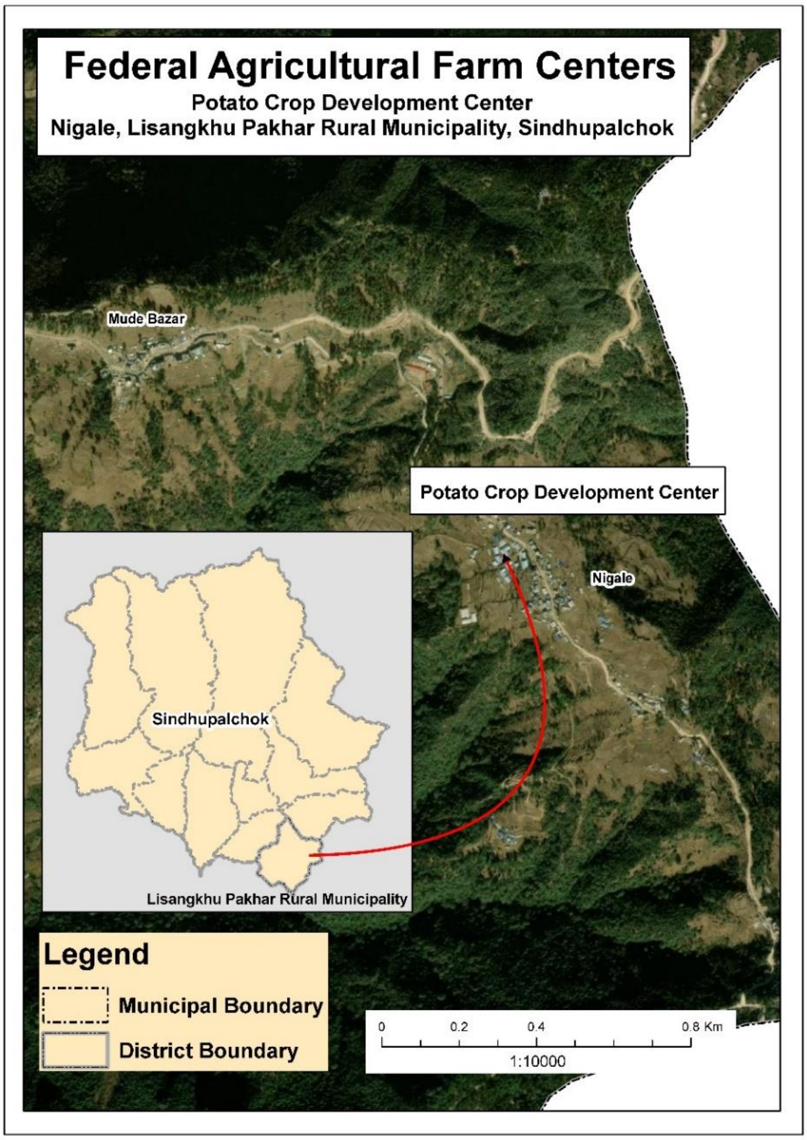
Center for Agricultural Infrastructure Development and Mechanization Promotion

(CAIDMP)

Hariharbhawan, Lalitpur, Nepal



FINAL REPORT

VOLUME – I (MAIN REPORT)

For

Detailed Project Report (DPR) Preparation for the Infrastructure Development of Federal Agricultural Farm Centers (Potato Crop Development Center, Nigale, Sindhupalchok, Bagmati Province)

Submitted By:

GOEC - RAJDEVI - RECON JV

May, 2023

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Preparation of Detail Project Report (DPR) for the Infrastructure Development of Federal Potato Crop Development Center

Package-CAIDMP/CS/QCBS-04/2078/079

May, 2023

This document is final report of work, for the project "Preparation of Detail Project Report (DPR) for the Infrastructure Development of Federal Potato Crop Development Center, Package CAIDMP/CS/QCBS-04/2078/079undertaken by Center for Agricultural Infrastructure Development and Mechanization Promotion (CAIDMP) Office. This document provides the objectives, scopes, detail methodology, summary of existing status of farm center, SWOT analysis, financial analysis, resource analysis, major problems and issues along with project site and finally proposed master plan of Potato Crop Development Center, Nigale.

PROJECT INFORMATION

Name of the Project	Preparation of Detail Project Report (DPR) for the Infrastructure Development of Federal Package-CAIDMP/CS/QCBS-04/2078/079 Potato Crop Development Center
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Name of the Consultant	GOEC Nepal P. Ltd. (GOEC) JV with Rajdevi Engineering Consultant (P) LTD. (RAJDEVI) & Research Engineers Consultant (RECON) Buddhanagar, Kathmandu, Nepal Tel. 4783060,4784344, Fax: 4784344, e-mail: goecnepal10@gmail.com
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Last but not the least, we would like to thank all the experts and technical team of GOEC Nepal (P) Ltd. – RAJDEVI (P) Ltd. – RECON (P) Ltd. for their effort and hard work for the preparation of this final report.

Project Team

ABBREVIATIONS AND ACRONYMS

ADS	Agriculture Development Strategy
AICL	Agriculture Inputs Company Limited
AKC	Agriculture Knowledge Center
BoQ	Bill of Quantity
CAIDMP	Center for Agricultural Infrastructure Development and Mechanization Promotion
CCTV	Closed - Circuit Television
DGPS	Differential Ground Positioning System
DHM	Department of Hydrology and Meteorology
DMG	Department of Mines and Geology
DoA	Department of Agriculture
DoS	Department of Survey
DPR	Detail Project Report
DUDBC	Department of Urban Development and Building Construction
EIA	Environmental Impact Assessment
FY	Fiscal Year
GDP	Gross Domestic Product
GMO	Genetically Modified Organism
GoN	Government of Nepal
GIS	Geographical Information System
GPS	Global Positioning System
ha	Hectare
HDP	High Density Polythene
HT	High Tension
HVAC	Heating, Ventilation & Air Conditioning
HYD	Hydrology
IS	Indian Standard
KV	Kilo Volt
MoALD	Ministry of Agriculture and Livestock Development
MoF	Ministry of Finance
mt	Metric ton
NAP	National Agriculture Policy 2004
NARC	Nepal Agricultural Research Council
NEA	Nepal Electricity Authority
NSB	National Seed Board
NSV	National Seed Vision, 2013-2025
OPV	Open Pollinated Variety
PBS	Pre-basic Seed
PCC	Plain Cement Concrete
PCDC	Potato Development Center

PMAMP	Prime Minster Agriculture Modernization Project
PRA	Participatory Rural Appraisal
PVC	Poly Vinyl Chloride
RCC	Reinforced Concrete Cement
TPS	True Potato Seed
ToR	Terms of Reference
QA	Quality Assurance
QC	Quality Control
QMAS	Quality Assurance cum Management System
SMS	Subject Matter Specialist
SQCC	Seed Quality Control Centre
SWOT	Strength, Weakness, Opportunity and Threat
3D	Three Dimensional

1 INTRODUCTION

Government of Nepal (GoN) has highly prioritized the infrastructural development and capacity enhancement of the government run agriculture and livestock farms/centers. Guided by the fifteenth plan, GoN has focused on infrastructure development for the best utilization of limited resources through infrastructural and non-infrastructural capacity enhancement of government farms/centers in the current Fiscal Year (FY) 2078/79.

The Consultancy services on Detailed Project Report (DPR) Preparation for the Infrastructure Development of Federal Agricultural Farm Centers, Package No: 4 was commenced by the signing of agreement between GOEC-RAJDEVI-RECON JV (hereinafter referred as "Consultants") and Center for Agricultural Infrastructure Development and Mechanization Promotion (CAIDMP), Harihar Bhawan, Lalitpur (herein after referred as “Client).

1.1 Background

With the globalization, rapid urbanization is an ongoing dynamic process and is the most dominant phenomenon in all developing countries and Nepal is no exception. Urbanization results in rapid population growth followed by pressure on the demand for jobs, housing, clean water, transportation, social services, as well as more and quality food commodities. Analysis on migration trends of Nepalese community revels that more people are moving towards the urban and semi urban areas in search of better livelihoods and facilities. Rapidly growing urbanization obviously demands more and quality food commodities and in turns the modern infrastructures and other systems on agriculture business. To our context the demand for edible commodities especially fresh vegetables and fruits is growing rapidly due to faster rate of urbanization and increasing population but in contrast market system and value chain for agricultural production is not growing rapidly due to lack of timely availability of quality inputs and proper management of output. Therefore, production and distribution of adequate quantity and quality seed, seedling and sapling are pre-requisites for meeting increasing demand for food grains, vegetables and fruits in the country. In addition, proper development of market system helps to boost production and productivity and that also plays important role to improve the livelihoods of farmers which enable them supply healthy foods through efficient management of agricultural production and products.

Agriculture is one of the dominant sectors of Nepal's economy in terms of its contributions to food production, employment, revenue generation, and foreign exchange earnings. It is the key component of Nepal's economy accounting for 25.8% of Gross Domestic Product (GDP) in the FY 2021/22 and employing more than 60% of labor force (MoF, 2022). It creates a diverse array of jobs and employment from farming to small-scale enterprises and agro industries.

Despite huge population engagement, financial or technical inputs and country's priority, the performance of agricultural sector has not been adequate towards self-sufficiency to meet the ever-increasing food demand and livelihoods needs of population. Lack of adequate dissemination of technologies developed from research, inefficient management of scientific manpower, lack of laboratories for analysis of problems, and other infrastructure have further impeded the modernization, mechanization, commercialization, and industrialization of agriculture. Basically, the challenges have been observed on disseminating the modern tools and technology to farmers and integrating processing and trade of agricultural products. As a result, food imports have not decreased as expected. The return on investment in manufactured foods could not be increased proportionately through proper storage, processing, and value addition. Hence, it’s a right time to take an appropriate action focused on enhancing production and productivity, food and nutrition security and creating employment through modern and commercial resource production system based on optimal use of available farm resources.

The Agriculture Development Strategy, 2015-2035 (ADS) emphasizes on commercialization, mechanization, and diversification of agricultural and livestock products to make the sector competitive. To meet the goals and objectives set by ADS, sectorial plan and policies on agriculture sector, GoN has highly prioritized the infrastructure development and capacity enhancement of the government run agriculture and livestock farms/centers. Besides these, the 15th Plan (2019/20–2023/24) in its working policy of agriculture sector aimed to utilize unused lands of the government’s agriculture farms/centers for the production of seeds, saplings, fingerlings, breeds and breed improvement. In current FY 2078/79 GoN has focused on infrastructure development plan for the best utilization of resources and capacity enhancement of government farms/centers. Considering these facts Master Plan of federal agricultural farms/centers will be prepared in this FY and these farms/centers will be reformed in upcoming FY based on the prepared Master Plan.

1.2 Relevancy of the Task

Nepal is situated in the lap of great Himalayas and has favorable agroecological diversity for agricultural production. Department of Agriculture (DoA) had owned 40 farms/centers before the adoption of federal system. These farms/centers were the resource centers for cereals, vegetables, fruits, fisheries, sericulture, and honeybee. The administrative structures of these farms/centers have been reformed and aligned with the constitutional provision after the political and administrative restructuring of entire country based on GoN (cabinet level) decision of July 16, 2018 (Ashadh 32, 2075). Now, the number of farms/centers under DoA have been squeezed to only 14. Basically, those farms were established with an objective to act as a resource center for inputs (source seeds, seedlings, saplings, fingerlings, etc.) and to provide both technical and extension services to the farming communities.

Out of these14 farms, 5 farms are related to fruits development, 4 farms are related to potatoes, vegetable and species crops,2 farms are related to honeybee and silk, 2 farms are related to cereal seed production, and 1 farm is related to mechanization promotion including resource center for seeds and saplings. Due to changing roles and responsibilities of farms in new federal context, the poor infrastructural, institutional, human resource and technological capabilities have limited their performance to execute their roles and responsibilities. Based on these evidences, CAIDMP has approved a program to prepare Master Plan of the following federal farms/centers under DoA for infrastructural, institutional, human resource and technological advancement during the current FY 2078/79.

Table 1.1: Details of Farm/Center

#	Sector	Name of farm/center	Resource center	Farm area, ha	Province
1	Horticulture	Potato Crop Development Center, Nigale, Sindhupalchok	Quality seed potato and True Potato Seed (TPS)	5.5	Bagmati
2	Horticulture	Citrus Development Center, Tansen, Palpa	Quality citrus sapling, vegetable seeds and floriculture	9.2	Lumbini
3	Agronomy	Agriculture Development Farm, Sundarpur, Kanchanpur	Improved seed and source seed of cereals and pulses	24	Sudurpaschim

1.3 Objectives and Scope of the Work

A. Objectives of the Study

The objectives of the task is to prepare MASTER PLAN of the federal farms/centers under DoA for the best utilization of resources through enhancement of infrastructural and non-infrastructural capacity, human resource and technologies for the advancement of farm services on quality seed, sapling and crop production, postharvest processing, preservation, value addition, innovative technology dissemination and capacity building of technicians and farmers so that these farms will contribute on introducing crop diversity, increasing productivity and optimizing resource use efficiency, and entrepreneurship development.

B. Scope of the Study

In order to meet the objectives of the study, the scope of the work of proposed task shall include but not limited to the followings.

- ✓ Conduct a comprehensive survey of the existing farm, including its physical infrastructures using standard engineering methods/tools for the design of various structured and non-structured requirements within the farm.
- ✓ Conduct analysis of farm assets, institutional capacity, human resources, institutional responsibilities, infrastructure and non-infrastructure needs, technology and financial needs of respective farms to transform them to meet the assigned mandate.
- ✓ Conduct detail analysis of soil, water, and climate and disaster vulnerability of respective farms and recommend solution, alternatives and measures, if any.
- ✓ Conduct analysis of Government policies, plans, programs and budget related to agriculture focused on farms/centers development.
- ✓ Conduct analysis of current agriculture practices-farming practices, cropping patterns, crop diversification, technological adoption and potentials to improve and diversify farm income.
- ✓ Comprehensive Master Plan illustrating the different farm structures (office and staff quarter building, guest house and training hall, tissue culture lab and other lab, screen house, nursery, demonstration facilities and other protected structure, structures for postharvest processing, preservation, value addition, potential storage facilities like ware houses and cold storage, machinery shade, irrigation facilities), non-structural requirements (like open space, orchard, cropping area etc.), and utilities (water, electricity, drainage, farm road, parking, walking path, etc.) with locations and dimensions with all technical specifications.
- ✓ Prepare efficient farm operation model and business plan for at least 10 years based on current and future potential of major farm products and available resources. Preparation of revenue generation plan to make farms self-sustainable for recurrent cost and incentive scheme for the staffs while preparing business plan.
- ✓ Conduct environmental study (as per requirement of Environment Protection Act 2076 and Environment Protection Regulation 2077) including their mitigation measures like solid and liquid waste management, pesticide management etc.
- ✓ Suggest implementation plan for technology adoption related to the scope of concerned farms/centers.
- ✓ Design, estimation and costing of all requirements for the farm structures and non-structural requirements and utilities with optimal engineering standards.
- ✓ Follow all requirement and standard code of practices for all design works as per the norms of Department of Urban Development and Building Construction (DUDBC) and the MoALD for similar facilities.
- ✓ Carry out geo investigation test using Standard Penetration Test method and any other tests required specific to farms/centers.
- ✓ Prepare the specification of construction materials and work units (e.g., brickwork, RCC, PCC, etc.) as per DUDBC guidelines.

- ✓ Prepare visuals and 3D models of the design/plan of farms/centers using computer software.
- ✓ Prepare construction planning with master schedule and construction program for development of the project.
- ✓ Obtain Municipal Approval of the development plan from the corresponding municipality.
- ✓ The detail discussions among team of consultants, CAIDMP officials and stakeholders will be guiding site specific needs, structural and non-structural requirements and the details planning. This task demands site specific, need based requirement as indicated in scope of services.

1.4 Structure of the Report

The report is organized into three volumes that address the expected outcomes of the study according to the set objectives and scopes. These volumes are further organized into various chapters, as required, to include the overall aspects of the plan.

Volume I-Main Report: It includes the executive summary, background, objectives, scope and methodology of the study and summary of existing status of the farm center. It also analyzes the Strength, Weakness, Opportunity and Threat (SWOT) as well as infrastructure demand for farm/center development and presents the Master Plan of Potato Crop Development Center, Nigale. The Master Plan includes various infrastructure, non-infrastructure and utility requirements like Tissue Cultural Lab, Soil Lab, Plant Protection Lab, Training Hall, Canteen, Staff Quarters, Guest House, Dormitory, Water supply, Road, Fencing, Parking, Electrification, Security etc.

Volume II-Maps/Drawings: It includes different maps like location map, satellite map of the farm center as well as drawings (Architecture and Structural) of different structures which was proposed in the Master Plan of farm center.

Volume III-Cost Estimation: It includes the cost estimation of all the proposed physical infrastructures in the farm/center.

2 METHODOLOGY

The methodology was developed such that it helps to achieve the predefined objective and scope of work of the proposed consulting services within stipulated timeframe as well as requirement of Terms of Reference (ToR) of the study and the practical experience of the consultant gained in similar projects. GOEC-RAJDEVI-RECON JV has rich experience of such type of studies and projects in different districts of the country. Such experience of our firms was extremely useful for the present study.

The methodology for this study was designed such that it captures four overall aspects of farms/centers to deliver their defined services. These aspects include (a) overall management practices and productivity of farms/centers, (b) service delivery, linkage and collaboration with stakeholders, (c) resources, infrastructures and mechanization, and (d) production (seeds, saplings and seedlings), distribution/sale (marketing) and benefit cost analysis. Brief about methodologies is presented below. Flow of entire methodology adopted has been presented in Figure 2.1.

Approach:

The consultant team employed "participatory" approach for conducting the proposed study involving the concerned authorities in study site. Professional and relevant team of experts did field visit and team used prudent tools, processes, and technologies that have been tested and proven effective at the field level wherever applicable. The team fully used available and applicable primary/secondary information and data with established professional standards, sound engineering procedures, and all standards/guidelines/instructions formulated by GoN. Team maintained close coordination and effective communication with all stakeholders and clients. Both qualitative and quantitative data/information were was collected for using a combination of qualitative and quantitative methods from secondary and primary sources.

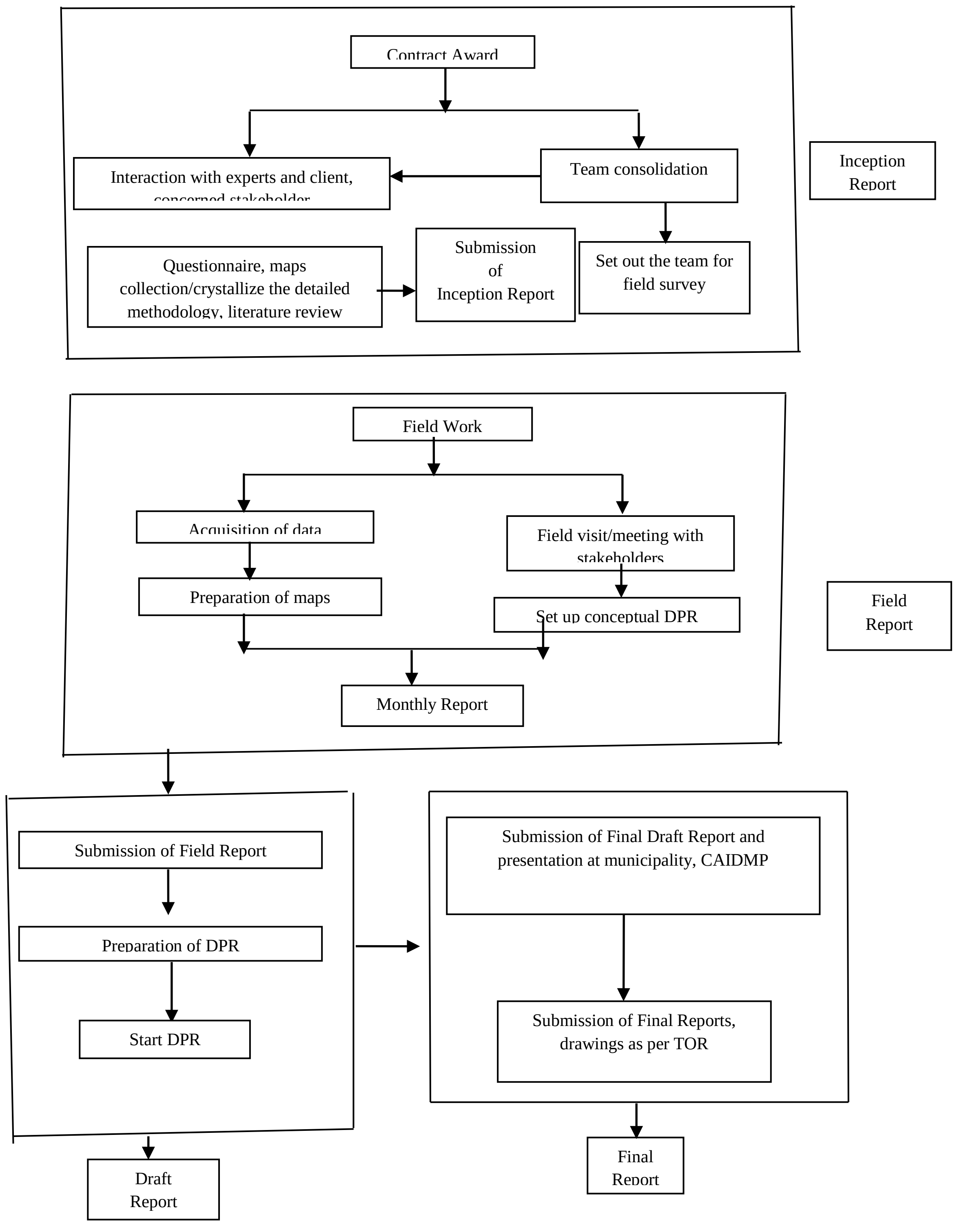


Figure 2.1: Flow chart of methodolo

The methodologies adopted by team for this study are described in detail below:

2.1 Team Formation and Discussion Meetings

The team was organized and assigned with their respective roles for the success of the project. The team conducted several meetings in Consultant's office through personal as well as virtual medium. Besides the key experts, supports from several other professionals were also obtained for the effective and efficient delivery of the task.

A manning schedule was prepared to outline the requirements of a project, project planning steps, goals, and team members involved in the project (Figure 2.2). It provides visibility to Client and Consultant both regarding the project activities and involvement of different staff on it.

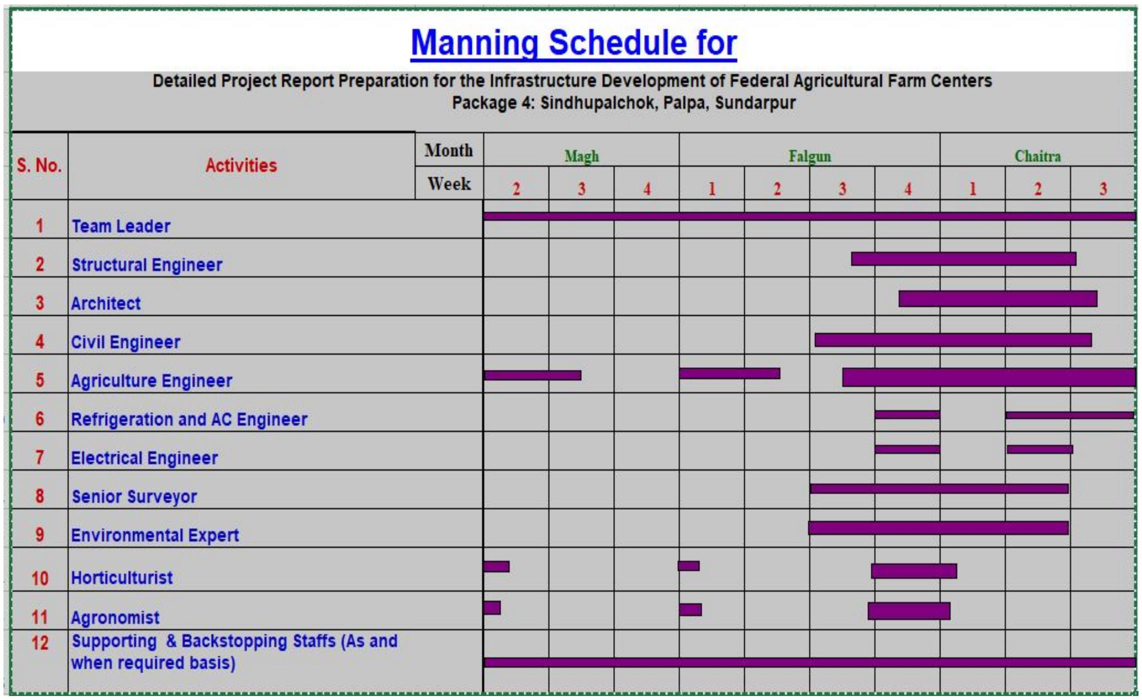


Figure 2.2: Manning Schedule

2.2 Interactive Meetings with the Client

CAIDMP played the guiding and supportive role in completing this project. Several meetings were organized with CAIDMP. Positive response or feedback and guidance were obtained in all consultation meetings.

2.3 Review of Literature

Reports and publication were reviewed to gather qualitative and quantitative data/information Following documents were reviewed during the study:

Policies:

- ✓ National Agriculture Policy, 2004
- ✓ Agriculture Development Strategy, 2015-2035
- ✓ Fifteenth Plan, 2019/20-2023/24
- ✓ Climate Change Policy, 2067
- ✓ Land Use Policy, 2072
- ✓ Public Private Partnership Policy, 2072
- ✓ National Seed Vision, 2013-2025
- ✓ National Seed Policy, 2056
- ✓ Agribusiness Promotion Policy, 2063
- ✓ Irrigation Policy, 2070
- ✓ Agriculture Mechanization Policy, 2071

Laws:

- ✓ Seed Act, 2045
- ✓ Seed Regulation, 2069
- ✓ Irrigation Regulation, 2056
- ✓ Environment Protection Regulation, 2054
- ✓ Agriculture and Livestock Insurance Directive, 2077

Documents:

- ✓ Statistical Information on Nepalese Agriculture, 2020/2021
- ✓ Annual reports of study farms/centres
- ✓ Annual reports of fruits, potato and cereal related institutions
- ✓ Master Plans of farms/centres (if any)
- ✓ Agriculture Infrastructure Development Program Implementation Procedure, 2078
- ✓ Private Nursery Strengthening Program Implementation Internal Procedure, 2077
- ✓ Agriculture Produce Storage House (Silo) Construction Implementation Procedure, 2075
- ✓ Disbursement Procedure for Subsidized Electricity Tariff for Cold Storage to Store Agriculture Produce and Milk Chilling Centre, 2075
- ✓ Agriculture Infrastructure Development Procedure, 2075
- ✓ Seed Production, Supply and Management Directive, 2078
- ✓ Meteorological data/information
- ✓ Internet

Maps:

Relevant documents and maps were identified, collected and studied during the study period to obtain preliminary information on the project plan, design, and suitability of the structures proposed in the study area. Relevant maps, especially the 1:25000 scale topographic and digital maps covering all the study area including the watershed area, aerial photographs, geological maps, land utilization maps, land classification maps, soil maps, along with design and drawings of structures proposed in the project area were obtained.

All these documents and maps were reviewed and activities for any change required in any earlier planning, design and construction were finalized and reported to the Client. Beside these, legal documents were also reviewed so that the Consultant can advise project management regarding any claim by contractors that harm accomplishment of the study. The consulting team studied the reports, Topographical Maps, and Cadastral Maps. The team also used FINNIDA maps as well.

2.4 Collection of Secondary Data and Information

The consultant team collected and reviewed secondary data and information. Secondary data and information were gathered from previous study reports, policy, maps, design guidelines, design standards, specification, and legislations. These reviews had a special focus on the best practices of farm/centers as well as on technical and engineering standards of the farm structures, agricultural data of the farm/center and current demand supply of the farm/center.

2.5 Field Study

After the approval of Inception Report, the consultant team of experts moved to field and conducted field survey of the prospective sites of farm/center to assess and verify identified sites considering technical, engineering, agricultural, hydrological, socioeconomic, demand-supply and trading volume of agricultural products and environmental aspect of the study farm/center.

2.5.1 Overall Observation

The study team made observations right from the approach road leading to farm/center from the main highway together distant view and overall observation of the farm/center. In this case of PCDC, Nigale, the distance from Kathmandu to PCDC Nigale is about 106 km (Google Distance). An earthen gravel approach road at right side of Pushpalal Highway (Khadichaur – Jiri portion) from Mudhe market center leads to PCDC Nigale. The length of the approach road from Mudhe market center to PCDC is about 1.3 km. Although the approach road is earthen gravel but the condition of road is quite good and quite stable during monsoon reason too. A glimpse of approach road and walkthrough in the approach have been presented in Figure 2.3.

Figure 2.3: Walkthrough in approach road to PCDC

2.5.2 Preliminary Discussions with Farm/Center Officials

The first consultative meeting in PCDC, Nigale office was organized on 12th March 2023 chaired by Mr. Bijay Kumar Giri, Chief and Senior Horticulture Development Officer, in the presence of staffs and consultant study team members.

The meeting was started after a brief introductory session where everyone in the meeting introduced themselves. First of all, the study team briefed about the purpose of the study. It was followed by the power point presentation which briefly described about the center.

Discussion Aspect/Issues:

The discussion was focused on some important aspects/issues related to production and distribution of different kinds of potato seed. The issues discussed are presented below:

- ✓ Existing condition and problems and possibilities of the center
- ✓ Proposed structures (Storage, Tissue Culture Laboratory, Screen House, Guest House etc.) and their locations
- ✓ Water supply (deep boring)
- ✓ Upgradation of existing structures (Canteen, Toilet, Training Hall etc.)
- ✓ Parking
- ✓ Production Technology
- ✓ Human Resource
- ✓ Business Model
- ✓ Fencing

2.5.3 Focus Group Discussion (FGD)

Two FGDs were organized during two visits of PCDC involving all staffs of the center. The overall situation and general issues and problems of the center were discussed during FGD.

Reports and documents especially the Annual Reports were collected and discussed during FGD.

2.5.4 Key Informant Interview (KII)

KIIs were organized with PCDC Nigale Chief and Subject Matter Specialists (SMSs) to discuss on specific technical and key issues related to the center including specific requirement of PCDC. Discussions were also focused on location, design and capacity of proposed infrastructure to make optimum and best use of available space. Need for strengthening of existing infrastructure was reiterated instead of construction of new structure to avoid encroachment of limited growing area of the center.

In addition, KII was organized with chief and staffs of central institution of potato crop in Kathmandu i.e., National Potato, Vegetable and Spices Crop Development Center, Kirtipur to discuss on national level scenario of potato seed demand and supply/production and government vision of PCDC as well as government priority plan and program.

A semi-structured questionnaire/checklist was used to gather information through FGD and KII (Annex 7). Pre-testing of semi-structured questionnaire/checklist was done during the first meeting at PCDC Nigale.

2.5.5 Site Verification with Farm/Center Officials

The study team thoroughly visited all A, B and C blocks with specific observation of the location for new construction, strengthening of existing structures and quick measurement wherever felt necessary.

The list of participants in FGD/KII and walkthrough observation in PCDC Nigale are presented in annex section.

2.5.6 Survey

Surveyor Team has surveyed the whole center with the help of the officials appointed in the center. Total boundary, current infrastructure and location for possible infrastructures were also surveyed for the planning purpose. Total Station, Measuring Tape, Peg, Hammer, Reflector etc. were the instruments used to carry out the survey work.

2.5.7 Geo Investing Test

Geo investing test has been carried out in the center. It gives power to consider educated investing decisions and identify risk.

Scope:

- Drilling of 100mm nominal diameter bore holes each of 10.5 m depth at two specified locations.
- Conducting standard penetration tests in the boreholes at 1.50 m interval in depth & at every change of strata, whichever is earlier.
- Collecting disturbed soil samples from bore holes at regular interval and at every identifiable change of strata to supplement the boring records.
- Recording the depth of ground water table in all the boreholes if observed up to the depth of exploration during boring work as per specifications.
- Conducting the laboratory tests on selected disturbed / undisturbed soil samples collected from various bore holes, Preparation and submission of reports.

2.6 Consultation Meetings with Central Level Institutions

After a certain level of field visit, study team had consultation meetings with the central level institutions of farm/centers located in Kathmandu. Semi-structured checklist was used to gather information and data from these institutions. A semi-structured questionnaire/checklist was used to gather information through central level institutions (Annex 2).

2.7 Design Approach

Based on the design principle, standards, findings of the primary and secondary data and consensus built during meeting with concerned stakeholder, conceptual master plan and Conceptual Building Floor Plan were developed. The orientation of building was planned as per desired wind direction and existing main approach road. Master Plan was developed as per function of individual buildings in one cluster and linkage by different hierarchy of road network and footpath. Functional linkage of different activity was also considered. Closed Circuit Television (CCTV) and solar backup system were provided for emergency light, security and power cut period.

Following points were considered at the time of design.

• The orientation of block	• Easy for construction
• The orientation of rooms	• Security
• Minimum circulation space	• Use of local building materials and techniques.
• Compact planning	• Low maintenance cost of building
• Simple building form	• Follow architects' standards for planning and space requirements

Proper utilization of existing spaces into more planned and efficient space has been the major challenge during preparation of detail master plan of the PCDC Nigale.

During the preparation of Master Plan, following factors have been considered prior to the planning and designing:

a. Physical condition of the site;
b. Existing land demarcation;
c. Existing access/approach road to the site;
d. Existing water supply;
e. Storm water drain outlet;
f. Solid Waste Disposal; and
g. Electricity and telecommunication line

2.8 Planning

Based on the discussions with the farm/center, the infrastructural, non-infrastructural, utility and other needs were identified. Planning was done as per the needs identified. Following points were considered to boost the purpose of planning:

- Planning purpose
- Use of facts and data
- Plan according to specific objectives
- Build in accountability
- Review

3 POLICY REVIEW

Constitution of Nepal

In September 2015, Nepal's Constituent Assembly passed a new constitution aimed at transforming Nepal from a unitary country into a federal republic with three levels of government - the federation, the province, and the local. The Constitution grants greater authority and autonomy to more subnational units of government ensuring coordinated planning, sufficient human capacity and adequate fiscal resources. Since PCDC Nigale is under federal government, it is the responsibility of DoA to look after the overall management of federal farms and centers. However, the Constitution guides for the coordinated efforts of all levels of governments in planning, human resources development and fiscal resource planning.

The Article 25 (4) and (5) make provision for land reforms, management and regulation in accordance with law for the purposes of enhancement of product and productivity of lands, modernization and commercialization of agriculture, environment protection and planned housing and urban development.

Nepal enshrines the Right to Food and other related provisions in new constitution. Article 36(1) ensures right to food for every citizen, Article 36(2) ensures that every citizen has right to be protected against food scarcity that may cause threat to life, Article 36(3) ensures that every citizen has right to food sovereignty as provided by law, and Article 42 - right to social justice - includes provision on food. The explicit constitutional recognition of the right to food will also be instrumental in the implementation of Zero Hunger Challenge Initiatives in the country. Article 42(4) mentions that every farmer shall have the right to have access to lands for agro activities, select and protect local seeds and agro species which have been used and pursued traditionally, in accordance with law. The government farms and centers support achievement of food and nutrition directly and indirectly.

Article 290 makes provisions relating to Guthi (trusts) in which the Federal Parliament shall make necessary laws in relation to the rights of the trust and the farmers enjoying possessory rights over trust lands in a manner not to be prejudicial to the basic norms of the trusts.

Provision for agriculture has been made in Schedule-5 (List of Federal Power), Schedule-6 (List of State Power), Schedule-7 (List of Concurrent Powers of Federation and State), Schedule-8 (List of Local Level Power), and Schedule-9 (List of Concurrent Powers of Federation, State and Local Level) of the Constitution. Accordingly, implementation of agriculture development programs including extension and use of resources lie largely at local level.

National Agriculture Policy, 2004

The long-term vision of National Agricultural Policy, 2004 (NAP) is to bring about an improvement in the livelihoods of people through a sustainable agricultural development to be achieved by transforming the current subsistence-oriented farming system into a commercial and competitive farming system.

It has defined three objectives to ensure food security and alleviate poverty by achieving a high and sustainable economic growth through a commercial and competitive farming system. To achieve these, NAP has defined three objectives: (1) increase agricultural production and productivity; (2) make agriculture competitive in regional and world markets by developing bases for commercial and competitive farming system; and (3) conserve, promote and properly utilize natural resources, environment and bio-diversity. Twenty-six policies have been defined to achieve the first objective, 23 policies to achieve the second objective and seven objectives to achieve the third objective. In addition, three policies have been defined for the implementation and monitoring of NAP. Thus, production and supply of quality seeds, seedlings and saplings are basic and important inputs to enhance agricultural production and productivity. The role of government farms and centers which are still the major sources for such inputs have significant role even in the federalized context.

The local entities shall have to be made capable and responsible to implement policies which are localized whereas department and directorates of the center will have to implement policies and programs which involves more than one local entity and district. Considering fragility of land, NAP guides for a scientific land-use system and discourages non-agricultural use of fertile agricultural land.

The Policy directs to provide special facilities for farmers classified as having less than half a hectare of land and lacking irrigation facilities, farmers belonging to Dalit and Utpidit classes and other marginal farmers and agricultural workers.

The policy also emphasizes on development of large production pockets of products which have comparative advantage in order to attain economies of scale that match the demands of the market. NAP points out the need for development of agricultural roads, rural electrification, irrigation, agricultural credit and marketing arrangements in such pockets besides technologies and technical services.

The Policy alerts on the negative impact of use of agro-chemicals on soil, water, and environment. Thus, emphasis on the production, use and promotion of organic fertilizers. NAP also recommends to establish gene banks and in situ to conserve together with promotion and utilization of agro-forestry system to improve the condition of degraded forests and natural reservoirs.

Policy provision has been made for double track management system in government farms and centers with a view to ensuring the maximum possible utilization of resources without compromising the basic objective of the farms and centers.

NAP suggests formation of a National Agricultural Development Board at the nation level, a Central Agricultural Development Committee at the center, and Regional Agriculture Development Committee in the regions to implement and monitor NAP. At local level, the Policy suggests formulation of District Agriculture Development Committees and Village Development Committees to formulate, implement, and monitor and evaluate plans in accordance with the Local Self-Governance Act.

Agriculture Development Strategy 2015-35 (ADS)

Nepal's agriculture policies have been shaped by the ADS since 2015. The strategy has a 20-year vision and 10-year action plan and roadmap. It envisages a self-reliant, sustainable, competitive and inclusive agricultural sector that drives economic growth and contributes to improved livelihoods and food and nutrition security. ADS emphasize on commercialization, mechanization, and diversification of agricultural and livestock products to make the sector competitive. To meet the goals and objectives set by ADS, sectorial plan and policies on agriculture sector, GoN has highly prioritized the infrastructure development and capacity enhancement of the government run agriculture and livestock farms/centers.

ADS has identified potato as one of the higher commercialized crops apart from rice, wheat and vegetables with a commercialization rate of 30-59 %. On the contrary, NARC priority is on cereals but not high value products.

There is wide productivity gap in crops. For example, the current paddy yield is 3.8 mt/ha against the potential of 10-12 mt/ha (para 93). The constraints to the realization of such potential are - limited availability of quality and affordable seeds, low Seed Replacement Rate SRR in cereals, and insufficient fertilizer availability for both cereal and horticultural crops (para 94).

Nepal's agricultural import and export trade comprises about 17.5% of total trade. Agricultural trade is dominated by export of lentils, tea, cardamom, fruit, ginger, and medicinal and aromatic plant products (MAPs), and import of fruit, cereals, vegetables, beans (mostly peas), dairy products, meat animal, and raw materials for processing (oilseeds) and manufacturing (fibers for carpets, garments and textiles). There is good potential for import substitution in vegetables, fruit, beverages, dairy and meat. Export value of the top three high value crops namely cardamom, fruits, and tea are only one-quarter of the value of cereal and dairy imports (para 99).

Rising incomes are changing food demand from cereals towards more protein, fruit, vegetables and processed foods. The government horticulture farms and centers can play crucial role availing quality fruits and vegetable seeds, seedlings and saplings for meeting their increasing demand. In the South Asia region, per capita consumption of rice declined from 20% to 15% of consumer food spending (1980-2008), while 85% of consumer food spending is on vegetables, meat, dairy and fish. Following this trend, farmers get about four times the income per ha from high value products than from rice (para 155).

The strategy does not deal with the seed sector separately but emphasizes on the implementation of seed policies, especially the National Seed Vision 2013-2025 (NSV) through investments in resources and capacity building and covering both crop and fodder seeds. The ADS is based on the concept of value chains, a welfare and market-based growth strategy, and sustainability and inclusive perspectives. Its seed related activities are consistent with the NSV, the Agricultural Biodiversity Policy 2005, and the Seed Regulations 2013. The key seed related features in the ADS are to:

- enhance the capacity of seed research stations to produce breeder and foundation seed in partnership with international agencies and increasing funding for public research institutions and stations, universities, and private sector industries;
- research to focus on maintaining good quality land races and open pollinated varieties of crops in areas dominated by subsistence agriculture;
- strengthen public-private-cooperative partnerships to grow the national seed industry;
- produce hybrid seed to address increased demand from farmers;
- pilot a voucher system for distributing subsidized seed in marginal areas; and
- strengthen and upgrade seed laboratories and declare seed sovereignty for food security.

The GoN has developed and implemented several policies and programs to promote fruit and vegetable development in the country. Agriculture Perspective Plan (1995-2015) has included apple as a high value crop for high hills and mandarin orange as high value crop for mid hills (APROSC and JMA, 1995). The 20-year Horticulture Master Plan which was prepared in 1991 with an assistance of Asian Development Bank, was not approved by the government but has been used as a guiding document by horticulture planners.

Agriculture Mechanization Policy, 2014

The GoN introduced this policy in 2014. The goal of this policy is to conduct research and develop, promote and increase adoption of agriculture tools and machineries to increase agricultural productivity and make agriculture sustainable and competitive. The policy defines four objectives. The first objective is to increase agriculture productivity through appropriate agriculture mechanization suitable to physiographic and economic situation of the country. The second object emphasizes on increasing access of farmers and entrepreneurs to agricultural machinery and services. Similarly, the third objective aims to identify and promote women and environment friendly agriculture tools and machinery. The last objective is to develop institutional set-up to set quality standard, regulate, monitor and promote agriculture mechanization. These all imply that agriculture mechanization is crucial not only to increase agricultural production but also to reduce cost of production. Thus, mechanization could be one of the strategies for farms and centers to produce resources cost effectively.

Agriculture and Livestock Insurance Directive, 2020

On 30 November 2020, GoN brought out Agriculture and Livestock Directive, 2077 after amending the existing Crop and Livestock Insurance Directive, 2069. This insurance policy covers 14 types of risks related to agriculture and livestock. There are five types of insurance policies related to agriculture (vegetable, cereals, spices, fruits and others like honey, tea and coffee) and three types insurance policy related to livestock (animal, poultry and fish). Currently, 20 insurance companies are involved in agriculture and livestock insurance in the country. Such insurance policies can be integrated with seed production programs to promote and enhance seed production because the insurance policy guarantees recovery of some costs.

Fifteenth Plan, 2019/20-2023/24

Long-term vision of the Fifteenth Plan (2019/20-2023/24) is 'Prosperous Nepal, Happy Nepali'. A prosperous, independent, and socialism-oriented economy with a happy, healthy, and educated citizens enjoying equality of opportunities, dignity, and high standards of living. Some of the long-term national goals of the Plan are - accessible modern infrastructure and intensive connectivity, development and full utilization of human capital potentials, high and sustainable production and productivity, healthy and balanced environment, and high and equitable national income (Sub-section 2.4 and 2.5).

The annual average growth rate for agriculture is estimated at 5.5 %. The Fifteenth Plan envisages decrease in agriculture sector contribution to GDP. It will have decreased to 22.3% from the current 27% by the end of the Plan (Sub-section 2.9) but agricultural productivity will have increased to 4 metric ton (mt) per hectare from the current 3.1 mt per hectare. The SRR for major crops will have reached 25 per cent by the end of the planning period. The productivity per hectare will have reached 22 mt for potatoes at the end of the Plan. The quality seeds, seedlings and saplings can contribute substantially in achieving this goal and the government farms and centers have important roles to play for this.

Through agriculture research program, 2 varieties of potato for chips and 2 varieties for consumption will have to be developed. The SRR for major crops will have reached to 25% by the end of the planning period.

The 15th Plan in its working policy of agriculture sector aims to utilize unused lands of the government's agriculture farms/centers for the production of seeds, saplings, fingerlings, breeds and breed improvement. Hence, GoN has focused on infrastructure development for the best utilization of resources and capacity enhancement of government farms/centers form the fiscal year 2078/79 (Sub-section 4.4).

National Seed Vision (NSV) 2013-2025

The NSV envisages development of 251 additional varieties, 191 open-pollinated varieties (OPVs) and 60 hybrids. The private sector companies are expected to develop 20 hybrids including 10 of vegetables, 5 of maize and 5 of rice but no OPV. The NSV emphasizes on maintaining seed cycle through seed multiplication. The NSV projects that the country would need 88 mt of breeder seed, 2,978 mt of foundation seed and 92,527 mt of improved rice, wheat, maize and vegetable seed per year by 2025. Here, the role of government farms and centers is very much important.

On seed processing and conditioning, the seed storage capacity of public and private institution is to be upgraded to 50,000 mt and seed processing capacity to 55 mt/hr. Similarly, the NSV targets the development of a buffer stock of 10,000 mt of the seeds of major food crops.

On marketing of seed, the NSV calls for training 6,000 traders; developing marketing networks, reducing vegetable seed imports by 30 mt/year (from 240 mt per year in 2010 to 210 mt/year in 2025), and increasing vegetable seed exports from 160 mt/year to 750 mt/year in 2025.

Overall, the NSV calls for availing 92,737 mt (local production 92,527 mt and import 210 mt) seeds per year to achieve a SRR of 90% in vegetables by 2025. More importantly, NSV has set the target of growing 90,000 ha of vegetables using domestically produced hybrid seed to produce 6.8 million mt of grains to meet the food requirements of 36.5 million people in 2025.

The NSV calls for the following policy updates to achieve the above targets: (a) establish an agriculture biotechnology center and develop guidelines on genetically modified organisms and its seed; (b) introduce a subsidy mechanism across the seed value chain to benefit the poor, disadvantaged, vulnerable and women headed households for home gardening and semi-commercial seed use, promptly popularize locally developed new OPV and hybrid varieties, and import processing and storage equipment; (c) upgrade the roles of National Seed Board (NSB) for inter-ministerial coordination for forestry and agriculture seed and strengthen the role of private sector and NGOs to achieve NSV's targets; (d) regulate quality assurance across the seed cycle and support strategies for seed grower mechanization, development of high yielding and short duration crop varieties, seed insurance, and provision of short-term and long-term credit for market support to entrepreneurs for the development of the national seed industry. '

Thus, NSV is an important guideline for public and private seed producer entities to set target for production of resources like seeds, seedlings and saplings in the country.

Seed Act, 1988

The Seed Act, 1988 was promulgated to avail quality seeds under a well-planned system of production, processing, and testing to increase crop production. The NSB was established under this act to advise the government on formulating and executing seed-related policies. The act was amended in 2008 to address seed industry demands and issues. This Act is a guideline as well as legally mandatory tasks to be followed by government as well as private seed producing entities for the production and distribution of quality seeds, seedlings, saplings and genetic materials.

Seed Regulations

The Seed Regulations were formulated in 1997 and revised in 2013 and relate to the Seed Act, 1988. They define the institutional setup with three sub-committees under the NSB. The varietal approval, release and registration sub-committee is responsible for receiving and evaluating varietal proposals from the public and private sectors and submitting them to the NSB for approval. The planning and monitoring sub-committee are responsible for preparing seed policy and monitoring plan and submitting them to NSB for approval. It also manages seed in the country, coordinates between public and private sectors and fixes seed prices. The quality control and management sub-committee is responsible for preparing minimum seed quality standard of seed and submitting them to NSB for approval. The Seed Quality Control Centre (SQCC) is the secretariat of NSB and is responsible for all the secretarial activities of NSB, including the regulation of seed laboratories, notification and de-notification of varieties, providing import/export permits, licensing of private crop inspector, seed sampler and seed analysts, and seed compensation.

Since seed price is fixed by the Planning and Monitoring Sub-committee of NSB, both public and private seed producing entities need to detail out the cost of production in order to enable the seed producing entities find areas where cost can be reduced. Without such elaborated costing, it is very difficult to pin point the weak areas where cost can be reduced and be efficient in producing seed at low cost to be competitive in the seed market.

Land Use Policy 2015

Encroachment over arable lands, forests, Government and public lands, and various natural resources is rampant these days in Nepal due to fast growing population, internal migration, unmanaged and rapid urbanization. Hence, this policy was formulated to protect these lands. The policy has classified entire land of the country into 11 categories as listed below.

(a) Agricultural Zone

(b) Residential Zone

(c) Commercial Zone

(d) Industrial Zone

(e) Mines and Minerals Zone

(f) Cultural and Archaeological Zone

(g) River and Lake-Reservoir Zones

(h) Forest Zones

(i) Public Use and Open Space Zone

(j) Building Materials (Stone, Sands, Concrete) Excavation Zone

(k) Other Zones as specified as per necessity.

The policy discourages conversion of aby land type. "Agriculture Zone" denotes the zone where agricultural production (cereal, cash, horticulture crops etc.), animal husbandry, fisheries, agricultural forest products and plants planted in private land, are existed or may be existed. This term also denotes any specific zone which is declared as agricultural zone by GoN, among others.

Land Use Act 2076 and Land Use Regulation 2079 were enforced to implement the Land Use Policy 2069. These laws provided legal base to classify land as per Land Use Policy 2069. The GoN made mandatory provision to classify land into agriculture and non-agriculture land before making division of land. Some municipalities have started classifying their land through Land Use Commission. Unfortunately, most such municipalities have classified their land under non-agriculture land category without rigorous exercise and long-term vision of food security and nutrition. For example, most municipalities in Kathmandu valley have classified their land under non-agriculture land category. This will negatively impact on agriculture and threaten the sustainability of agriculture sector in the long run. This demands for crops and varieties which have high productivity per unit of land. The role of government farms and centers is crucial for this.

Industrial Policy 2010

The Industrial Policy 2010 has prioritized agriculture and agro-forestry industries for investment and provides additional incentives and facilities to these industries.

Guidelines

Twelve guidelines exist for maintaining seed quality covering the delegation of authority on the seed value chain, private sector involvement, harmonizing Nepal’s seed-related rules and regulations with neighboring countries and quality control mechanisms.

The Directives of Seed Production and Management in Private Sector, 2016, made provisions of varietal development and promotion, varietal conservation and breeder seed production; foundation/source seed production, and hybrid seed production to the private sector (persons or organizations). However, they need to get license from SQCC after fulfilling the minimum requirements set by this directive. Previously, these facilities were mostly under the public sector, including NARC for varietal development and breeder seed production, except LIBIRD, and foundation seed production with NARC, Department of Agriculture and/or the AICL.

The Community Based Seed Production (2000) and Community Seed Bank (2009) guidelines provide frameworks to support local institutions engaged in seed production and conservation.

Similarly, Seed Production Guideline for Pipeline Varieties (2017) creates a window for the multiplication of seed of pre-release/pipeline varieties by farmer groups, cooperatives and companies. It addresses the shortage of source seed while releasing varieties and guides the development of a framework for scaling out new varieties through the fast-track approach.

Directives on Provision of Subsidy on Construction of Cold Store, 2070

Government of Nepal has approved this directive to make government grant processing towards establishment of cold storage facilities on wholesale markets by the private, cooperatives, public and non-government sectors transparent and effective. The objectives of this guideline are to:

- make farmers able to sell their perishable agricultural produce more profitably based on market demand and price,
- help consumers have year-round availability of food produce like fruits and vegetables in the agricultural markets,
- contribute towards procurement and management of quality food produce for domestic and international markets, and
- increase consumable produce through reduction if loss of perishable agricultural produce.

This guideline has provisioned for eligibility of applicant, grant proposal screening process, evaluation committee and criteria for evaluation, grant administration including the size of grant and the ratio of matching grant.

Double Track System of Government Farm and Center Management

Effective management of farms and centers had always been the subject of concern of GoN since several years in the past. Hence, Double Track System was introduced in 2003 AD for the management of government farms/stations. A double track system is a management system to be implemented *in* government farms and centers for maximum possible utilization of resources. For the first time, it was tested in Horticulture Centre, Nawalpur, Sarlahi. This system involved implementation of regular program together with implementation of additional income generating program with profitable business plan. This was planned, approved and implemented in Nawalpur. The income generated from the implementation of additional program was divided as follows:

- ✓ 15% to be deposited in the government treasury;
- ✓ 25% set aside as program expenses fund;
- ✓ 30% to be used in repair and maintenance and stock replenishment in the farm; and
- ✓ 30% to be paid as incentive to the staff involved.

To promote Double Track System of management of government farms and centers, explicit policy provision has been made in Policy No. 29 of National Agriculture Policy, 2061 too (MoAC, 2009). But, this system of farm management was discontinued without any formal assessment of its implementation.

Ministry of Agriculture and Livestock Development (MoALD)

MoALD is an apex organization for the overall growth and development of agriculture and livestock sector in the country. It has seven divisions within the ministry. There are three departments (Department of Agriculture, Department of Livestock Services, and Department of Food Technology and Quality Control), two councils (Nepal Agricultural Research Council and Nepal Veterinary Council), one board (Nepal Tea and Coffee Development Board), and two committees (Cotton Development Committee and Kalimati Fruits and Vegetables Market Development Committee). Agriculture Input Management and Technology Section under Agriculture Development Division of MoALD looks after seed, seedling and sapling related matters in the Ministry.

Department of Agriculture (DoA)

DoA has been restructured as per GoN decision made on 27/3/2075 after federalization. Accordingly, there is one Director General, four Deputy Director Generals and 11 Sections under DoA. There are six central entities and 14 farms and centers under these entities.

There has been changes in the goals and responsibilities of DoA. The overall goal of the department is to ensure food security and contribute to poverty alleviation through diversification and commercialization of agriculture. The specific goals are listed below.

- Increase production and productivity to meet increasing domestic and external demand for agriculture commodities,
- Increase production and productivity of raw materials needed for ago-based industries,
- Contribute to poverty reduction through the implementation of productive and employment generating programs for small, marginal and women farmers, and
- Implement sustainable agriculture development programs maintaining balance between agriculture development and environment protection.

Similarly, the roles, responsibilities and working procedures of DoA have also changed after federalization. The study farms and centers are guided by the objectives and working procedures of DoA. The working procedures of DoA are given below (published on 20/11/2018).

- Farmers' groups should be adopted as facilitators of agricultural extension programs, and agricultural development programs should be conducted and groups will be gradually transformed into cooperatives.
- Transferring technology by conducting employment oriented vocational agricultural training to increase the capacity and efficiency of agricultural manpower and employment opportunities through employment oriented vocational agricultural training.
- Identifying pocket areas for specific crops and commodities based on local potential and comparative advantage and assisting in product specialization of potential crops and commodities.
- Conducting a special program for the production and use of agricultural produce that can be produced locally in areas that are sensitive from the point of view of food and nutrition security and where food production is low.
- Prioritizing crop-specific pocket package programs in irrigated areas with access to transportation facilities and emphasizing production and promotion of low-volume crops and commodities based on local potential in remote districts without irrigation, transportation, and other facilities.
- Conducting a special program to produce and use agricultural produce that can be produced locally in areas that are sensitive from the point of view of food and nutrition security and where food production is low.
- Prioritizing crop-specific pocket package programs in irrigated areas that have access to transportation facilities and emphasizing on the production and promotion of low-volume crops and goods based on local potential in remote districts that lack irrigation, transportation, and other facilities.
- Development and dissemination of agricultural technology with the participation of entrepreneurial farmers and the private sector, development and expansion of resource and distribution centers to bring stability in the supply of production resources.
- Emphasizing agricultural commercialization and marketing by selecting and implementing agricultural development programs based on the concept of Value Chain Approach.
- To support the marketing of agricultural produce by developing market information flow and infrastructure in accordance with the public-private partnership concept,
- Emphasizing the arrangement of subsidized agricultural loans and insurance and tax facilities in agricultural industries and trade,
- Emphasis on coordination, facilitation and regulatory role from the government level,
- Validate technology by conducting Adaptive Research;

- Conducting agricultural mechanization program to develop labor oriented and commercial agriculture system,
- Emphasis on agricultural diversification by protecting, promoting and making good use of indigenous knowledge of local crops and products.
- Encouraging local community leadership in biodiversity conservation,
- Encouraging to conduct production growth, employment and income related programs based on agricultural biological diversity and encouraging to conduct related market and industry business.
- To establish and operate agricultural resource centers based on community management to provide agricultural production materials, equipment, information, and communication in rural areas,
- Crop diversification and commercialization programs through scientific land use
- Strengthening the coordination of government, non-government and private sector agencies related to agricultural development to bring effectiveness in the social mobilization of the target group.
- Encouraging contract farming and cooperative farming, strengthening the structure of agricultural cooperatives and agricultural cooperatives from the center to the village level.
- Conducting agricultural programs giving priority to the upliftment of women and marginalized communities,
- Conducting programs in such a way that there is a balance between agricultural products and agro-based industries.

National Potato, Vegetables and Spies Crop Development Centers is looking after matters related to potato crop in DoA.

4 SITUATION ANALYSIS AND NEED ASSESSMENT

4.1 Background of the Center

In FY 2027/28 BS, Swiss hikers who were hiking to Sagarmatha from Lamo Sanghu using this route, utilized this place as camping site and started cultivating potato varieties of Dejire, C.F.J and Lady Rojita by leasing farmer's land. From FY 2032/33, GoN (then His Majesty's Government of Nepal) established the center in 108 Ropani 13 Aana land in Jethalal-9 VDC currently known as Lisankhu Pakhar Rural Municipality.

The center was attacked twice during insurgency period (2059/01/06 and 2061/02/03 BS). During that period contact office was shifted to Mudhe market center until reconstruction was completed. The office was shifted to its present new constructed facilities in Shrawan of 2069. Location map of PCDC is shown in Figure 4.1.

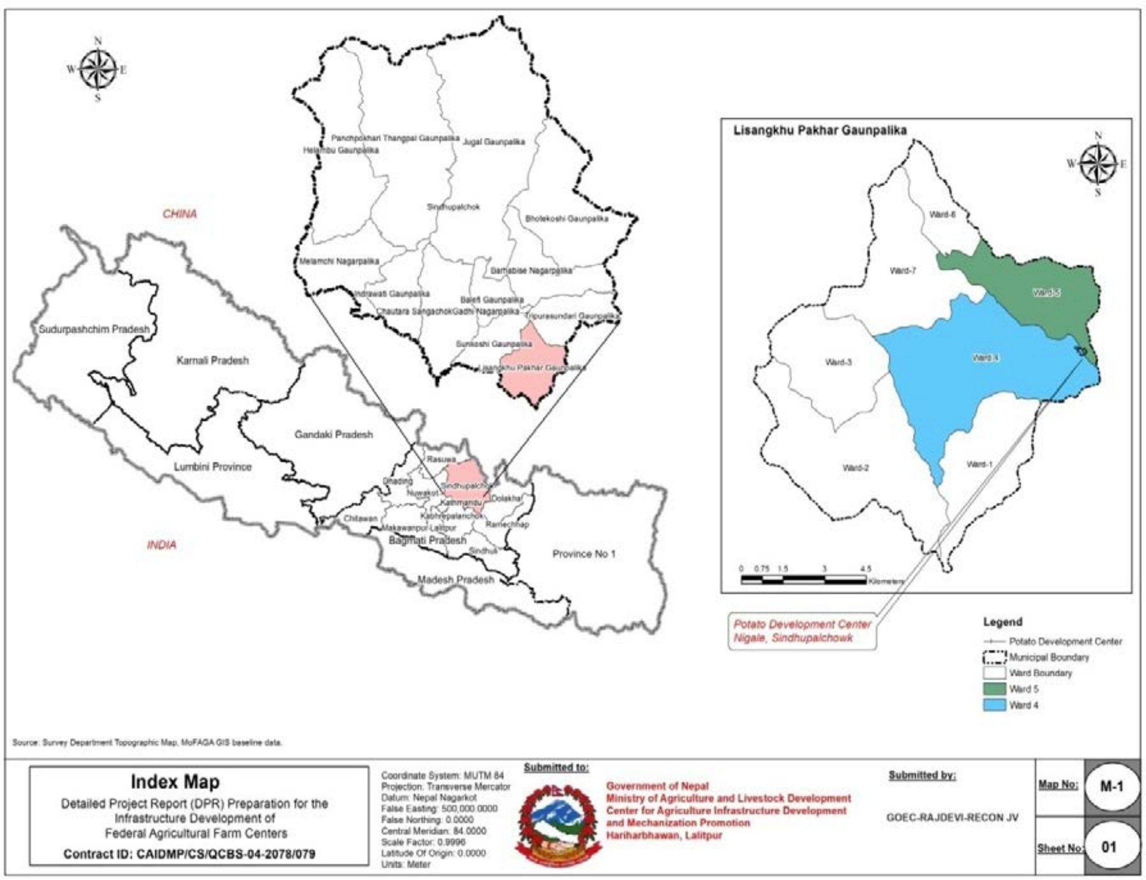


Figure 4.1: Location map of Potato Crop Development Center, Nigale, Sindhupalchowk

PCDC Nigale is located at an elevation range of 2450 m to 2,520 meters from mean sea level in Sindhupalchowk district of Bagmati Province. It is located in Ward No. 5 of Lisankhu Pakhar Rural Municipality. Satellite Image and some glimps of PDC, Nigale are presented in Figures 4.2 and 4.3.

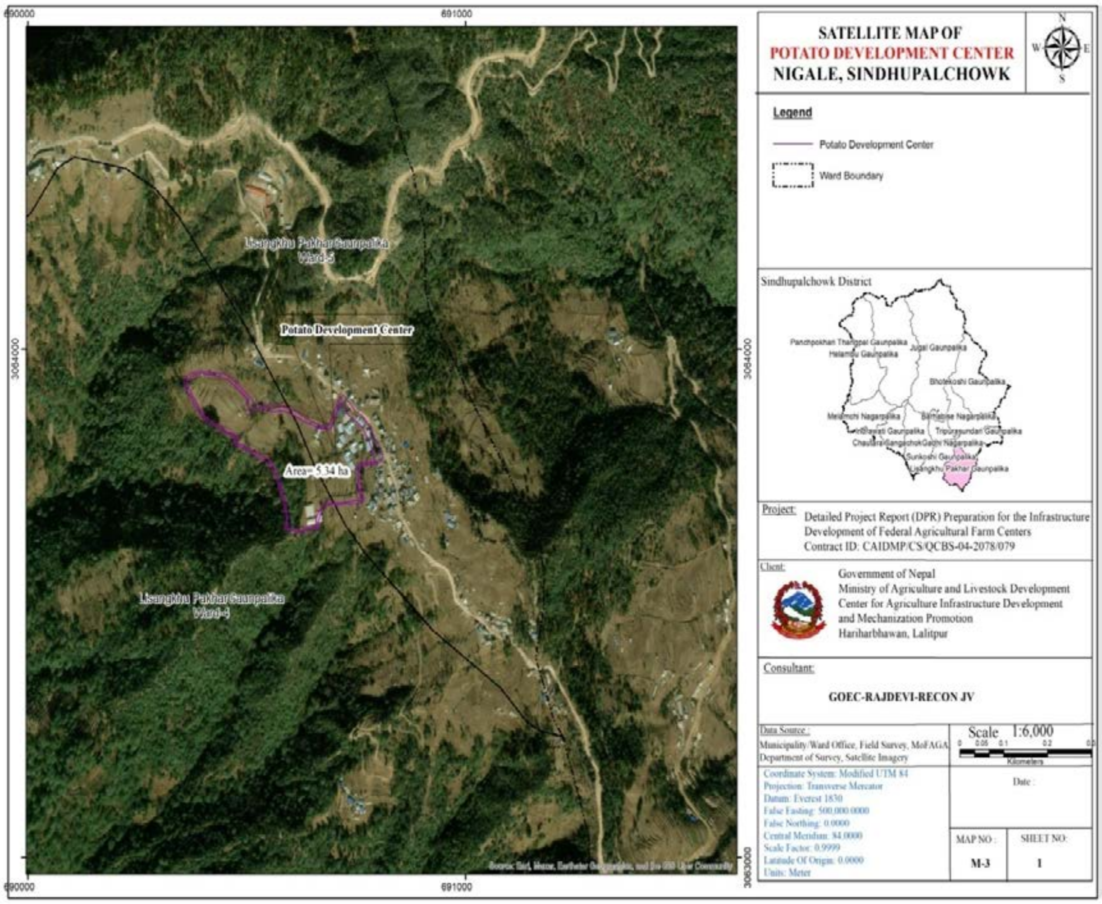


Figure 4.2: Satellite Image of Potato Crop Development Center, Nigale



Figure 4.3: Some glimpse of site

Vision

PCDC has a vision of contributing in the agriculture sector of Nepal through potato crop development with the motive of:

- Contribute in poverty reduction;
- Generate employment opportunity;
- Support in the attainment of food security; and
- Eventually contributing to national economy.

Goal

The goal of the center is to produce and provide quality potato seed to farming community to increase the production and help the national goal of poverty reduction.

Objectives

- Increase production and productivity of potato through the adoption of modern farming technology,
- Build the capacity of the farmers in sustainable good potato cultivation practices,
- Establish a monitoring and evaluation system to achieve the annual production target of the center,
- Distribute pre-basic seed (PBS), true potato seed (TPS) and different generation potato seed to farmers,
- Provide in-vitro potato plant to PBS producers, and
- Collect and conserve different potato varieties.

Strategy

- Maximum utilization of the resources,
- Promote variety development,
- Enhance research in modern potato cultivation process,
- Increase potato production, and
- Produce virus free potato seeds.

Rainfall and Temperature

Climate:	Temperate
Minimum Temperature:	-8°C
Maximum Temperature:	19°C - 23°C
Annual average temperature (maximum):	15°C
Annual average temperature (minimum):	9°C
Annual average rainfall:	2,500 mm
Annual average humidity:	82%

Heavy rain falls in Ashadh, Shrawan and Bhadra. Frost starts from the month of Kartik and snowfalls in Poush, Magh and Falgun.

