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Analysis and Design of a Water Storage Tank Using BIM and Plaxis3d

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ABSTRACT :

This study proposes an integrative framework for comprehensively analysing and designing a water storage tank, combining advanced software tools such as Robot Structures for wind analysis, Revit for tank design, Plaxis3D for ground improvement assessment, and One Click LCA for sustainability evaluation. The technique begins with the conceptualization of the tank's geometry and components in Revit, followed by structural analysis in Robot Structures to investigate the effect of wind forces on the tank's stability and integrity. Plaxis3D is then used to investigate soil-structure interactions and evaluate ground conditions, ensuring the tank's foundation is strong and solid. Concurrently, One Click LCA examines the environmental effects, ensuring that the tank design is consistent with sustainability objectives. This project uses iterative refining and optimization procedures to create a water storage tank design that not only meets legal standards but also incorporates environmental conscience and performance excellence.

Keywords: BIM (Building Information Modelling), LCA (Life Cycle Analysis), Plaxis3d, Robot Structural analysis.

INTRODUCTION :

GENERAL

Building Information Modelling (BIM) represents a transformative approach to the design, construction, and management of buildings, rooted in the convergence of visionary concepts and technological advancements. Originating in the 1960s and 1970s, architects and engineers sought computer-aided design and management tools, but were hindered by technological limitations. However, Chuck Eastman's seminal paper in 1975 laid the conceptual foundation for BIM, envisioning a system where a central model linked to a database could revolutionize the industry. The late 1970s and early 1980s saw the emergence of pioneering BIM software such as Eastman's Building Description System (BDS), RUCAPS, and ArchiCAD, albeit limited by high costs and specialized hardware requirements. Building Information Modelling (BIM) represents a transformative approach to the design, construction, and management of buildings, rooted in the convergence of visionary concepts and technological advancements. Originating in the 1960s and 1970s, architects and engineers sought computer-aided design and management tools, but were hindered by technological limitations. However, Chuck Eastman's seminal paper in 1975 laid the conceptual foundation for BIM, envisioning a system where a central model linked to a database could revolutionize the industry. The late 1970s and early 1980s saw the emergence of pioneering BIM software such as Eastman's Building Description System (BDS), RUCAPS, and ArchiCAD, albeit limited by high costs and specialized hardware requirements.

The term "Building Information Modelling" was formally introduced in 1992, marking a significant milestone. Subsequent decades witnessed a steady evolution as computing technology advanced and software became more accessible, driving the widespread adoption of BIM within the construction industry. This adoption was fueled by recognition of BIM's myriad advantages, including enhanced collaboration, error minimization through improved coordination, and streamlined workflows across the building lifecycle. BIM's applications are extensive and impactful. In design and construction phases, it facilitates clash detection, improves coordination among various disciplines, enables precise quantity takeoffs and cost estimations, and enhances design visualization through 3D models and virtual reality tools. During facility management and operations, BIM supports space management, maintenance scheduling, energy efficiency analysis, and the creation of digital twins for ongoing performance monitoring. Moreover, the integration of BIM with Life Cycle Assessment (LCA) signifies a holistic approach towards sustainability in construction. By combining BIM's rich data capabilities with LCA's methodology for assessing environmental impacts throughout a building's lifecycle, the industry can make informed decisions to minimize environmental footprints and optimize resource usage. In summary, BIM's journey from conceptualization to widespread adoption has been marked by innovation and technological progress. Its transformative impact on the construction industry is evident in its ability to optimize workflows, enhance communication, and foster a more efficient, cost-effective, and sustainable built environment. As BIM continues to evolve, driven by advancements like cloud computing and open standards, its role in shaping the future of construction remains paramount.

METHODOLOGY :

2.1 Revit Modelling

Revit, an Autodesk BIM software, facilitates the creation of intelligent 3D models for water storage tanks. The project setup involves selecting architectural or structural templates, defining units, and establishing levels and grids. Architectural drawings are imported as reference using the "Import CAD" tool. Structural elements like columns and beams are modeled with specific dimensions and constraints, supporting the tank's structure. Slabs are sketched using the "Floor" tool, ensuring compliance with standards and adjusting thickness accordingly. For the rectangular part, a new project is initiated with defined levels and grids. Reference planes are used to outline tank dimensions, and walls are created using structural components aligned with these planes. Properties such as material, thickness, and height are adjusted. A top slab is added to complete the tank structure. Throughout the process, Revit provides tools for compliance checking and basic structural analysis. The resulting 3D model and plans accurately represent the water storage tank's design and dimensions, facilitating efficient collaboration among architects, engineers, and contractors.

