ASSIGNMENT

Course Code	CME511A
Course Name	Building and Allied Services Management
Programme	M. Tech. in CEM
Department	Civil Engineering
Faculty	Dr. S P Sreenivas Padala

Name of the Student:	Sumanth A V
Reg. No:	24ETCE040009
Batch:	2024
Course Leader:	Dr. S P Sreenivas Padala

RAMAIAH UNIVERSITY OF APPLIED SCIENCES

Faculty of Engineering & Technology						
Ramaiah University of Applied Sciences						
Department	Civil Engineering					
Course	M. Tech. in Structural Engineering/ M.Tech in Construction Engineering & Management					
Batch	2024	Course Start Date	16.12.24			
Course Code	CME511A					
Course Title	Building and Allied Services Management	Laboratory	Y	√	**N**	
Course Leader(s)	Dr. S P Sreenivas Padala					

Course Assessment

Reg.No.	24ETCE040009	Name of the Student	**Sumanth A V**

Component -1: (Assignment, Presentation on Assignment submitted and Term Test) (1.A+1.B+1.C)

1.A Assignment 1

Sections		Marking Scheme	Max Marks	First Examiner Marks	Part Total	Second Examiner
Part-A	A.1	Factors affecting the selection of construction site and propose a site	5			
	A.2	Plan multi storey commercial building within 100 ft x 100ft plot.	10			
	A.3	Various structural systems available for proposed building.	7			
	A.4	Selection of an effective structural system for proposed building	8			
		Part-A Max Marks	30			
Part-B	B.1	Importance of constructability assessment	5			
	B.2	Different types of construction loads	5			
	B.3	Constructability scenarios during construction phase	10			
		Part-B Max Marks	20			
		Total Assignment 1	**50**			
		Reduced maximum marks (Assignment 1)	**25**			

1.B Assignment 2

Sections		Marking Scheme	Max Marks	First Examiner Marks	Part Total	Second Examiner
Part-C	C.1	Requirements for efficient performance of a proposed building	2			
	C.2	Various interface problems associated with building services and civil - MEP integration	3			
	C.3	Cost distribution of MEP services and economical design of building services	10			
	C.4	Design of MEP services for a proposed building	10			
		Part-C	**25**			

Presentation on Assignment (1 and 2) submitted

Attribute	**Max Marks**	**Marks First Examiner**	**Marks Second Examiner**
Technical Content	05		
Grasp and Explanation	05		

Quality of Slides and Delivery	05		
Q & A	05		
References and citation of references	05		
Total	**25**		
Total Assignment 2	**50**		
Reduced maximum marks	**25**		
1.C Term Test (100 marks)			
Attribute	**Max Marks**	**First Examiner Marks**	**Second Examiner Marks**
Term test 1	50		
Term test 2/ Tool Test/Laboratory Test/ Tutorials with homework/ Case study	50		
Total	**100**		
Reduced maximum marks (Term test)	**50**		

Marks - Continuous Evaluation				
Component-1	Reduced Maximum Marks	Marks (First Examiner)	Marks (Second Examiner)	**Remarks**
1.A	**25**			
1.B	25			
1.C	50			
Total Marks	**100**			
Reduced to 50 Marks	**50**			
IMPORTANT: Component marks have to be rounded off to the next higher integer and entered in the above fields.				

Course Marks Tabulation							
Component	**Maximum Marks**	**First Examiner**	**Second Examiner**				
Component-1 Total	**50**			Pass		Fail	
Component-2: **SEE**	**50**			Pass		Fail	
Maximum Marks	100			Pass		Fail	
IMPORTANT: 1. Component 1 and 2 total marks have to be rounded off to the next higher integer and entered in the above fields. 2. A minimum of 40% required for a pass in both components.							

Signature of First Examiner

Signature of Second Examiner

RAMAIAH UNIVERSITY OF APPLIED SCIENCES

Declaration Sheet			
Student Name	Sumanth A V		
Reg. No	24ETCE040009		
Programme	M-Tech	Batch	Full-Time 2024
Course Code	CME511A		
Course Title	Building and Allied Services Management		
Course Date	16-December-2024	To	
Course Leader	Dr. S P Sreenivas Padala		

Declaration

The assignment submitted herewith is a result of my own investigations and that I have conformed to the guidelines against plagiarism as laid out in the Student Handbook. All sections of the text and results, which have been obtained from other sources, are fully referenced. I understand that cheating and plagiarism constitute a breach of university regulations and will be dealt with accordingly.

Signature of the student		Date	21-03-2025
Submission date stamp (by Examination & Assessment Section)			

Signature of the Module Leader and date	Signature of Reviewer and date

CONTENTS

A.1 Factors affecting the selection of construction site and propose a site

• Choosing a construction site is an essential phase in the planning and development of any construction endeavor. Various factors influence this choice, ranging from environmental to economic and regulatory aspects. Below are some significant factors that affect the selection of a construction site:

1. Location

• **Proximity to Resources:** The site must be nearby essential resources such as labor, materials, and suppliers.

• **Accessibility:** The site should be readily accessible via road, rail, or other transportation modes for efficient material delivery and transportation of workers.

• **Proximity to Markets:** Being close to target markets can decrease transportation expenses for products and services once the building is up and running.

• **Safety and Security:** The area should present a low risk of crime, natural disasters (e. g. , flooding, earthquakes), or other safety issues.

2. Topography and Soil Conditions

• **Land Slope:** The landscape needs to be appropriate for construction; steep slopes may necessitate extra preparation, raising costs.

• **Soil Stability:** The soil's quality must be evaluated for its capacity to support the structure without the risk of subsidence or uneven settling. Poor soil may lead to costly foundation work.

• **Flood Risks:** Areas susceptible to flooding should be avoided unless mitigation strategies can be implemented.

3. Zoning Laws and Use of Land Zoning constraints: Investigate the regional zoning laws and land land-use plans to make sure the property is earmarked for the planned use (residential, commercial, industrial, etc.).

• **Building codes and permits:** before the project begins obtaining any required permissions and permissions so as to follow local building codes.

• **Environmental Impact:** The building initiative should meet environmental laws regarding water use, energy use, and waste management.

4. Circumstances on the environment Modified design of the building, construction schedule (e.g., extreme temperatures or precipitation), and choice of construction materials used all depend on the local climate.

• Proximity to natural preserves, wetlands, or wildlife habitat affects site selection because of preservation regulations and potential constraints.

Sites with high levels of air, water, or noise pollution can raise costs for mitigation and damage the health of occupants and workers by affecting pollution levels. energy and infrastructure

5. Access to resources: availability of fundamental utilities like water, electricity, natural gas, sewage and telecommunications is essential. Infrastructure Support: Public services (hospitals, existence of close roads, transportation systems, and libraries), schools, etc.) makes the site more suitable for building.

• **Waste Management:** One must have the correct waste handling and disposal facilities.

6. Financial considerations

• **Major determining is land cost;** it affects the general project budget. Locations in first-class areas usually have higher prices.

• **Labor availability:** the availability of trained labor and their cost in the region will affect project timelines and costs.

• **Potential for Future Growth:** The value of the property over time can be increased by a location with future development prospects (e.g., new infrastructure or business growth).

7. Legal and title problems Title and ownership: check land owner and see to it it is free from legal conflicts or encumbrances. Deeds and land titles must be unambiguous.

• **Land history:** Before uses of the land should be checked for any possible environmental pollution or issues, including deserted industrial sites containing dangerous elements.

8. Public Opinion: Before ground is broken, local people and communities might have thoughts or worries to be addressed. Impact on Local Communities: Evaluate how construction and subsequent site usage will affect local communities including employment generation, traffic, and other social factors.

9. Budget and cost considerations

Development Expense: The cost of site development—including land preparation, installing of utilities, and any necessary environmental rehabilitation needs to be taken into account. Long-term maintenance costs related to environmental elements choose a site that lowers them with erosion, floods, or soil erosion.

10. Safety risk notes sites in areas with great amounts of natural disaster risk (earthquakes, floods, tornados) should be subjected to thorough assessment.

• **Welfare of Workers:** If the site is situated in a region known for accidents or dangerous conditions, especially for building workers, think about how safe it would be.

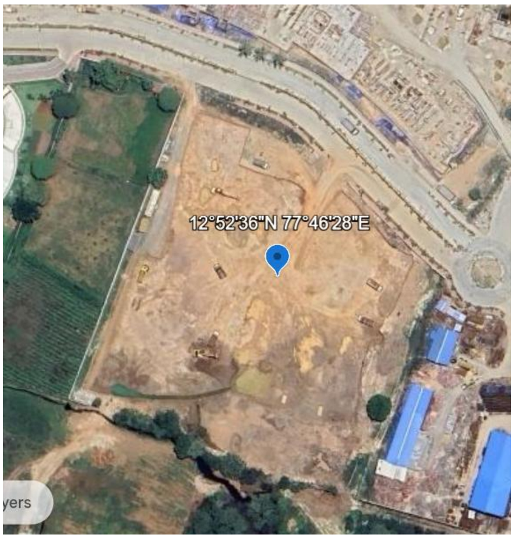

Fig-1 Site location

Fig-2 View of proposed site

A.2 Plan a multi-storey commercial building within 100 ftx100ft plot.

