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Analysis and Design of Hostel Building by using STAAD Pro

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ABSTRACT: STAAD or (STAAD.Pro) is a structural analysis and design computer program originally developed by Research Engineers International in Yorba Linda, CA. In late 2005, Research Engineer International was bought by Bentley Systems

The collected data is analysed and a 3-D model is generated using STAAD Pro. The various loads acting on the structure is calculated and the structure is analysed for the various load combinations. Design of the building is done. The obtained results are analysed. Manual calculation and design of slabs, beams, staircase and columns are done. Also, the design of the pile foundation and pile cap is done.

I. INTRODUCTION

1.1 AIM AND SCOPE OF WORK

Human life is affected due to nature's forces like floods, hurricanes, tornadoes, earthquakes etc. The structural design for a building must ensure that the building is able to stand safely, to function without excessive deflections or movements which may cause fatigue of structural elements, cracking or failure of fixtures, fittings or partitions, or discomfort for occupants. It must account for movements and forces due to temperature, creep, cracking and imposed loads. It must also ensure that the design is practically buildable within acceptable manufacturing tolerances of the materials. It must allow the architecture to work, and the building services to fit within the building such that it is functional (air-conditioning, ventilation, lighting etc.).

The aim of this project work is to analyze 5-storeyed hostel building for different load combinations using STAAD Pro software. Based on the analysis, design of the structure is done mainly in accordance with IS specifications.

1.2 DESIGN PHILOSOPHIES

The limit state method is adopted for the analysis and design of the structure. IS codes, SP-16 and SP-32 charts are used as an aid for detailing and design purpose.

The major requirements of a properly designed building are:

- a) **GOOD STRUCTURAL CONFIGURATION:** Its size, shape and structural system carrying loads are such that they ensure direct and smooth flow of inertia forces to the ground.
- b) **LATERAL STRENGTH:** The maximum lateral (horizontal) force that it can resist is such that the damage induced in it does not result in collapse.
- c) **ADEQUATE STIFFNESS:** Its lateral load resisting system is such that the earthquake-induced deformations in it do not damage its contents under low-to moderate shaking.
- d) **GOOD DUCTILITY:** Its capacity to undergo large deformation under severe earthquake shaking even after yielding is improved by favourable design and detailing strategies.

1.3 COMPONENTS OF THE STRUCTURE

The components of the structure are mainly classified into

- a) Superstructure
- b) Substructure

Superstructure is the part of the building that lies above the ground line. These are subjected to lateral loads like the wind load, earthquake load, and other dead and live loads.

Substructure is the foundation of the building. The type of foundation adopted for the hostel building under consideration is pile foundation.

1.3.1 PILE FOUNDATION

A deep foundation is a type of foundation distinguished by the depth on which they are embedded into the ground.

Piles are generally driven into the ground in situ. The types of piling are DMC Piling and rotary piling.

In DMC Pile Foundation the bentonite suspension is pumped into the bottom of the hole through the drill rods and it overflows at the top of the casing. The mud pump should have the capacity to maintain a velocity of 0.41 to 0.76 m/s, to float the cuttings.

The depth of piling was decided by testing the underground soil samples (to obtain level bed). It is not possible in hard rocks. Tremie pipe is inserted into pile holes for pile concreting.

II. LITERATURE SURVEY

L. C. Tibude et. al 2022, conducted a comparative seismic analysis of a multistory building with and without floating columns. Three cases were analyzed: a normal framed building without floating columns, a building with floating columns, and a building with struts supporting floating columns. The findings aim to improve the seismic performance of buildings with floating columns by identifying the impact of their presence and proposing proper design solutions for enhanced stability and safety.

P. Guruswamy Goud et. al (2024) ensures that the structure is designed to safely withstand all loads it may encounter throughout its lifespan while meeting serviceability requirements, such as limits on deflection and cracking. STAAD Pro software is utilized for structural analysis and design, specifically calculating the reinforcement required for concrete sections.

The design process adheres to the provisions of IS: 456 (2000), ensuring compliance with Indian standards. Beams are analyzed and designed to resist flexure, shear, and torsion, ensuring the structural integrity and durability of the system. Anushri A. Isall et. al (2022) analyzed beam forces (F_x , F_y) and moments (M_x) for models with 5m, 6m, and 7m spacings. F_x values were highest, while F_y values were lowest across all spacings. The maximum moment (M_x) was consistently observed in models with an angle of 1 in 10, highlighting the influence of spacing and configuration on structural performance.

