Design of a Commercial Building, Hydrology Study, and Infrastructure Design of Housing Society

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Bachelor of Engineering in Civil Engineering

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ABSTRACT

The hydrology study is a crucial aspect of the project. It entails a comprehensive analysis of the site's hydrological characteristics, including rainfall patterns, water sources, and drainage systems. The study aims to assess potential flood risks, soil erosion, and water resource management.

The ongoing housing society projects in Pakistan are not properly catering storm water drain system in design which results in flooding of the area specially in monsoon season, causing material and life losses. This project will undertake Hydrology study of a real time on going housing society and will carry out detailed analysis based on past precipitation data. We shall provide solution for drainage of maximum intensity of storm water with least cost covering 30 years precipitation data of a real time housing society area,

The next phase involves the design and planning of a commercial building. The objective is to create a modern, functional, and aesthetically pleasing structure that caters to the commercial needs of the community. The design considers factors such as accessibility, and sustainability, ensuring that the building complements the surrounding environment and adheres to all local regulations and safety standards.

In addition to above, the housing society infrastructure design phase focuses on creating a sustainable and livable environment for residents. It includes the planning of roads, utilities, green spaces, and community facilities. The design ensures efficient land use, minimizes environmental impact, and incorporates innovative solutions including water supply, drain system, sewerage system and a link road.

This project will be modelled in BIM up to 5D (3D model, time and cost), which is the future of construction Industry,

CHAPTER 1

INTRODUCTION

1.1 SCOPE:

This project shall encompass following:

- Hydrological assessment, drainage and flood risk assessment, stormwater management, regulatory compliance, long term planning and cost engagement.
- Road network and transportation, utilities and services, greenspaces and recreation areas, environmental consideration, regulatory compliance, project management and timeline.
- Architectural design, structural engineering, load combination development and analysis, sustainability, aesthetics, safety and security, regulation implementation, cost effectiveness.

1.2 BACKGROUND

In the context of urban development, there is a growing need for integrated and sustainable solutions that cater to the commercial, residential, and environmental needs of a community. The absence of a well-designed, efficient, and aesthetically pleasing commercial building within the community and The need for a commercial space that meets modern business requirements and local building codes while being environmentally sustainable is now a well know aspect of construction industry. Limited understanding of the local hydrological conditions, including rainfall patterns, potential flood risks, and water resource management and the need to develop strategies for responsible water resource management within the housing society to prevent environmental degradation and protect residents from potential flooding. The absence of well-planned and efficiently designed infrastructure, including roads, utilities, green spaces, and community facilities, to support the needs of the housing society. The necessity to ensure regulatory compliance, safety, and accessibility for all residents and stakeholders.

1.3 PROBLEM STATEMENT

In the context of urban development, there is a growing need for integrated and sustainable solutions that cater to the commercial, residential, and environmental needs of a community. Structural and infrastructure design are applications based while past 30 years hydrology study is for designing stormwater system with improved futuristic approach.

1.4 OBJECTIVES

- ✓ Hydrology study of a housing society.
- ✓ Infrastructure design of the housing society.
- ✓ Design of a G+3 commercial building.

CHAPTER 2

LITERATURE REVIEW

2.1 BACKGROUND

Construction industry is working on the same principle as of before with limited advancements in comparison with the on-going modern practices and technology. Pakistan is a bit more in backward mindset as still excel sheets and primavera are being used for scheduling and cost analysis. In the world of modern technology BIM is introduced to overcome the many flaws of cost, time and other main features that effect the project directly or indirectly. This project will use BIM up to 5D analysis for all objectives to limit the project being uneconomical because every hurdle has an adverse effect on stakeholders' pockets.

2.2 BUILDING INFORAMTION MODELLING (BIM)

Building Information Modeling (BIM) is a digital process that involves creating and managing a 3D model of a building or infrastructure project. BIM technology is widely used in the construction and architecture industries to design, construct, and manage buildings and infrastructure more efficiently and collaboratively. 2D and 3D Modelling can be done in other software, but BIM stands out due to its additional features of connection bridge between stakeholders, resource management, safety procedures, Data integration, visualization, lifecycle management, and sustainability.