The rules of the selected commercial project in Bengaluru city were examined by the BBMP. The structures FAR, as proposed by BBMP, was approved. According to the bye-laws, a building covering area of 60% (as per Table 6 of bye-law) is required for plot area from 750sq.m to 1000sq.m, and a maximum height 15m is permitted with a FAR of 1.5.

- The minimum setbacks required for a building of height between 12m to 15m is 5m.

- Total plot area in square meters is 929sq.m
- Buildable area maximum is 1.5 * 929 = 1393.5 sq.m.
- Floor count = . = 2.5no. (100% Building coverage area). .
- For 50% Building coverage area, floor count = 5no.

As a result, the project is looking at G + 3 floors for the number of floors (without basement).

Land size = 100ft x 100ft

Maximum Buildup Area

Area covered Floor count = 1393.5 sq.m = 60% of 929 = 557.4 sq.m

Floor count = 5no. (maximum)

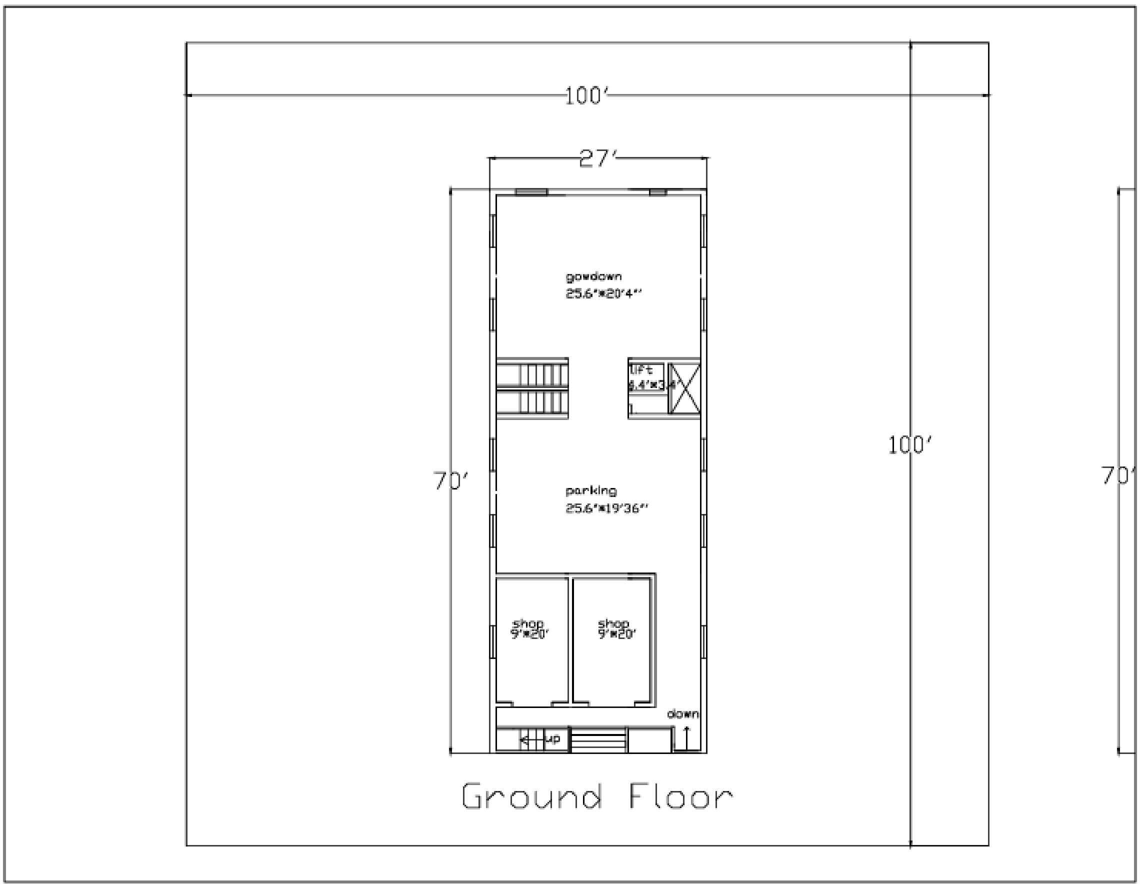

Fig-3 Ground Floor Plan.

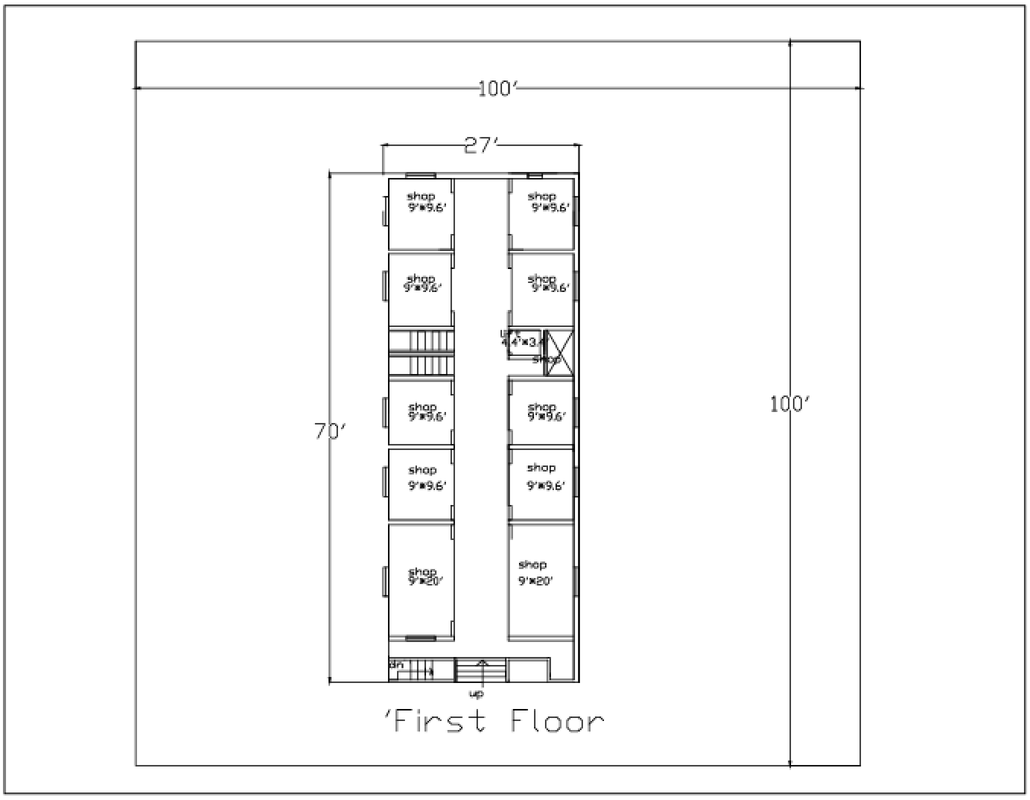

Fig-4 First Floor Plan.

