contiguous to the building shall be taken.
21. Height of room: means the vertical distance between the floor and the lowest point excluding beam and column on the ceiling of the room;
22. Occupancy group: means the principal occupancy for which a plot, a building or a part of a building is used or intended to be used; for the purposes of classification of a plot or building according to occupancy, an occupancy shall be deemed to include the subsidiary occupancies which are contingent upon it;
23. Parking space: means an area enclosed or unenclosed, sufficient in size to park vehicles, together with a driveway connecting the parking space with a street and permitting ingress and egress of vehicles;
24. Permit: means a permission or authorization in writing by the Secretary to carry out work;

25. Persons with disability: means, persons with disability as defined in clause (1) of section 2 of the Persons with Disabilities (Equal Opportunities, Protection of Rights and Full Participation) Act, 1995 (1of 1996);
26. Plinth: means the portion of a structure between the surface of the surrounding ground and surface of the floor, first above the ground;
27. Plot: means a parcel or piece of land enclosed by definite boundaries as described in the document in support of ownership of the plot;
28. Plot area: means the area of the land as per the records of the revenue authorities as authenticated by a possession certificate, land tax receipt issued by the Village Officer;
29. Rear yard: means the open space extending laterally along the rear side of the plot and forming part of the plot; any side yard can be interchanged with rear yard.
30. Road level: means the officially established elevation of the centre line of the road upon which a plot abuts and if there is no officially established elevation, the existing elevation of the center line of the road;
31. Road width: shall be the minimum existing width of the road at any point.
32. Section: means a Section in the Act;
33. Service lane: means a lane provided at the rear or side of a plot for service purposes;
34. Set back line: means a prescribed building line drawn with reference to the central line or boundary of a street, on the street side of which nothing can be erected or re-erected except compound wall;
35. Side yard: means an open space extending laterally between any side of a building and the boundary of the plot facing that side other than front and rear yard and forming part of the plot; any side yard can be interchanged with rear yard
36. Site: means a plot and its surrounding precincts;
37. Storey: means the portion of a building included between the surface of any floor and the surface of the floor next above it, or if there be no floor above it, then the space between any floor and the ceiling next above it;
38. Street: means a private or a public path giving access to more than one plot or building;
39. Street level: means the level at the centre line of the street
40. Street line: means the line defining the side limits of a street;

41. Sunshade or weather shade: means a sloping or horizontal structural overhang usually provided over openings on external walls to provide protection from sun and rain;

4.3 SOFTWARES USED FOR THE PROJECT

4.3.1 Auto CAD

AutoCAD is a commercial computer aided design and and drafting software application, developed and marked by Autodesk, AutoCAD was first released in December 1982 as a desktop app running on microcomputers with internal graphics controllers. Before AutoCAD was introduced, most commercial CAD programs ran on main frame computers or minicomputers, with each CAD operator (user) working at a separate graphics terminal. AutoCAD is also available as mobile and web apps. AutoCAD is primarily used for 2 dimensional drawings, and even though 3D modelling is available in AutoCAD is used in industry, by architects, project managers, engineers, graphic designers, city planners and other professionals.

4.3.2 SAP2000

SAP2000 is structural analysis and design software program developed by Computers and Structures, Inc. (CSI). It is widely used by structural engineers for designing and analysing structural models of buildings, bridges, towers and other structures. The software provides a user friendly interface for creating and analyzing Complex structural models. It supports various types of analysis, including static dynamic linear and nonlinear analysis. It also includes a wide range of material and elements types such as steel, concrete, composite and timber elements to model any type of structure.

4.3.3 SketchUp

SketchUp is a 3D modelling software that is widely used in a variety of fields, including architecture, engineering, construction, and interior design. Originally developed in 2000 by @Last Software, it was acquired by Google in 2006 and later sold to Trimble Navigation in 2012. SketchUp is renowned for its user-friendly interface and ease of use, making it accessible to both professionals and beginners.

4.3.4 Microsoft Office

Microsoft Office, often referred to as MS Office, is a suite of productivity software applications developed by Microsoft Corporation. It was first released in 1989

and has since become one of the most widely used office suite software programs in the world. The suite is designed to assist users in various tasks related to document creation, data management, and communication, enhancing productivity in both personal and professional environments.

- Microsoft Word (Word processor)
- Microsoft Excel (Spread sheet program)
- Microsoft Power Point (Presentation program)

Microsoft Office remains a cornerstone in the realm of productivity software, widely adopted by businesses, educational institutions, and individuals. Its integration of powerful applications for word processing, data analysis, presentations, and communication helps users efficiently manage their tasks, enhancing productivity and collaboration across various domains.

4.4 SURVEYING

Surveying is the science, art, and technology of determining the relative positions of points on, above, or beneath the Earth's surface. Involves measuring distances, angles, and elevations to map and plan various projects.

4.4.1 Reconnaissance Survey

A reconnaissance survey is the preliminary investigation and inspection of an area to gather essential information for planning and designing engineering or construction projects. It provides a broad overview of the area and helps in deciding the best course of action for further detailed surveys.

Location (10.791754410087787, 76.67488039256375)

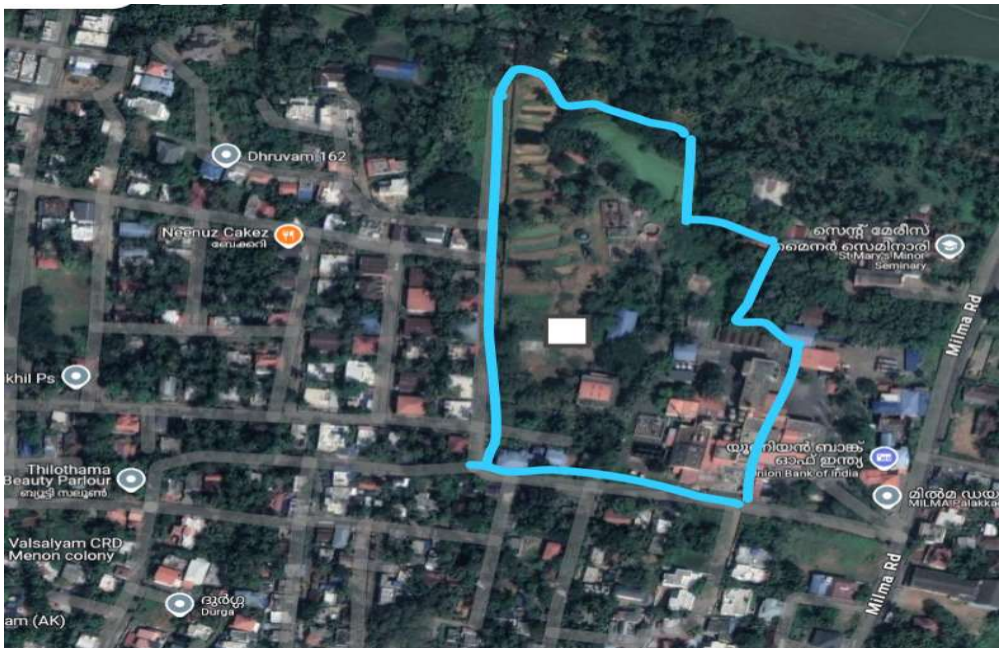

Fig. 4.1 Location of the Proposed Site

This above Fig. shows the location of Milma Plant at Kalleppully Palakkad Dist. The white colored rectangle represents the proposed building.

4.4.2 Detailed Survey

Detailed Survey refers to a precise survey conducted to collect detailed data about the topographical and physical features of an area. The Total Station is an advanced, versatile instrument that integrates electronic distance measurement (EDM) and angular measurements with digital data recording, making it a preferred choice for detailed surveys.

Fig. 4.2 Site Plan

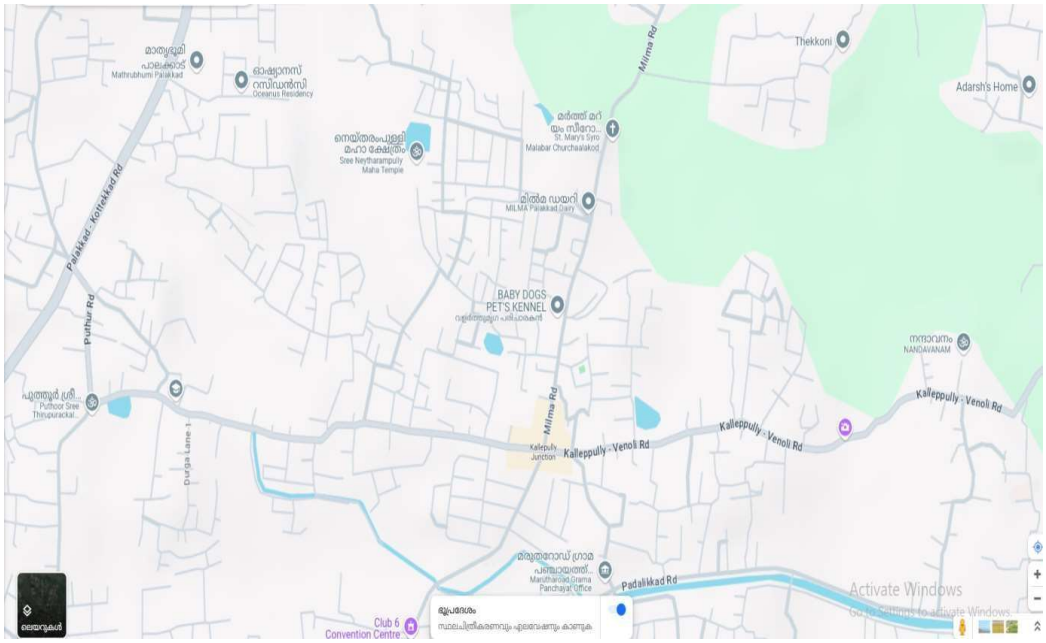

Fig. 4.3 Location on Map

Fig 4.2 and 4.3 show the site plan and location map obtained from Google Maps, respectively

4.5 FUNCTIONAL PLANNING

4.5.1 General Background

This phase involves consideration of the various requirements and factors affecting the general layout and dimensions of the structure and results in the choice of one or perhaps several alternative types of structure, which offer the best general solution. The primary consideration is the function of the structure and secondarily as aesthetics, sociology, law, economics, and the environment also be taken into account. In addition, there are structural and constructional requirements and limitations, which may affect the type of structure to be designed. Reconnaissance survey is conducted and site plan is prepared. For the planning section, we have collected the required information, mainly used codes are: -

- National Building Code of India
- Kerala Municipal / Panchayath Building Rules (2019)

4.5.2 Set Back details

Category of Building: Storage Building (Group H)

Table 4.1: Set back Details for the proposed building

Description	**A Site**
Set back: Front	18.00 m
Back	10.00 m
Side	6.00 m
Coverage	11.42 %
Floor Space Index	0.144
Access width	15.00 m
Parking	15 Nos.