2.2 Robot Structural analysis

The 3D structural model of the water storage tank is created in accordance with Indian standards, including IS 875 and IS 1893. Structural components such as columns, foundations, slabs, and beams are accurately modeled with appropriate material properties. Wind load calculations adhere to IS 875-3:2015, considering factors like basic wind speed, terrain roughness, and topography. Structural analysis using RSA evaluates behavior under loads, ensuring compliance with code requirements. Optimization adjusts member sizes and connections for efficiency while meeting safety criteria. Detailed reports document analysis, design, and code compliance, ensuring accuracy and regulatory approval. Iterative processes address any deficiencies or design changes.

2.3 LCA Software Integration

One Click LCA seamlessly integrates with Revit, facilitating Life Cycle Assessment (LCA) for buildings. Architects, engineers, and designers can assess environmental impacts from material selection to end-of-life considerations. The software boasts a comprehensive database of Environmental Product Declarations (EPDs), ensuring accurate evaluations encompassing factors like embodied carbon and energy consumption. Integration with Revit enables early-stage analysis and informed decision-making, enhancing sustainability practices throughout the design and construction process.

The process begins with accessing the One Click LCA plugin within Revit's Add-Ins tab. Users can choose to export the entire model or specific building elements for analysis. Material properties can be defined within the plugin window, ensuring precise environmental impact calculations based on actual materials. Once initiated, Revit translates the elements into IFC format, which is sent to One Click LCA for processing. Results are accessible within the One Click LCA project workspace, enabling stakeholders to analyse environmental impacts and make informed decisions.

With various subscription plans tailored to project needs, One Click LCA offers flexibility and accessibility. While specific functionalities may vary, comprehensive user guides and tutorials assist users in maximizing the benefits of the integration. Overall, the integration of Revit with One Click LCA streamlines the LCA process, empowering stakeholders to prioritize sustainability throughout the building lifecycle.

2.4 Plaxis3D

A thorough geotechnical investigation precedes Plaxis3D modelling, understanding soil qualities critical for accurate analysis. Using the software, a 3D finite element model integrates soil layers, ground surface, and stone columns. Stone column properties like diameter (0.6m), length (20m), and spacing (1.5m) are defined, alongside material attributes. A refined finite element mesh ensures precision around columns and key areas. Loads and boundary conditions mimic real-world scenarios. Plaxis3D then analyses stone column behaviour under loads, assessing settlement, bearing capacity, and lateral displacement. Results interpretation gauges stone columns' effectiveness in enhancing ground stability and minimizing settlement, considering stress distribution and settlement profile.

CONCLUSIONS :

The development of 3D models of the Water Storage Tank using Revit signifies a shift towards more efficient and collaborative design processes. Revit's capabilities allow for the creation of detailed and accurate models, enabling architects, engineers, and contractors to work together seamlessly. With its integrated approach, Revit enhances collaboration and accuracy in tank design, ensuring that all stakeholders have access to the latest information in real-time. This leads to improved decision-making and streamlined workflows throughout the design and construction phases. Utilizing Robot Structures for structural analysis ensures that the water storage tank can withstand wind forces while maintaining structural integrity and safety. By simulating various scenarios and analyzing structural responses, Robot Structures enables engineers to optimize the tank's design, ensuring it meets safety standards and regulatory requirements. This integration of structural analysis software enhances the reliability and performance of the tank, providing confidence in its ability to withstand external loads. Furthermore, incorporating sustainability considerations into the tank design process is facilitated by tools like One Click LCA. By analyzing environmental impacts and optimizing material selection, One Click LCA helps reduce the project's carbon footprint and promotes sustainable design practices. This aligns with the growing emphasis on sustainability in the construction industry and underscores the importance of considering environmental factors in design decisions. Ground improvement techniques, such as stone columns examined with Plaxis3D, play a crucial role in enhancing foundation stability and reducing settlement hazards. Plaxis3D allows engineers to model and analyze the behavior of stone columns under various loads, providing insights into their effectiveness in improving ground conditions. By implementing ground improvement measures, the risk of settlement-related issues is mitigated, ensuring the long-term stability and performance of the water storage tank.

Overall, the integration of advanced software tools like Revit, Robot Structures, One Click LCA, and Plaxis3D facilitates a comprehensive and sustainable approach to water storage tank design. By leveraging these technologies, designers can optimize performance, enhance collaboration, and address environmental concerns, ultimately delivering safer, more efficient, and environmentally friendly infrastructure solutions.

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