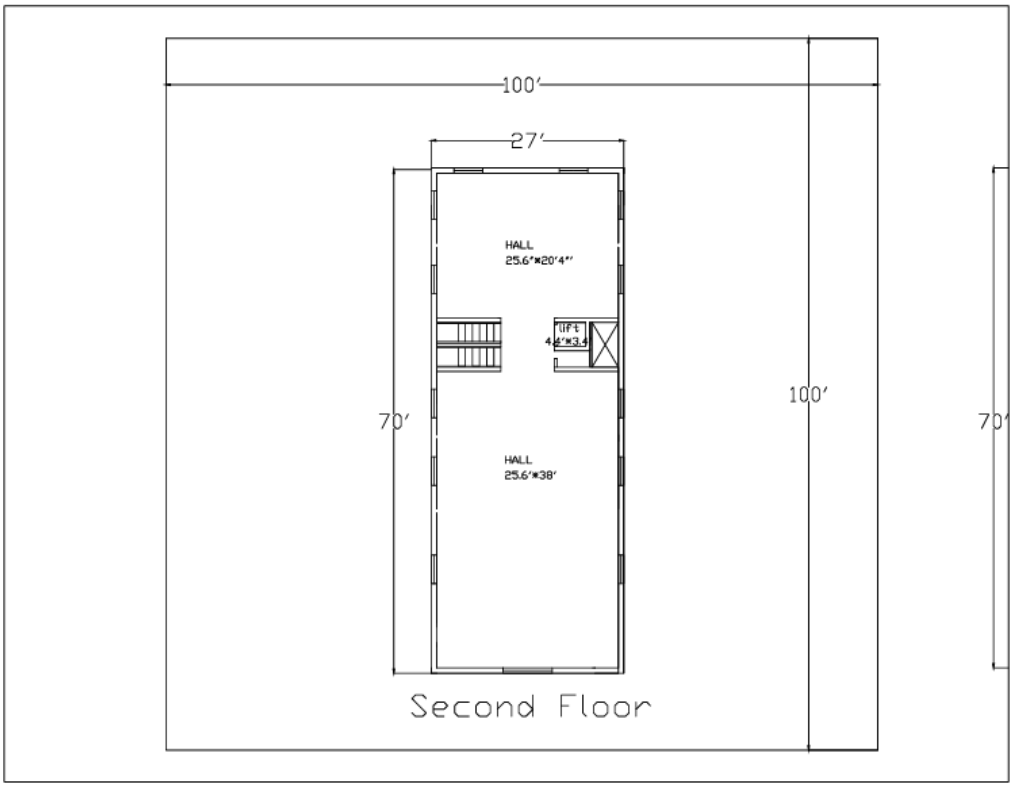

Fig-5 Second Floor Plan.

A.3 Various structural systems available for proposed building.

1. Steel structural systems:

Fig-6 Steel structural systems

• **Steel Frame System:** Steel beams and columns support it. Good for big-span constructions and multi-story structures.

• Braced frame system includes diagonal bracing to counteract side forces, like winds and earthquakes.

• Moment-Resisting Frame is based on stiffening links between beams and columns that help the structure resist lateral pressures.

• Steel Truss System: Appropriate for wide-range buildings including stores and theaters.

2. Reinforced Concrete Systems

Fig-7 Reinforced Concrete Systems

• **Rigid Frame System:** Beams and columns are formed as a single unit to withstand lateral and vertical loads.

• **Shear Wall System:** Vertical walls constructed to endure lateral loads, typically utilized in tall buildings.

• **Flat Slab and Flat Plate System:** Slabs that lack beams create a versatile open area, frequently employed in office spaces and parking facilities.

• **Post-Tensioned Concrete:** Incorporates tensioned cables within concrete slabs for enhanced strength and decreased material use.

3. Composite Structural Systems

Fig-8 Composite Structural Systems

• **Steel-Concrete Composite:** Incorporates steel columns and beams paired with concrete slabs for superior strength and effective load management.

• **Precast Concrete System:** Off-site manufactured components (walls, slabs, columns) are put together on location, accelerating the construction process.

4. Load-Bearing Masonry System

Fig-9 Load-Bearing Masonry System

• Appropriate for low-rise commercial structures.

• Employs brick, concrete, or stone walls to carry structural loads.

5. Timber Structural Systems

Fig-10 Timber Structural Systems

• **Heavy Timber Frame:** Substantial wooden beams and columns for visually appealing and eco-friendly designs.

• **Cross-Laminated Timber (CLT):** Pre-manufactured wood panels utilized for walls, floors, and roofs.

6. Space Frame and Shell Structures

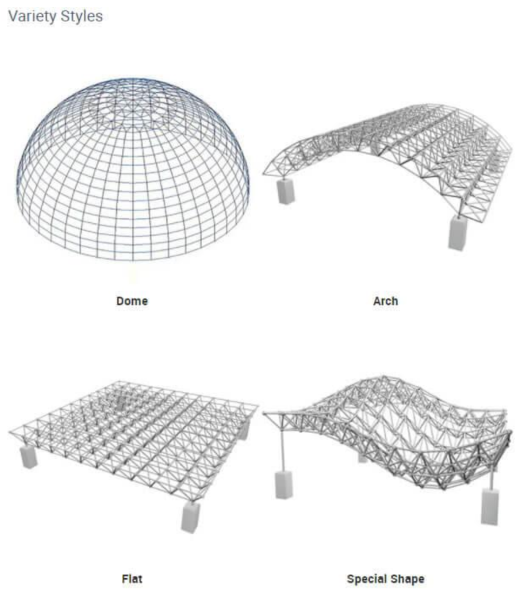

Fig-11 Space Frame and Shell Structures

• **Space Frame System:** A three-dimensional truss framework composed of linked steel or aluminum components, utilized for expansive spans.

• **Shell Structures**: Slim, curved surfaces such as domes and folded plates, commonly employed in stadiums and airports.

7. Tensile and Fabric Structures

Fig-12 Tensile and Fabric Structures

• Employs high-strength cables and membranes to form lightweight, adaptable enclosures (e. g. , sports arenas, exhibition halls).

8. Hybrid Structural Systems

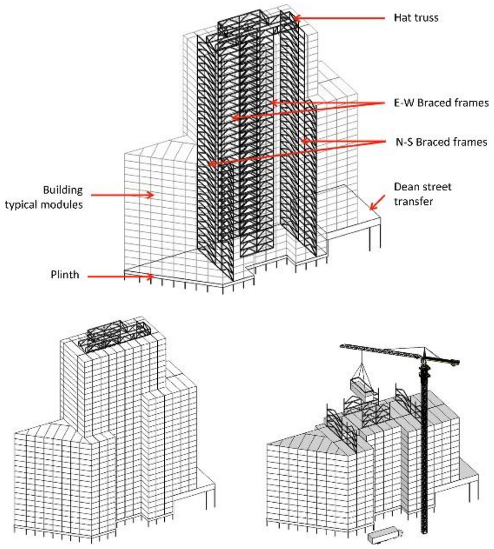

Fig-13 Hybrid Structural Systems

• An amalgamation of steel, concrete, and other materials to enhance performance, like a core shear wall paired with an external steel frame.

A.4 Selection of an effective structural system for proposed building

Criteria	**Steel Frame**	**Reinforced Concrete Frame**	**Precast Concrete**
Material	Structural steel beams and columns	Reinforced concrete columns and beams	Precast concrete elements (walls, beams, slabs)
Construction Speed	Fast (prefabricated components, easy assembly)	Moderate (on-site casting requires curing time)	Very fast (factory-made components, quick installation)
Cost	Higher material cost, lower labor cost	Moderate cost Lower material cost, reduced labor cost	reduced labor cost

Flexibility in Design	Highly flexible (long spans, open floor plans)	Moderate flexibility	Limited flexibility (predefined element sizes)
Structural Performance	Excellent strength-to-weight ratio, good seismic resistance	Strong but heavier, good for seismic zones	Strong and durable, but heavier than steel
Sustainability	Recyclable steel, lower carbon footprint if locally sourced High	embodied carbon, but durable	More sustainable with proper production methods
Maintenance	Low maintenance but prone to corrosion if not protected Minimal maintenance but risk of cracking	Minimal maintenance but risk of cracking Low maintenance, but repairs may be complex	Low maintenance, but repairs may be complex
Fire Resistance	Needs fireproofing (coatings, encasement)	Naturally fire-resistant	Naturally fire-resistant
Seismic Performance	Excellent ductility, absorbs seismic forces well Good, but heavier structure may increase seismic loads	Good, but heavier structure may increase seismic loads Good seismic performance if properly designed	Good seismic performance if properly designed
Best For	Large open spaces, fast-track projects, high seismic areas	Mid-range budgets, conventional office buildings	Budget-conscious projects, rapid construction needs

Justification for Selecting the Reinforced Concrete Frame System

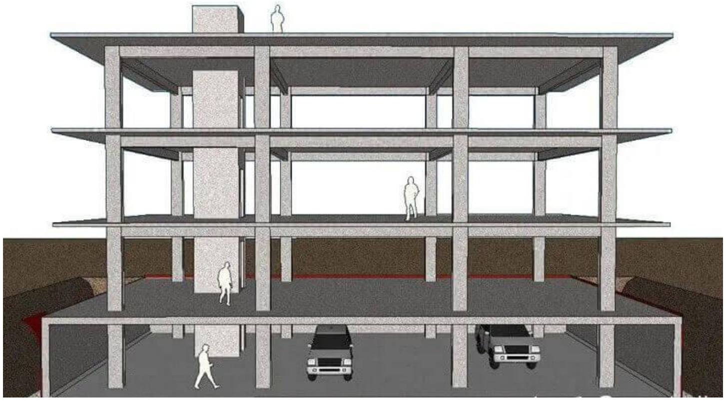

Fig-14 Reinforced Concrete Frame System

The Reinforced Concrete Frame System stands out as an exceptionally effective option for mid-rise offices, hotels, and hospitals owing to its durability, fire resistance, and cost efficiency. This system comprises columns and beams that create a rigid framework, offering remarkable load-bearing capabilities and ensuring long-term structural integrity.