The table shows the Kerala Municipal Building Rule requirements compared with provided at the proposed building site. Building Permit is necessary for construction or installation, and the rules specify the requirements for obtaining one.

The drawings are shown in Annexure as follows;

Ground Floor Plan-Annexure - A1

First Floor Plan-Annexure - A2

Second Floor Plan-Annexure - A3

Cross Section YY-Annexure	-	A4
Cross Section XX-Annexure	-	A5
Elevation-Annexure	-	A6
Site Plan-Annexure	-	A7
Site Layout-Annexure	-	A8
3D View-Annexure	-	A9
Plinth Beam Layout	-	A10
Column Layout	-	A11
Footing Layout	-	A12

4.5.3 Provision of facilities

Table 4.2: Space Provided in Ground Floor

Sl. No.	Name of Room	No.	Size in (m)	Area ($m^{2)}$
1.	Office Room	1	6.77x2.77	18.75
2.	Record Room	1	6.77x2.77	18.75
3.	Entrance Lobby	1	3.27x2.77	9.06
4	Loading Area	1	3.27x1.5	4.90
5.	Godown Area	1	17.27x13.27	229.17

Table 4.3: Space Provided in First Floor

Sl. No.	Name of Room	No.	Size in (m)	Area ($m^{2)}$
1.	Godown	1	17.27x16.27	280.98

The above tables 4.2 and 4.3 shows the area details of the proposed building after the discussion from MRCMPU Ltd

CHAPTER 5

STRUCTURAL ANALYSIS

5.1 LOADS ACTING ON A STRUCTURE

5.1.1 Dead Load

Dead loads are permanent or stationary loads that are transferred to structures throughout their life span. It is primarily due to the weight of the structural members, the permanent partition wall, the fixed permanent equipment, and the weight of different materials. The dead loads include loads that are relatively constant over time, including the weight of the structure itself and immovable features such as carpet. The roof is also a dead weight. Dead loads are also known as permanent or static loads. IS codes used: IS-875: 1987, Part 1; Dead Load.

Unit weight of reinforced concrete	:	25.00 kN/m^3
Floor finish considered	:	1.00 kN/m^2
Unit weight of Masonry Wall	:	14.00 kN/m^3

5.1.2 Live Load

Live loads are also called imposed loads, and they are either moving loads or movable loads that do not have any acceleration or impact. All these loads are part of what an occupant brings into the building. These items are normally furniture and movable partitions.

The live loads will continuously change inside a building, therefore floor slab have to be designed to carry either a uniformly distributed load or a concentrated loads at any time. The acceptable live load will vary considerably based on the occupancy and expected use of structure.

IS 456:2000 stipulates the combinations of loads to be considered in the design of the structures. Whichever combination produces the most unfavourable effect on the building foundation or structural members concerned will be adopted.

The whole structural system and its loading conditions might be of a complex nature, so to make the analysis simpler, we use certain simplifying assumptions related to the quality of material, member geometry, nature of applied loads, their distribution, the type of connections at the joints, and the support conditions. This shall help make

the process of structural analysis quite simple. Therefore floor slab have to be designed to carry either a uniformly distributed load or a concentrated loads at any time. The acceptable live load will vary considerably based on the occupancy and expected use of structure.

IS codes used: IS 875: 1987 Part 2; imposed loads

Rooms	:	3.00 kN/m^2
Office	:	2.50 kN/m^2
Staff Room	:	2.50 kN/m^2
Passage	:	4.00 kN/m^2
Floor finish considered	:	1 kN/m^2
Unit weight of Masonry Wall	:	14 kN/m^3

5.1.3 Load Combination

IS 456:2000 stipulates the combinations of loads to be considered in the design of the structures. Whichever combination produces the most unfavourable effect on the building foundation or structural members concerned will be adopted.

1.5(DL+LL)

Analysis results from the critical load combinations are used for the design of the structural member.

5.2 STRUCTURAL ANALYSIS

Building frames consist of multi-storied and panelled network of beams and columns, which are built monolithically. This provides connection to the members. All the members of such a frame are continuous at their ends. The analysis of framed structure thus means the determination of internal forces like axial compression, bending moment, shear force, for which these members are to be designed.

A structure refers to a system of two or more connected parts used to support a load. It is an assemblage of two or more basic components connected to each other so that they serve the user and carry the loads developing due to the self and superimposed loads safely without causing any serviceability failure. Once the preliminary design of a structure is fixed, the structure must then be analysed to make sure that it has the required strength and rigidity.

To analyse a structure correctly, certain idealisations are to be made as to how the members are supported and connected together. The loadings are supposed to be taken from the respective design codes and local specifications, if any. The forces in the members and the displacements of the joints are found using the theory of structural analysis.

The whole structural system and its loading conditions might be of a complex nature, so to make the analysis simpler, we use certain simplifying assumptions related to the quality of material, member geometry, nature of applied loads, their distribution, the type of connections at the joints, and the support conditions. This shall help make the process of structural analysis quite simple.

5.3 ANALYSIS USING SAP2000

SAP 2000, the popular structural analysis and design software, has been in use across the globe since 1975. Computer and Structures, Inc. (CSI) is a structural and earthquake engineering Software Company founded in 1975. General-purpose software for integrated structural analysis and design. SAP2000 may be utilised for analysing and designing practically all types of structures: buildings, bridges, towers, transportation, industrial, and utility structures.

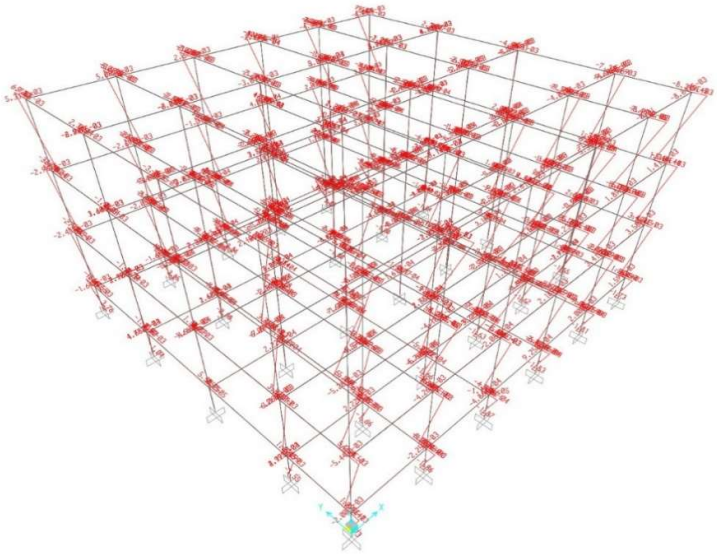

Fig. 5.1 shows the moment distribution diagram.

The above fig.5.1 shows the analysed structure given from the SAP2000 software analysis.

CHAPTER 6

DESIGN OF STRUCTURAL STEEL

6.1 GENERAL

The design of steel column joints and laterally supported beams follows a systematic approach to ensure structural integrity and compliance with standards IS 800:2007. For column joints, determine the forces at the connection (axial load, shear, and moment), select an appropriate joint type (bolted or welded), and design end plates, stiffeners, and anchor bolts as required. Verify load transfer capacity, weld strength, and bolt adequacy while ensuring sufficient edge distances and plate thickness to prevent local failures. For a laterally supported beam, identify span, load types, and material properties, then compute bending moments, shear forces, and reactions. Select a suitable beam section, ensuring bending strength using plastic section modulus and shear capacity using web area. Since the beam is laterally supported, lateral-torsional buckling (LTB) is not a governing factor, but local buckling and deflection limits must be checked. Finally, design shear or moment connections using bolts or welds, considering end conditions and compatibility with the column joint, ensuring safe and efficient load transfer.

6.2 DESIGN OF BEAM

Steel Beam ISHB 400 design based on values obtained from SAP2000 that involves load analysis, section selection, and cross section design and code compliances checks to ensure that the beam is safe, efficient, and cost-effective for the given application.

The details of selected slabs are shown in Table 6.1

Table 6.1: Bending Moment and Shear Force Details of Steel

l_e (m)	V_d (kN)	V_u (kN)	M_u (kNm)	M_d (kNm)	Type
4.50	477.63	120	71.44	382.42	Laterally Supported Beam

Step – 1: Section Properties

From IS 800:2007, Page – 138

l_e = 4.50 m

W = 77.40 kg/m

A = 98.66 cm^2

Z_P = 1556.33 cm^3

Z_e = 1404.20 cm^3

h = 400 mm

r_1 = 14 mm

b_f = 250 mm

t_w = 9.1 mm

t_f = 12.7 mm

d = h-2 (t_f + r_1)

= 400 – 2(12.7+14)

= 346.6 mm

b = $\frac{bf-tw}{2}$

= $\frac{250-9.1}{2}$

= 120.45 mm

Step – 2: Classification of selected section

From Table 2, Page – 18, I – Section

Z_P = 1556.33 cm^3

$\frac{b}{tf}$ = $\frac{120.45}{12.7}$

= 9.48

$\frac{d}{tw}$ = $\frac{346.6}{9.1}$

$= \quad 38.088$

$\in \quad = \quad \left(\frac{250}{F_y}\right)^{1/2}$

$= \quad \left(\frac{250}{250}\right)^{1/2}$

$= \quad 1$

Check

$\frac{b}{t_f} < 10.50 \quad \in = 9.48 < 10.5$

$\frac{d}{t_w} < 10.50 \quad \in = 38.09 < 105$

∴ The section is Compact

Step – 3: Check for Design Shear (Page – 59)