Potato is an important crop of Nepal. Due to its short vegetative cycle and high cash value, it plays an important role in country's food production and poverty reduction. Despite its significance in food security and cash generation, the average productivity is one of the lowest (16.73 mt/ha) in the world. Lack of appropriate production technologies in the country and use of inferior seed tubers by majority of the farmers are some major limiting factors. The Fifteenth Plan aims to attain potato productivity of 22 mt/ha by the end of Plan period in FY 2023/24.

The continuous GoN efforts have resulted in increasing production and productivity leading to decreasing import since last few years. According to Department of Customs data, 341,914 tons of potatoes worth Rs 8.77 billion was imported in FY 2076/77 and it decreased to 339,622 tons worth Rs 8.49 billion in FY 2077/78. The data for the first five months of current FY 2078/79 (187,858 tons worth Rs 4.80 billion) also indicates decline in potato import in the same period in FY 2077/78 (218,305 tons worth Rs. 5.52 billion). This indicates the contribution of potato crop in national economy particularly in reducing trade imbalance.

Potato – a high value cash crop

Figure 4.4: Administrative building

Overall Observation of the Center

Since PCDC Nigale is the only government center for potato development, it is facing several challenges to serve the entire nation and develop as "Center of Excellence". Some of the major findings of the study are listed below.

- The proposed site has already existing structures like office building, store, quarter, guard room, canteen, training hall etc. These structures were reconstructed by GoN after the damage of old structures during insurgency and by the massive earthquake in 2015. However, need for new structures have been realized to address the emerging issues and challenges as well as for meeting increasing demand for potato for table and industrial uses.
- The farm center has good accessibility of road network. But there is a need for upgradation of internal road.
- The center has only one entry gate which is essential for the security.
- Some of the existing structures like Rustic Store, Training Hall and toilets need to be upgraded.
- Proper management of parking space and landscaping is highly needed.

- Provision of footpath has not been taken into consideration.
- The center does not have some most needed infrastructures like Dormitory, Guest House, Staff Quarter, Storage, Public Toilet, Modern Tissue Culture Lab, Soil Lab, Plant Protection Lab, Sales Counter etc.).
- All buildings have slope roof with CGI sheet roofing material.
- Barbed wire boundary has fallen in several places.

Various methods were used to gather information on infrastructure and non-infrastructure needs of the center as mentioned in the methodology earlier. SWOT technique was also used to analyze situation of PCDC Nigale. SWOT analysis is a device that helps managers to evaluate the strengths, weaknesses, opportunities and threats involved in any business enterprise. A SWOT analysis can help them gain insights into the past and think of possible solutions to existing or potential problems, either for an existing business or for a new venture. In fact, strengths and weaknesses are internal issues whereas opportunities and threats are external issues. Brief analysis of SWOT of the center has been presented below.

Strength:

- Production of disease-free variety of potato.
- Production of quality seed/tuber.
- Production of in-vitro tissue culture plants.
- Employment generation of local community.
- Potato cultivation training to the farmers.
- Conservation of 36 potato germplasms.

Weakness:

- Unbalanced demand and supply of quality seeds i.e., demand far exceeding the supply.
- Lack of potato varieties for processing especially for chips and finger chips.
- Lack of insufficient infrastructures especially laboratory, staff, quarter, cold storage, rustic store, and curing house.
- Limited cultivated land.
- Existing terraced land is narrow and all blocks do not have access road.
- Lack of modernized equipment such as planter, furrow maker, mini harvester and pick-up van for transportation of seeds.
- Water scarcity for irrigation.
- Low voltage and power fluctuation problem for tissue culture lab.
- Lack of well-developed irrigation facility.
- Drainage problem along internal road side.
- Inadequate budget.

- Lack of advanced technology related training, exposure visits within and outside the country.
- Untimely availability of mother plants.

Opportunity:

- Increasing demand for quality seed/tubers and the center has potentiality to contribute to fulfill some unmet demand.
- Centre has potential to be developed as a learning center and center of excellence.
- Center has very good capability to produce mother plants through tissue culture but only NARC has been mandated to produce mother plants through tissue culture.
- The center has potential to increase revenue through the sale of quality seed which ultimately will have multiplier effect on national economy by increasing production and productivity.
- Conservation of local potato germplasms.
- Local employment opportunity.

Threat:

- Possibility of unhealthy competition between private and government seed suppliers.
- Infestation of destructive diseases and pests. Currently, diseases like late blight, wilting and wart diseases and insects like thrips have been occurring and damaging crop and reducing yield.
- Lack of skilled human resources especially biotechnologists and agriculture engineer.
- Negative impact of climate change on potato production. Long drought, increasing incidence of hailstorm and frost are some of the manifestations of climate change.

4.2 Human Resource

The center has a total of 15 personnel. Out of total, five are gazette officers and the rest are non-gazette and personnel without class. Transfer is a regular phenomenon in the government organization. However, quick (short tenure) transfer of staffs particularly the Chief of the center is not desirable to provide stimulus to the vision and objective of the center. The table shows a reasonable average tenure of 4.6 years of center chief which is quite good. A tenure of five year is reasonably good to implement plans and programs with commitment and provide right direction and impetus to the center.

The approved post of the center and their current status is shown in the table below. The table shows about 40 percent vacant posts which will impair achieving goal, vision and target of the center in producing quality resources. In addition, it impairs monitoring, supervision and implementation of activities of the center. More importantly, the current trend is towards modern biotechnology but the center as well as the entire agriculture service system of GoN lacks Biotechnology faculty (Samuha). Currently, the center has met such demand by contracting a Biotechnologist. Permanent post is one of the motivational factors to retain the expertise as well as motivate such personnel to work with high efficiency in any organization. Hence, at least two officer level posts of Biotechnologist and the supporting staffs should be created in the agriculture service system together with the provision of promotion and professional development with higher studies and training. In addition, there is a need for an Agriculture Engineer and an Agriculture Extension Officer for the management of development and technology dissemination activities like training, demonstration, visits and linkage development to support development of PCDC Nigale as Center of Excellence. An Agriculture Engineer will facilitate operation, repair and maintenance of farm equipment and other machinery. Similarly, additional support staffs are also needed especially for tissue culture laboratory.

Table 4.1: Officials in the center

#	Post	Position	Regular post, no.	Fulfilled post, no.	On contract, no.
1	Senior Horticulture Development Officer	Gazetted 2nd class	1	1	-
2	Horticulture Development Officer	Gazetted 3rd class	2	2	-
3	Soil Officer	Gazetted 3rd class	1	1	-
4	Biotechnologist (on contract)	Gazetted 3r;d class	-	-	1
5	Plant Protection Officer	Gazetted 3rd class	1	0	-
6	Junior Technician	Non-gazetted 1st class	4	3	-
7	Kharidar	Non-gazetted 2nd class	1	1	-
8	Junior Accountant	Non-gazetted 3rd class	1	0	-
9	Light Vehicle Driver	No class	1	0	1
10	Office Assistant	No class	3	1	-
Total			**15**	**9**	**2**

The motivation for work of the current Chief and the staffs was found very high. It should be continued. However, there is a need to sustain such spirit by making provision for specialization in potato development through training on new technology and higher studies, improvement and strengthening of livelihoods amenities like good staff quarter facilities, canteen, and regular water and electricity supply.

4.3 Land Resource and Irrigation

Land Resource

Total area of PCDC Nigale is 108 Ropani 13 Aana based on measurement done by Survey Department. The center’s 83% land (90 Ropani) has been used for crop growing and the rest 17% land has been used for internal road, office building, quarter including steeply slope and forest areas and others. Current land utilization of the center is shown in the table 4.2.

Table 4.2 Land utilization of the center

#	Infrastructures	Area 'ha'
1	Screen house	0.12
2	Existing Road	0.3
3	Existing Infrastructure	0.23
4	Forest	0.5
5	Kholsi	0.03
6	Farm Area	3.29
7	Play ground	0.02
8	Chief Quarter and Guest House	0.04
9	Uncultivated area	0.81
	Total	**5.34**

Source: Survey data of Potato Crop Development Center, Nigale.

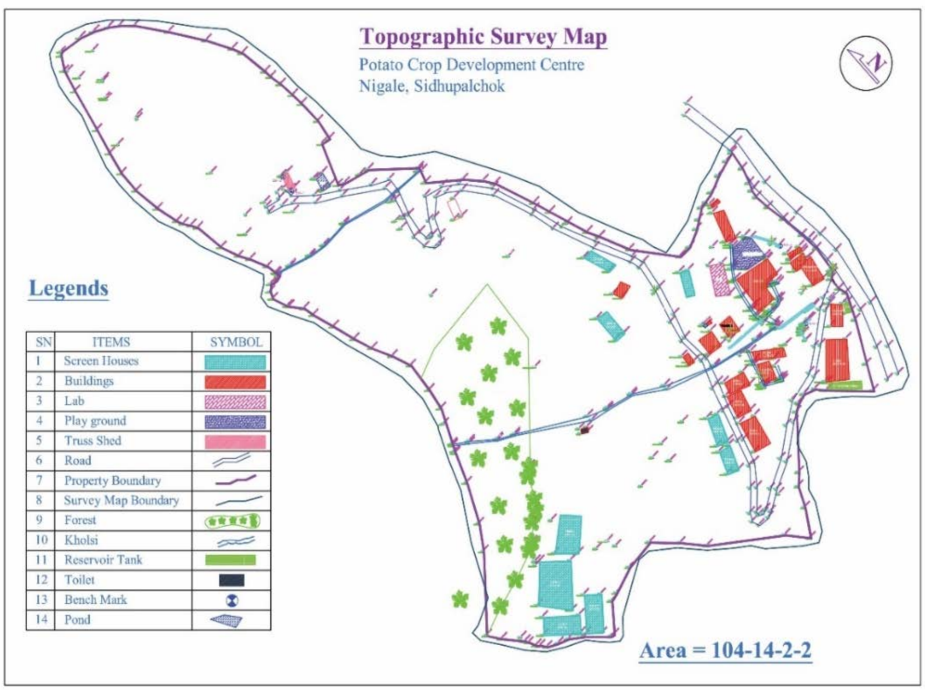


Figure 4.5 Topographic srvey map of the center.

Above map shows the current physical layout of the farm. Buildings, roads, ponds, lab, etc. are represented accordingly to the legends. The total area of the center as per the survey department is 108 ropani and 13 aana. But our surveyed data shows the area to be 104 ropani 14 aana.

Center has rented 12 ropani of land nearby the centre. To meet the demands of the potato seeds, the center should be provided with more land to function effectively and efficiently.

Irrigation Facility in the Farm

Efficient conservation, management, and use of irrigation water are critical for successful production especially under rainfed or drought condition. Frequently, extremely hot and dry conditions can reduce production over large area of the farm thereby limiting production/supplies and driving prices up. Profit opportunities exist for the producer with a well-organized water management plan when these conditions occur.

Precise irrigation requirements can be predicted based on crop water use and effective precipitation values. Lack of water influences crop growth in many ways. Its effect depends upon the severity, duration, and time of stress in relation to the stage of growth. Nearly all vegetable crops are sensitive to drought during critical periods for irrigation. Average water requirement of potato crop is 500-700 mm. Plant growing stage and tuber shoot formation stage are two critical period for irrigation in potato.

In PCDC Nigale there is lack of irrigation facility. It is said that it is solely depend on natural rain water. The annual rainfall is more than sufficient but it is not equally distributed throughout the year. Though it is a center for quality seed production, supplementary irrigation facility is must.

For this purpose, as there is no permanent source of irrigation, it is advised to develop a DEEP TUBEWELL system and secondly develop a water harvesting systems from building roofs and construction of at least 4 to 5 water reservoirs to collect rain water.

The rain water is collected in the plastic tanks from various building roofs. The construction of RCC reservoir will be completed having Length* Breadth*Depth as 5m*4m*2m (about 40,000 liter) or as the land area available.

Screen house should be provided with Ultra-Violet (UV) filtered water for the seeds. UV Water Treatment Plants are an exceptionally effective way to kill microbial contamination in water and is renowned for harmless and most cost-effective way to disinfect water for many diverse industrial applications ranging from the home purification of drinking water to sterilizing water supply of entire towns to cities.

A UV water purifier kills the microbiologically unsafe water with UV light. Whenever the water is exposed to the rays, it disrupts the DNA of microorganisms. Due to this disruption, the living organisms cannot replicate themselves and make us sick if we drink that water. UV water purifiers are safe and effective.

How does a UV system work?

- In a water purification system, a stainless-steel chamber is present. Inside which there is a glass quartz sleeve that holds the UV lamp is emitting ultraviolet rays.
- 2. The water is inserted through the water inlet, and it is directly exposed to UV light, where it attacks the genetic code of microorganisms and rearranges their DNA.
- 3. It eliminates the microorganisms' ability to function and reproduce. Now, because a microorganism cannot copy and replicate, it cannot infect other organisms such as human beings when it comes in their contact.
- 4. After the water is freed from the microorganisms, it goes out through a water outlet, further processed and purified

4.4 Farm Machinery and Equipment

Mechanization has been necessary in both public and private farms owing to lack of human and animal labor. This has directly impacted on crop productivity, cost of production and sustainability of the farm. Several externalities and drudgery associated in traditional farming and low or no return in farming has made farming least attractive to youths. Now, several time and cost saving and drudgery reducing farm machinery, tools and equipment are available in Nepal. Use of such machinery in the farm/centers will help reduce cost and increase production and productivity substantially.

Although PCDC Nigale owns some farm machinery and equipment as listed in Table 4.3 but it still lacks some modern ones such as small four-wheel Sworaj made tractor very much suited to small counters, ridger, planter, harvester, irrigation method etc. Machinery and equipment needed for the cultivation and lab should be properly maintained and some are to be auctioned.

Table 4.3 List of farm machinery and equipment in the center

#	Description	Unit	Quantity	Condition of goods	
				To be maintained	To be auctioned
1	Generator	Piece	2		
2	Water Pump	Piece	3		2
3	UPS	Piece	2		

#	Description	Unit	Quantity	Condition of goods	
				To be maintained	To be auctioned
4	Battery BDC	Piece	4		
5	Solar Panel	Piece	6		
6	Stabilizer	Piece	3		
7	Inverter	Number	3		2
8	Transformer	Number	1		
9	Solar Dryer	number	4		
10	Electric Pole	Number	1		
11	Microscope	Number	1		
12	Centrifuge Machine	Number	1		
13	Incubator	Number	4		
14	Autoclave	Number	2		
15	Hot Plate	Number	1		
16	Elisa Reader and Washer	Number	1		
17	Reserve Osmosis Water Purification System	Number	1		
18	Laminar Air Flow Funning Hood		1		
19	pH Meter	Number	3		
20	Tissue Culture Rotator	Number	1		
21	Vernier Caliper	Piece	1		
22	Spray Pump	Number	12	5	7
23	Grain Moisture Meter	Number	2		
24	Power and Mini Tiler	Number	5	4	
25	Seed Dressing Drum	Number	1		
26	Aluminum Drum	Number	2		
27	Laboratory Furniture	Number	20		
28	Ox	Number	4		
29	Software	Piece	1		
30	G P S	Piece	1		
31	Fridge	Piece	2		
32	Electric Scale	Number	3		3

4.5 Soil Properties

Soil management plays important role for increasing production and productivity of crops. Crop production can be increased substantially (as much as 58%) with the improvement of soil fertility. Therefore, soil management is crucial for boosting yield. The recent soil analysis report [test conducted at Central Agriculture Laboratory, Harihar Bhawan, Test Registration No.: 56 (Block A), 57 (Block B) and 59 (Block C)] obtained from the office has been collected and the results interpreted. Soil fertility has also been estimated based on the Digital Soil Map of Nepal to draw the information on soil fertility of the center.

Based on the soil test report as in Table below, it can be seen that there is not much variation among the different blocks in terms of pH, organic matter and total nitrogen but there is great variation in available phosphorus and potassium content of the soil. This requires due attention on the proper management of potassium. In all, the soil is very good for agricultural production.

Table 4.4 Soil test report

Location	**pH**	**Organic matter, %**	**Total Nitrogen, %**	**Available Phosphorus, Kg/ha**	**Available potassium, Kg/ha**	**Remarks**
Block A	6.05	4.68	0.23	80.15	331.01	
Block B	6.05	5.88	0.29	245.49	241.05	Near cattle shed
Block B	6.19	4.76	0.23	229.92	211.06	Development site
Block C	6.01	5.84	0.29	109.46	510.94	
Mean	*6.075*	*5.29*	*0.26*	*166.255*	*323.515*	

Source: PCDC

The farm has slightly acidic soil pH which is highly suitable for most of the crops and the organic matter content is also under high category. Organic matter is the major constituent of soil that determines soil health. Since, the soil of the farm has more than 5% organic matter, it could be said that soil is healthy enough to sustain crop production and its ecological functions. Total nitrogen content is also under high category, therefore, there will not be any problem on nitrogen management. It is evident from the report that the existing management incorporate high amount of organic matter. Available phosphorus content greatly varies within the blocks but on an average, the available phosphorus content is also very high. Block A and Block C has high available phosphorus. With regards to available potassium, it also varies greatly within the blocks. Block A and Block C have high available potassium and the rest have medium content of available potassium. When we consider the average potassium content, it falls under high category.

In a nutshell, the soil fertility status of PCDC Nigale is very good but due consideration has to be given to potassium management in future, though it is still in good position.

Extracting the data from Digital Soil Map, it is found that the soil has 5.8 pH, 3.85% organic matter, 0.12% total N, 42 kg/ha of available phosphorus and 245 kg/ha of available potassium. The result is at par with soil pH, available potassium and to some extent with organic matter and total N but variation was seen in available phosphorus which Digital Soil Map depicted medium category.

Table 4.5 Data extracted from Digital Soil Map, 2023

Location	**pH**	**Organic matter, %**	**Total Nitrogen, %**	**Available Phosphorus, Kg/ha**	**Available potassium, Kg/ha**	**Zinc ppm**	**Boron, Ppm**	**Sand, %**	**Clay, %**

Nigale Farm	5.72	3.84	0.12	42.1	245.22	2.18	0.82	70.13	10.15

The data from Digital Soil Map shows the soil has more sand and is sandy loam in texture. Based on the percentages provided, the soil can be classified as a sandy loam soil. Sandy loam soils typically have good drainage due to their high sand content, while also retaining some moisture due to the presence of silt and clay. These soils are generally considered productive and easy to work with, as they provide a good balance of soil structure and nutrient availability. Sandy loam soils are commonly used for a variety of crops, including vegetables, fruits, and grains. However, they may require careful management to maintain soil fertility and prevent erosion due to their sandy nature.

Boron and zinc content in the soil is in medium category, care should be taken for micronutrient deficiency which is widespread in Nepalese soil.

4.6 Cropping Pattern

Different varieties of potato crops are grown in PCDC Nigale. The potato-vegetable is the dominant cropping pattern in the open field of the center. The basic potato seeds and TPS are produced in the open field of the center from Magh to Shrawan. The PBS are produced in screen house – first crop from Falgun to Ashadh and the second crop from Shrawan to Mangshir. In-vitro plantlets are produced in two seasons - the first during the spring season (Falgun to Ashadh) and the second during the autumn season (Ashoj to Kartik). These are presented in Table 4.6.

Table 4.6 Cropping pattern

Seed Type	Baisakh	Jestha	Ashadh	Shrawan	Bhadra	Ashoj	Kartik	Mangshir	Poush	Magh	Falgun	Chaitra
Basic Seed in Field				**Harvest**						**Plant**		
TPS Seed					**Harvest**					**Plant**		
PBS in Screen House			**Harvest**	**Plant**					**Harvest**		**Plant**	

In-Vitro Plants in Lab													

The minor crops such as vegetables like cauliflower, cabbage, radish and carrot are grown after harvesting potato seed. Rayo/mustard is cultivated round the year. The center has adopted such cropping pattern to generate revenue to GoN. Buckwheat can also be introduced during lean period of winter season. The calendar of minor crops is presented in Table 4.7.

Table 4.7 Cropping calendar

#	Minor crops	Crop calendar
1	Cauliflower	Shrawan – Poush
2	Cabbage	Shrawan – Poush
3	Raddish	Shrawan – Poush
4	Carrot	Shrawan – Poush
5	Rayo	Round the year

4.7 Financial Resource

The budgetary support, expenditure and revenue of the center are in increasing trend since the last decade. The budget spending capacity of the center looks quite good. The average budgetary support to the center was calculated at Rs. 15.8 million whereas average expenditure was Rs. 13.6 million during the last decade (Table 4.8).

Table 4.8: Budget, expenditure and revenue

Fiscal year	Budget, Rs. '000	Expenditure, Rs. '000	Revenue, Rs.
2069/070	5839	5757.9	376500
2070/071	9349	9293	196495
2071/072	8964	8772	819262
2072/073	9284	8017.3	465983
2073/074	8591	7684.4	479010
2074/075	16915	12726.9	570092
2075/076	16825	13299.8	708435
2076/077	33009	24869	742175
2077/078	22459	18377	1094138
2078/079	26770	25135.40	1831334
Average	**15801**	**13593**	**-**

Source: PCDC Nigale.

The revenue generated from the center is increasing in every year since the last decade. Now (till Chaitra 2079/80), it has reached to Rs. 2.35 million which is very much encouraging and attempts should be made at covering at least direct cost of production of seeds. Narrowing the gap between production cost and revenue is one of the criteria set by Auditor General to evaluate the performance of farm/station operating under sustainable way (Shrestha, et. al., 2021). Thus, future efforts should be geared towards maintaining 1:1 ratio of budget expense (at least direct production cost) to revenue or meeting at least direct costs incurred in the production of source seeds in the center. Use of fallow land for growing other reasonable crops like vegetable during lean period would be one of the strategies to cover expenditure as it is being practiced in this center.

The performance evaluation of farms and centers should not be based only on revenue generation. It should be based on both revenue generation and other benefits or services provided to the farmers and frontline extension workers such as recommendation of technologies, technical services, training, and technical publications to justify the sustainability of the farms and centers.

4.8 Production and Distribution

Generally, traditional potato seed is bulky requiring large area for production and high cost for transportation. In Nepal, road network and transportation facilities are still very poor. Hence, the GoN focus has shifted from traditional seed production/supply to modern biotech and TPS program. In line with this, the center, now, produces five kinds of potato seed as listed below.

- PBS
- TPS
- In-vitro potato plants
- Basic potato seed
- Certified 1 and 2 seed

Table 4.9: Seed production, distribution/sale and price

#	Types of potato seed	FY 2077/78	FY 2078/79	FY 2079/80 target	Price, Rs. per unit FY 2079/80
1	PBS, no. of tubers	28,180	39,000	45,000	16/tuber
2	TPS, kg	8.325	9	10.12	35,000/kg
3	Basic seed, mt	7.432	12	2	75/kg
4	Certified 1 seed, mt	-	-	5	70/kg
	Certified 2 seed (in leased land), mt	-	-	8	65/kg
5	In-vitro, jar (@ 10 plants per jar)	860	2,010	3,000	500/jar

Although, PCDC Nigale has started adopting new technology of potato seed production but the current seed production capacity of the center is very low (Table 4.9). It was mainly due to lack of well-organized and facilitated modern tissue culture laboratory, well facilitated screen houses and permanent expert and assistants for biotechnology.

Table 4.10: Present and future seed production target in the center

#	Seed type	Present status	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
1	PBS, no. of tubers	45,000	150,000	200,000	250,000	300,000	500,000	500,000	500,000	500,000	500,000	500,000
2	TPS, kg	10	10	10	10	10	10	10	10	10	10	10
3	Basic 1 Seed, mt	5	10	12	15	15	15	15	15	15	15	15
4	Certified 1 seed	5	7	10	12	12	12	12	12	12	12	12
	Certified 2 Seed (leased land), mt	8	8	6	6	5	5	5	5	5	5	5
5	In-vitro plants, jar	3,000	4,000	5,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000

Based on available land resources (following the principle of last and least sacrifice on crop growing land) and proposed construction of critical and important infrastructures, the future plan of potato seed production has been proposed. Development of infrastructure has been planned such that all new construction and improvement/strengthening activities will be completed by the fifth year of Master Plan implementation. Hence, a gradual increment on production target of potato seeds (except for TPS) have been proposed in Table 4.12. The demand for TPS has been reported constant since past few years. Hence, the target for TPS has been maintained as in the past i.e., production target at 10 kg every year. The production of Certified 2 seeds will be decreased from the current 8 mt to 6 mt in the second and the third year and 5 mt from fourth year onwards. The center will support farmers to produce these seeds in their own farm. Production of in-vitro jars will be increased from the current 3,000 jars to 4,000 and 5,000 jars in the second and the third year and 10,000 jars from fourth year onward.

4.9 Infrastructure

PCDC, Nigale was visited thrice including pilot testing of study methods as well as pre-testing of semi-structured checklists. The study team used various methods, strategies and measures to gather information about the farm and centers. The existing physical infrastructure in the center are shown in the table below:

Table 4.11: Existing physical infrastructure in the center

#	Physical infrastructure	Quantity

#	Physical infrastructure	Quantity
1	Office building	1
2	Quarter	5
3	Canteen	1
4	Training hall	1
5	Laboratory	1
6	Screen house (including 1 under construction)	6
7	Internal motorable road	1 km
8	Others:	
	Cattle shed	1
	Rustic store	1
	Processing house	1
	Curing house	1
	Dormitory	1
	Cattle feed store	1
	Farm store house	1

The team started observation right from the access road to farm from main highway, farm landscape from distance, main entrance gate and fencing. The observations were also made on physical infrastructures, internal road, drainage, cultivated areas, sources of water, irrigation system, drinking water system, electrification, waste management and waste disposal. The study team visited entire center and physical infrastructures together with center officials. Sites for new physical infrastructures were identified and measurements were taken where needed. Final discussion was held to decide on major aspects to be focused in the Master Plan. The order of infrastructure development in the order of priority (based on minutes of decision made at the center) is presented in Table 4.12 below.

Table 4.12: Proposed list of physical infrastructures in the order of priority

#	Decision Details	Priority Order
1	Construction of wire mesh fence around the farm.	1
2	Construction of dormitory for trainees.	2
3	Strengthening of road from main entrance gate to motor garage.	3
4	Re-electrification in the buildings within the center.	4
5	Construction of plant tissue culture laboratory	5
6	Improvement of existing terraces and making terraces/plots in forested area for the production of seed potato.	6
7	Construction aeroponic house for the production of Pre-basic Seed (PBS)	7
8	Extension and strengthening of existing kitchen.	8
9	Construction of a curing house in Block C.	9
10	Strengthening of rustic store.	10
11	Construction of sales counter.	11

12	Strengthening of training center.	12
13	Reconstruction of farm store house.	13
14	Construction of staff residence and a guest house.	14
15	Construction of cold store.	15
16	Construction of a toilet in Block C	16
17	Installation of CCTV Camera in office building, laboratory and screen house.	17
18	Construction of glass house office room.	18
19	Construction of soil and plant protection building.	19

4.10 Disaster and Vulnerability

Hailstorm, diseases and insect pests occur regularly in this location. A major earthquake occurred in 2015. Hence, the new buildings should follow the required guidelines for earthquake resistant. In 2044/045, the potato production program was stopped due to occurrence of bacterial wilt disease. The disease was brought under control only in 2052/053. The seed potato production program, external service operation program and dissemination of potato cultivation technology resumed at full-fledged state only from 2054/055 onwards.

5 PROPOSED MASTER PLAN

Proper utilization of existing spaces into more planned and efficient space has been the major challenge during preparation of detail master plan of the Potato Crop Development Center at Nigale. It was mainly due to maximization of resource use especially the limited land area.

The existing condition of the site and the surrounding situation of the site were studied. Following factors were analyzed rigorously prior to designing of any structure.

a. Physical condition and landscape of the site,
b. Existing land demarcation,
c. Approach road to the site,
d. Existing water sources,
e. Storm water drain outlet,
f. Solid waste management and disposal system,
g. Electricity and telecommunication lines,
h. Any other features that will impose restrictions or facilities further site planning and design process and building extension, and
i. Features that need to be integrated into the master plan and designing of the building.

Master Plan has been prepared based on situation and need analysis of the Center. As shown in requirements of standard Model of center and on the basis of opinion survey with officials of CAIDMP, officials of PCDC Nigale and experts, the following design concept have been proposed to develop it as "Center of Excellence" as well as a " Research Institute".

- During the preparation of Mater Plan of center, maximum care has been given to incorporate the proposed building in the existing scenario. Since the existing structures are in good and operable condition these buildings are kept as it is and whenever addition of floor is required, building strength has been considered.
- Master Plan of site is prepared in harmony of greenery, water bodies, paved walkways, and vehicle driveway, surface parking spaces with shed and other supporting building.
- The Master Plan has been prepared incorporating surface drainage and sewerage system, water supply system, external lighting system, security system, and other necessary infrastructures.
- A storied new tissue culture lab has proposed to meet increasing demand for various kinds of quality potato seeds and the existing tissue culture lab is inadequate and quite congested.
- Road and pedestrian footpath are arranged as linkage between different zone so that movement of vehicle and people is very smooth, resulting in low conflict between them.
- A sufficient area for parking has been proposed at the side entry gate.

- All facilities such as soil lab, plant protection lab, cold storage, staff quarter, guest house, dormitory, public toilets, standby generator, CCTV, and a landscape garden have been provided in the proposed site.
- A sufficient landscaping has been proposed nearby office building.
- Design of building is prepared in the concept of earthquake resistance.

Table 5.1: Proposed facility with the coverage area

S. N.	Facilities	Quantity	Area (Sq. M)
1	Boundary Wall	1,825 meters length	
2	Plant Tissue Culture Lab	1	177.5
3	Dormitory Block	1 no. (28 people)	194
4	Soil and Plant Protection Lab	1	78.5
5	Library	1	
6	Staff Quarter	1 no. (3 family)	98
7	Farm Toilets	2	30.27
8	Cold Storage	1	401
9	Sales Counter cum Information Center	1	15.5
10	Parking area for four-wheel and two-wheel vehicles	Sufficient area	
11	Provision of fire hydrant	As appropriate	
12	Provision of CCTV	Covering all area	

Figure 5.1: Proposed Master Plan

5.1 Human Resource

The present number and type of staffs in the Center are not adequate to meet emerging demand for quality seed production and scaling-up production. The Center is focusing on modern seed production technology particularly the use of biotechnology, the Biotechnologist is needed. However, demand for such human resource has been met through the recruitment of Biotechnologist on contract. Such arrangement does not guarantee continuity of personnel for long period of time. In fact, the Agriculture Service of GoN does not have faculty (*Samuha*) for Biotechnology. Hence, the Center should take initiative through *Tippani* in making provision of permanent staff recruitment of Biotechnology faculty to the higher authority. Hence, at least two officer level posts of Biotechnologist and the supporting staffs should be created in the agriculture service system together with the provision of promotion and professional development with higher studies and training. In addition, there is a need for an Agriculture Engineer and an Agriculture Extension Officer for the management of development and technology dissemination activities like training, demonstration, visits and linkage development to support development of PCDC Nigale as Center of Excellence. An Agriculture Engineer will facilitate operation, repair and maintenance of farm equipment and other machinery. Similarly, additional support staffs are also needed especially for tissue culture laboratory.

5.2 Land Resource

According to the survey data, the site coverage by the farm land is 53,372.19 sq, m. (104-14-2-2 in ropani-aana-paisa-dam). The area which is nearby approach road is occupied by infrastructures like office, guard house, training hall, staff quarter, canteen etc. The rest part has been used as potato cultivation land. The entire farm land has been proposed to be divided into 6 plots. Construction of additional internal road has also been proposed to have road access in all plots.

Farm plot area is designed based on the contour elevation considering less principle of less disturbance of natural slope. Farm plots have been divided based on the land slope and ease of irrigation application and machinery use. Zoning and proposed plotting plan of farm site is shown as below:

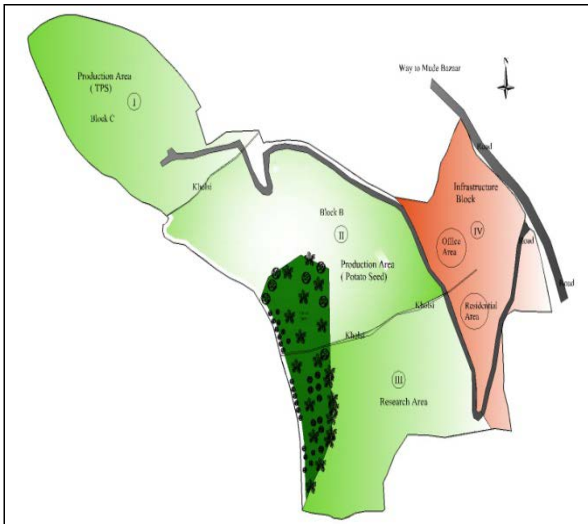
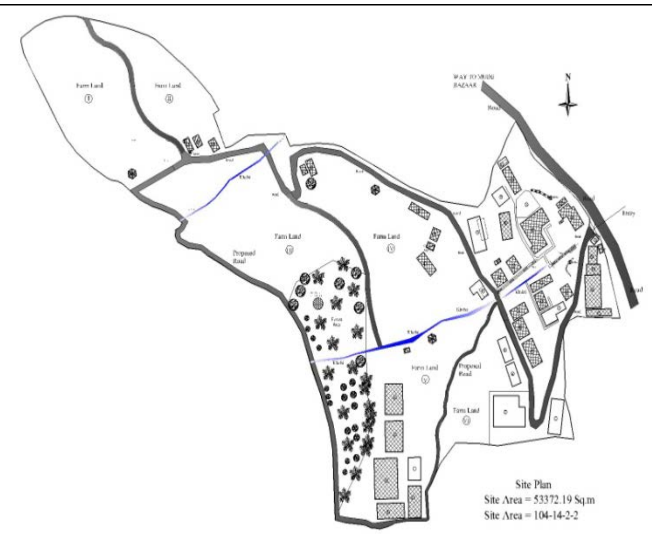
	
Existing blocks	**Proposed plotting plan**

Figure 5.2 Existing blocks and Proposed Plotting Plan

Demonstration Plots

PCDC Nigale is emerging as resource center as well as center of excellence. Hence, some plots will have to be set aside as demonstration plots to demonstrate performance as well as seed cultivation methods of different varieties to trainees, researchers, and visiting farmers and entrepreneurs. Demonstration will have to be done on post-harvest technology like cleaning, grading, packaging and storage.

5.3 Infrastructure Design

Requirements and Facilities of "Standard Model" for the Center.

The requirements and facilities to be provided in PCDC Nigale is governed by the available site area, the volume of transaction, available surrounding, existing facilities, infrastructures, and directives issued by line agencies.

Based on case study, literature review and visit of the center in different places, the consultant has proposed the requirement for the standard model in PCDC, Nigale. Description of these are presented below

a. Farm Road

There is no standard for farm road as prescribed by the Department of Road. Thus, the proposed farm roads have considered the mobility of agriculture machinery like tractor in hill area.

Farm Road	Carriage width, m	Shoulder width, m	Total road way, m
Hill	3	.5	4

b. Irrigation System

Water harvesting structures have been proposed to irrigate potato crop in open field as well as supply Ultra Violate (UV)-treated water in the screen houses. Rain water harvesting will be done from the slopped roofs of the buildings and collected in plastic water tanks. Supplement irrigation through garden pipes has been proposed for meeting water requirement during critical stages i.e., during plant growth stage and tuber shoot formation stage.

Tentative Cost of 5000 lit/h UV Purifier Plant:

1.	Cost of Plant ($ 1000.00 *132)	NRs	13,20,000.00
2.	Transportation Cost and taxes etc	NRs.	265,000.00
3.	Cost for Installation all complete electrical works	NRs.	40,000.00
4.	Cost of shed for the plants	NRs.	50,000.00
5.	Sub-total	NRs	16,75,000.00
6.	Contingency @ 10 %	NRs	1,67,500.00
	Total	**NRs**	**18,42,500.00**

In Words NRs, Eighteen Lacs Forty-Two Thousand and Five Hundred only.

The proposed system is able to filter 5000 liters of water per hour. It needs to be connected with a water tank and screen house. As the UV filtered water is necessary only inside screen house, the connection should be limited to screen house only with a possible extension point.

c. Screen House

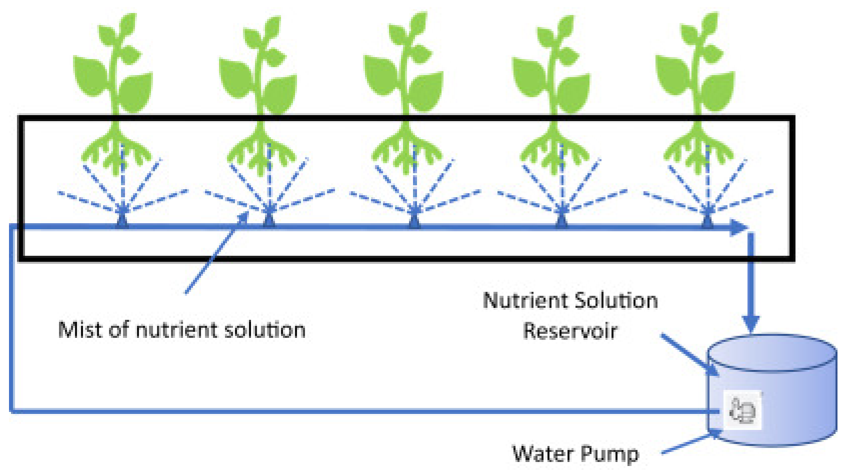
Considering and analyzing trends of the invitro plant sale, Size of screen house are designed. There are already five numbers of screen houses in the proposed farm. Since the forest area is nearby the screen house area, in the proposed master plan, the existing forest area has been deducted to have more land and that land can be utilized to construct more screen houses. To boost crop yields even higher, for the first phase of master plan implementation, only one screen house (coverage area: 127 sq. m) has been proposed.

d. Form

The form of the building is guided by the function of the structure. In the proposed farm center, newly constructed buildings are of rectangular in shape having slope roof.

e. Aeroponic Cultivation of Potato Seed

Aeroponics is the process of growing plants in an air or mist environment without the use of soil or misting the roots with hydroponic solutions, which are suspended in the air. It does not use soil or aggregate medium.



Aeroponics provides crops with much stronger and healthier root systems it has a much higher potential performance than a standard hydroponic system. All aeroponics systems require an enclosure to hold in the humidity and prevent light from reaching the roots (this is typically a plastic bin with holes drilled for each plant), plus a separate tank to hold the nutrient solution.
This system maximizes nutrient absorption while putting less stress on the plant itself, leading to produce that is healthier overall. Plants grown through aeroponics contain higher nutritional value all while having better color, texture, and taste. Studies have shown that plants grown aeroponically can grow five times faster than plants grown in soil. Both aeroponics and hydroponics utilize water rather than soil to deliver the nutrients and oxygen plants require.
In general, aeroponics favors a slightly more acidic environment, somewhere around a pH of 6 with the safe range being anywhere between 5 and 7. The primary nutrients for aeroponics are nitrogen, phosphorus, and potassium and are used by plants in different amounts according to

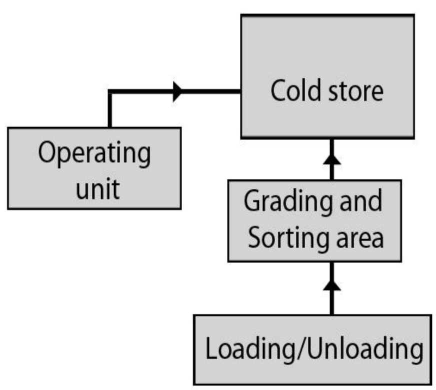
the growth stage. Secondary nutrients are calcium, magnesium, and sulfur, and micro-nutrients are iron, zinc, molybdenum, manganese, boron, copper, cobalt, and chlorine.
In general, following tools are required for aeroponics.

- A container/reservoir to store the nutrient solution.
- Mist nozzles.
- Nutrient pump.
- Baskets to suspend plants.
- Tubing to distribute water from the nutrient pump to the mister heads.
- An enclosed growing chamber for the root zone.
- Timer to turn the pump on and off.

High pressure aeroponics require a pump that can produce enough to pressurize the water to produce the ideal droplet size of 20 to 50 microns. These pumps are generally diaphragm pumps or reverse osmosis booster pumps. The pump must produce a steady 80 P.S.I. at the required nutrient flow. Water temperature should be kept between 68-72°. The lower the water temperature, the more oxygen the water holds and the less chance there is of harmful bacteria, fungi and pathogens breeding (which can infect the clones and kill them before they root).

f. Cold Store

Seed potatoes are best stored in cold store maintained at 2-4°C. However, controlling carbon dioxide is also important as much as cold room temperature and humidity control in cold storage. A cold storehouse of 50 mt to store potato seed has been designed as per projection for potato seed production. It is of one-story building having Receiving Area, Grading and Sorting Area, Pre-cooling Room, Office Room, Ante Room, Cold Chambers, Dispatched Area. Plinth area is about 400 sq. meter and stone texture has been proposed for facade treatment. Basic layout of cold storage has been schematically presented below.



g. Sales Counter cum Information Center

For the ease of buyers and others, sales counter cum information center has been proposed to facilitate farmers, entrepreneurs and other people to obtain information about PCDC Nigale, services from the Center, and varieties, quantity and price of potato seeds. The seed counter cum information center will display and distribute posters, pamphlets, leaflets, booklets and samples of potato seeds. Billing will be done from this counter.

h. Shed for Machinery and Transit

Machinery sheds area designed considering the possible number of machineries needed for demonstration and for farm use. Transits shed are designed for collecting agricultural products and as a resting place for farm workers and employees. There is a necessity of sheds in different location so that farmers can take rest for a while after doing hard work as well as to protect them from rain, wind, sun hazards. There is already one shed at Block C. Therefore, only one hexagonal type shed having 15.5 sq. meter area has been proposed in the farm center which is nearby the screen house area. All these sheds will have electrification.

i. Compost Pit

A modern compost pit has been designed for making compost manure from plant and degradable farm wastes. In this method, composting materials are allowed to decompose in a pit or trench. This method is suitable for dry or cold areas like Nigale. There is existing compost manure at Block B. The pit will have roof with corrugated sheet.

j. Boundary Fences

The old barbed wire around the boundary of the center has been fallen in several places. Based on past experiences of the center and considering the sloppy terraced landscape, a galvanized wire mesh compound wall with concrete base has been proposed. The center has already built such structure in about 175 meters length and the new construction will have to be done in about 1,825 meters length. The minimum height should be of 5 feet. Compound wall or fence prevents the trespassing of ordinary people, stray and wild animals inside the premise of the centers.

k. Guard Room

There is an existing guard house nearby the main entry gate. This existing block is of one storey having area of about 69 sq. meters with slope roof. Guardroom has been kept in the strategic location i.e., at the main entrance of the center.

l. Rustic Store

Seed potatoes should be stored such that they are safe from moisture, heat, insects, rats and microorganisms. They have to be stored until they are sown in the field in the next season. A rustic store already exists in the Center. However, potato seeds cannot be stored for longer period in this rustic store. Some defects have been detected in the rustic store. Such defects mainly include lack of ventilation in the roof. The exhaust fan has been sealed with fiber glass. Such fiber glass should be replaced with steel wire mesh. The fan installed in the ceiling is sending back hot air risen in the ceiling to the potato seed stored. It should be removed. In addition, the store lacks adequate light. Some transparent glass fiber needs to be placed on the roof. It is also recommended to install some zero energy exhaust roof fans for the continuous vent of hot air from the rustic store.

m. Plant Tissue Culture, Soil and Plant Protection Labs

There is growing demand for biotech/tissue culture crops globally because of their enormous benefits to the environment, animal and human health, and improvement of global food security, sustainability, and climate change mitigation. Biotech crops also increase crop productivity, help conserve biodiversity, provide better environment by saving on pesticide use and reducing CO_2 emissions, and help alleviate poverty by uplifting the economic situation of small farmers and their families.

There is already one Tissue Cultural Lab in the proposed site. However, that lab has some issues so another advanced lab has been proposed. The proposed tissue lab is of 2-storeys having tissue related lab in ground floor and library, store is in first floor. Separate entrance for each floor has been designed considering the contamination issues. This block is of rectangular in shape, slope roof having plinth area of 177.5 sq. meter. In Plant Tissue Culture Lab, there are rooms like reception, pantry, changing room, sanitization area, Media Preparation Room, Autoclave and Sterilization Room, Transformation room, Utensil Store Room, Growth Room. All sensitive rooms have fixed glass window and insulated doors.

Labs like soil lab, plant protection lab are necessary in the center. Crop protection helps to keep plants healthy and maintain sustainable yields. Soil testing is to provide an accurate assessment of the soil fertility to make fertilizer recommendations. Soil test reports generally provide with appropriate fertilizer application recommendations for nitrogen, phosphorous, potassium and lime. Soil testing also allows for determining the micronutrient requirements of crop. Similarly, regular survey and surveillance of insect pests and diseases is needed to produce healthy seed. Establishment of modern tissue culture, soil and plant protection labs have been proposed in the Center. This block is of 2 storeys having Soil Lab in ground floor and Plant Protection Lab in first floor. Plinth area is about 78 sq. meters. To maintain the uniformity with other buildings of existing site, the proposed block has been designed having slope roof with stone texture in exterior walls.

n. Training Hall

Trainings improve farmers' and entrepreneur’s skills and knowledge in areas such as planting techniques, agronomy, irrigation, pest management, harvesting, grading, storage, packaging transportation etc. These skills enable farmers to improve production and productivity, protect their seeds against weather-related shocks, and smooth their incomes year-round. Therefore, to transfer the latest technology to the farmers as well as others, training hall with required facilities is very important for the center. Strengthening of existing training hall has been proposed.

There is an existing training block near by the administrative building where 25-30 people can have training at once. This existing training block is of one storey having area of about 134 sq. meters with slope roof. Since the area of this block cannot be extended, interior part can be modified to have well equipped training hall i.e., digital screen, nesting chairs, conversion of cement punning flooring into wooden flooring etc.

o. Toilet

This block has been proposed in two locations i.e., at C block and at back side of canteen area. This block is designed with separate male and female toilet having basic requirement. Female toilet has two nos. of water closet and wash basin whereas male toilet has one nos. of water closet, 3 urinal and 2 wash basins. Plinth area is about 30 sq. meter.

p. Canteen

Canteen is one of the basic requirements where office staffs, farmers and visitors can be refreshed and take rest for some time. There is an existing canteen block at north side of proposed farm center. This existing block is of one storey having area of about 96 sq. meters with slope roof. However, to serve 25-30 people at once, the dining area of canteen is not quite enough. Hence, existing canteen block should be modified i.e., especially layout of the kitchen and dining. Kitchen should be of modular type. Dining area should be spacious to accommodate up to 30 people at once. So, the internal partition wall should be removed to have more space.

Since the existing canteen block coverage area cannot be extended, sit out block having 81 sq. meter area nearby canteen block has been proposed where up to 50 people can have meal at once.

q. Guest House/ Dormitory Block

The primary function of the Guest House/ Dormitory block is to provide the space for the guest/trainees for accommodation for short duration at reasonable price. The local farmers as well as other people come to the Centre from various places for training and purchasing seed. For some people it will be late to return back to their home. Hence, Guest House/Dormitory block have been proposed within the Center for them to rest for short time or for a night.

This block is of 2 storeys having ground and first floor is for dormitory (14 nos each floor). In case of dormitory, 10 rooms are 2-bedded and two rooms are 4-bedded. There is a common room, ladies and gent's toilet also in ground and first floor. This block is designed having slope roof with stone texture on facade to maintain the uniformity. And also, the block is of rectangular in shape having plinth area 194 sq. meter.

r. Staff Quarter

Staff quarter is useful for the office staff. Staff quarter does not only save time and money for daily travelling but also increases work efficiency.

The proposed site has already 7 nos. of staff quarters. However, that number does not meet the required target. Therefore, another staff quarter block has been designed. New block is L-shaped building having slope roof with plinth area of 98 sq. meter. There is a living room, kitchen, attached toilet and bedroom in each quarter. Altogether there are 3 nos. of staff quarter in this block.

s. Sewerage and Drainage

Sewerage and drainage system are necessary and basic infrastructure for the center. Drainage should be managed well and regularly to improve the environmental situation. This infrastructure will be provided as per engineering point of view in the Center.

In case of sewerage system, there is the provision of Septic tank to collect toilet waste whereas for the collection of organic and other waste, space has been allocated for the disposal of garbage. The waste has been self-managed.

Separate waste management space with fencing and gate is kept in farm land. Regular cleaning of proposed area, collection of waste and transport to collection yard will be the responsibility of PCDC. Degradable and safe wastes will be used for the preparation of manure

t. Water Facility

Facility for drinking water is one of the most important factors for people living in the farm as well as for plants for irrigation. It can be used as drinking water, for sanitation and cleaning toilet and in the laboratories. The seed quality is uncertain and is generally reduced tremendously in the absence of assured water supply through irrigation. This will raise questions on the sustainability of center. Water should be available for 24 hrs.

There is a RVT and water tank at a corner of the site. To run the proposed modern tissue culture laboratory, for irrigating plants and for the use of officials working and living in the center, existing water supply is not sufficient. Hence, deep boring has been proposed.

u. CCTV with Street Lighting

CCTV is essential for the security of the farm land as well as office building. For security of the farm land during night as well as day time, CCTV facility will be provided in the proposed site. This provision enables the sense of security in every aspect. In addition, street lighting has been proposed only in critical areas (mostly in turning points and adequately in office and residential areas) which facilitates movement of people and vehicle but does not affect so much on natural system such as movement of nocturnal creatures. The electric poles have been proposed at every 25 meters interval along the sides of internal road.

v. Cross-ventilation in the buildings

Cross ventilation is one of the most important aspects of building. The orientation of building, height of room and other ventilation friendly architectural details will be considered while planning and designing of buildings in the center.

5.4 Disaster and Vulnerability

From the earthquake point of view, the proposed buildings are designed as low-rise building. Proposed block like cold store, staff quarter, public toilet, sit out area, sales counter is one storey building whereas soil and plant protection lab block, tissue culture lab are two storey buildings. In addition, dormitory block is two storey building. The existing buildings need renovation to resist earthquake. Lightning is another dangerous disaster that occurs in the Center or nearby the Center. So, all the measures should be carried out to make the Center safe from lightning.

5.5 Business Model of the Center

Business model of PCDC Nigale has been developed based trend analysis of area, production and yield of potato, supply of potato seed, current and emerging issues related to potato seed demand and supply, and problems and constraints faced by PCDC Nigale for the expansion of its capacity. There is increasing trend in production and yield but decreasing trend (y = -394.84x + 197396) in area (Figure 5.3). Hence, enhancing productivity through the adoption of modern technology is one of the important strategies in potato crop production. Disease free quality seed can be produced with the adoption of modern technology.

Trend Analysis of Potato Area, Production and Yield

Trend analysis shows negative trend for area, positive but nominal increment for production yield (please see figure below). The competing uses of land for other purposes is exerting tremendous pressure on land area for potato. In such scenario, infrastructures which support attainment of higher yield is necessary. Adoption of biotechnology is essential to attain higher production and productivity from limited land. Hence, establishment of a well facilitated modern tissue culture laboratory has been proposed in addition to other infrastructures which support for expanding the capacity of PCDC Nigale and its human resources.

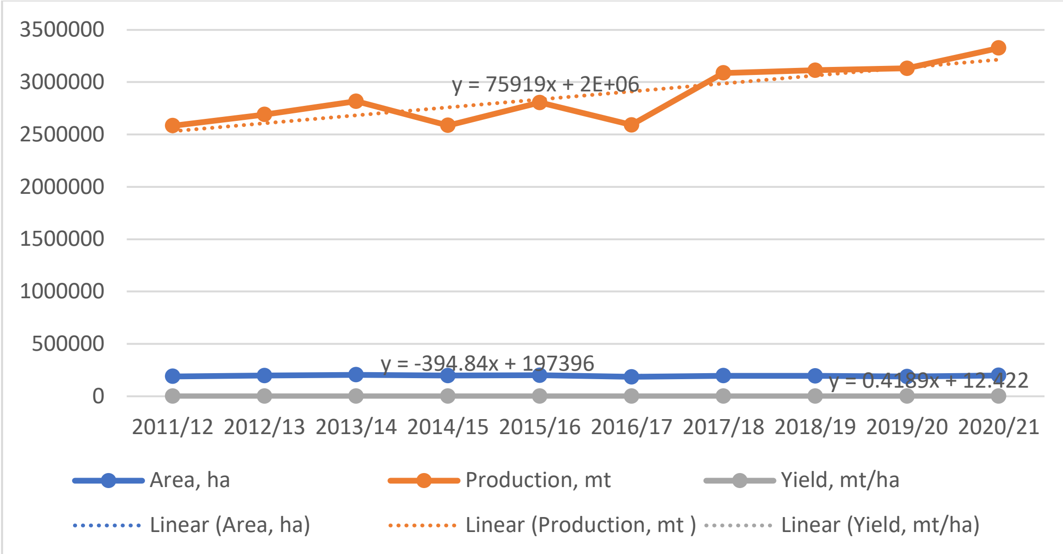


Figure 5.3: Trend in potato area, production and yield in the last 10 years

Analysis of Demand and Supply Gap

Nepal being a hilly and mountainous country with difficult road access and substantially high cost of transportation, and other benefits of tissue culture seed materials as mentioned earlier in this report, the importance of PBS, in-vitro plants and basic seed is extremely high. However, there is a wide gap between demand and supply of such potato seed. The current demand for PBS is estimated at 1,100,000 tubers but the supply is only 450,583. The gap for PBS is 649,417 tubers. The capacity of PCDC, Nigale will be increased from the current 45,000 PBS tuber production to 500,000 PBS tuber after improvement of its capacity. This will meet about 77% of unmet demand of 649,417 PBS tubers.

Table 5.2: Production/supply of potato seed in Nepal

#	Potato seed producing organizations	In-vitro, plant bottles	PBS, no. of tubers	Basic seed, mt	Certified 1 seed	Certified 2 seed	TPS, kg
1	Nepal Agricultural Research Council, Khumaltar	50000	200583				
2	Potato Crop Development Center, Nigale	1000	40000	5	5	10	10
3	Private sector		200000				
Total		**51000**	**440583**	**5**	**5**	**10**	**10**

Sources: NPRP (National Potato Research Program). 2018. Annual Report (2017/18). NPRP, Nepal Agriculture Research Council, Lalitpur, Nepal.
Interaction with PCDC Nigale officials in March 2023.

The center is severely constrained with land to produce TPS and basic seeds. Therefore, the center is renting about 12 Ropani of land to meet some of such unmet demand. Hence, PCDC Nigale was recommended to explore possibility of purchasing adjoining lands during FGDs and KIIs. Similarly, the PBS seed production has been constrained due to inadequate screen houses and lack of well-equipped and well-facilitated modern tissue culture lab and human resources.

There is wide gap between the national demand for all types of potato seed (please see table below). The center has been severely constrained with land to produce TPS and basic seeds. Currently, the center is renting about 12 Ropani of land to meet some of such unmet demand. Hence, PCDC Nigale was recommended to explore possibility of purchasing adjoining lands during FGDs and KIIs. Similarly, the PBS seed production has been constrained due to inadequate screen houses and lack of well-equipped and well-facilitated modern tissue culture lab and human resources.

Contribution to meeting national demand from PCDC Nigale after implementation of Master Plan ranges from less than 1% for certified 1 and 2 to 20% for in-vitro, 33% for PBS, and 50% for TPS production (Table 5.3). It will have considerable multiplier effect on production and productivity of potato in the country. The current national demand has been mentioned based on discussion with PCDC, Nigale.

Table 5.3: Demand and supply/production of potato seed in Nepal

Type of seed	**Current national demand***	**Current national supply**	**Additional supply by PCDC Nigale after DPR**	**National demand met by PCDC after Master Plan, %**
In-vitro, Jars	20,000	51,000	10,000	50
PBS, tubers	1,100,000	450,583	500,000	45
Basic seed, mt	-	5	15	-
Certified 1 seed, mt	40,000	5	12	0.03
Certified 2 seed, mt	90,000	8	5	0.001
TPS, kg	20	10	10	50

Implementation of PCDC Nigale proposed Master Plan is expected to meet about 50% national demand for In-vitro jars, 50% for TPS, 45% for PBS, 0.03% for first generation seed, and 0.001% for second generation seed (please see table above). It will have considerable multiplier effect on production and productivity of potato in the country. The current national demand has been mentioned based on discussion with PCDC, Nigale. It is recommended that the center explore possibility of purchasing or renting private land adjoining the center.

Costing and Pricing of Potato Seed

Realistic pricing is crucial for the viability and wide adoption of the technology. Adoption of biotechnology seeds by poor and smallholder farmers will be very low if the price is very high. Hence, detail pricing should be done so that it will help to find areas where cost can be reduced. The pricing of different kinds of potato seed by NARC and PCDC Nigale has been presented in the table below.

Table 5.4: Pricing of potato seed in NARC (2017/18) and PCDC Nigale

#	Seed type	NARC Khumaltar price, Rs. unit	PCDC, Nigale price, Rs. /Unit
1	**PBS grade:**		
	>5 g size	15/tuber	16/tuber
	>1 g size	12/tuber	
	0.5-1 g size	10/tuber	
	0.25-0.5 g size	2/tuber	
	<0.25 g size	1/tuber	
2	**In-vitro plantlets:**		
	In-vitro (single plant)	17/plant	
	In-vitro (test tube)	200/test tube	
	In-vitro (jam bottle)	500/jar	500/jar
3	**Basic seed:**		75/kg
	Basic-1	70/kg	70/kg
	Basic-2	65/kg	65/kg

Sources: NPRP (National Potato Research Program). 2018. Annual Report (2017/18). NPRP, Nepal Agriculture Research Council, Lalitpur, Nepal. Interactive meeting with PCDC, Nigale officials.

Increasing production of seed does not guarantee sale. Hence, promotional activities will have to be undertaken by PCDC Nigale to avoid undesired storage and loss of valuable resource and a great loss in revenue. The current revenue from the sale of basic potato seed is Rs. 379,806. The possible bridges for the gap are presented below.

Product Line Gap Strategy: In order to fill this gap, introduction and production of new and potential species/varieties of potato seed should be given high priority. For example, the demand for chips and French Fry or finger chips potato is increasing due to increasing demand from the increasing number of restaurants, party palaces, resorts and hotels together with increasing preferences of consumers towards fried potatoes. The potatoes produced in Nepal break during frying. Hence, efforts should be made at introduction (research and development) of chips and French Fry or finger chips potato species or varieties in the center. Russets are best for French fries.

They are dense and have less moisture, which is key to avoiding soggy fries. This mealy potato is high in starch and low in moisture which makes them absolutely delicious for Frenkch fries. The high starch content in russet potatoes makes for a fluffy baked potato. Russet potatoes are floury, incredibly fluffy and their pale-yellow flesh turns a wonderful golden brown when fried. They are rich, creamy and sweet and taste like they've already been buttered. Agria, Lady Amarilla, Lady Britta, Lady Jo, Premiere, Atlantic, Endeavour, Ranger Russet (USA) and Pink Lady (USA) are suitable for chips. Yukon gold potatoes are all-purpose potatoes that can be used for frying.

Distribution Gap Strategy: This gap can be filled by expanding distribution coverage. The market of produced seeds can be expanded through publicizing the products in various agro-fairs, distributing free samples in potential pockets, advertising in social media, national/regional print and audio/visual media, entering into contractual arrangement with the distributors. Coordination with local governments, PMAMPs and the AKCs can also be another strategy as they have demonstration programs and distribution of potato seeds in subsidy.

Change Gap Strategy: For this strategy, the center needs to encourage nonusers try the seed and encourage existing users to use more. Free technical support with the seed can be another strategy to attract the non-users. Therefore, an extension officer has been proposed for this purpose together with implementation of other activities like training programs, field level problem based practical trainings, and motivational visits to the successful production pockets. These will encourage the existing users to plant more biotech seeds. Policy reforms for land consolidation can be another strategy to attract producer farmers as well as large corporate house to establish new potato pockets, blocks, zones and super zones.

Competitive Gap Strategy: This gap can be filled by improving the centre's position through taking extra market share from existing competitors especially the importers. The center may itself run the subsidy program in biotech potato pocket and block establishment thereby attracting the producer farmers and entrepreneurs. Improvement and/or establishment of supportive facilities like soil, plant protection laboratories, and training facilities within PCDC Nigale could also improve center's market share thereby luring end users to get extra services from one or the same place.

Organizational Management and Capacity Development

Capacity development is crucial for improving farm efficiency, profitability, sustainability and for achieving objectives of the Center. Capacity development includes training, education, and exposure activities to change knowledge, skill and attitude of the office staffs. It also involves partnerships with universities and research institutions to provide technical support and capacity enhancement. Employees need technological knowledge and skills to successfully work with any new devices or machinery. Furthermore, the organizational re-structuring particularly addition of biotechnologist and supports staffs, extension officers and soil and plant protection laboratories should be added in PCDC Nigale.

Policy, Regulatory Framework and Budget

The government should implement policies that promote the adoption of modern technology, encourage private-public partnerships, develop and strengthen capacity through training and education, create favorable market conditions, implement sustainable practices, and offer financial incentives.

It is recommended that the government prioritize investment in modern technology and equipment as well as research and development in the Centre. Additionally, the government should ensure that adequate training and extension services are provided to the farmers to improve their skills and knowledge on improved farming. It is also recommended that favorable policies are developed to support sale and distribution of biotech seeds and products as well as enhance infrastructure and transportation facilities.

Coordination and Effective Linkage

The gap analysis found weak coordination and lack of linkage among multi stakeholders. There are different mechanisms developed for coordination and linkage among multi stakeholders to achieve Centre's objectives.

The study team has felt the importance and mechanism of coordination for agriculture sector development among three tiers of government in Nepal. Vertical policy coordination can be maintained by establishing and coordinating National Agriculture Technical Working Group (NATWG), Provincial Agriculture Technical Working Group (PATWG) and Sub-provincial Agriculture Technical Working Group. Also, strong horizontal coordination among NARC, academic institutes, provincial agriculture ministries, provincial agriculture directorates, agri-business, AKC, and private service providers is required for the technology verification and dissemination after generating technology from research organizations.

Schedules 5 to 9 of Constitution of Nepal have defined the powers or jurisdictions or ToR of federal, provincial and local governments. It requires high level of horizontal and vertical coordination.

Mechanization and Automation

The replacement of human task with machine is normally considered as mechanization. Currently only about 40% of the farm works are mechanized and remaining 60% works are performed manually. PCDC Nigale has high potentiality for mechanization and automation. Full mechanization with automation system will reduce the operational cost thereby increasing the farm productivity and profitability. The benefits associated with automation are reduced manual labor cost, improved product quality, less hazardous working environment, reduced production cost, increased market value and improved professional esteem. Hi-tech greenhouses with automation facilities should be added in the farm as a demonstration and training centers for farmers and entrepreneurs.

Output based Incentive Model

In FY 2079/80, total cost of production (as expenditure) was Rs 38 million and revenue collected from the farm was Rs. 2,346,414. Currently, farm employees and manager do not have incentive to produce more and lower the cost of production. In addition, working time in the farms and center is more than any other government offices. In such situation government farms and centers are not the preferred institutions for government employees to work. Following incentive schemes have been proposed to increase production and productivity of the farm/center. The explicit strategy of the proposed schemes is to increase profitability and the implicit strategy is to reduce the cost through work efficiency. This strategy directly benefits to government as well as employees and indirectly to farmers in terms of their increased access to quality seed and increased production and productivity. Four types of schemes have been proposed with attainment of defined profit levels as a condition to get part of profit as incentive to the manager/chief and employees of the farm/center. The proposed schemes, conditions and incentives are schematically presented below.

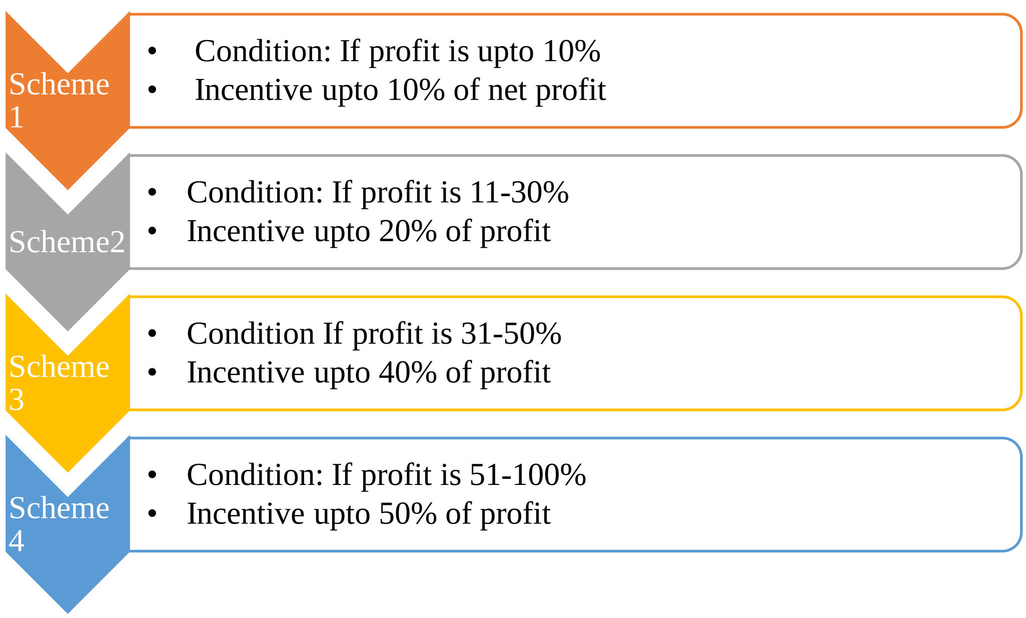


Figure 5.4: Details of proposed schemes

Large Seed Producer Model

The capacity of government farms and centers is highly constrained in scaling-up seed production at large scale. The major constraining factors are availability of land, source seed, human resource and budgetary provisions. Hence, incentive plan to encourage private entities like large seed producer farmers, farmer groups, cooperatives and companies to produce seed in large area and quantity has been proposed. Incentives such as availing source seed, technical support on regular basis, linkage development with the market, and machinery and equipment will attract large seed producers in potato seed business.

