DESIGN AND ANALYSIS OF IRREGULAR SHAPED BUILDING

[1]Vamsi Jagannath Bankuru and [2]B. Krishna Naik

[1]M. Tech student, Department of Civil engineering, MVR College of Engineering & Technology, An Autonomous Institutions, Approved by AICTE, Affiliated to JNTU Kakinada, Paritala, NTR district, Andhra Pradesh-521180, India.

[2]Assistant Professor, Department of Civil engineering, MVR College of Engineering & Technology, An Autonomous Institutions, Approved by AICTE, Affiliated to JNTU Kakinada, Paritala, NTR district, Andhra Pradesh-521180, India.
Corresponding author e-mail: vamsi.bankuru@gmail.com

ABSTRACT: Different shapes can be adopted in the building construction. Different shapes of Buildings will behave differently. It depends on shape of the structure, load applied, area of cross sections, quality of materials, etc. In this Project C-Shaped (G+8) and E -shaped buildings were taken plans and designs of buildings were made using Staad Pro Software. From the obtained results, Section Displacements, shear forces and bending moments were compared for both the Buildings. This project presents an overview of Design and analysis of irregular shaped building using STAAD pro without lateral load.
This paper is an experimental study evaluating Generating structural framing plan (irregular building). Creating model of irregular building in STAAD PRO. Application of loads on the member. Analysis of the structure.

Keywords: Building shapes; C-Shaped; E -shaped; Staad Pro Software; Section Displacements;

I. INTRODUCTION

Building construction is the branch of engineering that focuses on the design and construction of structures, such as homes. Humans require food, clothing, and shelter in order to survive; a simple structure might be defined as such. Throughout human history, humans have relied on buildings to live and work in. But it's not only about creating buildings; it's also about designing efficient structures so that they can accomplish their primary goal. Engineers and architects design, plan, and arrange the structures, among other things, using constantly evolving ways for constructing dwellings affordably, swiftly, and to the needs of the community. Different sorts of buildings, such as residential and commercial, exist. For the most part, residential structures are those that are referred to as "homes" or "houses." There are many different names for different types of residential dwellings. Offices and the like are examples of commercial structures where the general public may perform their professional duties. STAAD Pro, a widely used design programme, is being used in our project to analyses and design a C-shaped structure (G + 8). The following benefits led us to choose STAAD Pro as our software of choice:
• User-friendly interface, • Compliance with Indian Standard Codes, • Versatility in handling any sort of issue, and• Accuracy in the answer

Irregular residential buildings

Many pieces of contemporary urban infrastructure may be found in non-conformist structures. Irregular buildings have mass stiffness and strength irregularities. Structural engineers have a greater task when dealing with structures that are located in a seismically active area. Perceptual criteria and irregularity standards specified by guidelines may describe "irregular" constructions like L, C, A, and E-shaped plans as "apparent" irregularities when the diaphragms are stiff and the columns are distributed according to the form. The error in measuring the size of structural parts and the ambiguity in determining the center of mass and stiffness may lead to the appearance of asymmetry in a supposedly symmetric construction.

One of the most common ways to describe AutoCAD is that it is the use of computers to aid in the development, revision, and optimization of a design.2. Drawings for building and manufacture may be created in this method. In 1982, John Walker created it with the aid of AUTODESK and has been keeping it running ever since.

In the second place, STAAD.PRO: It is a structural design software application. It has a cutting-edge user interface, sophisticated visualization features, and adheres to internationally recognized design standards. It is used to create 3D models, conduct

analysis, and develop multi-material products. Several steel, concrete, and wood design regulations are supported by the commercial edition of STAAD PRO. Structural engineers may use this programme to automate their work and eliminate the laborious and time-consuming manual operations.

Design and estimation of a G+4 residential building by Aradhana Chavan and others. The study involves a G+4 building with parking on the bottom level and 2BHK apartments on the rest of the floors. STAAD PRO is used for design and analysis, while MS-EXCEL is used for estimate. DR Deshmukh et al. G+19 Multi-Story Building Analysis and Design. STAAD-PRO, a well-known civil engineering software programme, was used to design the multistory structure, and the research also incorporates wind and seismic load calculations. STAAD-Pro and manual calculations are also compared for the results of earthquake loads applied to structures via the seismic coefficient approach.