$V_d \quad = \quad \frac{V_n}{\gamma_{mo}}$

$V_n \quad = \quad \frac{A_v F_y}{\sqrt{3}}$

$V_d \quad = \quad \frac{A_v F_y}{\sqrt{3}\,\gamma_{mo}}$

$A_v \quad = \quad h \times t_w$

$= \quad 400 \times 9.1$

$= \quad 3640 \text{ mm}^2$

$\therefore V_d \quad = \quad \frac{3640\ x\ 250}{\sqrt{3}\ x\ 1.1}$

$= \quad 477.63 \text{ kN}$

$V_u \quad = \quad 63.5 \text{ kN (Obtained from SAP2000)}$

$V_d > V_u$

Hence safe

Check for Low shear or High shear

$0.6\ V_d$ = 0.6 x 477.63

= 286.58 kN > Vu

Low shear case

Since $0.6\ V_d > V_u$

Step – 4 Check for design moment (M_d)

(Page – 53, Clause: 8.2.1.2)

For low shear

$M_d = \frac{\beta_b Z_P F_y}{\gamma_{mo}} < \frac{1.2\ Z_e F_y}{\gamma_{mo}}$

β_P = 1 (For Compact section)

$M_d = \frac{1 \times 1556.33 \times 10^3}{1.1}$

= 353.711 kNm

$\frac{1.2\ Z_e F_y}{\gamma_{mo}} = \frac{1.2 \times 1402.2 \times 10^3 \times 250}{1.1}$

= 382.42 kNm

353.711 < 382.42

∴ M_d = Design Moment = 353.711 kNm

M_u = 71.44 kNm (Obtained from SAP2000)

$M_d > M_u$

Hence safe

Step – 5: Check for Deflection

(Page – 31, Table – 6)

a). Permissible deflection, $\frac{L}{300} = \frac{4500}{300}$

= 15mm

b). Maximum deflection of SSB with UDL, Δ = $\frac{5wl^4}{384EI}$

E = $2x10^5$ N/mm^2

I = 28083.5 cm^4

w = Working load

$= \frac{Factored\ load}{F.O.S}$

$= \frac{28.2}{1.5}$

= 18.8 kNm

Δ Actual = $\frac{5wl^4}{384EI}$

$= \frac{5\ x\ 18.8\ x\ 4500^4}{384 \times 2 \times 10^5 \times 28083.5 \times 10^4}$

$= \frac{3.8545875 \times 10^{16}}{2.1568 \times 10^{16}}$

= 1.787 mm

Δ Perm > Δ Actual

Hence safe

Step – 6: Check for Web Buckling (F_{ub})

(Page – 18)

$\frac{d}{t} \leq 67\epsilon$

$\frac{d}{t_w} = \frac{346.6}{9.1} = 38.09 \leq 67\epsilon$

No need to check web buckling

Step – 7: Check for Web Crippling (F_w)

(Page – 67)

$F_w = \frac{(b+n_2)t_w F_y}{\gamma_{mo}}$

$n_2 = 2.5(t_f+r_1)$

= 2.5 (12.7+14)

= 66.75mm

Assume b = 75mm

$F_w = \frac{(75+6 \ .75)\times 9.1\times 250}{1.1}$

= 293.16 kN

$F_w > V_u$

Hence safe

So the section ISHB 400 is provided as beam

6.3 DESIGN OF COLUMN

Steel Column ISHB 450 design based on values obtained from SAP2000.ISHB 450 sections are often used in the design of steel structures because they are strong, versatile and can withstand significant loads. In the context of designing a steel column ISHB 450, SAP is commonly used to analyse and determine the design load the column must carry. The design load obtained from SAP refers to the load values derived from the analysis, including axial load (Compression or Tension), Bending moments, and shear forces, that the steel column will need to resist under different loading conditions. These loads are used in conjunction with the material strength, section properties, and design codes (like IS 800 for steel structures) to determine the appropriate safety factors, capacity, and stability of the steel column in the final design.

Once the design load is obtained from SAP2000, structural engineers use it to ensure that the ISHB 450 column is properly sized, and its performance meets safety, durability, and serviceability requirements according to the relevant building codes and standards

Step – 1: Section Properties from SP: 6(1):1964

Select ISHB 450 @ 92.5 kg/m

Area = 117.89 cm^2

= 11789 mm^2

I_{xx} = 40349.9 cm^4

= 40349.9 x 10^4 mm^4

I_{yy} = 3045 cm^4

r_{xx} = 18.50 cm

r_{yy} = 5.08 cm

W = 92.50 kg/m

h = 450 mm

b_f = 250 mm

t_w = 11.30 mm

t_f = 13.70 mm

Check for Axial Load Capacity of a Column ISHB 450

Assume

f_y = 250 N/mm^2

Given

L = 3500 mm

A_e = 11789 mm^2

r_{min} = 50.80 mm

Step – 1: Calculation of Effective Length

Both sides are hinged

Effective Length = 1 KL

= 1x3500

= 3500 mm

Step – 1: Calculation of Slenderness Ratio

$\lambda = \frac{KL}{r_{min}}$

$= \frac{3500}{50.80}$

= 68.90

Step – 3: Check for Buckling Class

(From page no.44, Table no.10)

For I section

$t_f \leq 40$ mm

$13.70 \leq 40$ mm

So, Buckling Class = c

From page 42, Table 9(c)

By Interpolation

$f_{cd} = 153.76$ N/mm^2

Design Axial Load Capacity

$P_d = A_e \times f_{cd}$

$= 11789 \times 153.76$

$= 1812.66$ kN > 322.00 kN (Obtained from SAP)

Hence Safe.

Since it is an I Section, it was safe to carry the axial load capacity compared to the Design load obtained from the SAP2000.So the section ISHB 450 was provided as Column section

6.4 DESIGN OF JOINT

Design of Bolt – IS 800:2007

Assume Bolt grade 4.6

12mm dia bolt (M_{12} bolt)

$d_0 = 12 + 1$

$= 13$ mm

$t = 8$mm

$F_{ub} = 400$ N/mm^2

F_{yb} = 240 N/mm^2

Fe 410 Plate

F_u = 410 N/mm^2

F_y = 250 N/mm^2

Step – 2: Calculation of shearing strength of bolt (V_{dsb})

$V_{dsb} = \frac{V_{nsb}}{\gamma_{mb}}$

= (n_n = 1, n_s = 0) Lap joint

$V_{nsb} = \frac{F_y}{\sqrt{3}} (n_n A_{nb} + n_s A_{sb})$

$= \frac{400}{\sqrt{3}} \left(1 \times 0.78 \, x \frac{\pi}{4} \times 12^2\right)$

= 20.37 kN

$V_{dsb} = \frac{20.37}{1.25}$

= 16.29 kN

Step – 3: Calculation of bearing capacity bolt

$V_{dpb} = \frac{V_{npb}}{\gamma_{mb}}$

V_{npb} = 2.5 kb of F_u

kb is smaller of

$\frac{e}{3d_o}$

$\frac{P}{3d_o} - 0.25$

$\frac{F_{ub}}{F_u}$

1

P_{min} = 2.5d

= 2.5 x 12

= 30mm

e = 1.5 d_0

= 1.5 x 13

= 19.5 ≅ 20mm

$\therefore$ kb = $\frac{20}{3\,x\,13} = 0.512$

$\frac{30}{3\,x\,13} - 0.25 = 0.519$

$\frac{400}{410} = 0.98$

1

kb = 0.512

V_{npb} = 2.5 *x* 0.512 *x* 12 *x* 8 *x* 410

= 50.46 kN

V_{dpb} = $\frac{50.46}{1.25}$

= 40.369 kN

Bolt values = Min {V_{dsb}, V_{dpb}}

= Min {16.29, 40.369}

B.V = 16.29 Kn

Step – 4: Calculation of No. of bolts

Load = 122 kN

No. of bolts = $\frac{Load}{B.V}$

= $\frac{122}{16.29}$

= 7.5 ≅ 8 Nos.

Step – 5: Check for Plate strength

T_{dn} = $\frac{0.9\,A_n\,F_u}{\gamma_{ml}}$

A_n = $(b - nd_0)t$

$n = 2$

$A_n = (120 - 2 \times 13)8$

$= 752 \text{ mm}^2$

$T_{dn} = \frac{0.90 \times 752 \times 410}{1.25}$

$= 221.98 \text{ kN} > 122 \text{ kN}$

Hence safe

Step – 6: Calculation of strength of plate due to yielding

$T_{dg} = \frac{A_g F_y}{\gamma_{mo}}$

$= \frac{(120 \times 8) \times 250}{1.1}$

$= 218.18 \text{ kN} > 122 \text{ kN}$

Hence safe.

CHAPTER 7

STRUCTURAL DESIGN OF RCC MEMBERS

7.1 LIMIT STATE METHOD

In this method of design based on limit state concepts, the structure shall be designed to safely withstand all loads liable to act on it throughout its life. It shall also satisfy the serviceability requirements, such as limitations on deflection and cracking. The acceptable limit for the safety and serviceability requirements before failure is determined on the basis of the most critical limit state and shall be checked for other limit states.

The design values are derived from the characteristic values through the use of partial safety factors, one for material strength and another for loads. There are two limit states: the limit state of collapse and the limit state of serviceability.

7.1.1 Limit State of Collapse

The resistance to bending, shear, torsion, and axial loads at every section shall not be less than the approximate value at the section produced by the most probable unfavourable combination of loads on the structures using the appropriate partial safety factors.