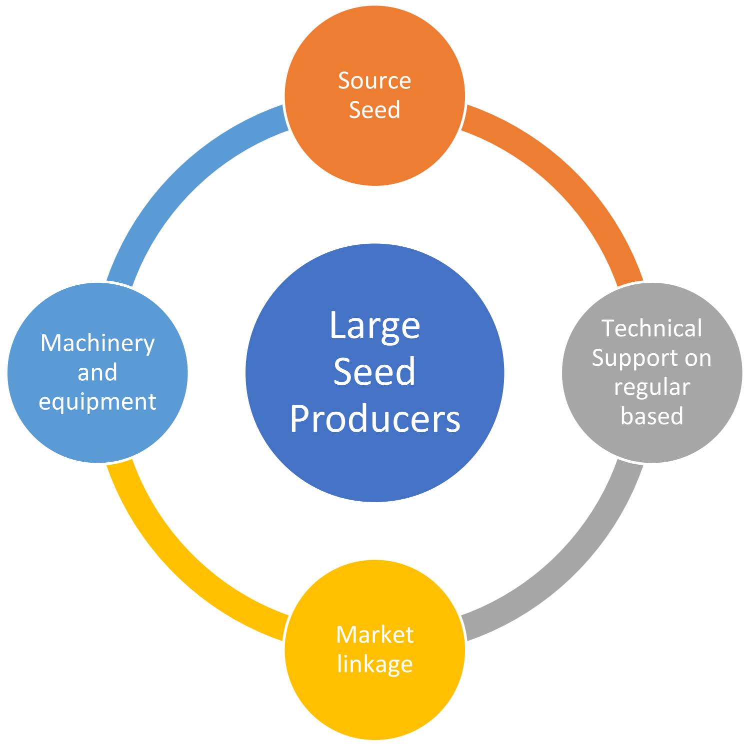


Figure 5.5: Large seed producer model

More specifically, the incentives to such entities should include the following.

- Guaranteed supply of quality source seed,
- Training on seed production and post-harvest technology,
- Scheduled technical advice,
- Scheduled field supervision,
- Facilitation for access to subsidy on tools, equipment, machinery and storage,
- Facilitation to access credit in banks and financing institutions,
- Facilitation for insurance of seed production, and
- Facilitation to link markets including Agriculture Inputs Company Limited (AICL), AKCs, PMAMP and other projects to sale seeds produced.

This will increase the demand for source seed as well as increase seed production and distribution to increase SRR. The resultant effect is on production, productivity and food and nutrition security.

Small Farmer Scheme

In Nepal, about 52 percent farmers are smallholder farmers who own less than 0.5 ha of cultivated land. Such smallholder farmers should also be supported to have larger impact on the economy. Studies have found that smallholder farmers are efficient producers. A package of supports in seed, training, subsidy, technology, post-harvest, and market linkage will enhance their capacity to increase seed production.

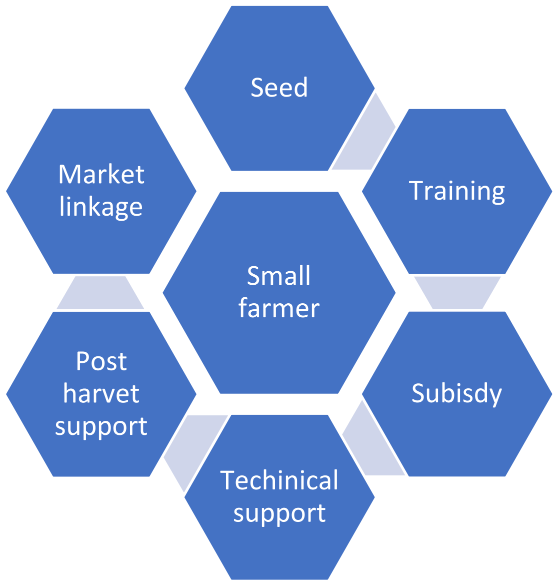


Figure 5.6: Small farmer model

Financial Analysis

Financial analysis of the Center has been done based on data obtained from PCDC Nigale and NARC. These data mainly included price of potato seeds, production target, and cost of infrastructures. Prices of potato seeds (Table 5.5) have been used to calculate the benefit or cash inflow from the sale of potato seeds. NPV and IRR have been calculated to carry out the financial analysis.

Table 5.5: Price of potato seeds

#	Type of seed	Price
1	PBS, Rs. /Tuber	16
2	In-vitro, Rs. /Jar	500
3	Basic seed, Rs. /Kg	75
4	Certified 1 seed, Rs. /Kg	70
	Certified 2 seed, Rs. /Kg	65
5	TPS, Rs. /Kg	35,000

Above listed price has been considered to calculate the benefit from the sale of the potato seed.

Farm operation model has been prepared at least for 10 years based on current and future potential of major farm products and available resources. This includes current status and 10 years production plan. The focus has been on increasing PBS, in-vitro plants and basic seeds. Since the demand for TPS has remained stagnant since some years in the past. Hence, its production has been fixed at base year 2078/79 production i.e. 10 kg annually (Table 5.7). The production of PBS has been increased from the present 45,000 tubers to 500,000 tubers, in-vitro jars from the current or base year 3,000 jars to 10,000 jars, and basic and certified 1 and 2 seeds from the current 18 mt to 32 mt. annually. Such drastic increase (233 to 1011%) in production of different kinds of potato seed (except TPS and Certified 2 seed) is expected to directly impact on increasing supply of source seeds and production and productivity of seed potato and table potato in the country. As mentioned earlier production of TPS will be maintained at current level and production of Certified 2 seed will be done thorugh faemrs instead of PCDC Nigale. Table 5.6 gives the all types of potato seed production target of PCDC for 10 years. ‘0’ year is considered as base year i.e. 2078/79.

Table 5.6: Seed production target

Year	PBS, no. of tubers	In-vitro, jars	Basic seed, mt	Certified 1 seed, mt	Certified 2 seed, mt	TPS, kg
0	45000	3000	5	5	8	10
1	150000	5000	10	7	8	10
2	200000	7000	12	10	6	10
3	250000	10000	15	12	5	10
4	300000	10000	15	12	5	10
5	500000	10000	15	12	5	10
6	500000	10000	15	12	5	10
7	500000	10000	15	12	5	10
8	500000	10000	15	12	5	10
9	500000	10000	15	12	5	10
10	500000	10000	15	12	5	10

Cash flows or benefit from the seed sale has been presented in Table 5.6. The cash inflow from the sale of PBS, in-vitro and basic seed ranges from Rs. 3.5 million in base year to Rs. 17 million from year five to 10th year.

Table 5.7: Benefit or cash inflow from seed sale/distribution

Year	PBS, no. of tubers	In-vitro, jars	Basic seed, mt	Certified 1 seed, mt	Certified 2 seed, mt	TPS, kg	Total cash flow, Rs.
0	720000	1500000	375000	350000	520000	350000	3815000
1	2400000	2500000	750000	490000	520000	350000	7010000
2	3200000	3500000	900000	700000	390000	350000	9040000

3	4000000	5000000	1125000	840000	325000	350000	11640000
4	4800000	5000000	1125000	840000	325000	350000	12440000
5	8000000	5000000	1125000	840000	325000	350000	15640000
6	8000000	5000000	1125000	840000	325000	350000	15640000
7	8000000	5000000	1125000	840000	325000	350000	15640000
8	8000000	5000000	1125000	840000	325000	350000	15640000
9	8000000	5000000	1125000	840000	325000	350000	15640000
10	8000000	5000000	1125000	840000	325000	350000	15640000

Cash outflow (COF) and cash inflow (CIF) analysis has been done to judge the investment from the financial point of view. Major construction costs which are directly linked in enhancing production of potato seed has been considered as COF. Cost of construction of plant tissue culture lab, cold storage and electrification has been included in such cost. The COF is estimated at Rs. 44 million. Similarly, CIF was calculated based on production target and price of seed. The CIF ranged from Rs. 2.5 million in base year to 17.9 million from fifth to tenth year (Table 5.8). Net cash flow was calculated by subtracting COF from CIF. Finally, Net Present Value (NPV) and Internal Rate of Return (IRR) were calculated based on CIF, COF and net cash flow. Most commercial banks in Nepal charge an interest rate (or cost of capital) of 10% for agriculture business. Hence, this interest rate was taken for financial analysis.

NPV calculates the present value of cash flows (inflows and outflows) of an investing using the cost of capital as an appropriate discounting rate. Mathematically, NPV can be described in the equation given below.

$$\mathbf{NPV} = \frac{\mathbf{R_t}}{(\mathbf{1} + \boldsymbol{i})^{\boldsymbol{t}}}$$

Where,

NPV = Net Present Value
Rt = Net cash flow at time t
i = Discount rate
t = Time of cash flow

Similarly, IRR is the rate of return at which the sum of discounted cash inflows equals the sum of discounted cash outflows. In other words, IRR is that discount rate at which the NPV of an investment is zero. Mathematically, IRR can be described in the equation given below.

$$\mathbf{NPV} = \mathbf{R1} + \frac{[\mathbf{NPV1} * (\mathbf{R2} - \mathbf{R1})]}{(\mathbf{NPV1} - \mathbf{NPV2})}$$

Where,

R1 = Lower discount or return rate
R2 = Higher discount or return rate
NPV1 = Higher NPV
NPV2 = Lower NPV

Both NPV and IRR were calculated by using financial function of Microsoft Excel in the computer.

Table 5.8: Benefit from seed sale/distribution

Year	Cost or cash out flow (COF), Rs.	Benefit or cost inflow (CIF), Rs.	Net cash flow, Rs.
0	49617266	3815000	-45802266
1		7010000	7010000
2		9040000	9040000
3		11640000	11640000
4		12440000	12440000
5		15640000	15640000
6		15640000	15640000
7		15640000	15640000
8		15640000	15640000
9		15640000	15640000
10		15640000	15640000
Rate	10%		

IRR: 22.23%

NPV: Rs. 31,807,861

The NPV was estimated at Rs. 31,807,861 and IRR 22.23%. Since NPV is positive and IRR is greater than going interest rate, the investment on Master Plan is highly justifiable.

5.6 Environment Plan

Food production causes large environmental impacts. The environmental impact of agriculture involves impacts on different factors such as soil, water, air. Agriculture contributes to a number of environmental issues that cause environmental degradation. Environmental degradation has significant impact on society and economy and it is hard to quantify. These impacts have long-lasting effects on communities, economy and it is very challenging to restore or repair on its previous form. Agriculture practices and farm center are also leading source of pollution in many countries. Agriculture farms and centers have various environmental impacts which are discussed below.

PCDC Nigale is facing the problem of irrigation. The constant source of water for irrigation should be managed either from deep boring or from rain water harvesting or new study should be carried out to find out water source for the Center. The existing source of water i.e. from nearby stream is not sufficient in dry season since the water discharge is very low. This water is also used by local people of Mude area. Till date there is no any dispute between local people and the Center regarding water use. But if water uses issues arise at any time, first priority should be given to the local people. During monsoon season discharge is high.

Use of plastic in such agriculture farms and centers is usual and frequent for making plastic tunnels, mulching, nursery, packing etc. Moreover, environmental effects of plastic is damaging to soil health, microorganisms and beneficial organisms like earthworms. Plastic used in agriculture is hard to recycle because of contamination by agricultural chemicals. For mulching and others activities, biodegradable material should be used in order to decrease the use of plastic in such Centers.

Soil degradation is also one of the environmental factors noticed in the farms and centers. The common problems associated with soil degradation is water logging, compaction, and erosion. During pre-monsoon and monsoon seasons water logging and soil erosion is usual and frequent in this Center and it is nexus with draining out of topsoil from this area. To reduce the soil erosion, proper drainage system and water energy releasing techniques should be adopted and soil should be enriched with the organic matter to protect the soil surface from drying out. Utis is found in the periphery of this area which is quite common in hilly areas of Nepal.

The expansion of Center is very difficult because of social problems. Market area is increasing in the periphery of this Center. Public are unwilling to give their land since some of the public have limited land, some expect very high price and some others don't want to sell their ancestral land. So, one of the options to expand cultivated land is to cut down the trees located at the lower periphery of the Center. More importantly, the existing forest area is shading the screen houses which is not desirable. Legal formalities should be initiated to remove at least one third of the forest trees. The land should be levelled well to bring it under cultivation.

Some wild animals were reported damaging potato crop inside the Center. To monitor the entrance of wild animals, CC camera will have to be installed in strategic locations. In addition, wire mesh boundary has been proposed throughout the boundary of the Center. This will also minimize loss of standing crop by the wild animals.

Poor ventilation has been observed in many structures of the Center. Provision for proper ventilation should be made in especially in rustic store and plant tissue culture laboratory. Poor ventilation in laboratory is hazardous to health as well as lab activities.

Plant and other degradable wastes can be used for making compost which can help to protect environment and control soil erosion. Non-organic wastes can be recycled and reused in order to reduce the quantity of wastes.

Disposal mechanism for lab wastes should be made. Sharp wastes such as broken glass, guide wires and staples have to be disposed in separate container. Biohazard wastes include infectious wastes and contaminated personal protective equipment. These have to be placed in separate container. Chemical wastes such as chemicals, gloves and tubing should be placed in separate container. All lab wastes have to be incinerated or disposed in safe area.

Use of pesticide and chemical fertilizer is common and frequent. Use of these materials have huge impact on the environment. Pesticides used for killing insect pests can affect non-targeted species such as plants, animals and humans. The negative effects of pesticides are not just in the area of application. Runoff, drift and seepage can carry pesticides deep into the soil and water system and in distant places or fields, grazing areas, human settlements and undeveloped areas. Over time, repeated application of pesticides increases pest resistance while its effect on other species will facilitate pest resurgence. Integrated pest management and use of organic fertilizer can help to mitigate the harmful impact of pesticides and chemical fertilizer. Some of the health and safety issues in this Center also arise from chemical exposure, falling from height, accident caused by farm machinery, vehicles, lack of training and accident in confined spaces. The steps that have to be considered to reduce the health and safety issues are given below.

- Use of PPE while exposing in laboratory. Ventilation and lighting system should be good.
- Checking of the electrical system frequently.
- Inspect and repair machine before the busy season. A well-maintained machine will operate more efficiently and reduce the chance of an injury.
- Use proper equipment and procedures during working time.
- Management of manure pit and organic fertilizer should be done in open space. Ensure that all workers receive specific instructions about health and safety issues before work time.
- Take time to learn basic first aid, CPR and emergency response.

With the increased mechanization and increased use of plastic simultaneously may raise environmental issues in future. Introducing degradable/compostable plastics could be another important step for plastic waste management or alternatively the farm plastic wastages should be linked with the recycling industries.

6 CONCLUSION AND RECOMMENDATIONS

PCDC, Nigale has been playing important role in producing potato seeds since 2032. However, in FY 2044/45, potato production program was stopped due to resurgence of brown powdery mildew disease. Besides producing potato seeds, this center has been involved in training farmers, conducting demonstration and other technology transfer activities.

The productivity of potato in Nepal is very low (national average 16 mt/ha) when it is compared with other countries and with that of research stations and farms. The possibility of increasing productivity is very high with the use of quality seed. The demand for high quality biotech potato seeds is increasing worldwide including Nepal. The center has some strengths in producing such seeds. However, the present infrastructure, human resources and other facilities of the center are not adequate to meet the current demand of the country. Hence, construction of new critical infrastructures, strengthening of existing infrastructures, change in organizational structures (inclusion of additional soil and plant protection laboratories), addition of important human resources like biotechnologist, extension officer, agriculture engineer and some support staffs have been proposed in PCDC Nigale. The GoN should place high priority on investing in these to meet unmet demand for quality seed in order to have multiplier effect on the economy through the increased production and productivity of potato in the country.

During the preparation of Master Plan of the Center, maximum care has been given to strengthen and build on the existing ones. Very few new infrastructures have been proposed to avoid reduction in extremely limited land resource. Based on the design principle and standards as well as findings of the primary and secondary data as well as consensus built during the meetings with concerned stakeholders, Master Plan and building floor plans were developed.

The proposed project is dedicated for the development of Center with a unique design to be built in natural environment. The site is designed with latest architectural concepts using Nepal National Building Code and established design parameters. With all of the concepts, it has achieved an optimum level efficiency and effectiveness using modern method and technologies. In all respect, the site is attractive and influential reflecting its time and architecture.

Business model of PCDC Nigale has been developed based on trend analysis of area, production and yield of potato as well as demand, supply and current and emerging issues related to potato seed in the country.

Lastly, detail Architectural and Engineering Design has been done with detail survey and analysis of site. Planning and Design Concept started with topography of site and design requirement. All the design works have been carried out within the framework of design criteria like safety factor, illumination and economical factor, reliability of the system, flexibility of the system and other technical factors.

Based on the identified gaps, the following recommendations have been made in accordance with the set objectives and terms of reference of PCDC Nigale.

Human Resource

At least two Gazetted Class III level posts of Biotechnology Group should be created in PCDC Nigale with the provision of further professional development in the Agriculture Service at federal government.

At least three Non-gazetted Class I level posts of Biotechnology Group should be created in PCDC Nigale with the provision of further professional development in the Agriculture Service at federal government.

Two Gazetted Class III level posts one each of Agriculture Extension and Agriculture Engineering should be added in PCDC Nigale.

Higher studies and training related to biotechnology, screen house management, aeroponics, potato seed production and storage, pest management etc. should be provided to the personnel working in the farm.

Frequent transfer and deputation of Chief and other staffs should be stopped. The minimum tenure of Chief should be fixed at five year and the existing two-year non-transfer policy should be strictly implemented for all other staffs.

New Construction

A modern plant tissue culture lab should be constructed to expand the capacity of the center to produce quality potato seeds.

At least 2 high tech screen houses should be constructed corresponding to the increased capacity of tissue culture lab.

A soil and a plant protection laboratory should be constructed for regular soil testing and survey surveillance of insect, pest and diseases.

Programmatic Interventions

Production plan should be prepared based on analysis of national demand and supply balance sheet of potato seed.

Farm operations should be mechanized which reduce cost and drudgery as well as enhance production and productivity. These mainly include use of tractor, power tiller, ridger, drip irrigation, sprinkler irrigation, irrigation by garden pipe, rain water harvesting, potato harvester, power sprayer, yellow sheet, pheromone trap and light trap to control insect pests.

Paid technical services for the interested farmers and entrepreneurs should be started in PCDC Nigale. The center should develop package and obtain approval of higher authority in principle before implementing such programs.

Output based Incentive Model should be implemented in the center to motivate and incentivize PCDC Nigale employees to produce more and cost effectively. PCDC Nigale should develop package for such system and obtain approval of higher authority in principle before implementing such Model.

Double Track System of farm/center management should be tried in rented land adjacent to PCDC Nigale to increase production of potato seeds. PCDC Nigale should develop package for such system and obtain approval of higher authority in principle before implementing such System.

Large Seed Producer Model should be tried with package of incentive plan to encourage private entities like large seed producer farmers, farmer groups, cooperatives and companies to produce seed in large area and quantity.

The center should grow suitable vegetable crops and buckwheat in fallow lands during lean periods to increase revenue and narrow the gap between revenue and expenditure.

Market Interventions

Nepal’s product line gap should be filled through the introduction and production of new and potential species/varieties of potato seed such as chips and French Fry potato. Hence, efforts should be made at introduction and distribution of chips and French Fry potato species or varieties in the Center.

Distribution gap should be filled by publicizing the products in various agro-fairs, distributing free samples in potential pockets, advertising in social media, radio, television, FM, national/regional print and audio/visual media, entering into contractual arrangement with the distributors. Coordination with local governments, PMAMPs and the AKCs can also be another strategy as they have demonstration programs, seed multiplication program and distribution of potato seeds in subsidy.

The center should encourage non-users try the seed and encourage existing users to use more. Free technical support with free sample seed can be another strategy to attract the non-users.

The center should encourage producer farmers as well as large corporate houses to consolidate land and establish new potato pockets, blocks, zones and super zones.

The center itself should run the subsidy program for biotech potato pocket and block establishment to attract producer farmers and entrepreneurs to further multiply seeds.

Budget, Expenditure and Revenue

Sufficient capital budget should be allocated to meet the basic physical infrastructures needs of the Center. Unproductive operational costs should be cut down.

The Center should organize paid training programs in addition to regular training programs.

Detail costing of each type of potato seed should be done so that it will help to find areas where cost can be reduced.

The Center should put its best efforts in maintaining 1:1 ratio of budget expense (at least direct production cost) to revenue through improvement in management. These may include - mechanization to reduce cost and to increase efficiency, minimizing wastes during harvesting, post-harvest handling and storage, mass production etc.

The performance evaluation of farms and centers should not be based only on revenue generation. It should be based on both revenue generation and other benefits or services provided to the farmers, entrepreneurs and frontline extension workers such as recommendation of technologies, technical services, training, and technical publications to justify the sustainability of the farms and centers.

Linkage and Coordination

Strong and functional linkage should be established with NARC and academic institutions for the development of new varieties and for assured supply of parent seed.

Strong coordination mechanism should be developed with AKCs, PMAMP, AICL, seed producer farmers, entrepreneurs and cooperatives to scale-up source seed multiplication and distribution throughout the country.

Policy and Legal Provision

Center has very good capability to produce mother plants through tissue culture but only NARC has been mandated to produce mother plants through tissue culture. Administrative and legal procedures should be initiated to delegate authority to the Center to produce mother plants through tissue culture.

ANNEXES

Annex 1: List of participants in FGD/KII/Walkthrough Observation

SN	Name	Position	Organization
1	Mr. Bijay Kumar Giri	Chief	Potato Crops Development Centre, Nigale
2	Ms. Manita Tamang	Horticulture Development Officer	Potato Crops Development Centre, Nigale
3	Mr. Bijay Rana Magar	Biotechnologist (on contract)	Potato Crops Development Centre, Nigale
2	Mr. Himal Bhusal	Technical Assistant	Potato Crops Development Centre, Nigale
3	Mr. Yagna Raj Sahi	Technical Assistant	Potato Crops Development Centre, Nigale
4	Mr. Krishna Nath Yogi	Technical Assistant	Potato Crops Development Centre, Nigale
5	Mr. Dr. Shiddi Ganesh Shrestha	Team Leader	GOEC-RAJDEVI-RECON JV
6	Mr. Deo Narayan Yadav	Civil Engineer	GOEC-RAJDEVI-RECON JV
7	Mrs. Shruty Shrestha	Architectural Engineer	GOEC-RAJDEVI-RECON JV
8	Mr. Jay Prakash Mandal	Senior Surveyor	GOEC-RAJDEVI-RECON JV
9	Mr. Bidya Sagar Mallik	Agriculture Engineer	GOEC-RAJDEVI-RECON JV
10	Mr. Sanjib Kumar Deo	Refrigeration and Air Conditioning Engineer	GOEC-RAJDEVI-RECON JV
11	Mr. Lal Bahadur Bhujel	Electrical Engineer	GOEC-RAJDEVI-RECON JV
12	Mr. Pabitra Dahal	Environment Expert	GOEC-RAJDEVI-RECON JV
13	Mr. Prabin Rawal	Structure Engineer	GOEC-RAJDEVI-RECON JV
14	Mr. Deonath Yadav	Agronomist	GOEC-RAJDEVI-RECON JV
15	Mr. Suresh Kumar Verma	Horticulturist	GOEC-RAJDEVI-RECON JV
16	Mr. Saksham Dhakal	Officer	GOEC-RAJDEVI-RECON JV
17	Mr. Vesh Raj Pun Magar	Architectural Engineer	GOEC-RAJDEVI-RECON JV
18	Mr. Nabin Acharya	Civil Engineer	GOEC-RAJDEVI-RECON JV
19	Mr. Suraj Shrestha	Civil Engineer	GOEC-RAJDEVI-RECON JV

Annex 2: Six Central Entities and 14 farms/centers under these entities.

#	Central entities	#	Farms and centers under central entity
I	Center for Agricultural Infrastructure Development and Mechanization Promotion (CAIDMP)	1	Agriculture Mechanization Promotion Center, Naktajhij, Dhamusha
II	National Potato, Vegetable and Spices Crop Development Center, Khumaltar	2	Vegetable Development Center, Khumaltar, Lalitpur
		3	Vegetable Seed Production Center, Rukum
		4	Cardamom Development Center, Fikkal, Ilam
		5	Potato Development Center, Nigale, Sindhupalchowk
III	Crop Development and Agrobiodiversity Conservation Center, Shreemahal, Lalitpur	6	Agriculture Development Farm, Chandradangi, Jhapa
		7	Agriculture Development Farm, Sundarpur, Kanchanpur
IV	National Fruit Development Center, Kirtipur	8	Coffee Development Center, Gulmi
		9	Temperate Horticulture Development Center, Marpha, Mustang
		10	Tropical Horticulture Development Center, Nawalpur, Sarlahi
		11	Citrus Development Center, Tansen, Palpa
		12	Sub-tropical Horticulture Center, Kirtipur
V	Industrial Entomology Development Center, Harihar Bhawan, Lalitpur	13	Sericulture Development Center, Khopasi, Kavreplanchowk
		14	Apiculture Development Center, Godawari, Lalitpur
VI	Central Agriculture Laboratory, Harihar Bhawan, Lalitpur	-	-

Annex 3: Chief and their Duration in PCDC

Sn	Name	Duration	
		From	**To**
1	Maheshwar Sapkota	2033 Shrawan	2034 Shrawan
2	Bhola Prasad Adhikari	2034 Kartik	2034 Kartik
3	Hira Mani Adhikari	2034 Kartik	2037 Ashwin
4	Gajendra Sen Niraula	2037 Ashwin	2040 Magh
5	Tara Lal Lama	2040 Magh	2050 Jetha
6	Shyam Prasad Dhakal	2050 Jetha	2062 Magh
7	Late Narayan Prasad Bhandari	2062 Chaitra	2067 Ashwin
8	Raj Kumar K. C	2067 Falgun	2070 Ashwin
9	Krishna Prasad Paudel	2070 Kartik	2076 Chaitra
10	Late Hari Prasad Gurung	2076 Chaitra	2077 Bhadra
11	Bijay Kumar Giri	2077 Bhadra	Till today

Annex 4: Current Employee in the PCDC

Sn	Employee Name	Position
1	Bijay Kumar Giri	Senior Horticulture Development Officer
2	Manita Tamang	Horticulture Development Officer
3	Bijay Rana Magar	Bio-technologist
4	Himal Bhusal	Technical Assistant
5	Yagna Raj Sahi	Technical assistant
6	Krishna Nath Yogi	Technical assistant
7	Sandip Chongbang	Kharidar
8	Dev Bahadur Shrestha	office assistant
9	Krishna Bahadur Shrestha	Office assistant
10	Anu Shrestha	Office assistant
11	Raj Kumar Shrestha	Watchman
12	Om Bahadur Shrestha	Watchman
13	Rina Joshi	Gardener
14	Jagdish Poudel	Driver

Annex 5: Farm Machineries and Equipment

#	Description	Unit	Quantity	Condition of goods		Remarks
				To be maintenance	To sell auction product	
1	Laboratory	Number	3			
2	Motorcycle	Number	4	2		
3	Toyota Pickup	Number	1	1		
4	Nissan Jeep	Number	1			
5	Television	Number	1			
6	Digital Camera	Number	2		2	
7	Camera Lens	Number	4		4	
8	Cheque Writer	Number	1		1	
9	Ladder	Number	1			
10	Notice Board	Number	1			
11	Office Chief Name Board	Number	1			
12	Hill Tank	Number	2			
13	Desktop Computer	Piece	8		4	
14	Laptop	Piece	7	2		
15	Printer	Piece	4			
16	Photocopy Machine	Piece	4	1		
17	Scanner	Piece	1			
18	Projector	Piece	7		2	
19	Monitor	Piece	2			
20	Heater	Piece	17		10	
21	Table Fan	Piece	7		5	
22	Generator	Piece	2			
23	Water Pump	Piece	3		2	
24	Vacuum Cleaner	Piece	2			
25	Ups	PIECE	2			
26	Battery BDC	Piece	4			
27	Solar Panel	Piece	6			
28	Stabilizer	Piece	3			
29	Drill Machine	Number	1			
30	Mixer	Number	1			
31	Inverter	Number	3		2	
32	Geyser	Number	1			
33	Transformer	Number	1			
34	Solar Dryer	number	4			
35	Electric Pole	Number	1			
36	Mike	Number	1		1	
37	Sound System Box	Piece	1			

#	Description	Unit	Quantity	Condition of goods		Remarks
				To be maintenance	To sell auction product	
38	Book	Number	1		1	
39	Microscope	Number	1			
40	Balance Taraju	Number	7		3	
41	Centrifuge Machine	Number	1			
42	Incubator	Number	4			
43	Autoclave	Number	2			
44	Hot Plate	Number	1			
45	Elisa Reader And Washer	Number	1			
46	Reserve Osmosis Water Purification System	Number	1			
47	Laminar Air Flow Funning Hood		1			
48	Ph Meter	Number	3			
49	Tissue Culture Rotator	Number	1			
50	Vernier Caliper	Piece	1			
51	Spray Pump	Number	12	5	7	
52	Grain Moisture Meter	Number	2			
53	Power And Mini Tiler	Number	5	4		
54	Seed Dressing Drum	Number	1			
55	Aluminum Drum	Number	2			
56	Table	Piece	23			
57	Daraj	Piece	5		7	
58	Steel Daraj	Piece	17			
59	Tea Table	Number	16		5	
60	Bench	Piece	15			
61	Low Bed	Piece	34	7	10	
62	Rack	Piece	15			
63	Wooden Daraj	Number	4			
64	Cabinet Counter	Number	4		4	
65	Laboratory Furniture	Number	20			
66	Ox	Number	4			
67	Software	Piece	1			
68	Telephone	Number	3			
69	G P S	Piece	1			
70	Camera Flash	Number	1		1	
71	Gas Cylinder	Number	5			

#	Description	Unit	Quantity	Condition of goods		Remarks
				To be maintenance	To sell auction product	
72	Refrigerator	Piece	2			
73	Juice Extractor	Number	3			
74	Oven	Number	2			
75	Electric Scale	Number	3		3	
76	Chair	Piece	67		12	
77	Sofa Set	Piece	6			
78	Revolving Chair	Piece	15	2	4	

Annex 6: Cold Stores in Nepal

#	Cold Store Name	Address	Capacity, mt	Current status	Established Year
1	Yadav Ice and Cold Store	Kalaiya Municipality 10 Bara	2000	Running	2045
2	Nepal Cold Storage	Parawanipur Bara	2400	Running	2042
3	Shivshakti Ice and Cold Store	Uchidiha 1 Bara	2500	Running	2057
4	Madhyamanchal Cold Store	Prasauni Bara	4000	Banned	
5	Maisthan Cold Store	Parawanipur Bara	3000	Running	2063
6	Manakamana Cold Store Inaruwa	Inaruwa-9 Sunsari	2000	Running	2063
7	Hanuman Cold Store Sirha Choharba	Choharba Siraha	1000	Closed	2050
8	Susandeep Cold Store	Suda ga bi sa Kanchanpur	2000	Running	2058
9	Pradhan Mini Cold Store	Lilachok Narayangadh	600	Running	2044
10	Kohinoor Cold Store	Balaju Kathmandu	12000	Running	2033
11	Himshikhar Cold Store	Danchi Kathmandu	3000	Running	2062
12	Budhathoki Cold Store	Sitapaila Kathamndu	1000	Running	
13	Saptakoshi Cold Store	Dharampur Saptari	1000	Running	
14	Western Cold Store	Parsiyang Pokhara 5	2500	Running	2059
15	Himalayan Cold Store	Jagati Bhakatapur	1000	Running	2056
16	Bagmati Cold Store	Sipadole Bhaktapur	1200	Running	
17	Planchok Bhagwati Cold Store	Panchkhal Kavre	1800	Running	2057
18	Jagdamba Cold Store	Panauti Sunthan Kavre	5000	Running	
19	Panchkhal Cold Store	Budol Banepa Kavre	2500	Running	2055
20	Swargdwar Cold Store	Dang	500	Running	2063
2	Butwal Cold Store	Butwal Rupandehi		Closed	

#	Cold Store Name	Address	Capacity, mt	Current status	Established Year
1					
22	Siddharth Cold Store	Bhairwa Rupandehi	2500	Running	
23	Ramjanki Cold Store	Biratnagar Morang	4000	Running	2057
24	Ganesh Cold Store	Biratnagar 5 Morang	1500	Running	
25	Purwanchal Cold Store	Biratnager Morang	2700	Running	2056
26	Gita Cold Storage	Janakpur Dhanusha	2000	Running	2050
27	Ramjanki Cold Store	Binhi 3	1500	Running	2058
28	Bheri Cold Store	Janakpurdham Dhanusha	2500	Running	
29	Shanti Cold Storage	Kohalpur Banke	2000	Running	2033
30	Royal Cold Storage	Damak Jhapa	2500	Running	2061
31	Kailash Cold Storage Pvt	Birtamod Charpane	800	Running	2058
32	Pradhan Mini Cold Storage Chitwan	Bharatpur Chitwan	1200	Running	2057
33	Sindhuli Cold Storage Ka Na Pa Dhungewas	Ka Na Pa Dhungrabas	500	Running	2044
34	Ranjitkar Cold Storage	Malangwa Sarlahi	1000	Running	2065
35	Shuva Cold Storage	Chpakaiya Birgunj	500	Running	
36	Durga Cold Storage	Hetauda Makawanpur	1000	Running	
37	Dhangadhi Cold Storage	Dhangadhi Kailali	1000	Running	
38	Kalanki Cold Storage	Kathamandu	1000	Closed	
39	Swastik Cold Storage	Gandak Birgunj Parsa	2000	Closed	

#	Cold Store Name	Address	Capacity, mt	Current status	Established Year
40	Balaju Cold Storage	Parawanpur Inarwa	1000	Running	
41	Junar Sit Griha Sindhuli	Ka Na Pa Sindhuli	500	Running	
42	Ashok Prabhab Shit Bhandar Inruwa	Inaruwa Sunsri	700	2067	
43	Chitwan Cold Storage	Bharatpur	2000	Closed	
44	Devighat Cold Storage	Jiling Ga Bi Sa Nuwakot	6000	Running	2070
45	Phalphooltarkari Shit Bhandar	Banke Nepalgunj	3000	In construction	2074/075
46	Krishi Upaj Shitbhandar	Badyatal Gaupalika	1800	In construction	2074/075
47	Ugratara Shitbhandar	Amargadhi Nagarpalika	1000	In construction	2074/075
48	Sana Kisan Krishi Shakari Shit Bhandar	Tulsipur Upmahanagarpalika	100	In construction	2073
49	Krishi Upaj Shit Bhandar	Ghorahi Upmahanagarpalika	2000	In construction	2074/075
50	Rapti Sitbhandar	Lamahi Nagarpalika	2800	In construction	2074/075
51	Sudurpachimanchal Shit Bhandar	Dhangadhi Upanagarpalika	3000	In construction	2074/075
Total		**-**	**105100**	**-**	**-**

Annex 7: Semi-structured Checklist/Questionnaire

Semi-structured Checklist/Questionnaire

For the Preparation of Detailed Project Report (DPR) for the Infrastructure Development of Federal Agricultural Farm/Centers

GENERAL GUIDELINE FOR FGD/KII

1. **Overall management practices and productivity of farm/center:**

   - **Field observation** to have overall image of farm management, operation, maintenance, seeds, seedlings, saplings and mother plants

   - **FGD** with the farm staffs to gather information about technical knowhow and skills of the field staff, problems and issues and overall management practices and productivity potentiality of the farm/center

   - **KII** with experts to gather information about SWOT or Gap analysis

   - **Review of past progress reports** (including master plan) of the farm to analyze organizational structure, budget allocation, current farm production and productivity, farm potentiality, production of seeds, seedlings and saplings, and mother plants. Need to obtain all relevant documents and soft copies from the farm/center.

2. **Service delivery, linkage and collaboration with stakeholders:**

   - **Service delivery:** seeds, seedlings, sapling, technical or extension services etc.

   - **Linkage and collaboration:** private nursery, AKC, Palikas, PMAMP and other projects, farmer groups, cooperatives and market outlets for the distribution of seeds, seedlings and saplings etc.

3. **Infrastructures and mechanization:**

   - **Infrastructures:** road, irrigation system, drainage, office building, laboratory, tissue culture chamber, green-houses, shade houses, nursery houses, cold chamber, storage, power supply (electricity, solar, wind)

- **Machinery, tools and equipment:** tractor, power tiller, potato planter, potato diggers, sprayers, drone etc.

4. **Product (seeds, saplings and seedlings) distribution/sale (marketing) and benefit cost analysis**

- From farm
- Through private nursery
- Through farmer groups, cooperatives and market outlets
- Through AKC and Palikas
- Through PMAMP and other projects
- Total operating cost and revenue

FGD/KII

Date of FGD/KII:

5.Name of resource persons/participants and position participating in FGD/KII:

#	Name	Position	Signature
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

6.Organization Structure:

7.Name, position and academic qualification of staffs (including daily wage and contract):

#	Name	Position	Faculty/Samuha	Academic qualification & specialization
1				
2				
3				
4				
5				
6				
7				
8				

8.Names of farm/center chiefs:

#	Name	Working period	
		Start	Complete
1			
2			
3			
4			
5			
6			
7			
8			

9.Historical background of the farm/center:

10. Vision and objectives of the farm/center:

11. Meteorological data:

Weather parameters	Monthly average											
	B	J	A	S	Bh	As	K	M	P	Ma	Fa	Ch
Temp (Min.), ^{o}C												
Temp (Max.), ^{o}C												

Humidity, %												
Precipitation, mm												
Sunshine, hrs												

12. Master plan of farm/center: Yes/No

If yes, please obtain photocopy of Master Plan.

13. Types of land in the farm:

#	Type of land	Area, Ropani	Remarks
1	Abbal		
2	Doyam		
3	Sim		
4	Chahad		
5	Forest		
6	Water bodies		
7	Others (specify):		

14. Land use of the farm:

#	Land use	Area, Ropani	Ownership (like GoN or leased)
1	Office building		
2	Quarter area		
3	Canteen		
4	Training hall		
5	Laboratory		
6	Plastic house		
7	Road (km)		
8	Cultivated area:		
	a.		
	b.		
	c.		
9	Others (specify)		

15. Soil map:

Land/plot	Texture	pH	NPK and organic matter content, %

			Nitrogen	Phosphorus	Potash	Organic matter

16. Existing physical infrastructures in the farm:

#	**Land use**	**No./capacity**	**Area, Ropani**
1	Office building		
2	Quarter		
3	Canteen		
4	Training hall		
5	Laboratory		
6	Plastic house		
7	Road		
8	Others (specify)		

17. Major programs and budget in the past 5 years:

#	Major program	2078/79		2077/78		2076/77		2075/76		2074/75	
		Target	Budget	Target	Budget	Target	Budget	Target	Budget	Target	Budget

18. Annual demand and production

Products	Unit	Annual demand	Annual supply or production	If demand exceeds supply, suggested measures to increase supply
Seeds:				
Saplings:				
Seedlings:				
Other products:				

19. Price and production cost of seeds, saplings, seedlings and other products of farm/center

Products	Direct cost items	Direct cost per kg/unit	Selling price, NPR per kg/unit
Seeds:	Material		
	Labor		
	Others (specify)		
Saplings:	Material		
	Labor		
	Others (specify)		

Products	Direct cost items	Direct cost per kg/unit	Selling price, NPR per kg/unit
Seedlings:	Material		
	Labor		
	Others (specify)		
Other products:	Material		
	Labor		
	Others (specify)		

20. Cropping patterns and farm practices

#	Season and crop	Cropping from ….. month to ….. month	Area in ha
Monsoon/summer:			
1			
2			
3			
4			
5			
Winter:			
1			
2			
3			
4			
5			
6			
7			
Spring:			

1			
2			
3			
4			

21. Supply/production and demand gap

Seed, sapling, seedling produced by farm/center	**Production quantity (specify unit)**	**Actual demand**	**Reasons for gap in demand and supply**	**Suggestions for improvement of gap**

22. Need for new technology, cost of new technology and timeframe for adoption in farm

#	New technology needed	Cost of new technology, Rs. '000	Timeframe for adoption of new technology
1			
2			
3			
4			
5			

23. Problems and issues related to production (policy, legal, investment/budget, technology, human resources, infrastructure etc.)

#	Problems or issues	Suggestions to overcome problems or issues
1		
2		
3		

#	Problems or issues	Suggestions to overcome problems or issues

24. Problems and issues related to sale (policy, legal, investment/budget, technology, human resources, infrastructure etc.)

#	Problems or issues	Suggestions to overcome problems or issues
1		
2		
3		

25. Source of water and problems and issues related to water supply

Place of water source	

Distance, km	
Discharge, l/s	
Dispute or problem in using water in farm/Center	
Suggestion to overcome dispute	
Suggestion for alternative source	

26. Problems and issues related to power supply

#	Problems or issues	Suggestions to overcome problems or issues
1		

#	Problems or issues	Suggestions to overcome problems or issues
2		

27. Need for new construction of physical infrastructure or realignment or strengthening of road network within the farm/center

#	Problems or issues	Suggestions to overcome problems or issues
1	<u>New physical infrastructures:</u>	
2	<u>Road network:</u>	

28. Problems and issues related to capacity development

#	Problems or issues	Suggestions to overcome problems or issues
1		

#	Problems or issues	Suggestions to overcome problems or issues
2		
3		

29. Occurrence of major disasters (earthquake, landslide, hailstone, pests and diseases etc.) in the past

Type of disaster	Year of occurrence	Measures adopted	Suggestions to overcome

30. Strength, weakness, opportunity and threat (SWOT) related to seed, sapling, seedling and other inputs production in the farm/center

SWOT	Please mention
Strength	

SWOT	**Please mention**
Weakness	
Opportunity	
Threat	

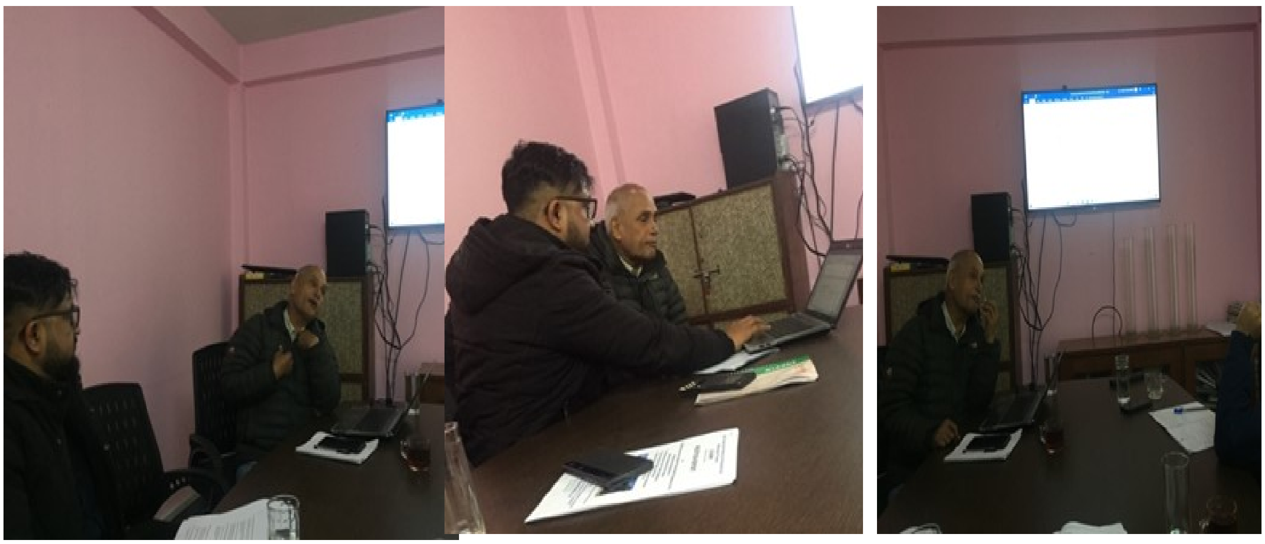
31. Construction materials

#	**Name of material**	**Source/market place**	**Distance, km**

#	**Name of material**	**Source/market place**	**Distance, km**
1	Sand		
2	Aggregate		
3	Brick		
4	Cement		
5	Reinforcement		

Annex 8: Photos of Presentation, Desk Study, Field Visit and Minutes

Photos of Inception Report Presentation



Photos of Inception Desk Study

Our Experts with PCDC Staffs.

Exploring Current Training Hall.

Rusting House Inspection.

Possible Deep Boring Site visit.

Possible Site to build an arch bridge.

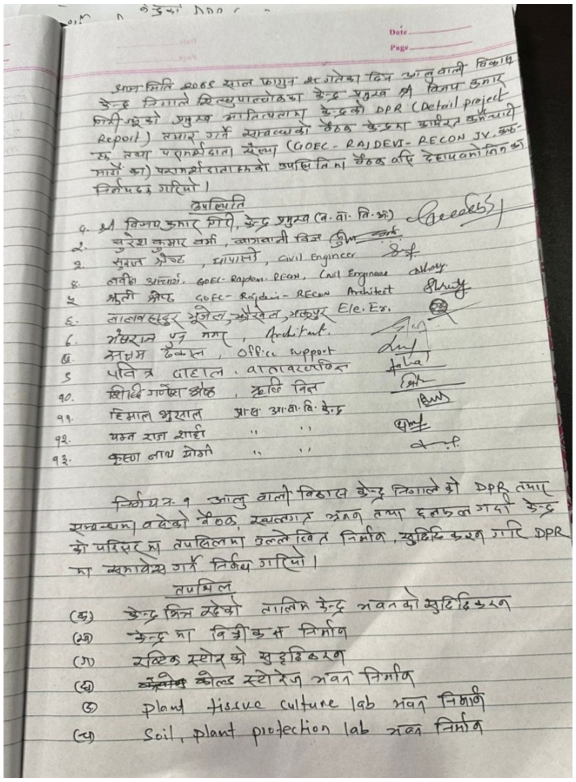
Experts and Staffs Discussing the issues of the Center.

Inspection of current Water Source for the Center.

Potato Crop Development Center, Nigale

Outlook Area of Potato Crop Development Center, Nigale

Discussion with the team of Potato Crop Development Center, Nigale



आज मिति २०८१ साल फागुन २८ गतेका दिन आलु बाली विकास केन्द्र निगाले सिन्धुपाल्चोकका केन्द्र प्रमुख श्री विजय कुमार गिरी ज्यूको प्रमुख आतिथ्यतामा केन्द्रको DPR (Detail project Report) तयार गर्ने सम्बन्धको बैठक केन्द्रमा कार्यरत कर्मचारी हरु तथा परामर्शदाता संस्था (GOEC - RAJDEVI - RECON JV. का मार्गे का) परामर्शदाता हरुको उपस्थितिमा बैठक बसि देहायको निर्णयहरु गरियो।

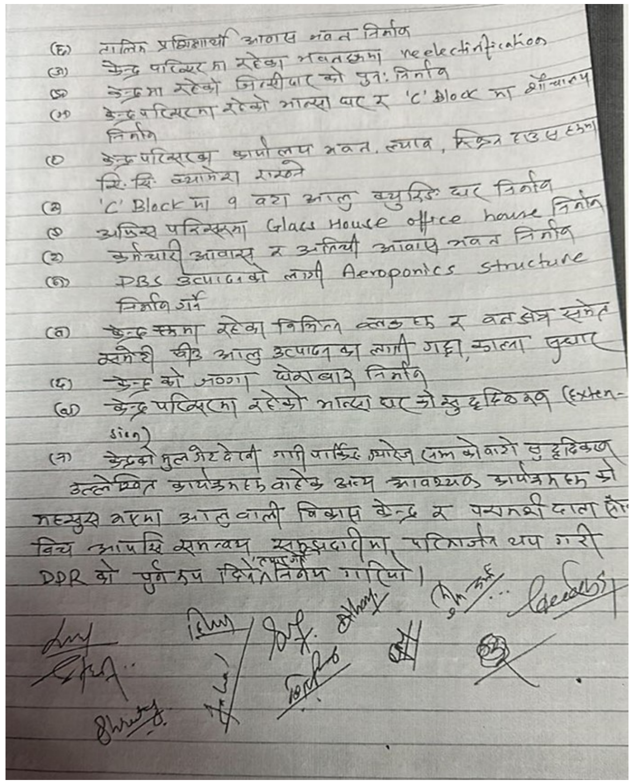
उपस्थिति

1. श्री विजय कुमार गिरी, केन्द्र प्रमुख (आ. बा. वि. के.)
2. सुरेश कुमार वर्मा, बागवानी विज्ञ
3. सुरज श्रेष्ठ, द्यापासो, Civil Engineer
4. नवीन आचार्य, GOEC- Rajdevi- RECON, Civil Engineer
5. श्रुती श्रेष्ठ GOEC- Rajdevi- RECON Architect
6. लालबहादुर भुजेल, औरखेल, भक्तपुर Ele. Er.
7. मेघराज पुन मगर, Architect.
8. सक्षम ढकाल, Office support
9. पवित्र दाहाल, वातावरणविद
10. सिद्धि गणेश श्रेष्ठ, कृषि विद
11. हिमाल भुसाल प्रा.स. आ.बा.वि. केन्द्र
12. यमन राज शाही " "
13. कृष्ण नाथ योगी " "

निर्णय न. १ आलु बाली विकास केन्द्र निगालेको DPR तयार सम्बन्धमा बसेको बैठक, स्थलगत भ्रमण तथा छलफल गर्दा केन्द्र को परिसरमा तपसिलमा उल्लेखित निर्माण, सुदृढिकरण गरि DPR मा समावेश गर्ने निर्णय गरियो।

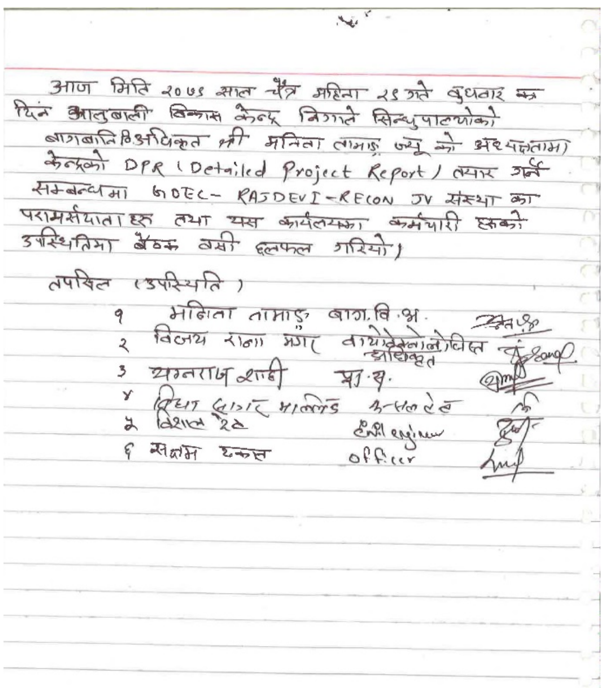
तपसिल

(क) केन्द्र भित्र रहेको तालिम केन्द्र भवनको सुदृढिकरण
(ख) केन्द्र मा बिक्री कक्ष निर्माण
(ग) रष्टिक स्टोर को सुदृढिकरण
(घ) ~~[illegible]~~ कोल्ड स्टोरेज भवन निर्माण
(ङ) plant tissue culture lab भवन निर्माण
(च) Soil, plant protection lab भवन निर्माण



(छ) तालिम प्रशिक्षार्थी आवास भवन निर्माण
(ज) केन्द्र परिसर मा रहेका भवनहरुमा re electrification
(झ) केन्द्रमा रहेको जिरीघर को पुन: निर्माण
(ञ) केन्द्र परिसरमा रहेको भान्सा घर र 'C' Block मा शौचालय निर्माण
(ट) केन्द्र परिसरका कार्यालय भवन, ल्याब, स्क्रिन हाउस हरुमा सि. सि. क्यामेरा राख्ने
(ठ) 'C' Block मा १ वटा आलु क्युरिङ घर निर्माण
(ड) अफिस परिसरमा Glass House office house निर्माण
(ढ) कर्मचारी आवास र अतिथी आवास भवन निर्माण
(ण) PBS उत्पादनको लागि Aeroponics structure निर्माण गर्ने
(त) केन्द्र स्कमा रहेका विभिन्न ब्लक हरु र वन क्षेत्र समेत मर्मेरी बीउ आलु उत्पादन का लागी गह्रा, कुलो सुधार
(थ) केन्द्र को जग्गा घेराबार निर्माण
(द) केन्द्र परिसरमा रहेको भान्सा घर को सुदृढिकरण (Extension)
(ध) केन्द्रको मुल गेट देखि गाडी पार्किङ ग्यारेज सम्म को बाटो सुदृढिकरण

उल्लेखित कार्यक्रमहरु बाहेक अन्य आवश्यक कार्यक्रम हरु को महसुस भएमा आलु बाली विकास केन्द्र र परामर्शदाता हरु बिच आपसि समन्वय सहमतिमा परिमार्जन थप गरी DPR को पुर्ण रुप दिने तयार गर्ने निर्णय गरियो।



आज मिति २०८१ साल चैत्र महिना २६ गते बुधवार ~~का~~ दिन आलुबाली विकास केन्द्र निगाले सिन्धुपाल्चोको बागबानि वि.अधिकृत श्री मनिता तामाङ ज्यू को अध्यक्षतामा केन्द्रको DPR (Detailed Project Report) तयार गर्ने सम्बन्धमा GOEC- RAJDEVI-RECON JV संस्था का परामर्शदाता हरु तथा यस कार्यालयका कर्मचारी हरुको उपस्थितिमा बैठक बसी छलफल गरियो।

तपसिल (उपस्थिति)

१ मनिता तामाङ बाग.वि.अ.
२ विजय राना मगर बायोटेक्नोलोजिस्ट अधिकृत
३ यमनराज शाही प्रा.स.
४ दिपा कुमार भण्डारि अ-सल टेक
५ विशाल रट Civil engineer
६ सक्षम ढकाल Officer

Photos of Minutes

REFERENCES

Dionglay, C. 2022. 5 Ways Biotech Crops Slow Down Climate Change. https://www.isaaa.org/blog/entry/default.asp?BlogDate=2/9/2022

Gautam, I.P. 2016. Seed and Ware Potato Storage and processing status in Nepal. https://www.researchgate.net/publication/310803506_Seed_and_Ware_Potato_Storage_and_processing_status_in_Nepal

APROSC (Agricultural Projects Services Center) and **JMA** (John Mellor Associates Inc). 1995. National Planning Commission and Asian Development Bank, Kathmandu, Nepal.

MoAC (Ministry of Agriculture and Cooperatives). 2009. Compendium of Policy, Act, Regulation and Orders related to Agriculture. MoAC, Kathmandu, Nepal.

MoALD (Ministry of Agriculture and Livestock Development). 2022. Statistical Information on Nepalese Agriculture, 2020/21. MoALD, Kathmandu, Nepal.

MoLJPA (Ministry of Law, Justice and Parliamentary Affairs). 2016. The Constitution of Nepal, MoLJPA, Kathmandu, Nepal.

NIA (Nepal Insurance Authority). 2022. Agriculture and Livestock Insurance Report, 2078. NIA, Lalitpur, Nepal.

NPC (National Planning Commission). 2020. The Fifteenth Plan, Fiscal Year 2019/20-2023/24. NPC, Kathmandu, Nepal.

NPRP (National Potato Research Program). 2018. Annual Report (2017/18). NPRP, Nepal Agriculture Research Council, Lalitpur, Nepal.

Raj, Aditi. Undated Plant Tissue Culture: Laboratory Requirements. Plant Tissue Culture: Laboratory Requirements (biologydiscussion.com)

Shrestha, G.P., Subedi, G., Baral, S.P. and Atreya, P.N. 2021. Horticulture Resource Centre Development for Sustainable Development of Horticulture Sector. Proceeding of 12th National Horticulture Seminar 2021. https://horticulturenepal.org/uploads/main_attachment/1631268839_Latest%20Corrected_12th%20proceeding-35-45.pdf

SQCC (Seed Quality Control Center). 2013. National Seed Vision, 2013-2025. SQCC, Harihar Bhawan, Lalitpur, Nepal.

GEOTECHNICAL INVESTIGATION REPORT FOR A CONSTRUCTION OF PROPOSED BUILDING

Table of Content

List of Figures

List of Tables

1. GENERAL INTRODUCTION

This report is prepared as per agreement between Ministry of Agriculture and Livestock Development, National Center for Potato, Vegetable and Spice Crops Development, Potato Development Center, Nigale, Sindhupalchowk and GOEC-RAJDEVI-RECON JV to determine bearing capacity and subsurface exploration for the foundation design of Cold Store Building located in Nigale Bazzar, Mude, Sindhupalchowk District, Nepal. Prime Civil Lab Pvt. Ltd., Chandragiri-14, Naikap, Kathmandu has taken all the responsibility for the soil investigation, laboratory tests and preparation of report for this project.

2. SCOPE OF INVESTIGATION

The scope of work includes the following:

- Drilling of 100mm nominal diameter bore holes each of 10.5 m depth at two specified locations.
- Conducting standard penetration tests in the boreholes at 1.50 m interval in depth & at every change of strata, whichever is earlier.
- Collecting disturbed soil samples from bore holes at regular interval and at every identifiable change of strata to supplement the boring records.
- Recording the depth of ground water table in all the boreholes if observed up to the depth of exploration during boring work as per specifications.
- Conducting the laboratory tests on selected disturbed / undisturbed soil samples collected from various bore holes, Preparation and submission of reports.

3. FIELD INVESTIGATIONS

3.1 Penetration Tests

Standard Penetration Tests: It consists of driving a Split Spoon sampler with an outside dia. of 50 mm into the soil at the base of borehole. Driving is accomplished by a drop of hammer weighing 63.5 kg falling freely through a height of 750 mm onto the drive head. First of all, the spoon is driven 150 mm into the soil at the bottom of the borehole. It is then driven further 300 mm and the number of blows (N values) required to drive this distance is recorded. Standard Penetration Tests (SPT) were conducted in the boreholes at 1.5 m intervals. The tests were conducted in accordance with IS:2131-1981.

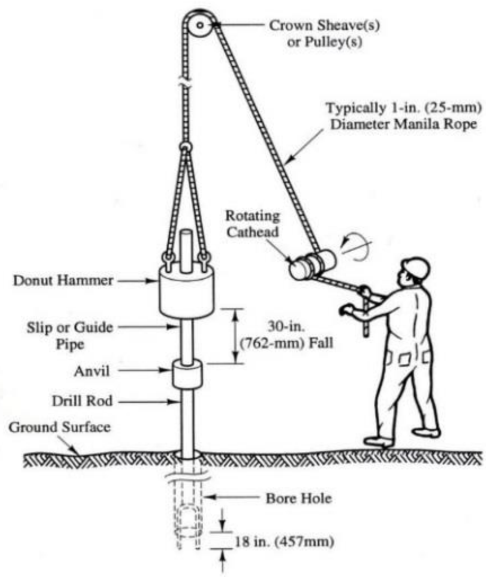


Figure 1: Standard Penetration Test

Dynamic Cone Penetration Test (DCPT): It consists of driving a cone by blows of hammers. The number of blows for driving the cone through a specified distance is a measure of the dynamic cone resistance. Dynamic Cone Penetration test are performed by a 50 mm cone. The method for DCPT is similar to that of SPT. First of all, the cone is driven 100 mm into the soil at the bottom of the bore hole. It is then driven further 200 mm and the number of blows (N_{cbr} values) required to drive this distance is recorded.

The result i.e., N_c values first corrected to the Standard Penetration Test (SPT) value (N) and that provides and estimation of degree of compaction of soil strata, values of angles of internal friction (ϕ) and allowable bearing capacity. The dynamic cone resistance is correlated with the SPT (N) as given below.

N_c = 1.5 N for depth up to 3 m
= 1.75 N for depth 3 to 6 m
= 2 N for depth greater than 6 m

3.2 Sampling

(i) Disturbed Sample:

Disturbed samples were collected from the split spoon after conducting SPT. Before any sample was taken, the borehole was cleaned up of loose disturbed soil deposited during boring operation. The samples which were obtained from bailer and in the SPT tube were preserved as representative disturbed samples for finding out index properties. The samples thus obtained were placed in airtight double plastic bags, labeled properly for identification and later transported to the lab for analysis.

(ii) Undisturbed Sample:

Undisturbed Sample are extracted by means of thin wall tube (Shelby tube). The tubes are pushed into the ground and the samples are recovered mechanically. The tube are sealed with wax and wrapped with airtight polythene sheets and then bound by adhesive tapes and properly labelled. The tubes were properly packed in a wooden box so as to minimize the disturbances during transportation to the laboratory and avoided the changes of moisture content of sample. These sample are used for the determination of strength and consolidation parameters.

3.3 Ground Water Table

Prediction of depth of ground water table needs the installation of piezometers and regular monitoring of those for at least a year. Since, the period and the installation are beyond the scope of the work, visual examination was performed to find the depth. Ground Water Table (GWT) was monitored at the depth mentioned in the borehole logs attached in the annex of this report during drilling up to the depth of 12m.

4. LABORATORY TESTS

The laboratory tests were conducted on selected representative disturbed and undisturbed samples collected in core boxes, were transported to lab in Kathmandu, Nepal. All of the tests were conducted confirming to the specifications as per IS codes. The following tests were conducted:

Table 1: The Laboratory Tests and their referred codes.

SN	Type of Test	IS Code Referred	Remarks
1	Bulk and dry density	By Calculations	
2	Moisture content	IS:2720 (Part-2)-1992	
3	Grain size/ Hydrometer analysis	IS:2720 (Part-4)-1992	
4	Atterberg Limits	IS:2720 (Part-5)-1992	
5	Specific Gravity	IS:2720 (Part-3)-1992	
6	Drained Direct shear test	IS:2720 (Part-13)-1986	

The results of laboratory tests have been presented in the annex section of this report.

5. STANDARDIZATION OF SPT VALUE

The recorded SPT values are converted to standardized energy N_{60} as per Skempton (1986):

$$N_{60} = \frac{N_{rec}\eta_H\eta_B\eta_S\eta_R}{60}$$

N_{60} = SPT N value corrected for field procedure

N_{rec} = measured penetration number

η_H = hammer efficiency (%) = 0.55 for hand drop hammer

η_B = correction for borehole diameter = 1.0 for 65 mm to 115 mm dia. Borehole

η_S = sampler correction =1.0 for standard sampler

η_R = correction for rod length = 0.75 for rod length 0.0 – 3.0 m

= 0.8 for rod length 3.0 – 4.0 m

= 0.85 for rod length 4.0 – 6.0 m

= 0.95 for rod length 6.0 – 10.0 m

= 1.0 for rod length greater than 10.0 m

Correction for Overburden:

In granular soils, the value of N is affected by the effective overburden pressure. For that reason, the value of N_{60} obtained from field exploration under different effective overburden pressures should be changed to correspond to a standard value. That is, $(N_1)_{60} = C_N N_{60}$

where, $C_N = \sqrt{\frac{100}{\sigma_z'}}$ as per Liao and Whitman 1987

Dilatancy Correction (for fine sand and silts below water table)

Terzaghi and Peck (1976) gave correction for water pressure as, If $N_{rec} \leq 15$, then $N_{corr} = N_{rec}$

$N_{rec} \geq N_{corr} = 15+½(N_{rec}-15)$

Table 2: Correction of Field SPT values.

Depth (m)	Measured SPT		Correction for					N_{60}		$(N_1)_{60}$	
	BH1	BH2	Over burden	Hammer efficiency	Rod Length	Borehole diameter	Sampler Type	BH1	BH2	BH1	BH2
1.5	17	21	1.70	0.55	1	0.75	1	11.7	14.4	19.9	24.5
3.0	22	25	1.70	0.55	1	0.75	1	15.1	17.2	25.7	29.2
4.5	22	25	1.70	0.55	1	0.85	1	17.1	19.5	29.1	33.1
6.0	25	32	1.54	0.55	1	0.85	1	19.5	24.9	30.1	38.5
7.5	22	29	1.38	0.55	1	0.95	1	19.2	25.3	26.4	34.9
9.0	23	27	1.26	0.55	1	0.95	1	20.0	23.5	25.2	29.6
10.5	24	32	1.17	0.55	1	1	1	22.0	29.3	25.7	34.2

For Refusals corrected SPT values are taken as 50

6. GENERAL GEOLOGY OF THE SITE

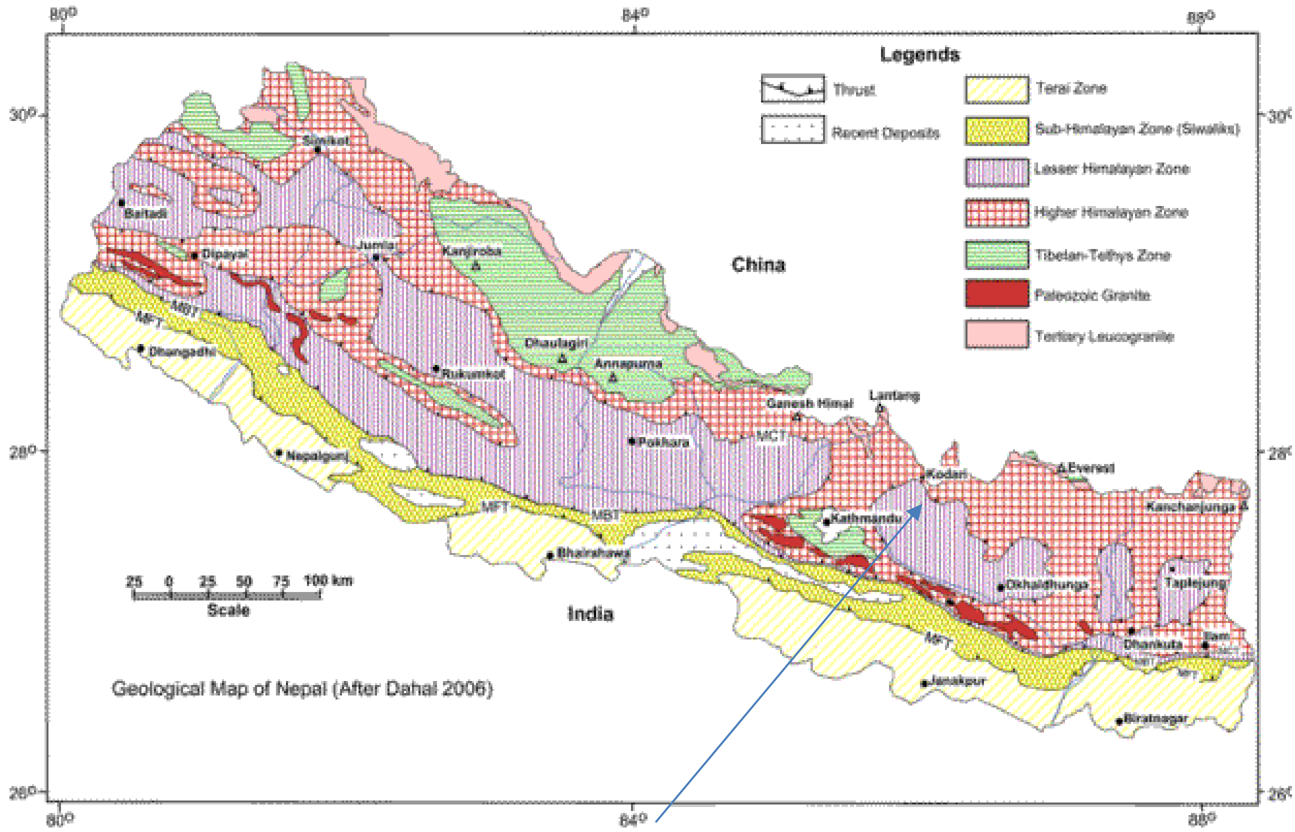


Figure 2: Geological map of Nepal showing the site location. (Modified from Dahal, 2006)

The proposed site lies in Nigale Bazzar, Mude, Sindhupalchowk District. Geologically, the proposed site area for the Geotechnical investigation lies in the Lesser Himalayan Zone. The proposed site primarily lies in Lesser Himalaya zone between the Sub-Himalaya (Siwaliks) in the south and Higher Himalaya zone in the north. The Main Boundary Thrust (MBT) separates Siwaliks at the south and

Main Central thrust separates Higher Himalaya at the north and west. The Siwalik rocks are basically consisting of sedimentary rocks (mudstone, sandstone, and conglomerate), while the Lesser Himalayan rocks are basically the low-grade metamorphic rocks (e.g., slate, phyllite, schists, garnet-schists, metasandstone and quartzite). Generally, the range exhibits very rugged terrain with deeply dissected gullies and steep slopes.