One of its primary benefits is its built-in fire resistance, which improves safety in commercial and institutional structures. Moreover, reinforced concrete is readily available locally and is budget-friendly, rendering it a sensible choice for developments that require a balance between structural quality and financial limitations.

The design versatility in reinforced concrete frames enables tailored floor plans, catering to various architectural and functional requirements. Additionally, it performs effectively in seismic regions when designed with shear walls, making it a dependable and adaptable solution for numerous commercial uses.

B.1 Importance of constructability assessment

Constructability assessment is an essential procedure during the planning and design stages of construction projects. It concentrates on analyzing the feasibility and simplicity of executing a design, aiming to uncover possible difficulties prior to the start of construction. Here's why it's crucial:

1. Cost Savings

By evaluating constructability at an early stage, potential problems that might result in expensive alterations or delays can be pinpointed. Modifying designs or procedures to enhance their constructability can greatly cut down the total expenses of the project.

2. Improved Project Timeline

Constructability assessments aid in expediting the construction process. Spotting potential barriers, inefficiencies, or unclear aspects of the design can avert delays, ensuring that the project progresses as planned.

3. Risk Mitigation

It assists in recognizing risks associated with labor, materials, and equipment. By identifying these concerns early, construction teams can adopt proactive measures to alleviate them, decreasing the chances of incidents or unexpected issues during construction.

4. Enhanced Quality

Confirming that a design is feasible in practical terms helps uphold high-quality benchmarks. It allows for a more realistic strategy regarding construction methods, materials, and techniques, thereby enhancing the overall quality of the final product.

5. Better Collaboration

Involving the construction team during the initial stages (design phase) encourages cooperation among architects, engineers, and contractors. This early participation aids in incorporating practical insights and feedback, which can improve the feasibility of the design.

6. Compliance and Safety

A constructability assessment can verify that the design adheres to safety standards and building regulations. Detecting design flaws or safety hazards early on enables easier modifications to conform to legal and regulatory standards.

7. Resource Optimization

The assessment assists in pinpointing the most effective utilization of resources, such as labor, equipment, and materials. This leads to improved resource distribution and minimized waste.

8. Sustainability

Early analysis of constructability can promote more sustainable methods, as it may reveal chances to implement eco-friendly materials or processes that enhance the project's energy efficiency or resource conservation.

B.2 Different types of construction loads

Construction loads are the different forces and stresses that act on a structure throughout its design, construction, and operation. Comprehending these loads is vital for guaranteeing the safety, stability, and longevity of a building or infrastructure. Here are the primary categories of construction loads:

1. Dead Loads

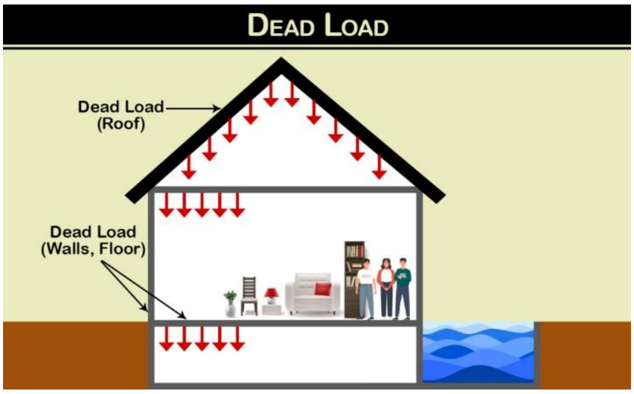

Fig-15 Dead Loads

• **Definition:** These are the fixed loads on a structure that arise from its own weight and the weight of all immovable elements (e. g. , walls, floors, roof, beams, columns, etc.)

Examples:

• Weight of building materials such as concrete, steel, and roofing.

• Permanent fittings like built-in furniture, equipment, or plumbing systems.

2. Live Loads

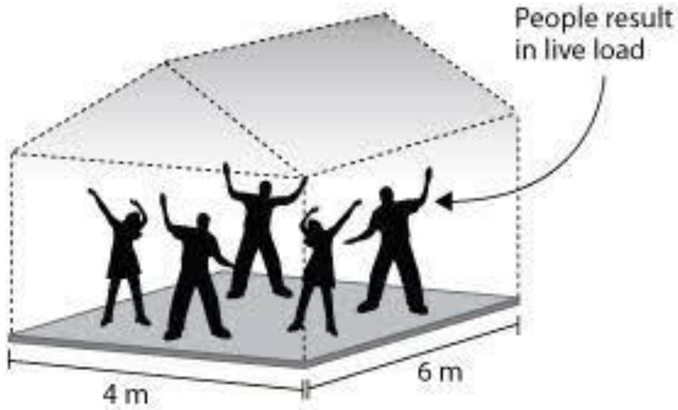

Fig-16 Live Loads

• **Definition:** These are temporary or movable loads that a structure is intended to support. They may vary over time based on usage.

• Examples:

• Occupants of the building (people).

• Furniture and movable items.

• Vehicles in parking garages.

• Accumulated snow on roofs.

3. Wind Loads

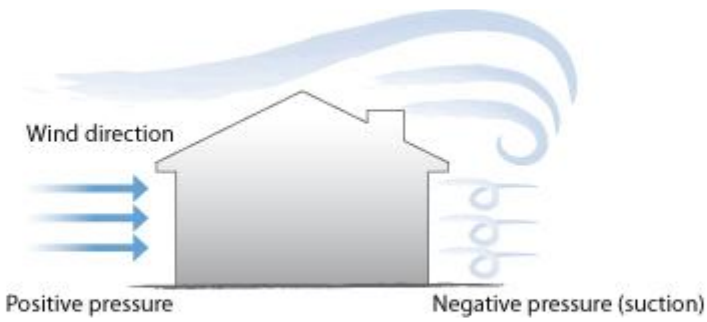

Fig-17 Wind Loads

• Definition: These loads arise from the force applied by wind pressure on the structure. Wind loads differ based on factors like wind speed, height of the structure, and location.

• Examples:

• Lateral forces acting against the building's surfaces.

• Uplift forces on roofs or tall structures.

4. Seismic Loads (Earthquake Loads)

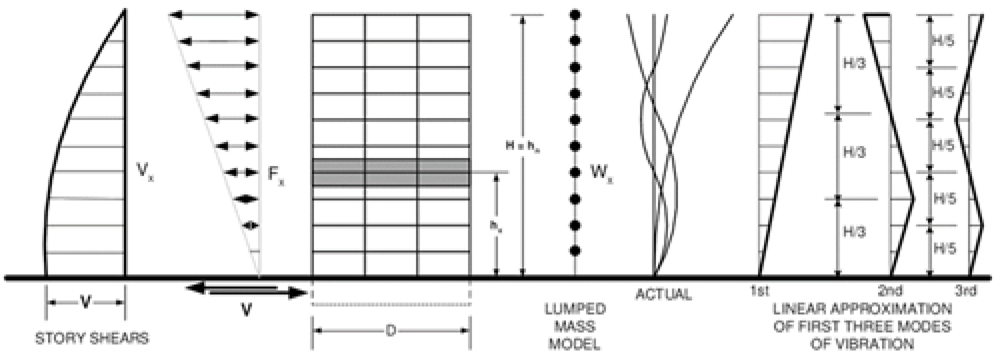

Fig-18 Seismic Loads (Earthquake Loads)

• **Definition:** These loads are generated by the forces produced by earthquakes, resulting in ground motion and vibrations that impact the structure.

• Examples:

• Lateral forces that create horizontal shaking.

• Vertical forces due to ground shaking.

5. Snow Loads

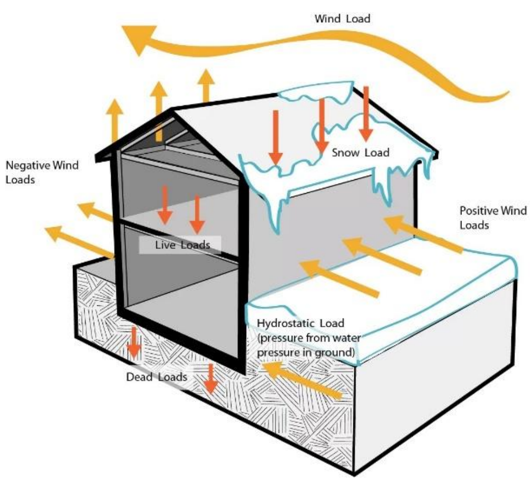

Fig-19 Snow Loads

• **Definition:** These are the loads caused by snow buildup on a building's roof or other surfaces. The amount of snow varies with climate, temperature, and local snowfall trends.

• Examples:

• Snow buildup on roofs, balconies, and various surfaces.