Also investigated was how various irregular structures in pushover analysis performed when subjected to three distinct lateral load configurations [Ravikumar C.M, et. al. (2012)]. Several programmers, including ETABS, SAP2000, MIDAS/gen and SATWE, were used to analyses the reaction spectrum, time history, and connecting slab in-plan stresses in conjunction with a real project using inclined columns. SAP2000 and ETABS time history analysis findings are almost identical. Because SAP2000 lacked the idea of story, postprocessing was much more difficult. There are no alternatives to SAP2000 when it comes to gym or space truss constructions, although ETABS is suggested for conventional structures [Hu Kai et al. (2012)].

CSI-ETABS (version 9.7) was used to examine the seismic response characteristics of G+10 vertically irregular structures, including story drift, story deflection, and story shear [Abdul Rahman et al. (2013)]. ETABS V9.7.1 software was used to determine characteristics such as storey drift, storey shear, and storey moment in a 14-story structure with various shear wall locations. Shear walls and frames were analyzed using all possible load combinations. In the dynamic study, wind and earthquake loads were treated as external lateral

loads [Mon (2014)]. STAAD.pro was used to model and test the stability of a 20-story structure with horizontal irregularity. The L-shape, the H-shape, and the U-shape were all proposed for investigation. An earthquake load analysis is performed using IS 1893: 2002 and the IS 875 standards for dead loads, live loads, and wind loads. [Gaur et.al. (2014)] employed parameters including internal forces and roof displacement for the evaluation. No. 12 eccentrically braced frame (EBF) structures were constructed and examined for their fundamental periods. According to statistical comparisons, the Rayleigh data was better matched to the 3-variable power model than equations that were simply dependent on height [Young Kelly et al. (2016)].

RCC Seismic behavior of a ten-story building with and without shear walls was studied. According to Chandurkar et al. (2013), a massive shear wall was ineffective in buildings with ten or less stories, but it was successful in high-rise structures. According to Encina Javier et al. (2013), they provided findings of a study of free plan structures using a simpler model based on sub structuring of the structural components, such as WCA, perimeter frame, and floor slabs (finite element model).

Staad Pro software

An advanced, but simple-to-use software application, STADD PRO, is best suited for the design and evaluation of complex computer systems. There are no other modelling, analysis, or layout tools that can compare to the capabilities of STADD PRO Version 8's user-friendly and sophisticated graphical interface. This is all made possible via the use of a shared database. STADD PRO, although being simple and straightforward for smooth systems, can handle the most significant and complex building models, which include a wide range of nonlinear behaviors, making it the tool of choice for structural engineers in the construction industry.

• TABS, the precursor of STADD PRO, has been around for more than 30 years, and it has long been understood that homes are a wholly distinct kind of systems. In its early versions, STADD PRO provided strategies for input, output, and numerical solution that took into account the particular inclinations of building kind systems. This provided a tool that provided large economic monetary savings in time, as well as improved accuracy compared to elegant reasoning programmers.

• STADD PRO presented computationally complex analytical possibilities that include dynamic

nonlinear behavior and strong CAD-like drawing tools in a graphical and object-based interface as computer structures and pc interfaces progressed. Because it looks so different from previous versions from 30 years ago, STADD PRO Version 8's mission is unchanged: to supply professionals with the most novice-friendly and comprehensive software programme application for the evaluation and format of homes. As a result, the contemporary launch adheres to the same philosophical approach advocated by certain apps, namely:

• With horizontal beams and vertical columns, most of the homes have a simple geometry. Even though STADD PRO allows for almost any building structure, a simple grid device defined by horizontal flooring and vertical column traces is usually sufficient for installing building geometry quickly.

• • A lot of properties have similar floor plans. Because of this similarity, we can reduce computing effort.

• Common building language is used to define both the inputs and outputs. Models in STADD PRO are defined logically as a flow of non-descript nodes and elements, as opposed to a circulation of them in gigantic reason applications, with the help of the helpful resource of way of ground, column, bay, and wall. In this way, the description of the structure is clear, succinct, and comprehensive in scope.

• People tend to be very tall and wide when it comes to most dwellings. These measurements have a significant impact on the body's stiffness. Because it works on the member stiffness, STADD PRO does not employ the same technique as most other programmers that operate on centerline-to-centerline dimensions.