7. SEISMICITY AND LIQUEFACTION

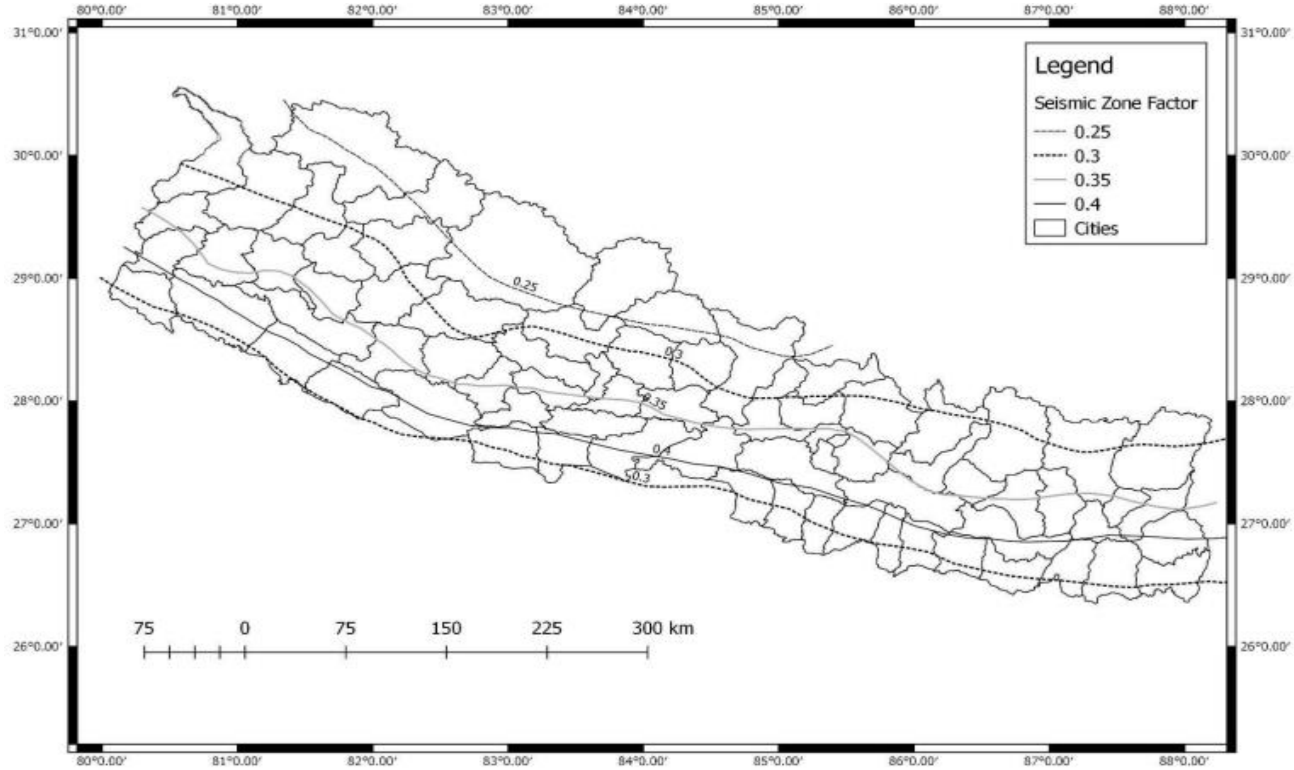


Figure 3: Seismic hazard of Nepal.

Ground motion can be simply quantified by peak values of expectable acceleration, velocity and/or displacement. Empirical relationships, called attenuation equations, can be derived from the interpretation of available strong motion records and relate peak ground motion parameters to magnitude and distance from the source of energy release. Attenuation equations are sensitive to the estimates of distance and magnitude, especially in the near-field. Peak ground acceleration (PGA) often represents the main seismic evaluation parameter for simplified analysis purposes. The peak ground acceleration (usually as a fraction of the peak) is the earthquake ground motion parameter usually used in the seismic coefficient method of analysis. Attenuation model of Young's et al (1997) for subduction zones for bed rock was used in development of seismic hazard map of Nepal.

Liquefaction

Saturated loose to medium dense cohesion less soils and low plastic silts tend to densify and consolidate or temporarily liquefy when subjected to cyclic shear deformations inherent with large seismic ground motions. Pore-water pressures within such layers increase as the soils are cyclically loaded, resulting in a decrease in vertical effective stress and shear strength. If the shear strength drops below the applied cyclic shear loadings, the layer is expected to transition to a semi fluid state until the excess pore-water pressure dissipates. When liquefaction takes place in a particular soil then the bearing capacity of the soil disappears, and the structure built on it gets tilts or even sinks.

Analysis of Liquefaction

In general, for clean sand, if the SPT value is less than 30, the soil is prone to liquefaction. The increase in fines content, however, increases the liquefaction resistance of soil. Here, in our analysis, increase in fine content from 35% and greater is considered to be no liquefaction strata. In this report, the soil liquefaction analysis has been done based on SPT N value.

The factor of safety (FS) against liquefaction in terms of CSR (Cyclic stress ratio) and CRR (cyclic resistance ratio) is defined by

$$FS = \frac{CRR_{7.5}}{CSR_{7.5,\sigma}}$$

Where, $CRR_{7.5}$ is the cyclic stress ratio (CRR) for earthquakes of magnitude 7.5 and $CSR_{7.5,\sigma}$ is the normalized cyclic stress ratio (CSR) for earthquakes of magnitude 7.5 and effective overburden pressure of 100 kPa.

$CSR_{7.5,\sigma}$ Is given by (Idriss and Boulanger, 2006)

$$CSR_{7.5,\sigma} = 0.65 \frac{\sigma_v}{\sigma'_v} \frac{a_{\max}}{g} \frac{\gamma_d}{MSF} \frac{1}{K_\sigma}$$

σ_v is the total vertical stress; σ'_v is the effective vertical stress; $a_{\max}$ is the peak horizontal ground surface acceleration; g is the acceleration of gravity; γ_d is the nonlinear shear stress mass participation factor (or stress reduction factor), MSF is the magnitude scaling factor; K_σ is the correction factor for effective overburden. The consideration of factors K_σ and Kα (for sloping ground) is beyond routine practice and can be precisely estimated using the method of Youd et al. (2001) if necessary.

The term γ_d provides an approximate correction for flexibility in the soil profile given by:

$$\gamma_d = \frac{(1 - 0.4113z^{0.5} + 0.04052z + 0.001753z^{1.5})}{(1 - 0.4177z^{0.5} + 0.05729z - 0.006205z^{1.5} + 0.00121z^2)}$$

Where, z = depth below ground surface in meters.

Cyclic resistance ratio (CRR), the capacity of soil to resist liquefaction, can be obtained from the corrected blow count $(N_1)_{60}$ using empirical correlations proposed by Seed et al. (1985). The CRR curves for a fines content of < 5% (clean sands) can be approximated by Youd et al. (2001)

$$CRR_{7.5} = \frac{1}{34-(N_1)_{60}} + \frac{(N_1)_{60}}{135} + \frac{50}{[10.(N_1)_{60}+45]^2} - \frac{1}{200}$$

For $(N_1)_{60}$ < 30. For $(N_1)_{60} \geq 30$, clean granular soils are classified as non-liquefiable. The CRR increases with increasing fines content and thus $(N_1)_{60}$ should be corrected to an equivalent clean sand value, $(N_1)_{60CS}$ (Youd et al. 2001)

$$(N_1)_{60CS} = (N_1)_{60};\ \mathrm{FC} \leq 5\%$$

$$(N_1)_{60CS} = \exp[1.76-(190/FC^2)]+[0.99+(\mathrm{FC}^{1.5}/1000](\mathrm{N}_1)_{60};\quad 5\% \leq \mathrm{FC} \leq 35\%$$

$$(N_1)_{60CS} = 5+1.2(N_1)_{60};\ \mathrm{FC} \geq 35\%$$

Where $(N_1)_{60}$ is the SPT blow count normalized to an overburden pressure of approximately 100 kPa and a hammer energy ratio of 60% expressed as (Youd et al. 2001)

$$(N_1)_{60} = NC_N C_E C_B C_R C_S$$

Where N = measured standard penetration resistance; C_N =factor to normalize N to a common reference effective overburden stress (1 atm.); C_E = correction for hammer energy ratio; C_B = correction factor for borehole diameter; C_R =correction factor for rod length; C_S =correction for samplers with or without liners. The factor C_N is given by

$$C_N = \frac{2.2}{1.2+\sigma'_v/P_a}$$

Following the recommendation of NCEER 1996 (Youd et al. 2001), the lower and upper bounds for MSF values can be defined by $MSF = 10^{2.24}/M_w^{2.56}$ and $MSF = (M_w/7.5)^{-3.3}$, respectively (M_w is the moment magnitude). Similarly, K_σ is given by (Youd et al., 2001)

$$K_\sigma = (\sigma'_v/p_a)^{(f-1)}$$

Where p_a is the atmospheric pressure (100 kPa) and f is assumed to be 0.75 (a value of 0.6-0.8 is recommended in Youd et al., 2001).

Iwasaki (1982) was used to calculate Liquefaction Potential Index (L.P.I) and to calculate the severity of site towards liquefaction.

$$\mathrm{LPI} = \int_0^{20} F(z).w(z)\mathrm{d}z$$

where z is depth of the midpoint of the soil layer (0 to 20 m) and dz is differential increment of depth. The weighting factor, w(z), and the severity factor, F (z), are calculated as per the following expressions:

$F(z) = 1 - FS$ for $FS < 1.0$

$F(z) = 0$ for $FS \geq 1.0$

$w(z) = 10 - 0.5z$ for $z < 20$ m

$w(z) = 0$ for $z > 20$ m

Table 3: The level of liquefaction Severity

LPI	Iwasaki et al. (1982)	Luna and Frost (1998)	MERM (2003)
$LPI = 0$	Very low	Little to none	None
$0 < LPI < 5$	Low	Minor	Low
$5 < LPI < 15$	High	Moderate	Medium
$15 < LPI$	Very high	Major	High

<u>Literatures Reviewed:</u>

After recent review of various research papers from various country and various soil condition. The following assumption is taken in consideration either the Soil is Susceptible to liquefaction or not:

- Clayey layer with fines greater than 35% with Liquid Limit greater than 35, having Plasticity Index greater than 12 and moisture content lower than 85% of Liquid limit isn't susceptible towards liquefaction.
- Soil having natural moisture nearly equal to Liquid Limit may experience behaviour similar to liquefaction so proper mechanism should be designed to encounter the situation.
- If the Plasticity Index (PI) of the soil is equal or greater than 7 than such soil layer isn't susceptible to liquefaction. (Boulanger and Idriss, 2006)

Soil with PI < 12 and ration of Water Content to Liquid Limit (Wc/LL) > 0.85 will be susceptible to liquefaction. (Bray and Sancio, 2006).

Identification of Liquefaction

The present site consists of medium dense silty sand with fine gravel in general at the foundation level of subsurface. Observing the subsurface condition from the borehole exploration and tracking borehole logs, ***Liquefaction analysis has been carried out to identify the liquefaction potential.***

It is recommended to carry out liquefaction analysis if the continuous layer of loose sand pockets is observed during excavation at the time of construction.

Table 4: Liquefaction Analysis for BH1 for PGA =0.30g, M=7.5, GWT at 1.50 m

Depth (m)	Corrected SPT (N_{60})	Major Soil type	Fine contents %	Plasticity Index	Unit wt (KN/m^3)	Total Stress (KN/m^2)	Eff stress (KN/m^2)	C_N	$(N_1)_{60}$	$(N_1)_{60cs}$	γ_d	Kσ	CRR	$CSR_{M,\sigma}$	FS	Liquefaction	F(z)	w(z)	H	F(z).w(z).H	Liquefaction Potential Index	Severity (Iwasaki,1982)
1.5	11.69	medium sand	10		17.00	26	26	1.70	19.87	21.00	0.990	1.407	0.228	0.137	1.66	No	0	9.25	1.5	0.00	**0.00**	**Very Low**
3.0	15.13	medium sand	10		17.00	51	36	1.70	25.71	27.05	0.979	1.288	0.340	0.208	1.63	No	0	8.5	1.5	0.00		
4.5	17.14	medium sand	9		17.00	77	47	1.70	29.14	30.07	0.969	1.207	-	0.254	-	No	0	7.75	1.5	0.00		
6.0	19.48	medium sand	9		17.00	102	58	1.54	30.06	31.00	0.958	1.147	-	0.287	-	No	0	7	1.5	0.00		
7.5	19.16	medium sand	9		17.00	128	69	1.38	26.44	27.33	0.943	1.099	0.348	0.311	1.12	No	0	6.25	1.5	0.00		
9.0	20.03	medium sand	11		17.00	153	79	1.26	25.23	27.11	0.923	1.059	0.341	0.327	1.04	No	0	5.5	1.5	0.00		
10.5	22.00	medium sand	11		17.00	179	90	1.17	25.66	27.55	0.894	1.026	0.355	0.336	1.05	No	0	4.75	1.5	0.00		

Table 5: Liquefaction Analysis for BH2 for PGA =0.30g, M=7.5, GWT at 1.50 m

Depth (m)	Corrected SPT (N_{60})	Major Soil type	Fine contents %	Plasticity Index	Unit wt (KN/m^3)	Total Stress (KN/m^2)	Eff stress (KN/m^2)	C_N	$(N_1)_{60}$	$(N_1)_{60cs}$	γ_d	$K\sigma$	CRR	$CSR_{M,\sigma}$	FS	Liquefaction	F(z)	w(z)	H	F(z).w(z).H	Liquefaction Potential Index	Severity (Iwasaki,1982)
1.5	14.44	medium sand	10		17.00	26	26	1.70	24.54	25.86	0.990	1.407	0.310	0.137	2.26	No	0	9.25	1.5	0.00	**0.00**	**Very Low**
3.0	17.19	medium sand	8		17.00	51	36	1.70	29.22	29.85	0.979	1.288	0.458	0.208	2.20	No	0	8.5	1.5	0.00		
4.5	19.48	medium sand	7		17.00	77	47	1.70	33.11	33.63	0.969	1.207	-	0.254	-	No	0	7.75	1.5	0.00		
6.0	24.93	medium sand	7		17.00	102	58	1.54	38.47	39.04	0.958	1.147	-	0.287	-	No	0	7	1.5	0.00		
7.5	25.25	medium sand	7		17.00	128	69	1.38	34.85	35.39	0.943	1.099	-	0.311	-	No	0	6.25	1.5	0.00		
9.0	23.51	medium sand	9		17.00	153	79	1.26	29.62	30.56	0.923	1.059	-	0.327	-	No	0	5.5	1.5	0.00		
10.5	29.33	medium sand	9		17.00	179	90	1.17	34.22	35.22	0.894	1.026	-	0.336	-	No	0	4.75	1.5	0.00		

8. BEARING CAPACITY ANALYSIS

The allowable bearing capacity of sub-soil strata for Open foundation has been computed from shear and settlement failure considerations.

8.1 For Open foundation

Allowable Bearing Capacity

The bearing capacity analysis has been carried out for foundation soil. The well-known Indian Standard (IS 6403:1981) has been used to compute bearing capacity of soil on the basis of shear failure criteria.

For clayey soil (Φ=0)

The values are computed from unconfined compressive strength (UCS) as,

$q_{ult} = C_u N_c d_c S_c$ Refer IS:6403, Clause 5.3

where, C_u = undrained cohesion of soil, obtained from UCS

N_c = 5.14

S_c =shape factor, For square foundation, S_c =1.3

For rectangle foundation, $S_c = 1 + 0.2\frac{B}{L}$

$d_c = 1 + 0.2\frac{D_f}{B}\sqrt{N_\emptyset}$

Factor of Safety = 3.0

For c-Φ soil,

General shear failure,

$$q_{ult} = cN_cS_cd_ci_c + \gamma D\left(N_q - 1\right)S_qd_qi_q + 0.5\gamma BN_\gamma S_\gamma d_\gamma i_\gamma W'$$

Local Shear failure,

$$q'_{ult} = \frac{2}{3}cN'_cS_cd_ci_c + \gamma D\left(N'_q - 1\right)S_qd_qi_q + 0.5\gamma BN'_\gamma S_\gamma d_\gamma i_\gamma W'$$

Factor of Safety = 3.0

Bearing capacity factor shall be determined for general shear failure Φ

for local shear failure $\emptyset' = tan^{-1}\left(\frac{2}{3}tan\emptyset\right)$

The bearing capacity are computed as per the table below:

Angle of friction (Φ°)	N_c	N_q	N_γ
0	5.14	1	0
5	6.49	1.57	0.45
10	8.35	2.47	1.22
15	10.98	3.94	2.65
20	14.83	6.4	5.39

Angle of friction (Φ˚)	N_c	N_q	N_γ
25	20.72	10.66	10.88
30	30.14	18.4	22.4
35	46.12	33.3	48.03
40	75.31	64.2	109.41
45	138.88	134.88	271.76
50	266.89	319.07	762.89

Shape and depth factors are determined as per IS:6403-1981

Shape of Base	Shape Factors		
	S_c	S_q	S_γ
Continuous strip	1.0	1.0	1.0
Rectangle	$1+0.2\frac{B}{L}$	$1+0.2\frac{B}{L}$	$1-0.4\frac{B}{L}$
Square	1.3	1.2	0.8
Circle	1.3	1.2	0.6

Depth factors are calculated as:

$$d_c = 1 + 0.2\frac{D_f}{B}\sqrt{N_\emptyset}$$

$$d_q = d_\gamma = 1 \; for \; \emptyset < 10°$$

$$d_q = d_\gamma = 1 + 0.1\frac{D_f}{B}\sqrt{N_\emptyset} \; for \; \emptyset > 10°$$

Allowable Bearing Pressure from Settlement Criteria

In granular soils,

The settlement of granular soils can also be evaluated by the use of a semiempirical strain influence factor proposed by Schmertmann et al. (1978). According to this method, the settlement:

$$s_e = c_1 c_2 \Delta q \sum_0^{z_i} \frac{I_z}{E_s}\Delta z$$

where,

S_e = net allowable settlement

C_1 = correction factor for the depth of foundation $= 1 - 0.5\frac{q}{\Delta q}$

C_2= correction factor to account into creep in soil $= 1 + 0.2 log\left(\frac{time\ in\ year}{0.1}\right)$

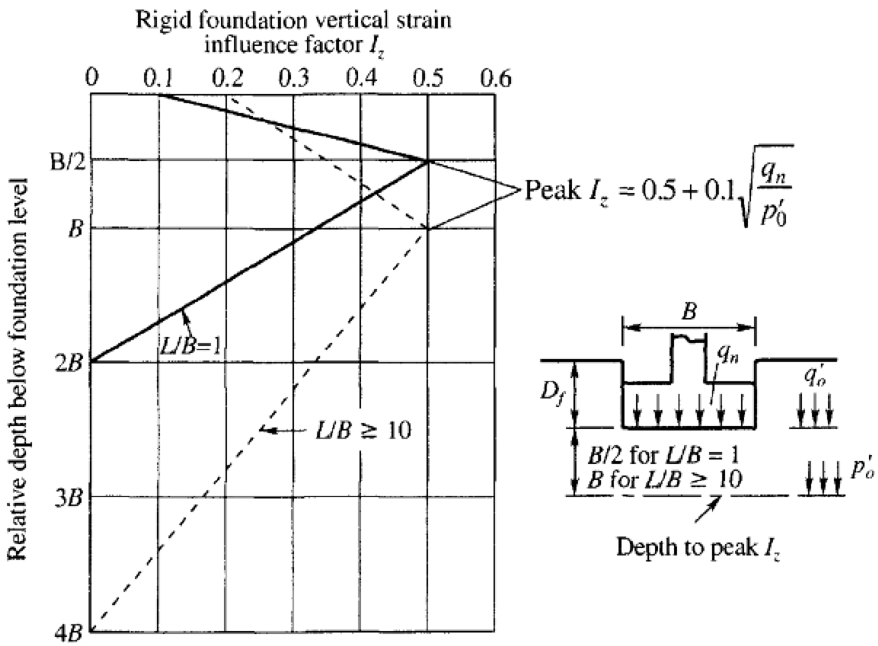
Δq= difference between stress at level of foundation and overburden pressure

I_z= vertical strain influence factor

Es= Modulus of Elasticity of soil = 2.5 x q_c in kg/cm^2

Where, q_c (cone penetration parameter) is related to SPT as,

Soil Type	$\frac{q_c}{N_{60}}$
Silts, sandy silts, slightly cohesive silt-sand mixtures	2-4
Clean fine to medium sands and slightly silty sands	3-5
Coarse sands and sands with little gravel	4-5
Sandy gravels with gravel	6-8



From In-situ SPT results,

The bearing capacity for open foundation are computed as per the Meyerhof's (1965) modified by Bowles (1977) as,

$$q_{safe} = 12.5N_{60}\left(\frac{3.28B+1}{3.28B}\right)^2 f_d \left(\frac{S}{25}\right) x\, R_{w1}$$

Where,

N_{60} = Standard Penetration Value for Average energy ratio of 60%

B = width (m)

S = Settlement (mm)

f_d = 1+0.33 (D/B) ≤ 1.33

R_{w1} = water correction factor = 0.5

For cohesive soil,

If the clay layer is encountered, the settlement is calculated as:

$$s_e = \frac{H}{1+e_0} C_c \log_{10}\left(\frac{(P_o + \Delta P)}{P_o}\right)$$

where, s_e = consolidation settlement (m)

H = thickness of soil (m)

e_o = initial void ratio

C_c = compression index, obtained from consolidation test results

For preliminary analysis, *IS:8009 (Part I)-1976, clause 9.2.2* recommends,

$C_c = 0.009(Liquid\ Limit - 10)$

$C_c = 0.30(e_o - 0.27)$

P_o = effective pressure at mid height of layer (kN/m^2)

ΔP = pressure increment (kN/m^2)

As per IS: 8009 clause 9.5, correction factors for rigidity and depth are applied

8.2 For bored cast in-situ concrete piles

The pile capacity are calculated as per Annex B: of IS 2911 (Part 1/Sec 2): 2010 as,

For cohesionless soil,

$$Q_u = A_p\left(\frac{1}{2} D\gamma N_\gamma + P_D N_q\right) + \sum_{i=1}^{n} K_i P_{di} tan\delta_i A_{si}$$

where, A_p = cross sectional area of pile (m^2)

D = diameter of pile shaft (m)

γ = effective unit weight of soil at pile tip (kN/m^2)

N_γ & N_q = bearing capacity factors depending on friction angle at pile tip

P_D = effective overburden pressure at pile tip (kN/m^2)

$\sum_{i=1}^{n}$ = Summation for pile installed layers 1 to n and contributing positive skin friction

K_i = coefficient of earth pressure applicable for the ith layer

P_{Di} = effective overburden pressure for the ith layer (kN/m^2)

δ_i = angle of wall friction between pile and soil for ith layer

A_{si} = surface area of pile shaft in the ith layer m^2

Factor of safety =2.5

Notes:

1) N_γ factor is taken for general shear failure as per IS: 6403
2) N_q factor is obtained from Fig. 1. Annex B, of IS 2911 (Part 1/sec2): 2010

3) K_i, the earth pressure coefficient depending on the nature of soil strata, type of pile, spacing of pile and its method of construction.

4) δ, angle of wall friction may be taken equal to friction angle of soil around pile stem

5) The maximum effective overburden at the pile tip should correspond to the critical depth, which may be taken as 15 times the diameter of the pile shaft for $\Phi \leq 30^\circ$ and increasing to 20 times for $\Phi \geq 40^\circ$

Piles in cohesive soils

$$Q_u = A_p N_c c_p + \sum_{i=1}^{n} \alpha_i \, c_i A_{si}$$

where,

A_p	=	cross-sectional area of pile tip (m^2)
N_c	=	bearing capacity factor, taken as 9
c_p	=	average cohesion at pile tip (kN/m^2), taken from UCS of soil
$\sum_{i=1}^{n}$	=	summation for pile installed layers 1 to n and contributing positive skin friction
α_i	=	adhesion layer for the ith layer depending on the consistency of soil
c_i	=	average cohesion for the ith layer (kN/m^2)
A_{si}	=	surface area of pile shaft in the ith layer

Use of SPT data for pile capacity in cohesionless soil

As per Meyerhof,

$$Q_u = 13N \frac{L}{B} A_p + \frac{\overline{N} A_s}{0.5}$$

where,

N	=	average N value at pile tip
L	=	length of penetration of pile in the bearing strata (m)
B	=	diameter or minimum width of pile (m)
A_p	=	cross-sectional area of pile tip (m^2)
N	=	average N value along the pile shaft
A_s	=	surface area of pile shaft (m^2)

The end bearing resistance value shall not exceed $130NA_p$.

For non-plastic silt or very fine sand, pile capacity is modified as:

$$Q_u = 10N \frac{L}{B} A_p + \frac{\overline{N} \, A_s}{0.60}$$

9. SAMPLE CALCULATION

The allowable bearing capacity (KN/m^2) for isolated footing of 2.4 m x 2.4 m at depths of 1.5 m and raft foundation of 10.0 m x 10.0 m at depth of 2.5m is presented below selecting the minimum SPT-N values from each depth of all the boreholes.

For 2.4 m x 2.4 m isolated footing at depth of 1.5 m

a) *For shear failure criterion,*

From laboratory tests:

Friction angle =30.0˚, cohesion=0 kN/m^2, Bulk density = 17.0 kN/m^3, GWT at 0 m

Shape factors		Depth Factors		Inclination Factors		Bearing Capacity factors	
S_q	1.58	d_q	1.18	i_q	1.00	N_q	18.40
S_c	1.61	d_c	1.25	i_c	1.00	N_c	30.14
S_γ	0.60	d_γ	1.00			N_γ	15.07
General Shear failure criteria from Hansen 1970 q_{ns} =						149.38	kN/m^2

b) *From settlement criterion,*

As per the Meyerhof's (1965) modified by Bowles (1977),

$$q_{safe}=12.5N_{60}\left(\frac{3.28B+1}{3.28B}\right)^2 f_d\left(\frac{S}{25}\right)x\,R_{w1}$$

= 150.62 kN/m^2 for 25 mm settlement

Settlement as per Schmertmann et al. (1978) for q_{ns}= 149.38 kN/m^2

layer		Z	I_z	N_{60}	q_c (kN/m^2)	E_{si}(kN/m^2)	$\frac{\Delta Z_i}{E_{si}} I_{zi}$
1.50	3.00	1.50	0.707	13.41	10725	26813	3.95E-05
3.00	4.50	1.50	0.386	13.41	10725	26813	2.16E-05
4.50	6.00	1.50	0.064	16.13	12907	32267	2.99E-06
							6.41E-05
Depth correction factor c1							0.962
Creep correction factor c2							1.540
Peak influence factor Izp							0.771
Expected settlement (mm)							13

Expected settlement < 25 mm (OK)

Adopted allowable bearing capacity is minimum of shear failure and that of settlement criterion.

Hence, adopted allowable bearing capacity = 149.38 kN/m^2

For 10.0 m x 10.0 m raft foundations at depth of 2.5 m

a) *For shear failure criterion,*

From laboratory tests:

Friction angle =30.0˚, cohesion=0 kN/m^2, Bulk density = 17.0 kN/m^3, GWT at 0 m

Shape factors		Depth Factors		Inclination Factors		Bearing Capacity factors	
S_q	1.58	d_q	1.07	i_q	1.00	N_q	18.40
S_c	1.61	d_c	1.10	i_c	1.00	N_c	30.14
S_γ	0.60	d_γ	1.00			N_γ	15.07
General Shear failure criteria from Hansen 1970 q_{ns} =						295.22	kN/m^2

b) From settlement criterion,

As per the Meyerhof's (1965) modified by Bowles (1977),

$$q_{safe}=12.5N_{60}\left(\frac{3.28B+1}{3.28B}\right)^2 f_d\left(\frac{S}{25}\right)x\,R_{w1}$$

$= 167.37$ kN/m^2 for 40 mm settlement

Settlement as per Schmertmann et al. (1978) for q_{ns} =167.37 kN/m^2

layer		Z	I_z	N_{60}	q_c (kN/m^2)	E_{si}(kN/m^2)	$\frac{\Delta Z_i}{E_{si}} I_{zi}$
2.50	4.00	1.50	0.271	15.46	12369	34014	1.19E-05
4.00	5.50	1.50	0.441	17.53	14025	38569	1.72E-05
5.50	7.00	1.50	0.612	19.43	15541	42737	2.15E-05
7.00	8.50	1.50	0.624	19.30	15443	42468	2.21E-05
8.50	10.00	1.50	0.557	20.36	16286	44787	1.87E-05
10.00	11.50	1.50	0.491	23.68	18944	52097	1.41E-05
11.50	13.00	1.50	0.424	32.85	26278	72264	8.79E-06
13.00	14.50	1.50	0.357	37.43	29944	82347	6.50E-06
14.50	16.00	1.50	0.290	42.01	33611	92431	4.70E-06
16.00	17.50	1.50	0.223	45.83	36667	100833	3.32E-06
17.50	19.00	1.50	0.156	45.83	36667	100833	2.32E-06
19.00	20.50	1.50	0.089	45.83	36667	100833	1.33E-06
20.50	22.00	1.50	0.022	45.83	36667	100833	3.32E-07
							1.33E-04
						Depth correction factor c1	0.942
						Creep correction factor c2	1.540
						Peak influence factor Izp	0.669
						Expected settlement (mm)	29

Expected settlement < 40 mm (OK)

Adopted allowable bearing capacity is minimum of shear failure and that of settlement criterion.

Hence, adopted allowable bearing capacity = 167.37 kN/m^2

10. RECOMMENDATION

i The allowable bearing capacity (KN/m^2) for various size of isolated and raft foundations at varying depths (measured from existing ground level) are below:

Table 6: Recommended Bearing Capacity for Isolated footing (25mm Settlement)

Size of isolated footing (L=B)	Depth of foundation (m)					
	1.5	**1.8**	**2.1**	**2.4**	**2.7**	**3.0**
1.5	151	173	176	179	184	189
1.8	149	170	173	175	178	182
2.1	149	163	171	172	174	177
2.4	149	158	165	171	172	174
2.7	148	154	160	165	171	173
3.0	146	151	156	161	167	172
3.3	144	149	154	159	164	169
3.6	142	147	152	158	162	167
3.9	142	147	152	157	161	168
4.2	143	148	152	159	166	173
4.5	144	150	157	164	171	178
4.8	150	156	163	170	175	181

Table 7: Recommended Bearing Capacity for Raft Foundation (40mm Settlement)

Size of raft foundation (L=B)	Depth of foundation (m)							
	1.5	**1.8**	**2.1**	**2.4**	**2.7**	**3.0**	**3.3**	**3.6**
5.0	147	158	168	178	185	193	201	210
10.0	141	149	158	165	171	177	183	190
15.0	138	147	155	161	167	172	177	183
20.0	137	145	153	159	164	169	174	179
25.0	137	144	152	158	163	168	173	177
30.0	136	144	151	157	162	167	171	176
35.0	136	143	151	157	161	166	171	175
40.0	136	143	150	156	161	165	170	174

ii The modulus of subgrade reaction of the soils are tabulated below:

Table 8: Modulus of Subgrade Reaction of the soil.

Depth	**Ks =1.8N_{60} (mN/m^3), BH-1**	**Ks =1.8N_{60} (mN/m^3), BH-2**
1.5 m	30.60	37.80
3.0 m	39.60	45.00
4.5 m	39.60	45.00
6.0 m	45.00	57.60
7.5 m	39.60	52.20
9.0 m	41.40	48.60
10.5 m	43.20	57.60

iii The minimum bearing capacity obtained from both general shear failure criteria and settlement failure are recommended for the design purpose for isolated footing and mat footing.

iv As per NBC: 105:2020, the soil type of the site is: Soil Type C -Soil Sites.

v Design Parameters: Friction Angle = 30.0°, Cohesion = 0.0 KPa, Unit Weight = 17.0 KN/m^3

vi Construction of foundation on filling should be avoided.

vii It is recommended for Compaction at the foundation level.

viii The site is not susceptible to liquefaction potential.

ix The foundation Design Engineer does not need to strictly follow the depth and dimension of foundation selected in the bearing capacity analysis of this report. Designer is free to select any other foundation dimension and depth depending upon the load of the structure. Therefore, once the size and depth of the foundation is finalized the calculation may need to be refined during design phase based on the parameters obtained from this investigation.

Care should be taken for the following during excavation and construction of the building foundation.

- The slope of the excavation should be maintained at about 45° to prevent the slope from collapsing during excavation or construction period.
- Presence of seepage water and consideration of probable rise in water table in monsoon, sidefall is eminent. So, at the time of construction of foundation, it is recommended to design appropriate site protection measures based on soil properties obtained on this report.

Bore Hole Log

Prime Civil Lab Pvt. Ltd.

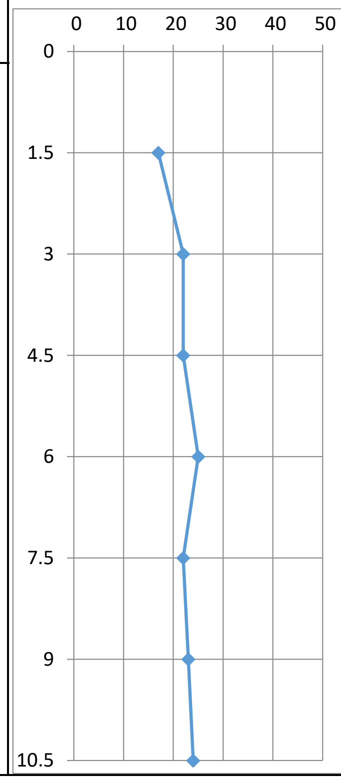
Drilling Log

Project: Detail Geotechnical Soil Investigation of Cold Store Building
Location: Nigale Sindhupalchowk District
Client: Potato Development Center, Nigale, Sindhupalchowk
Date: **2079-12-13**
Borehole No: **1**

Ground water: Nil

Soil Description	Symbol	Depth, m	Sample No. &Type	No. of blows 10/15 cm	No. of blows 10/15 cm	No. of blows 10/15 cm	N_c-Value	N-Value
Brown color Silty Sand with Fine Gravel		- 1						
			SPT	10	8	9		17
		- 2						
		- 3	SPT	9	10	12		22
		- 4						
			SPT	10	11	11		22
		- 5						
		- 6	SPT	11	12	13		25
		- 7						
			SPT	9	10	12		22
		- 8						
		- 9	SPT	10	10	13		23
		- 10						
			SPT	10	11	13		24

N-Value **SPT** **DCPT**



End Depth *** Completed at 10.50m** **Ground: Dry**

Types of Soil		**N Value**					
Granular Soil	Compactness	**0 to 4**	**4 to 10**	**10 to 30**	**30 to 50**	**> 50**	
		Very Loose	Loose	Med. Dense	Dense	Very Dense	
Cohesive Soil	Consistency	**0 to 2**	**2 to 4**	**4 to 8**	**8 to 16**	**16 to 32**	**> 32**
		Very Soft	Soft	Med. Soft	Stiff	Very Stiff	Hard

Note: N value = 50 is taken for the values that comes greater than 50 for the exploration depth.

Prime Civil Lab Pvt. Ltd.

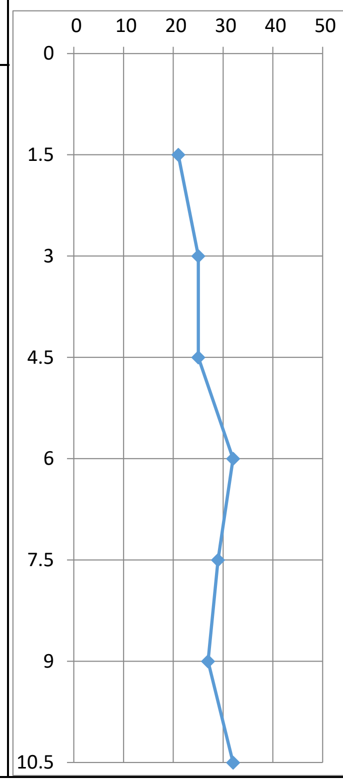
Drilling Log

Project: Detail Geotechnical Soil Investigation of Cold Store Building
Location: Nigale Sindhupalchowk District
Client: Potato Development Center, Nigale, Sindhupalchowk
Date: **2079-12-14**
Borehole No: **2**

Ground water: Nil

Soil Description	Symbol	Depth, m	Sample No. &Type	No. of blows 10/15 cm	10/15 cm	10/15 cm	N_c-Value	N-Value
Brown color Silty Sand with Fine Gravel		- 1						
			SPT	8	11	10		21
		- 2						
		- 3	SPT	7	10	15		25
		- 4						
			SPT	9	11	14		25
		- 5						
		- 6	SPT	11	15	17		32
		- 7						
			SPT	10	13	16		29
		- 8						
		- 9	SPT	10	12	15		27
		- 10						
			SPT	10	14	18		32

N-Value SPT DCPT



End Depth *** Completed at 10.50m** **Ground: Dry**

Types of Soil		**N Value**					
Granular Soil	Compactness	**0 to 4**	**4 to 10**	**10 to 30**	**30 to 50**	**> 50**	
		Very Loose	Loose	Med. Dense	Dense	Very Dense	
Cohesive Soil	Consistency	**0 to 2**	**2 to 4**	**4 to 8**	**8 to 16**	**16 to 32**	**> 32**
		Very Soft	Soft	Med. Soft	Stiff	Very Stiff	Hard

Note: N value = 50 is taken for the values that comes greater than 50 for the exploration depth.

Laboratory Test Result

Summary of Results

Project Name: Detail Geotechnical Soil Investigation of Cold Store Building
Location: Nigale Sindhupalchowk District
Date: 1-4 Baishak, 2080

Bore Hole	Depth (m)	Water content	Grain size fraction			Specific Gravity	Shear strength parameters		Remarks
			% fines	Sand	Gravel		c (kPa)	Φ	
BH-1	1.5	17.29%	9.6%	76.4%	14.0%	2.62	0.0	30.4	
BH-1	3.0	16.98%	9.8%	79.8%	10.4%	2.66	0.0	30.7	
BH-1	7.5	15.96%	8.7%	83.3%	8.0%	2.62	0.0	x	
BH-1	10.5	14.20%	10.9%	76.8%	12.3%	2.66	0.0	x	
BH-2	1.5	17.18%	9.8%	78.2%	12.0%	2.66	0.0	30.0	
BH-2	3.0	17.26%	7.9%	83.1%	9.0%	2.64	0.0	31.1	
BH-2	6.0	16.45%	7.4%	81.6%	11.0%	2.62	x	x	
BH-2	9.0	14.95%	8.7%	80.1%	11.2%	2.66	x	x	

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Project Name: Detail Geotechnical Soil Investigation of Cold Store Building
Location: Nigale Sindhupalchowk District
Date: 1-4 Baishak, 2080

Moisture Content Determination

Bore hole	depth (m)	Mass of empty can (gm)	Mass of can + wet sample (gm)	Mass of dry sample + can (gm)	Mass of wet sample (gm)	Mass of dry sample (gm)	Mass of water (gm)	moisture content (%)	Remarks
BH-1	1.5	32.42	428.79	370.37	396.37	337.95	58.42	17.29%	
BH-1	3.0	35.18	316.38	275.56	281.20	240.38	40.82	16.98%	
BH-1	7.5	32.51	396.73	346.60	364.23	314.09	50.13	15.96%	
BH-1	10.5	32.59	337.69	299.75	305.10	267.16	37.94	14.20%	
BH-2	1.5	32.37	326.90	283.73	294.54	251.36	43.17	17.18%	
BH-2	3.0	31.58	335.91	291.11	304.33	259.53	44.80	17.26%	
BH-2	6.0	34.75	290.87	254.70	256.12	219.95	36.17	16.45%	
BH-2	9.0	34.36	375.51	331.13	341.15	296.77	44.37	14.95%	

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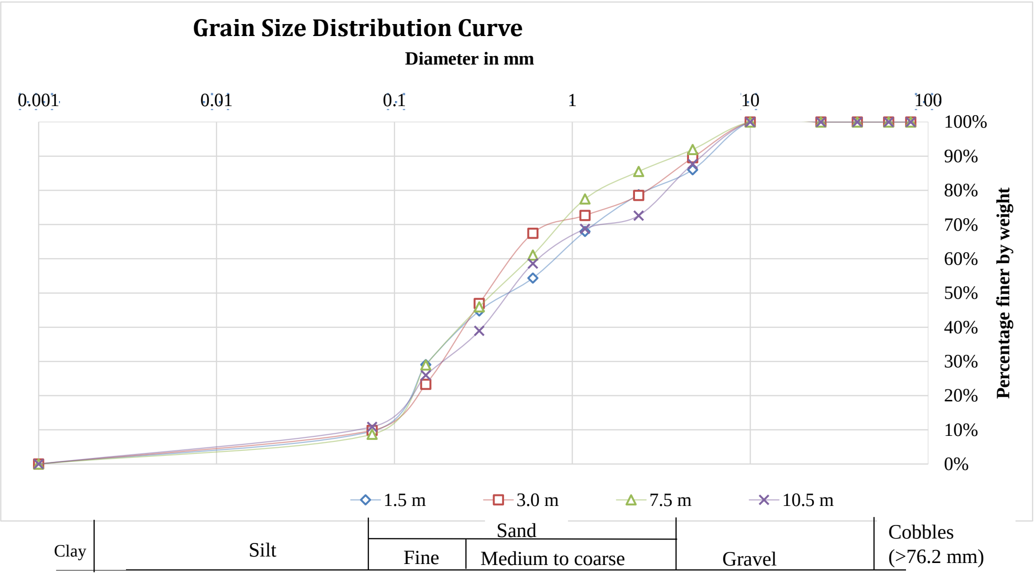
Grainsize Analysis Test Results

Project Name: Detail Geotechnical Soil Investigation of Cold Store Building
Location: Nigale Sindhupalchowk District
Date: 1-4 Baishak, 2080

Bore Hole: BH-1



Sieve size (mm)	1.5 m % finer	3.0 m % finer	7.5 m % finer	10.5 m % finer
80 mm	100%	100%	100%	100%
60 mm	100%	100%	100%	100%
40 mm	100%	100%	100%	100%
25 mm	100%	100%	100%	100%
10 mm	100%	100%	100%	100%
4.75 mm	86%	90%	92%	88%
2.36 mm	79%	79%	86%	73%
1.18 mm	68%	73%	77%	69%
600 μ	54%	67%	61%	59%
300 μ	45%	47%	46%	39%
150 μ	29%	23%	29%	26%
75 μ	10%	10%	9%	11%
pan	0%	0%	0%	0%

Clay/Silt=	9.6%	9.8%	8.7%	10.9%
Sand=	76.4%	79.8%	83.3%	76.8%
Gravel=	14.0%	10.4%	8.0%	12.3%
C_u=	11.0	6.5	7.2	9.9
C_c=	0.4	1.0	0.5	0.8

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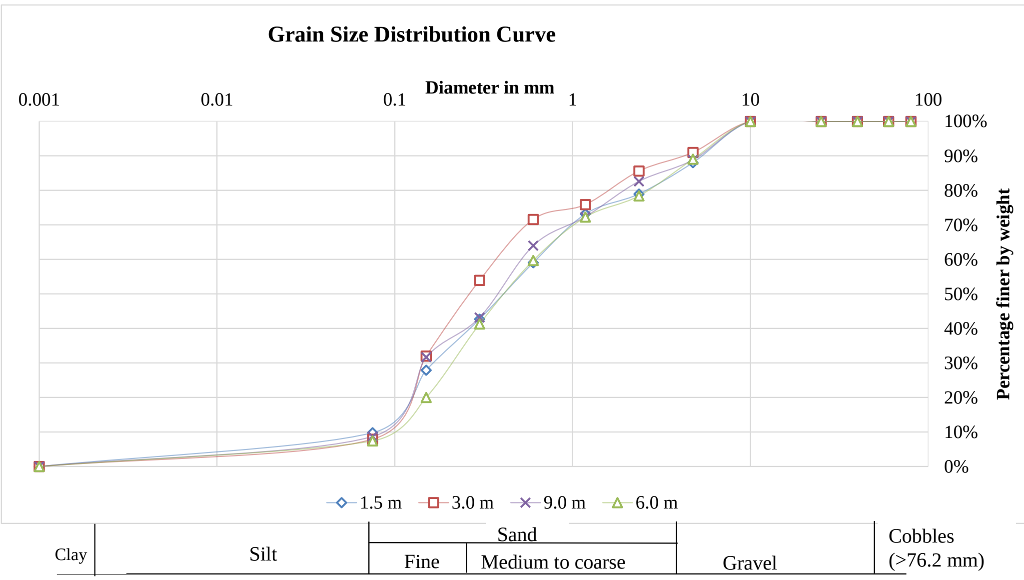
Grainsize Analysis Test Results

Project Name: Detail Geotechnical Soil Investigation of Cold Store Building

Location: Nigale Sindhupalchowk District

Date: 1-4 Baishak, 2080

Bore Hole: BH-2



	1.5 m	3.0 m	6.0 m	9.0 m
Sieve size (mm)	**% finer**	**% finer**	**% finer**	**% finer**
80 mm	100%	100%	100%	100%
60 mm	100%	100%	100%	100%
40 mm	100%	100%	100%	100%
25 mm	100%	100%	100%	100%
10 mm	100%	100%	100%	100%
4.75 mm	88%	91%	89%	89%
2.36 mm	79%	86%	78%	83%
1.18 mm	73%	76%	72%	72%
600 µ	59%	72%	60%	64%
300 µ	43%	54%	41%	43%
150 µ	28%	32%	20%	32%
75 µ	10%	8%	7%	9%
pan	0%	0%	0%	0%

Clay/Silt=	9.8%	7.9%	7.4%	8.7%
Sand=	78.2%	83.1%	81.6%	80.1%
Gravel=	12.0%	9.0%	11.0%	11.2%
C_u=	8.4	4.9	6.8	6.8
C_c=	0.6	0.6	0.9	0.5

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Specific Gravity Test Results

Project Name: Detail Geotechnical Soil Investigation of Cold Store Building
Location: Nigale Sindhupalchowk District
Date: 1-4 Baishak, 2080

Bore Hole	Depth	Wt. of Pyc+ Water (Full)	Wt. of Pyc Empty and Dry	Wt. of Pyc.+ Oven Dry Sample	Wt.of Pyc. + Sample +Water (Full)	Wt. of Oven Dry Sample	Specific Gravity	Remarks
BH-1	1.5	186.08	97.50	147.50	216.96	50.00	2.62	
BH-1	3.0	187.71	97.50	147.50	218.89	50.00	2.66	
BH-1	7.5	186.00	97.50	147.50	216.90	50.00	2.62	
BH-1	10.5	187.60	97.50	147.50	218.78	50.00	2.66	
BH-2	1.5	185.55	97.50	147.50	216.75	50.00	2.66	
BH-2	3.0	186.36	97.50	147.50	217.45	50.00	2.64	
BH-2	6.0	185.65	97.50	147.50	216.60	50.00	2.62	
BH-2	9.0	185.60	97.50	147.50	216.78	50.00	2.66	

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Direct Shear Test Results

Project Name: Detail Geotechnical Soil Investigation of Cold Store Building
Location: Nigale Sindhupalchowk District
Date: 1-4 Baishak, 2080

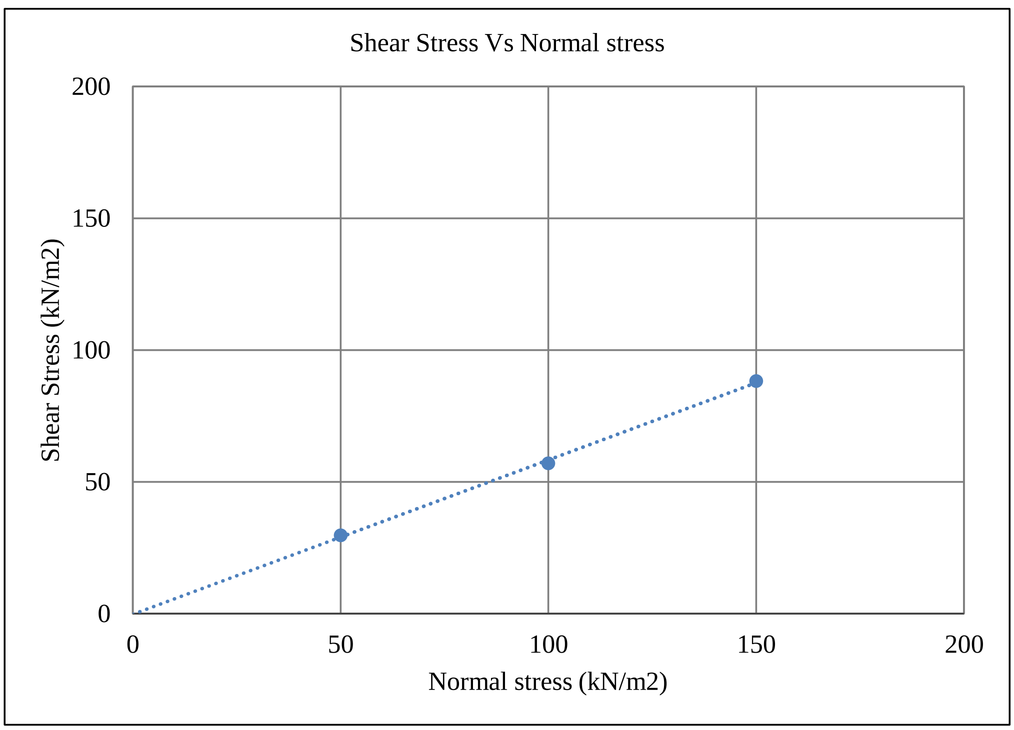
Bore Hole: BH-1 Depth, m: 1.5

Test Method	Ref: IS 2720 Part 5

Displacement Reading Factor : 0.01 mm/div
Force Reading Factor : 0.0026247 kN/div Strain Rate (mm/min): 1.25

Specimen Length : 6 cm Specimen Width : 6 cm Height of Specimen : 3.1 cm

Hanger Load (gm):		1800	3600	5400
Normal/ Axial Stress (kPa):		50	100	150
Peak	Shear Stress, Kpa	29.67	56.98	88.23
	Displacement, mm	4.2	6.2	6.2



cohesion= 0.0 kN/m2
friction angle = 30.4 °

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Direct Shear Test Results

Project Name: Detail Geotechnical Soil Investigation of Cold Store Building
Location: Nigale Sindhupalchowk District
Date: 1-4 Baishak, 2080

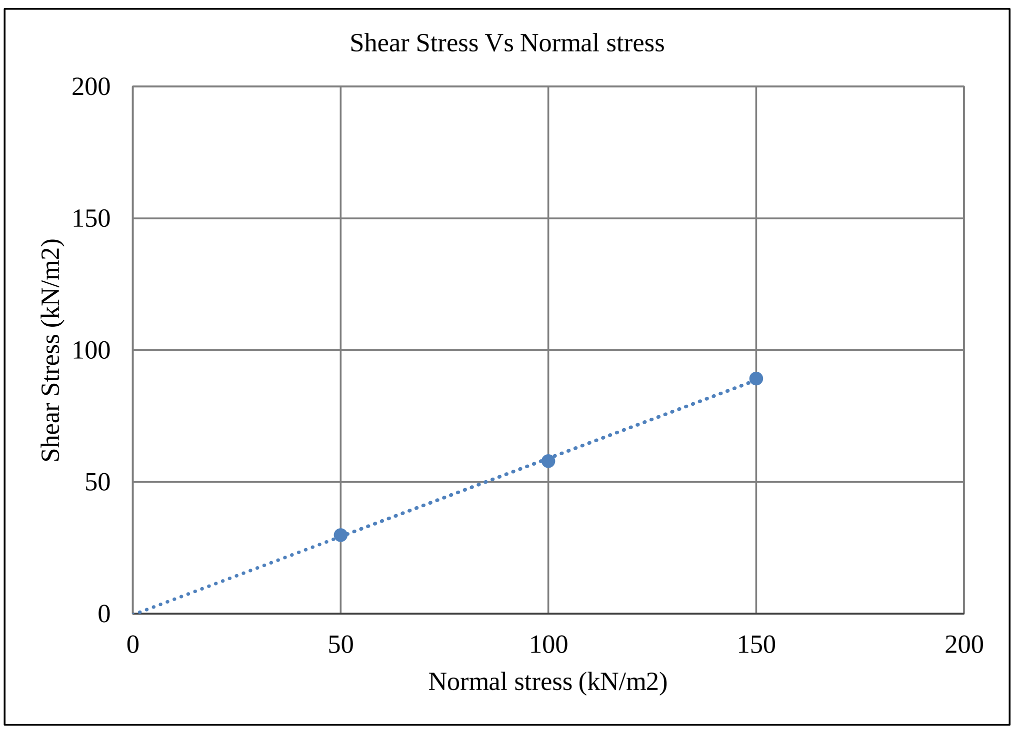
Bore Hole: BH-1 Depth, m: 3

Test Method	Ref: IS 2720 Part 5

Displacement Reading Factor : 0.01 mm/div
Force Reading Factor : 0.0026247 kN/div Strain Rate (mm/min): 1.25

Specimen Length : 6 cm Specimen Width : 6 cm Height of Specimen : 3.1 cm

Hanger Load (gm):		1800	3600	5400
Normal/ Axial Stress (kPa):		50	100	150
Peak	Shear Stress, Kpa	29.79	57.84	89.14
	Displacement, mm	5.4	5.8	6.2



cohesion= 0.0 kN/m2
friction angle = 30.7 °

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Direct Shear Test Results

Project Name: Detail Geotechnical Soil Investigation of Cold Store Building
Location: Nigale Sindhupalchowk District
Date: 1-4 Baishak, 2080

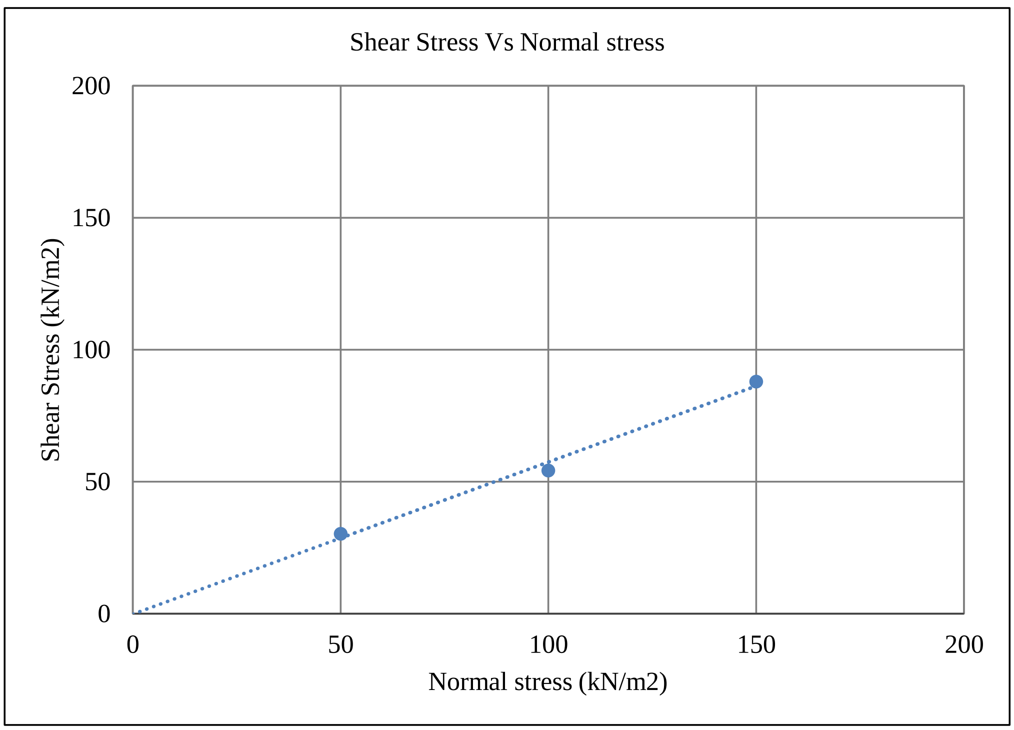
Bore Hole: BH-2 Depth, m: 1.5

Test Method	Ref: IS 2720 Part 5

Displacement Reading Factor : 0.01 mm/div
Force Reading Factor : 0.0026247 kN/div Strain Rate (mm/min): 1.25

Specimen Length : 6 cm Specimen Width : 6 cm Height of Specimen : 3.1 cm

Hanger Load (gm):		1800	3600	5400
Normal/ Axial Stress (kPa):		50	100	150
Peak	Shear Stress, Kpa	30.23	54.23	87.86
	Displacement, mm	5.4	5.8	6.2



cohesion= 0.0 kN/m2
friction angle = 30.0 °

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Direct Shear Test Results

Project Name: Detail Geotechnical Soil Investigation of Cold Store Building
Location: Nigale Sindhupalchowk District
Date: 1-4 Baishak, 2080

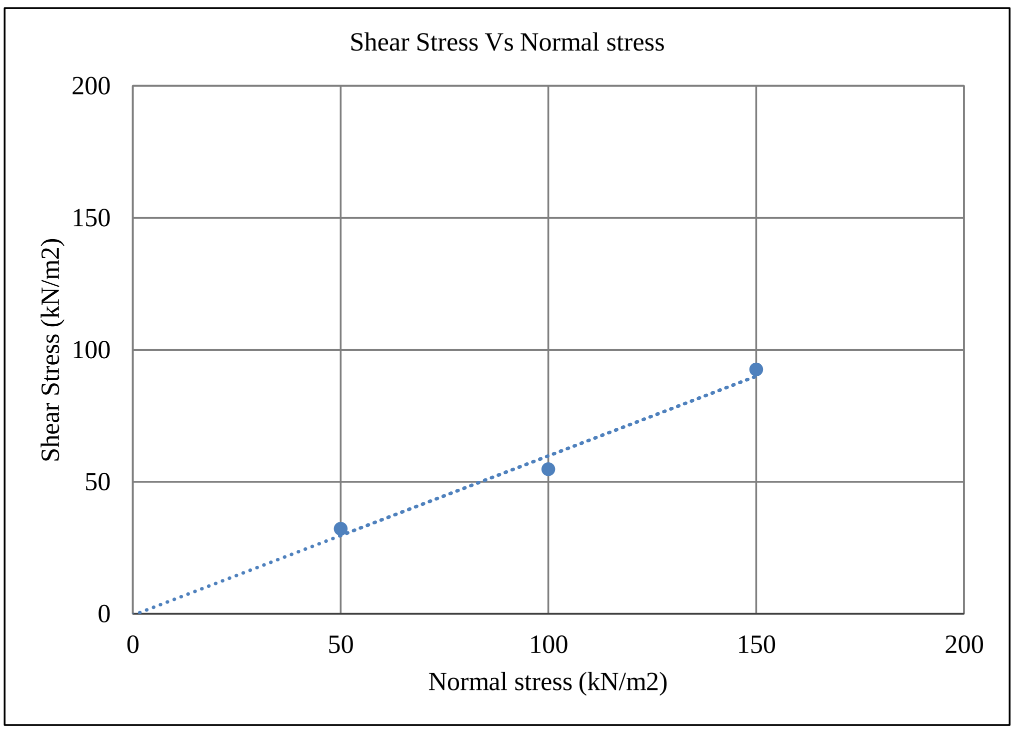
Bore Hole: BH-2 Depth, m: 3.0

Test Method	Ref: IS 2720 Part 5

Displacement Reading Factor : 0.01 mm/div
Force Reading Factor : 0.0026247 kN/div Strain Rate (mm/min): 1.25

Specimen Length : 6 cm Specimen Width : 6 cm Height of Specimen : 3.1 cm

Hanger Load (gm):		1800	3600	5400
Normal/ Axial Stress (kPa):		50	100	150
Peak	Shear Stress, Kpa	32.17	54.68	92.54
	Displacement, mm	6.2	6	6.6

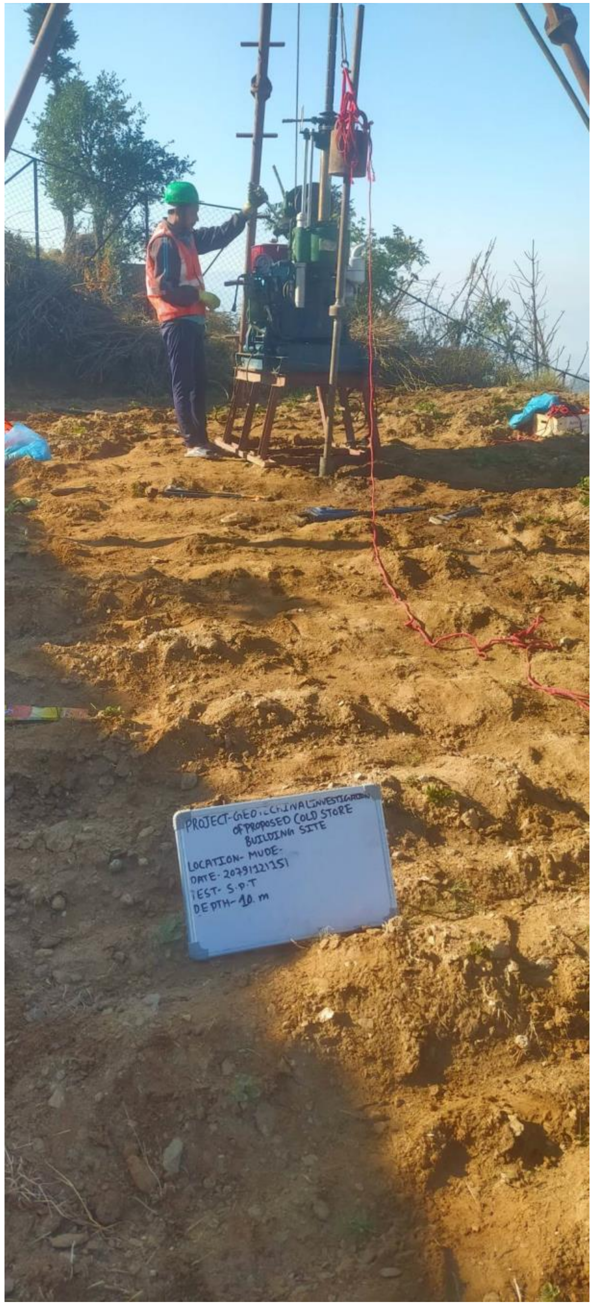


cohesion= 0.0 kN/m2
friction angle = 31.1 ˚

Figures and Photographs


PROJECT-GEOTECHINAL INVESTIGATION
OF PROPOSED COLD STORE
BUILDING SITE
LOCATION- MUDE-
DATE- 2079|12|14|
TEST- S.P.T
DEPTH-1.5 m


Latitude: 27.678514
Longitude: 85.933917
Elevation: 2501.65±41 m
Accuracy: 28.7 m
Time: 03-29-2023 08:30
Note: patato farm
PROJECT-GEOTECHINAL INVESTIGATION
OF PROPOSED COLD STORE
BUILDING SITE
LOCATION- MUDE-
DATE- 2079|12|15|
TEST- S.P.T
DEPTH- 10. m
Powered by NoteCam


PROJECT-GEOTECHINAL INVESTIGATION
OF PROPOSED COLD STORE
BUILDING SITE
LOCATION- MUDE-
DATE- 2079|12|15|
TEST- S.P.T
DEPTH- 10. m


PROJECT-GEOTECHINAL INVESTIGATION
OF PROPOSED COLD STORE
BUILDING SITE
LOCATION- MUDE-
DATE- 2079/12/24
TEST- S.P.T
DEPTH- 6.m.
B.H. TWO


PROJECT-GEOTECHINAL INVESTIGATION
OF PROPOSED COLD STORE
BUILDING SITE
LOCATION- MUDE-
DATE- 2079/12/24
TEST- S.P.T
DEPTH- 3.m.
B.H. TWO


PROJECT-GEOTECHINAL INVESTIGATION
OF PROPOSED COLD STORE
BUILDING SITE
LOCATION- MUDE-
DATE- 2079/12/23
TEST- S.P.T
DEPTH- 1.5.m.


PROJECT-GEOTECHINAL INVESTIGATION
OF PROPOSED COLD STORE
BUILDING SITE
LOCATION- MUDE-
DATE- 2079/12/14
TEST- S.P.T
DEPTH-7.5 m.


PROJECT-GEOTECHINAL INVESTIGATION
OF PROPOSED COLD STORE
BUILDING SITE
LOCATION- MUDE-
DATE- 2079/12/14
TEST- S.P.T
DEPTH-10.m.


PROJECT-GEOTECHINAL INVESTIGATION
OF PROPOSED COLD STORE
BUILDING SITE
LOCATION- MUDE-
DATE- 2079/12/14
TEST- S.P.T
DEPTH 3.m

STRUCTURE REPORT

1. COLD STORAGE

TO WHOM IT MAY CONCERN

This report comprises the summary of the structural design of Cold storage of Federal agriculture farm. The report consists of design procedures adopted, assumptions made, and the input assign in the design. During design it is assumed that the client will completely followed the architectural as well as the structural design drawings. It is also assumed that the construction will be supervised by a professional engineer.