Abhishek Thakur et. al (2023). Various studies analyzed multistory high-rise buildings under seismic loads, considering different seismic zones and soil conditions. Researchers used tools like STAAD.Pro, SAP 2000, and ETABS for modeling and analysis, supported by manual calculations for validation. The focus was on understanding seismic performance, soil-structure interaction, and optimizing design elements like floating columns and shear walls to enhance structural safety.

III. METHODOLOGY

The various steps involved in the project are:

- Data Collection
- Analysis of the data
- Model generation
- Load calculation
- Building analysis
- Design of building
- Result analysis
- Manual calculation and design of slabs, beams, staircase and columns
- Design of pile foundation and pile cap

IV. RESULTS AND DISCUSSION

A structure consists of an assembly of individual structural elements such as truss elements, beams, columns, slabs, cable or arch proportioned to resist the loads and forces.

4.1 STRUCTURAL ANALYSIS

It's the calculation of the response of the structures to actions.

4.2 ACTIONS

An action is a physical phenomenon that produces stress and deformation in the structures.

Actions include:

- Loads (self-weight)
- Variation in temperature
- Settlement of support

4.3 RESPONSE OF STRUCTURES

It's the physical change produced in structure due to action on structures. It includes,

- External Force quantities –Reactions
- Internal Force quantities–Bending Moment, Shear, Axial force and stress
- Displacement quantities – Deflection and Strain Their response of structure is calculated mathematically.

4.4 LOADS ACTING

Loads can usually be considered to be primary or secondary. Secondary loads are those loads due to temperature changes, construction eccentricities, shrinkage of structural materials, settlement of foundations, or other such loads. Despite the fact that each and every load and loading. Combination should be considered in order to reduce the chance of structural failure; the determination of the loading remains a statistical exercise. Each and every load cannot be foreseen; thus, it is critical to determine the worst case that is reasonable to assume to act up on the structure. The sources of primary loading include the materials from which the structure was built, the occupants, their furniture, and various weather conditions, as well as unique loading conditions experienced during construction, extreme weather and natural catastrophes.

Primary loads are divided in to DEAD LOADS and LIVE LOADS. When considering the possible combinations of these two categories of loading, the odds of certain loads occurring simultaneously are assumed to be null.

CALCULATION: The loads taken for analysis are dead load, live load, wind load and seismic load. Since the structure will be erected in zone-3, seismic design should also be done. The loading standards ensure structural safety and eliminate wastage that may be caused due to unnecessary heavy loading without proper assessment.

4.5 DEAD LOADS

Dead Loads are those loads which are considered to act permanently; they are "dead," stationary, and unable to be removed. The self-weight of the structural members normally provides the largest portion of the dead load of a building. Permanent non-structural elements such as roofing, concrete, flooring, pipes, ducts, interior partition walls, Environmental Control Systems machinery, elevator machinery and all other construction systems within a building must also be included in the calculation of the total dead load.

It is calculated as per IS 875 (Part-1): 1987 Unit weight of RCC and brickwork is adopted as 25kN/m^3 and 20kN/m^3 respectively. Fig. 5 show show Dead Load is input in STAAD Pro.