• Engineers should be able to immediately utilize the results generated by the usage of the software packages they've created. It's possible that general-purpose laptop packages create large results that would need extra processing before they could be used structurally.

Methodology
1. Assigning Proper Dimensions, Use of Appropriate Values and Extracting out.
2. Analysis and Design of G+8 Building Using Staad Pro.
3. Input Geometry, Property, Material and Support Condition.

4. Input Specifications and Load Case Details for Mass, Dead Load, Live Load, wind load, seismic load and Load Combinations.
5. Analysis After the completion of all the above steps we have performed the analysis and checked for errors.
6. Finally concrete design is performed as per IS 456: 2000 by defining suitable design commands for different structural components.
7. After the assigning of commands again we performed analysis for any errors.
8. Generation of Report

II. WORKING WITH STAAD.PRO

Input Generation

Text editors or the GUI Modeling capability may be used to construct the STAAD input file. The STD input file may be edited or produced using any text editor. The input file is generated by the GUI Modeling function through an interactive menu-driven graphics approach. The input file contains a sequence of progressively performed commands.
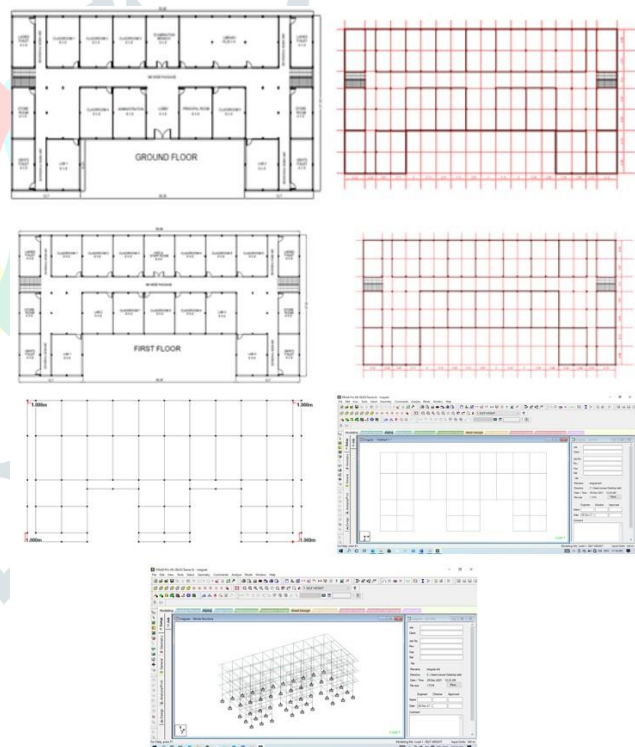

Fig.1 AutoCAD plans for two buildings

Type of Structure

A Superstructure is a collection of components. Frame, plate/shell, and solid element structures may all be analyzed and designed using STAAD's structural analysis and design capabilities. STAAD

may be used to evaluate almost any structure. With loads applied in any plane, the most generic kind of SPACE framework is the three-dimensional framed structure known as a SPACE. Loads in the same plane are tied by a global X-Y coordinate system for a PLANE structure. Truss members of a TRUSS construction can only be subjected to axial member forces and cannot be bent. Floor structures are two or three-dimensional structures with no horizontal mobility (FX, FZ, and MY are all restricted at every joint). Floor framing is a great example of a FLOOR structure in a building's global X-Z plane. In a FLOOR construction, columns may also be represented if the structure is not subjected to horizontal loading. A SPACE structure must be examined if there is any horizontal load.

Generation of The Structure
Material Constant

In terms of physical properties, the material constants include modulus of elasticity, weight density, Poisson's ratio, coefficient of thermal expansion, composite damping ratio, and beta angle. The analysis cannot proceed until the members' E values are known. It is only when the structure's own weight is taken into consideration that weight density is utilized. Shear modulus (often known as G) is calculated using Poisson's ratio.

$$G = 0.5 \times E / (1 + POISS)$$

Support

With various versions, support is designated as PINNED, FIXED, or FIXED (known as FIXED BUT). All translational movement and rotational movement are restricted by a pinned support. A pinned support, on the other hand, will respond to all pressures, but will not withstand any moments. The movement of an object restrained by a fixed support is restricted in all directions.