2.2.1 2D BIM

2D plans are though a simplest one but a 2D BIM model mainly focuses on 2D drawings, plans, and elevations, but still incorporates data and information associated with these 2D representations. They provide a simplified visual representation of project, which can be more accessible to stakeholders who may not be familiar with 3D modeling software. This means that the 2D drawings can be generated from the 3D model, ensuring consistency and accuracy in the representation of the project.

2.2.2 3D BIM

3D BIM, or 3D Building Information Modeling, is an advanced digital technology and methodology used in the construction and architecture industries to create detailed, three-dimensional representations of building projects. 3D BIM encourages collaboration and coordination among project stakeholders, including architects, engineers, contractors, and subcontractors. All parties can work on the same 3D model, enabling real-time communication and reducing conflicts and errors. This visualization helps in making informed design and construction decisions.

2.2.3 4D BIM

4D BIM, or Four-Dimensional Building Information Modeling, is an advanced technology and methodology that extends the capabilities of traditional 3D BIM by adding the dimension of time. In 4D BIM, a time-based component is integrated into the digital model, allowing project stakeholders to visualize and manage the project not only in three dimensions but also over time. 4D BIM is particularly valuable for large and complex construction projects where scheduling, sequencing, and resource management are critical. It allows for better project control, reduced construction delays, and improved decision-making throughout the project's lifecycle. Clash detection in terms of time is the main point in this.

2.2.4 5D BIM

5D BIM, or Five-Dimensional Building Information Modeling, takes the capabilities of 3D and 4D BIM a step further by adding a financial or cost dimension to the digital model. It combines the three spatial dimensions (3D), time (4D), and project cost (5D) to provide a comprehensive and integrated approach to construction project management. The fifth dimension in 5D BIM is the cost dimension. It involves associating cost data with the 3D model and the project schedule. 5D BIM enhances project management by providing a holistic view that integrates project cost, schedule, and the physical elements of the project. It supports better decision-making, improved cost control, and reduced project risks.

2.3 BIM ENHANCING

The construction industry is continually evolving and Building Information Modeling (BIM) is at the forefront of these changes. BIM enhancements in the construction industry are driven by technological advancements and the need for increased efficiency, sustainability, and collaboration.

2.3.1 Building Structures

In the construction industry, building enhancement has become a pivotal focus, driven by the need for sustainable and efficient structures. This paradigm shift involves incorporating advanced technologies and materials, such as energy-efficient insulation, smart building systems, and eco-friendly construction methods, to reduce environmental impact and operational costs. In essence, building enhancement in the construction industry represents a holistic approach that combines innovation, sustainability, safety, and aesthetics to create structures that stand the test of time and meet the evolving needs of society.

2.3.2 Hydrological Systems

Building Information Modeling (BIM) enhances the hydrological system in construction by providing a comprehensive digital representation of the project. This allows for accurate analysis and simulation of water flow, drainage, and flood risk, aiding in efficient design and planning. BIM enables collaborative data sharing among stakeholders, reducing errors and improving decision-making. It also facilitates the integration of real-time weather and environmental data for more precise hydrological predictions, enhancing construction project resilience and sustainability.

2.3.3 Infrastructure Designs

Building Information Modeling (BIM) enhances infrastructure design by providing a digital framework that integrates all project information, fostering collaboration among architects, engineers, and contractors. BIM allows for real-time visualization of projects, enabling better decision-making and reducing errors. It also facilitates accurate cost estimation and scheduling, optimizing resource allocation. BIM's data-rich models improve maintenance and operations, extending the infrastructure's lifecycle. Overall, BIM enhances efficiency and quality throughout the entire infrastructure design and construction process.

2.4 BIM PLUGINS

Building Information Modeling (BIM) plugins are add-on software tools or extensions that can be integrated into popular BIM software applications to enhance their functionality for specific tasks in the construction industry. Some extensions are:

2.4.1 Revit Plugin

Autodesk Revit, one of the most widely used BIM software applications, has a robust ecosystem of plugins. These plugins can assist with tasks such as advanced rendering, family creation, quantity takeoff, and clash detection.

2.4.2 AutoCAD Plugin

AutoCAD, another Autodesk product, supports numerous plugins for various construction-related tasks, including structural analysis, electrical design, and 3D modeling.