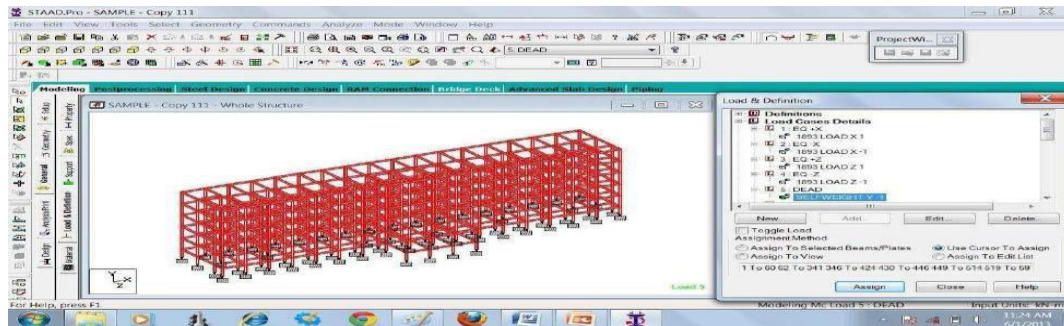


Fig.1 Dead Load

4.5.1 LIVE LOADS

Live loads, referred to as **probabilistic loads** or imposed loads, are temporary, of short duration, or moving. These dynamic loads may involve considerations such as impact, momentum, vibration, slosh dynamics of fluids, fatigue, etc. The magnitudes of live loads are difficult to determine with the same degree of accuracy that is possible with dead loads. They are determined from code provisions. The load assumed to be produced due to intended use or occupancy of a building including the weight of movable partitions, distributed and concentrated loads, impact and vibration loads, excluding wind load, seismic load and stress due to variation in temperature etc, are obtained from IS875(Part- 2):1987. Fig. 6 shows the STAAD provision for including Live Load and the magnitude of Live Loads for different parts of the building is given in Table 1.

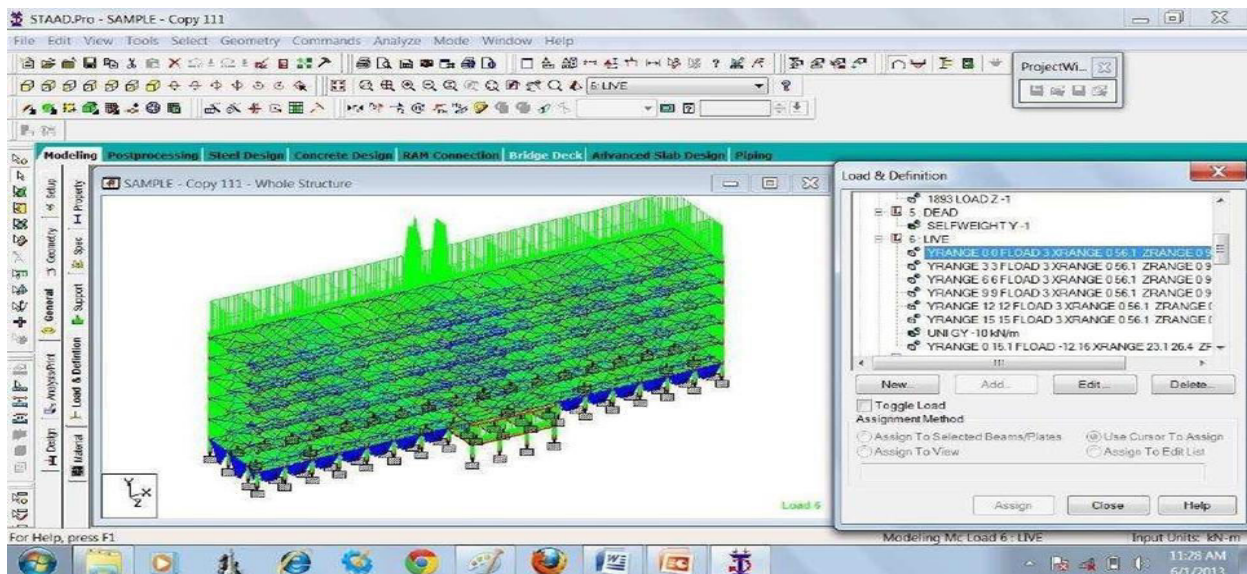


Fig2.LiveLoad

Table 1: Live Loads

Sl No.	Occupancy Classification	UDL (kN/m ²)
1	Store	6
2	Kitchen	4
3	Corridor	4

4.5.2 WIND LOADS

Wind is the relative motion of air to the surface of the earth. Wind speed in atmospheric boundary layer increases with height from zero at ground level to maximum at gradient height, these light change in wind direction, within this height is neglected.

Typically, buildings are designed to resist a strong wind with a very long return period, such as 50 years or more. The design wind speed is determined from historical records using Extreme value theory to predict future extreme wind speeds.