Type for Concrete Design

Concrete members may be constructed using the following cross sections. Primitive Rectangular& Square) and T-shape Beam (Primary). Prismatic is a column filler (Rectangular, Square and Circular) Design Parameter

In order to design in accordance with IS 13920, a number of parameters are included in the software. It accepts all of the parameters required to design in accordance with IS: 456. There are additional requirements that must be satisfied if the design is done in accordance with IS: 13920. Default parameter values have been chosen based on the most often used integers in traditional design. This handbook provides a comprehensive description of the available options and their default settings, which may be used to tailor the design to the specific needs of the user. For concrete design, millimeters and Newtons must be declared as length and force units.

Beam Design

Flexure, shear, and torsion are all considerations in the design of beams. The axial force may be taken into account if necessary. The critical load instances at various parts of the beams are identified by rescanning all active beam loadings for all of these forces. The member's breadth must be at least 200mm in order to be designed in accordance with IS: 13920. A width-to-depth ratio of at least 0.3 is recommended for the member.

Design for Flexure as with the IS 456 design, the process is the same here. However, in accordance with IS-13920, the following requirements are met: M20 is the preferred grade of concrete as a starting point. In addition, only Fe415 steel reinforcements may be employed. 3. The minimum tension steel ratio is provided by: min $=0.24(fck / fy)^{(1/2)}$ on any face at any segment. Positive steel ratios must be at least equal to half of the negative steel ratios on each joint face. It is required that each section's top and bottom faces be reinforced with steel that is at least one-fourth the maximum negative moment steel available at the joint's face.

Column Design

According to IS 4562000, columns are built to withstand axial and biaxial moments. It's important to note that columns are also built to withstand shear forces. The column design of STAAD has taken into account all of the primary criteria for choosing longitudinal and transverse reinforcement as specified by IS: 456. However, in order to integrate IS 13920's regulations, the following conditions have to be met: l the minimum concrete grade should be M20 at a minimum. 2 Only grade Fe115 or lower steel reinforcements may be utilized. 3 For columns with unsupported lengths more than 4 meters, the smallest column dimension must be less than 300 millimeters in length. 4 The perpendicular to the shortest cross-sectional dimension ratio should be no less than 0. Except in the case of specific restricting reinforcement, the spacing of hoops must not exceed half of the column's lateral dimension at any one

time. Where flexural yielding is possible, special restricting reinforcement should be added on each side of any section at least a length lo from each joint face, towards the mid span. Lo must not be less than a greater lateral dimension of the member at the section where yielding occurs, b) 116 of clear span of the member, and c 445mm. There should be no less than 75 mm between hoops used as special confining reinforcement and the minimum member size, but the distance shouldn't be more than 100 mm.
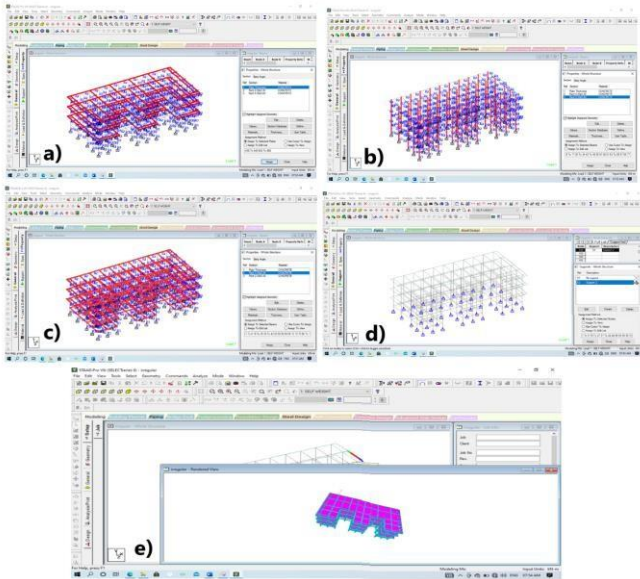

Fig.2 a) Slab thickness assign, b) Column property assign, c) Beams property assign, d) Support, and e) 3d view of E-shaped structure
Design Operation: Structural members may be designed using a wide range of tools in STAAD, including the ability to study individual components. There are a variety of design procedures that may be performed at the member design facilities. These facilities may have a design issue.