• Ice accumulation that adds extra load.

6. Thermal Loads

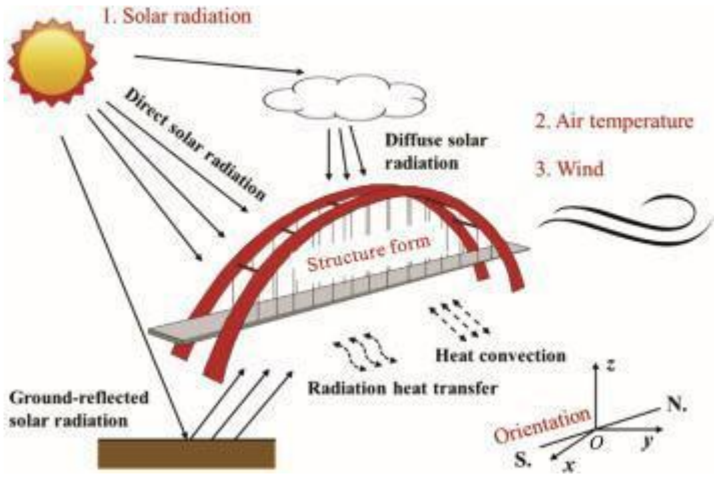

Fig-20 Thermal Loads

• **Definition:** These loads are induced by temperature fluctuations that lead to the expansion or contraction of building materials.

• Examples:

• Expansion and contraction of steel beams and concrete as temperatures vary.

• Material movement caused by heating and cooling cycles.

7. Construction Loads

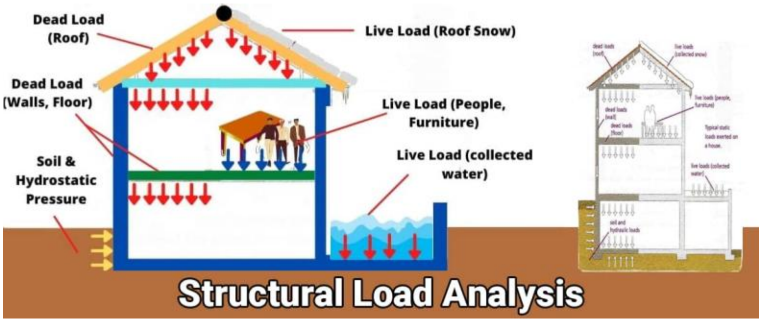

Fig-21 Construction Loads

• **Definition:** These are the loads imposed on a structure during the construction phase. They may be temporary and include loads from machinery, workers, or building materials.

• Examples:

• Machinery like cranes or scaffolding.

• Construction materials such as steel beams, concrete, and formwork.

8. Impact Loads

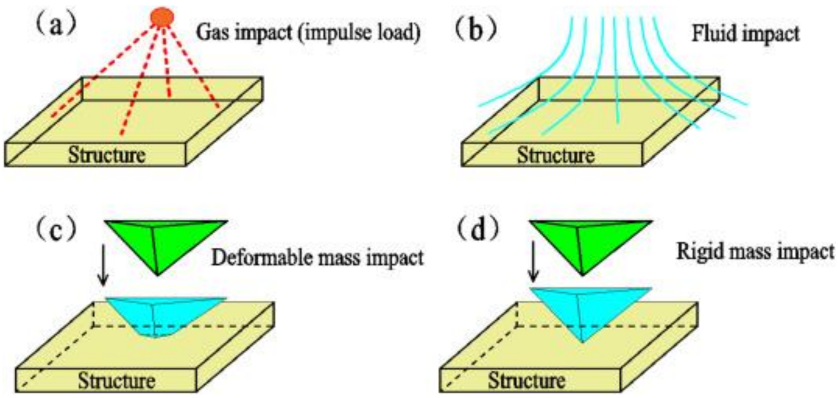

Fig-22 Impact Loads

• **Definition:** These are brief loads that occur when an object strikes a structure, usually involving rapid or sudden application of force.

• Examples:

• Impacts from vehicles.

• Falling debris or objects.

• Equipment impacts or accidents.

9. Hydrostatic Loads

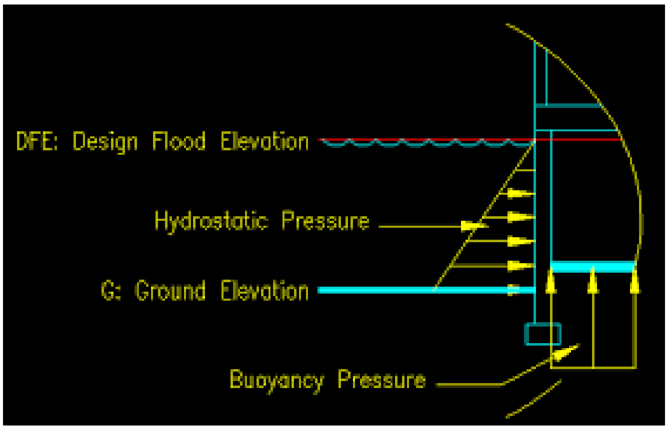

Fig-23 Hydrostatic Loads

• **Definition:** These loads result from the pressure exerted by water on a structure, particularly in foundations or underground structures.

• Examples:

• Groundwater pressure on basement walls.

• Forces from saturated soil on underground structures.

10. Soil Loads

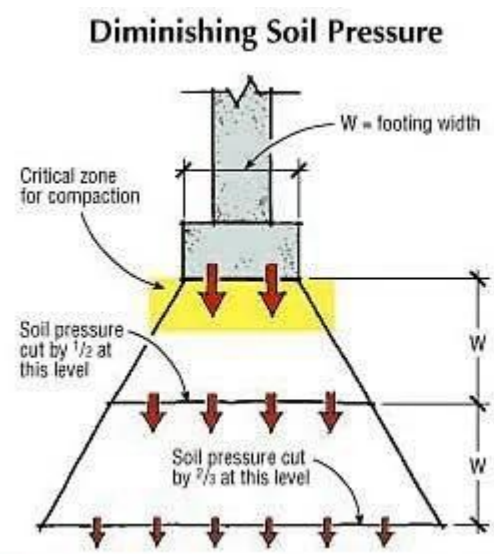

Fig-24 Soil Loads

• **Definition:** These loads stem from the pressure applied by soil on the foundations of a structure. The weight of the soil and its movement or settling can influence a building's foundation.

• Examples:

• Settlement or shifting of soil beneath the foundation.

• Soil pressure on retaining walls.

11. Construction Equipment Loads

Fig-25 Construction Equipment Loads

• **Definition**: These loads pertain to the forces exerted by heavy construction machinery and equipment utilized during the building process.

• Examples:

• Cranes, excavators, and bulldozers that exert localized pressures on foundations or slabs.

12. Live Load Variations

• **Definition:** These pertain to alterations in the live load resulting from changes in use or occupancy.

• Examples:

• Alterations in occupancy density (increased number of individuals in a room or building).

• Variations in the kinds of equipment or machinery utilized within a space.

B.3 Constructability scenarios during construction phase

During the construction phase, constructability scenarios can arise that influence how smoothly the project advances. These scenarios usually involve practical obstacles, design problems, or unforeseen circumstances that may necessitate modifications to preserve efficiency, quality, and safety. Below are several frequent constructability scenarios encountered during the construction phase:

1. Unforeseen Site Conditions

• **Scenario:** While excavating or working on the foundation, workers come across unexpected soil conditions, such as rock, underground water, or contaminated soil.

• **Impact:** This could postpone construction, elevate costs, and necessitate alterations in design or methods (e. g. , extra reinforcement or different foundations).

• **Solution:** Reassessing the foundation design, modifying construction techniques (e. g. , drilling instead of digging), or implementing dewatering procedures.

2. Design Issues with Buildability

• **Scenario:** The design necessitates construction methods that are challenging to execute, such as intricate connections between building components that are difficult to assemble or align.

• **Impact**: Labor-intensive and time-consuming work, potential safety hazards, or installation errors.

• **Solution:** Redesigning or streamlining certain connections, utilizing prefabricated components, or changing materials to facilitate easier assembly.

3. Material Shortages or Supply Chain Delays

• **Scenario:** A scarcity or delay in the delivery of essential materials (e. g. , steel, concrete, specialized finishes) obstructs progress.

• **Impact:** Delays in the project timeline, rescheduling of work, potential cost increases, and inefficient use of labor.

• **Solution:** Identifying alternative materials, adjusting the construction schedule to concentrate on tasks not reliant on the delayed materials, or locating new suppliers.

4. Labor Shortages

• **Scenario:** A deficiency of skilled labor, either due to workforce unavailability, high turnover, or inadequate training, results in delays and potential quality concerns.

• **Impact:** Diminished productivity, construction errors, and delays in crucial tasks.