7.1.2 Limit State of Serviceability

The deflection and cracking of concrete members should not adversely affect the appearance or durability of the structure. It should be within acceptable limits. The structural designs of members are given in this chapter, and all the details are given in Annexure D of IS 456: 2000

7.2 DESIGN OF SLAB

The details of selected slabs are shown in Table 7.1

Table 7.1: Bending Moment and Shear Force Details of Slab

Slab No.	L_x (m)	L_y (m)	Depth (mm)	M_{ux} (kNm)	M_{uy} (kNm)	V_u (kNm)	Type
S1	3	3.5	120	5.34	5.11	18.96	Two way
S2	3.5	4.5	120	8.21	9.33	22.20	Two way

Step – 1: Type of Slab

From IS 800:2007, Page – 138

Slab Size = 3500mm x 3000 mm

l_y = 3500 mm

= 3.50 m

l_x = 3000 mm

= 3.00 m

$\frac{l_y}{l_x}$ = $\frac{3.50}{3.00}$

= 1.17 < 2

Hence it is two-way slab

Step – 2: Effective depth

Assume overall depth, D = 120 mm

Assume clear cover = 20mm

Assume reinforcement = 10mm ϕ

Effective depth, d (x - dir.) = $20 - 20 - \frac{10}{2}$

= 95 mm

Effective depth, d (y - dir.) = $120 - 20 - 10 - \frac{10}{2}$

= 85 mm

Step – 3: Effective span

x – Direction

c/c distance between supports = $3.00 + \frac{0.20}{2} + \frac{0.20}{2}$ m

l_{ex} = 3.20 m

Clear span + Effective depth = 3.00 + 0.095 mm

= 3.095 m

∴ Adopt least values as the effective span, l_{ex} = 3.095 m

y – Direction

c/c distance between supports = $3.50 + \frac{0.20}{2} + \frac{0.20}{2}$

l_{ey} = 3.70 m

Clear span + Effective depth = 3.50 + 0.085

= 3.585 m

∴ Adopt least values as the effective span, l_{ey} = 3.585 m

Step – 4: Load Calculation

Dead load = 25 D

= 25 x 0.12

= 3.00 kN/m^2

Live load = 4.00 kN/m^2

Floor finish = 1.00 kN/m^2

Total load = 8.00 kN/m^2

Factored load, w_u = 8.00 x 1.50

= 12 kN/m^2

Step – 5: Bending Moment and Shear Force

Edge condition = One short edge continues

By Interpolation, $\frac{l_y}{l_x}$ = 1.17

α_x = 0.0465

α_y = 0.037

M_{ux} = $\alpha_x \times w_u \times l_{ex}^2$

= $0.0465 \times 12 \times 3.095^2$

= <u>5.345 kNm</u>

M_{uy} = $\alpha_y \times w_u \times l_{ey}^2$

= $0.037 \times 12 \times 3.585^2$

= <u>5.706 kNm</u>

Vu = $\frac{w_u l_{ex}}{2}$

= $\frac{12 \times 3.095}{2}$

= 18.57 kN

Step – 6: Check for effective depth

$M_{u\,(lim)}$ = 0.138 f_{ck} bd^2

= 0.138 x 20 x 1000 x 95^2

= 24.909 kNm > 5.345 kNm

Hence the provided depth is ok.

Step – 7: Desing of Main reinforcement

Along shorter span in *x* – direction (Middle strip)

Width of middle strip = $\frac{3}{4}$ of I_y

$= \frac{3}{4} \times 3.585$

$= 2.689$

$= 2.69\text{m}$

$M_{ux} = 0.87 \times f_y \times A_{st} \times d \left(1 - \frac{A_{st} f_y}{b\ d\ f_{ck}}\right)$

$5.345 \times 10^6 = 0.87 \times 415 \times A_{st} \times 95 \left(1 - \frac{A_{st}\ 415}{1000 \times 95 \times 20}\right)$

$5.345 \times 10^6 = 34299.75\ A_{st} (1 - 2.184 \times 10^{-4}\ A_{st})$

$5.345 \times 10^6 = 34299.75\ A_{st} - 7.49\ A_{st}^2$

$-7.49\ Ast^2 + 34299.75\ A_{st} - 5.345 \times 10^6 = 0$

$A_{st} = \frac{-34 \quad .75 \pm \sqrt{34299.75^2 - (4 \times -7.49 \times -5.345 \times 10^6)}}{2 \times -7.49}$

$= \frac{-34299.75 \pm 31880.04}{2 \times -7.49}$

$= 161.53\ \text{mm}^2, 4417.88\ \text{mm}^2$

$A_{st} = 161.53\ \text{mm}^2$

$A_{st\ min} = \frac{0.12}{100} \times 1000 \times 120$

$= 144\ \text{mm}^2 < 161.53\ \text{mm}^2$

Hence ok

Assuming 10 mm dia. bar

Spacing $= \frac{1000\ A_s}{A_{st}}$

$= \frac{1000 \times \frac{\pi}{4} \times 10^2}{161.53}$

$= 486.22\ \text{mm} \cong 450\ \text{mm}$

Check for spacing

Spacing should be minimum of the following

a). 450 mm

b). 300 mm

c). 3d = 3 x 95

= 285 mm

So, adopt 285 mm spacing

Provide 10 mm ϕ at 285 mm spacing

A_{st} (Provided) = $\frac{1000\ A_s}{s}$

= $\frac{1000\times\frac{\pi}{4}\times10^2}{285}$

= 275.58 $mm^2 \cong 275\ mm^2$

Along longer span in *y* – direction (Middle strip)

Width of middle strip = $\frac{3}{4}$ of I_x

= $\frac{3}{4}\times3.7$

= 2.775 m

M_{uy} = $0.87 \times f_y \times A_{st} \times d\left(1-\frac{A_{st}\ f_y}{b\ d\ f_{ck}}\right)$

5.706×10^6 = $0.87 \times 415 \times A_{st} \times 85\left(1-\frac{A_{st}\ 415}{1000\times85\times20}\right)$

5.706×10^6 = $30689.25\ A_{st}\ (1 - 2.44 \times 10^{-4}\ A_{st})$

5.706×10^6 = $30689.25\ A_{st} - 7.49\ A_{st}^2$

$-7.49\ Ast^2 + 30689.25\ A_{st} - 5.706 \times 10^6$ = 0

A_{st} = $\frac{-30689.25\pm\sqrt{30689.25^2-(4\times-7.49\times-5.706x10^6)}}{2\times-7.49}$

= $\frac{-30689.25\pm jkkkkk}{2\times-7.49}$

= 195.23 mm^2 or 3902 mm^2

A_{st} = 195.23 mm^2

$A_{st\ min}$ = $\frac{0.12}{100}$ x 1000 x 120

$= \quad 144\ mm^2 < 195.23\ mm^2$

Hence ok

Assuming 10 mm dia. bar

Spacing $= \quad \frac{1000\ A_s}{A_{st}}$

$= \quad \frac{1000 \times \frac{\pi}{4} \times 10^2}{195.23}$

$= \quad 402.77\ mm \cong 400\ mm$

Check for spacing

Spacing should be minimum of the following

a). 400 mm

b). 300 mm

c). 5d $= \quad 5 \times 95$

$= \quad 475\ mm$

So, adopt 300 mm spacing

Provide 10 mm ϕ at 300 mm spacing

A_{st} (Provided) $= \quad \frac{1000\ A_s}{s}$

$= \quad \frac{1000 \times \frac{\pi}{4} \times 10^2}{300}$

$= \quad 261.799\ mm^2 \cong 260\ mm^2$

Width of edge strip along x – direction $= \quad l_y - \frac{\left(\frac{3}{4}\right) \times l_y}{2}$

$= \quad 3.095 - \frac{2.775}{2}$

$= \quad 0.16\ m$

Width of edge strip along y – direction $= \quad l_x - \frac{\left(\frac{3}{4}\right) \times l_x}{2}$

$= \quad 3.2 - \frac{2.69}{2}$

$= \quad 0.51$ m

Step – 8: Check for shear stress

Nominal shear stress, $\tau_v = \frac{V_u}{bd}$

$= \frac{18.57 \times 10^3}{1000 \times 95}$

$= 0.195$ N/mm^2

Design strength of concrete, $P_t = \frac{100\ A_{st}}{bd}$

$= \frac{100 \times 275}{1000 \times 95}$

$= 0.289$ %

By Interpolation

x = 0.01872

$\tau_{c\ max}$ = 2.8 N/mm2,

$\tau_v < \tau_{c\ max}$

τ_c = 0.36 + 0.01872

= 0.379 N/mm^2

k = 1.30 (From Page – 72) (D = 120 mm)

k x τ_c = 1.30 x 0.379

= 0.493 N/mm^2 > 0.195 N/mm^2

Hence slab is safe in shear

Step – 9: Check for Deflection (IS 456:2000, Page – 38, Fig. 4)

$\frac{l}{d}$ max = $\frac{l}{d}$ basic $\times k_t \times k_c \times k_f$

P_t = 0.289 %

$\frac{l}{d}$ basic = 20

k_c = 1

k_f = 1

fs = 0.58 x f_y x $\frac{A_{st}\ required}{A_{st}\ provided}$

= 0.58 x 415 x $\frac{161.53}{275}$

= 141.38 N/mm^2

k_t = 1.95 (Fig. 4)

$\frac{l}{d}$ max = 20 x 1.95 x 1 x 1

= 39

$\frac{l}{d}$ provided = $\frac{3585}{95}$

= 37.73

$\frac{l}{d}$ max > $\frac{l}{d}$ provided

Hence safe in deflection

Step – 10: Torsional reinforcement

Mesh size = $\frac{l_x}{5}$

= $\frac{3095}{5}$

= 619 mm ≅ 650 mm

Area of Steel = $\frac{3}{4}$ x Ast required

= $\frac{3}{4}$ x 161.53

= 121.15 mm^2

Assume 8 mm ϕ bar

Spacing = $\frac{1000\ A_s}{A_{st}}$

= $\frac{1000 \times \frac{\pi}{4} \times 8^2}{121.15}$

= 414.90 mm ≅ 400 mm

Provide 8mm mesh of bars at 400 mm c/c

Step – 11: Bending of Alternate bar

Bend alternate bars at a distance of 0.20 l_x = 0.20 x 3095

= 619 mm ≅ 650 mm

Bend @ 650 mm from center of support

Bend alternate bars at a distance of 0.20 l_y = 0.20 x 3585

= 717 mm ≅ 750 mm

Bend @ 750 mm from center of support

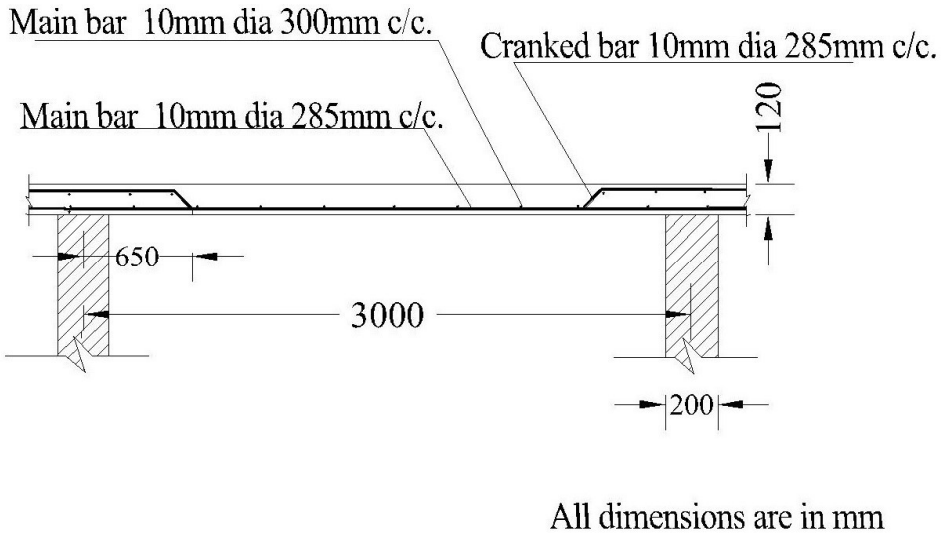

Fig. 7.1 Slab Reinforcement Details

The reinforcement details of the slabs are shown in Figure 7.1, depicting the arrangement, spacing, and placement of reinforcement bars as per the structural design specifications.