2.4.3 Cost Estimation Plugin

Various plugins are available for cost estimation and quantity takeoff tasks, helping to create accurate construction budgets.

2.4.4 Safety and Compliance Plugin

Some plugins are developed to assist in safety planning and regulatory compliance, making it easier to ensure construction projects adhere to industry standards and safety guidelines.

2.4.5 Navisworks Plugin

Autodesk Navisworks is used for 3D coordination and clash detection. Plugins can extend its capabilities for tasks like model comparison, file format support, and advanced reporting.

2.4.6 Document Management Plugin

Plugins can improve document management, collaboration, and data sharing within BIM platforms, streamlining communication among project stakeholders.

2.5 RESEARCH PAPER STUDY

Following were the papers related to our scope other than BIM:

2.5.1 Implementation of Building Information Modeling (BIM) in Pakistan Construction Industry

BIM has altered the way of designing, constructing and operating buildings. BIM utilization led to augmented profitability, reduced cost, reduced project duration and enhanced customer-client relationships. Implementation of BIM has progressed rapidly. In a global scale, in 2007 it was 26% and in 2016 it reached 57%. BIM implementation is an enduring problem in developing countries. In Pakistan only 11% of related industry has implemented BIM and only to generate 3D models which is a very limited part of BIM

2.5.2 Urban hydrology and water management ± present and future challenges

The future challenges within urban water management during the next decades will be to organize cross sectorial cooperation between several actors in order to introduce innovative water technologies, management systems and institutional arrangements which are able to meet the multiple objectives of equity, environmental integrity and economic efficiency, simultaneously maintaining or/and providing high level of water services for urban residents.

2.5.3 Reframing socio-hydrological research to include a social science perspective

Socio-hydrology research has opened up a new way of dynamic thinking about humans and water, which has further extended research of human-water interactions to a domain that views people and their behaviors as endogenous and co-evolving components in water cycle dynamics. However, this research field is still at an exploratory stage and better understanding of the interactions between the two systems is needed in both depth and scope, requiring wide interdisciplinary collaboration.

2.5.4 Analysis of Benefits, Advantages and Challenges of Building Information Modelling in Construction Industry

The studies show both the BIM advantages and disadvantages. The project recommends BIM application to construction managers with a note on the challenges of using BIM tools. The construction components and scheduling progress are run by BIM based 4D scheduling which results in good construction planning. Additionally, building information modelling tools examine the enhanced usage of 3D, 4D and model scheduling.

2.5.5 Hydrologic responses of single land use urban and forested watersheds and their implications to improving urban drainage design.

While some peak flow models performed satisfactorily, the research paper suggests that there is still room for improvement in peak flow estimates. Research could aim to enhance the accuracy of these estimates to support better drainage system and storm water control measure (SCM) design. Understanding the effects of land use and land cover changes (LULC) on hydrological responses, as suggested in the research, can inform decisions about green spaces, impervious surfaces, and stormwater retention features within the society.

2.5.6 Slow flow fingerprints of urban hydrology

Urbanization brings about significant changes in watershed processes related to streamflow. Contrary to the simple conceptual model of a single distinctive urban baseflow response, the study finds that urban watersheds exhibit a more complex and variable slow flow response. This paper emphasizes that the observed slow flow is heterogeneous and not a single consistent type. It helps us understanding the sources of this heterogeneity and how it varies across different urban settings.

2.5.7 Urban hydrological responses to climate change and urbanization in cold climates

The study successfully calibrated and validated an urban hydrological model, demonstrating that the model accurately represents observed data for hydrological processes in the urban area. The study finds that future changes in precipitation and temperature, as modeled under Representative Concentration Pathways 4.5 and 8.5 (RCP4.5 and RCP8.5), have a clear influence on urban streamflow throughout the year. This suggests that climate change will significantly impact the hydrology of the urban catchment. While urbanization has a direct impact on the hydrological response due to changes in impervious surfaces (e.g., roads, buildings), the study suggests that the effects of climate change are expected to have a more significant impact on the seasonal distribution of urban streamflow. This highlights the importance of considering both urbanization and climate change in urban hydrological modeling and planning.