4.5.3 EARTHQUAKE LOADS

Seismic loading is one of the basic concepts of earthquake engineering which means application of an earthquake-generated agitation to a structure. It happens at contact surfaces of a structure either with the ground, or with adjacent structures, or with gravity waves from tsunami. Seismic loading depends, primarily, on:

- Anticipated earthquake's parameters at the site-known as seismic hazard
- Geotechnical parameters of the site
- Structure's parameters

Sometimes, seismic load exceeds ability of a structure to resist it without being broken, partially or completely. Due to their mutual interaction, seismic loading and seismic performance of a structure are intimately related. Fig. 7, 8, 9, 10 show EQ load is included in the analysis using STAAD Pro.

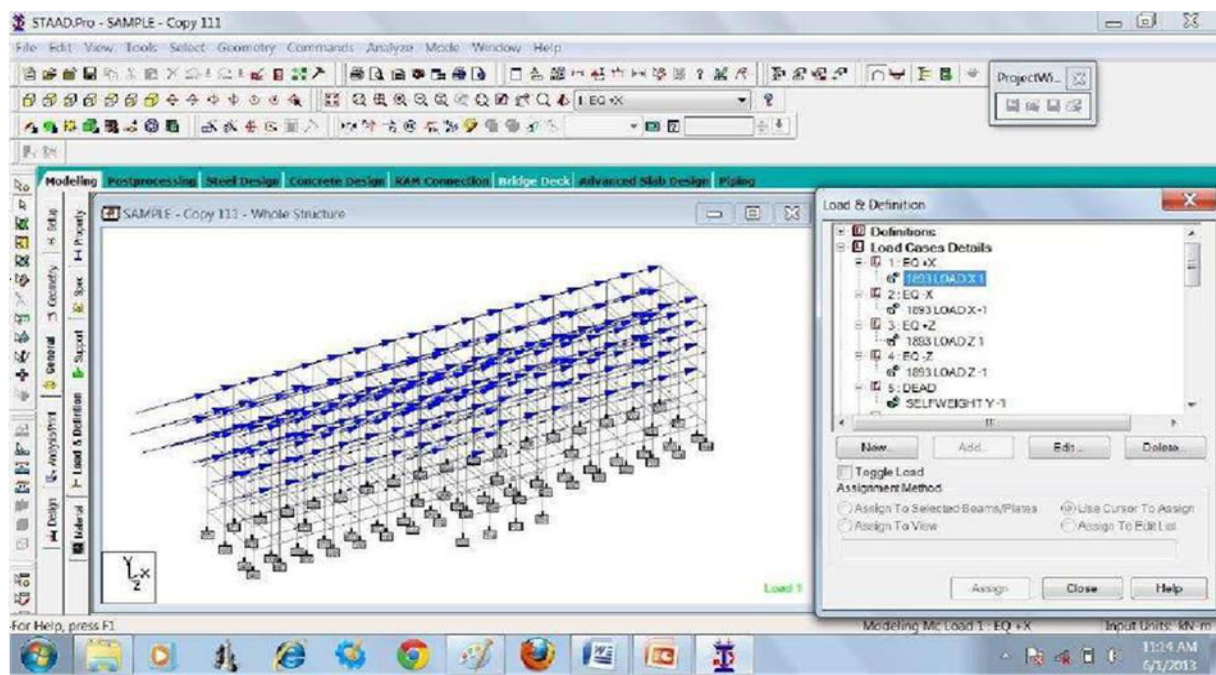


Fig. 3 Earthquake Load in +X direction

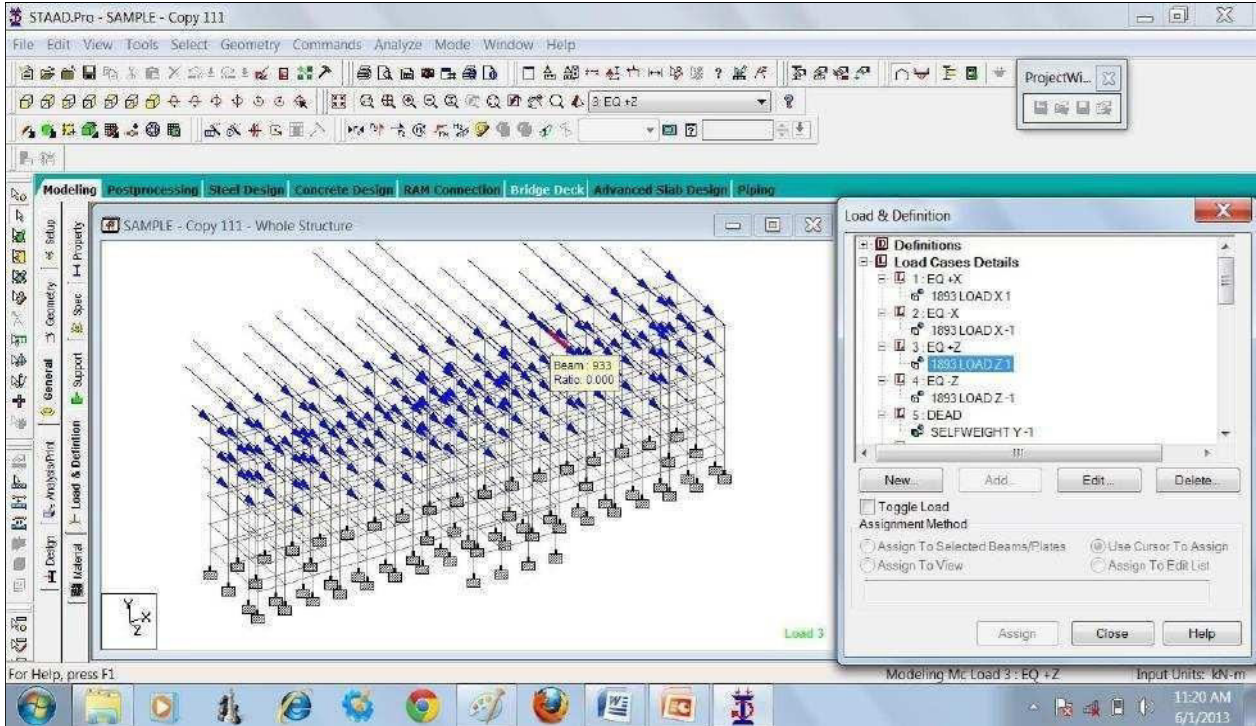


Fig.4 Earthquake Load in +Z direction

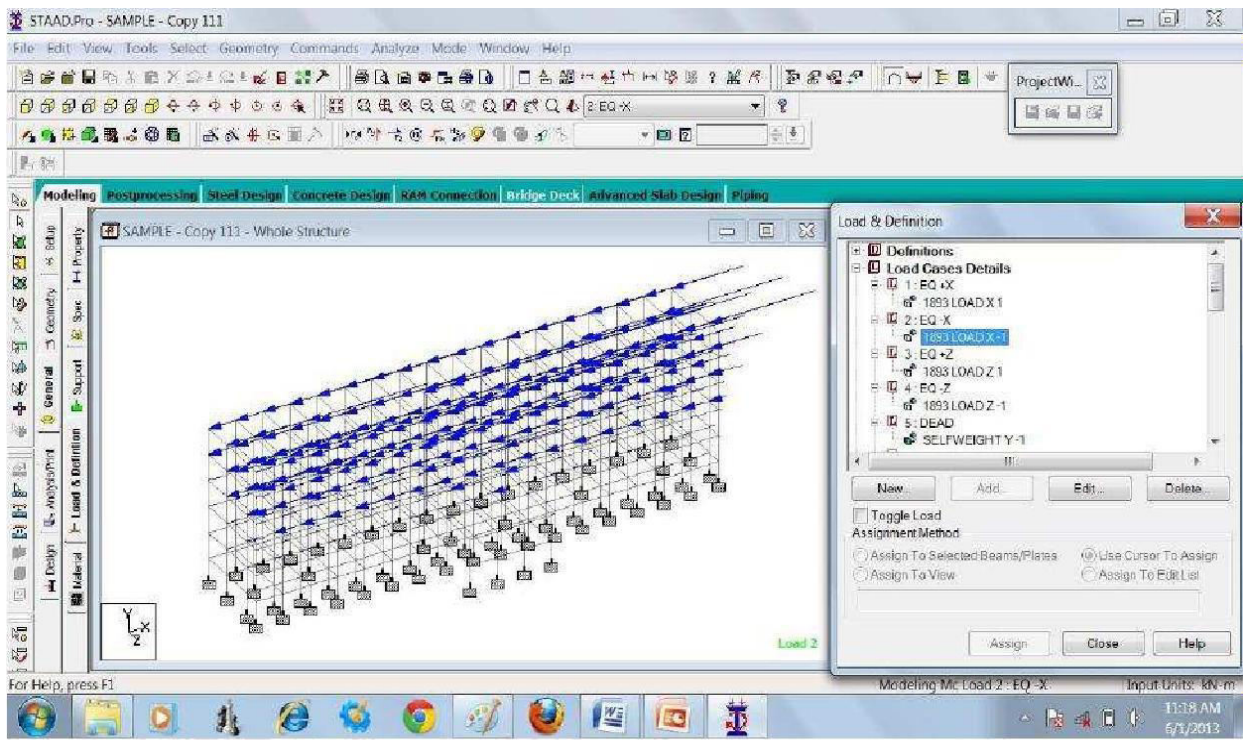


Fig.5 Earthquake Load in -X direction

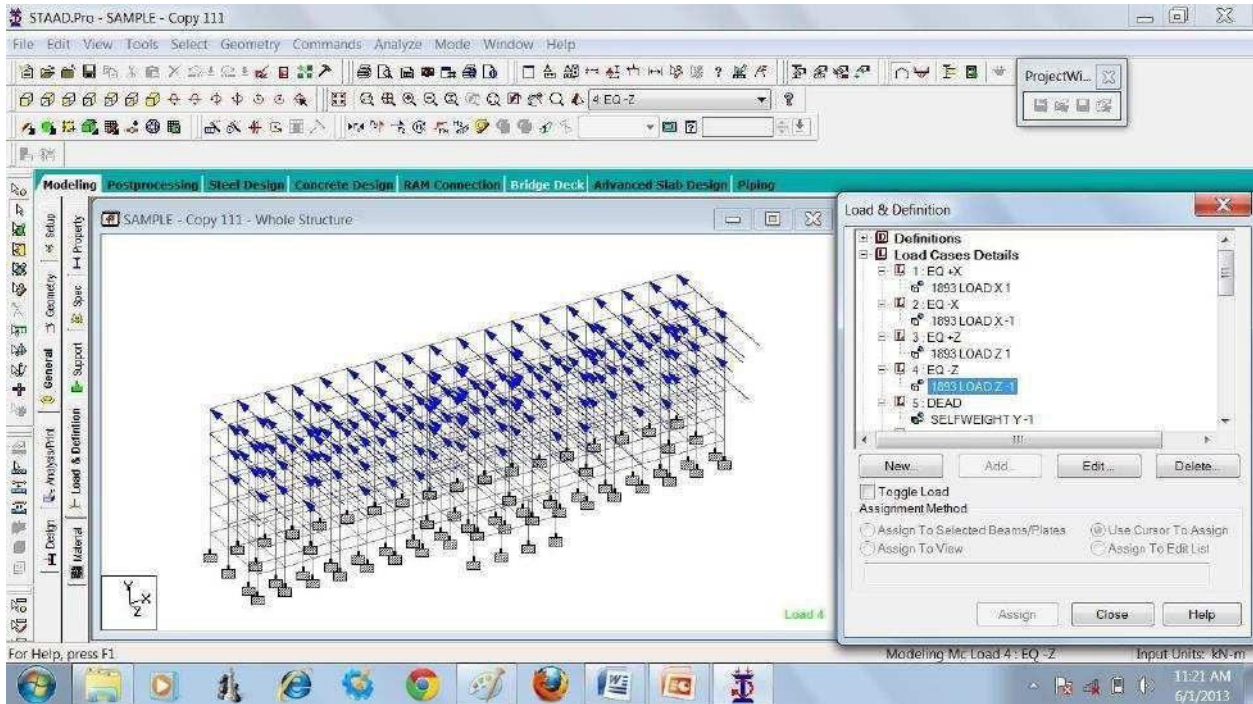


Fig6 Earthquake Load in Z-direction

V. CONCLUSION

The aim of our project was planning, analysis and design of a multi-storeyed, earthquake resistant residential building. We were able to complete the project in a successful and efficient manner by considering all there levant features given as nine chapters.

Planning of this building has been done based on the space requirements suggested by the prevailing rules stipulated in Kerala Building Rules, 1999. The design is completely based on relevant Indian Standard Codes. The analysis has been done with the help of STAAD Pro and the drawings have been made with the help of AutoCAD. We have completed this project to the best of our knowledge and ability.

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