Table 7.2: Slab Reinforcement Details

Slab No.	Depth (m)	Reinforcement details				Type
		Mid strip Shorter span	Mid strip Longer span	Edge Strip	Torsional	
		3/4 of ly	3/4 of lx	1/4 (ly/ lx)	lx/5	
1	120	10mm Dia bar @ 285 mm c/c	10mm Dia bar @ 300 mm c/c	10mm Dia bar @ 300 mm c/c	8 mm Dia. bar @ 400 mm c/c	Two way

Table 7.2 presents the bar bending schedule for the designed slab, detailing the specifications, dimensions, and quantities of reinforcement bars required as per the structural design.

7.3 DESIGN OF PLINTH BEAM

Table 7.3 The Details of Selected Plinth Beams

No.	Column No.	Width (cm)	Depth (cm)	M_u (kNm)	V_u (kN)
PB1	Plinth Beam	25	30	41.28	47.18
PB2	Plinth Beam	25	40	74.76	64.58

Name of Beam : PB1

Length of Beam : 3.50m

Grade of Concrete : M20

Reinforcement : HYSD bar of grade Fe 415

f_{ck} = 20 N/mm^2

f_y = 415 N/mm^2

b = 0.25 m

D = 0.30 m

Support Thickness = 0.50 m

Step – 1: Effective depth

Assume overall depth, D = 300 mm

Assume effective cove r = 40mm

Assume reinforcement = 16mm ∅

Effective depth, d = 300-40

= 260 mm

Step – 2: Effective Span

a). Centre to center distance between supports

$3.25 + \frac{0.50}{2} + \frac{0.50}{2}$ = 3.75 m

b). Clear span + Effective depth

3.25 + 0.26 = 3.51 = 3.50m

Adopt least value as the effective span, l = 3.50m

Step – 3: Check for Effective Depth

M_u = 41.28 kNm

V_u = 47.18 kN

Compare M_u and M_u limit

$M_{u\,(lim)} = 0.138\, f_{ck}\, bd^2$

$= 0.138 \times 20 \times 250 \times 260^2$

= 46.64 kNm

$M_{u\,(lim)} > M_u$

Hence the adopted depth is ok.

Step – 4: Calculation of tensile reinforcement

M_u = $0.87 \times f_y \times A_{st} \times d \left(1 - \frac{A_{st} f_y}{b\ d\ f_{ck}}\right)$

41.28×10^6 = $0.87 \times 415 \times A_{st} \times 260 \left(1 - \frac{A_{st}\ 415}{250 \times 260 \times 20}\right)$

A_{st} = 529.13 mm^2

Check for Maximum & Minimum Ast

Min A_{st} = $\frac{0.85}{f_y}$ x (250x260)

= 133.13 mm^2

Max A_{st} = 0.04 x b x D

= 0.04 x 250 x 300

= 3000 mm^2

133.13 mm^2 < 529.13mm^2 < 3000 mm^2

Assume 16mm dia. bars

No. of bars = $\frac{529.13}{\frac{\pi}{4} \times 16^2}$

= 2.63, Adopt 3 Nos.

Hence area provided = 3 x $\frac{\pi}{4}$ x 16^2

= 603.185 mm^2

Step – 5: Check for Shear stress

τ_v = $\frac{V_u}{bd}$

= 0.725 N/mm^2

Maximum Shear stress, τ_{max} = 2.8 N/mm^2

$\tau_v < \tau_{max}$

Hence ok

Design Shear strength of concrete

P_t = $100 \frac{A_{st}}{bd}$

$= \quad 100 \text{ x } \frac{603.185}{250 \times 260}$

$= \quad 0.927\ \%$

$\tau_c \quad = \quad 0.60\ N/mm^2$

$\tau_v > \tau_c$

Hence shear reinforcement have to be designed

Step – 6: Minimum Shear Reinforcement

$V_{us} = V_u = \tau_{cbd} = 8180\ N$

Assuming 8mm dia. 2 legged stirrups

$A_{sv} \quad = \quad 2 \text{ x } \frac{\pi}{4} \text{ x } 8^2$

$= \quad 100.53\ mm^2$

Spacing of Stirrups, $S_v \quad = \quad \frac{0.87 \times f_y A_{sv}}{V_{us}}$

$= \quad 1153.67\ mm$

Check for spacing

The minimum spacing should be minimum of the following

a. 1153 mm

b. $S_v \leq \frac{A_{sv} \times 0.87 \times f_y}{0.4b} \quad = \quad 362.96\ mm$

c. 0.75d $\quad = \quad 195 \quad = \quad 200mm$

d. 300 mm

Adopt 8mm dia. 2 legged stirrups @ 200 mm c/c spacing

Step – 7: Check for Deflection (IS 456:2000, Page – 38, Fig. 4)

$P_t \quad = \quad 0.927\ \%$

$\frac{l}{d}$ basic $\quad = \quad 20$

$\frac{l_e}{d_{max}} \quad = \quad \frac{l}{d}$ basic x k_t x k_c x $k_f \quad = 18$

k_c = 1

k_f = 1

Fs = 0.58 x fy x $\frac{A_{st}\ required}{A_{st}\ provided}$

= 0.58 x 415 x $\frac{529.130}{603.185}$

= 211 N/mm^2

k_t = 0.90

$\frac{l}{d}$ basic = 20 x 0.90 x 1 x 1 = 18

$\frac{l}{d}$ provided = 3500/260 = 13.46

$\frac{l}{d}$ provided ≤ $\frac{l}{d}$ max

Hence safe in condition

Step – 8: Check for Development Length

L_d = $\frac{\phi\ \sigma s}{4\ \tau b\ d}$

= $\frac{16 \times 0.87 \times 415}{4 \times 1.4 \times 1.6}$

= 644.73 mm

$L_d \leq \frac{1.3\ M1}{V} + L_0$ = 1259mm

Hence the codal requirements are satisfied.

Step – 9: Detailing

PB1 size = 250mm x 300mm

Tensile reinforcement of 16 mm dia. bars of 3 Nos.

8mm dia. 2 legged stirrups @ 200 mm c/c

Table 7.4 Plinth Beam Reinforcement Details

No.	Type	Size (cm)	Tensile Reinforcement	Stirrup Holder	Stirrups
PB1	Plinth Beam	25 x 30	16 mm dia. 3 Nos.	16mm dia. 2 Nos.	8mmm dia. 2 legged @ 200 mm c/c
PB2	Plinth Beam	25 x 40	16 mm dia. 4 Nos.	16mm dia. 2 Nos.	8mmm dia. 2 legged @ 300 mm c/c

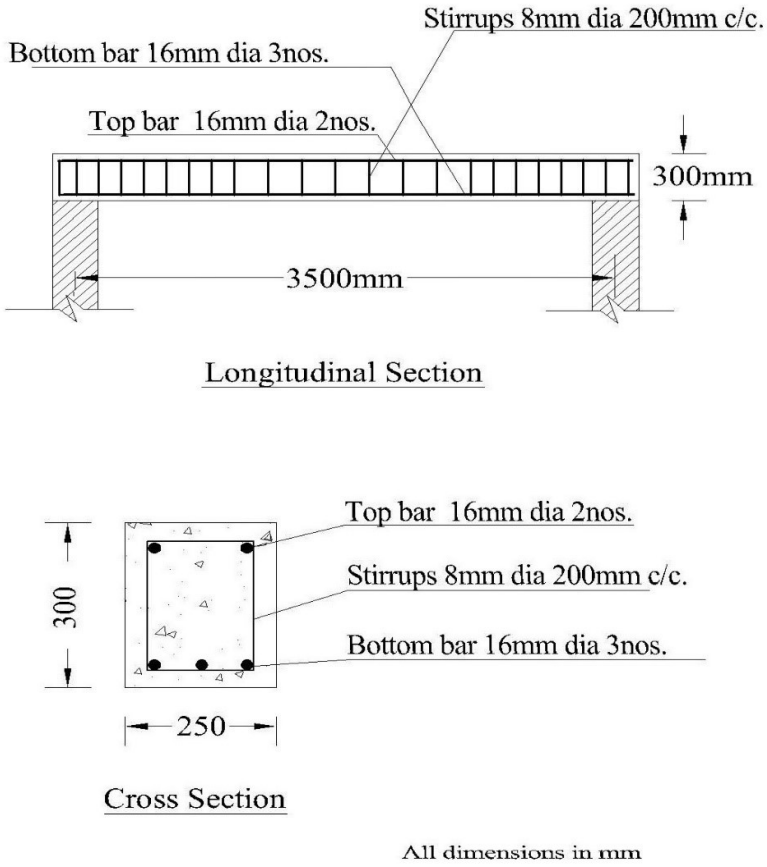

Fig. 7.2 Plinth Beam Reinforcement Details

The results obtained after designing the plinth beam are presented in Table 7.4, while Figure 7.2 provides a detailed drawing of the plinth beam, illustrating its dimensions, reinforcement details, and structural specifications.