2.5.8 Spatial resolution considerations for urban hydrological modelling

Evaluating the performance of Low Impact Development (LID) tools in large-scale urban areas presents challenges due to the need for high spatial resolution in hydrological modeling and the limited availability of field measurements for model calibration. The research first calibrates high-resolution models for three small-scale study catchments (ranging from 6 to 12 hectares). These high-resolution models allow for detailed representation of surface characteristics and processes within these catchments.

2.5.9 Urban hydrology and water management – present and future challenges

The research paper emphasizes the importance of data and modeling, it does not specify the need for comprehensive data collection and case studies to support urban water management decisions. Research could focus on improving data collection methods and case studies that showcase effective urban water. The effectiveness of technical solutions in urban water management depends on various factors, including climate, social, economic, and cultural conditions. These factors should be considered when developing water management strategies.

2.5.10 Enhancing future resilience in urban drainage system: Green versus grey infrastructure

The research contributes to the development of sustainability assessment methodologies for urban drainage systems. It is needed to consider and address the complex uncertainties related to climate change and urbanization when assessing the resilience of urban drainage systems (UDSs). The research aims to enhance UDS resilience by comparing green and grey infrastructure strategies, it does not specify how these uncertainties are quantified, integrated into the analysis, or how resilience strategies can effectively address a wide range of possible future scenarios.

2.6 APPLICATIONS OF BIM

Building Information Modeling (BIM) is a digital representation of the physical and functional characteristics of an infrastructure. It's widely used in the construction industry to improve project efficiency, accuracy, and collaboration. Here are 10 applications of BIM in the construction industry:

- 2.5.1 Design and Visualization: BIM enables architects and designers to create 3D models that provide a realistic visual representation of the project, helping stakeholders better understand the design intent.
- 2.5.2 Cost Estimation: BIM models can be used to create accurate cost estimates, enabling more precise budgeting and project cost control.
- 2.5.3 Construction Planning: BIM aids in the development of construction schedules and logistics plans, allowing for better coordination of trades and materials.
- 2.5.4 Energy Analysis: BIM can be used to simulate the energy performance of a building, helping to design and construct more energy-efficient structures.
- 2.5.5 4D and 5D BIM: Adding the time (4D) and cost (5D) dimensions to BIM models allows for the visualization of construction sequencing and cost implications, aiding in project management.
- 2.5.6 Collaboration: BIM facilitates collaboration and information sharing among all project stakeholders, including architects, engineers, contractors, and owners, reducing communication breakdowns.
- 2.5.7 Document Management: BIM centralizes project documentation, making it easier to manage and share files. It helps in project documentation by bringing all project-related documents and data into a unified digital environment.
- 2.5.8 Maintenance and Renovation: BIM is valuable for planning and executing maintenance and renovation projects by providing accurate existing condition data. BIM software includes an audit trail, which records changes and actions taken on project documents.

2.5.9 Data Integration: BIM goes beyond simple file storage; it also integrates these documents with the 3D model of the building or infrastructure project. This integration ensures that documents are contextually linked to specific elements in the model. For example, you can click on a wall in the 3D model and access documents related to that wall's construction, materials, and maintenance.

2.5.10 Real-Time Collaboration: BIM facilitates real-time collaboration among project team members, regardless of their physical location. Multiple users can work on the same document simultaneously, making changes and updates visible to all relevant parties instantly.

CHAPTER 3

3.1 METHODOLOGY

3.1.1 Literature Review

Ample study of previous work of different personalities linked with the scope of this project to understand the latest advancements and to gain knowledge in-order to work on the left-out drawbacks and flaws in-collaboration with BIM latest tools and techniques and to avoid the duplication.

3.1.2 Soil Bearing Capacity

Conduct a geotechnical site investigation to collect soil samples at varying depths. Perform laboratory tests on the soil samples, including the Standard Penetration Test (SPT) or the Cone Penetration Test (CPT), to determine soil properties such as cohesion, friction, and density. Use the soil test results to classify the soil type and assign a suitable bearing capacity value based on recognized soil classification systems. Consider any additional factors such as depth, groundwater table, and the type of foundation to adjust the bearing capacity value. Ensure that the calculated bearing capacity exceeds the load imposed by the structure to ensure a stable foundation design.