• **Solution:** Hiring additional workers, providing on-site training, adjusting tasks to accommodate available skill sets, or subcontracting specific tasks to specialized firms.

5. Inaccurate As-Built Conditions

• **Scenario:** The actual site conditions (existing structures, utilities, etc.) differ from how they were depicted in the design drawings, resulting in conflicts or clashes with the planned construction.

• **Impact:** Extra costs to amend discrepancies, project delays, and increased rework.

• **Solution:** Conducting thorough site surveys prior to commencing construction, utilizing 3D modeling (BIM) to pinpoint potential clashes, and making necessary design modifications.

6. Equipment Breakdown

• **Scenario:** Heavy machinery or critical equipment (cranes, excavators, etc.) unexpectedly breaks down during construction.

• **Impact:** Delays in finishing tasks that require heavy lifting or machinery, increased rental expenses, and potential safety risks.

• **Solution:** Ensuring regular maintenance of equipment, having backup machinery on-site, or altering the schedule to allow for maintenance or replacement.

7. Safety Concerns and Hazards

• **Scenario:** During construction, unforeseen safety hazards emerge, such as unstable scaffolding, hazardous materials, or unsafe work practices.

• **Impact:** Worker injuries, project delays, fines, and damage to the project's or contractor's reputation.

• **Solution:** Carrying out regular safety audits, addressing safety issues promptly, implementing improved safety protocols, or utilizing more protective equipment.

8. Changes in Local Regulations

• **Scenario:** Mid-construction, local authorities enforce new building codes or zoning regulations that necessitate design modifications or construction adjustments.

• **Impact**: Additional compliance costs, project delays, and possible redesigns.

• **Solution:** Frequently monitoring for regulatory changes, keeping in touch with local organizations, and allowing for adaptability in the design to accommodate regulatory updates.

9. Coordination Issues Among Trades

• **Scenario:** Various construction teams (e. g. , electrical, plumbing, HVAC) encounter coordination challenges, such as conflicting timelines or work misalignment.

• **Impact:** Setbacks in one area can delay others, leading to a chain reaction of setbacks and possible rework.

• **Solution:** Enhanced project management and communication, utilizing integrated scheduling software, having regular coordination meetings, and establishing clear transition points for each trade.

10. Unforeseen Weather Conditions

• **Scenario**: Severe weather events, such as heavy rainfall, snowfall, or strong winds, hinder construction activities, primarily outdoor work.

• **Impact:** Work progress setbacks, safety issues, and potential material damage.

• **Solution:** Creating a weather contingency strategy, rescheduling specific tasks, and using weather-resistant materials or coverings during the building process.

11. Incorrect or Incomplete Documentation

• **Scenario:** Mistakes in the construction documents (drawings, specifications, or instructions) cause misinterpretations or incomplete building execution.

• **Impact:** Rework, increased expenses, and delays while making corrections.

• **Solution:** Frequently checking documentation for mistakes before commencing construction, employing BIM for more precise modeling, and delivering clear directions to the construction crew.

12. Utility Interruption or Disruptions

• **Scenario**: Unexpected utility problems (water, gas, electricity) interrupt construction activities, either from outages or the need to redirect utilities on-site.

• **Impact**: Delays, extra costs, and potential redesigns to adjust for utility rerouting.

• **Solution:** Early detection and relocation of utilities, close collaboration with utility providers, or altering the timeline around utility-related tasks.

13. Scheduling Conflicts

• **Scenario:** Delays in one segment of the construction project (e. g. , foundation pouring) create a ripple effect, postponing subsequent tasks or resulting in overlaps in work.

• **Impact:** Inefficient labor utilization, overlapping activities, and delays in the overall project timeline.

• **Solution:** Implementing a more thorough and adaptable construction timeline, prioritizing critical path tasks, and ensuring improved task sequencing.

14. Quality Control Issues

• **Scenario:** Inferior materials or craftsmanship result in defects that necessitate rework or repairs, influencing the overall quality and schedule.

• **Impact**: Elevated costs for material substitutions or labor, delays in project completion, and reduced client satisfaction.

• **Solution:** Stringent quality control protocols, regular inspections, improved material sourcing, and promptly addressing quality concerns.

Constructability scenarios during construction phase

Here are answers to the constructability scenarios during the construction phase, based on the second question where we recognized some common scenarios:

1. Unforeseen Site Conditions

• **Solution:**

• **Conduct Pre-Construction Site Surveys:** Ensure comprehensive geotechnical surveys and environmental testing take place before commencing construction to gain a better understanding of site conditions.

• **Flexible Design Adjustments:** Design foundations and structures with adaptability to accommodate unexpected situations, such as differing soil types.

• **Contingency Plans:** Establish contingency budgets and time allowances for unanticipated challenges like rock, water, or hazardous soil.

2. Design Issues with Buildability

• **Solution:**

• **Collaborative Design Review:** Schedule regular design assessments with architects, engineers, and contractors to evaluate practical constructability during the design phase.

• Simplify Design Elements: Streamline complex connections, joints, and materials that may be challenging to construct on-site.

• Prefabrication: Utilize prefabricated components or modular construction for intricate parts to ease the build process and enhance quality control.

• Alternative Materials: Select materials that are easier to manage and install, if necessary.

3. Material Shortages or Supply Chain Delays

• **Solution:**

• **Early Procurement and Stockpiling:** Acquire essential materials at the project's outset and ensure a buffer stock for crucial items that may encounter supply interruptions.

• **Alternative Sourcing:** Locate alternative suppliers or substitute materials that meet the project's quality specifications and prevent delays. Supply Chain Management: Establish an effective supply chain management system to monitor materials in real-time and predict delays.

4. Labor Shortages

• **Solution:**

• **Skilled Workforce Development:** Provide training programs for current workers to enhance their skills, ensuring that labor is well-prepared for specialized tasks.

• **Subcontracting:** Employ specialized subcontractors for particular assignments where in-house labor may be insufficient.

• **Incentive Programs:** Introduce performance incentives to motivate the retention of skilled workers and boost productivity.

5. Inaccurate As-Built Conditions

• **Solution:**

• **Updated Surveys and Modeling:** Prior to starting major construction, conduct precise site surveys, and utilize Building Information Modeling (BIM) to refresh design documents.

• **Clash Detection:** Employ BIM or other clash detection tools to identify and resolve discrepancies between the design and actual site conditions.

• **Close Coordination:** Ensure strong coordination between the design team and the construction crew for ongoing updates on site conditions.

6. Equipment Breakdown

• **Solution:**

• **Regular Maintenance:** Guarantee that all construction equipment is routinely maintained and serviced to avoid breakdowns during critical phases.

• **Backup Equipment:** Keep backup machinery available on-site, particularly for essential tasks, or make arrangements with rental companies for prompt equipment replacement.

• **Monitor Equipment Health:** Implement monitoring systems that track the condition and usage of vital machinery, facilitating predictive maintenance.

7. Safety Concerns and Hazards

• **Solution:**

• **Safety Audits and Risk Assessments:** Execute daily or weekly safety audits and risk evaluations to pinpoint potential hazards on-site.

• **Safety Training:** Provide continuous safety training for all workers, emphasizing the correct utilization of equipment and protective measures.

• **On-Site Safety Officers:** Appoint a qualified safety officer to ensure all workers comply with safety protocols and promptly address any issues.

8. Changes in Local Regulations

• **Solution:**

• **Stay Updated with Regulations:** Consistently check for updates on local building codes, zoning regulations, and safety standards to remain informed of potential changes.

• **Design Flexibility:** Incorporate flexibility in the design and project timeline to manage possible regulatory changes without major interruptions.

• **Engagement with Authorities:** Keep consistent communication with local authorities to clarify requirements and resolve any uncertainties.

9. Coordination Challenges Among Trades

• **Solution:**

• **Project Scheduling Integration:** Create a comprehensive project schedule utilizing construction scheduling software that harmonizes the efforts of all trades and guarantees timely coordination.

• **Regular Coordination Gatherings**: Conduct weekly or bi-weekly coordination gatherings to address issues promptly, review overlapping tasks, and tackle conflicts.

• **Transparent Documentation:** Ensure all work orders, plans, and communication are well-documented and available for all team members.

10. Unexpected Weather Conditions

• **Solution:**

• **Weather Delay Planning:** Factor in weather-related delays in the project schedule and prepare contingency plans for severe weather scenarios, such as employing weatherproof covers for outdoor activities.

• **Reorganize Crucial Tasks:** If adverse weather is predicted, reorganize tasks that are not dependent on weather conditions (e. g. , indoor finishing activities).

• **Weather-Resistant Materials**: Utilize materials that can endure short-term exposure to adverse weather conditions or shield sensitive materials on-site.