The designer will not be responsible if any alteration or change to the structural system is made by the client or contractor without the prior permission from the designer, or the alteration to the non-structural system is made such that the weight of each individual floor or the weight of the whole building is altered by more than 10% of the design weight of the floor and the total weight

The design calculations and derivations are limited only to let the concerned people know the methodology adopted. However, the calculation may be provided to the client or the concerned authorities when needed, upon request.

GOEC-RAJDEVI-RECON JV

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[CHAPTER 1] INTRODUCTION

1.1. General

This report summarizes the structural analysis and design of RC framed building with steel truss. It has planned to utilize the building for office purpose. The structural analysis in this building considers ground floor plus one storey. The aim of design is the achievement of an acceptable probability that structures being designed will perform satisfactorily during their intended life. With an appropriate degree of safety, they should sustain all the loads and deformations of normal construction and use and have adequate durability and adequate resistance to the effects of misuse and fire. Structural Analysis of the concerned building has been done in details with analysis and designs software.

The analysis and design has been based on the prevailing codes that are in practice in Nepal, the National Building code of Nepal (NBC2020/1994) and the IS code at places required. This report consists of the design procedures adopted, the assumptions made, the inputs made in the design and the design output.

1.2. Assumptions

The following assumptions are taken into consideration in the seismic resistant analysis and design of structures:

- Adequate supervision and quality systems are provided during execution of the works.
- Construction is carried out by personnel having the appropriate skill and experience.
- Construction materials and products confirm to the pertinent codes and specifications.
- The structure is adequately maintained.
- The structure is used in accordance with the design brief.
- An earthquake is not likely to occur simultaneously with maximum flood, wind, waves or tides.
- Resonance as visualized under steady state sinusoidal excitation will not occur, as the small duration of earthquake is not enough to build up resonance amplitudes. Subsoil does not considerably settle or slide due to earthquake at the site of structure.

This report is divided into three chapters. Chapter one begins with introductions and general description, Chapter two comprises the numerical modeling, analysis and design; Chapter three presents the summary and recommendations.

1.3. Salient Features

1.3.1. Project Information

Type of building : Cold Storage

Location : Sindhupalchowk ,Nigale

Plinth Area : 336.64 sq.m

1.3.2. Building Features

The building has some special features which are listed below:

Type of Building :Special RC Moment Resisting Frame Structure

Wall Type : Brick Masonry Wall
Footing Type : Isolated Footing
Depth of foundation : 1500 mm
Dimension (m) (centre to centre)
L 2180 m

B 2180m

Storey Height (m) : 3.45 m
Total Height (m) : 6.64 m
No of Storey : Ground +Truss

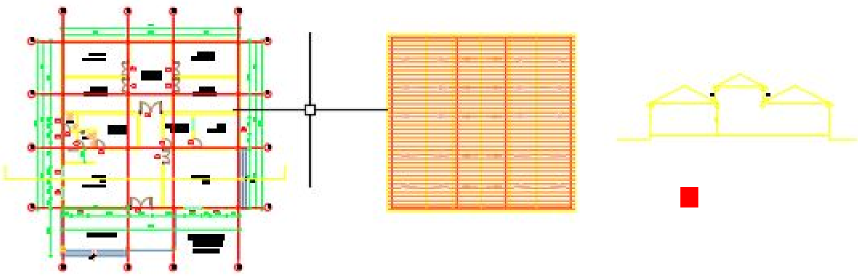


Figure 1-1: Plan of Building

For More Detail Refer Architectural Drawing.

1.3.3. Site Condition

Type of Soil : Type B, Medium Soil. As per NBC 105:2020

Allowable Bearing Capacity: 130 KN/m2 (Assumed)

Seismic Zone Factor: 0.3 as per NBC 105:2020

[CHAPTER 2] ANALYSIS TECHNOLOGY AND METHOLODOGY

2.1. General

After completion of Architectural design, the layout of columns and beams are done without affecting the Architectural functions of building so far. Structure is modeled using finite element method. A three-dimensional beam element having 12 DOF with 6 DOFs at each node were used for modeling beams and columns in the building.

The structure is analyzed by the linear elastic theory to calculate internal actions produced by anticipated design loads. The analysis is carried out using state of art three dimensional structural analysis programs like ETABS 2020 The design loads considered as per the relevant codes of practice comprise dead load due to permanent structures, live load due to occupancy of the structure and seismic load due to anticipated earthquake possible at the proposed location. A number of load combinations are considered to obtain the maximum values of design stresses.

Following considerations is made during modeling, analysis and design.

- The structures are Reinforced Concrete Special Moment Resisting Frame (SMRF) type. Beams and columns are considered as the structural load resisting elements. Although non-structural components like wall plaster, infill walls, floor finishing etc. has comes effects on structural performance, they are considered only as loading.
- For all Structural elements, M20 grade of concrete is used.
- Centre-line dimensions are followed for modeling, analysis and design.
- Floor slabs are assumed to be rigid in their own plane. The slab action has been modeled by rigid floor diaphragms. Slabs are also considered in modeling. Slab is modeled as shell element.
- Beam and columns are modeled as frame elements.
- The main beams rest centrally on columns to avoid local eccentricity.
- Foundation is assumed to be fully rigid at the plinth level.
- The beam-column joint is not modeled in detail.
- Preliminary sizes of structural components are assumed by experience.
- Seismic loads were considered acting in the horizontal direction (along either of the two orthogonal directions of building) and not along the vertical direction, since it is not considered to be significant for design of structural member’s suitable load combinations as suggested by NBC.
- NBC 105:2020 are used.

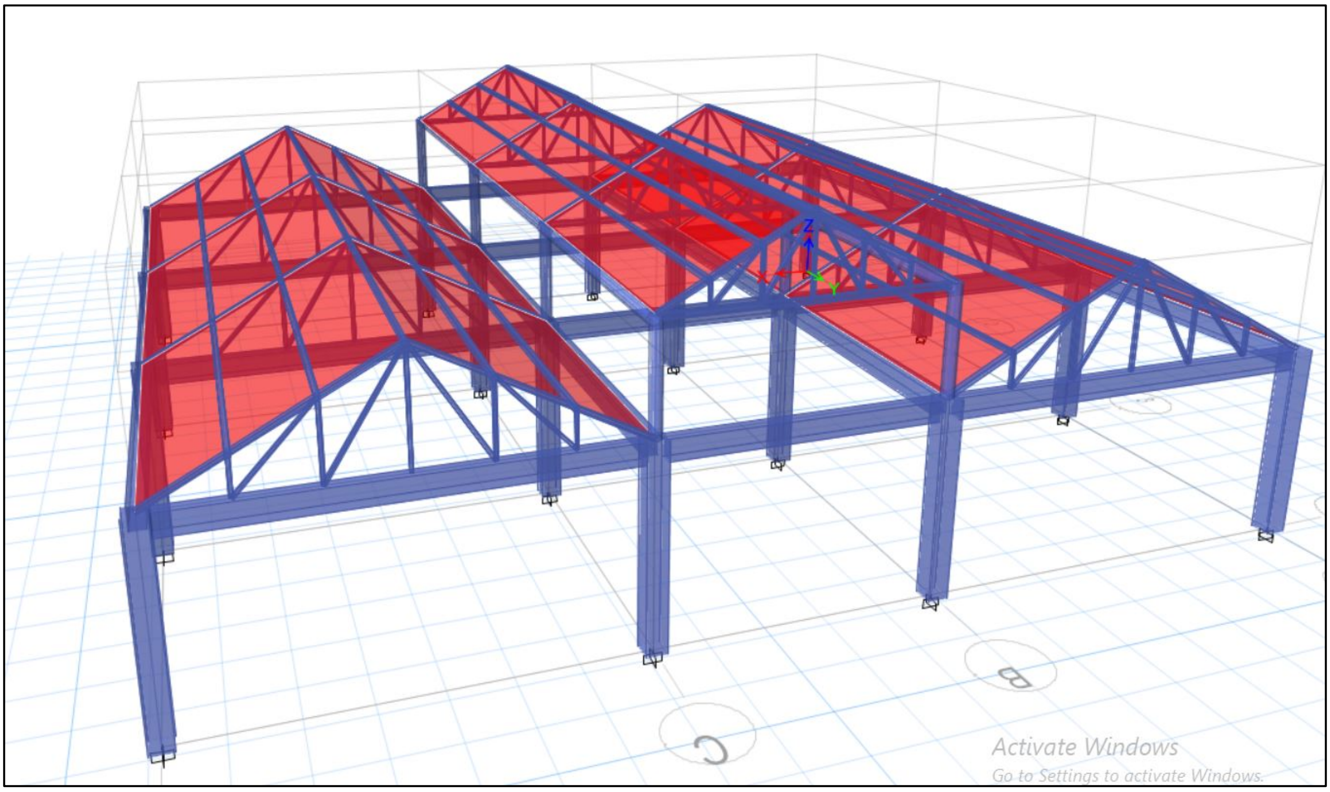


Figure 2-1: 3D- Model of Building

2.2. Codes and Standard Used

For the structural analysis and design, the following codes and standard are followed:

- IS 456- 2000 Code of practice for plain and reinforced concrete
- IS 875-1987 Code of practice for design loads (other than earthquake) for buildings and structures
- NBC 105:2020 Criteria for Earthquake Resistant Design of Structures,
- IS 13920-1993 Code of practice for ductile detailing of reinforced concrete structures subjected to seismic forces
- NBC Nepal Building Code

2.3. Software Used

The following software is used for the structural analysis and design. ETABS 2020, version 20.0.0 ETABS is a special purpose finite element analysis and design program developed specifically for building systems. With ETABS, models are defined logically floor-by-floor, column-by-column, bay-by-bay and wall-by-wall and not as a stream of non-descript nodes and elements as in general purpose programs. The software has very powerful numerical methods, design procedures and international design codes, all working from a single comprehensive database. At its core, it utilizes the same analysis engine as used by SAP2000.

Among others, ETABS can do model generation, seismic and wind load generation, finite element-based linear and non-linear static and dynamic analysis, concrete frame design (column and beam) and shear wall design.

[CHAPTER 3] ANALYSIS

3.1. Material Properties

3.1.1. Concrete

All components of plain and reinforced concrete are M20 grade as specified in design.

Modulus of Elasticity [E_c] = 5000 $\sqrt{f_{ck}}$ N/mm^2 (Cl. 6.2.3.1, IS 456:2000)

= 22360.68 N/mm^2 for M20 Grade Concrete

Poisson's Ratio [U] = 0.2

Unit Weight = 25 KN/m^3

Characteristic Strength [f_{ck}] = 20 N/mm^2 for M20 Grade Concrete

The structural design strength is derived from the characteristic strength multiplied by a coefficient 0.67 and divided by the material partial safety factor. The partial factor for concrete in flexure and axial load is 1.5.

3.1.2. Reinforcement Steel

Characteristic strength of high yield steel is taken as 500 Mpa (TMT) for main longitudinal and shear rebar and material partial safety factor is to be 1.15. Modulus of Elasticity [E_s] = 2x10^5 N/mm^2

Poisson's Ratio [U] = 0.3

3.2. Section Properties

Preliminary Size of Members

The preliminary sizes of Beam, Column, and Slab were chosen based on experience.

Beam : 230 mm x 350 mm (Main Beam)

Column : 350 mm x 350 mm

Thickness : 127 mm (Floor Slab)

: 150 mm (Staircase Slab)

During the analysis, beam and column are modeled as frame elements whereas slabs, are modeled as area element.

3.3. Loading

The following considerations are made during the loading on the structural model:

- The loads distributed over the area are imposed on the area element and the loads distributed over the length are imposed on the frame elements whenever possible.
- Where such loading is not possible, equivalent conversion to different loading distribution is carried to load the model near the real case as far as possible.

For lateral load, necessary calculations are performed to comply with the requirements of NBC 105:2020.

3.3.1. Load Cases

The following load cases are used for the loading during the analysis.

Load Name	Load Type	Description	Unit	Remarks
DL	Dead	Self-weight of the structure	KN/m^2	
WL	Dead	Wall Load	KN/m	On beam
FL	S. Dead	Floor Finish Load	KN/m^2	On slab
PL	S. Dead	Partition Wall Load	KN/m^2	On floor slab
LL	Live	Imposed Load	KN/m^2	On floor slab
RLL	Live	Imposed Load	KN/m^2	On terrace slab
EQx	Quake	Equivalent Static Lateral Load	KN	
EQy	Quake	Equivalent static lateral load	KN	

3.3.2. Load Combinations:

The load combinations are based on NBC 105:2020. The following load combinations are specified as per NBC 105:2020:

Static Load Combination:

1.2DL+1.5LL

Seismic Load Combination:

DL + λLL ±E
Where, λ = 0.6 for storage facilities
= 0.3 for other usage

The following load combinations are used during analysis

Table 3-1: Load Combination

S.N.	NAME
1	1.2DL + 1.5LL
2	DL+0.3LL+EQX
3	DL+0.3LL-EQX
4	DL+0.3LL+EQY
5	DL+0.3LL-EQY

3.4. Estimation of Load:

The loads on the building are based on Indian codes of Practices. The unit weight of different structural and non-structural elements are derived from IS 875 Part 1 and presented in Table 3. The load calculations are based on actual measured drawings. The self-weight of beams, columns and slabs are calculated by the program. Similarly the imposed loads are applied on the slab as area load in KN/m^2 and values of imposed loads are tabulated in table below.

- The weight of infill walls are calculated and applied on beams as line weight in KN/m.
- Partition wall load are assigned as uniformly distributed area load in slab as area load in KN/m^2.
- Floor finishing load are assigned as area load in slab.
- Single type of Live load is assigned in each panel of slab.
- A frame load is applied as parapet loading on the exterior frame of the roof level.
- The roof is assumed accessible and loaded with roof live load as per Indian Standard, IS 875 -1987(part2) but this load is not considered during seismic load.

3.4.1. Unit Weight (Dead Load)

Dead loads for analysis are calculated as per Indian Standard, IS 875 -1987(part1). Unit weights of different material used are given below.

Unit Weight of Material

S.N.	Type	Value	
1	Reinforced Concrete	25	KN/m^3
2	Brick Masonry	18.85	KN/m^3
3	Screed	21	KN/m^3
4	Marble	26.7	KN/m^3
5	Plaster	20.4	KN/m^3

Dead Load Calculation

Depth of Beam=	350	mm
Floor Height =	3450	mm
Height of Parapet Wall =	0	mm

<u>Dead Load of Walls</u>

Dead Load of 9" thick wall without opening =	17.02	KN/m
Dead Load of 9" thick wall with 25% opening =	12.76	KN/m
Dead Load of 9" thick wall with 40% opening =	10.21	KN/m
Dead Load of 4" thick wall without opening =	10.3	KN/m
Dead Load of 4" thick wall with 25% opening =	7.72	KN/m

Dead Load of 9" thick parapet wall =	0	KN/m

Floor Loads

Thickness of Slab =	127	mm
Tile =	0.1	KN/m^2
Thickness of tile =	12.5	mm
Thickness of tile with plaster =	25	mm
Thickness of Marble =	20	mm
Thickness of Screed =	50	mm
Thickness of Cement Plaster =	12.5	mm

Dead Load of Structural Slab =	3.175	KN/m^2
Dead Load of Tile =	0.1	KN/m^2
Dead Load of Marble =	0.534	KN/m^2
Dead load of Screed =	1.05	KN/m^2
Dead Load of Cement Plaster =	0.255	KN/m^2
Total Dead load of Floor Finish (Tile) =	1.15	KN/m^2
Total Dead load of Floor Finish (Marble) =	1.87	KN/m^2
Total Dead load of Floor Finishes (Cement Punning) =	1.05	KN/m^2

3.4.2. Live Load

The magnitude of live load depends upon the type of occupancy of the building. These are to be chosen from code IS875:1987(part II) for various occupancies. The live load distribution varies with time. Hence each member is designed for worst combination of dead load and live loads. Live loads for office building are given below:

3.4.3. Seismic Load

The seismic load calculation is done by equivalent static method. The equivalent static method is used for all serviceability limit state (SLS) calculations regardless of the building characteristics.

For ultimate limit state (ULS), the Equivalent Static Method may be used when at least one of the following criteria is satisfied:

- The height of the structure is less than or equal to 15m.
- The natural time period of the structure is less than 0.5 secs
- The structure is not categorized as irregular and the height is less than 40m.

Table 3-2: Horizontal design spectrum coefficient

We have,

Frame Type	=	Reinforced Concrete Moment Resisting Frame

Height of Building,H	=	3.45	m
Soil Type	=	Type B	
Approximate Fundamental Period of Vibration	=	$k_t H^{3/4}$	
	=	$0.075 * H^{3/4}$	
	=	0.190	sec
Amplified period of vibration, T1 sec	=	**0.237**	sec
		$1+(\alpha-1)*T/T_a$	if $T<T_a$
Spectral Shape Factor, $C_h(T)$	=	α	if $T_a<=T<=Tc$
		$\alpha[K+(1-K)(T_c/T)^{2]}$	if $T_c<=T<=6$
	=	2.250	
Seismic Zoning Factor, Z	=	0.350	
Importance Factor, I	=	1.000	
Elastic Site Spectra, (CT1)	=	$C_h(T)*Z*I$	
	=	0.788	
Ductility Factor, Rμ	=	4.000	
Overstrength Factor for ultimate limit. Ωu	=	1.500	
Overstrength Factor serviceability limit. Ωs	=	1.250	
Horizontal Base Shear Coefficient for ultimate limit, $C_d(T1)$	=	$\frac{C(T1)}{R\mu * \Omega u}$	
	=	**0.131**	
Elastic Site Spectra for serviceability limit, (C_sT1)	=	0.20*(CT1)	
	=	0.1575	
Horizontal Base Shear Coefficient for serviceability limit, $C_d(T1)$	=	$\frac{Cs(T1)}{\Omega s}$	
	=	**0.126**	

For Vertical Distribution of Seismic Forces
From Clause 6.3 NBC 105:2020
For Structure having time period T<= 0.5 sec

k = 1

For Structure having time period T>= 2.5 sec

k = 2

so,

k = 1.00

[CHAPTER 4] ANALYSIS OUTPUT

The analysis results are discussed in this chapter. Equivalent Static Method is used. The major discussion are focused on the eccentricity, story shear, inter story drift, maximum displacement and base shear along two orthogonal directions. The column and beam size and reinforcement are then designed for maximum forces.

4.1. Modal Time Period and Mass Participation Factor

As per NBC 105:2020 section 7.3 a sufficient number of modes shall be included in the analysis to include at least 90% of the total seismic mass in the direction under consideration. Analysis was carried out for first 12 modes so that the mass participation satisfies this criterion in both orthogonal directions. Following table shows time period and mass participation ratio for all modes:

Table 4-1: Modal Participating Mass Ratio

Mode	Period	UX	UY	SumUX	SumUY
	sec				
1	0.5	0.1436	0.5219	0.1436	0.5219
2	0.471	0.4934	0.1803	0.637	0.7021
3	0.368	0.1053	0.0108	0.7422	0.7129
4	0.223	0.0063	0.1999	0.7485	0.9128
5	0.187	0.2419	0.0116	0.9904	0.9245
6	0.163	0.0096	0.0755	1	1

4.2. Storey Drift

As per section 5.6.3 NBC 105:2020, the storey drift in any storey shall not exceed 0.025 times the storey height at ultimate limit state. In this building the storey drift is limited to 75 mm. From the analysis the displacements of the mass centre of various floors are obtained and are shown in Table below along with storey drift:

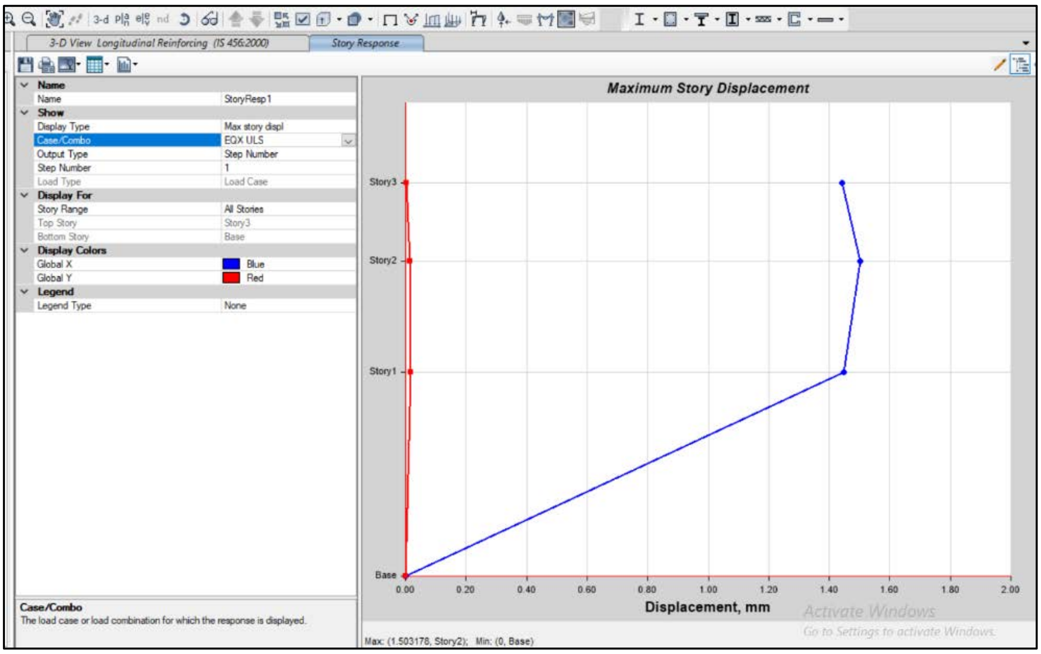


Figure:Storey Displacement due to EQx

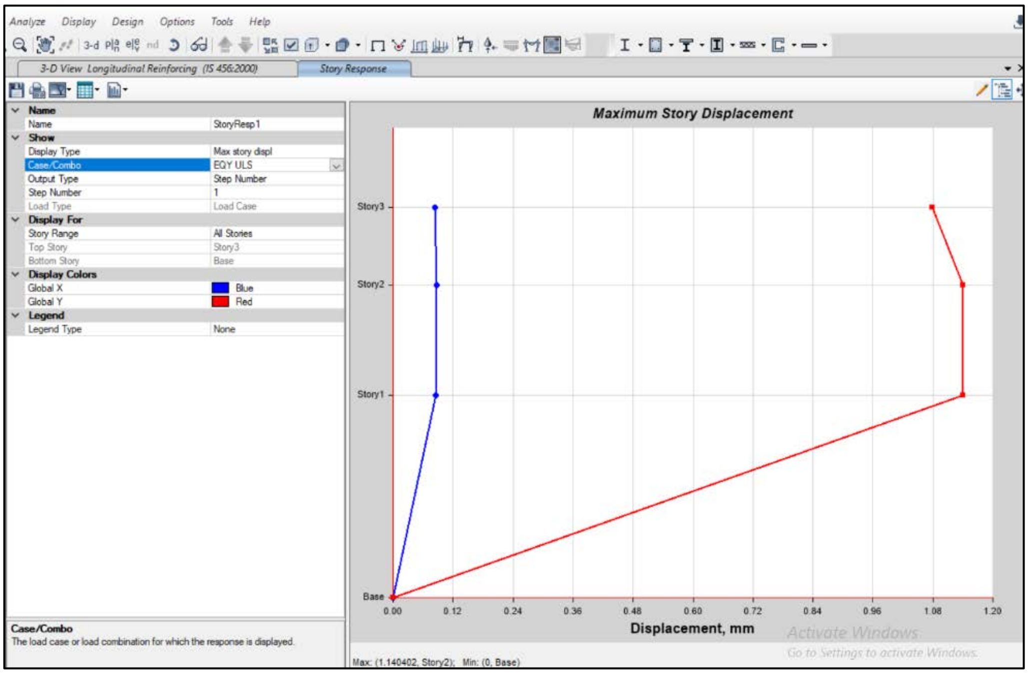


Figure:Storey Displacement due to EQy

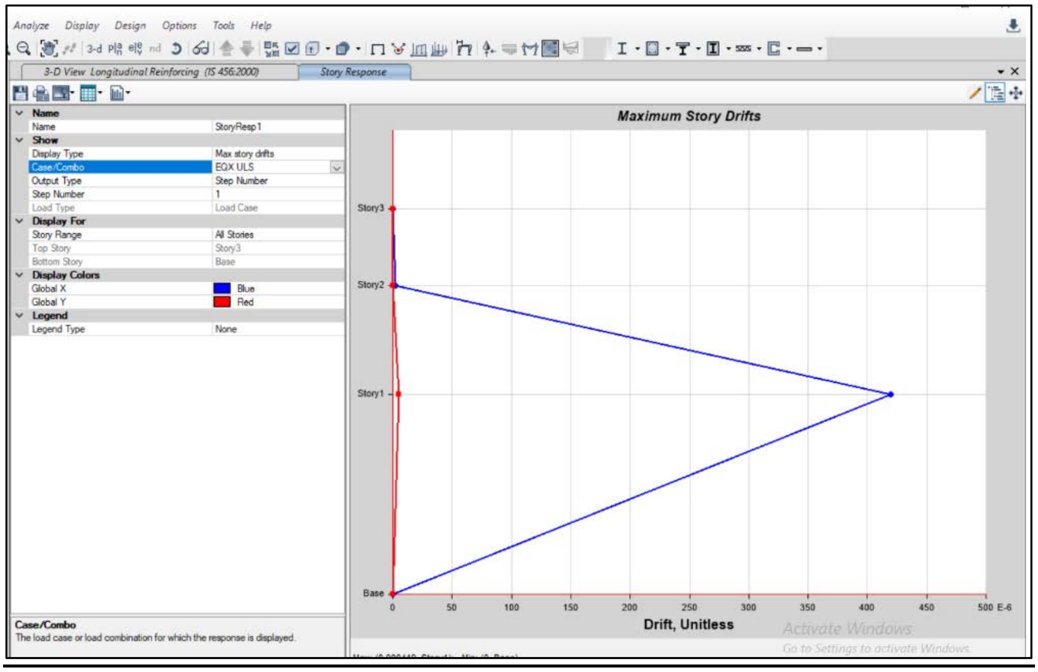


Figure:Storey Drift due to EQx

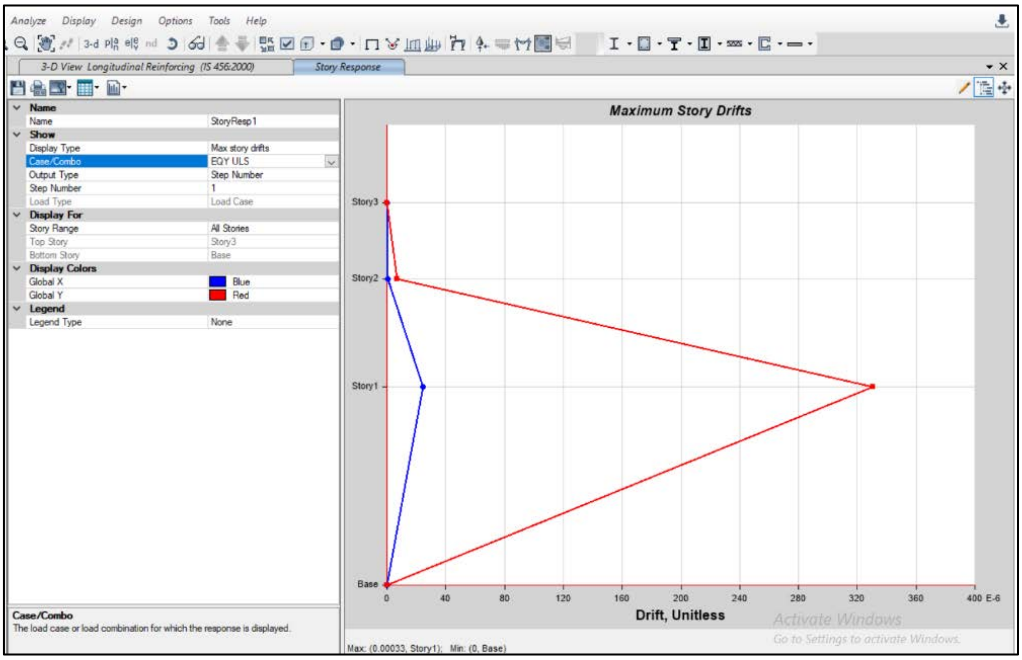


Figure:Storey Drift due to EQy

4.3. Force Diagram

The sample output of forces obtained from ETABS analysis for envelope have presented below as a sample only. The output forces are axial force, Shear force and Moments

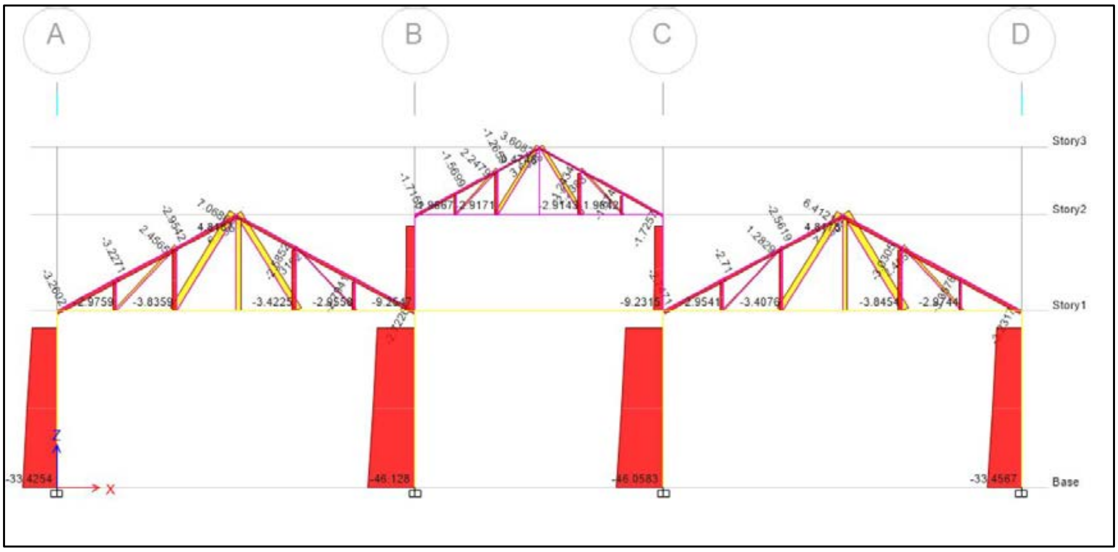


Figure 4-1: Axial Force Diagram

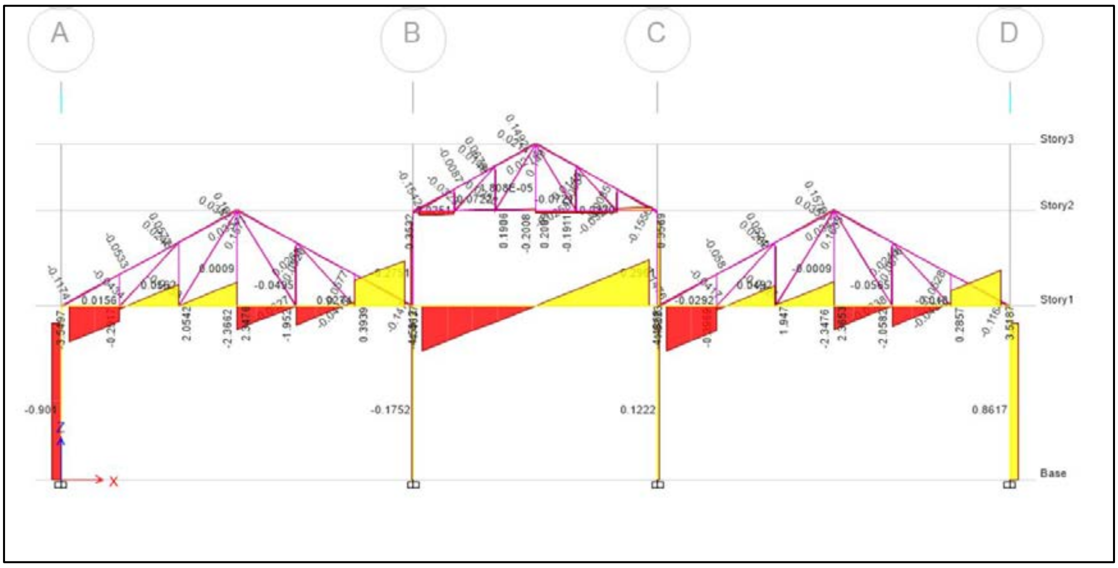


Figure 4-2: Shear Force Diagram

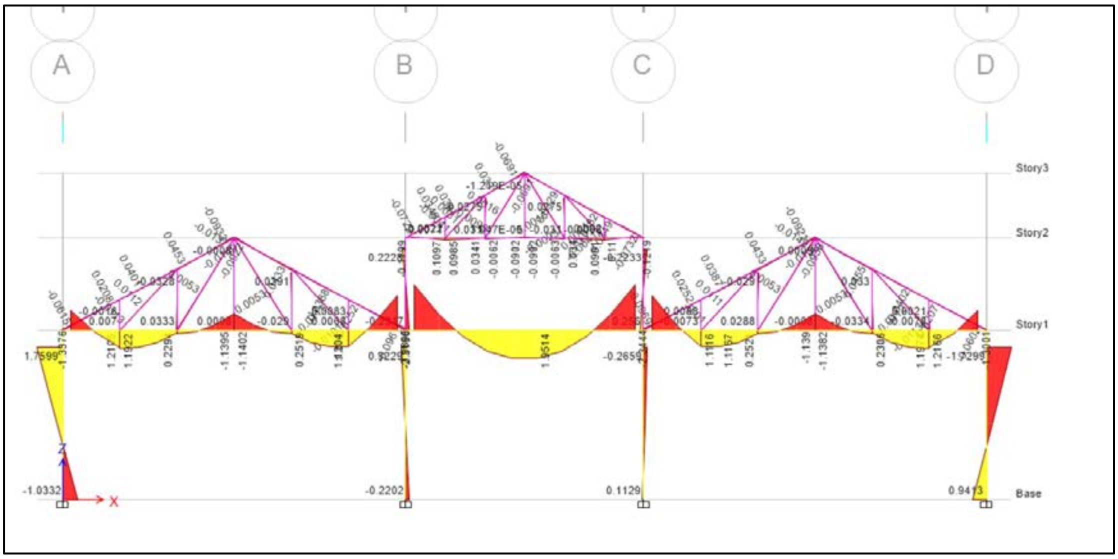


Figure 4-3: Bending Moment Diagram

4.4. Base Reaction

The reaction at the support of the column for the load combination of 1.2DL+1.5LL is picturized below as given by the software:

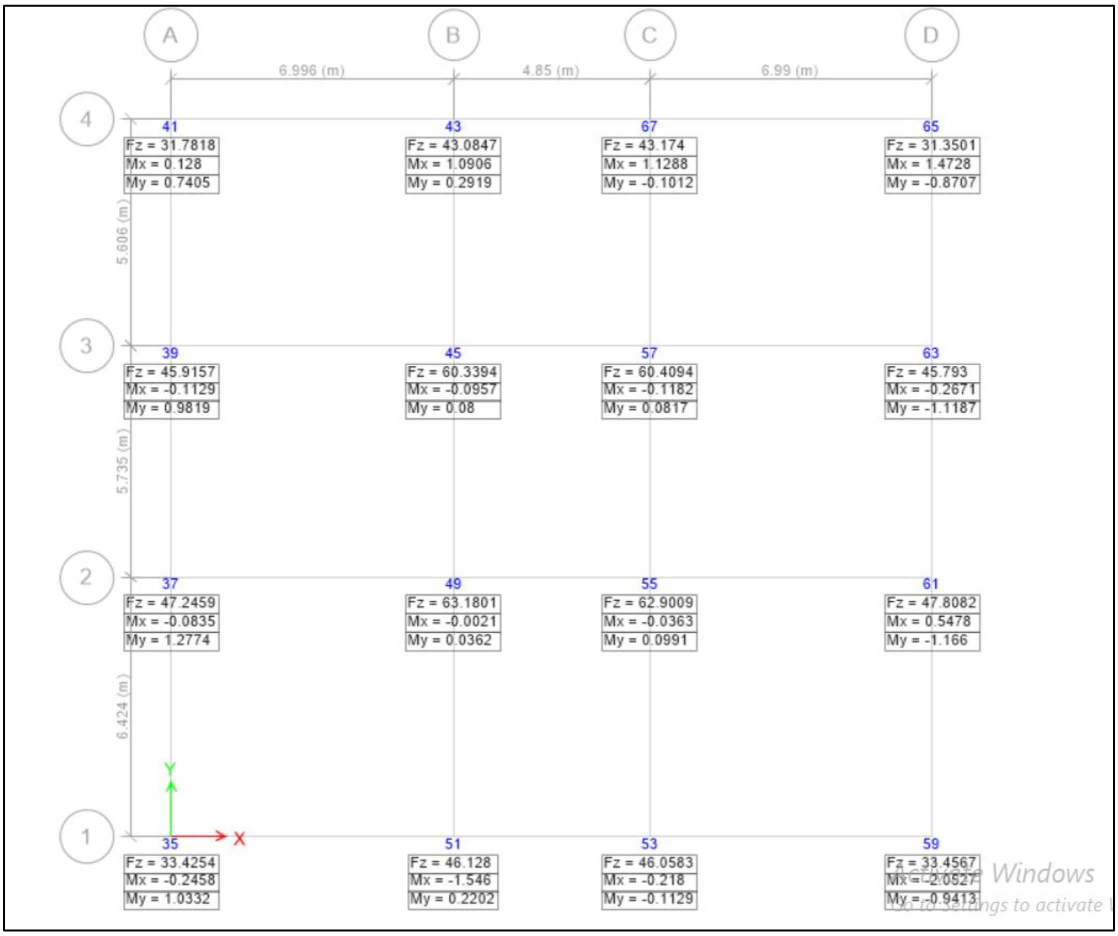
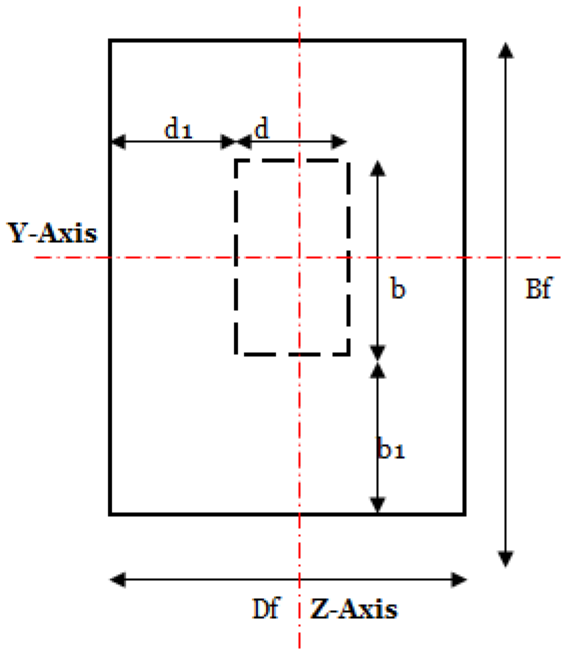


Figure 4-4: Base Reaction Force

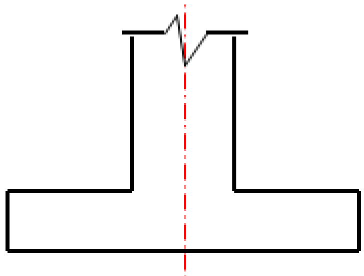
[CHAPTER 5] DESIGN OF STRUCTURAL MEMBER (SAMPLE DESIGN)

5.1. Footing Design

DESIGN OF ISOLATED FOOTING - SPREADSHEET
AS PER IS 456: 2000



Data:	Column no.		
	load case	2	
	Concrete grade, M	20	
	Steel grade, Fe	500	
	Axial load, kN	136	kN
	My, kNm	0	kNm
	Mz, kNm	0	kNm
	Column size, b	450	mm
	Column size, d	450	mm
	SBC of soil, kN/m2	130	kN/m²
	Design factor	1.5	
Pressure:	Axial load	136	kN
	App. Self weight	13.6	kN
	Total weight	149.6	kN
	Area of footing	1.15	m2
	size of footing, Bf	2.5	mt
	size of footing, Df	2.5	mt
	Projection, b1	1.025	mt
	Projection, d1	1.025	mt



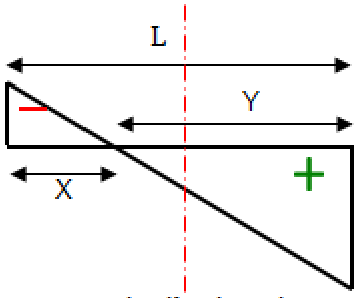
Footing Pressure,

Pmax = P/A + My/Zy + Mz/Zz

Pmax 21.76 kN/m²

Pmin = P/A - My/Zy - Mz/Zz

Pmin 21.76 kN/m²



Pressure Distribution Diagram

Eccentricity:

Y	1.25	mt
X	1.25	mt
L	2.5	mt
2/3 L	1.67	mt
b	2.5	mt
qu	32.64	kN/m²
Eff. qu	32.64	kN/m²

Shear Chk.

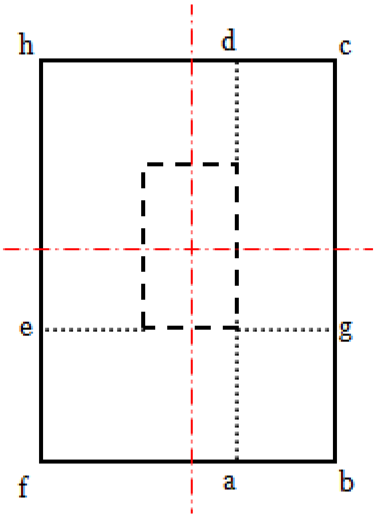
One way Shear : At distance d from face of column.

pt assumed	0.25	%
Designed shear stress	0.36	N/mm²
vu	59.16	
d=	85.21	mm
d provided	300.00	mm

Two way Shear : At distance d/2 from face of column.

Perimeter	3000	mm	
S.F. at this section	185.64	kN	
Ks	1.00		
tc	1.12	N/mm²	
tv	0.21	N/mm²	
Resistance	1,006.23	N/mm²	Safe

Flexure design:



For section efbg		
pressure@f	21.76	kN/m²
pressure@b	21.76	kN/m²
Moment@eg. Meg	17.15	kNm
Mu	25.72	kNm
d provided	300.00	mm
Mu/bd2	0.29	N/mm²
pt	0.120	%
pt provided	0.250	
Ast	750.0	mm²/m width
provide	16#	@150c/c
Ast Provided	**1206**	**mm²/m width**

Check in other direction :

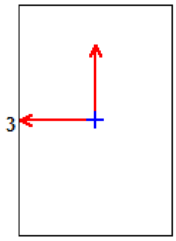
For section abcd		
pressure@b	21.76	kN/m²

pressure@c	21.76	kN/m^2
Moment@ad, Mad	17.15	kNm
Mu	25.72	kNm
d req	98.32	mm
M/bd2	0.29	
pt	0.205	%
Ast	615	mm^2/m width
provide	16#	@150c/c
Ast provided	**1206**	**mm^2**

5.2. Beam Design

ETABS Concrete Frame Design

IS 456:2000 + IS 13920:2016 Beam Section Design (Summary)



Beam Element Details

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF	Type
Story1	B19	79	BEAM 230*350	DConS51	6249	6424	1	Ductile Frame

Section Properties

b (mm)	h (mm)	b_f (mm)	d_s (mm)	d_{ct} (mm)	d_{cb} (mm)
230	350	230	0	25	25

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
22360.68	20	1	500	500

Design Code Parameters

γ_C	γ_S
1.5	1.15

Factored Forces and Moments

Factored M_{u3} kN-m	Factored T_u kN-m	Factored V_{u2} kN	Factored P_u kN
-5.2595	0.134	5.5116	0

Design Moments, M_{u3} & M_t

Factored Moment kN-m	Factored M_t kN-m	Positive Moment kN-m	Negative Moment kN-m
-5.2595	0.1988	0	-5.4583

Design Moment and Flexural Reinforcement for Moment, M_{u3} & T_u

	Design -Moment kN-m	Design +Moment kN-m	-Moment Rebar mm²	+Moment Rebar mm²	Minimum Rebar mm²	Required Rebar mm²
Top (+2 Axis)	-5.4583		160	0	39	160
Bottom (-2 Axis)		0	40	0	0	40

Shear Force and Reinforcement for Shear, V_{u2} & T_u

Shear V_e kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm²/m
11.8321	0	29.9	6.3311	254.94

Torsion Force and Torsion Reinforcement for Torsion, T_u & V_{U2}

T_u kN-m	V_u kN	Core b_1 mm	Core d_1 mm	Rebar A_{svt} /s mm²/m
0.134	5.5116	200	320	0

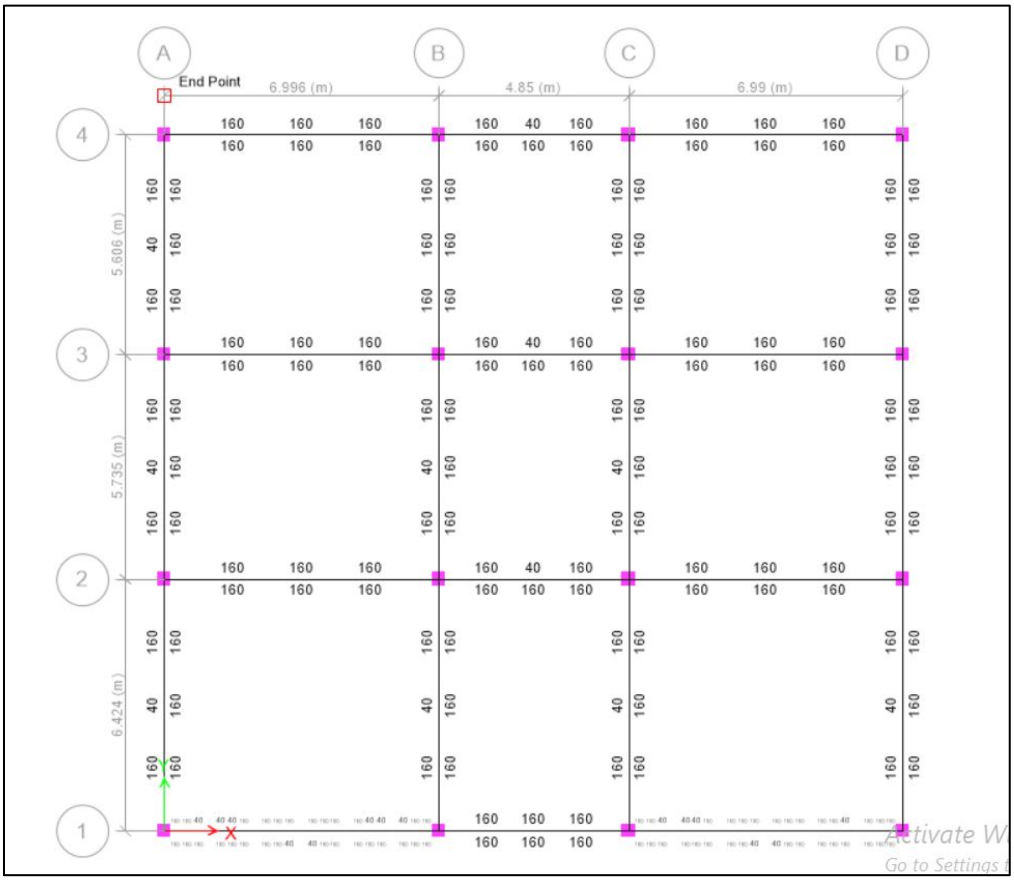
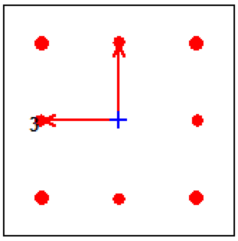


Figure 5-1: Beam Design Output in First Floor

5.3. Column Design

ETABS Concrete Frame Design

IS 456:2000 + IS 13920:2016 Column Section Design (Summary)



Column Element Details

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF	Type
Story1	C2	44	COL 350*350	DConS47	3100	3450	1	Ductile Frame

Section Properties

b (mm)	h (mm)	dc (mm)	Cover (Torsion) (mm)
350	350	58	30

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
22360.68	20	1	500	500

Design Code Parameters

γ_C	γ_S
1.5	1.15

Axial Force and Biaxial Moment Design For P_u , M_{u2} , M_{u3}

Design P_u kN	Design M_{u2} kN-m	Design M_{u3} kN-m	Minimum M_2 kN-m	Minimum M_3 kN-m	Rebar Area mm²	Rebar % %
50.7868	38.4549	3.6642	1.0157	1.0157	980	0.8

Axial Force and Biaxial Moment Factors

	K Factor Unitless	Length mm	Initial Moment kN-m	Additional Moment kN-m	Minimum Moment kN-m
Major Bend(M3)	0.661444	3100	1.4657	0	1.0157
Minor Bend(M2)	0.631232	3100	-4.1974	0	1.0157

Shear Design for V_{u2} , V_{u3}

	Shear V_u kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm²/m
Major, V_{u2}	17.734	51.0246	40.8795	17.734	387.95
Minor, V_{u3}	22.2927	51.0246	40.8795	22.2927	387.95

Joint Shear Check/Design

	Joint Shear Force kN	Shear V_{Top} kN	Shear $V_{u,Tot}$ kN	Shear V_c kN	Joint Area cm²	Shear Ratio Unitless

	Joint Shear Force kN	Shear V_{Top} kN	Shear $V_{u,Tot}$ kN	Shear V_c kN	Joint Area cm²	Shear Ratio Unitless
Major Shear, V_{u2}	0	0	69.7653	547.8367	1225	0.127
Minor Shear, V_{u3}	0	0	87.2067	547.8367	1225	0.159

(1.4) Beam/Column Capacity Ratio

Major Ratio	Minor Ratio
0.509	0.639

Additional Moment Reduction Factor k (IS 39.7.1.1)

A_g cm²	A_{sc} cm²	P_{uz} kN	P_b kN	P_u kN	k Unitless
1225	9.8	1470	432.7697	50.7868	1

Additional Moment (IS 39.7.1)

	Consider M_a	Length Factor	Section Depth (mm)	KL/Depth Ratio	KL/Depth Limit	KL/Depth Exceeded	M_a Moment (kN-m)
Major Bending (M_3)	Yes	0.899	350	5.859	12	No	0
Minor Bending (M_2)	Yes	0.899	350	5.591	12	No	0

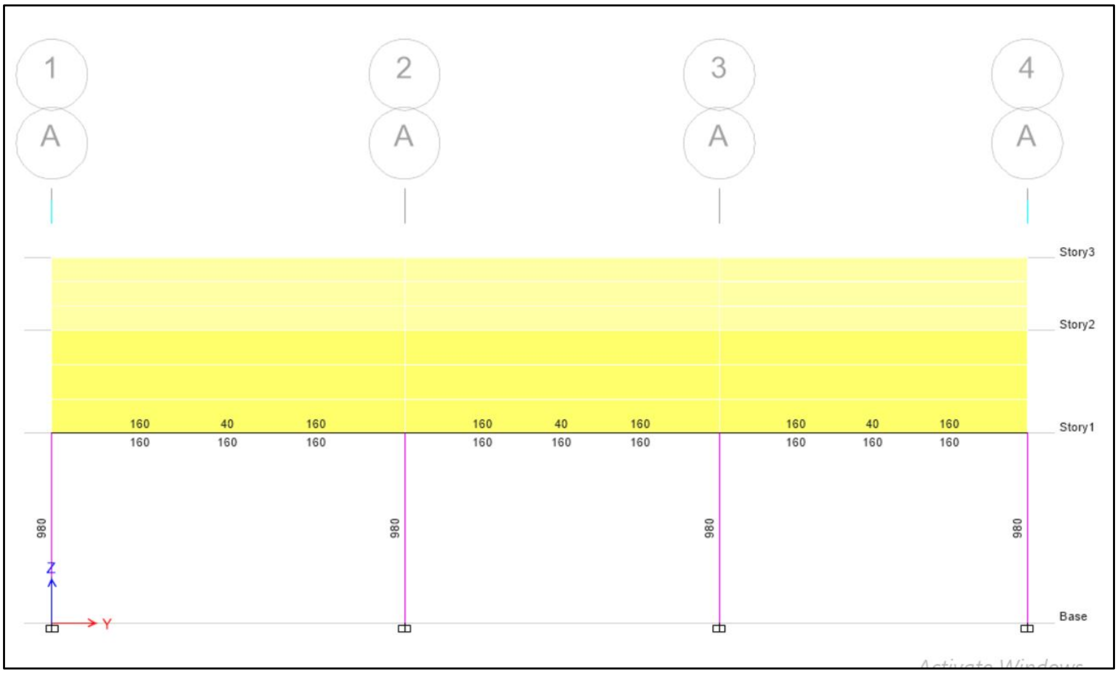


Figure 5-2: Column Deisgn Output Along Grid A-A

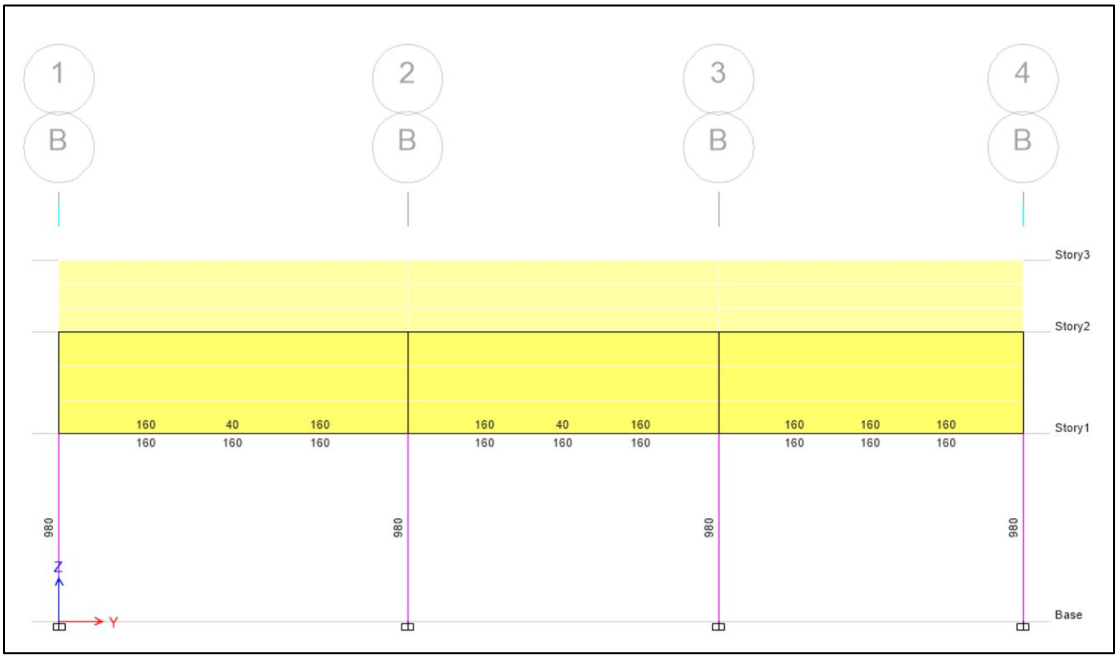


__Figure 5-3: Column Design Output Along Grid B-B__

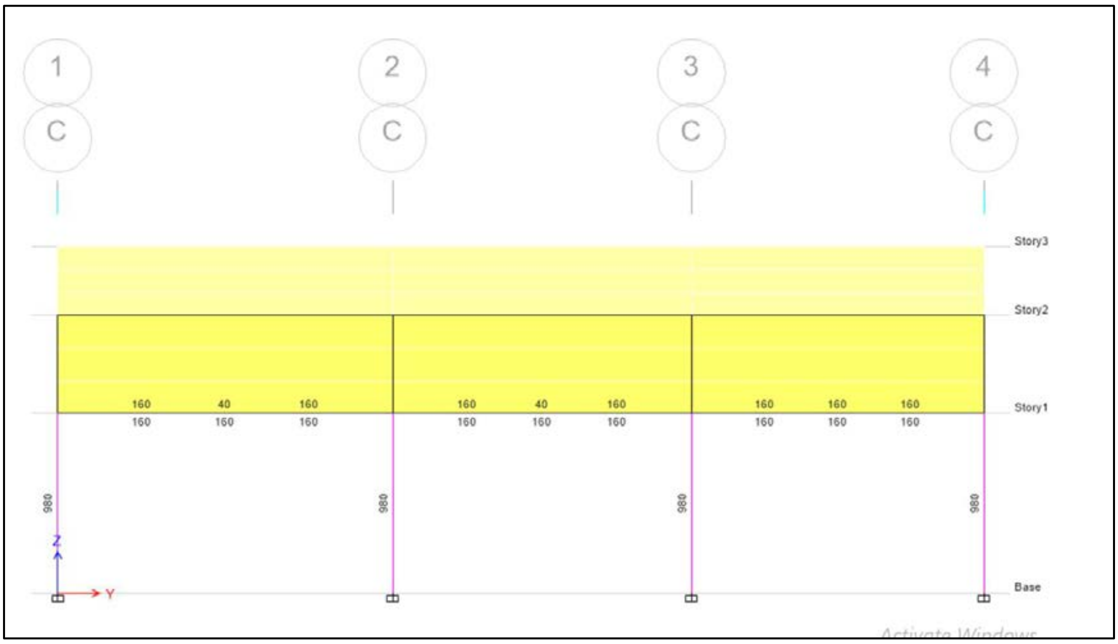


__Figure 5-7: Column Design Output Along Grid C-C__

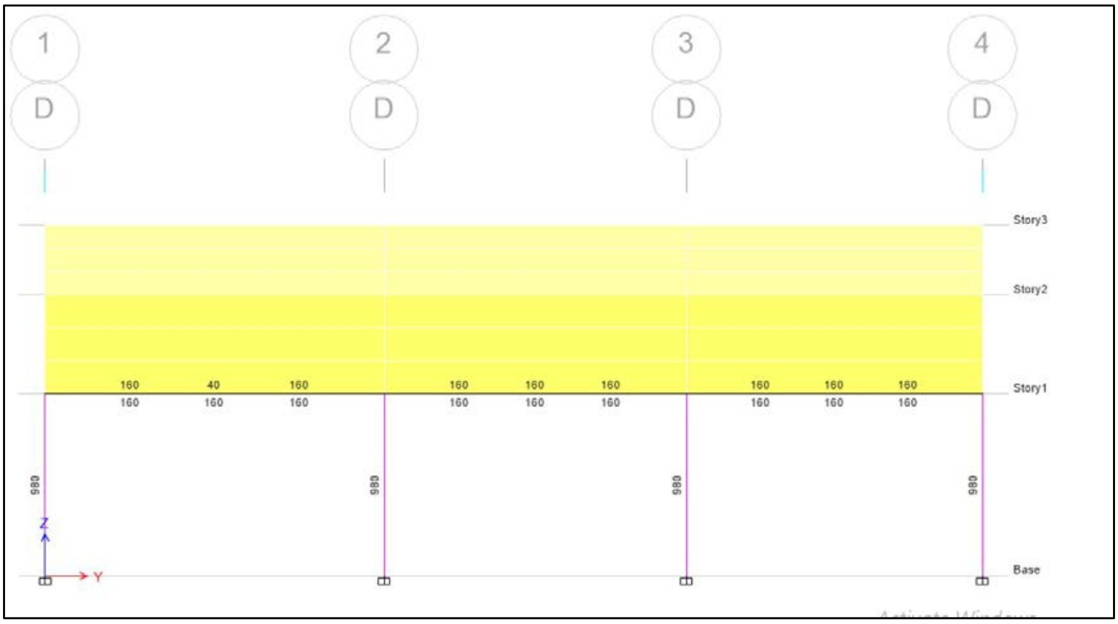


Figure 5-8: Column Design Output Along Grid D-D

References

- IS 456- 2000 Code of practice for plain and reinforced concrete
- IS 875-1987 Code of practice for design loads (other than earthquake) for buildings and structures
- IS 1893-2002 Criteria for Earthquake Resistant Design of Structures,
- IS 13920-1993 Code of practice for ductile detailing of reinforced concrete structures subjected to seismic forces
- NBC Nepal Building Code
- Design of Reinforced Concrete Structure – A.K. Jain
- Limit State Design of Substructure- Swamisharan
- ETABS manual V 20

2. DORMITARY BLOCK

TO WHOM IT MAY CONCERN

This report comprises the summary of the structural design of Dermitory block of Federal agriculture farm,Sindhupalchowk. The report consists of design procedures adopted, assumptions made, and the input assign in the design. During design it is assumed that the client will completely followed the architectural as well as the structural design drawings. It is also assumed that the construction will be supervised by a professional engineer.

The designer will not be responsible if any alteration or change to the structural system is made by the client or contractor without the prior permission from the designer, or the alteration to the non-structural system is made such that the weight of each individual floor or the weight of the whole building is altered by more than 10% of the design weight of the floor and the total weight

The design calculations and derivations are limited only to let the concerned people know the methodology adopted. However, the calculation may be provided to the client or the concerned authorities when needed, upon request.

GOEC-RAJDEVI-RECON JV

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[CHAPTER 1] INTRODUCTION

1.1. General

This report summarizes the structural analysis and design of RC framed building. It has planned to utilize the building for office purpose. The structural analysis in this building considers ground floor plus two storey and steel truss . The aim of design is the achievement of an acceptable probability that structures being designed will perform satisfactorily during their intended life. With an appropriate degree of safety, they should sustain all the loads and deformations of normal construction and use and have adequate durability and adequate resistance to the effects of misuse and fire. Structural Analysis of the concerned building has been done in details with analysis and designs software.

The analysis and design has been based on the prevailing codes that are in practice in Nepal, the National Building code of Nepal (NBC2020/1994) and the IS code at places required. This report consists of the design procedures adopted, the assumptions made, the inputs made in the design and the design output.

1.2. Assumptions

The following assumptions are taken into consideration in the seismic resistant analysis and design of structures:

- Adequate supervision and quality systems are provided during execution of the works.
- Construction is carried out by personnel having the appropriate skill and experience.
- Construction materials and products confirm to the pertinent codes and specifications.
- The structure is adequately maintained.
- The structure is used in accordance with the design brief.
- An earthquake is not likely to occur simultaneously with maximum flood, wind, waves or tides.
- Resonance as visualized under steady state sinusoidal excitation will not occur, as the small duration of earthquake is not enough to build up resonance amplitudes. Subsoil does not considerably settle or slide due to earthquake at the site of structure.

This report is divided into three chapters. Chapter one begins with introductions and general description, Chapter two comprises the numerical modeling, analysis and design; Chapter three presents the summary and recommendations.

1.3. Salient Features

1.3.1. Project Information

Type of building : Dermitory block

Location : Sindhupalchowk

Plinth Area : 194.273 sq.m

1.3.2. Building Features

The building has some special features which are listed below:

Type of Building :Special RC Moment Resisting Frame Structure

Wall Type : Brick Masonry Wall
Footing Type : Isolated Footing
Depth of foundation : 1500 mm
Dimension (m) (centre to centre)
L 2180 m

B 2180m

Storey Height (m) : 3.3 m
Total Height (m) : 11.75 m
No of Storey : Ground + two Storey

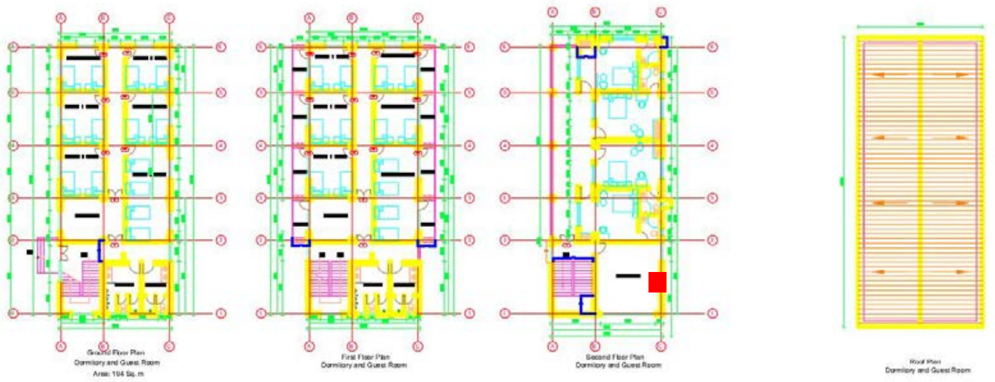

Figure 1-1: Plan of Building

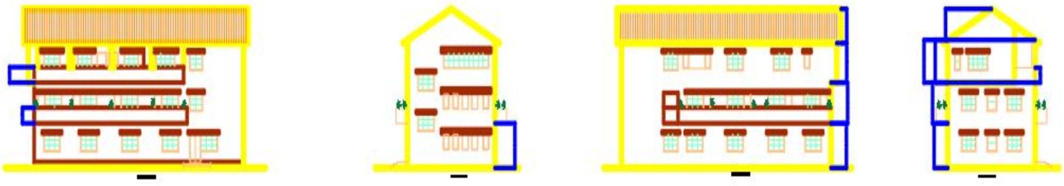

Figure 1-2: Elevation of Building

or More Detail Refer Architectural Drawing.

1.3.3. Site Condition

Type of Soil : Type C, Medium Soil. As per NBC 105:2020

Allowable Bearing Capacity: 130 KN/m2 (Assumed)

Seismic Zone Factor: 0.3 as per NBC 105:2020

[CHAPTER 2] ANALYSIS TECHNOLOGY AND METHOLODOGY

2.1. General

After completion of Architectural design, the layout of columns and beams are done without affecting the Architectural functions of building so far. Structure is modeled using finite element method. A three-dimensional beam element having 12 DOF with 6 DOFs at each node were used for modeling beams and columns in the building.

The structure is analyzed by the linear elastic theory to calculate internal actions produced by anticipated design loads. The analysis is carried out using state of art three dimensional structural analysis programs like ETABS 2020 The design loads considered as per the relevant codes of practice comprise dead load due to permanent structures, live load due to occupancy of the structure and seismic load due to anticipated earthquake possible at the proposed location. A number of load combinations are considered to obtain the maximum values of design stresses.

Following considerations is made during modeling, analysis and design.