3.1.3 3D Modelling of Commercial Building

Begin by collecting architectural and structural drawings, specifications, and any relevant site survey data. Choose a 3D modeling software like AutoCAD, Revit, SketchUp, or other specialized tools, depending on your needs and expertise. Use the software to create the building's 3D geometry, including walls, floors, roof, and structural elements. Add finer details like doors, windows, fixtures, and interior elements. Ensure accuracy and precision. Apply textures, materials, and lighting to create a realistic visualization of the commercial building. Review and refine the model as needed.

3.1.4 Designing of Commercial Building

Define the purpose and requirements of the building, considering factors like size, layout, functionality, and regulatory compliance. Create preliminary design concepts, including floor plans, exterior aesthetics, and space allocation. Consider the needs of occupants and clients. Develop detailed architectural and engineering plans, incorporating structural, electrical, plumbing, and HVAC systems, and ensure compliance with building codes. Select materials and systems that align with the project's sustainability goals and budget. Focus on energy efficiency, durability, and aesthetics. Oversee construction, manage budgets, and ensure quality control. Collaborate with various stakeholders and professionals to bring the commercial building design to life.

3.1.5 Validation of Design

Validation of design in a construction project is a crucial process that ensures the feasibility and reliability of the proposed plans. It involves a comprehensive review of architectural, structural, and engineering designs to verify compliance with local building codes, safety standards, and client requirements. This validation helps in identifying potential flaws and discrepancies in the design, allowing for necessary adjustments before construction begins. It also facilitates cost control, risk mitigation, and a smoother project execution. Effective design validation is an integral part of delivering successful and safe construction projects.

3.1.6 Analysis of Loading in Design

The analysis of loading in the design of a construction project is a critical process that involves evaluating and quantifying the various forces and loads that a structure will encounter during its lifetime. This includes dead loads (permanent forces like the weight of the building itself), live loads (temporary forces like occupants and furniture), and environmental loads (such as wind and seismic forces). Through careful analysis, engineers ensure that the structure can safely bear these loads without failure, ensuring the safety and durability of the construction. This analysis informs material selection, structural design, and the overall stability of the project, ultimately contributing to the success and longevity of the built environment.

3.1.7 Analysis of Precipitation Data

Analyzing precipitation data in a construction project is essential for effective project management. This data helps in assessing the impact of weather on construction timelines and budgets. It allows project managers to plan for weather-related delays, optimize scheduling, and implement erosion control measures as needed. Precipitation analysis also aids in risk management by identifying potential flooding or soil stability issues. Overall, a thorough understanding of precipitation data is crucial for ensuring construction projects stay on track and within budget.

3.1.8 Validation of Data

Data validation is the process of ensuring that data is accurate, consistent, and reliable. It involves checking data for errors, inconsistencies, and completeness to ensure its quality and usability. Validation methods can include range checks, format checks, and cross-referencing with external sources to verify data accuracy. Effective data validation is crucial for making informed decisions, minimizing errors, and maintaining data integrity in various applications, from databases to data entry forms. It helps organizations trust and leverage their data for improved decision-making and operational efficiency.

3.1.9 Designing of Stormwater Drain System

Designing a storm water drain system in a construction project involves careful planning to manage and control rainwater runoff effectively. The process includes assessing site topography, soil conditions, and local regulations to determine the system's layout and capacity. Engineers must select appropriate materials and structures for drainage, including pipes, culverts, and retention basins. The design should prioritize water quality by incorporating features such as sedimentation basins and filter systems to remove pollutants. Proper maintenance and regular inspections are essential to ensure the system's continued functionality and prevent flooding and erosion issues.

3.1.10 Verification of Design

Verification of design in construction projects is a crucial process that ensures the accuracy, compliance, and feasibility of architectural and engineering plans. It involves a rigorous examination of blueprints and specifications to confirm they adhere to building codes and regulations, as well as project requirements. This verification helps identify potential design flaws, inconsistencies, and omissions before construction begins, reducing the risk of costly errors and delays. Additionally, it fosters collaboration between architects, engineers, and contractors to refine the design and enhance constructability, ultimately contributing to a successful and efficient construction process.