11. Incorrect or Insufficient Documentation

• **Solution:** Review and Approval Procedures: Implement a comprehensive review and approval process for all construction documents prior to finalization.

• **Clear Communication:** Utilize detailed and precise specifications, and provide clear documentation for every aspect of the project to prevent misunderstandings.

• **BIM Implementation:** Deploy BIM technology to generate 3D visualizations that assist in identifying any inconsistencies between drawings and the actual construction.

12. Utility Interruptions or Disruptions

• **Solution:**

• **Utility Surveys Before Construction:** Prior to the commencement of construction, confirm that a thorough survey of existing utilities has been performed, and utility maps have been revised.

• **Utility Coordination:** Collaborate with local utility providers to prevent unexpected interruptions during construction, or identify locations where utilities can be temporarily disabled or redirected.

• **Contingency Plans:** Establish a backup power plan, such as temporary generators, in case of electrical outages.

13. Conflicts in Scheduling

• **Solution:**

• **Critical Path Method (CPM):** Utilize CPM or other advanced scheduling methodologies to prioritize tasks and determine dependencies, ensuring that critical tasks are completed punctually.

• **Float Management:** Identify sections of the schedule that have some leeway (float) and adjust tasks as needed to prevent delays on the critical path.

• **Ongoing Progress Monitoring:** Hold daily or weekly progress meetings to evaluate milestones and confirm that the project remains on schedule.

14. Quality Control Challenges

• **Solution:**

• **On-Site Inspections:** Perform routine inspections to verify that quality standards are fulfilled and materials are installed properly.

• **Quality Control Strategy:** Develop a comprehensive quality control strategy that specifies materials, methods, and criteria for inspections.

• **Third-Party Testing:** Engage third-party quality assurance services to evaluate materials and workmanship, ensuring compliance with project specifications.

C.1 Requirements for efficient performance of a proposed building

1. Structural Performance Requirements

A properly designed structural system must guarantee stability, strength, and safety in varying conditions:

• **Load-Bearing Capacity**: Must accommodate dead loads, live loads, wind loads, and seismic forces without significant deflection.

• **Lateral Stability:** Implementation of reinforced concrete frames, shear walls, or braced frames to withstand earthquakes and wind loads.

• **Foundation Design:** A robust and stable foundation system (pile, raft, or strip footing) tailored to soil conditions.

• **Material Durability:** Application of high-strength concrete, steel reinforcement, and corrosion-resistant materials to ensure longevity.

• **Seismic and Wind Resistance:** Designed according to seismic codes (IS 1893, ACI 318, Eurocode 8) and wind standards.

2. Architectural and Functional Efficiency

The design must emphasize space usage, flexibility, and accessibility to improve functionality:

• **Efficient Space Planning:** A well-organized layout for offices, retail areas, service zones, and circulation spaces.

• **Flexibility in Design:** Modular design to permit future alterations and expansions.

• **Fire Safety and Egress Routes:** Adherence to fire codes (NFPA, NBC) including fire exits, sprinklers, and emergency staircases.

• **Aesthetic and Ergonomic Design:** A balance between visual appeal, comfort, and accessibility (ADA compliance).

3. Mechanical, Electrical and Plumbing (MEP) Requirements

Effective MEP systems guarantee smooth operations, safety, and energy efficiency:

• **HVAC (Heating, Ventilation and Air Conditioning):** Adequate air circulation, energy-efficient cooling/heating systems.

• **Electrical System:** Sufficient power supply, backup generators, and renewable energy integration (solar, wind).

• **Plumbing and Water Supply:** Leak-proof water distribution, wastewater management, and rainwater harvesting systems.

• **Fire Protection Systems:** Automatic sprinklers, fire alarms, smoke detectors, and fire-resistant materials.

4. Sustainability and Energy Efficiency

An eco-friendly building approach boosts sustainability and decreases operational costs:

• **Energy-Efficient Design:** LED lighting, smart controls, energy-efficient appliances.

• **Sustainable Materials:** Utilization of low-carbon concrete, recycled steel, and environmentally friendly finishes.

• Water Conservation: Rainwater harvesting, greywater recycling, and low-flow fixtures.

• **Thermal Insulation and Green Roofs:** Enhances energy efficiency and diminishes the heat island effect.

• **Smart Building Technology:** IoT-based automation, real-time monitoring of energy use.

5. Construction and Maintenance Efficiency

For a commercial building to be cost-effective and durable:

• **Quality Control During Construction: Frequent** material testing, non-destructive testing (NDT), and structural monitoring.

• **Prefabrication and Modular Construction:** Minimizes construction time and enhances precision.

• **Lifecycle Cost Analysis:** Choosing materials and systems that lower long-term maintenance expenses.

• **Regular Maintenance Plan:** Scheduled inspections, repairs, and upgrades to prolong building longevity.

C.2 Various interface problems associated with building services and civil - MEP integration

The combination of Building Services (including HVAC, plumbing, electrical, and fire protection systems) with civil engineering and MEP (Mechanical, Electrical, and Plumbing) systems is an essential component of construction and can lead to various interface challenges. These challenges stem from the intricacies of synchronizing distinct systems that must work together harmoniously within a building framework. Below are some of the most prevalent interface challenges and their possible resolutions.

1. Clash Between Structural and MEP Systems

• Problem:

MEP systems frequently conflict with structural components, such as beams, columns, or slabs, because of restricted available space. This can result in obstacles when routing ducts, pipes, or cables, necessitating expensive redesigns or delays.

• Cause:

A lack of adequate coordination among structural engineers, architects, and MEP designers during the initial design phase.

• Solution:

• **BIM (Building Information Modeling):** Employ BIM to model all systems and detect clashes in the virtual environment before construction commences.

• **Early Coordination:** Conduct regular design meetings and foster collaboration between structural, civil, and MEP teams to guarantee that space allocation is thoroughly planned.

2. Coordination Between Different MEP Systems

• Problem:

Several MEP systems (e. g. , HVAC, plumbing, electrical, fire protection) may not properly align or may vie for the same spaces within walls, ceilings, and floors.

• Cause:

Inadequate comprehensive planning to accommodate all systems, or dependence on individual system designs without considering the complete layout.

• **Solution:**

• **Integrated Design Approach:** Embrace an integrated design approach where MEP engineers collaborate closely with civil and structural engineers from the outset to ensure that systems are optimized and fit within the designated space.

• **Use of Multi-disciplinary Coordination Software:** Utilize tools like Navisworks or Revit for coordination and clash detection across all systems.

3. Access for Maintenance

• **Problem:**

Limited space or inappropriate positioning of MEP systems makes maintenance or future upgrades challenging, especially if systems are concealed behind structural elements or in difficult-to-access locations.

• **Cause:**

A lack of planning for maintenance access when designing the MEP and structural systems.

• **Solution:**

• **Maintenance Access Planning:** Design the layout with specific maintenance access points, such as service ducts, crawl spaces, or raised floors.

• **Clearance Requirements:** Adhere to industry standards for clearances around MEP systems to ensure safe and convenient access for repairs, replacements, or upgrades.

4. Vibration and Noise Interference

• **Problem**:

Vibrations and noise produced by mechanical systems (e. g. , HVAC, pumps, or elevators) can disrupt the comfort of building occupants, particularly in sensitive areas like classrooms or offices.

• Cause:

Inaccurate installation or insufficient isolation between mechanical systems and the building structure can lead to the transmission of noise and vibration.

• Solution:

• **Vibration Isolation:** Utilize vibration-damping materials and decoupling techniques to separate mechanical systems from structural elements.

• **Acoustic Insulation:** Implement noise-reducing solutions such as soundproofing materials in ceilings, walls, and floors surrounding loud MEP systems.

• **System Placement:** Carefully locate noisy equipment away from sensitive areas or install sound barriers.

5. Overloading of Services

• Problem:

MEP systems may become overloaded owing to improper sizing or incorrect load calculations, resulting in inefficiencies, system failures, or subpar service performance.

• Cause:

Poor coordination between the design and the actual load requirements of the building services, especially when the demand rises (e. g. , an increase in electrical load or water consumption).

• Solution:

• **Comprehensive Load Analysis:** Ensure a detailed analysis of the building's load needs, considering potential future expansions or alterations in usage.

• **Redundancy in Critical Systems:** For essential systems like power supply or fire protection, include redundancy to accommodate unforeseen demand increases.

6. Conflicting Codes and Standards

• Problem:

Civil, structural, and MEP systems must adhere to various codes, standards, and regulations, which may result in conflicts or non-compliance if not effectively coordinated.

• **Cause:**

Inability to align the design with local building codes, MEP regulations, or safety standards, particularly within multi-disciplinary teams.

• **Solution:**

• **Regulatory Compliance:** Ensure the project aligns with all relevant codes (e. g. , ASHRAE, NFPA, local fire and safety codes) while incorporating civil, structural, and MEP requirements.