General Comment

Here are some broad remarks on how STAAD implements Indian Standard code of practice (S: 800-1984) for structural steel design. The concepts of allowed stress design guide the design philosophy and procedures for member selection and code validation. Overstress and stability issues are acknowledged as the two primary causes of failure. The sections that follow outline the most important characteristics of the permitted stresses and the stability criteria that are being applied. In order to withstand the design loads without exceeding the permitted stresses,

members are proportioned in such a way as to minimize their weight. As part of the program's code verification process, we look for key loading conditions as well as regulating code criteria. Stiffeners and other local effects like flange buckling and web crippling are normally considered to be taken care of by the end user.

Amount of stress that is permitted: STAAD's member design and code verification are based on the IS: 800 permissible stress design approach (1984). Using design loads and pressures, permissible stresses, and design constraints for the suitable material under service circumstances, it is possible to proportion structural members. Every feature of IS: 800 cannot be described in this handbook. IS: 800 and STAAD allowed stresses will be discussed in detail in this section, though. IS 800 will be cited when discussing acceptable stresses of different kinds.

As a result of several studies: Structural analysis and design may need the use of numerous tools at once. Changing input such as member attributes, support conditions, and so on in an input file is easy with STAAD since it enables for numerous analyses to be performed in the same run. It is possible to mix the results of many investigations for design objectives. To accommodate constructions with bracing, STAAD's INACTIVE capability may be used to temporarily disable some members for use in one load situation before reactivating them for use in another.

Post Processing Facilities

The STAAD may handle all of the output from the STAAD run. Proficient use of a graphical user interface.

Stability Requirements: All members' slenderness ratios are computed and compared to the relevant maximums. The maximum slenderness ratios for various members are summarized in IS: 800. The maximum slenderness ratio for each member may be determined in the STAAD implementation of IS: S00. A maximum slenderness ratio of 180 for compression members and 400 for tension members will be used if no maximum slenderness ratio is specified.

Check for Deflection: When doing CODE CHECKS and MEMBER SELECTION, the user may take deflection into account. It is possible to regulate the deflection check using three parameters. In addition to other strength and stability related parameters,

deflection is used. Based on the most recent analysis findings, the local deflection is calculated.

Checking the Code: It is the goal of code checking to determine whether a part of code is capable of meeting the relevant design code criteria Using IS 800(1984) standards, the code is checked. Code-checking computations use forces and moments at specific points on the members. The BEAM argument or the SECTION command may be used to specify sections. Checking of the code is based on the forces and moments at the endpoints of the members if no sections are supplied.

III. ANALYSIS
PHYSICAL PARAMETER OF BUILDING

Live load = 2.5 kN/m² (all over slabs)
Location = Palwancha
Depth of foundation below ground = 1.5 m
Type of soil = Type II, Medium as per IS:1893
Allowable bearing pressure = 200KN/m²
Minimum thickness of footing = 0.305 m,
External Wall thickness of Brick = 0.23 m
Internal wall thickness of AAC block = 0.15 m
Parapet wall thickness of AAC block = 0.15 m
Parapet wall height = 1m
Columns = 0.35 m X 0.4m
Beams = 0.3 m X 0.3 m.

Table 1 Description of the Building data

1	Details of the building	
a)	Structure	E-shaped college building
b)	stories	G+2
c)	Type of building	Irregular and Symmetrical in plan
d)	Flat area (l x b)	16m X 32m
e)	Height	9 m
f)	Support	Fixed
2	Properties of material	
a)	Grade of concrete	M30
b)	Grade of steel	Fe 500
c)	Density of reinforced concrete	25 kN/m³
d)	Young's modulus of M30 concrete, E_c	27386.13 kN/m²
e)	Poisson ration, μ_c	0.2
f)	Young's modulus steel, E_s	2 x 10⁸ kN/m²

3	Type of Loads & their intensities	
a)	Floor finish + slab	4.75 kN/m²
b)	Live load on floors	2 kN/m²
c)	External wall load on beams + plastering	14 kN/m²
d)	Internal wall load on beams + plastering	7.63 kN/ m²

Materials for The Structure

The materials for the structure were specified as concrete with their various constants as per standard IS code of practice.