- The structures are Reinforced Concrete Special Moment Resisting Frame (SMRF) type. Beams and columns are considered as the structural load resisting elements. Although non-structural components like wall plaster, infill walls, floor finishing etc. has comes effects on structural performance, they are considered only as loading.
- For all Structural elements, M20 grade of concrete is used.
- Centre-line dimensions are followed for modeling, analysis and design.
- Floor slabs are assumed to be rigid in their own plane. The slab action has been modeled by rigid floor diaphragms. Slabs are also considered in modeling. Slab is modeled as shell element.
- Beam and columns are modeled as frame elements.
- The main beams rest centrally on columns to avoid local eccentricity.
- Foundation is assumed to be fully rigid at the plinth level.
- The beam-column joint is not modeled in detail.
- Preliminary sizes of structural components are assumed by experience.
- Seismic loads were considered acting in the horizontal direction (along either of the two orthogonal directions of building) and not along the vertical direction, since it is not considered to be significant for design of structural member’s suitable load combinations as suggested by NBC.
- NBC 105:2020 are used.

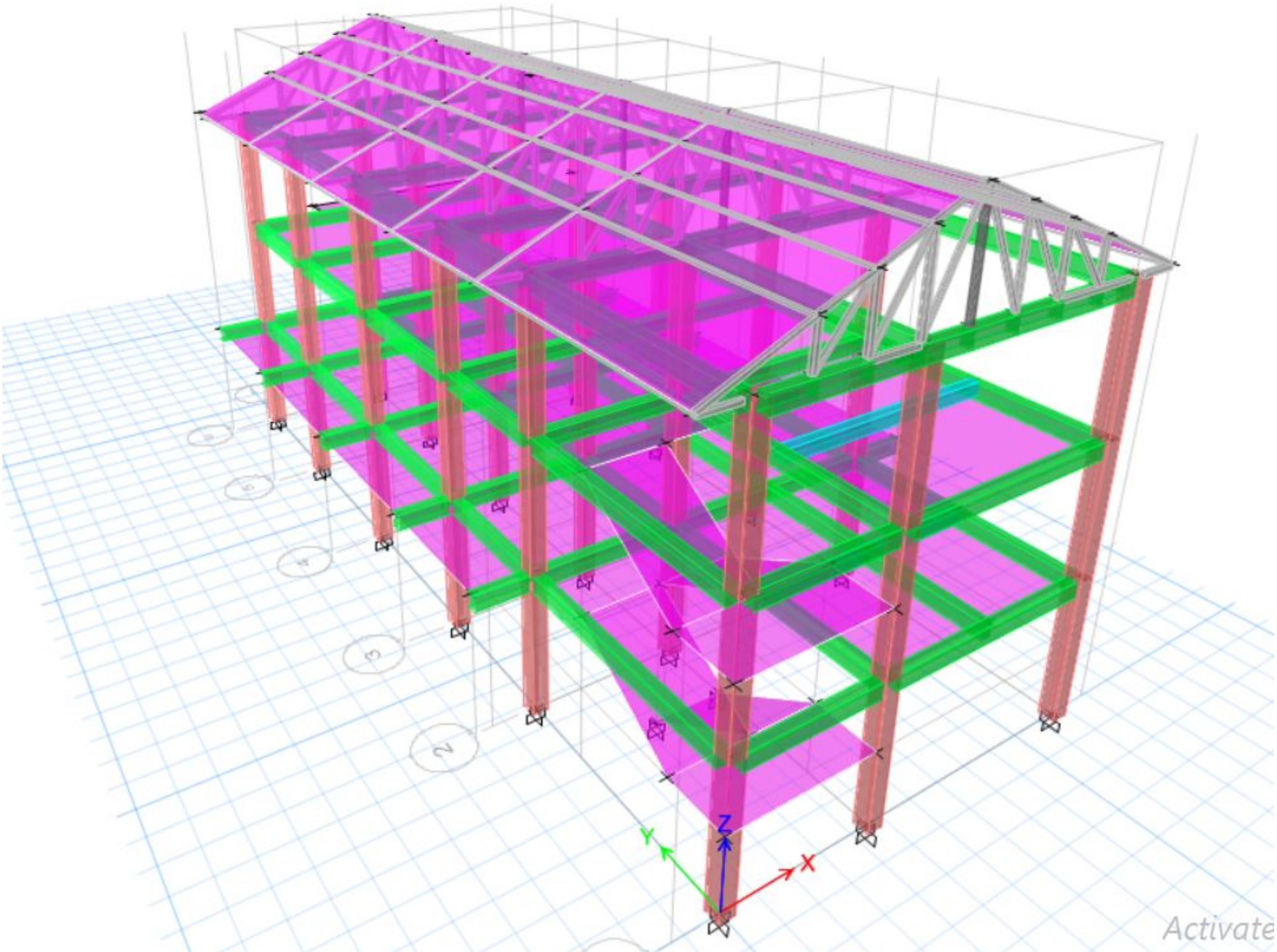

Figure 2-1: 3D- Model of Building

2.2. Codes and Standard Used

For the structural analysis and design, the following codes and standard are followed:

- IS 456- 2000 Code of practice for plain and reinforced concrete
- IS 875-1987 Code of practice for design loads (other than earthquake) for buildings and structures
- NBC 105:2020 Criteria for Earthquake Resistant Design of Structures,
- IS 13920-1993 Code of practice for ductile detailing of reinforced concrete structures subjected to seismic forces
- NBC Nepal Building Code

2.3. Software Used

The following software is used for the structural analysis and design. ETABS 2020, version 20.0.0 ETABS is a special purpose finite element analysis and design program developed specifically for building systems. With ETABS, models are defined logically floor-by-floor, column-by-column, bay-by-bay and wall-by-wall and not as a stream of non-descript nodes and elements as in general purpose programs. The software has very powerful numerical methods, design procedures and international design codes, all working from a single comprehensive database. At its core, it utilizes the same analysis engine as used by SAP2000.

Among others, ETABS can do model generation, seismic and wind load generation, finite element-based linear and non-linear static and dynamic analysis, concrete frame design (column and beam) and shear wall design.

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[CHAPTER 3] ANALYSIS

3.1. Material Properties

3.1.1. Concrete

All components of plain and reinforced concrete are M20 grade as specified in design.

Modulus of Elasticity [E_c] = 5000 $\sqrt{f_{ck}}$ N/mm^2 (Cl. 6.2.3.1, IS 456:2000)
= 22360.68 N/mm^2 for M20 Grade Concrete
Poisson's Ratio [U] = 0.2
Unit Weight = 25 KN/m^3
Characteristic Strength [f_{ck}] = 20 N/mm^2 for M20 Grade Concrete

The structural design strength is derived from the characteristic strength multiplied by a coefficient 0.67 and divided by the material partial safety factor. The partial factor for concrete in flexure and axial load is 1.5.

3.1.2. Reinforcement Steel

Characteristic strength of high yield steel is taken as 500 Mpa (TMT) for main longitudinal and shear rebar and material partial safety factor is to be 1.15. Modulus of Elasticity [E_s] = 2x10^5 N/mm^2
Poisson's Ratio [U] = 0.3

3.2. Section Properties

Preliminary Size of Members

The preliminary sizes of Beam, Column, and Slab were chosen based on experience.

Beam : 230 mm x 350 mm (Main Beam)
Column : 350 mm x 350 mm
Thickness : 127 mm (Floor Slab)
: 150 mm (Staircase Slab)

During the analysis, beam and column are modeled as frame elements whereas slabs, are modeled as area element.

3.3. Loading

The following considerations are made during the loading on the structural model:

- The loads distributed over the area are imposed on the area element and the loads distributed over the length are imposed on the frame elements whenever possible.
- Where such loading is not possible, equivalent conversion to different loading distribution is carried to load the model near the real case as far as possible.

For lateral load, necessary calculations are performed to comply with the requirements of NBC 105:2020.

3.3.1. Load Cases

The following load cases are used for the loading during the analysis.

Load Name	Load Type	Description	Unit	Remarks
DL	Dead	Self-weight of the structure	KN/m^2	
WL	Dead	Wall Load	KN/m	On beam
FL	S. Dead	Floor Finish Load	KN/m^2	On slab
PL	S. Dead	Partition Wall Load	KN/m^2	On floor slab
LL	Live	Imposed Load	KN/m^2	On floor slab
RLL	Live	Imposed Load	KN/m^2	On terrace slab
SL	S.Dead	Step Load	KN/m	On Beam
EQx	Quake	Equivalent Static Lateral Load	KN	
EQy	Quake	Equivalent static lateral load	KN	

3.3.2. Load Combinations:

The load combinations are based on NBC 105:2020. The following load combinations are specified as per NBC 105:2020:

Static Load Combination:

1.2DL+1.5LL

Seismic Load Combination:

DL + λLL ±E
Where, λ = 0.6 for storage facilities
= 0.3 for other usage

The following load combinations are used during analysis

Table 3-1: Load Combination

S.N.	NAME
1	1.2DL + 1.5LL
2	DL+0.3LL+EQX
3	DL+0.3LL-EQX
4	DL+0.3LL+EQY
5	DL+0.3LL-EQY

3.4. Estimation of Load:

The loads on the building are based on Indian codes of Practices. The unit weight of different structural and non-structural elements are derived from IS 875 Part 1 and presented in Table 3. The load calculations are based on actual measured drawings. The self-weight of beams, columns and slabs are calculated by the program. Similarly the imposed loads are applied on the slab as area load in KN/m^2 and values of imposed loads are tabulated in table below.

- The weight of infill walls are calculated and applied on beams as line weight in KN/m.
- Partition wall load are assigned as uniformly distributed area load in slab as area load in KN/m^2.
- Floor finishing load are assigned as area load in slab.
- Single type of Live load is assigned in each panel of slab.
- A frame load is applied as parapet loading on the exterior frame of the roof level.
- The roof is assumed accessible and loaded with roof live load as per Indian Standard, IS 875 -1987(part2) but this load is not considered during seismic load.

3.4.1. Unit Weight (Dead Load)

Dead loads for analysis are calculated as per Indian Standard, IS 875 -1987(part1). Unit weights of different material used are given below.

Unit Weight of Material

S.N.	Type	Value	
1	Reinforced Concrete	25	KN/m^3
2	Brick Masonry	18.85	KN/m^3
3	Screed	21	KN/m^3
4	Marble	26.7	KN/m^3
5	Plaster	20.4	KN/m^3

Dead Load Calculation		
Depth of Beam=	350	mm
Floor Height =	3300	mm
Height of Parapet Wall =	1150	mm

<u>Dead Load of Walls</u>

Dead Load of 9" thick wall without opening =	16.21	KN/m
Dead Load of 9" thick wall with 25% opening =	12.16	KN/m
Dead Load of 9" thick wall with 40% opening =	9.73	KN/m
Dead Load of 4" thick wall without opening =	9.81	KN/m
Dead Load of 4" thick wall with 25% opening =	7.36	KN/m
Dead Load of 9" thick parapet wall =	6.18	KN/m

<u>Floor Loads</u>

Thickness of Slab =	127	mm
Tile =	0.1	KN/m^2
Thickness of tile =	12.5	mm
Thickness of tile with plaster =	25	mm
Thickness of Marble =	20	mm
Thickness of Screed =	50	mm
Thickness of Cement Plaster =	12.5	mm

Dead Load of Structural Slab =	3.175	KN/m^2
Dead Load of Tile =	0.1	KN/m^2
Dead Load of Marble =	0.534	KN/m^2
Dead load of Screed =	1.05	KN/m^2
Dead Load of Cement Plaster =	0.255	KN/m^2
Total Dead load of Floor Finish (Tile) =	1.15	KN/m^2
Total Dead load of Floor Finish (Marble) =	1.87	KN/m^2
Total Dead load of Floor Finishes (Cement Punning) =	1.05	KN/m^2
Tread =	250	mm
Rise =	143	mm
Dead Load of Steps in staircase with floor finish=	4.1	KN/m^2
Water Tank Load =	3.92	KN/m^2

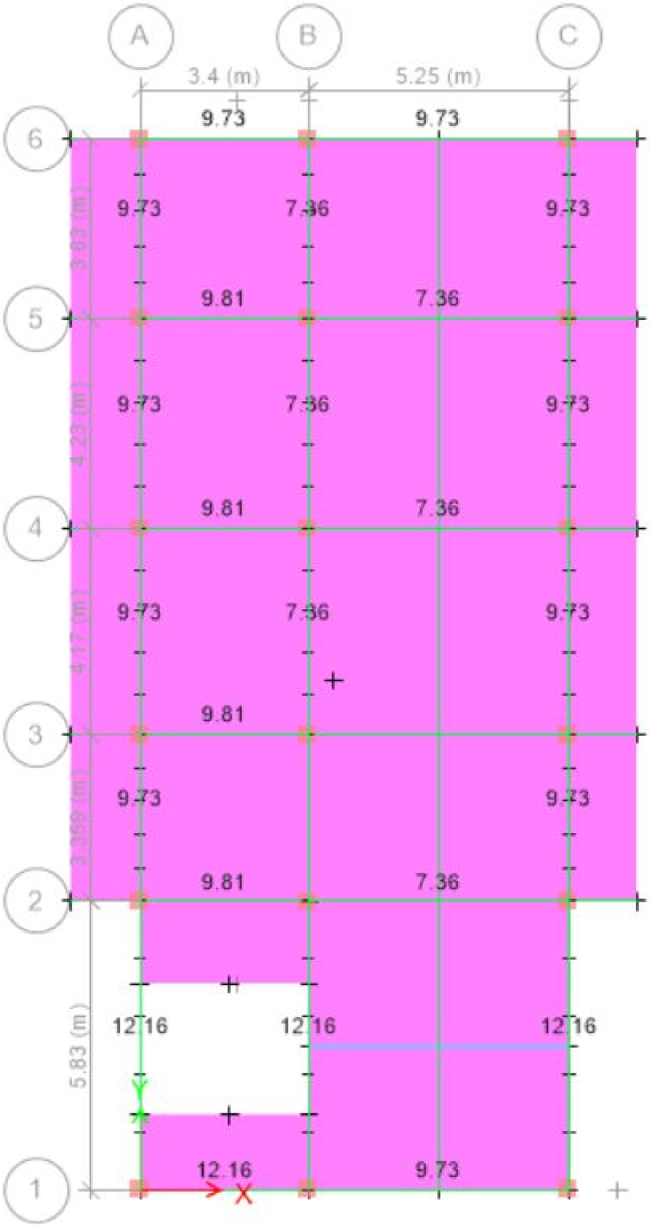


Figure 3-1: Wall Load storey 1

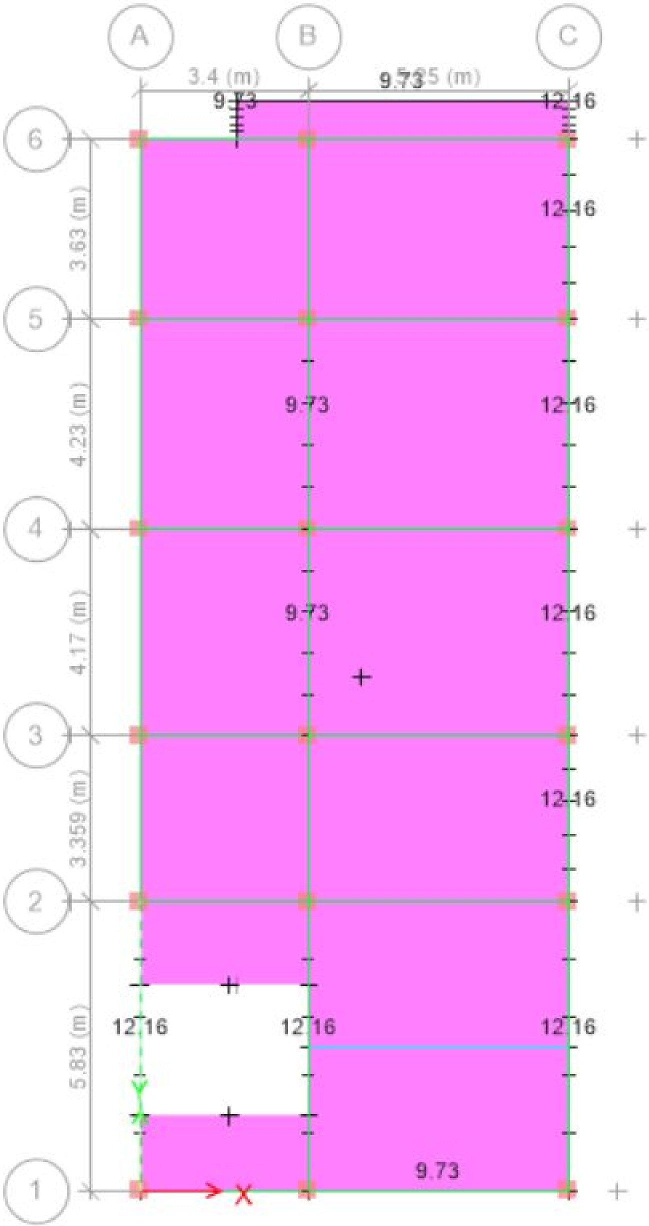


Figure 3-2: Wall Load storey 2

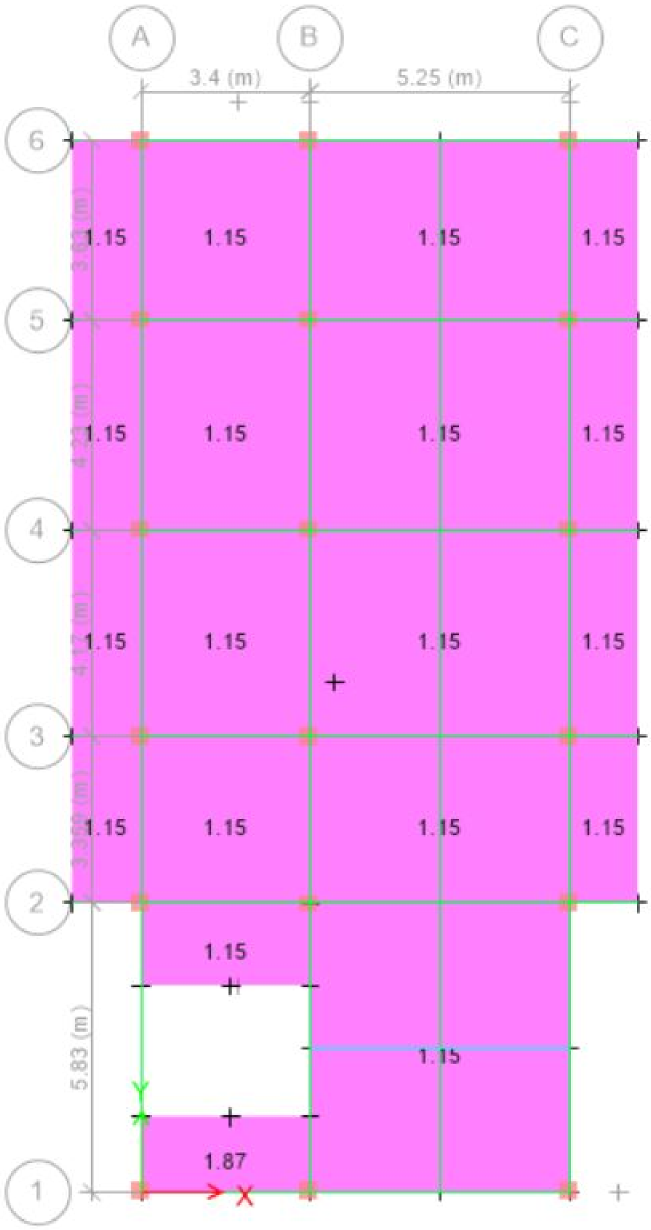


Figure 3-3: Floor Finish Load storey 1

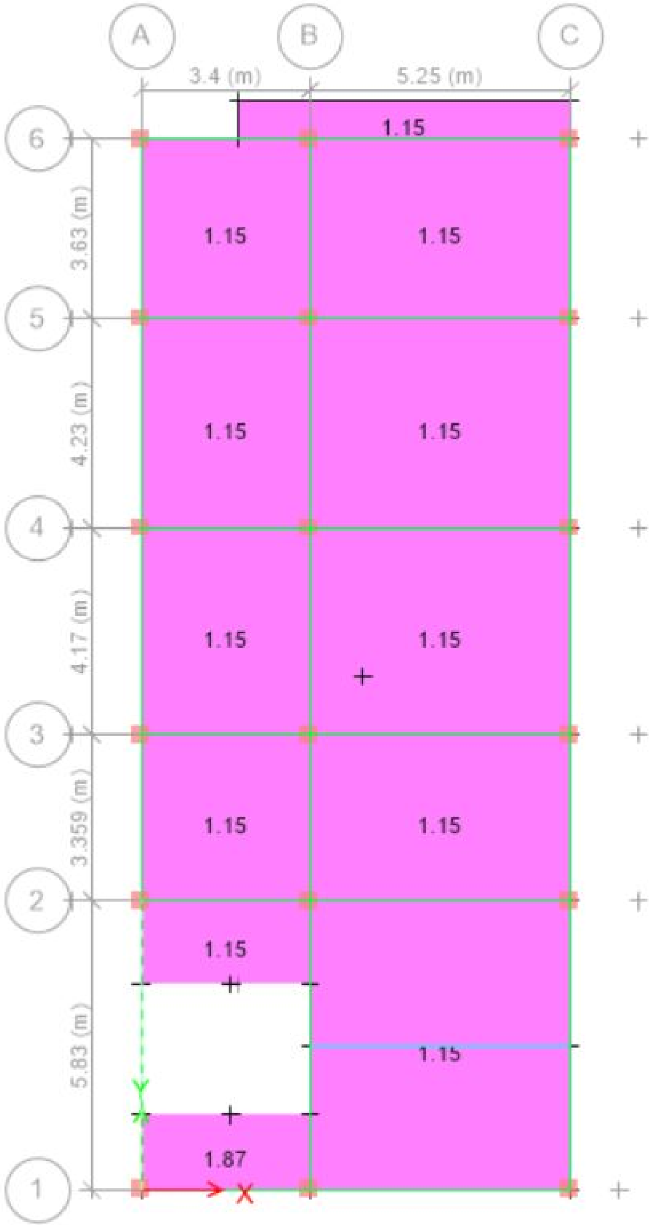


Figure 3-4: Floor Finish Load storey 2

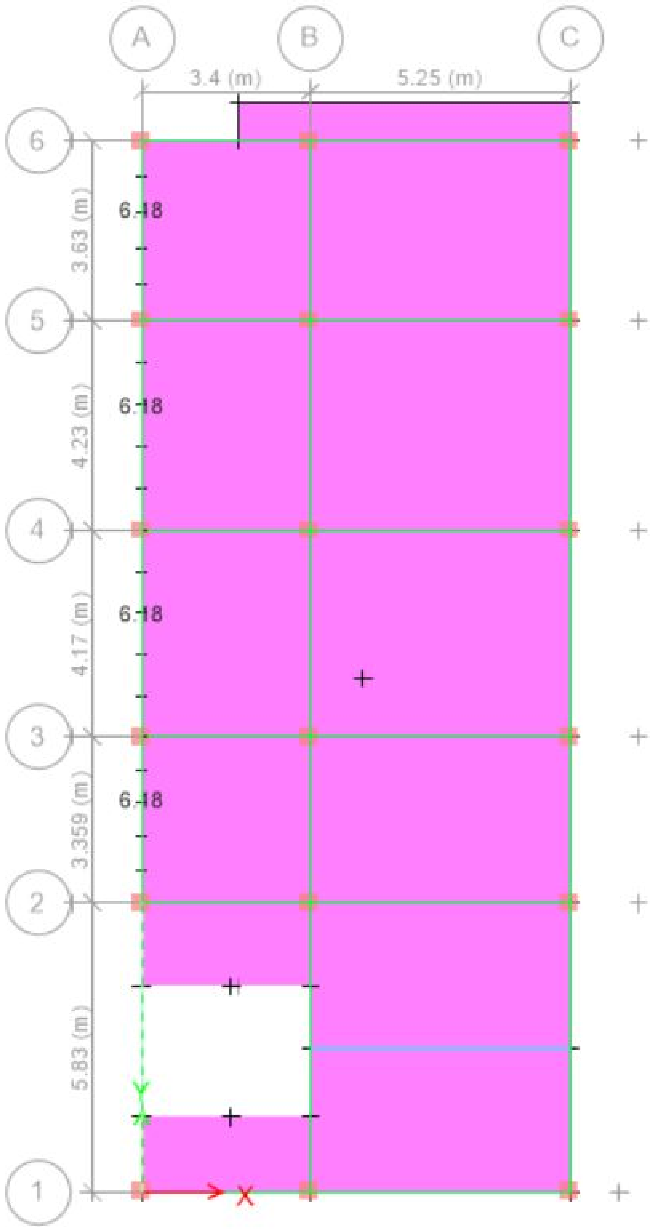


Figure 3-5: Parapet wall load storey 2

3.4.2. Live Load

The magnitude of live load depends upon the type of occupancy of the building. These are to be chosen from code IS875:1987(part II) for various occupancies. The live load distribution varies with time. Hence each member is designed for worst combination of dead load and live loads. Live loads for office building are given below:

S.N	Area type	Load	Unit
1	Office Rooms	2.5.	kN/m^2
2	Balcony staircase.corridors	4.0	kN/m^2
3	Library	4.0	kN/m^2
4	Toilet	2.0	kN/m^2
5	Office room with store	5.0	kN/m^2

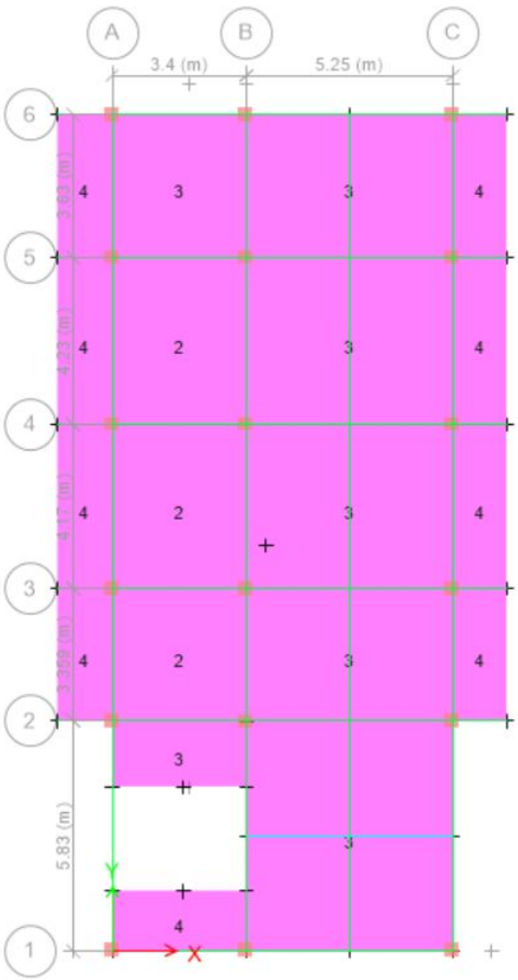


Figure 3-6: Live Load storey 1

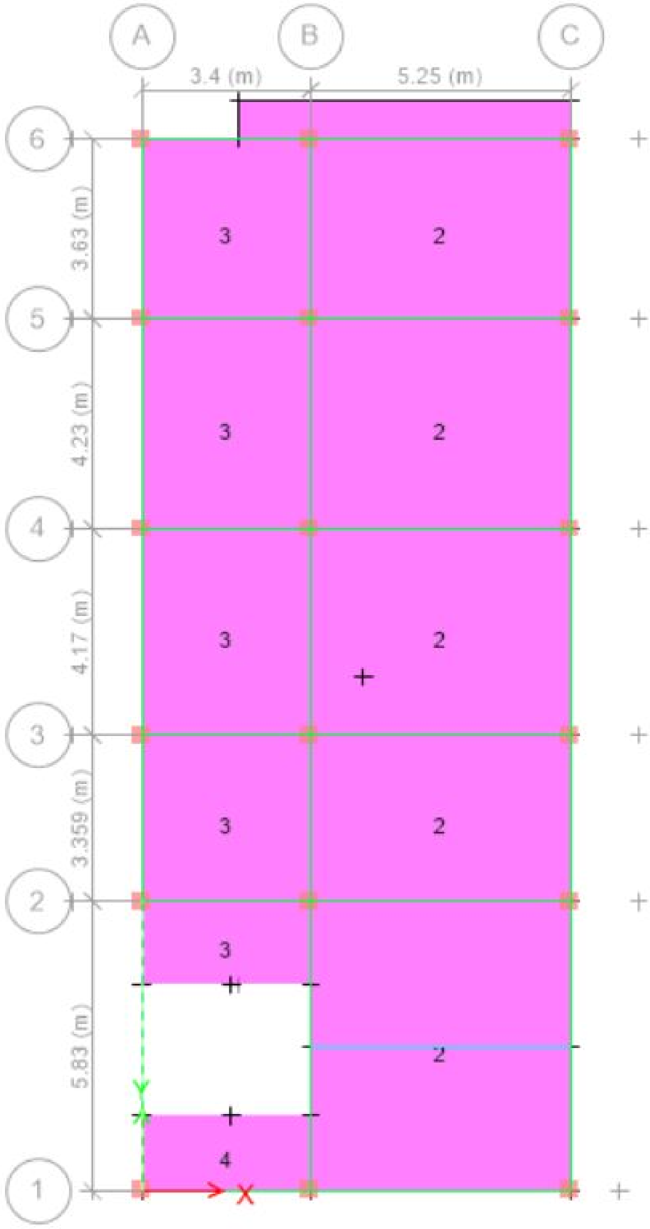


Figure 3-7: Live Load storey 2

3.4.3. Seismic Load

The seismic load calculation is done by equivalent static method. The equivalent static method is used for all serviceability limit state (SLS) calculations regardless of the building characteristics.

For ultimate limit state (ULS), the Equivalent Static Method may be used when at least one of the following criteria is satisfied:

- The height of the structure is less than or equal to 15m.
- The natural time period of the structure is less than 0.5 secs
- The structure is not categorized as irregular and the height is less than 40m.

Table 3-2: Horizontal design spectrum coefficient

We have,

Frame Type	=	Reinforced Concrete Moment Resisting Frame	
Height of Building,H	=	11.75	m
Soil Type	=	Type C	
Approximate Fundamental Period of Vibration	=	$k_t H^{3/4}$	
	=	$0.075*H^{3/4}$	
	=	0.476	sec
Amplified period of vibration, T1 sec	=	**0.595**	sec
		$1+(\alpha-1)*T/T_a$	if $T<T_a$
Spectral Shape Factor, $C_h(T)$	=	α	if $T_a<=T<=Tc$
		$\alpha[K+(1-K)(T_c/T)^{2]}$	if $T_c<=T<=6$
	=	2.500	
Seismic Zoning Factor, Z	=	0.350	
Importance Factor, I	=	1.000	
Elastic Site Spectra, (CT1)	=	$C_h(T)*Z*I$	
	=	0.875	
Ductility Factor, Rμ	=	4.000	
Overstrength Factor for ultimate limit. Ωu	=	1.500	
Overstrength Factor serviceability limit. Ωs	=	1.250	
Horizontal Base Shear Coefficient for ultimate limit, $C_d(T1)$	=	$\dfrac{C(T1)}{R\mu*\Omega u}$	
	=	**0.146**	
Elastic Site Spectra for serviceability limit, (C_sT1)	=	0.20*(CT1)	
	=	0.175	
Horizontal Base Shear Coefficient for serviceability limit, $C_d(T1)$	=	$\dfrac{Cs(T1)}{\Omega s}$	
	=	**0.140**	

For Vertical Distribution of Seismic Forces
From Clause 6.3 NBC 105:2020
For Structure having time period T<= 0.5 sec

k = 1

For Structure having time period T>= 2.5 sec

k = 2

so,

k = 1.00

[CHAPTER 4] ANALYSIS OUTPUT

The analysis results are discussed in this chapter. Equivalent Static Method is used. The major discussion are focused on the eccentricity, story shear, inter story drift, maximum displacement and base shear along two orthogonal directions. The column and beam size and reinforcement are then designed for maximum forces.

4.1. Modal Time Period and Mass Participation Factor

As per NBC 105:2020 section 7.3 a sufficient number of modes shall be included in the analysis to include at least 90% of the total seismic mass in the direction under consideration. Analysis was carried out for first 12 modes so that the mass participation satisfies this criterion in both orthogonal directions. Following table shows time period and mass participation ratio for all modes:

Table 4-1: Modal Participating Mass Ratio

Mode	Period	UX	UY	SumUX	SumUY
	sec				
1	0.5	0.1436	0.5219	0.1436	0.5219
2	0.471	0.4934	0.1803	0.637	0.7021
3	0.368	0.1053	0.0108	0.7422	0.7129
4	0.223	0.0063	0.1999	0.7485	0.9128
5	0.187	0.2419	0.0116	0.9904	0.9245
6	0.163	0.0096	0.0755	1	1

4.2. Storey Drift

As per section 5.6.3 NBC 105:2020, the storey drift in any storey shall not exceed 0.025 times the storey height at ultimate limit state. In this building the storey drift is limited to 75 mm. From the analysis the displacements of the mass centre of various floors are obtained and are shown in Table below along with storey drift:

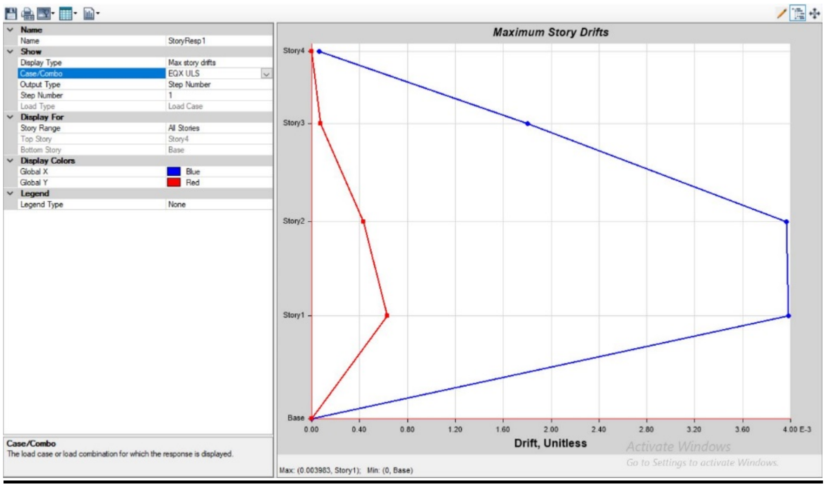


Table 4-2: Storey Drift due to EQx

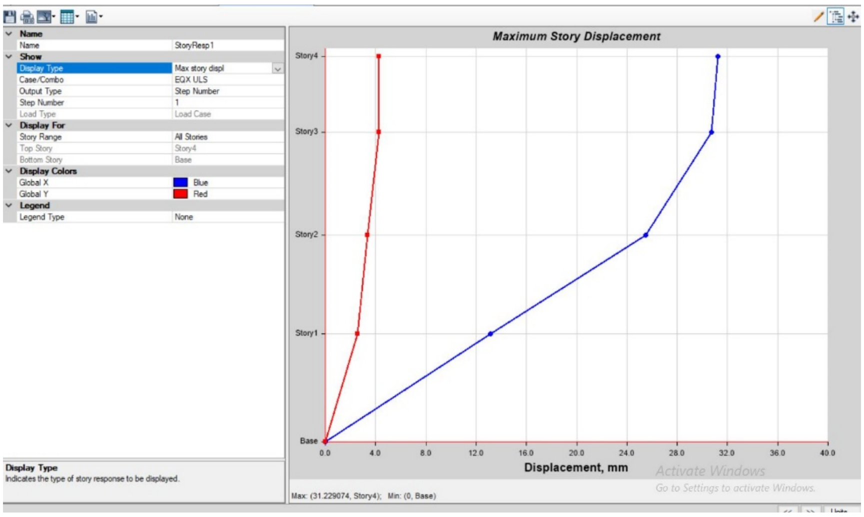


Figure 4-1:Storey Displacement due to EQx

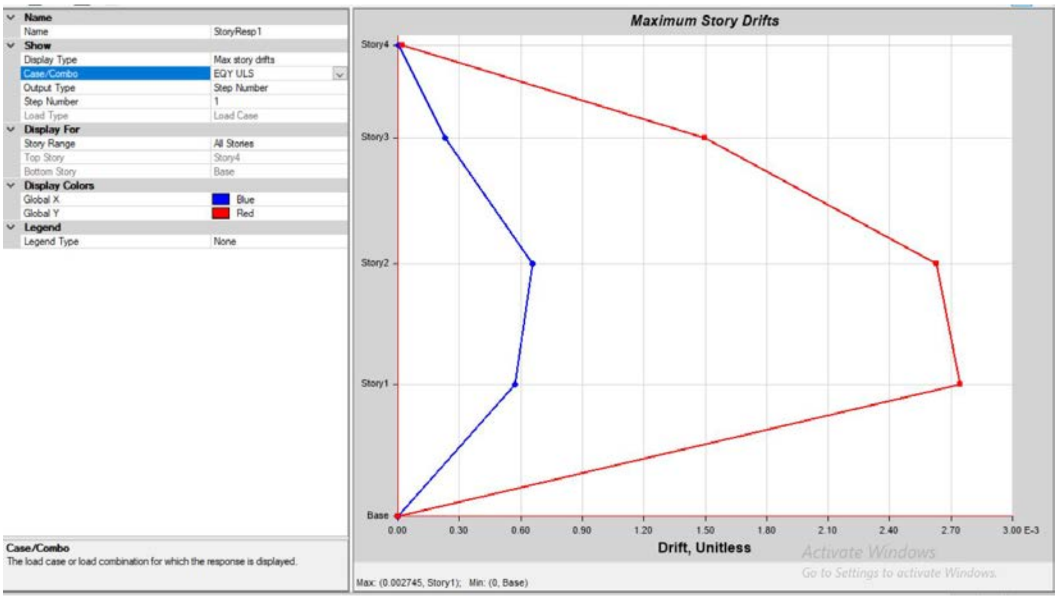


Table 4-3: Storey Drift due to EQy

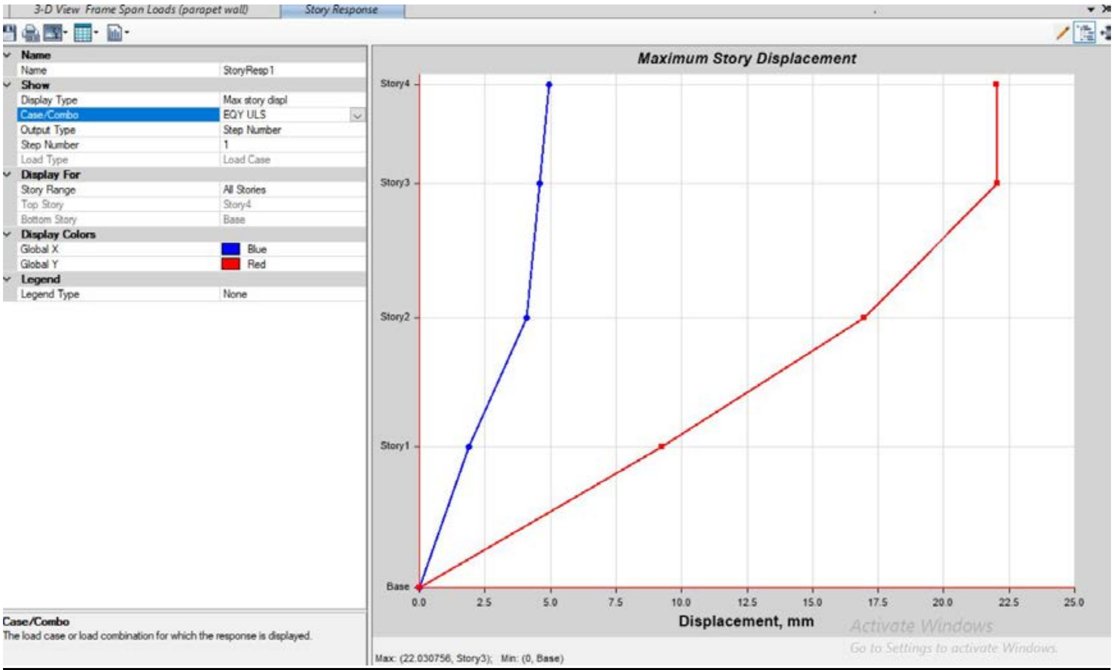


Figure 4-2: Storey Displacement due to EQy

4.3. Force Diagram

The sample output of forces obtained from ETABS analysis for envelope have presented below as a sample only. The output forces are axial force, Shear force and Moments

Figure 4-3: Axial Force Diagram

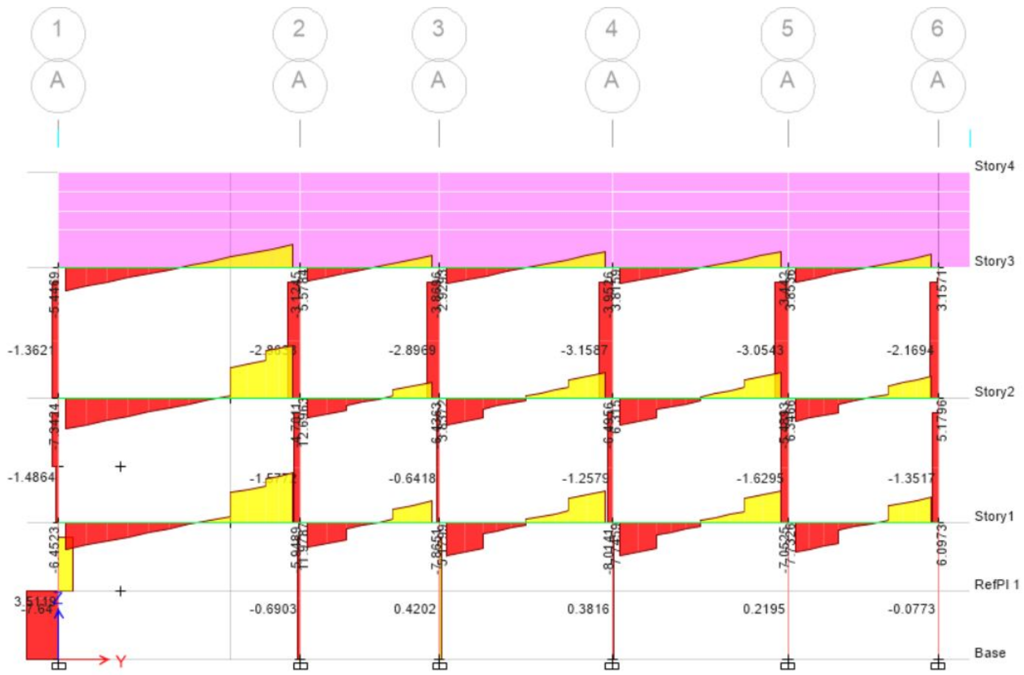


Figure 4-4: Shear Force Diagram

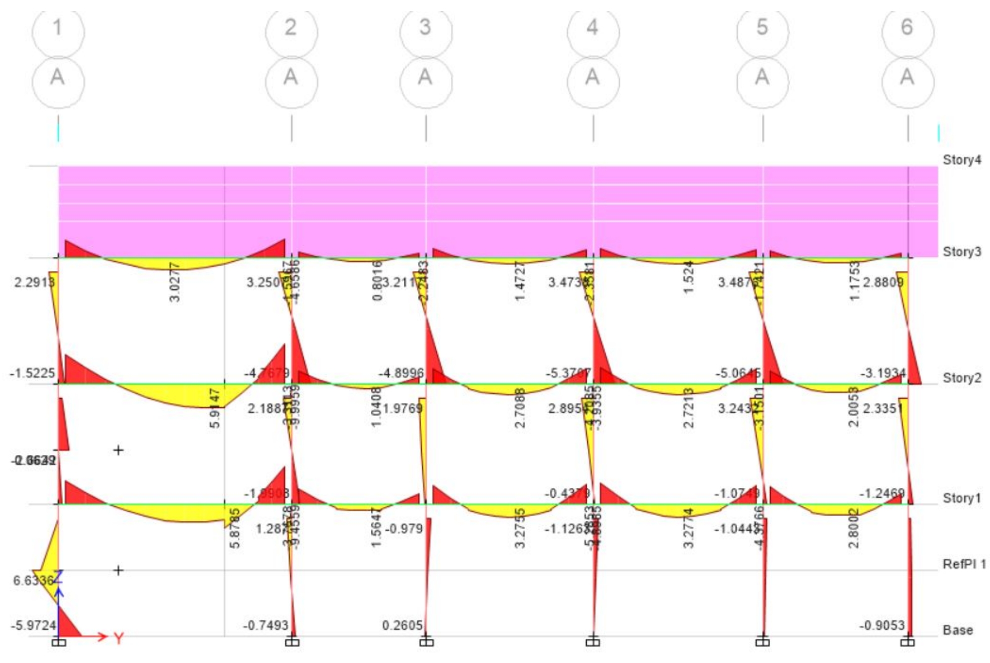


Figure 4-5: Bending Moment Diagram

4.4. Base Reaction

The reaction at the support of the column for the load combination of 1.2DL+1.5LL is picturized below as given by the software:

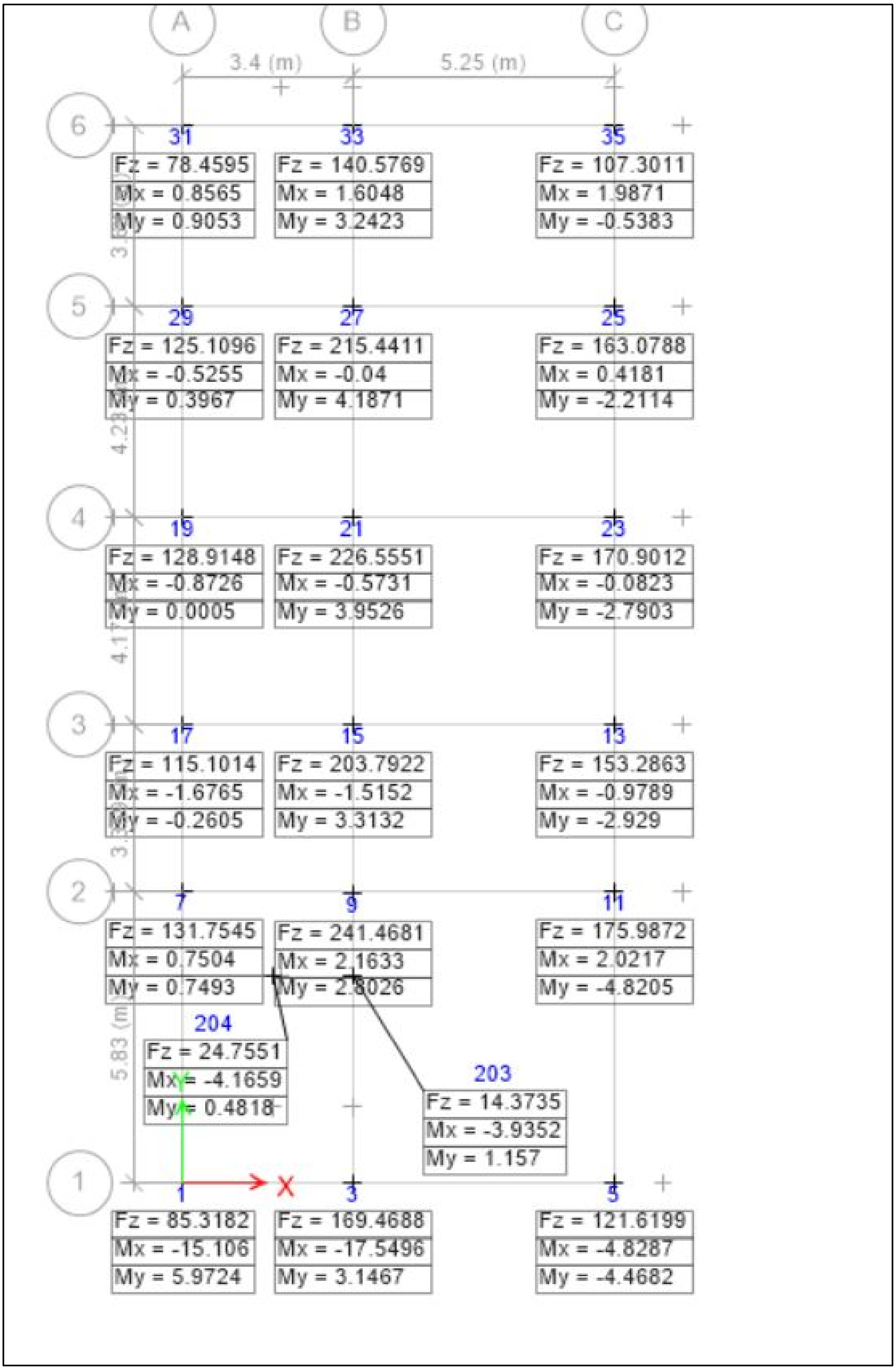


Figure 4-6: Base Reaction Force

[CHAPTER 5] DESIGN OF STRUCTURAL MEMBER (SAMPLE DESIGN)

5.1. Slab Design:

DESIGN OF SLAB

Input parameters

	5.25*3.6		
Span:	30		
Edge Condition:	One Short Edge Continuous		
Length of Shorter Span	Ly	3630	mm
Length of Longer Span	Lx	5250	mm
Take,			
Diameter of bar (Φ):		8	mm
Clear Cover (cc):		20	mm
Material (fy)			
Fe		500	Grade Steel
Concrete Grade (fck)			
M		20	
Depth of Slab (D):		127	mm
		0.1 27	m

S. N.	Reference	Description and Calculation	Remarks
1	IS 456:2000; cl.22.2	Effective Length Calculation and Determination of Type of Slab	
		Effective Depth = 103 mm	
		Effective Length (Ly) =	
		clear span + effective depth = 3503	
		Similarly,	
		Effective Length (Lx) = 5123	
		Again,	
		Center to Center Distance Between the Support	
		Along X-direction= 5250	
		Along Y-direction= 3630	
		Taking Shorter of two,	
		Lx= 5123	
		Ly= 3503	
		Then,	
		Long Span to Short Span Ratio,	
		Ly/Lx = 1.46	<2

Hence, it is
TWO WAY SLAB

2 Load Calculation

Assume width = 1m = 1000mm

Self weight of slab =	3.175	KN/m per unit width
Light Parttion Wall load =	1	KN/m per unit width
Floor Finish Load =	1.15	KN/m per unit width
Live Load =	4	KN/m per unit width
Total load =	9.325	KN/m per unit width
Factored Load (Wu) = 1.5(DL+LL)	13.9875	KN/m per unit width

3 IS 456:2000 Table 26

Design Moment Calculation

Moment Coefficients

For Negative Moment:

αy = 0.037

αx = 0.043

For Positive Moment

αy = 0.028

αx = 0.032

We have,

Moment

$$Mx = \alpha x*Wu*lx^2$$

$$My = \alpha y*Wu*lx^2$$

For Ast,

Mu = 0.87*fy*Ast*d*(1-(Ast*fy/(b*d*fck)))

For Spacing,

$$Spacing = (1000/Ast)*(\pi\Phi^{2/4})$$

Maximum Spacing =3d or 300 mm whichever is greater

Minimum reinforcement (Ast)=0.12% of bD

Now, The Calculation are shown in the tabular form

Short Direction (Y-direction)

αy	My (KN m)	Ast Calculated (mm$^{2)}$	Spacing Required (mm)	Spacing Provided (mm)	Ast provided (mm^2)

Moment at Continuous Edge (-ve)	0.043	15.79	389.05	129.20	150.00	335.10
Moment At Mid Span (+ve)	0.032	11.75	281.41	178.62	150.00	335.10

Long Direction (X-direction)

	αx	Mx (KN m)	Ast Calculated (mm^2)	Spacing Required (mm)	Spacing Provided (mm)	Ast provided (mm^2)
Moment at Continuous Edge (-ve)	0.037	13.58	329.51	152.55	150.00	335.10
Moment At Mid Span (+ve)	0.028	10.28	243.85	206.14	150.00	335.10

4 Check the Depth in Bending

We have,

Mu = 0.36*fck*b*xu,l*(d-0.416*xu,l)

where, xu,l = 0.46*d

Solving,

d= 76.77

which is less than d provided OK

5 Check the slab in Shear

Along the Short span

Shear Force= Vy= Wu*Ly/3

16.33 KN

Along the Long Span

Shear Force= Vy= ((Wu*Ly)/4)*(2-(Lx/Ly))

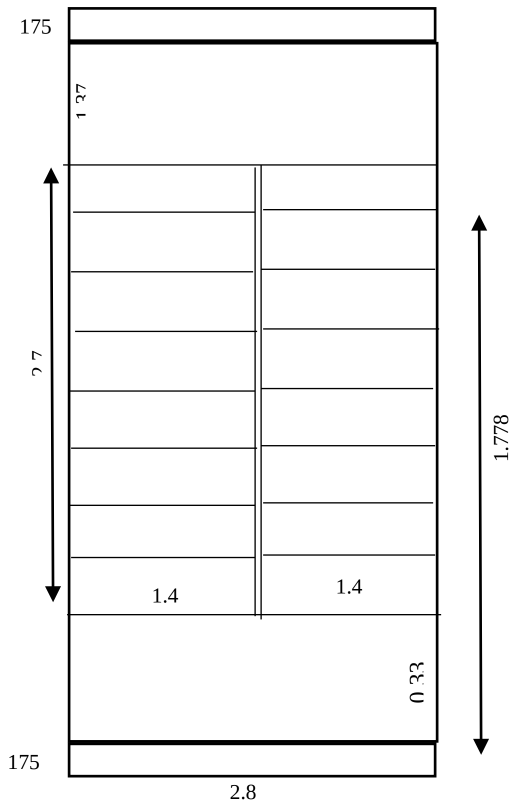
6.585 KN

	IS 456:2000, table 20	Maximum Shear Stress in Slab is Given by: τuv=Vu/(b*d) = 0.158 We Know that, Maximum Allowable shear stress τuc,max= 2.8 N/mm2 For M 20	
	IS 456:2000,cl 40.2.1.1 IS 456:2000, table 19	We have Percentage of Tension Steel(%Ast)= 0.325 and K= 1.3 For D= 127mm τc= 0.48 N/mm2 Therefore, τuc= k*τc = 0.624 N/mm2 Since τuv<τuc<τuc max Hence Safe in Shear	OK
6	IS 456:2000, cl 23.2.1	<u>Check for Deflection Control</u> (Leff/deff)actual< basic value*k1 k1=modification factor for tension reinforcement Ly/d= 34.01 we have, α = 26 β = 1 γ = 1.8 δ = 1 λ = 1 So, α*β*γ*δ*λ = 46.8 Hence, Safe in deflection	OK
7		<u>Development Length</u> Ld=0.87fy*Φ/(4*τbd) = 580 mm	

5.2. Staircase Design

Given,

Total Width of Staircase (W)	=	2.8	m
Width of each flight (Wf)	=	1.4	m
Tread (T)	=	300	mm
	=	0.3	m
Rise (R)	=	150	mm
	=	0.15	m
Floor to Floor Height (h)	=	3	m
no of Riser in First Flight (Nr1)	=	10	
no of Riser in Second Flight (Nr2)	=	10	
Total Going in First Flight (G1)	=	2.7	m
Total Going in Second Flight (G2)	=	2.7	
Length of First Landing	=	1.37	m
Length of Second Landing	=	0.33	m
Width of Support at first edge	=	175	mm
Width of Support at second edge	=	175	mm
Size of Main Reinforcement (dr)	=	16	mm
Size of Distribution Reinforcement	=	10	mm
Clear Cover (cc)	=	20	mm
Grade of Steel (fy)	=	500	
Grade fo Concrete (fck)	=	20	



<u>Design of Staircase</u>

Design of the staircase is based on the design of the longest flight

Effective Span of Flight	=	Center to Center Distance Between the Supports	
	=	4.575	m

Let us Take,

Thickness of Waist Slab (D)	=	150	mm	*(Approx. 1/20 of span)*
Then, Effective Depth (d)	=	122	mm	

<u>Loads Per Unit Width</u>

<u>Loads on each flight</u>

Weight of Waist Slab per m length in plan

Wwaist = 4.2 KN/m

Weight of Steps per m length in plan

Wstep = 1.88 KN/m

Floor Finish Load = 1.58 KN/m2

Total Dead Load per m length in plan

(DL) = 7.66 KN/m

Live Load = 4 KN/m2

Total Live Load per m length in plan

(LL) = 4 KN/m

Total DL+ LL = 11.66 KN/m

Factored Load, Wu = 18 KN/m

Loads on Landing

Loads On Each Landing

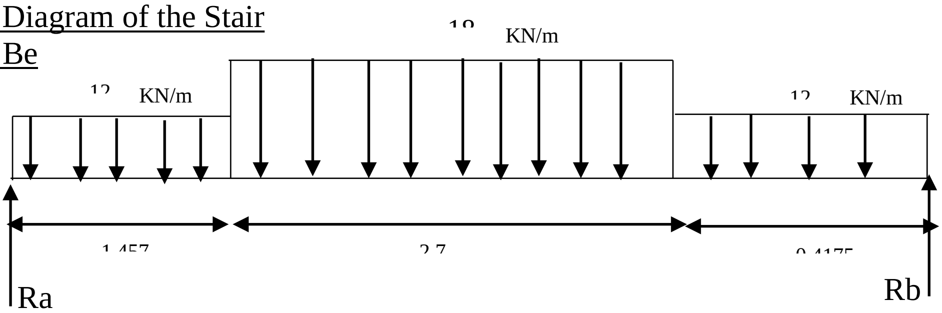
DL = 3.75 KN/m

LL = 4 KN/m

Total DL+LL = 7.75 KN/m

Factored Load = 12 KN/m

Load Diagram of the Stair Shall Be



Design Moment

Reaction At Support A,

Ra = 33.708
7 KN

Reaction At Support B,

Rb = 37.391
3 KN

Bending Moment is maximum where shear force is equal to zero

Let x be the distance from the start of going where shear force is equal to zero

then,

x = 0.9010 m

4

Hence, Maximum Bending Moment occurs at 2.359 m from support A

Maximum Bending Moment,

Mu = 43.7 KNm

Maximum Allowed Bending Moment for Singly reinforced section of M20 concrete with Fe500 bars

Mulim = $Rubd^2$

= $2.66bd^2$

39.5914 <43.7

Hence,Section can be designed asDoubly reinforced Section

Area of Reinforcement

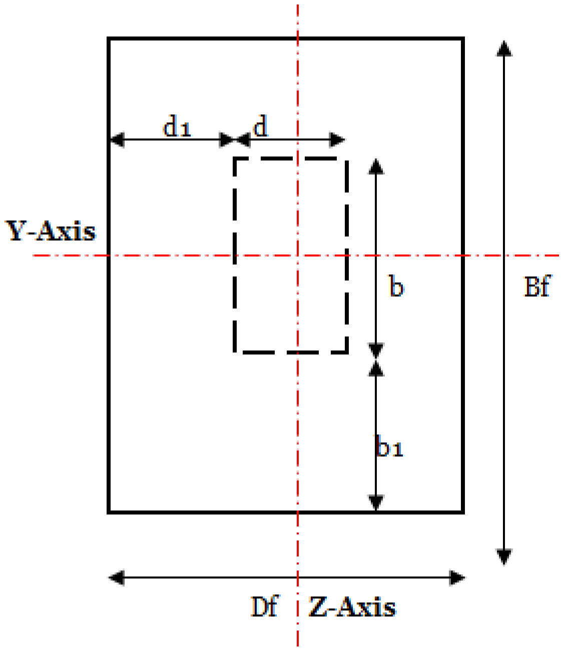
	Ast Required	Spacing Required	Spacing Provided	Ast Provided
Main Bar	1049	191.67	125	1608.5
Distribution Bar	180	436.332	150	523.599

Development Length

Ld = 906.25 mm

5.3. Footing Design

DESIGN OF ISOLATED FOOTING - SPREADSHEET
AS PER IS 456: 2000

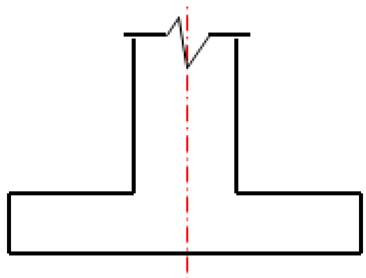


Data:

Column no.			
load case	2		
Concrete grade, M	20		
Steel grade, Fe	500		
Axial load, kN	487.62	kN	
My, kNm	0	kNm	
Mz, kNm	0	kNm	
Column size, b	400	mm	
Column size, d	400	mm	
SBC of soil, kN/m2	120	kN/m²	
Design factor	1.5		

Pressure:

Axial load	487.62	kN
App. Self weight	48.762	kN
Total weight	536.382	kN
Area of footing	4.47	m2
size of footing, Bf	2.5	mt
size of footing, Df	2.5	mt
Projection, b1	1.050	mt
Projection, d1	1.050	mt



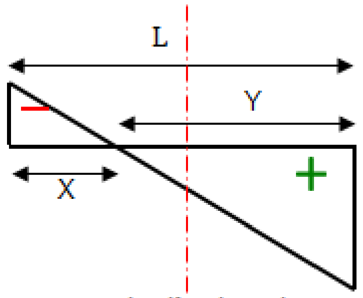
Footing Pressure,

$P_{max} = P/A + My/Zy + Mz/Zz$

Pmax	78.02	kN/m²

$P_{min} = P/A - My/Zy - Mz/Zz$

Pmin	78.02	kN/m²



Pressure Distribution Diagram

Eccentricity:

Y	1.25	mt
X	1.25	mt
L	2.5	mt
2/3 L	1.67	mt

b	2.5	mt
qu	117.0288	kN/m²
Eff. qu	117.0288	kN/m²

Shear Chk.

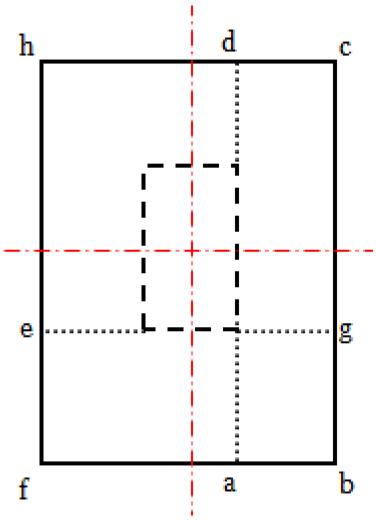
One way Shear : At distance d from face of column.

pt assumed	0.25	%
Designed shear stress	0.36	N/mm²
vu	219.429	
d=	257.60	mm
d provided	300.00	mm

Two way Shear : At distance d/2 from face of column.