7.4 DESIGN OF FOOTING

The axial load and columns are shown in Table 7.5

Table 7.5 Axial Loads on Column and Column Size

Footing No.	Column No.	Column Size (m)	Axial Load (kN)
F1	C1	0.25 x 0.50	775

Name of Footing : F1

Grade of Concrete : M20

Reinforcement : HYSD bar of grade Fe 415

f_{ck} = 20 N/mm^2

f_y = 415 N/mm^2

Column size = 0.25 x 0.50m

P_u = 775 kN (from SAP2000 analysis)

M_{ux} = 2.25 kNm

M_{uy} = 3.19 kNm

Step – 1: Calculate the area of footing

A $= \frac{w_c + w_f}{q_0}$

Where,

w_c = Load on column

w_f = Self-weight of footing + Pedestal if provided

q_0 = Safe bearing capacity of soil

Area, A $= \frac{775+3}{375} = 2.8$ m^2

Step – 2: Calculate the size of footing

Size of footing = Consider the length and width ratio of footing is same as the column

$\frac{x}{y} = \frac{250}{500}$

x = 1.50

y = 2.00

Assume Footing base of 2.00m x 1.50 m

Step – 3: Calculate soil pressure due to factored column load

$P_u = \frac{1.5\, w_c}{A_{prove}} = \frac{1.5 \times 775}{2 \times 1.5} = 387.50$ kN/m2

Step – 4: Depth of Footing

By one way shear – critical section is at a distance of d from face of column

SF in longer direction = P_u x Shaded area

= 387.50 x 2 x $\frac{(1.5-0.25)}{2}$ – d

= 968.75 – 775 d kN

SF in shorter direction = 387.50 x 1.5 x $\frac{(1.5-0.25)}{2}$ – d

= 290.625 – 581.25d

SF in shorter direction is more

SF resisted by concrete, V_c = τ_c x d

Assume P_t = 0.20

τ_c = 0.32N/mm^2

V_c = 0.32 x 10^3 x 1.5 x d kN

V_u = V_c

290.625 – 581.25 d = 0.32 x 10^3 x 1.5 x d

= 0.365 = 400mm

By Bending Moment method

Critical section is at face of column

BM in longer direction = 387.50 x 1.5 x 1.25 x $\frac{1.25}{2}$ = 454.10 kNm

BM in shorter direction = 3875.5 x 2 x 0.95 x $\frac{0.95}{2}$ x = 349.72 kNm

Hence BM in longer direction is larger

M_u = 454.10 kNm

M_u = M_u lim

d = $\sqrt{\frac{M_u}{0.138\, f_{ck}\, b}}$

= $\sqrt{\frac{454.10 \times 1000000}{0.138 \times 20 \times 1500}}$ = 331.14 mm

Highest value is accepted = 400mm

Assume covering of 50mm

Diameter of bars 16 mm in both directions

Overall depth, D = 400 + 50 + $\frac{16}{2}$ = 458 mm

Actual, d = 400 – 50 = 350 mm

Step – 5: Design of reinforcement along shorter span

349.72 x 10^6 = 0.87 x 415 x Ast x 350 x $\left(1 - \frac{415\, A_{st}}{20\times 2000 \times 350}\right)$

A_{st} = 3041.67 mm^2

A_{st} min = 0.12% x b x D

= $\frac{0.12}{100}$ x 1500 x 458 = 824.40 mm^2

P_t is assumed for one way shear design = 0.20

A_{st} = $\frac{0.20}{100}$ x 1500 x 458 = 1374 mm^2

As per IS Code (Clause: 34.3.1 (c) IS 456:2000)

Reinforcement in central band / total reinforcement in shorter direction

= $\frac{2}{\beta+1}$

Where,

$\beta = \frac{\text{longer side}}{\text{shorter side}}$

$= \frac{2}{1.5} = 1.33$

Reinforcement in central band $= \frac{2}{1.33+1} \times 1374$

$= 1179.40 \text{ mm}^2$

This reinforcement is distributed in central band 1.50 m width

Spacing of 20 mm dia. bars $= \frac{1500 \, x \frac{\pi}{4} \times 16 \times 16}{1179.40}$

$= 255.71$ mm

$= 250$mm

Provide 16mm dia. Bars @ 250mm c/c in central band. Balance area of steel is to be distributed in outer band.

$1374 - 824.40 = 549.60 \text{ mm}^2$

Spacing of 16mm dia. Bars $= \frac{1500 \text{ x area of 16mm dia.Bars}}{576}$

$= 548.47$ mm

Maximum spacing is 300 mm or 3d whichever is less

Provide 16mm dia. bars @ 300 mm c/c spacing in outer band

Along longer direction, d $= 350 - \frac{16}{2} - \frac{16}{2}$

$= 348$ mm

$454.10 \times 10^6 = 0.87 \times 415 \times Ast \times 350 \times \left(1 - \frac{415 \, A_{st}}{20 \times 1500 \times 350}\right)$

$4.995 \, A_{st}^2 - 126367.50 \, A_{st} + 454.10 \times 10^6 = 0$

$A_{st} = 4336.86 \text{ mm}^2$

A_{st} min $= 0.12\% \times b \times D$

$= \frac{0.12}{100} \times 1500 \times 458$

= 3110.40 mm^2

P_t is assumed for one way shear = 0.20

A_{st} = $\frac{0.12}{100}$ x 1500 x 458

= 824.40 mm^2

A_{st} required = 4336.8686 mm^2

Spacing of 16mm dia. bars = $\frac{1500 \text{ x dia.of 16mm dia. bar}}{4336.86}$

= 174.46

= 170 mm

Provide 16mm dia. bars @ 180mm c/c spacing

Step – 6: Check for development length

L_d = $\frac{0.87\ f_y\ \phi}{4 \times \tau \times bd}$

= $\frac{0.87 \times 415 \times 20}{4 \times 1.2 \times 1.6}$

= 940.23 mm

Available length in shorter direction = $\frac{1500-400}{2}$ – 50

= 500mm

940.23mm Hence OK

Table 7.6 – Reinforcement Details of Footings

Footing No.	Footing Size (m)	Reinforcement in Middle Strip		Reinforcement in Edge Strip	
		Shorter Span	Longer Span	Shorter Span	Longer Span
F1	2.00 x 1.50 x 0.45	16mm dia. @ 180 mm c/c distance	16mm dia. @ 250 mm c/c distance	16mm dia. @ 180 mm c/c distance	16mm dia. @ 180 mm c/c distance

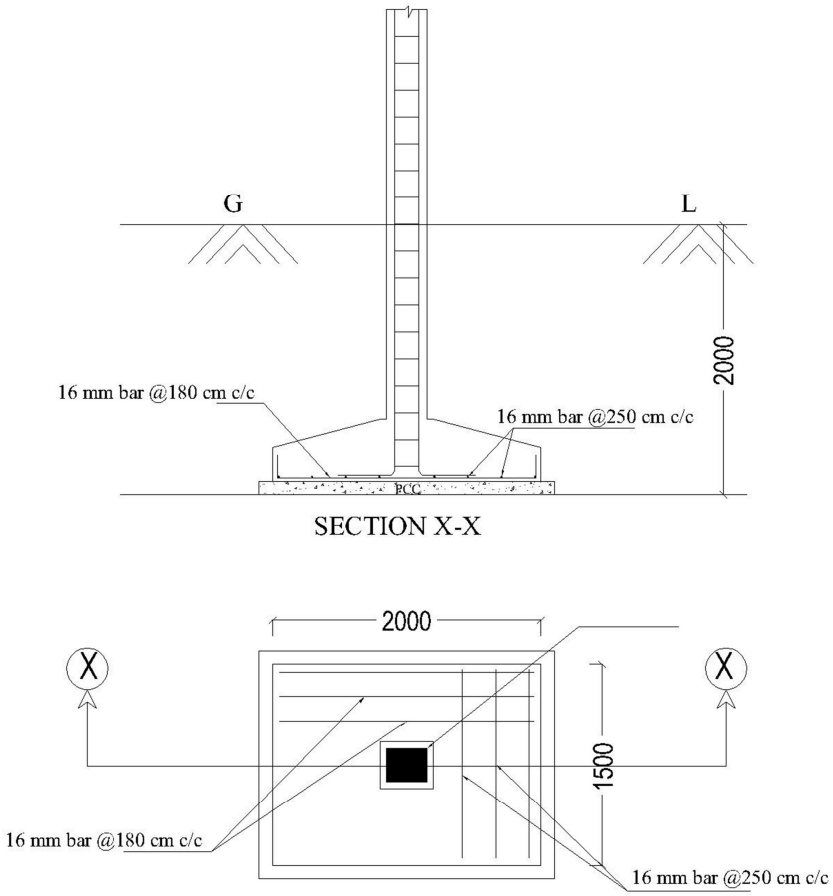

Fig. 7.3 Footing Reinforcement Details

The results obtained after designing the footing are presented in Table 7.6, while Figure 7.3 provides a detailed drawing of the plinth beam, illustrating its dimensions, reinforcement details, and structural specifications

CHAPTER 8

ESTIMATION

8.1 GENERAL

This estimate is for the construction of the new building for MRCMPU Ltd at Palakkad and was prepared based on DSR 2018, with a cost index of 36.44%. The total amount comes to Rs.1,45,00,000 (One Crore Forty Five Lakhs Only). All structural, masonry, plastering, painting works, ACP works, UPVC windows etc are included in the estimate. Provisions for electrification and water supply are made in the estimate. External works like internal roads within the site, a compound wall, a gate, and interlocking paving tiles are also included. Firefighting arrangements and solid and liquid waste management are considered by providing a lump sum amount in the estimate.