3.1.11 Assessment and Comparison

Assessment and comparison in construction projects involve the systematic evaluation of various aspects to make informed decisions. This process includes evaluating project proposals, contractors, materials, and methodologies. It requires a comprehensive analysis of cost estimates, project schedules, and risk factors to select the most suitable option. Comparing different alternatives helps in identifying the most cost-effective and efficient solutions, ultimately leading to successful project execution. Effective assessment and comparison are crucial for ensuring that construction projects meet their objectives within budget and on schedule.

3.1.12 Documentation

Documentation in a construction project is essential for ensuring transparency, compliance, and project success. It includes detailed plans, specifications, contracts, and permits, serving as a comprehensive record of the project's scope, schedule, and budget. These documents facilitate communication among stakeholders, assist in obtaining necessary approvals, and provide a historical reference for future maintenance and renovations. Proper documentation helps mitigate disputes and ensures accountability, making it a cornerstone of effective project management in the construction industry.

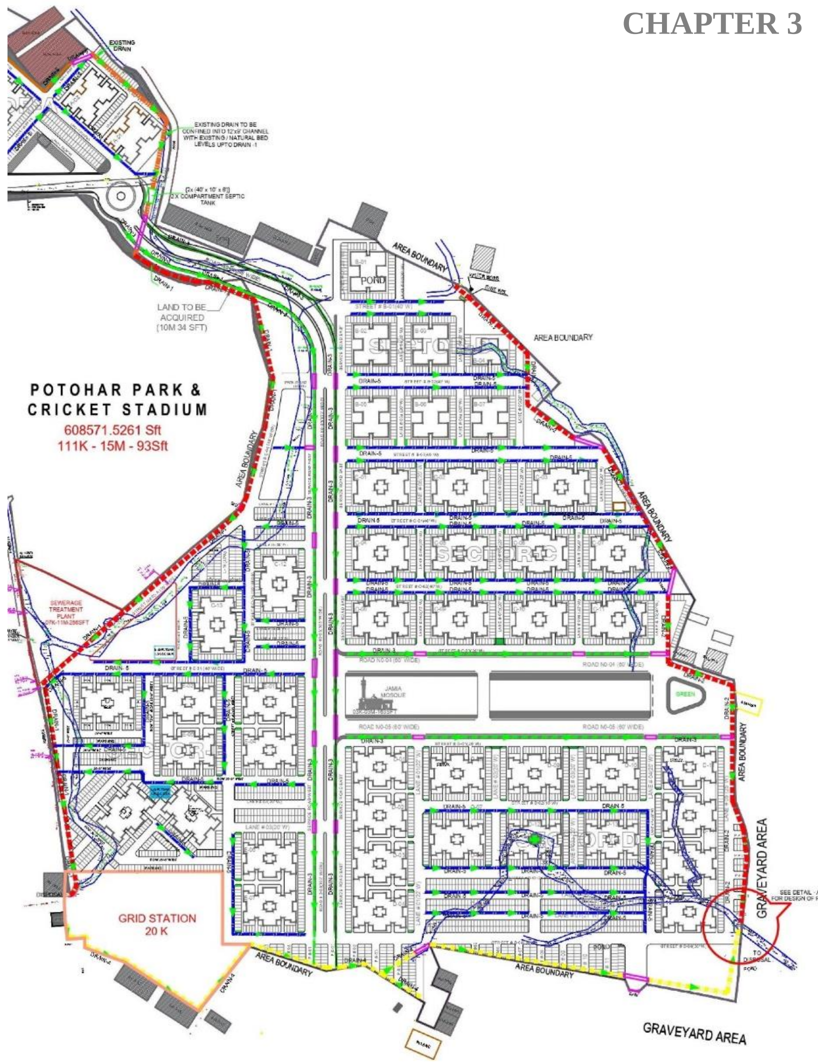
3.2 METHODOLOGY FLOWCHART

3.3 TIMELINE CHART

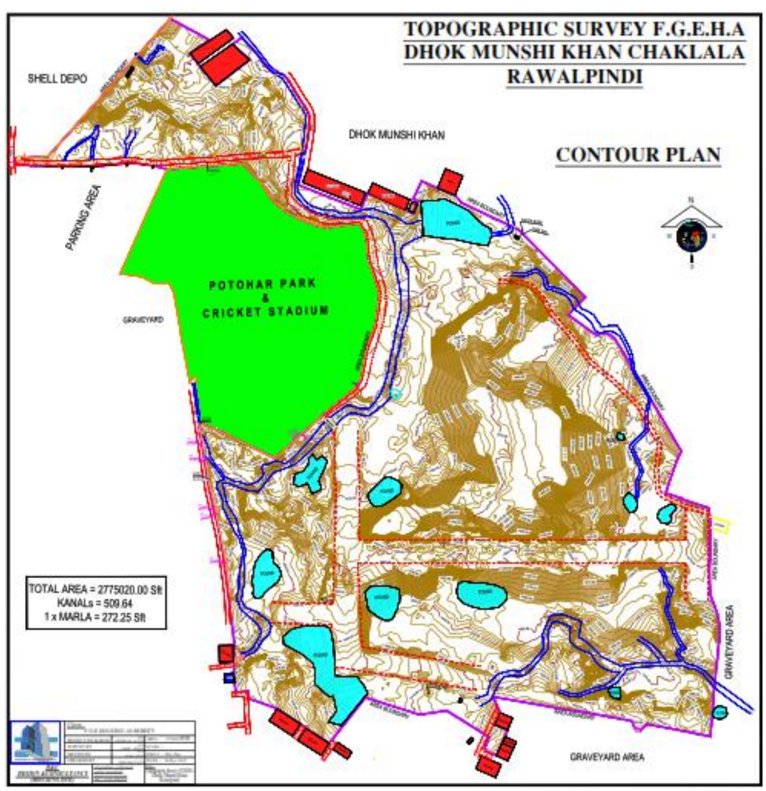
	Timeline	Aug 23	Sept 23	Oct 23	Nov 23	Dec 23	Jan 24	Feb 24	Mar24	Apr 24
1.	Topic + Literature Review									
2.	Methodology									
3.	3D Modelling, Design and Validation of Design of commercial building									
4.	Analysis and validation of precipitation, Design of Stormwater system									
5.	Validation/Verification of Design									
6.	Assessment and Comparison									
7.	Results and Documentation									

3.4 MAPS

Plan of Housing Society



Topographical Map



SOFTWARE INPUTS

- HEC-HMS