Perimeter	2800	mm	
S.F. at this section	674.09	kN	
Ks	1.00		
tc	1.12	N/mm²	
tv	0.80	N/mm²	
Resistance	939.15	N/mm²	Safe

Flexure design:



For section efbg

pressure@f	78.02	kN/m²
pressure@b	78.02	kN/m²
Moment@eg. Meg	64.51	kNm
Mu	96.77	kNm
d provided	300.00	mm
Mu/bd2	1.08	N/mm²
pt	0.265	%
pt provided	0.265	
Ast	794.4	mm²/m width
provide	16#	@150c/c
Ast Provided	**1206**	**mm²/m width**

Check in other direction :

For section abcd

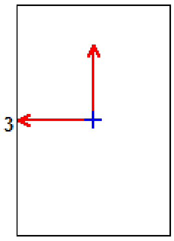
pressure@b	78.02	kN/m²
pressure@c	78.02	kN/m²
Moment@ad, Mad	64.51	kNm
Mu	96.77	kNm
d req	190.71	mm
M/bd2	1.08	
pt	0.265	%
Ast	794	mm²/m width

provide	16# @150c/c
Ast provided	**1206 mm²**

5.4. Beam Design

ETABS Concrete Frame Design

IS 456:2000 + IS 13920:2016 Beam Section Design (Summary)



Beam Element Details

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF	Type
Story1	B10	87	Beam 230*350	DL+0.3LL-EQXULS	175	4230	1	Ductile Frame

Section Properties

b (mm)	h (mm)	b_f (mm)	d_s (mm)	d_{ct} (mm)	d_{cb} (mm)
230	350	230	0	25	25

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
22360.68	20	1	500	500

Design Code Parameters

γ_C	γ_S
1.5	1.15

Factored Forces and Moments

Factored M_{u3} kN-m	Factored T_u kN-m	Factored V_{u2} kN	Factored P_u kN
-24.1598	7.9936	36.9283	-0.0625

Design Moments, M_{u3} & M_t

Factored Moment kN-m	Factored M_t kN-m	Positive Moment kN-m	Negative Moment kN-m
-24.1598	11.8576	0	-36.0173

Design Moment and Flexural Reinforcement for Moment, M_{u3} & T_u

	Design -Moment kN-m	Design +Moment kN-m	-Moment Rebar mm²	+Moment Rebar mm²	Minimum Rebar mm²	Required Rebar mm²
Top (+2 Axis)	-36.0173		282	7.183E-02	282	160
Bottom (-2 Axis)		0	160	7.183E-02	0	160

Shear Force and Reinforcement for Shear, V_{u2} & T_u

Shear V_e kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm²/m
50.8242	0	106.432	21.3383	907.48

Torsion Force and Torsion Reinforcement for Torsion, T_u & V_{U2}

T_u kN-m	V_u kN	Core b_1 mm	Core d_1 mm	Rebar A_{svt} /s mm²/m
7.9936	36.9283	200	320	520.69

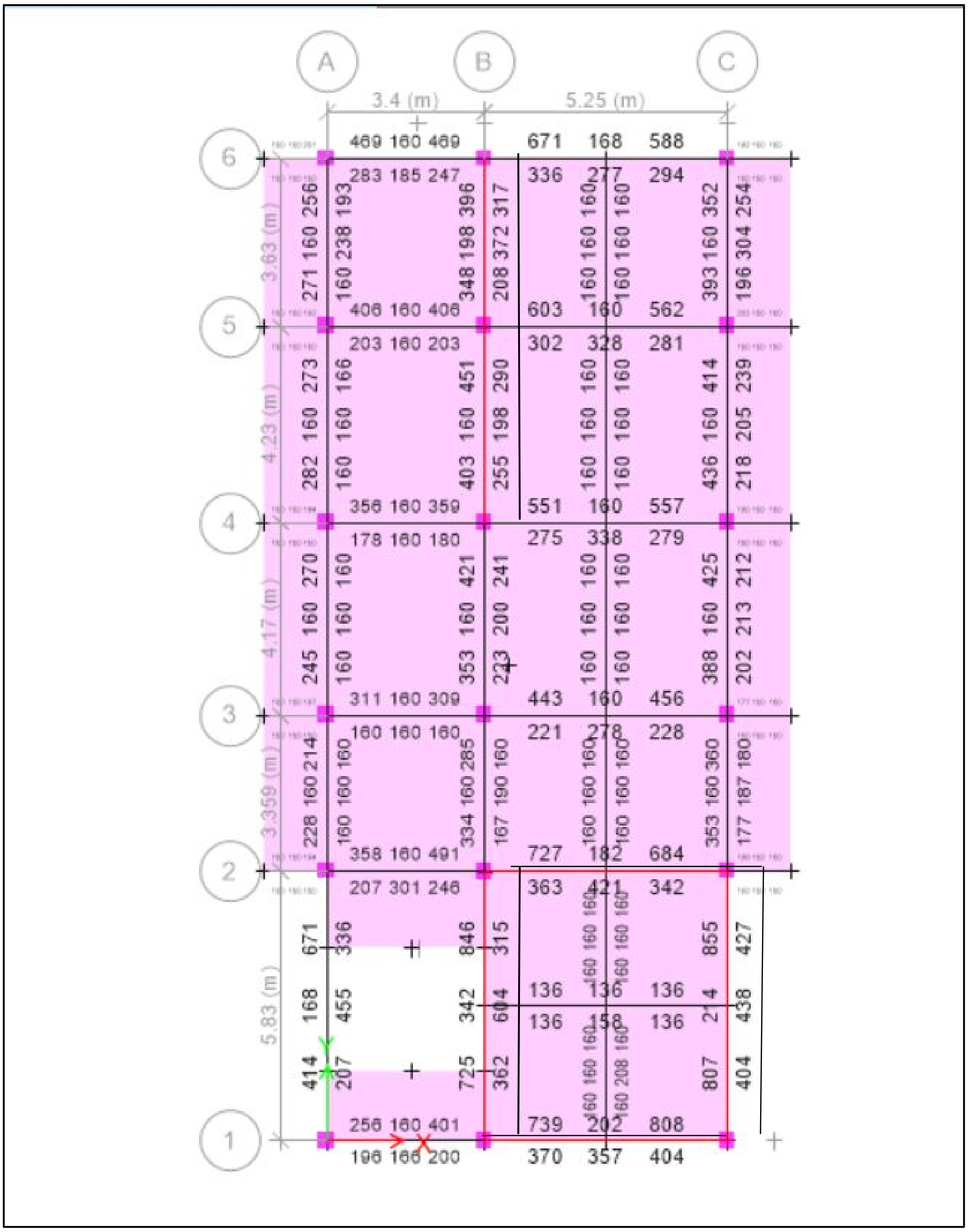


Figure 5-1: Beam Design Output in First Floor

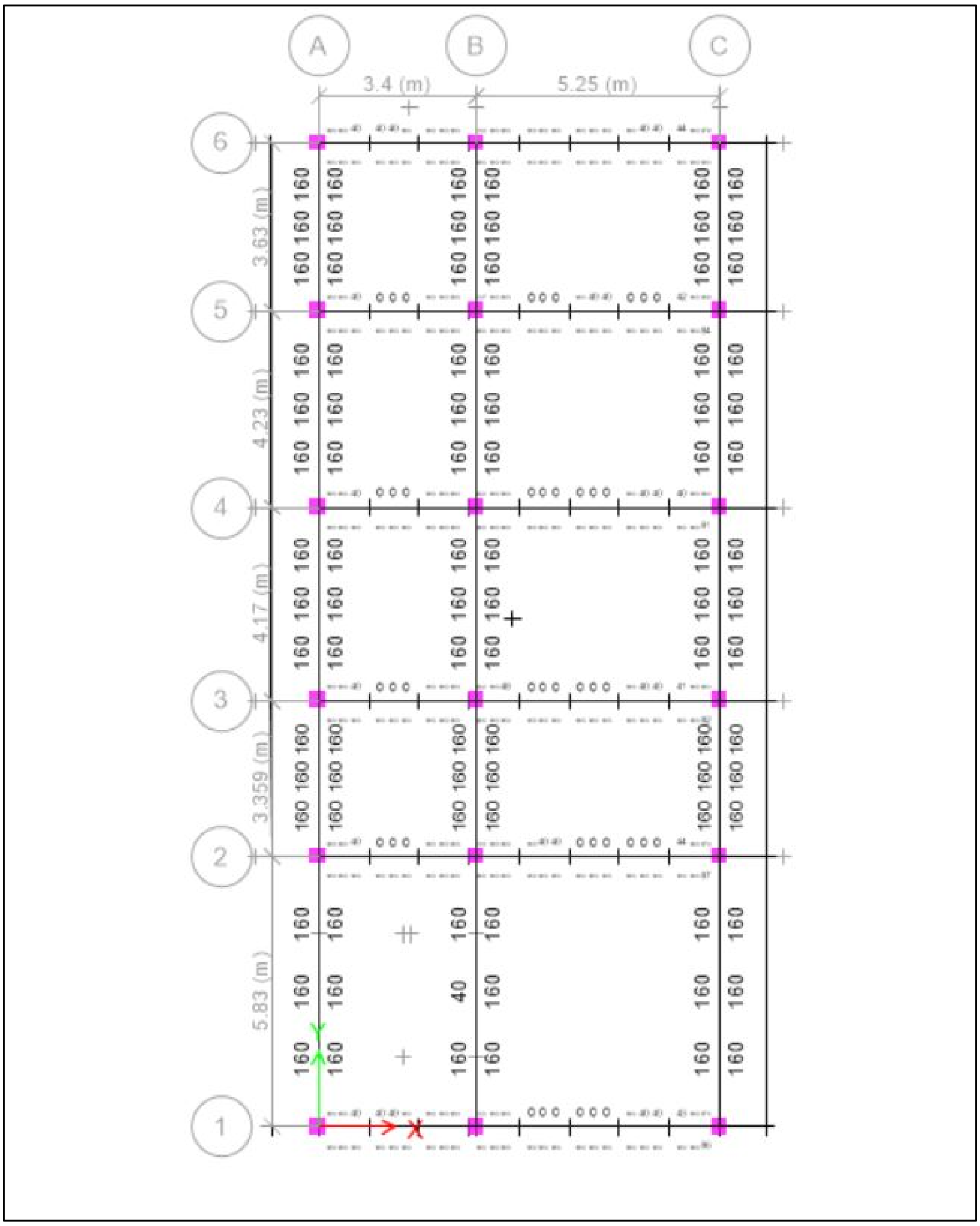
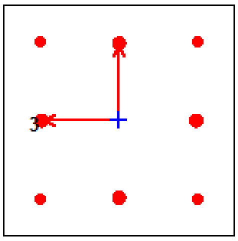


Figure 5-3: Beam Design Output in Third Floor

5.5. Column Design

ETABS Concrete Frame Design

IS 456:2000 + IS 13920:2016 Column Section Design (Summary)



Column Element Details

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF	Type
Story1	C16	16	Column 350*350	DL+0.3LL-EQXULS	0	3300	1	Ductile Frame

Section Properties

b (mm)	h (mm)	dc (mm)	Cover (Torsion) (mm)
350	350	58	30

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
22360.68	20	1	500	500

Design Code Parameters

γ_C	γ_S
1.5	1.15

Axial Force and Biaxial Moment Design For P_u , M_{u2} , M_{u3}

Design P_u kN	Design M_{u2} kN-m	Design M_{u3} kN-m	Minimum M_2 kN-m	Minimum M_3 kN-m	Rebar Area mm^2	Rebar % %
303.0492	-6.5529	-113.7096	6.061	6.061	2184	1.78

Axial Force and Biaxial Moment Factors

	K Factor Unitless	Length mm	Initial Moment kN-m	Additional Moment kN-m	Minimum Moment kN-m
Major Bend(M3)	0.663231	2950	-52.8529	0	6.061
Minor Bend(M2)	0.664957	2950	-6.4785	0	6.061

Shear Design for V_{u2} , V_{u3}

	Shear V_u kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm^2/m
Major, V_{u2}	51.5735	88.7927	40.8795	36.0318	387.95
Minor, V_{u3}	15.161	87.906	40.8795	15.161	387.95

Joint Shear Check/Design

	Joint Shear Force kN	Shear V_{Top} kN	Shear $V_{u,Tot}$ kN	Shear V_c kN	Joint Area cm²	Shear Ratio Unitless
Major Shear, V_{u2}	N/N	N/N	N/N	N/N	N/N	N/N
Minor Shear, V_{u3}	N/N	N/N	N/N	N/N	N/N	N/N

(1.4) Beam/Column Capacity Ratio

Major Ratio	Minor Ratio
N/N	N/N

Additional Moment Reduction Factor k (IS 39.7.1.1)

A_g cm²	A_{sc} cm²	P_{uz} kN	P_b kN	P_u kN	k Unitless
1225	21.8	1921.4103	458.5065	303.0492	1

Additional Moment (IS 39.7.1)

	Consider M_a	Length Factor	Section Depth (mm)	KL/Depth Ratio	KL/Depth Limit	KL/Depth Exceeded	M_a Moment (kN-m)
Major Bending (M_3)	Yes	0.894	350	5.59	12	No	0
Minor Bending (M_2)	Yes	0.894	350	5.605	12	No	0

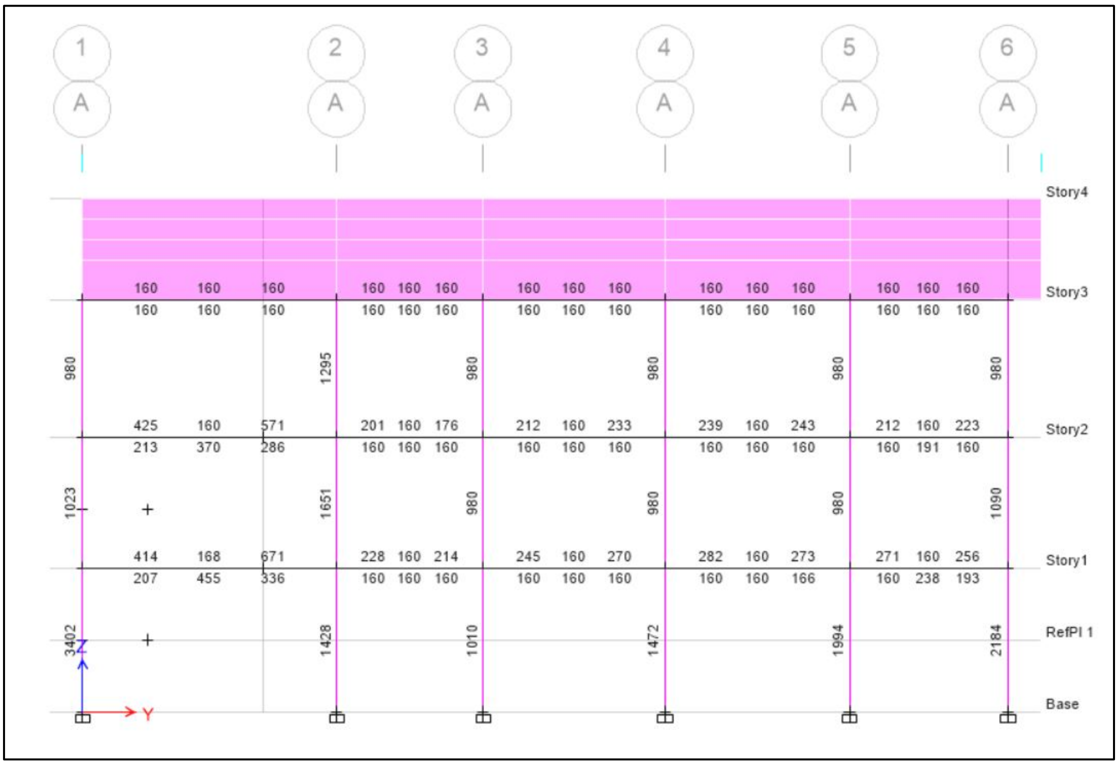


Figure 5-2: Column Deisgn Output Along Grid A-A

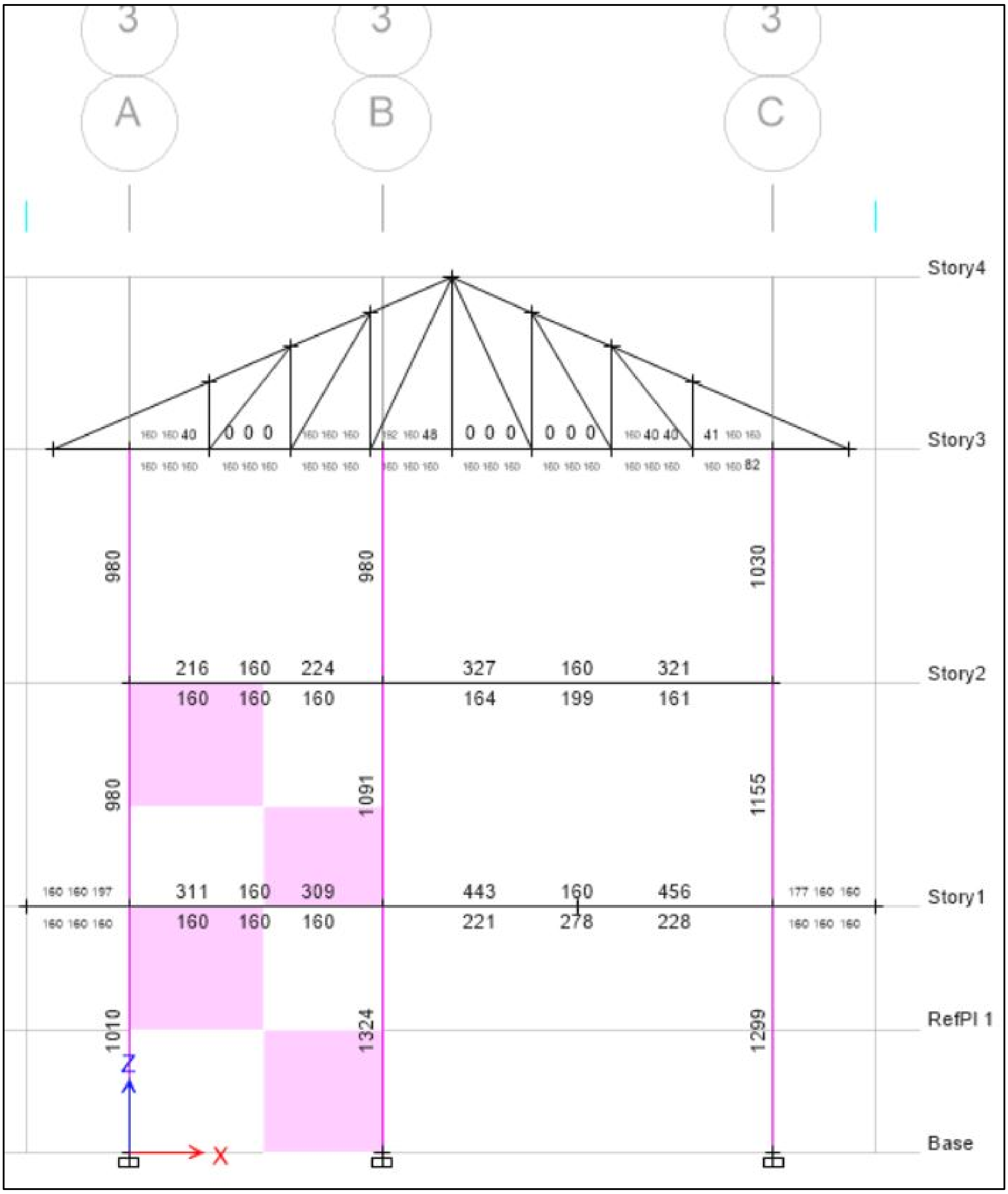


Figure 5-3: Column Design Output Along Grid 3-3

3. PLANT TISSUE CULTURE LAB

TO WHOM IT MAY CONCERN

This report comprises the summary of the structural design of Tissue cultural lab of Federal agriculture farm. The report consists of design procedures adopted, assumptions made, and the input assign in the design. During design it is assumed that the client will completely followed the architectural as well as the structural design drawings. It is also assumed that the construction will be supervised by a professional engineer.

The designer will not be responsible if any alteration or change to the structural system is made by the client or contractor without the prior permission from the designer, or the alteration to the non-structural system is made such that the weight of each individual floor or the weight of the whole building is altered by more than 10% of the design weight of the floor and the total weight

The design calculations and derivations are limited only to let the concerned people know the methodology adopted. However, the calculation may be provided to the client or the concerned authorities when needed, upon request.

GOEC-RAJDEVI-RECON JV

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[CHAPTER 1] INTRODUCTION

1.1. General

This report summarizes the structural analysis and design of RC framed building. It has planned to utilize the building for office purpose. The structural analysis in this building considers ground floor plus one storey. The aim of design is the achievement of an acceptable probability that structures being designed will perform satisfactorily during their intended life. With an appropriate degree of safety, they should sustain all the loads and deformations of normal construction and use and have adequate durability and adequate resistance to the effects of misuse and fire. Structural Analysis of the concerned building has been done in details with analysis and designs software.

The analysis and design has been based on the prevailing codes that are in practice in Nepal, the National Building code of Nepal (NBC2020/1994) and the IS code at places required. This report consists of the design procedures adopted, the assumptions made, the inputs made in the design and the design output.

1.2. Assumptions

The following assumptions are taken into consideration in the seismic resistant analysis and design of structures:

- Adequate supervision and quality systems are provided during execution of the works.
- Construction is carried out by personnel having the appropriate skill and experience.
- Construction materials and products confirm to the pertinent codes and specifications.
- The structure is adequately maintained.
- The structure is used in accordance with the design brief.
- An earthquake is not likely to occur simultaneously with maximum flood, wind, waves or tides.
- Resonance as visualized under steady state sinusoidal excitation will not occur, as the small duration of earthquake is not enough to build up resonance amplitudes. Subsoil does not considerably settle or slide due to earthquake at the site of structure.

This report is divided into three chapters. Chapter one begins with introductions and general description, Chapter two comprises the numerical modeling, analysis and design; Chapter three presents the summary and recommendations.

1.3. Salient Features

1.3.1. Project Information

Type of building : Tissue Cultural Lab

Location : Sindhupalchowk ,Nigale

Plinth Area : 179.154 sq.m

1.3.2. Building Features

The building has some special features which are listed below:

Type of Building :Special RC Moment Resisting Frame Structure

Wall Type : Brick Masonry Wall
Footing Type : Isolated Footing
Depth of foundation : 1500 mm
Dimension (m) (centre to centre)
L 2180 m

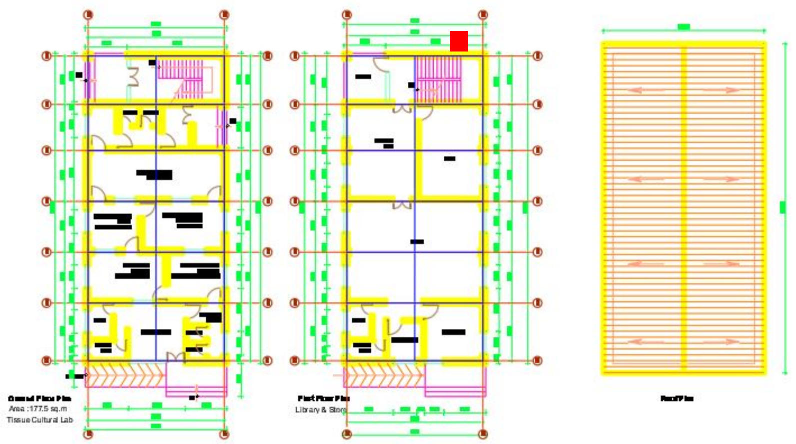
B 2180m

Storey Height (m) : 2.8448 m
Total Height (m) : 6.6896 m
No of Storey : Ground + one Storey+Truss

Figure 1-1: Plan of Building

Figure 1-2: Elevation of Building

For More Detail Refer Architectural Drawing.



1.3.3. Site Condition

Type of Soil : Type B, Medium Soil. As per NBC 105:2020

Allowable Bearing Capacity: 130 KN/m2 (Assumed)

Seismic Zone Factor: 0.3 as per NBC 105:2020

[CHAPTER 2] ANALYSIS TECHNOLOGY AND METHOLODOGY

2.1. General

After completion of Architectural design, the layout of columns and beams are done without affecting the Architectural functions of building so far. Structure is modeled using finite element method. A three-dimensional beam element having 12 DOF with 6 DOFs at each node were used for modeling beams and columns in the building.

The structure is analyzed by the linear elastic theory to calculate internal actions produced by anticipated design loads. The analysis is carried out using state of art three-dimensional structural analysis programs like ETABS 2020 The design loads considered as per the relevant codes of practice comprise dead load due to permanent structures, live load due to occupancy of the structure and seismic load due to anticipated earthquake possible at the proposed location. A number of load combinations are considered to obtain the maximum values of design stresses.

Following considerations is made during modeling, analysis and design.

- The structures are Reinforced Concrete Special Moment Resisting Frame (SMRF) type. Beams and columns are considered as the structural load resisting elements. Although non-structural components like wall plaster, infill walls, floor finishing etc. has comes effects on structural performance, they are considered only as loading.
- For all Structural elements, M20 grade of concrete is used.
- Centre-line dimensions are followed for modeling, analysis and design.
- Floor slabs are assumed to be rigid in their own plane. The slab action has been modeled by rigid floor diaphragms. Slabs are also considered in modeling. Slab is modeled as shell element.
- Beam and columns are modeled as frame elements.
- The main beams rest centrally on columns to avoid local eccentricity.
- Foundation is assumed to be fully rigid at the plinth level.
- The beam-column joint is not modeled in detail.
- Preliminary sizes of structural components are assumed by experience.
- Seismic loads were considered acting in the horizontal direction (along either of the two orthogonal directions of building) and not along the vertical direction, since it is not considered to be significant for design of structural member’s suitable load combinations as suggested by NBC.
- NBC 105:2020 are used.

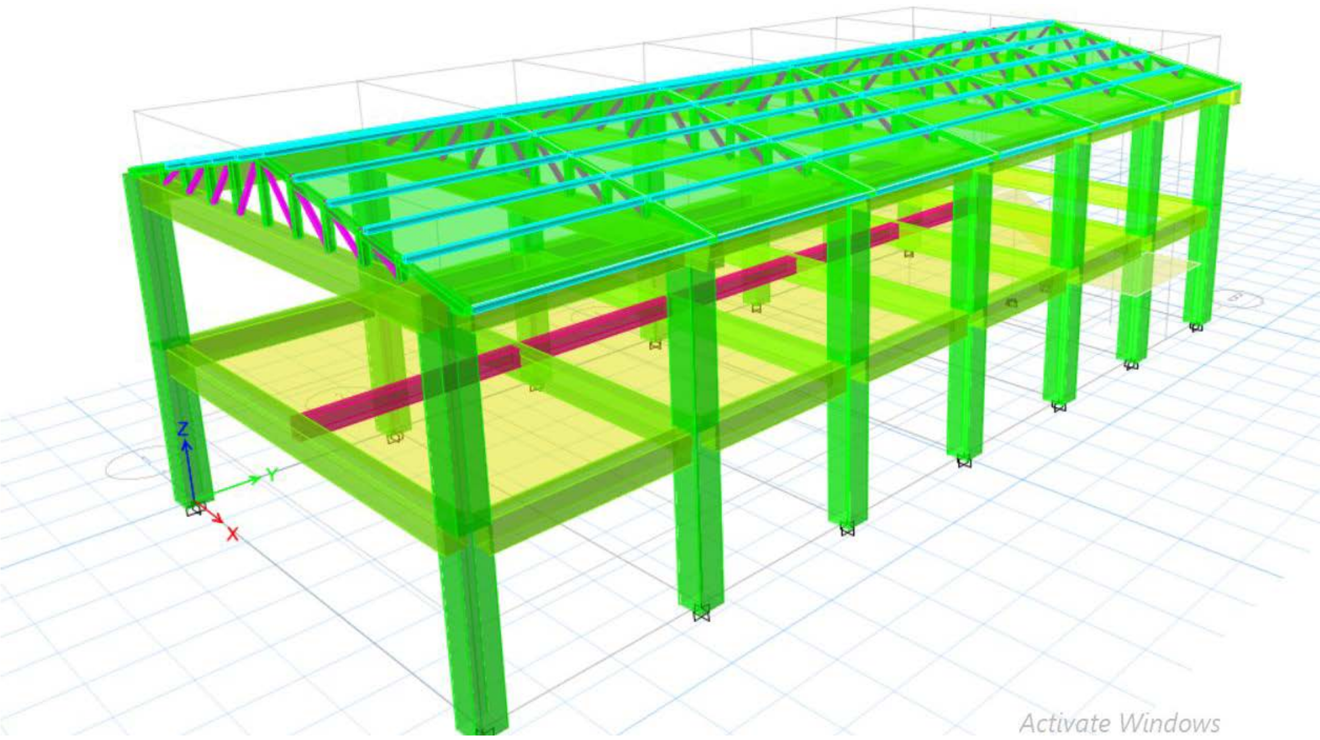


Figure 2-1: 3D- Model of Building

2.2. Codes and Standard Used

For the structural analysis and design, the following codes and standard are followed:

- IS 456- 2000 Code of practice for plain and reinforced concrete
- IS 875-1987 Code of practice for design loads (other than earthquake) for buildings and structures
- NBC 105:2020 Criteria for Earthquake Resistant Design of Structures,
- IS 13920-1993 Code of practice for ductile detailing of reinforced concrete structures subjected to seismic forces
- NBC Nepal Building Code

2.3. Software Used

The following software is used for the structural analysis and design. ETABS 2020, version 20.0.0 ETABS is a special purpose finite element analysis and design program developed specifically for building systems. With ETABS, models are defined logically floor-by-floor, column-by-column, bay-by-bay and wall-by-wall and not as a stream of non-descript nodes and elements as in general purpose programs. The software has very powerful numerical methods, design procedures and international design codes, all working from a single comprehensive database. At its core, it utilizes the same analysis engine as used by SAP2000.

Among others, ETABS can do model generation, seismic and wind load generation, finite element-based linear and non-linear static and dynamic analysis, concrete frame design (column and beam) and shear wall design

[CHAPTER 3] ANALYSIS

3.1. Material Properties

3.1.1. Concrete

All components of plain and reinforced concrete are M20 grade as specified in design.

Modulus of Elasticity [E_c] = 5000 $\sqrt{f_{ck}}$ N/mm^2 (Cl. 6.2.3.1, IS 456:2000)

= 22360.68 N/mm^2 for M20 Grade Concrete

Poisson's Ratio [U] = 0.2

Unit Weight = 25 KN/m^3

Characteristic Strength [f_{ck}] = 20 N/mm^2 for M20 Grade Concrete

The structural design strength is derived from the characteristic strength multiplied by a coefficient 0.67 and divided by the material partial safety factor. The partial factor for concrete in flexure and axial load is 1.5.

3.1.2. Reinforcement Steel

Characteristic strength of high yield steel is taken as 500 Mpa (TMT) for main longitudinal and shear rebar and material partial safety factor is to be 1.15. Modulus of Elasticity [E_s] = 2x10^5 N/mm^2

Poisson's Ratio [U] = 0.3

3.2. Section Properties

Preliminary Size of Members

The preliminary sizes of Beam, Column, and Slab were chosen based on experience.

Beam : 300 mm x 450 mm (Main Beam)

Column : 450 mm x 450 mm

Thickness : 127 mm (Floor Slab)

: 150 mm (Staircase Slab)

During the analysis, beam and column are modeled as frame elements whereas slabs, are modeled as area element.

3.3. Loading

The following considerations are made during the loading on the structural model:

- The loads distributed over the area are imposed on the area element and the loads distributed over the length are imposed on the frame elements whenever possible.
- Where such loading is not possible, equivalent conversion to different loading distribution is carried to load the model near the real case as far as possible.

For lateral load, necessary calculations are performed to comply with the requirements of NBC 105:2020.

3.3.1. Load Cases

The following load cases are used for the loading during the analysis.

Load Name	Load Type	Description	Unit	Remarks
DL	Dead	Self-weight of the structure	KN/m^2	
WL	Dead	Wall Load	KN/m	On beam
FL	S. Dead	Floor Finish Load	KN/m^2	On slab
PL	S. Dead	Partition Wall Load	KN/m^2	On floor slab
LL	Live	Imposed Load	KN/m^2	On floor slab
RLL	Live	Imposed Load	KN/m^2	On terrace slab
SL	S.Dead	Step Load	KN/m	On Beam
EQx	Quake	Equivalent Static Lateral Load	KN	
EQy	Quake	Equivalent static lateral load	KN	

3.3.2. Load Combinations:

The load combinations are based on NBC 105:2020. The following load combinations are specified as per NBC 105:2020:

Static Load Combination:

1.2DL+1.5LL

Seismic Load Combination:

DL + λLL ±E
Where, λ = 0.6 for storage facilities
= 0.3 for other usage

The following load combinations are used during analysis

Table 3-1: Load Combination

S.N.	NAME
1	1.2DL + 1.5LL
2	DL+0.3LL+EQX
3	DL+0.3LL-EQX
4	DL+0.3LL+EQY
5	DL+0.3LL-EQY

3.4. Estimation of Load:

The loads on the building are based on Indian codes of Practices. The unit weight of different structural and non-structural elements are derived from IS 875 Part 1 and presented in Table 3. The load calculations are based on actual measured drawings. The self-weight of beams, columns and slabs are calculated by the program. Similarly the imposed loads are applied on the slab as area load in KN/m^2 and values of imposed loads are tabulated in table below.

- The weight of infill walls are calculated and applied on beams as line weight in KN/m.
- Partition wall load are assigned as uniformly distributed area load in slab as area load in KN/m^2.
- Floor finishing load are assigned as area load in slab.
- Single type of Live load is assigned in each panel of slab.
- A frame load is applied as parapet loading on the exterior frame of the roof level.
- The roof is assumed accessible and loaded with roof live load as per Indian Standard, IS 875 -1987(part2) but this load is not considered during seismic load.

3.4.1. Unit Weight (Dead Load)

Dead loads for analysis are calculated as per Indian Standard, IS 875 -1987(part1). Unit weights of different material used are given below.

Unit Weight of Material

S.N.	Type	Value	
1	Reinforced Concrete	25	KN/m^3
2	Brick Masonry	18.85	KN/m^3
3	Screed	21	KN/m^3
4	Marble	26.7	KN/m^3
5	Plaster	20.4	KN/m^3

Dead Load Calculation

Depth of Beam= 450 mm

Floor Height =	2844.8	mm
Height of Parapet Wall =	0	mm

Dead Load of Walls

Dead Load of 9" thick wall without opening =	11.81	KN/m
Dead Load of 9" thick wall with 25% opening =	8.86	KN/m
Dead Load of 9" thick wall with 40% opening =	7.09	KN/m
Dead Load of 4" thick wall without opening =	7.38	KN/m
Dead Load of 4" thick wall with 25% opening =	5.54	KN/m
Dead Load of 9" thick parapet wall =	0	KN/m

Floor Loads

Thickness of Slab =	127	mm
Tile =	0.1	KN/m^2
Thickness of tile =	12.5	mm
Thickness of tile with plaster =	25	mm
Thickness of Marble =	20	mm
Thickness of Screed =	50	mm
Thickness of Cement Plaster =	12.5	mm

Dead Load of Structural Slab =	3.175	KN/m^2
Dead Load of Tile =	0.1	KN/m^2
Dead Load of Marble =	0.534	KN/m^2
Dead load of Screed =	1.05	KN/m^2
Dead Load of Cement Plaster =	0.255	KN/m^2
Total Dead load of Floor Finish (Tile) =	1.15	KN/m^2
Total Dead load of Floor Finish (Marble) =	1.87	KN/m^2
Total Dead load of Floor Finishes (Cement Punning) =	1.05	KN/m^2
Tread =		250
Rise =		118.5
Dead Load of Steps in staircase with floor finish=	3.83	KN/m^2

Table 3-2: Unit Weight of Material

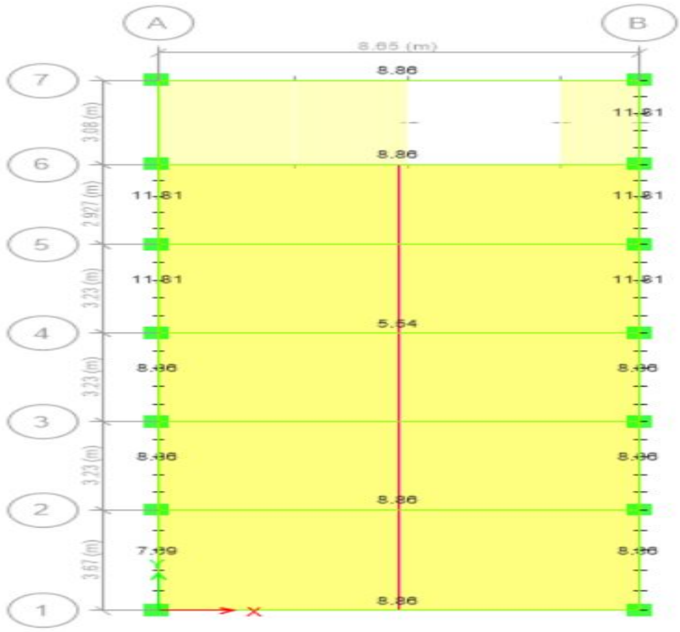


Figure 3-1: Wall Load

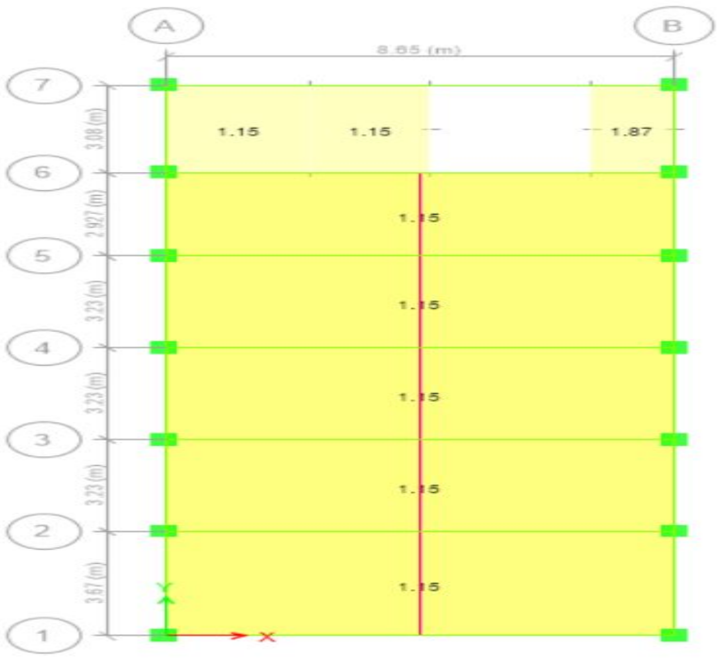


Figure 3-2: Floor Finish Load

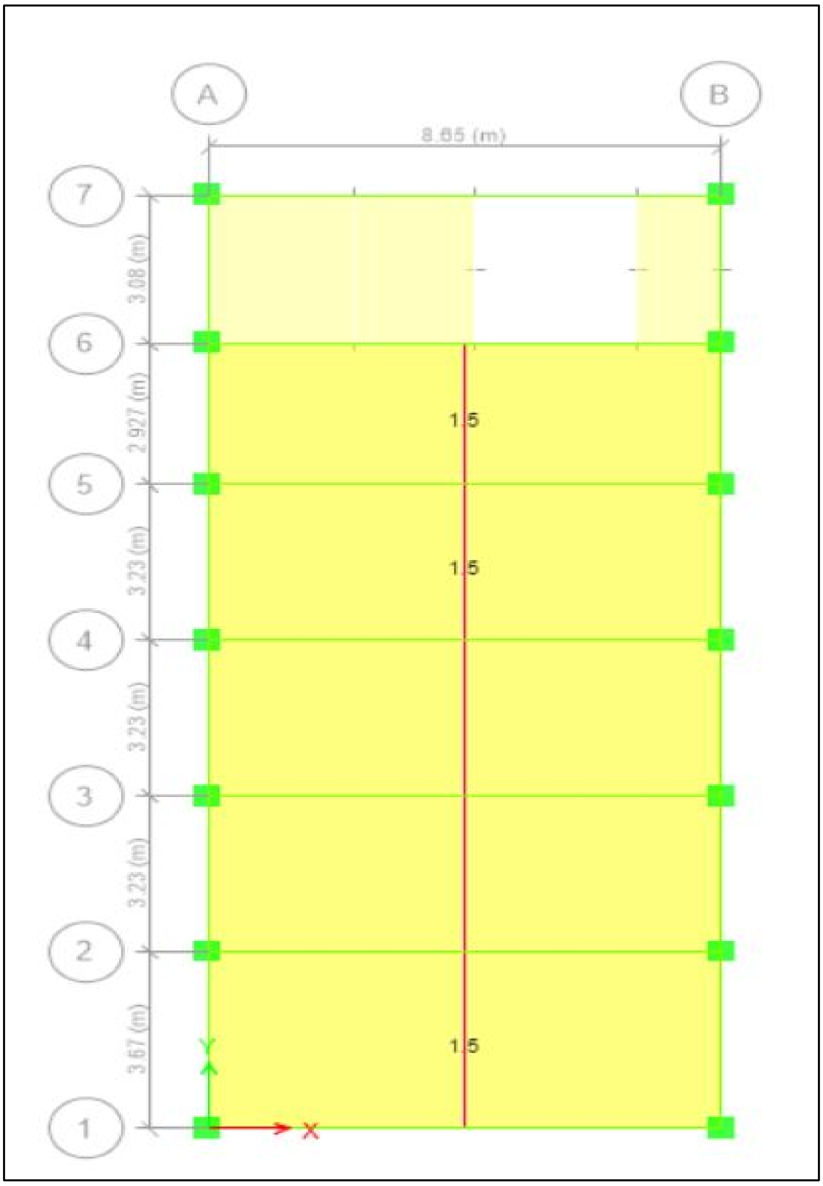


Figure 3-3: Partition Wall Load

3.4.2. Live Load

The magnitude of live load depends upon the type of occupancy of the building. These are to be chosen from code IS875:1987(part II) for various occupancies. The live load distribution varies with time. Hence each member is designed for worst combination of dead load and live loads. Live loads for office building are given below:

Table 3-3: Live Load for Office Building

S.N	Area type	Load	Unit
1	Office Rooms	4.0	kN/m^2
2	Balcony staircase.corridors	4.0	kN/m^2
3	Balcony, Staircase and Corridor	4.0	kN/m^2

4	Toilet	2.0	kN/m^2
5	Reception hall	4	kN/m^2
6	Store	4.0	kN/m^2
7	Library	8.0	kN/m^2

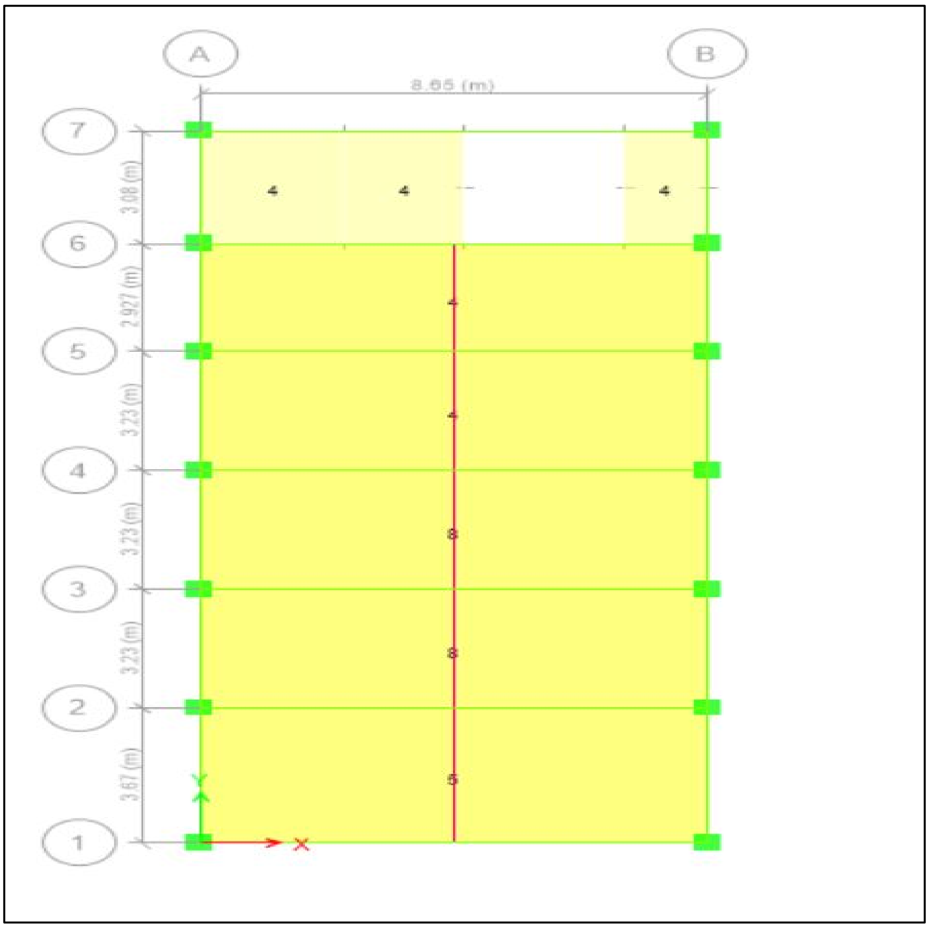


Figure 3-4: Live Load

3.4.3. Seismic Load

The seismic load calculation is done by equivalent static method. The equivalent static method is used for all serviceability limit state (SLS) calculations regardless of the building characteristics.

For ultimate limit state (ULS), the Equivalent Static Method may be used when at least one of the following criteria is satisfied:

- The height of the structure is less than or equal to 15m.
- The natural time period of the structure is less than 0.5 secs
- The structure is not categorized as irregular and the height is less than 40m.

Table 3-4: Horizontal design spectrum coefficient

We have,

Frame Type	=	Reinforced Concrete Moment Resisting Frame	
Height of Building,H	=	5.6896	m
Soil Type	=	Type B	
Approximate Fundamental Period of Vibration	=	$k_t H^{3/4}$	
	=	$0.075*H^{3/4}$	
	=	0.276	sec
Amplified period of vibration, T1 sec	=	**0.345**	sec
		$1+(\alpha-1)*T/T_a$	if $T<T_a$
Spectral Shape Factor, $C_h(T)$	=	α	if $T_a<=T<=Tc$
		$\alpha[K+(1-K)(T_c/T)^{2]}$	if $T_c<=T<=6$
	=	2.500	
Seismic Zoning Factor, Z	=	0.350	
Importance Factor, I	=	1.000	
Elastic Site Spectra, (CT1)	=	$C_h(T)*Z*I$	
	=	0.875	
Ductility Factor, Rμ	=	4.000	
Overstrength Factor for ultimate limit. Ωu	=	1.500	
Overstrength Factor serviceability limit. Ωs	=	1.250	
Horizontal Base Shear Coefficient for ultimate limit, $C_d(T1)$	=	$\frac{C(T1)}{R\mu*\Omega u}$	
	=	**0.146**	
Elastic Site Spectra for serviceability limit, (C_sT1)	=	0.20*(CT1)	
	=	0.175	
Horizontal Base Shear Coefficient for serviceability limit, $C_d(T1)$	=	$\frac{Cs(T1)}{\Omega s}$	
	=	**0.140**	

For Vertical Distribution of Seismic Forces

From Clause 6.3 NBC 105:2020

For Structure having time period T<= 0.5 sec

k = 1

For Structure having time period T>= 2.5 sec

k = 2

so,

k = 1.00

[CHAPTER 4] ANALYSIS OUTPUT

The analysis results are discussed in this chapter. Equivalent Static Method is used. The major discussion are focused on the eccentricity, story shear, inter story drift, maximum displacement and base shear along two orthogonal directions. The column and beam size and reinforcement are then designed for maximum forces.

4.1. Modal Time Period and Mass Participation Factor

As per NBC 105:2020 section 7.3 a sufficient number of modes shall be included in the analysis to include at least 90% of the total seismic mass in the direction under consideration. Analysis was carried out for first 12 modes so that the mass participation satisfies this criterion in both orthogonal directions. Following table shows time period and mass participation ratio for all modes:

Table 4-1: Modal Participating Mass Ratio

Mode	Period	UX	UY	SumUX	SumUY
	sec				
1	0.5	0.1436	0.5219	0.1436	0.5219
2	0.471	0.4934	0.1803	0.637	0.7021
3	0.368	0.1053	0.0108	0.7422	0.7129
4	0.223	0.0063	0.1999	0.7485	0.9128
5	0.187	0.2419	0.0116	0.9904	0.9245
6	0.163	0.0096	0.0755	1	1

4.2. Storey Drift

As per section 5.6.3 NBC 105:2020, the storey drift in any storey shall not exceed 0.025 times the storey height at ultimate limit state. In this building the storey drift is limited to 75 mm. From the analysis the displacements of the mass centre of various floors are obtained and are shown in Table below along with storey drift:

Table 4-2: Storey Drift due to EQx

Story	Elevation	Location	X-Dir	Y-Dir
	m			
Story2	6	Top	0.004115	0.000787
Story1	3	Top	0.0021	0.000443
Base	0	Top	0	0

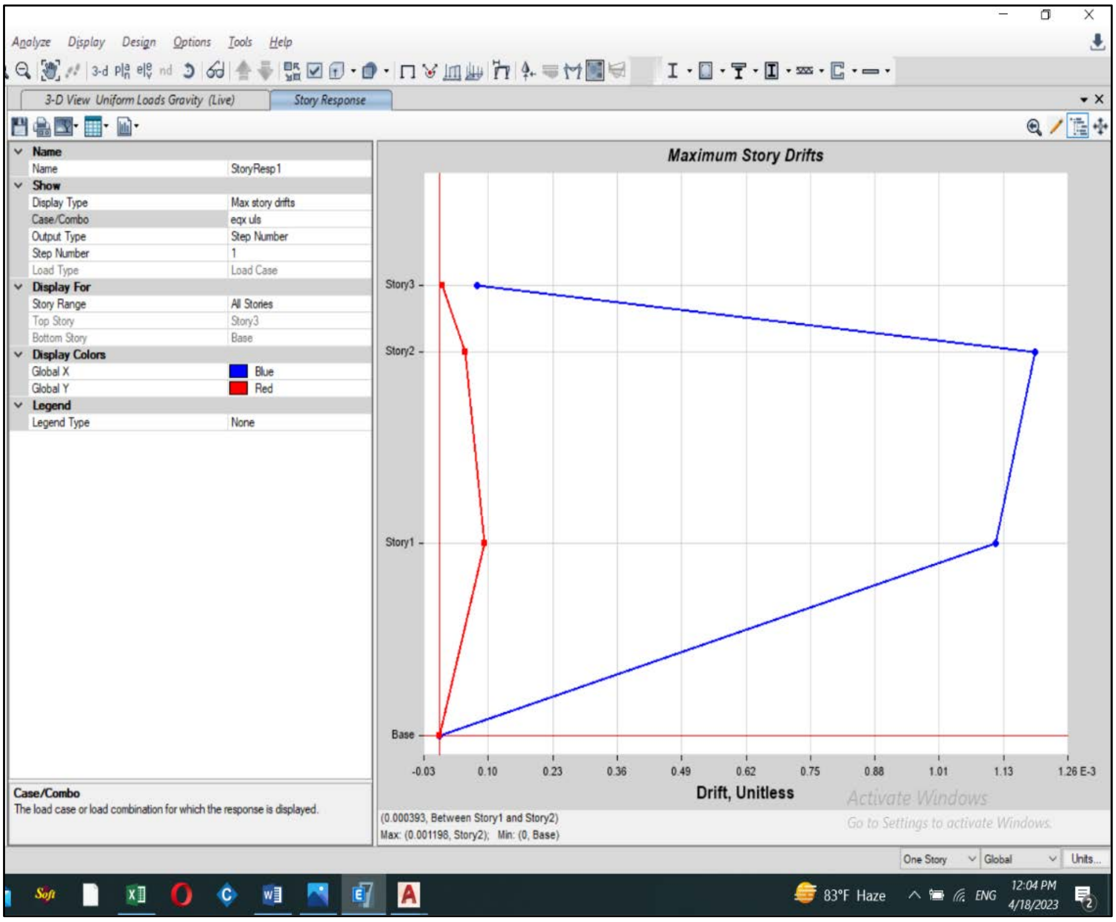


Figure 4-1:Storey Displacement due to EQx

Table 4-3: Storey Drift due to EQy

Story	Elevation	Location	X-Dir	Y-Dir
	m			
Story2	6	Top	0.000283	0.004264
Story1	3	Top	0.000315	0.002413
Base	0	Top	0	0

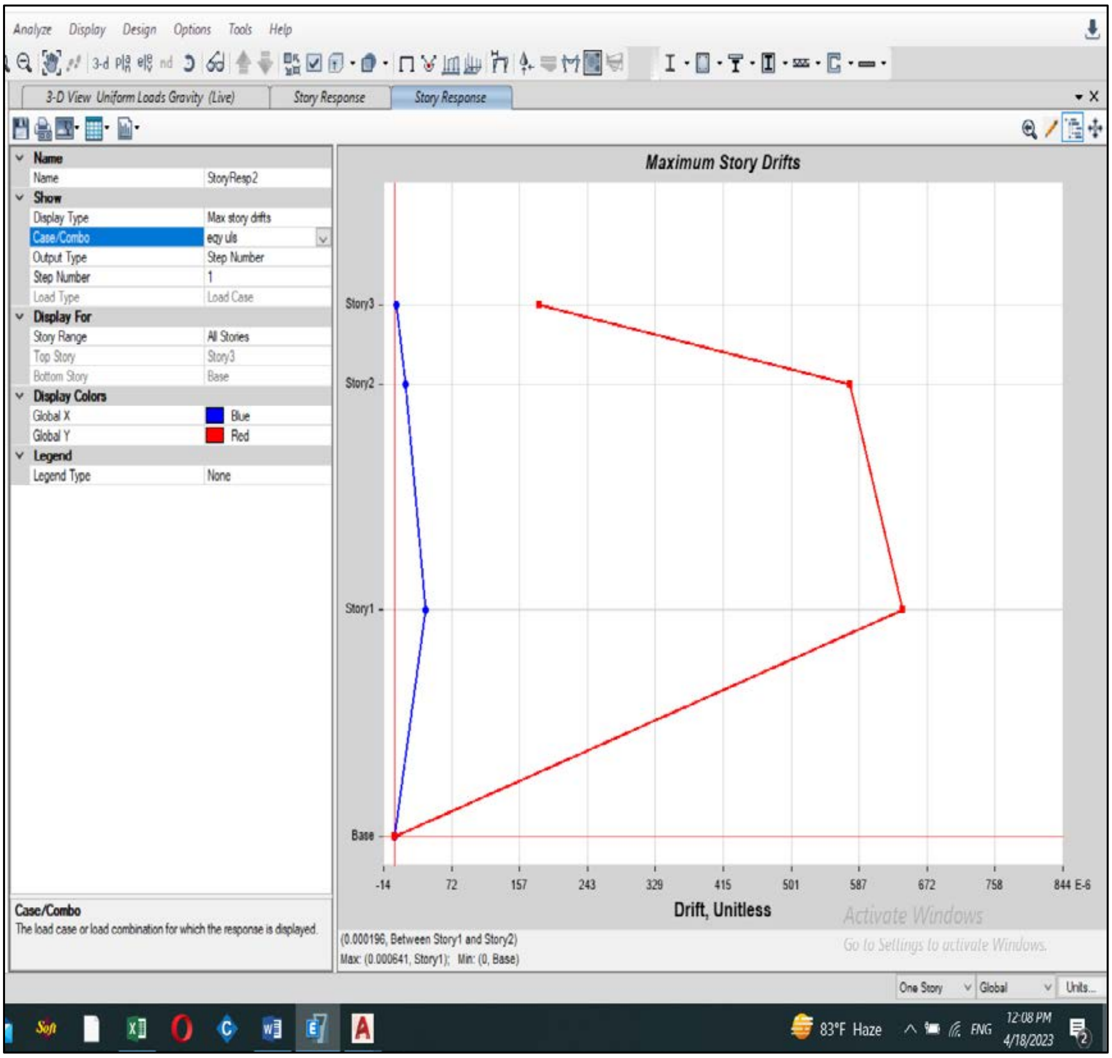


Figure 4-2: Storey Displacement due to EQy

4.3. Force Diagram

The sample output of forces obtained from ETABS analysis for envelope have presented below as a sample only. The output forces are axial force, Shear force and Moments

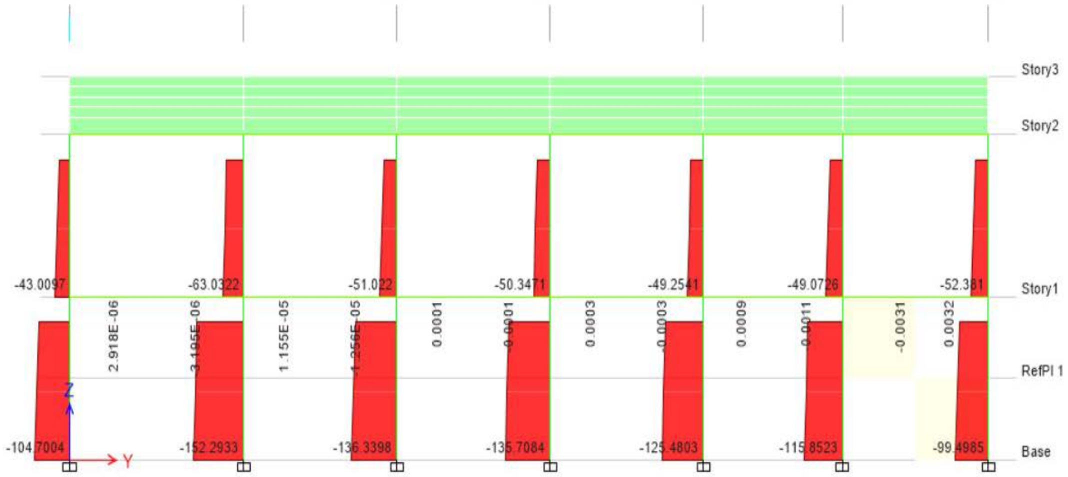


Figure 4-3: Axial Force Diagram

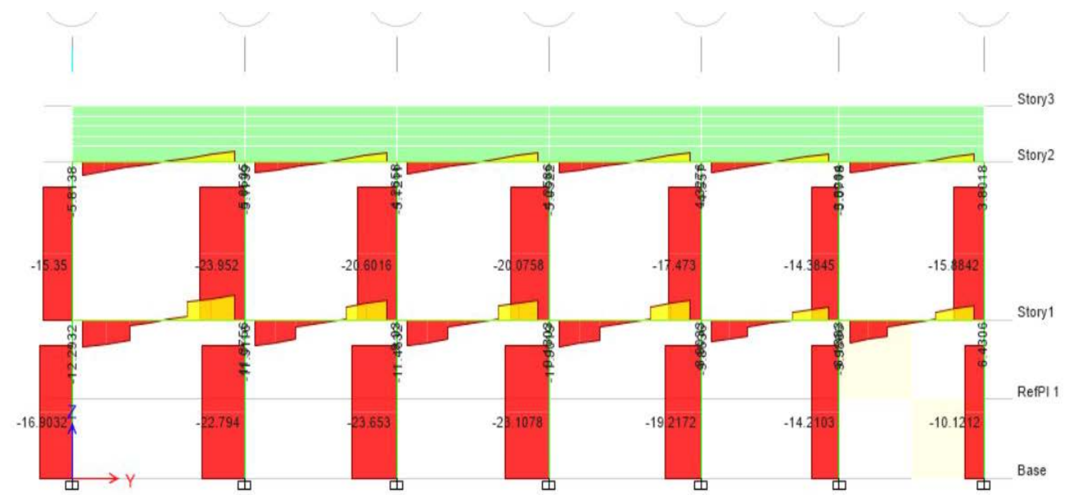


Figure 4-4: Shear Force Diagram

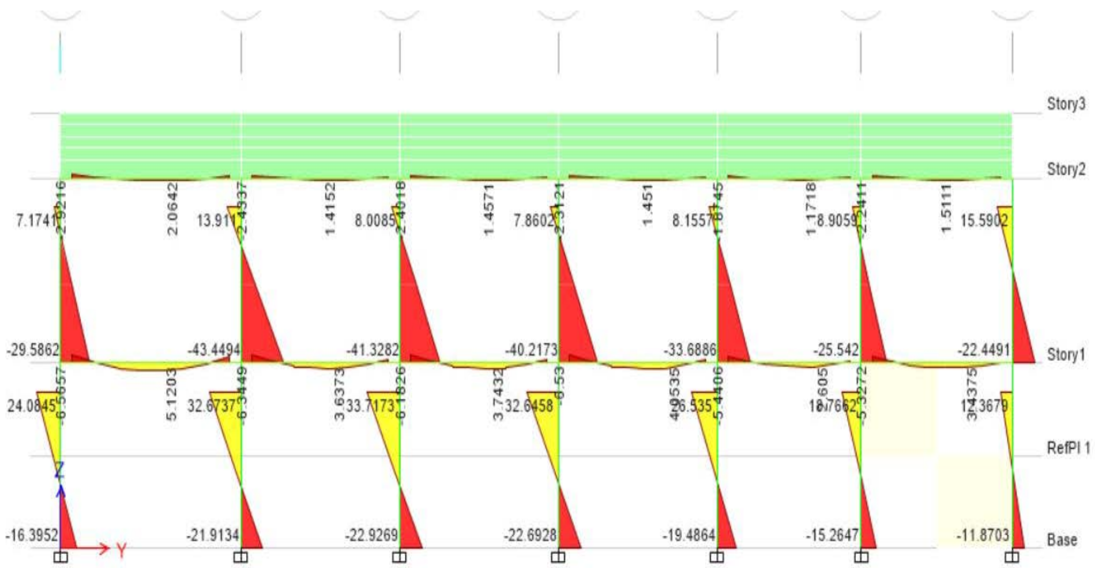


Figure 4-5: Bending Moment Diagram

4.4. Base Reaction

The reaction at the support of the column for the load combination of 1.2DL+1.5LL is picturized below as given by the software:

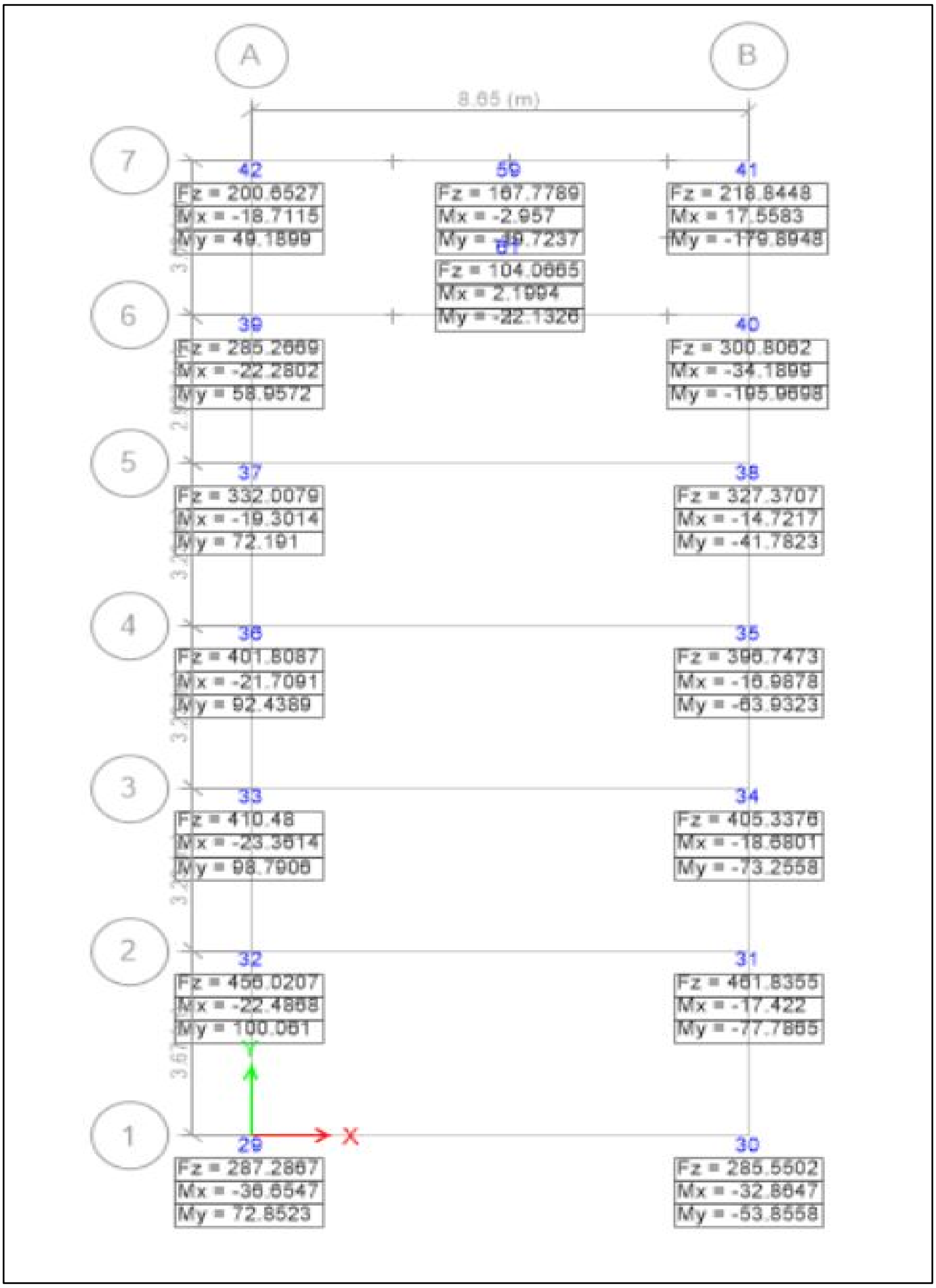


Figure 4-6: Base Reaction Force

[CHAPTER 5] DESIGN OF STRUCTURAL MEMBER (SAMPLE DESIGN)

5.1. Slab Design:

DESIGN OF SLAB

Input parameters

Span:	4.191*3.048		
Edge Condition:	One Short Edge Continuous		
Length of Shorter Span	Ly	3080	mm
Length of Longer Span	Lx	4263	mm
Take,			
Diameter of bar (Φ):		8	mm
Clear Cover (cc):		20	mm
Material (fy)			
Fe		500	Grade Steel
Concrete Grade (fck)			
M		20	
Depth of Slab (D):		150	mm
		0.15	m

S. N.	Reference	Description and Calculation	Remarks
1	IS 456:2000; cl.22.2	Effective Length Calculation and Determination of Type of Slab Effective Depth = 126 mm Effective Length (Ly) = clear span + effective depth = 2976 Similarly, Effective Length (Lx) = 4159 Again, Center to Center Distance Between the Support Along X-direction= 4263 Along Y-direction= 3080 Taking Shorter of two, Lx= 4159 Ly= 2976 Then, Long Span to Short Span Ratio, Ly/Lx = 1.39	<2

Hence, it is
TWO WAY SLAB

2 Load Calculation

Assume width = 1m = 1000mm

Self weight of slab =	3.75	KN/m per unit width
Light Parttion Wall load =	1	KN/m per unit width
Floor Finish Load =	1.15	KN/m per unit width
Live Load =	4	KN/m per unit width
Total load =	9.9	KN/m per unit width
Factored Load (Wu) = 1.5(DL+LL)	14.85	KN/m per unit width

3 IS 456:2000 Table 26

Design Moment Calculation

Moment Coefficients

For Negative Moment:

αy = 0.037

αx = 0.043

For Positive Moment

αy = 0.028

αx = 0.032

We have,
Moment

$Mx = \alpha x * Wu * lx^2$

$My = \alpha y * Wu * lx^2$

For Ast,
Mu = 0.87*fy*Ast*d*(1-(Ast*fy/(b*d*fck)))

For Spacing,

Spacing = $(1000/Ast)*(\pi\Phi^{2/4})$

Maximum Spacing =3d or 300 mm whichever is greater

Minimum reinforcement (Ast)=0.12% of bD

Now, The Calculation are shown in the tabular form

Short Direction (Y-direction)

αy	My (KNm)	Ast Calculated (mm^2)	Spacing Required (mm)	Spacing Provided (mm)	Ast provided (mm^2)

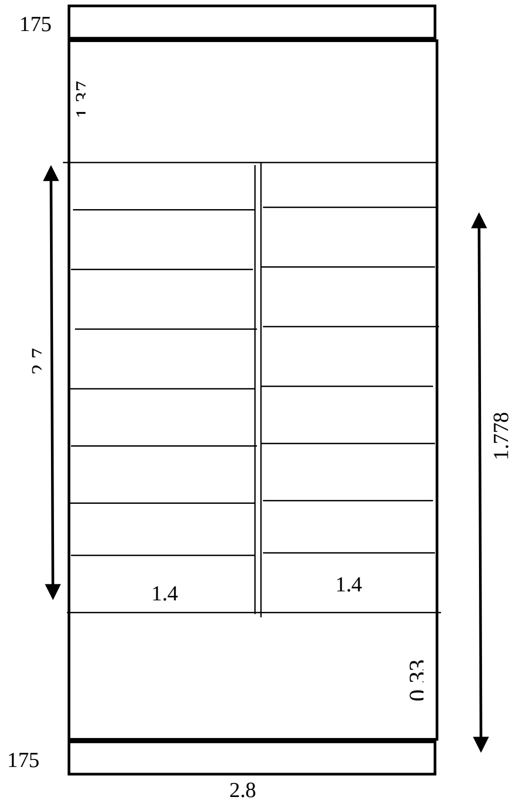
		Moment at Continuous Edge (-ve)	0.043	11.05	210.29	239.03	150.00	335.10	
		Moment At Mid Span (+ve)	0.032	8.22	154.72	324.89	150.00	335.10	
		Long Direction (X-direction)							
			αx	Mx (KNm)	Ast Calculated (mm^{2})	Spacing Required (mm)	Spacing Provided (mm)	Ast provided (mm^2)	
		Moment at Continuous Edge (-ve)	0.037	9.50	179.81	279.54	150.00	335.10	
		Moment At Mid Span (+ve)	0.028	7.19	134.83	372.81	150.00	335.10	
4		Check the Depth in Bending We have, Mu = 0.36*fck*b*xu,l*(d-0.416*xu,l) where, xu,l = 0.46*d Solving, d= 64.21 which is less than d provided							OK
5		Check the slab in Shear Along the Short span Shear Force= Vy= Wu*Ly/3 14.73 KN Along the Long Span Shear Force= Vy= ((Wu*Ly)/4)*(2-(Lx/Ly)) 6.657 KN							

		Maximum Shear Stress in Slab is Given by:	
		τuv=Vu/(b*d) = 0.116	
		We Know that,	
	IS 456:2000, table 20	Maximum Allowable shear stress	
		τuc,max= 2.8 N/mm2 For M 20	
		We have	
		Percentage of Tension Steel(%Ast)= 0.265	
		and	
	IS 456:2000,cl 40.2.1.1	K= 1.3 For D= 150mm	
	IS 456:2000, table 19	τc= 0.48 N/mm2	
		Therefore,	
		τuc= k*τc = 0.624 N/mm2	OK
		Since τuv<τuc<τuc max	
		Hence Safe in Shear	
6		<u>Check for Deflection Control</u>	
		(Leff/deff)actual< basic value*k1	
	IS 456:2000, cl 23.2.1	k1=modification factor for tension reinforcement	
		Ly/d= 23.62	
		we have,	
		α = 26	
		β = 1	
		γ = 1.8	
		δ = 1	
		λ = 1	
		So,	
		α*β*γ*δ*λ = 46.8	OK
		Hence, Safe in deflection	
7		<u>Development Length</u>	
		Ld=0.87fy*Φ/(4*τbd)	
		= 580 mm	

5.2. Staircase Design

Given,

Total Width of Staircase (W)	=	2.8	m
Width of each flight (Wf)	=	1.4	m
Tread (T)	=	300	mm
	=	0.3	m
Rise (R)	=	150	mm
	=	0.15	m
Floor to Floor Height (h)	=	3	m
no of Riser in First Flight (Nr1)	=	10	
no of Riser in Second Flight (Nr2)	=	10	
Total Going in First Flight (G1)	=	2.7	m
Total Going in Second Flight (G2)	=	2.7	
Length of First Landing	=	1.37	m
Length of Second Landing	=	0.33	m
Width of Support at first edge	=	175	mm
Width of Support at second edge	=	175	mm
Size of Main Reinforcement (dr)	=	16	mm
Size of Distribution Reinforcement	=	10	mm
Clear Cover (cc)	=	20	mm
Grade of Steel (fy)	=	500	
Grade fo Concrete (fck)	=	20	



<u>Design of Staircase</u>

Design of the staircase is based on the design of the longest flight

Effective Span of Flight = Center to Center Distance Between the Supports
= 4.575 m

Let us Take,

Thickness of Waist Slab (D) = 150 mm *(Approx. 1/20 of span)*

Then, Effective Depth (d) = 122 mm

<u>Loads Per Unit Width</u>

<u>Loads on each flight</u>

Weight of Waist Slab per m length in

plan

Wwaist = 4.2 KN/m

Weight of Steps per m length in plan

Wstep = 1.88 KN/m

Floor Finish Load = 1.58 KN/m2

Total Dead Load per m length in plan

(DL) = 7.66 KN/m

Live Load = 4 KN/m2

Total Live Load per m length in plan

(LL) = 4 KN/m

Total DL+ LL = 11.66 KN/m

Factored Load, Wu = 18 KN/m

Loads on Landing

Loads On Each Landing

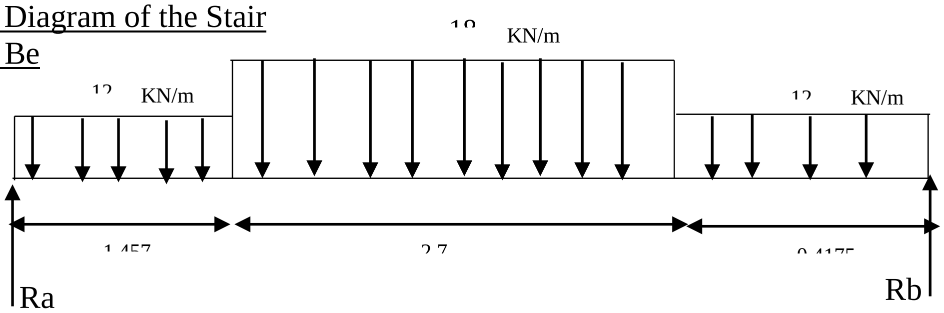
DL = 3.75 KN/m

LL = 4 KN/m

Total DL+LL = 7.75 KN/m

Factored Load = 12 KN/m

Load Diagram of the Stair Shall Be



Design Moment

Reaction At Support A,

33.708
Ra = 7 KN

Reaction At Support B,

37.391
Rb = 3 KN

Bending Moment is maximum where shear force is equal to zero

Let x be the distance from the start of going where shear force is equal to zero

then,

x = 0.90104 m

Hence, Maximum Bending Moment occurs at 2.359 m from support A

Maximum Bending Moment,

Mu = 43.7 KNm

Maximum Allowed Bending Moment for Singly reinforced section of M20 concrete with Fe500 bars

Mulim = $Rubd^2$

= $2.66bd^2$

39.5914 <43.7

Hence,Section can be designed asDoubly reinforced Section

Area of Reinforcement

	Ast Required	Spacing Required	Spacing Provided	Ast Provided
Main Bar	1049	191.67	125	1608.5
Distribution Bar	180	436.332	150	523.599

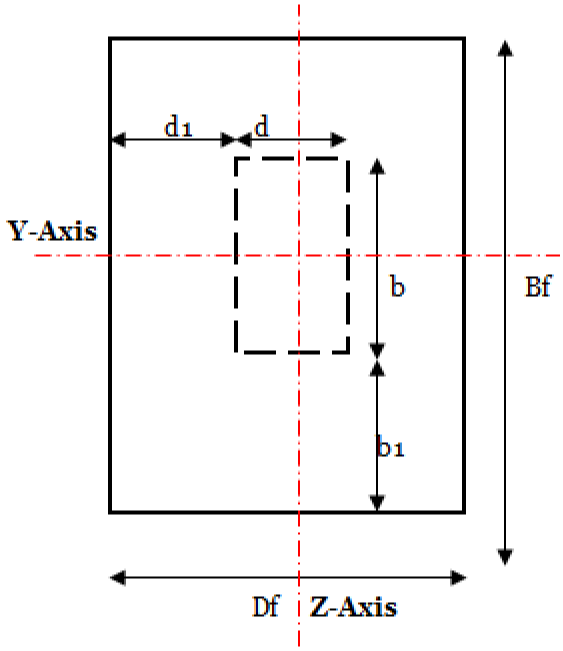
Development Length

Ld = 906.25 mm

5.3. Footing Design

DESIGN OF ISOLATED FOOTING - SPREADSHEET

AS PER IS 456: 2000



Data:

Column no.		
load case	2	
Concrete grade, M	20	
Steel grade, Fe	500	
Axial load, kN	136	kN
My, kNm	0	kNm
Mz, kNm	0	kNm
Column size, b	450	mm
Column size, d	450	mm
SBC of soil, kN/m2	130	kN/m²
Design factor	1.5	

Pressure:

Axial load	136	kN
App. Self weight	13.6	kN
Total weight	149.6	kN
Area of footing	1.15	m2
size of footing, Bf	2.5	mt
size of footing, Df	2.5	mt
Projection, b1	1.025	mt
Projection, d1	1.025	mt

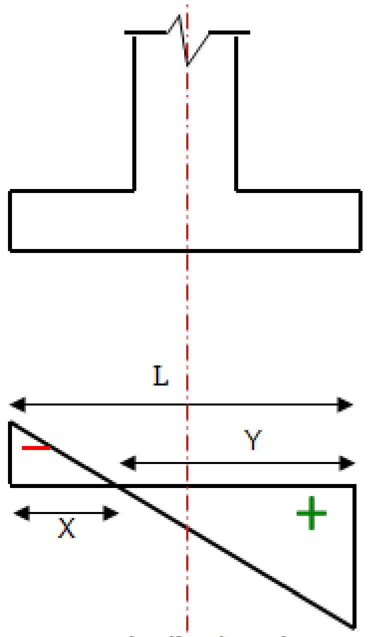
Footing Pressure,

$P_{max} = P/A + M_y/Z_y + M_z/Z_z$

Pmax	21.76	kN/m²

$P_{min} = P/A - M_y/Z_y - M_z/Z_z$

Pmin	21.76	kN/m²



Pressure Distribution Diagram

Eccentricity:

Y	1.25	mt
X	1.25	mt
L	2.5	mt
2/3 L	1.67	mt
b	2.5	mt
qu	32.64	kN/m²

Eff. qu	32.64	kN/m²

Shear Chk.