DETAILED ESTIMATE

Sl No	Description	Nos	Length	Breadth	Height	Quantity	Unit	Amount
1	2.8.1 Earth work in excavation by mechanical means (hydraulic excavator) /manual means in foundation trenches or drains (not exceeding 1.5 m in width or 10sqm in plan) including dressing of sides and ramming of bottoms , lift up to 1.5 including getting							
	Pit for footing	26.00	1.60	1.60	1.50	99.84		
						99.84	m^3	
			99.84	m^3 @	218.08	$/m^3$		21773.11
2	4.1.8 Providing and laying in position cement concrete of specified grade excluding the cost of centring and shuttering -all work up to plinth level 1:4:8 (1 cement,4 coarse aggregate, 8 graded stone aggregate 40mm nominal size							
	PCC for footing	26.00	1.60	1.60	0.10	6.66		
	PCC for floor	1.00	17.00	16.00	0.10	27.20		
						33.86	m^3	
			33.86	m^3 @	5869.06	$/m^3$		198702.90
3	5.1.2 Providing and laying in position specified grade of reinforced cement concrete excluding the cost centring shuttering finishing and reinforcement-All work up top plinth level 1:1.5:3 (1cement,1.5coarse sand 3 graded stone aggregate 20mm nominal size							
	1st footing	26.00	1.50	1.50	0.25	14.63		
	2nd footing	26.00	1.20	1.20	0.25	9.36		
	Column up to Plinth beam	26.00	0.50	0.30	1.70	6.63		
	Plinth beam	4.00	17.73	0.25	0.35	6.21		
		3.00	16.73	0.25	0.45	5.65		

Sl No	Description	Nos	Length	Breadth	Height	Quantity	Unit	Amount
		3.00	4.50	0.25	0.45	1.52		
		3.00	3.50	0.25	0.35	0.92		
		1.00	3.00	0.25	0.35	0.26		
						45.17	m^3	
			45.17	m^3 @	8145.84	/m^3		367922.14
4	5.9.1 Centring and shuttering including strutting etc and removal of formwork for foundations, footings, bases of columns etc for mass concrete							
	1st footing	26.00	6.00	0.00	0.25	39.00		
	2nd footing	26.00	4.80	0.00	0.25	31.20		
	Column up to Plinth beam	26.00	1.60	0.00	1.70	70.72		
	Plinth beam	8.00	17.73	0.00	0.35	49.64		
		6.00	16.73	0.00	0.45	45.17		
		6.00	4.50	0.00	0.45	12.15		
		6.00	3.50	0.00	0.35	7.35		
		2.00	3.00	0.00	0.35	2.10		
						257.34	m^2	
			257.34	m^2 @	254.19	/m^2		65411.98
5	7.1.1 Random rubble masonry with hard stone in foundation and plinth including levelling up with cement concrete 1:6:12 (1 cement : 6 coarse sand : 12 graded stone aggregate 20 mm nominal size) up to plinth level with: Cement mortar 1:6 (1 cement : 6 coarse sand)							
	Below plinth beam	10.00	3.00	0.60	1.60	28.80		

Sl No	Description	Nos	Length	Breadth	Height	Quantity	Unit	Amount
		2.00	2.60	0.60	1.60	4.99		
		6.00	4.00	0.60	1.60	23.04		
	For ramp	1.00	6.00	1.50	0.80	7.20		
	plat form	1.00	8.00	1.50	1.60	19.20		
						83.23	m^3	
			83.23	m^3 @	6777.10	/m^3		564071.59
6	2.25 Filling available excavated earth (excluding rock) in trenches, plinth, sides of foundation etc. in layers not exceeding 20 cm in depth, consolidating each deposited layer by ramming and watering, lead up to 50 m and lift up to 1.5 m.							
	for pit	26.00	1.50	1.50	1.00	58.50		
	for basement	1.00	17.23	16.23	1.00	279.64		
						338.14	m^3	
			338.14	m^3 @	243.22	/m^3		82243.12
7	10.2 Structural steel work riveted, bolted or welded in built up sections, trusses and framed work, including cutting, hoisting, fixing in position and applying a priming coat of approved steel primer all complete.							
	GF Column - ISHB 450	26.00	3.50		92.50	8417.50		
	Beam - ISHB 400	21.00	3.05		82.20	5264.91		
	Beam - ISHB 400	10.00	3.05		82.20	2507.10		
	Beam - ISHB 400	6.00	2.70		82.20	1331.64		
	FF Column - ISHB 450	26.00	3.50		92.50	8417.50		
	Beam - ISHB 400	21.00	3.05		82.20	5264.91		

Sl No	Description	Nos	Length	Breadth	Height	Quantity	Unit	Amount
	Beam - ISHB 400	10.00	3.05		82.20	2507.10		
	Beam - ISHB 400	6.00	2.70		82.20	1331.64		
	Tie - ISA 75x50	27.00	3.50		7.40	699.30		
	Tie - ISA 75x50	18.00	4.50		7.40	599.40		
	Tie - ISA 75x50	6.00	3.00		7.40	133.20		
	Stair - ISMB 200	4.00	4.50		25.40	457.20		
	Step - ISA 150X75	20.00	1.20		16.90	405.60		
	Canopy - ISMB 200	3.00	4.15		25.40	316.23		
	Reaper - ISA 75X50	5.00	3.50		7.40	129.50		
	Post - ISMB 200	2.00	3.00		25.40	152.40		
						37935.13	kg	
			37935.13	kg @	120.54	/kg		4572700.57
8	5.3 Reinforced cement concrete work in beams, suspended floors, roofs, having slope up to 15⁰ landings, balconies, shelves, chajjas, lintels, bands, plain window sills, staircases and spiral stair cases up to floor five level excluding the cost of shuttering, finishing and reinforcement, with1:1.5:3 (1 cement : 1.5 coarse sand (Zone III) : 3 graded stone aggregate 20 mm nominal size).							

Sl No	Description	Nos	Length	Breadth	Height	Quantity	Unit	Amount
	GF Main slab	1.00	17.70	16.70	0.12	35.47		
	Deduction - opening	-1.00	13.20	8.20	0.12	-12.99		
	FF Main slab	1.00	17.70	16.70	0.12	35.47		
	Lintel	10.00	3.10	0.20	0.15	0.93		
	Lintel	6.00	4.10	0.20	0.15	0.74		
		2.00	2.60	0.20	0.15	0.16		
						59.78	m^3	
			59.78	m^3 @	10810.73	/m^3		646230.85
9	5.9.3 Centring and shuttering including strutting, etc. and removal of form for: Suspended floors, roofs, landings, balconies and access platform							
	Ground floor Main slab	1.00	17.70	16.70		295.59		
	Deduction - opening	-1.00	13.20	8.20		-108.24		
	First floor Main slab	1.00	17.70	16.70		295.59		
						482.94	m^2	
			482.94	m^2 @	767.34	/m^2		370579.18
10	5.9.5 Centring and shuttering including strutting, etc. and removal of form for: Lintels, beams, plinth beams, girders bressumers and cantilevers							
	Lintel	20.00	3.10		0.15	9.30		
		12.00	4.10		0.15	7.38		
		4.00	2.60		0.15	1.56		
						18.24	m^2	

Sl No	Description	Nos	Length	Breadth	Height	Quantity	Unit	Amount
			18.24	m² @	611.22	/m²		11148.65
11	5.22.6 Steel reinforcement for R.C.C work including straightening, cutting, bending, placing in position and binding all complete up to plinth level Thermo - Mechanically Treated bars of grade Fe-500D or more							
	Ground floor and First floor	1.00	57.95		100.00	5795.00		
	Main slab 1st & 2nd footing	1.00	70.20		50.00	3510.00		
	Column up to Plinth beam	1.00	6.63		120.00	795.60		
	Plinth beam	1.00	14.55		120.00	1746.00		
	Lintel	1.00	1.82		110.00	200.20		
						12046.80	kg	
			12046.80	kg @	92.47	/kg		1113967.60
12	50.6.1.5 Solid block masonry using pre cast solid blocks (Factory made) of size 30x20x20cm or nearest available size confirming to IS 2185 Part I of 1979 for super structure up to floor two level thickness 20cm and above in: CM 1:6 (1 cement : 6 coarse sand) etc complete							
	Ground Outer wall	10.00	3.10	0.20	3.00	18.60		
	1st & 2nd footing	6.00	4.10	0.20	3.00	14.76		
		2.00	2.60	0.20	3.00	3.12		
	Deduction for opening	-10.00	3.10	0.20	0.15	-0.93		

Sl No	Description	Nos	Length	Breadth	Height	Quantity	Unit	Amount
		-6.00	4.10	0.20	0.15	-0.74		
		-2.00	2.60	0.20	0.15	-0.16		
	Ventilator	-16.00	1.00	0.60	0.15	-1.44		
	Rolling shutter	-1.00	3.00	0.20	3.00	-1.80		
						31.42	m³	
			31.42	m³ @	6230.62	/m³		195741.16
13	13.1.1 - 12 mm cement plaster of mix:1:4 (1 cement : 4 fine sand)							
	Ground floor wall	20.00	3.10		3.00	186.00		
		12.00	4.10		3.00	147.60		
		4.00	2.60		3.00	31.20		
	deduction for opening - shutter	-2.00	3.10		3.00	-18.60		
	ventilator	-32.00	1.00		0.60	-19.20		
	Basement	2.00	17.73		1.10	39.01		
		2.00	16.73		1.10	36.81		
						402.81	m²	
			402.81	m² @	295.46	/m²		119014.83
14	13.16.1 - 6 mm cement plaster of mix:1:3 (1 cement : 3 fine sand)							
	Ground floor ceiling	1.00	17.70	16.70		295.59		

Sl No	Description	Nos	Length	Breadth	Height	Quantity	Unit	Amount
		-1.00	13.20	8.20		-108.24		
	First floor ceiling	1.00	17.70	16.70		295.59		
						482.94	m²	
			482.94	m² @	251.70	/m²		121556.00
15	11.41.1 Providing and laying vitrified floor tiles in different sizes (thickness to be specified by the manufacturer) with water absorption less than 0.08% and conforming to IS : 15622, of approved make, in all colours and shades, laid on 20 mm thick cement mortar 1:4(1 cement : 4 coarse sand), including grouting the joints with white cement and matching pigments etc., complete. Size of Tile 500x500 mm.							
	Ground floor	1.00	17.70	16.70		295.59		
	First floor	1.00	17.70	16.70		295.59		
		-1.00	13.20	8.20		-108.24		
						482.94	m²	
			482.94	m² @	1403.75	/m²		677927.03
16	13.43.1 Applying one coat of water thinnable cement primer of approved brand and manufacture on wall surface: Water thinnable cement primer							
	Ground floor wall	20.00	3.10		3.00	186.00		
		12.00	4.10		3.00	147.60		
		4.00	2.60		3.00	31.20		
	deduction for opening - shutter	-2.00	3.10		3.00	-18.60		
	ventilator	32.00	1.00		0.60	-19.20		

Sl No	Description	Nos	Length	Breadth	Height	Quantity	Unit	Amount
	Basement	2.00	17.73		1.10	39.01		
		2.00	16.73		1.10	36.81		
	slab top	1.00	16.73		17.70	296.12		
						698.93	m²	
			698.93	m² @	66.46	/m²		46451.09
17	13.60.1 Wall painting with acrylic emulsion paint of approved brand and manufacture to give an even shade: Two or more coats on new work							
	Ground floor wall	20.00	3.10		3.00	186.00		
		12.00	4.10		3.00	147.60		
		4.00	2.60		3.00	31.20		
	deduction for opening - shutter	-2.00	3.10		3.00	-18.60		
	ventilator	-32.00	1.00		0.60	-19.20		
	Basement	2.00	17.73		1.10	39.01		
		2.00	16.73		1.10	36.81		
						402.81	m²	
			402.81	m² @	142.43	/m²		57372.51
18	13.61.1 Painting with synthetic enamel paint of approved brand and manufacture to give an even shade: Two or more coats on new work							
	Ground floor Column - ISHB 450	26.00	3.50		1.87	170.17		
	Beam - ISHB 400	21.00	3.05		1.77	113.37		