The HEC-HMS model simulates rainfall-runoff processes in a dendritic (single outlet) watershed. The model simulates the individual fluxes of the hydrologic cycle, such as snowmelt, infiltration, evapotranspiration, base flow, and channel routing. The model is applicable to a number of analyses, such as flood studies, reservoir spillway design, streamflow forecasting, urban drainage, future urbanization impacts, water quality, erosion and sediment transport.

- HBV-Lite

The HBV model is a semi-distributed hydrologic model to simulate catchment runoff. Below, you can find information on the version HBV-light. You also have the opportunity to download the program and helpful files to get started.

- ETABs

The ETABS is a well-known engineering software that helps in modeling tools and templates, analyzes the methods. Provide solutions and are based on code-based load prescription. It helps with understanding the static and dynamic analysis of shear wall building and multi-story structures.

- BIM Infrastructure

Building Information Modeling (BIM) is an intelligent 3D model-based approach that gives engineering and construction professionals the insight and tools to plan, design, and build highways and bridges more efficiently. The days of sharing documents with via copy plan sets and files from silo to silo through an asset's life are diminishing.

- Revit

Revit is a commercial building information modeling (BIM) software by the company Autodesk. It's generally used by architects, structural engineers, mechanical, electrical, and plumbing (MEP) engineers, designers, and contractors. Autodesk Revit allows users to create, edit, and review 3D models in exceptional detail.

- Twin Motion

Twin motion is a real-time 3D immersion software that produces high-quality images, panoramas and standard or 360° VR videos in seconds. Developed for architecture, construction, urban planning and landscaping professionals, Twin motion combines an intuitive icon-driven interface with the power of Unreal Engine by Epic Games. Twin motion is extremely easy to learn and use, regardless of the size and complexity of the project, the materials, the user's IT knowledge or their preferred BIM modeler.

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