Loading

The loadings were calculated partially manually and rest was generated using Staad.Pro generator.
The loading cases were categorized as:
     Self-weight   Dead load   Live load

Self-Weight

The self-weight of the structure can be generated by Staad.Pro itself with the self-weight command in the load case column
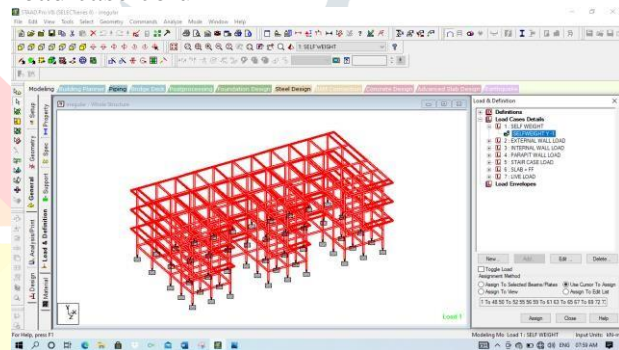

Fig.3 Self weight

Dead Load Slab Weight

Slab weight = depth of slab x unit weight = 0.150 x 25 = 3.75 KN/m2
Floor finish load = = depth of floor finish x unit weight = 0.050 x 20 = 1
Total weight = slab weight + floor finish load = 3.75 + 1 = 4.75 KN/m2

Wall Height

External wall thickness of brick=230mm (9")
Internal wall thickness of brick = 115mm (4'')
Wall Height=3m-0.3m=2.7m
Parapet wall height= 1m
Plaster external = 15mm
Plaster internal = 12mm
Total plaster = 27mm

Wall weight=wall height x wall thickness x unit weight

Ext. Wall weight= (2.7x.23x20) + (0.027 x 22 x 2.7) =14 KN/m.

Internal Wall weight= (0.115 x 2.7 x 20) + (0.024 x 2.7 x 22) =7.63 KN/m

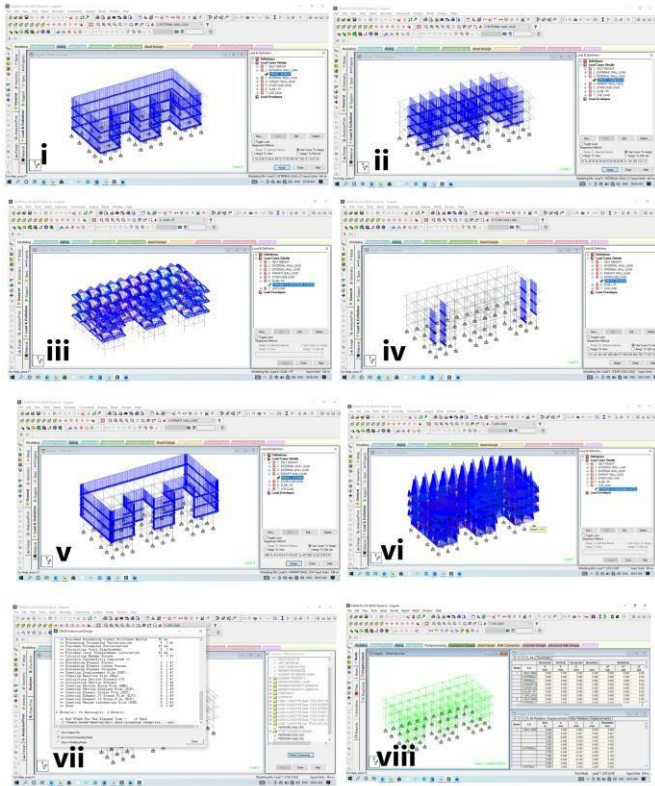Parapet wall weight=0.115 x 1 x 20 = 2.3 KN/m

Fig.4 i) External Wall load: ii) Internal Wall load: iii) Slab iv) floor finish load v) stair case load calculation vi) parapet wall load vii) The structure under live load, and viii) Displacements

Live Load

The live load considered in each floor & terrace was 2.5 KN/sq.m. The live loads were generated in similar manners as done in the earlier case dead load in floor. This may be done from the member load button from the load case column.

Load Combination

Taking into account all past loads, the structure has been assessed for suitable load combinations. First, the own weight, dead load, and live load were all taken into account. Instead of wind load, seismic load was taken into account in the second combination situation.