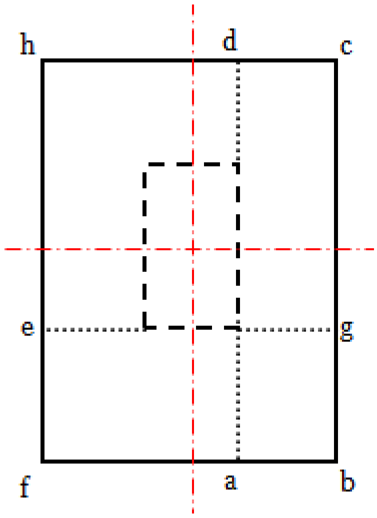
One way Shear: At distance d from face of column.

pt assumed	0.25	%
Designed shear stress	0.36	N/mm²
vu	59.16	
d=	85.21	mm
d provided	300.00	mm

Two way Shear : At distance d/2 from face of column.

Perimeter	3000	mm	
S.F. at this section	185.64	kN	
Ks	1.00		
tc	1.12	N/mm²	
tv	0.21	N/mm²	
Resistance	1,006.23	N/mm²	Safe

Flexure design:

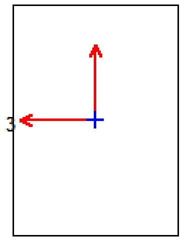


For section efbg		
pressure@f	21.76	kN/m²
pressure@b	21.76	kN/m²
Moment@eg. Meg	17.15	kNm
Mu	25.72	kNm
d provided	300.00	mm
Mu/bd2	0.29	N/mm²
pt	0.120	%
pt provided	0.250	
Ast	750.0	mm²/m width
provide	16#	@150c/c
Ast Provided	**1206**	**mm²/m width**

Check in other direction:

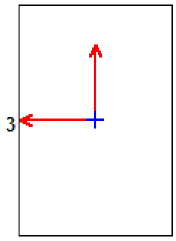
For section abcd		
pressure@b	21.76	kN/m²
pressure@c	21.76	kN/m²
Moment@ad, Mad	17.15	kNm
Mu	25.72	kNm
d req	98.32	mm
M/bd2	0.29	
pt	0.205	%
Ast	615	mm²/m width
provide	16#	@150c/c
Ast provided	**1206**	**mm²**

5.4. Beam Design



ETABS Concrete Frame Design

IS 456:2000 + IS 13920:2016 Beam Section Design (Summary)



Beam Element Details

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF	Type
Story1	B12	40	Beam 300*450	1.2DL+1.5LL	225	3670	1	Ductile Frame

Section Properties

b (mm)	h (mm)	b_f (mm)	d_s (mm)	d_{ct} (mm)	d_{cb} (mm)
300	450	300	0	25	25

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
22360.68	20	1	500	500

Design Code Parameters

γ_c	γ_s
1.5	1.15

Factored Forces and Moments

Factored M_{u3} kN-m	Factored T_u kN-m	Factored V_{u2} kN	Factored P_u kN
-18.5536	46.4617	50.3239	0

Design Moments, M_{u3} & M_t

Factored Moment kN-m	Factored M_t kN-m	Positive Moment kN-m	Negative Moment kN-m
-18.5536	68.326	49.7724	-94.2498

Design Moment and Flexural Reinforcement for Moment, M_{u3} & T_u

	Design -Moment kN-m	Design +Moment kN-m	-Moment Rebar mm²	+Moment Rebar mm²	Minimum Rebar mm²	Required Rebar mm²
Top (+2 Axis)	-94.2498		576	0	576	274
Bottom (-2 Axis)		49.7724	288	286	0	288

Shear Force and Reinforcement for Shear, V_{u2} & T_u

Shear V_e kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm²/m
50.3239	58.2514	239.8682	63.9366	1563.99

Torsion Force and Torsion Reinforcement for Torsion, T_u & V_{U2}

T_u kN-m	V_u kN	Core b_1 mm	Core d_1 mm	Rebar A_{svt} /s mm²/m
46.4617	50.3239	270	420	1563.99

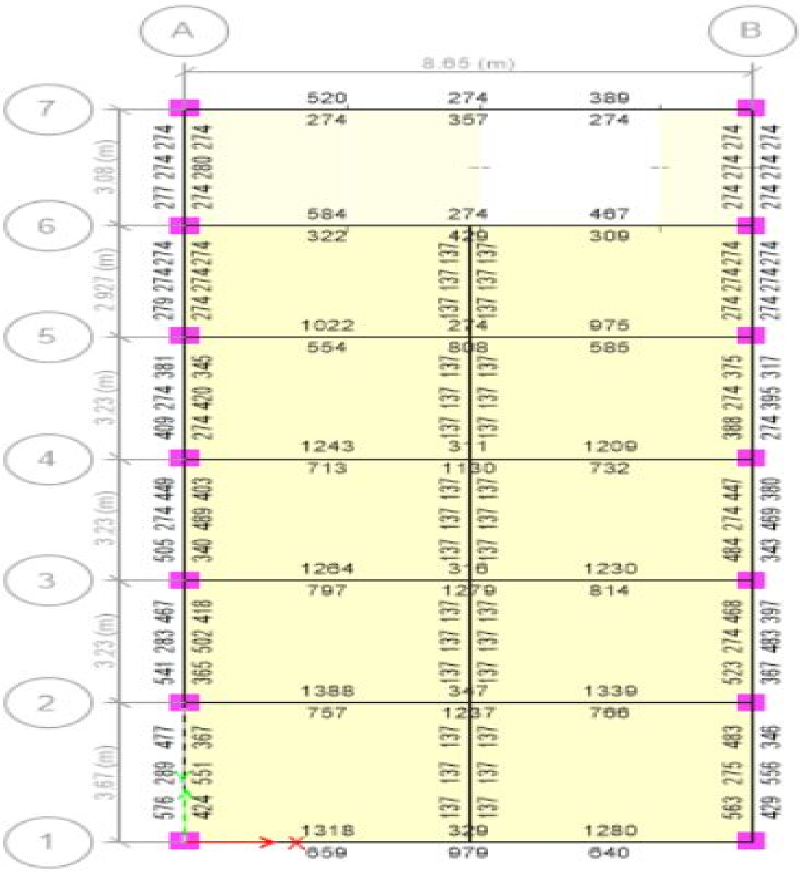


Figure 5-1: Beam Design Output in First Floor

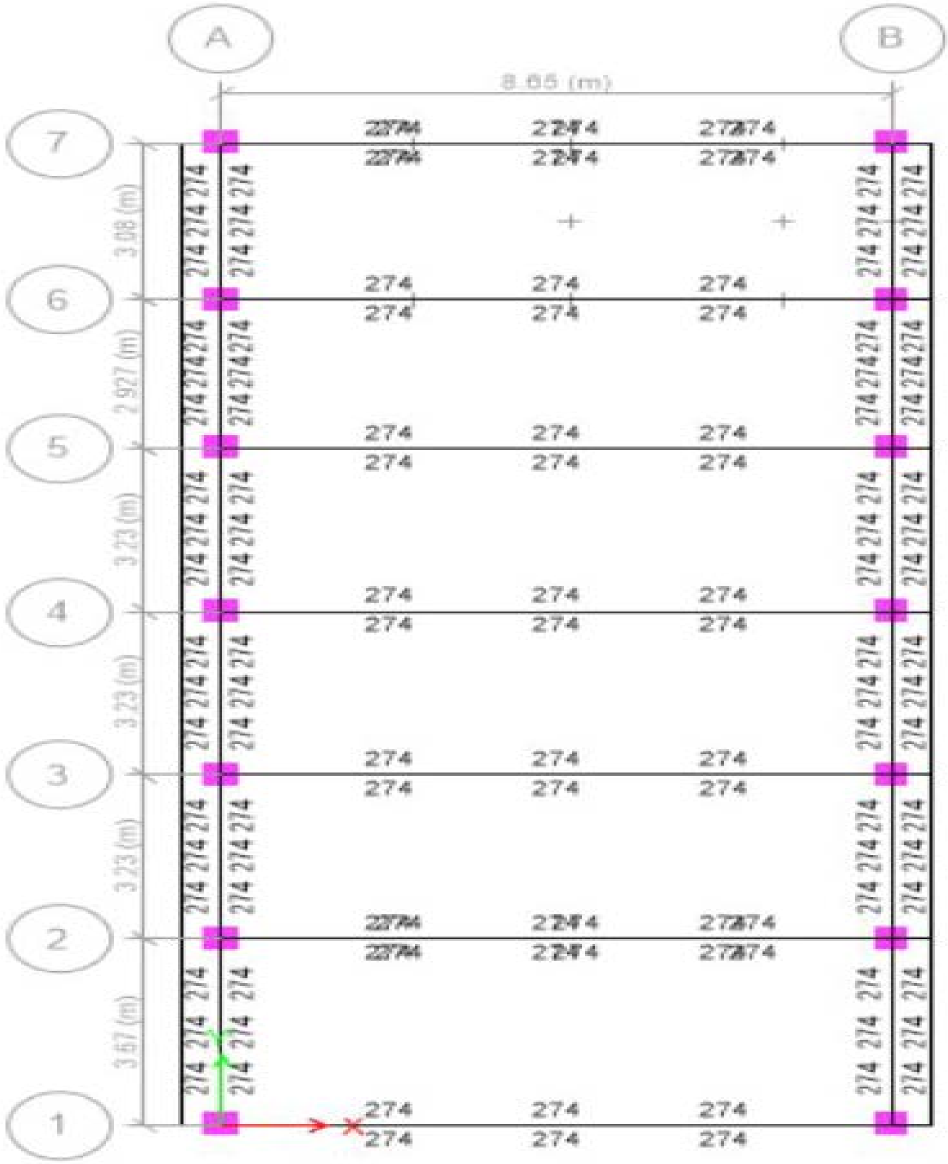
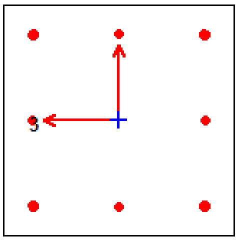


Figure 5-2: Beam Design Output in Second Floor

5.5. Column Design

ETABS Concrete Frame Design

IS 456:2000 + IS 13920:2016 Column Section Design (Summary)



Column Element Details

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF	Type
Story1	C8	22	column 450*450	DL+XLL-EQY	2394.8	2844.8	1	Ductile Frame

Section Properties

b (mm)	h (mm)	dc (mm)	Cover (Torsion) (mm)
450	450	58	30

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
22360.68	20	1	500	500

Design Code Parameters

γ_C	γ_S
1.5	1.15

Axial Force and Biaxial Moment Design For P_u , M_{u2} , M_{u3}

Design P_u kN	Design M_{u2} kN-m	Design M_{u3} kN-m	Minimum M_2 kN-m	Minimum M_3 kN-m	Rebar Area mm²	Rebar % %
230.9912	24.4859	134.2719	4.6198	4.6198	1691	0.84

Axial Force and Biaxial Moment Factors

	K Factor Unitless	Length mm	Initial Moment kN-m	Additional Moment kN-m	Minimum Moment kN-m
Major Bend(M3)	0.682401	2394.8	27.9011	0	4.6198
Minor Bend(M2)	0.64132	2394.8	-29.8126	0	4.6198

Shear Design for V_{u2} , V_{u3}

	Shear V_u kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm²/m
Major, V_{u2}	94.3981	97.1208	70.5594	94.3981	498.8
Minor, V_{u3}	62.3888	97.1208	70.5594	62.3888	498.8

Joint Shear Check/Design

	Joint Shear Force kN	Shear V_{Top} kN	Shear $V_{u,Tot}$ kN	Shear V_c kN	Joint Area cm²	Shear Ratio Unitless
Major Shear, V_{u2}	0	67.4272	472.9832	905.6075	2025	0.522
Minor Shear, V_{u3}	0	44.5635	269.6743	905.6075	2025	0.298

(1.4) Beam/Column Capacity Ratio

Major Ratio	Minor Ratio
0.814	0.538

Additional Moment Reduction Factor k (IS 39.7.1.1)

A_g cm²	A_{sc} cm²	P_{uz} kN	P_b kN	P_u kN	k Unitless
2025	16.9	2456.7437	792.0274	230.9912	1

Additional Moment (IS 39.7.1)

	Consider M_a	Length Factor	Section Depth (mm)	KL/Depth Ratio	KL/Depth Limit	KL/Depth Exceeded	M_a Moment (kN-m)
Major Bending (M_3)	Yes	0.842	450	3.632	12	No	0
Minor Bending (M_2)	Yes	0.842	450	3.413	12	No	0

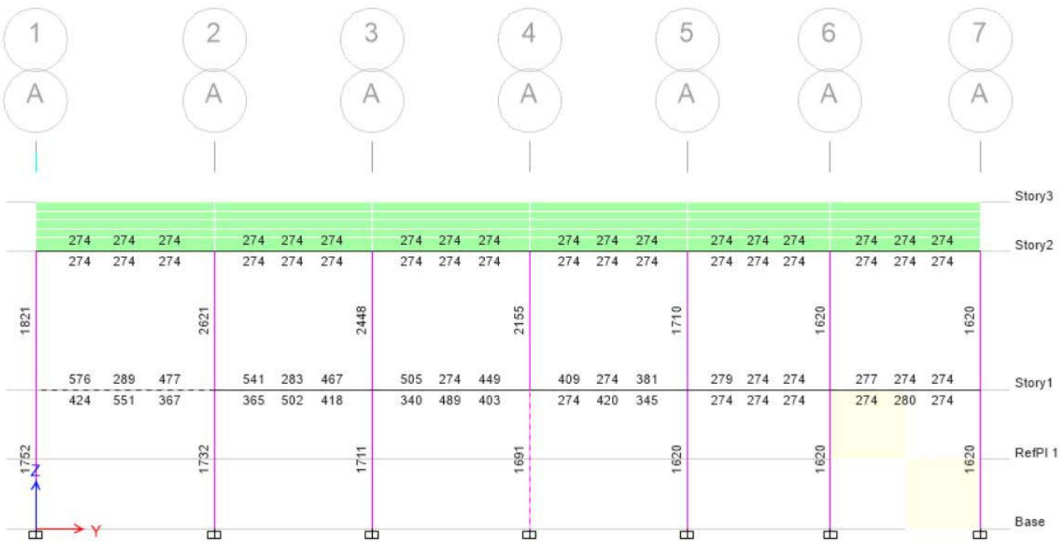


Figure 5-3: Column Deisgn Output Along Grid A-A

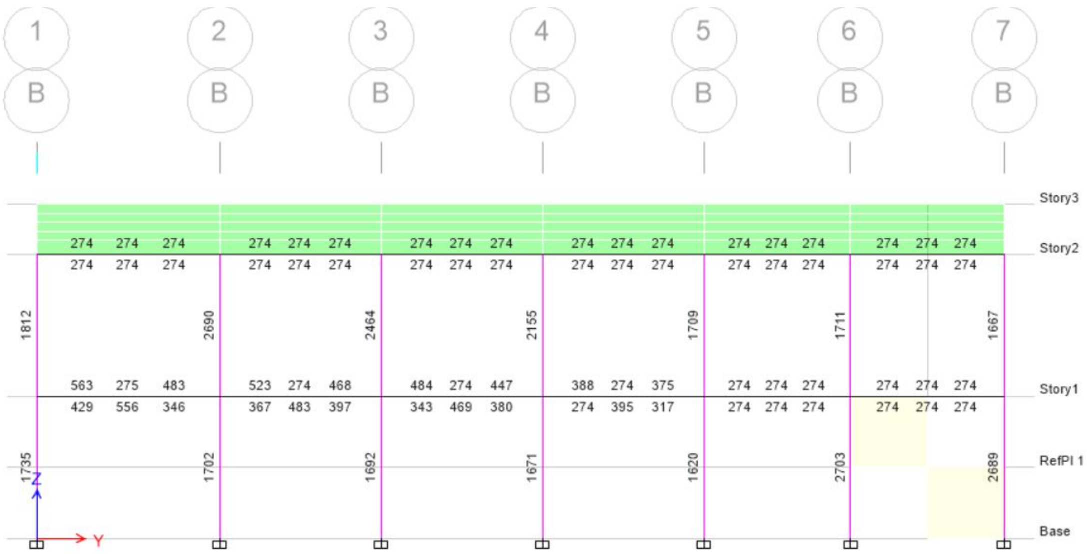


Figure 5-4: Column Design Output Along Grid B-B

References

- IS 456- 2000 Code of practice for plain and reinforced concrete
- IS 875-1987 Code of practice for design loads (other than earthquake) for buildings and structures
- IS 1893-2002 Criteria for Earthquake Resistant Design of Structures,
- IS 13920-1993 Code of practice for ductile detailing of reinforced concrete structures subjected to seismic forces
- NBC Nepal Building Code
- Design of Reinforced Concrete Structure – A.K. Jain
- Limit State Design of Substructure- Swamisharan
- ETABS manual V 20

Electrical & Allied Technical Specification

TABLE OF CONTENTS

1 INTRODUCTION

The terms and conditions mentioned in this section are in addition to what are stated in Bill of Quantity (BOQ) and the tender document. In case of any technical contradiction between the terms and conditions given as per laws and Regulation shall prevail.

2 SITE LOCATION

The tenderer shall visit the site, ascertain the local conditions, entry, traffic restriction, and obstructions if any and also site conditions. Whether the tenderer visits the site or not, he is deemed to have visited the site and ascertained all the site conditions. The tenderer shall allow in his tender for an extra likely to be incurred due to site conditions. No claim will be allowed on this account under any circumstances.

3 SCOPE OF WORK

Work under this section shall include the supply, installation, testing and delivery in perfect running conditions of the electrical installations for subject project.

These installations comprise, but are not limited to, the following chapters:

i. Telephone system
ii. Data System
iii. Public Address System
iv. Fire Alarm System
v. Closed Circuit Television System (CCTV) Videophone System
vi. Uninterruptable Power Supply (UPS)

The supply shall include all the equipment, accessories and other materials not enumerated in these specifications but found necessary for the completion and perfect functioning of the installations.

Work shall be executed in a first-class work-manlike manner in accordance with these specifications, the drawings and notes indicated therein, the instructions of the Engineer, the provisions of the Bill of Quantities delivered in place and tested to the full satisfaction of the Engineer.

Client will only show the location where all works required for NEA connection or other will be Contractor's responsibility. However, all items required for the safe and efficient operation/execution of the MEP (Mechanical, Electrical & Plumbing) work, whether explicitly stated in the following pages or not, shall be included by the Contractor.

The works covered shall include supply of all materials, labour, equipment and services in connection with the work complete as indicated. The contractor shall consult drawings, bill of quantities and specifications all together, which gives the total scope of the works.

The contractor shall include for the supply of the whole or the new materials in accordance with this specification and the whole of the work of fixing, installation, testing and commissioning necessary for the complete installation as set down in this specification and with the accompanying schedules and drawings, commencing from the supply authority's terminals. This also includes any materials, appliances, equipment not specifically mentioned herein or noted on the drawings as being furnished or installed but which are necessary and customary to make the installation complete in all respects. In general, the work to be performed under tills contract shall comprise supply and installation, testing & commissioning of the followings as per schedule of quantities.

4 APPLICABLE CODES AND STANDARDS

All the equipment and systems shall conform to the latest applicable National and International standards; and latest Rules and Regulation of the Local Authorities. However, materials and equipment shall be in accordance with the latest standard established by IS and NS.

The design, manufacture, installation, testing, commissioning and performance of all the equipment and system shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed. Nothing in this specification shall be construed to relieve the CONTRACTOR of his responsibility.

5 CATEGORIZATION OF COMPONENTS

Makes of certain items of materials are categorized by the Consultant and included in Schedule of rates; only those makes of items under the category indicated in tender documents shall be used in the work. For items of materials for which makes are approved by the Electrical Technical Expert, only such approved makes shall be permitted in the work.

All materials and Equipment shall be new and shall be in accordance with the standard established by IS and NS. Where materials of Equipment are specified or shown on the drawings by name of manufacturers, name plates, instruction plates, warning signs and any other marking whatsoever on the Equipment and accessories there of shall be in English/Nepali language. Equipment or materials of other manufacturers may be considered for use if of equal quality, appearance, electrical and mechanical characteristics and approved by the Electrical Technical Expert.

6 INSPECTION AND TESTING

6.1.1 The Purchaser or its Representative shall have the right to inspect and/or test the goods to confirm their conformity to the Technical Specification and the quality of performance after the supply and delivery of good to the Purchaser's premises.

6.1.2 The Purchaser may reject any Goods or any part thereof that fail to pass any test and/or inspection or do not conform to the specifications. The Supplier shall either rectify or replace such rejected Goods or parts thereof or make alterations necessary to meet the specifications at no cost to the Purchaser.

6.1.3 Whenever the Supplier is ready to carry out any such test and inspection, it shall give a reasonable advance notice, including the place and time, to the Purchaser. The Supplier shall obtain from any relevant third party or manufacturer any necessary permission or consent to enable the Purchaser or its designated representative to attend the test and/or inspection in expenses of supplier.

6.1.4 The supplier must compile all the above requirements.

7 ELECTRICL SUPPLY SYSTEM

Electrical power within the premises will be available at 400/230V AC, three phase, four wire, 50 Hz directly from the power utility. Hence, all systems within the premises, except where specifically specified as High Tension (HT) works, shall be rated for this degree of incoming supply.

All erection set-up, tools, appliances and safety precautions to be used by the Contractor for electrical services within the building shall also be suitable for work under this Low Tension (LT) class of electrical work.

8 COLOUR CODING

All outgoing and incoming power cables including point-wiring cables will follow the following colour coding phase indicating lamps wherever recommended.

Phase - 1 - Red (R); Phase - 2 - Yellow (Y); Phase - 3 - Blue (B); Neutral - Black (B); Earthing-Green (G).

9 ABBREVIATIONS

The following abbreviations have been used in the accompanying specifications, drawings and Schedule of Quantities.

GI	stands for Galvanized Iron.
MS	stands for Mild Steel.
HT	stands for High Tension.
HV	stands for High Voltage.
LV	stands for Low Voltage.
LT	stands for Low Tension.
PVC	stands for Polyvinyl Chloride.
PVCE	stands for High Density Polythene
A	stands for Amperes.
V	stands for Volts.
kV	stands for Kilo Volts.
kVA	stands for Kilovolt Ampere
ISS	stands for Indian Standard Specifications.
IS	stands for Indian Standard.
NEC	stands for National Electrical Code.
NEA	stands for Nepal Electricity Authority
DG	stands for Diesel Generator.
RYB	stands for Red, Yellow, Blue.
MCB	stands for Miniature Circuit Breaker.
ACB	stands for Air Circuit Breaker.
VCB	stands for Vacuum Circuit Breaker.
MCCB	stands for Moulded Case Circuit Breaker.
ELCB	stands for Earth Leakage Circuit Breaker.

RCCB	stands for Residual Current Circuit Breaker.
CT	stands for Current Transformer.
PT	stands for Potential Transformer.
DO	stands for Drop out Fuse.
SP	stands for Single Pole.
DP	stands for Double Pole.
TPN	stands for Triple Pole and Neutral.
MDB	stands for Main Distribution Panel.
SMDB	stands for Sub-Main Distribution Board (Panel).
FDB	stands for Final Distribution Board (Panel).
DB	stands for Distribution Board.
PVC	stands for Polyvinyl Chloride.
C/O	stands for Change-over Switch.
AC	stands for Alternating Current.
DC	stands for Direct Current.
SS	stands for Switched Socket/Selector Switch.
LED	stands for Light Emitting Diode

10 WORKMANSHIP

Workmanship and good appearance of the installation shall be of equal importance with its electrical and mechanical efficiency, and all portions of the work shall be so laid out and installed that the work as a whole is of uniform quality and shall present a neat appearance in a manner meeting the approval of Technical Expert. The Contractor shall verify in the field all measurements necessary of the electrical work and shall assume responsibility for their accuracy.

Materials which are defective or damaged during the progress of work shall be replaced or repaired in approved manner at the expenses of Contractor. The installation shall comply with all applicable laws and ordinances and with the requirements of Indian codes, Nepal Standard and as specified herein or shown on the drawings. The progress of the electrical work shall be carried out so as to conform to the entire installation shall be completed as soon as the condition of site and working places will permit. The work progress report shall be submitted at the end of every month to the Technical Expert.

All cutting, drilling, channelling, patching etc., required for installation of electrical work shall be carried out in a manner approved by the Technical Expert. Any defects in finishes, plasters, wood work, metal work, masonry, concrete, or other materials resulting from the performance of the work shall be replaced or repaired at no expense to the owner and to be satisfaction of the Technical Expert.

Upon completion of the electrical work the Contractor shall submit to the Technical Expert, reproducible drawings showing the layout, and connection of electrical system as constructed and denoting all information pertinent to the proper maintenance of the system.

If any alteration is found necessary, the Contractor will have to do the same on mutually agreed rates.

The work shall be carried out in the best workman like manner and any defect or minor changes in the design/ connection if pointed out shall be carried out by the Contractor without any extra charges.

11 QUANTITIES

All quantities mentioned in the bill of quantities may vary and the contractor will get payment according to measurement of actual work. The schedule of quantities is liable to alteration by deletion or addition as required.

12 CONCEPT OF DESIGN

12.1 LOW VOLTAGE

The characteristics of the electric supply shall be as follows:

Low voltage network: 3 phase, 4 wire - 50Hz

400V between phases.

230V between phases and neutral with a solidly earthed neutral.

All embedded conduits in concrete or in floor paving screed shall be PVC conduits and all surface-mounted conduits shall be heavy duty rigid PVC conduit unless otherwise mentioned.

All junction, derivation and outlet boxes shall be bakelite type or rigid PVC material. All outlet boxes for switches and sockets shall be bakelite type or rigid PVC material. All feeders shall be on cable trays in the false ceiling or in the shaft.

All feeder and derivation light points shall also run in floor screed or above false ceiling or in ceiling skirting.

The loading of circuits shall be as shown on drawings with no contradiction to the local practice in Nepal and in full compliance to the NBC 207 Codes or IS & requirements.

Separate circuits shall be provided for : a) Lighting and socket outlets. b) Air conditioning unit or exhaust fan.

The lighting design shall have a cross-section of 2,5 mm^2 and a circuit breaker of (1 x 10 A (or 6A)+ N), Minimum wire size shall be 2.5 mm^2.

The convenience socket outlet and exhaust fan shall have a cross section of 4mm^2 and a circuit breaker (1 x 16 A + N) unless otherwise mentioned on drawings.

All work pertaining to the telephone system shall be in accordance with these specifications and shall meet all applicable rules and regulations of the local authorities.

The fire alarm system shall be as approved by local civil defence & NBC: 207 (or IS) regulations as laid out for connection with break glasses, optical smoke and heat detectors, manual stations, indoor and outdoor alarm bells and automatically operated fire alarm panel with repeater panel. Furthermore, the connection with the firefighting system shall be provided.

In case of an alarm, the alarm bells or horns of this building shall sound. At the same time, the alarm shall be indicated optically and acoustically on the operator's panel. After the cause of alarm has been checked, a push button shall be operated for general alarm. The call to the fire brigade must be made by automatic phone dialer.

Earthing systems shall be TNS and in accordance with the requirements of the standards and codes mentioned in these specifications. The resistance of every earthing system shall be inferior to five (5) ohms after 15 days of installation.

Lightning protection system to be in according to the drawings, requirements of the standards and codes mentioned in these specifications. The system shall include Two Early Streamer Emission air terminals, 2 flat down conductors, 4 earth pits, all in full compliance with NFC-17-102.

Surge arresters to be in according to the drawings and in full compliance with the relevant IEC codes. The system shall include a type 1&2 surge arresters at both sides of Mains and generator, and one type 2 surge arrester at each panel as shown on drawings. Low current surge arresters to be installed at all low current systems.

All the equipment shall be fit for continuous work in the heaviest conditions in Beirut.

12.2 EXTRA LOW VOLTAGE

Work described here under shall apply to the supply and installation of all materials and execution of all works necessary for the extra low voltage systems in the project, namely, telephone system, data system, fire & intrusion alarm systems, paging system, and CCTV system.

The supply shall include all the equipment, accessories and other materials not enumerated in these Specifications but necessary for the completion and perfect functioning of the systems. All to be executed in accordance with these Specifications, the drawings and notes indicated therein and the instructions of the Engineer, delivered complete in place and tested to the full satisfaction of the Engineer.

The Contractor shall coordinate the works of the extra low voltage system with the other installations to avoid any interference or damage to any of the systems or installations.

12.3 GENERAL ELECTRICAL REQUIREMENTS

12.3.1 ACTUAL ROUTE OF CABLES AND CONDUITS

The location or conduits, cables, switchboards, cable trunking, etc is shown on the drawings approximately, therefore the actual route of cables and conduits may differ from the plans according to the details or the building construction and the conditions of execution of the installation.

The Contractor shall supply and install at his expense all secondary materials and special fittings found necessary to overcome the interference and to apply the modifications on the route of cables and conduits that are found necessary during the work to the complete satisfaction or the Engineer.

12.3.2 DRILLING AND CUTTING

The Contractor shall have to do all drillings and cutting of walls or other parts of the building for the complete proper installation of the conduits, cables, switchboards and other parts of equipment.

Beams, girders and other principal structural members shall not be cut or drilled unless permission has been granted by the Engineer.

If such drilling and cutting is made on finished surfaces, any marring of the surface shall be made good by repair or replacement at the Contractor's expense.

12.4 STUDIES TO BE PREPARED BY THE CONTRACTOR

These Specifications indicate the operation requirements of all the low and extra low voltage systems as well as the various types of materials to be used and their characteristics.

The Contractor shall prepare, according to the systems he is offering, all the wiring diagrams, the number and sizes of wires and cables necessary for the perfect functioning of each system.

Full selectivity, discrimination and coordination study shall be provided between consecutive breakers based on their characteristic curves.

These distribution circuits shall have enough capacity to fulfil the operation requirements under the heaviest load conditions.

No claim could be formulated by the Contractor under pretext of insufficiency of certain choices of Specifications indicated herein for the complete functioning of any of the systems required.

The above-mentioned layouts and wiring diagrams shall be presented to the Engineer for approval prior to the ordering of the materials.

13 INTERNAL WIRING

13.1 System of Wiring

The system of wiring shall consist of PVC insulated copper conductor wires in Metallic/PVC/PVCE conduits and shall be concealed or surface mounted as called for.

13.2 General

Prior to laying and fixing of conduits, the contractor shall carefully examine the drawings indicating the layout, satisfy Consultant/Engineer about the sufficiency of number and sizes of conduits, location of junction boxes, sizes and location of switch boxes and other relevant details. Any discrepancy found in the drawings shall be brought to the notice of the Consultant/Engineer. Any modification suggested by the Contractor shall be got approved by the Consultant/Engineer before the actual laying of conduits is commenced.

13.3 Materials

13.3.1 Conduits

Conduits and accessories shall conform to relevant IS/BS Standards. Heavy duty PVC conduits or FRL conduit or FRLS conduit or PVC conduits or galvanized steel conduits shall be used as called for in the Schedule of Quantities. Buried wiring passing under floor of ground floor shall run in PVC conduit. Joints between conduits and accessories shall be securely made to ensure earth continuity. Sample of all the conduits to be used shall be submitted before laying for approval from Consultant/Engineer.

The conduits shall be delivered to the site of construction in original bundles and each length of conduit shall bear the label of the manufacturer.

The number of 650/1100 volt grade PVC insulated copper/aluminium conductor wires that may be drawn in the conduits of various sizes are given below and space factor shall not exceed **40%.** Separate conduits shall run for all power outlet wiring. Conduit connections for PVC conduits shall be done perfectly. Junction Box and the conduit joint must be used where necessary. Metal Saddle of appropriate size must be used while laying the conductor.

Maximum permissible numbers of 650/1100 volt grade PVC insulated wires that may be drawn into rigid non-metallic or MS conduits are given below:

Size of wire nominal cross section area	Maximum number of wires within conduit of size (mm)				
sq.mm.	20	25	32	40	50
1.5	6	10	14	-	-
2.5	5	10	14	-	-
4	3	6	10	14	-
6	2	5	8	11	-
10	-	4	7	9	-
16	-	2	4	5	12
25	-	-	2	2	6
35	-	-	-	2	5

13.3.2 Connections

All jointing methods shall be subject to the approval of the Consultant /Engineer. Separate conduits shall run for all power outlet wiring.

The threads and sockets shall be free from grease and oil. Connections between screwed conduit and sheet metal boxes shall be by means of a brass hexagon smooth bore bush, fixed inside the box and connected through a coupler to the conduit. The joints in conduits shall be free of burrs to avoid damage to insulation of conductors while pulling them through the conduits.

13.4 Bends in Conduit

Where necessary, bends or diversions may be achieved by means of bends and / or circular inspection boxes with adequate and suitable inlet and outlet screwed joints. In case of recessed system each junction work shall be provided with a cover properly secured and flush with the finished wall surface. No bends shall have radius less than 2.5 times the outside diameter of the conduit.

13.5 Fixing Conduits

All conduits shall be installed so as to avoid steam and hot water pipes. After the conduits, junction boxes, outlet boxes and switch boxes are installed in position, their outlets shall be properly plugged or covered so that water, mortar, insects or any other foreign matter docs not enter into the conduit system. Surface conduits shall be fixed by means of spacer bar saddles at intervals not more than 500mm.

The saddles shall be of 3mm x 19mm galvanised mild steel flat, properly treated, primed and painted, securely fixed to supports by means of nuts and bolls/rail bolts and brass machines screws.

13.6 Switch Outlets and Junction Boxes

All outlet boxes for switches, sockets and other receptacles shall be rust proof and shall be of 1.6mm thick G.I. sheets, having smooth external and internal surfaces to true finish.

All outlet boxes for receiving plug sockets and switches shall be fabricated to approve sizes. All boxes shall have adequate number of knock out holes of required diameter and earthing terminal screws. All boxes shall have both fixed lugs and adjustable lug/lugs.

13.7 Inspection Boxes

Rush proof inspection boxes (Pull Box of min 1.21mm thick mild steel sheet having smooth external and internal finish shall be provided to facilities removal and replacement of wires, where required. These shall be provided if continuous length of conduit is more than 10 meter. The depth of the box shall be 100mm and shall have a hinged cover with push button lock.

13.8 Circuit for Telephone, TV, Computer Networking and Music System

Conduits and system of conducting for telephone, TV, Computer networking and alarm system shall be the same as far electrical system, except they shall be installed at least 150 mm away from the electrical conduits.

13.9 Conductors

All PVC insulated Copper/Aluminium conductor wires shall conform in all respects to standards as listed under sub-head "Regulations and Standards". The under sizing/gauge of the conductor is not acceptable. During the inspection Electrical Engineer have full authority to make the contactor to remove the installed cable and no extra payment will be done in replacement of it.

13.10 Bunching of Wires

Wires carrying current shall be so bunched that the outgoing and return wires are drawn into the same conduit. Wires originating from two different phases shall not run in the same conduit.

13.11 Drawing Conductors

The drawing and jointing of PVC insulated copper/aluminium conductor wires and cables shall be executed with due regard to the following precautions. While drawing wires through conduits, care shall be taken to avoid scratches and kinks, which cause breakage of conductors. There shall be no sharp bends.

Insulation shall be shaved off like sharpening of a pencil and it shall not be removed by cutting it square,

PVC insulated copper conductor wire ends shall be soldered (at least 20mm length).

Strands of wires shall not be cut for connecting terminals. The terminals shall have sufficient cross sectional area to take all strands and shall be soldered. Connecting brass screws shall have flat ends. All looped joints shall be soldered and connected through terminal block/connectors. The pressure applied to tighten terminal screws shall be just adequate, neither too much nor too less. Conductors having nominal cross sectional areas exceeding 4 sq.mm shall always be provided with cable sockets/shoes. At all terminals, brass flat washer of large area and approved steel spring shall be used. Brass nuts and bolts shall be used for all connections.

Only certified wireman and cable jointers shall be employed to do jointing work. All wires and cables shall bear the manufacturer's label and shall be brought to site in original packing. For all internal wiring, PVC insulated wires of 650/1100 volts grade shall be used. The sub-circuit wiring for point shall be carried out in loop system and no joints shall be allowed in the length of the conductors. If the use of joints connections unavoidable due to any specific reason, prior permission, in writing, shall be obtained from the Consultant /Engineer. No wire shall be drawn into any conduit, until all work of any nature, that may cause injury to wire, is completed. Care shall be taken in pulling the wires so that no damage occurs to the insulation of the wire. Before the wires are drawn into the conduits, the conduits shall be thoroughly cleaned of moisture, dust, dirt or any other obstruction by forcing compressed air through the conduits. The minimum size of PVC insulated conductor wires for all sub-circuit wiring for light points shall be 2.5 sq.mm copper equivalents and for all sub-circuit wiring for power points shall be 4 sq mm.

13.12 Joints

All joints shall be made at main switches, distribution boards, socket outlets, lighting outlets and switch boxes only. No joints shall be made in conduits and in junction boxes. Conductors shall be continuous from outlet to inlet.

13.13 Mains and Sub-Mains

Mains and Sub-Mains cable or wires where called for shall be of the rated capacity and approved make. Every main and sub-main wire shall be drawn into an independent adequate size conduit. An independent earth wire of the proper rating shall be provided for every single-phase sub-main. For every 3-phase sub-main, 2 nos. earth wires of proper rating shall be provided along with the sub-main. The earth wires shall be fixed to conduits by means of clips at not more than 1000mm distance. Where mains and sub-mains cable are connected to switchgear, sufficient extra lengths of cable shall be provided to facilitate easy connections and maintenance.

13.14 Load Balancing

Balancing of circuits in three-phase installation shall be planned before the commencement of wiring and shall be strictly adhered to.

13.15 Colour Code and Tagging of Conductors

Colour code shall be maintained for the entire wiring installation: red, yellow, blue for three phases, black for neutral, green (or YG) for earthing. Tagging/labelling of the conductors must be done and drawing shall be provided so that it will be easier for future maintenance and finding of circuits.

13.16 Wiring for CCTV Surveillance System

Each camera point outdoor/indoor is considered as a point and wiring shall be done using low loss CAT-6 cable from each point to the central monitor room as shown in the drawing in a PVCE conduit concealed inside RCC slab, ceiling, wall, underground as per site condition. Cable joints between camera point and central monitor system are not allowed. The cables shall be properly terminated at the face plate and properly numbered at control room for identification. All the civil works including chipping and finishing shall also be included in point wiring.

13.17 Wiring for Telephone System

Wiring of telephone points shall be done using telephone cables of various pairs in PVC conduit of at least 16 mm. internal diameter concealed inside wall and slabs. Tapping from one socket to other is not allowed. Each single telephone line shall be connected to floor Distribution point by 2 pair cable. Each telephone outlet shall be of single RJ 11 type with face plate on 18 SWG metal box flushed inside a wall.

At least 150mm separation shall be provided between electricity cable PVC pipe and telephone cable pipe. Each separate telephone line shall be considered as a point. Cost of telephone point wiring shall include the complete labour charge and cost of telephone cables of appropriate pair from main exchange to DP and to each telephone outlet including extra spare pair as per above specifications.

13.18 Wiring of Computer Points

Each point for Computer Network point is considered as a point and wiring shall be done using CAT-6 cable with Copper conductor shall be taken to every RJ45 outlet socket point from Computer networking Hubs (installed on different location). From Hubs to Hubs 50 Ohm coaxial cable shall be drawn and connected with suitable connectors. These cables shall be drawn through the PVC conduit without having mid-way joints. Where computer networking cable and electric cables are crossing each other an aluminium jacket screen is to be provided on the telephone cable for that crossing length but it shall not be less than one meter.

13.19 Earthing

All the non-current carrying metal parts of electrical installation shall be earthed properly. All metal conduits, trunking, cable sheaths, switchgear, distribution fuse boards and all other parts made of metal shall be bonded together and connected by means of specified earthing conductors to an efficient earthing system as per IS 3034-1966.

Earthing shall be carried out as per drawing with at least 600 mm. x 600 mm. x 5 mm (or required size of Rod Earthing). Pure copper plate buried at least 3m below ground and connecting respected to Main Distribution Panel, Transformer, EPABX system, Distribution Boards, Generators and where necessary with 25 x 3 mm copper strip (or required size of Flexible YG Cable) with test clamp/point in between. The earth resistance of the earthing electrode shall not exceed five (5) ohms.

The contractor shall furnish main earth connection to all electrical equipment chassis and metallic conduit by means of appropriately sized copper wires as specified herein or shown in drawing.

Earthing system shall be at least 1 meter away from the building foundation and the main earth to the building shall be obtained by tapping this system by earth wire of appropriate size as shown in the drawing. The connection of these earth wires by twisting shall not be allowed.

All the earth terminals of 15 A power sockets shall be connected by insulated copper conductor with 2.5 sq. mm. Copper cable emanating from the respective distribution board. The earth connection to the distribution board shall be obtained from the main switch board and main switch board in turn shall be connected to the earthing system by using copper wires of sufficient sizes a shown on the drawings.

Earthing set shall consist of the following:

1 no. of 600 cm x 600 cm x 5 mm. Copper plate or as per BOQ

1 no. of watering GI pipe 3.5 m x 50 mm dia.

Brick masonry with metal slab for inspection and earth connection.

Charcoal and salt filling.

Electrolytic bare copper wire secured to earth plate with cable shoe, nut bolt and also connected to the earth pipe with nut and bolt.

14 POWER CABLES

Medium voltage cable shall be aluminium/ copper conductor PVC insulated, PVC sheathed armoured conforming to IS 1554.cable shall be rated for a 1100 volts. The conductor of cables from

16 Sq. mm to 50 Sq. mm shall be stranded. Conductors shall be insulated with high quality PVC base compound a common covering shall be applied over the laid up core by extruded sheath of un-vulcanized compound. Armouring shall be applied over outer sheath of PVC sheathing. The outer sheath shall bear the manufacturer's name and trade mark at every meter length Cores shall be provided with following colour scheme of PVC insulation.

(a) 1 Core : Red/Black/Yellow/Blue

(b) 2 Core : Red and Black

(c) 3 Core : Red, Yellow and Blue

(d) 3 ½ or 4 Core : Red, Yellow, Blue and Black.

Short circuit rating of cable shall be as specified in IS 1554 Part-I.

Cable have been selected considering conditions of maximum connected loads, ambient temperature, grouping of cables and allowable voltage drop. However, the contractor shall recheck the size before cables are fixed and connected to service.

14.1 Laying of Wires/Cables

Lying of wires/cables between two points shall follow the following methods.

(a) Laying of cables directly in the ground in outdoor applications; and

(b) Laying or supporting of cables in cable ladders, trenches and ducts, or clipped on to the walls or structural members of the building.

Where cables are to be laid direct in ground these shall be laid in cable trenches at least 0.75 m below ground surface. The cable laid shall be covered with 100 mm finely sifted sand and protected on the top with transverse bricks across the trench cross-section. The trench shall then be backfield and compacted.

Where cable routes run under hard surfaces, or where cables have to be run inside masonry or structural components inside buildings, such cables shall be run in cable trays or cable ladder.

14.2 Wires/Cable Laying on wall/ceiling/cable trays

Wherever so specified, cables shall be laid along walls/ceiling or on cable trays. Cable shall be secured in position and dressed properly by means of suitable clamps, hooks, saddles etc. such that the minimum clear spacing between cables is diameter of the cable. Clamping of cables shall be at minimum intervals as below.

Type of cables	Size	Clamping by	Fixing intervals
MV	Up to and including 25 sq. mm	Saddles 1 mm thick	45 cm
MV	35 sq. mm to 120 sq. mm	Clamps 3 mm thick 25 mm wide	60 cm

The fixing intervals specified apply to straight runs. In the case of bends, additional clamping shall be provided at 30 cm from the centre of the bend on both sides.

14.3 Cable Entry into Buildings

Cable entry into buildings shall be made through PVCE pipes recessed in the floor.PVCE pipes shall be provided well in advance for service cable entries. The pipe shall

be filled with sand and sealed at both ends with bitumen mastic to avoid entry of water. Suitable size manholes shall be provided wherever required to facilitate drawing of cables as per requirements.

14.4 Testing of Cables

Prior to installation, buying of cables, following tests shall be carried out. Insulation test between phases, phase and neutral, phase and earth for each length of cable.

(a) Before laying

(b) After laying

(c) After jointing

On completion of cable laying work, the following tests shall be conducted in the presence of the consultant:

(a) Insulation Resistance Test (Sectional and overall)

(b) Continuity Resistance Test

(c) Earth Test.

All tests shall be carried out in accordance with relevant Standard code of practice and NEA Rules. The Contractor shall provide necessary instruments, equipment and labour for conducting the above tests and shall bear all expenses of conducting such tests.

15 TELEPHONE SYSTEM

Floor distribution point shall consist of sufficient nos. of Krone / Pouyet type tag block with frame inside a metal box with cover and locking arrangement. There must be sufficient space for cable termination inside the box. DP shall be flushed inside a wall mounted at a height of DB.

Telephone cables of appropriate pair from main exchange to DP and to each telephone outlet including extra spare pair as per above specifications, BOQ and drawings.

PVC pipe of various sizes in which the telephone cables will be run. There shall be at least 30% extra space inside the PVC pipe after the cable shall run for the ease of pulling cables.

It is the full responsibility of contractor to terminate all the cables in telephone socket, DP and MDF and provide complete and correct tag data to the owner.

16 EPABX SYSTEM

Supplier shall supply, deliver, install and commission of required extension line EPABX system as mentioned at BOQ. Telephone wiring will be done for both EPABX extension lines and direct co lines. EPABX of extension line capacity will be installed. Every working table, guard room, maintenance room, canteen & day care as well have extension lines.

Separate earthing shall be provided for telephone system and the earth resistance shall not exceed 5 ohm for this purpose. Specification of earthing is same as in earthing for electrical distribution system.

17 QUALITY ASSURANCE

17.1.1 Materials and equipment shall conform to the latest edition of reference specifications specified herein and to applicable codes and requirements of local authorities having jurisdiction.

i. Locally manufactured products of foreign approved makes and of similar quality shall be approved by the Engineer. The Engineer shall be the sole judge to determine whether the product is of the same quality or not.

ii. Code Requirements:

- Comply with the latest applicable standards of the following unless specified otherwise under each section:
- The equipment, materials and installation shall satisfy the following:
  - The specifications and technical conditions described in the present book of specifications.
  - All electrical works shall be in accordance with NBC 207 (or IS) Code while shall have precedence whenever available.
  - The General Specifications for Electrical Installations of the Local Authorities

iii. Tests after the completion of the installation shall satisfy the requirements of the standards mentioned above and as mentioned here after.

18 SUBMITTALS

18.1 Definitions

The required submittals of this division, in addition to the definitions of the General Conditions, and elsewhere in the contract documents, are further categorized for convenience as follows:

18.1.1 Product data shall include manufacturer's latest standard printed literature such as manufacturers installation instructions, catalogue cuts, colour charts, rough-in diagrams, wiring diagrams, and performance curves on materials, equipment and systems for this project. Product data shall include references to applicable specification section and item number. Product data shall be in addition to the required shop drawing submittals.

18.1.2 Shop drawings shall include specially prepared technical data with diagrams, performance curves, data sheets, schedules, templates, patterns, reports, calculations, plans, sections, details, measurements, not in standard printed form. Shop drawings shall be in addition to the required product data and shall indicate applicable specification section and item numbers.

18.1.3 Samples shall include physical examples of materials; in complete units for visual inspection. Samples shall indicate applicable specification section number and item numbers within that section.

18.1.4 Certificates shall include statements of applicability, certifying reports from governing agencies, industry standards, and testing agencies and applicable certificates specified in each section of the specification.

18.1.5 Test and Inspection reports shall include reports specified to be required in each section of the specifications.

18.2 Coordination and Sequencing

18.2.1 Coordinate preparation and processing of submittals with the construction schedule and progress so that the Work will not be delayed.

18.2.2 Coordinate and sequence submittals for Work and Work interfaced with other Work so that the processing of submittals will not be delayed by the lack of required coordination between submittals.

18.2.3 The obligation to coordinate the Work indicated on any submittal material with other trades and with field conditions is the responsibility of the Contractor. No claim will be allowed for Work that may have to be moved or replaced based on a claim that the work was placed in accordance with dimensions indicated on an approved submittal.

18.2.4 No claim for an extension of Contract Time will be approved because of Contractor's failure to coordinate submissions.

18.3 Shop Drawings

18.3.1 Before starting the work, the Contractor shall submit to the Engineer for his approval, the execution of shop drawings (4 copies to be submitted) for the entire installation, especially the transfer stations, the main connections and junctions, the final route of cables and conduits and the details of the switchboards, panels, exact location of all electrical outlets & device and any other part of the installation required by the Engineer. The Engineer reserves the right to alter of modify these plans if they are found to be insufficient or not complying with the established technical standards or if they do not afford the most satisfactory performance or accessibility for repairs.

18.3.2 Three sets of operating and maintenance instructions covering completely the operation and maintenance of electrical systems and automatic control equipment shall be furnished to the owner.

18.3.3 Where necessary, one set of operating and maintenance instructions for each electrical equipment shall be framed behind glass and hung where directed.

18.3.4 Where necessary, three sets of lubrication charts and manuals for each item of equipment shall be furnished to the owner.

18.3.5 At the end of the work, the Contractor shall present three sets of as-built drawings of the whole installation, with all details required by the Engineer, and with the technical data of all installed equipment.

18.4 Product Data

18.4.1 Submit product data as called for under "Submittals" in each individual specification section.

18.4.2 Product data shall be submitted for review. The Contractor shall indicate on copies of the literature the actual materials being submitted for review when literature contains selections.

18.5 Samples

18.5.1 Submit two (2) samples of each material (unless a different quantity is specified) as called for under "Submittals" in each individual section of the specifications without any additional cost to client.

18.5.2 Samples shall be delivered where directed by the Engineer.

18.5.3 Sidewalk delivery of samples will not be accepted.

18.6 Coordination Drawings

Prepare coordination drawings in accordance with provisions of the Contract Documents detailing major elements, components, and system of electrical equipment and materials in relationship with other systems, installations and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installation are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:

18.6.1 Indicate the proposed locations of major raceway systems, equipment, and materials. Include the following:

- Clearances for servicing equipment, including space for equipment disassembly required for periodic maintenance.
- Equipment connections and support details.
- Sizes and location of required concrete pads and bases.

18.6.2 Indicate scheduling, sequencing, movement and positioning of large equipment into the building during construction.

18.6.3 Prepare floor plans, elevations and details to indicate penetrations in floors, walls and ceilings and their relationship to other penetrations and installations.

18.7 Record Documents

Prepare record documents in accordance with the provisions of the Contract Documents. In addition to the requirements specified , indicate installed conditions for:

18.7.1 Major raceway systems, size and location, for both exterior and interior; locations of control devices; distribution and branch electrical circuitry; and fuse and circuit breaker size and arrangements.

18.7.2 Equipment locations (exposed and concealed), dimensioned from prominent building lines.

18.7.3 Approved substitutions, Contract Modifications and actual equipment and materials installed.

18.8 Instruction Manuals

The supplier shall prepare and produce instruction manuals in three language English and Nepali languages for the use, operation and the maintenance of the supplied equipment and installations.

18.9 Material of the Same Kind

All materials of the same kind of service shall be identical and made by the same manufacturer.

18.10 Test Certificate

The supplier shall submit test certificates where required. These shall be issued by an internationally recognized inspection office certifying that all equipment materials, construction and functions are in agreement with the requirements of these

Specifications and accepted Standards.

18.11 Test and Adjusting

After the wiring systems are completed, it shall be tested for all controls and defects. Any defects appearing shall be remedied before any apparatus, is installed.

Tests, both electrical and physical, shall be made of the various materials, equipment and installation comprising the electrical system.

After the entire installation has been completed all necessary adjustments shall be made until all Performance requirements are met.

19 TESTING OF INSTALLATION

19.1 General

At the completion of the work, the entire installation shall be subject to the following tests:

- Wiring continuity test
- Insulation resistance test
- Earth continuity test.
- Earthing resistance test

Besides the above, any other test specified by the local authority shall also be carried out. All tested and calibrated instruments for testing, labour materials and incidentals necessary to conduct the above tests shall be provided by the Contractor at his own cost.

19.2 Testing of Wiring

All wiring systems shall be tested for continuity of circuits, short circuits, and earthing after wiring is completed and before installation is energised.

19.3 Insulation Resistance Tests

The insulation resistance shall be measured between earth and the whole system of conductors, or any section thereof, with all fuses in place and all switches closed and except in concentric wiring, all lamps in position of both poles of the installation otherwise electrically connected together, with a direct current pressure of not less than twice the working pressure provided that it does not exceed 660 volts for medium voltage circuits. Where the supply is derived from AC three phase systems, the neutral pole of which is connected to earth, either direct or through added resistance, pressure shall be deemed to be that which is maintained between the phase conductor and the neutral. The insulation resistance measured, as above shall not be less than 50 divided by the number of points provided on the circuit, the whole installation shall have an insulation resistance greater than One Mega Ohm.

The insulation resistance between the frame work of housing of power appliances and all live parts of each appliance shall not be less than that specified in the relevant standard specification or where there is no such specification, shall not be less than half a Mega Ohm.

19.4 Testing of Earth Continuity Path

The earth continuity conductor, metallic envelopes of cables shall be tested for electric continuity; and the electrical resistance of the same, including the earthing lead but excluding any added resistance or earth leakage circuit breaker, measured from the connection with the earth electrode to any point in the earth continuity conductor in the completed installation, shall not exceed one ohm.

19.5 Testing of Polarity of Non-Linked Single Pole Switch

In a two wire installation a test shall be made to verify that all non-linked single pole switches have been connected to the same conductor throughout, and such conductor shall be labelled or marked for connection to an outer or phase conductor or to the non-earthed conductor of the supply. In the three or four wire installation, a test shall be made to verify that every non-linked single pole switch is fitted to one of the outer or phase conductor of the supply.

19.6 Acceptance of the Installation Work

The entire electrical installation shall be subject to the final acceptance of the Engineer as well as the local authorities.

20 SUMMARY

20.1.1 This section specifies administrative and procedure requirements regarding electrical work. Additional requirements are specified in various sections may be required during the execution of work due to project conditions.

20.1.2 Requirements of this section shall include, but not be limited to, the following:

- i. Submittals.
- ii. Coordination drawings (shop drawings).
- iii. Record documents (as built drawings).
- iv. Service and Maintenance manuals.
- v. Electrical installations.
- vi. Cutting and patching.
- vii. Temporary power and lighting.

20.1.3 The requirements of this section do not supersede or take precedence over any provision of the General Conditions and Supplementary General Conditions, and should any discrepancy become apparent between these requirements and the General Conditions and Supplementary General Conditions, the Contractor shall notify the Engineer, in writing, and the Engineer shall interpret and decide such matters in accordance with the applicable provisions of the General Conditions and Supplementary General Conditions.

21 STANDARD AND MAKE

All materials intended for this project shall be all new and as per specifications laid herein. Where equivalent types are available, samples shall be submitted to the project for formal approval before procurement is made.

22 CO- ORDINATION WITH OTHER TRADES

Since the electrical works will have to be carried out simultaneously with other trades, specially building construction works, proper coordination with this trades shall be maintained throughout the duration of works, so as to avoid any disputes or unnecessary increase in labour and materials. Hence the drawings shall be thoroughly studied and marked with necessary information laid along with dimensional details, if any, for other trades as well as for electricians. This is to ensure high standards of trade practice based in Codes of Practices.

23 TIME SCHEDULE

The tenderer shall be responsible for timely procurement and delivery of the items, off-loading at site, safekeeping at site, transport to the place of installation, installation, testing and commissioning of all the material that are included in his scope of work. Work shall be progressed and completed as per schedule mutually agreed upon. **Work schedule for mutually agreed upon time shall be provided by the successful bidder within 10 (Ten) days of contract awarded.**

24 GUARANTEE

After the completion of the work and before issuance of final certificate of virtual completion the contractor shall furnish a written guarantee by his acceptance of the contract that all work installed will be free from any defective materials and all defects and that all apparatus will develop capacities and characteristic specified and that if during a period of three (3) years from date of completion and acceptance work any such defects on workmanship or defective material, repair or otherwise correct the defects of deficiency without cost to the owner within a reasonable time. In the event of default on this guarantee by the contractor, the owner may have works done as required and charge the cost to the contractors.

25 MAINTENANCE OF ELECTRICAL SYSTEMS

The period of maintenance of the electrical and allied works shall commence from the date of the Certificate of Completion for the (main) works, provided the electrical and allied work installation is giving sufficient service to the employer for the intended use.

The term maintenance is applied to all Electrical, and ELV works and shall mean the following for a period of three (3) years from the commencement of the maintenance period for electrical works; the Contractor shall:

25.1.1 Guarantee the entire installation in respect of all defects, which may occur and undertake to repair such defects immediately at no cost whatsoever to the employer.

25.1.2 The maintenance work must be scheduled according to the recommended procedures set out in the manufacturer's catalogues.

25.1.3 During the maintenance period the Contractor shall undertake to train employer's staff in all aspects of servicing and maintenance of all equipment.

26 CAPACITY BUILDING

The CONTRACTOR needs to provide training to relevant employees fromClient and other stakeholders as directed by Client for capacity building. The CONTRACTOR shall prepare all the requisite audio/visual training aids that are required for successful completion of the training for all stakeholders. These include the following for all the stakeholders:

a. Training manuals
b. Computer based training modules
c. Presentations;
d. User manuals;
e. Operation and maintenance manuals

The CONTRACTOR shall maintain a copy of all the training material on the portal and the access will be provided to relevant stakeholders depending on their need and role. For each training session, the CONTRACTOR has to provide the relevant training material copies to all the attendees.

Important Notice to Bidders:

1. Bidders are requested to quote prices of genuine and good quality products only. Any samples submitted if found duplicate and inferior quality will be rejected outright by concerned

authority/consultant. Hence it is requested to take utmost care in filling up BOQ to avoid use of duplicate and inferior quality products.

2. Make and model no. of quoted items shall be mentioned in BOQ and a set of original catalogue of the quoted items shall be submitted along with the bid.

3. Designs are subject to change during contract negotiation and during implementation period due to site conditions and other reasons.