• **Cross-disciplinary Code Reviews:** Conduct a coordinated evaluation of all pertinent regulations with contributions from all teams to prevent conflicts.

7. Energy Inefficiency

• **Problem:**

Ineffective coordination between MEP systems can result in energy inefficiencies, such as inadequate insulation, leaks in HVAC ducts, or misalignment in electrical power distribution.

• **Cause:**

Insufficient holistic planning for energy-efficient design and failure to integrate MEP systems with the building's envelope and structure.

• **Solution:**

• **Sustainable Design Integration:** Strive for an integrated design that emphasizes energy efficiency implement energy-efficient HVAC systems, LED lighting, high-performance insulation, and smart building technologies.

• **Energy Modeling:** Utilize energy modeling tools to simulate the building's performance and identify opportunities for energy optimization before construction.

8. Improper Drainage and Water Management

• **Problem:**

Plumbing and drainage systems may not be effectively integrated with the building’s civil infrastructure, resulting in water accumulation or flooding, especially in basements or underground areas.

• **Cause:**

Insufficient coordination between plumbing systems, drainage plans, and the building's foundation and ground levels.

• **Solution:**

• **Water Management Planning:** Ensure proper drainage design is incorporated early in the design stage, including flood prevention systems (e. g. , sump pumps) and foundation waterproofing.

• **Coordination with Civil Engineers:** Civil engineers should assess plumbing and drainage systems to ensure their compatibility with the building’s foundation and exterior grading.

9. Temperature Control and Airflow Issues

• **Problem:**

HVAC systems may not consistently maintain temperature and airflow throughout the building, resulting in discomfort, particularly in large open-plan spaces or multi-story buildings.

• **Cause:**

Ineffectively integrated HVAC systems that fail to consider different zones, height variations across floors, or internal heat sources.

• **Solution:**

• **Zoning and Airflow Design:** Develop HVAC systems with zones customized to meet the distinct needs of various areas, ensuring proper duct sizing and routing.

• **Performance Testing:** After installation, conduct air balance testing to verify that airflow and temperature are evenly distributed.

10. Conflicting Schedule for MEP and Civil Work

• **Problem:**

The installation of MEP systems may experience delays due to alterations in the civil work schedule, such as late foundation work or postponed structural elements.

Cause:

Inadequate scheduling coordination among MEP contractors and civil construction teams.

• **Solution:**

• **Comprehensive Project Scheduling**: Create a thorough construction schedule that combines all disciplines (civil, structural, and MEP) to guarantee that every phase of the project is finished punctually.

• Frequent Coordination Meetings: Conduct frequent coordination meetings to assess the project schedule and confirm alignment across all teams.

C.3 Cost distribution of MEP services and economical design of building services

Sl. No	Particulars	Quantity	Units	Wastage QTY.	QTY. with WST	Material cost(Rs)	Total cost (Rs)
Mechanical							
1	Air Device Connected to HVAC	1	No	-	1	64,900	64,900
2	Duct	70	m	-	70	150	10,500
3	Duct Insulation (Scaled)	37	m^2	-	37	400	14,800
4	HVAC System	1	No.	-	-	7,00,000	7,00,000

5	Lift	1	No.	-	-	2,00,000	2,00,000
	Total (Mechanical)						9,89,900
Electrical						5/m	
1	Conduct wires	11,570	m	10%	12,730	5/m	63,650
2	Switches	58	No.	-	58	120/piece	6,960
3	Lighting	169	No.	-	169	250/piece	42,250
4	Conducts	434	m	10%	477	200/m	95,400
5	Sprinkler pipe (65mm dial)	202	m	10%	222	650/m	1,44,300
6	Smoke Detector	2	No.	-	2	1,000/piece	2,000
7	Sprinkler	52	No.	-	52	300/piece	15,600
	Total (Electrical)						3,70,160
Security System							
1	Security Cameras	17	No.	-	17	3,500	59,600
	Total (Security System)						59,500
Plumbing							

1	Pipes (12m per Piece of 2``&4``)	231	m	10%	254	260/m	66,040
2	Commodes	3(-3.5)	No.	-	3	8,000	24,000
3	Taps	12	No.	-	12	200/piece	2,400
	Total(Plumbing)						92,440
	Grand Total						15,11,500

C4. Design the building services for a proposed building.

The building services for a proposed building are

1. **FIRE DEMAND**

   Determine the amount of water needed for fire demand using different fire demand methods in the commercial building housing of 1500 people.

a. Kuichling's Formula:

$Q = 3182 \sqrt{P}$ where, P in thousands

$= 3182 \sqrt{2}$

= 4500 liters/min.

b. Freeman Formula:

$Q = 1136 \left(\frac{P}{10} + 10\right)$

Where, Q = amount of water required in liters/min.

P = Population in thousands.

$Q = 1136\left(\frac{1.5}{10} + 10\right)$

= 11530.4liters/min.

National Board of fire under writer's formula:

$Q = 4637\sqrt{P}\,(1 - 0.01\sqrt{P})$

$= 4637\sqrt{1.5}(1 - 0.01\sqrt{1.5})$

= 5609 liters/min.

2. **LIGHTING:**

Lumen method of lighting design,

$$N = \frac{(E*A)}{(F*U*M)}$$

E = Average illuminance in the working place = 300 lux

F = flux from one lamp =

2000lumens A = Area of the

working plane = 176m^2

U = Utilization factor = 0.5

M = maintenance factor = 0.8

$$N = \frac{(300*176)}{(2000*0.5*0.8)}$$

$= 73$

Hence, we use 66 fittings of 100-watt tube light.

3. **LIFT:**

a) Probable number of stops (S1):

$$S1 = N - N \left[\frac{N-1}{N}\right]^n$$

Where, N = maximum no. of stops

n = no. of people or car capacity = 6persons

Probable population,

$$P = \frac{3*200}{0.8} = 750\text{persons}$$

Car travel (L) = 2* 3 = 6m

$$S1 = 3 - 3\left[\frac{3-1}{3}\right]6 = 3 \text{ stops}$$

b) Upward Journey Time (Tu):

$$Tu = S1 \left[\frac{1}{N*V} + 2V\right]$$

Where, V = Car speed = 1.5m/s.

L = 6m

$$Tu = 3 \left[\frac{1}{3*1.5} + 2*1.5\right]$$

= 10.67 s

a) Downward Journey Time (Td):

$$Td = \frac{L}{V} + 2V$$

$$= \frac{6}{1.5} + 2(1.5) = 7s$$

c) Passenger Transfer Time (Tp):

Tp = 2n = 2(6) = 12**s**

d) Door Opening Time (To): Door speed, V_d = 0.4m/s Door width, W = 1.1m

$$To = 2(S_1 + 1) * \frac{W}{V_d}$$

= 2(3+1) * (1.1/0.4)

= **22s**

e) Round Trip Time:

RTT = Tu + Td + Tp + To

RTT = 10.67 + 7 + 12 + 22 = 51.67**s**

f) Handling Capacity:

$$H = \frac{300*Q*100}{T*P}$$

$$T = \frac{RTT}{N} = (51.67/3) = 17.22s$$

Q = 6*0.8 = 5**no.**

$$H = \frac{300*5*100}{17.22*750}$$

H = 11.25%

This is a Mid-end building.

4. SPRINKLER HEAD:

For area of one floor = 176m^2 For an ordinary hazard category,

Maximum floor area covered by one sprinkler head is 12m^2 Number of sprinkler head = (176/12) = 14.67 ≈ 15**no.s /floor** Total number of floors = 3no.s

Total no. of sprinkler head = 3*15= 45**no.s**

5. **SPRINKLER PIPE SIZING:**

Consider,

Effective length of pipework of steel = 30m.

Acceptable pressure loss = 0.02bar

Water flow rate = 52.8liters/min

For stainless steel, C = 120

Using Hazen – William's formula,

Internal pipe diameter, $d = \sqrt[4.87]{[(6.05 * 10^5 * L * Q^{1.85})/(C^{1.85} * p)]}$

$d = \sqrt[4.87]{[(6.05 * 10^5 * 30 * 52.8^{1.85})/(120^{1.85} * 0.02)]} = 50mm$

50mm nominal inside diameter is just to small. Therefore a **60 mm** nominal inside diameter steel pipe would be selected.

6. **AIRCONDITIONING SYSTEMS:**

Design a high velocity duct, Room volume = 528m^3

Air changes per hour = 6.

Quantity of air = (Room volume * Air changes per hr)/(time in seconds)

= (528 * 6)/3600

= 0.88**m^3/s.**

From table and graph, for pressure drop if 0.4pa/m and air velocity of 1.5m/s.

Duct size = 800mm.

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