Sl No	Description	Nos	Length	Breadth	Height	Quantity	Unit	Amount
	Beam - ISHB 400	10.00	3.05		1.77	53.99		
	Beam - ISHB 400	6.00	2.70		1.77	28.67		
	FF Column - ISHB 450	26.00	3.50		1.87	170.17		
	Beam - ISHB 400	21.00	3.05		1.77	113.37		
	Beam - ISHB 400	10.00	3.05		1.77	53.99		
	Beam - ISHB 400	6.00	2.70		1.77	28.67		
	Tie - ISA 75x50	27.00	3.50		0.25	23.63		
	Tie - ISA 75x50	18.00	4.50		0.25	20.25		
	Tie - ISA 75x50	6.00	3.00		0.25	4.50		
	Stair - ISMB 200	4.00	4.50		0.97	17.46		
	Step - ISA 150X75	20.00	1.20		0.40	9.60		
	Canopy - ISMB 200	3.00	4.15		0.97	12.08		
	Reaper - ISA 75X50	5.00	3.50		0.25	4.38		
	Post - ISMB 200	2.00	3.00		0.97	5.82		
	Rolling shutters	2.00	3.00		3.00	18.00		
	Hand rail	1.00	52.00		1.00	52.00		

Sl No	Description	Nos	Length	Breadth	Height	Quantity	Unit	Amount
		2.00	6.00		1.00	12.00		
						912.10	m²	
			912.10	m² @	134.56	/m²		122732.38
19	10.26.2 - Providing and fixing hand rail of approved size by welding etc. to steel ladder railing, balcony railing, staircase railing and similar works, including applying priming coat of approves steel primer. E.R.W. tubes							
	Ground floor	1.00	29.60		10.00	296.00		
	stair	1.00	6.00		10.00	60.00		
	steps	2.00	7.00		10.00	140.00		
						496.00	kg	
			496.00	kg @	152.98	/kg		75878.08
20	13.7.1 -12 mm cement plaster finished with a floating coat of neat cement of mix:1:3 (1 cement : 3 fine sand)							
	Top of First floor main slab	1.00	17.70	16.70		295.59		
						295.59	m²	
			295.59	m² @	403.74	/m²		119341.51
21	11.20.1 - Chequered precast cement concrete tiles 22 mm thick in footpath & courtyard, jointed with neat cement slurry mixed with pigment to match the shade of tiles, including rubbing and cleaning etc. complete on 20 mm thick bed of cement mortar 1:4 (1 cement : 4 coarse sand).Light shade pigment using white cement							
	Steps and plat form	1.00	17.70	1.50		26.55		

Sl No	Description	Nos	Length	Breadth	Height	Quantity	Unit	Amount
						26.55	m²	
			26.55	m² @	1447.00	/m²		38417.85
22	21.1.1.1Providing and fixing aluminium work for doors, windows, ventilators and partitions with extruded built up standard tubular sections/ appropriate Z sections and other sections of approved make conforming to IS: 733 and IS: 1285, fixing with dash fasteners of required dia and size, including necessary filling up the gaps at junctions, i.e. at top, bottom and sides with required EPDM rubber/ neoprene gasket etc. Aluminium sections shall be smooth, rust free, straight, mitred and jointed mechanically wherever required including cleat angle, Aluminium snap beading for glazing /panelling, C.P. brass/ stainless steel screws, all complete as per architectural drawings and the directions of Engineer-in-charge.(Glazing, panelling and dash fasteners to be paid for separately):For fixed portion Anodised aluminium (anodised transparent or dyed to required shade according to IS : 1868, Minimum anodic coating of grade AC 15)							
	Ventilators	16.00	3.80	0.70		42.56		
	Office partition	6.00	7.00	0.70		29.40		
						71.96	kg	
			71.96	kg @	502.18	/kg		36136.87
23	21.3.1 Providing and fixing glazing in aluminium door, window, ventilator shutters and partitions etc. with EPDM rubber / neoprene gasket etc. complete as per the architectural drawings and the directions of Engineer - in -Charge. (Cost of aluminium snap beading shall be paid in basic item):With float glass panes of 4.0 mm thickness							
	Ventilators	16.00	1.00	0.60		9.60		
	Office partition	6.00	3.00	3.00		54.00		

Sl No	Description	Nos	Length	Breadth	Height	Quantity	Unit	Amount
						63.60	m²	
			63.60	m² @	1184.01	/m²		75303.04
24	25.7 Designing, fabricating, testing, installing and fixing in position Curtain Wall with Aluminium Composite Panel Cladding, with open grooves for linear as well a curvilinear portions of the building , for all heights and all levels etc. including: a) Structural analysis & design and preparation of shop drawings for pressure equalisation or rain screen principle as required, proper drainage of water to make it watertight including checking of all the structural and functional design. b) Providing, fabricating and supplying and fixing panels of aluminium composite panel cladding in pan shape in metallic colour of approved shades made out of 4mm thick aluminium composite panel material consisting of 3mm thick FR grade mineral core sandwiched between two Aluminium sheets (each0.5mm thick). The aluminium composite panel cladding sheet shall be coil coated, with Kynar 500based PVDF / Lumiflon based flouro polymer resin coating of approved colour and shade on face # 1 and polymer (Service) coating on face # 2 as specified using stainless steel screws, nuts, bolts, washers, cleats, weather silicone sealant, backer rods etc. ACP							
	cladding - Front side	1.00	17.70		4.50	79.65		
	Left and Right side	2.00	16.70		4.50	150.30		
	Back side	1.00	17.70		4.50	79.65		
						309.60	m²	
			309.60	m² @	5104.85	/m²		1580461.56

Sl No	Description	Nos	Length	Breadth	Height	Quantity	Unit	Amount
25	10.6.1Supplying and fixing rolling shutters of approved make, made of required size M.S. laths, interlocked together through their entire length and jointed together at the end by end locks, mounted on specially designed pipe shaft with brackets, side guides and arrangements for inside and outside locking with push and pull operation complete, including the cost of providing and fixing necessary 27.5 cm long wire springs manufactured from high tensile steel wire of adequate strength conforming to IS:4454 - part 1 and M.S. top cover of required thickness for rolling shutters.80x1.2 mm M.S. laths with 1.25 mm thick top cover							
	Main door	1.00	3.00		3.00	9.00		
						9.00	m^2	
			9.00	m^2 @	3487.22	/m^2		31384.98
26	Provision for fire fighting system							570000.00
27	LS for Electrification and water supply							400000.00
28	Grand Total							12282470.55
29	Provision for GST (18%)							2210844.70
30	Unforeseen item if any							6684.75
	Total Estimate Amount							**14500000.00**

The final bill amount for the construction of the godown-cum-store block has been calculated to be ₹1,45,00,000 (Rupees One Crore Forty Five Lakh Only). This amount includes all associated costs, such as material procurement, labour charges, and applicable Goods and Services Tax (GST).

CHAPTER 9

CONCLUSION

In this project, we have planned, analyzed, and designed a building with ground floor, first floors and second floor for store cum godown building for MRCMPU Ltd. at Palakkad district. MRCMPU Ltd.is a union of more than 1000 village level Dairy Co-operative societies, the site is situated at Kallepuly 3 km away from Palakkad-Kozhikkode National Highway (NH- 966). The new building is proposed due to the insufficient infrastructural facilities in the existing Dairy building in the site which the storage of dairy machineries, Packing materials of ghee and milk products. The proposed project is designed as a Steel framed structure building with following details.

The plinth area the proposed building comes to 296.62 m^2 with loading platform area 11.40 m^2. Provided an office room and record room which connected to the passage from the main entrance. The area of record room comes to 18.75 m^2 and office room area comes to 18.75 m^2. Provided a ramp of slope 1 in 12 for easy movement of disabled persons as well as movement of trolleys. The building provided with Ground and first floor, and second floor for future expansion. Facilities for the disposal of liquid and solid wastes are also provided as per the KPBR Rules. In this structure analysis is done by using SAP2000 and design of concrete structures are done using IS 456:2000, steel structures are using IS: 800-2007 and SP-6 respectively. The total cost of the building comes to Rs 1, 45,00,0000 (Rs One Crore Forty Five Lakhs Only).

REFERENCES

1. **Fathi Abdrabbo, Zaki I. Mahmoud, Mariana Ebrahim** (2016) Structural design of Isolated column footings, *Alexandria Engineering Journal*,13,2665-2678

2. **IS 456:2000**, Indian Standard Plain and Reinforced Concrete code of practice

3. **IS 800:2007**, Indian Standard General Construction in Steel Code of practice

4. **M. AradhanaRao**, **P. Mohanrao, Y.Sombabu** (2019) A Case Study on Estimation and Costing of Multi-Storey Building*, International Journal of Advanced Research in Science, Engineering and Technology*, Vol-6, 455-462

5. **Ms. Suchita S. Kasare, Dr. Tushar G. Shende** (2023) Review on Comparison between Steel, RCC and Composite Structure, *Journal For Research in Applied Science and Engineering Technology,* Vol-11, 2813-2818

6. **Rajeshwari Patil, Shweta Anoor, Shweta Desai, Sudha Gajendra, Mithun Kumar** (2017) Analysis and Design of Building by using SAP-2000*, International Research Journal of Engineering and Technology ,* Vol-4,2491-2497

7. **S. Karthikeyan, K. M. Jeevananthan, T. Karis Prabakar, R. Harini** and **S. P. Murali Kannan** (2022) Structural Behaviour of Cold Formed Steel Sections Based on Fasteners, *Techniques and Innovation in Engineering Research,* vol-*6*, 1-12

8. **Shengfei Yang** and **Jiankai Zhu** (2023) Research on steel structure system of assembled building and its mechanical performance analysis, *Applied Mathematics and Nonlinear Sciences,*18, ISSN 2444-8656

9. **SP:6(1)-1964** Hand Book for Structural Engineering-Steel Sections

10. **The Kerala Municipal Building Rules** (KMBR) 2019.

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ANNEXURES