Base reactions

Node	L/C	Fx kN (Horizontal)	Fy kN (Vertical)	Fz kN (Horizontal)	Mx kNm (Moment)	My kNm	Mz kNm
1	1 self-weight	-0.152	97.443	1.376	0.621	0.000	0.070
	2 external wall load	-0.314	126.854	0.053	0.024	0.000	0.145
	3 internal wall load	0.073	44.736	4.823	2.176	0.000	-0.034
	4 parapit wall load	-0.095	6.069	-0.005	-0.002	0.000	0.044
	5 stair case load	0.002	-0.010	-0.000	-0.000	0.000	-0.001
	6 slab + ff	0.007	83.032	-1.390	-0.627	0.000	-0.003
	7 live load	-0.050	58.461	3.578	1.614	0.000	0.023
2	1 self-weight	-0.114	422.446	1.450	0.654	0.000	0.053
	2 external wall load	0.098	125.507	-0.221	-0.100	0.000	-0.045
	3 internal wall load	-0.054	45.560	4.991	2.251	0.000	0.025
	4 parapet wall load	-0.006	6.231	0.061	0.027	0.000	0.003
	5 stair case load	-0.009	-0.109	0.005	0.002	0.000	0.004
	6 slabs + ff	-0.065	83.975	-1.245	-0.562	0.000	0.030
	7 live load	-0.026	58.929	3.682	1.661	0.000	0.012

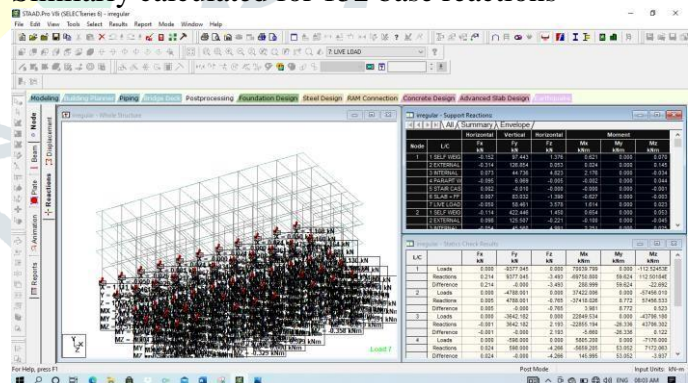Similarly calculated for 152 base reactions

Fig 5 base reactions

IV. DESIGNS

The IS code was followed for designing the structure for concrete. Details like Clear cover and the like were included in the specification. The window displayed below serves as the design input window. The members are planned as beams and

which ones as columns must then be defined as following.

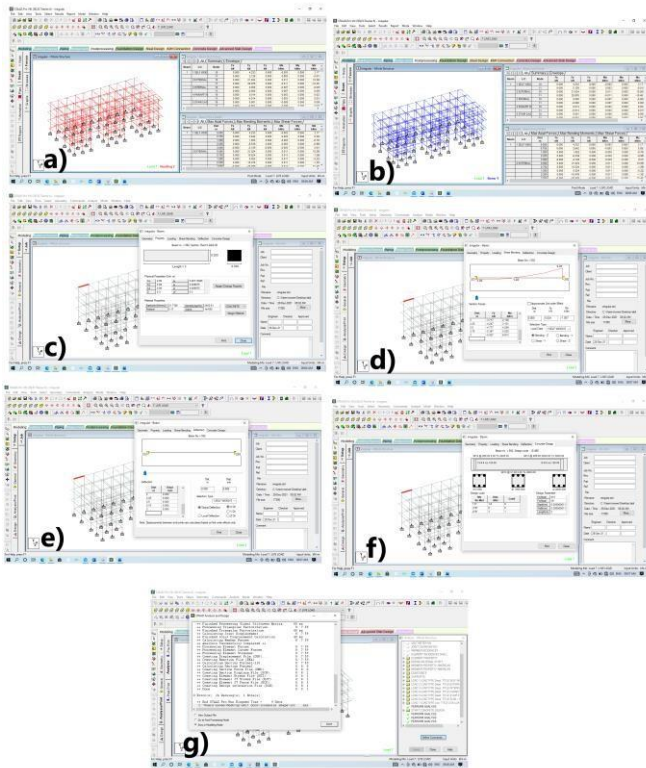   1.LOADS ON BEAMS 2.DESIGN OF BEAMS 3.LOADS OF COLUMNS 4.DESIGN OF COLOUMNS

Fig 6 a) BMD for all members, b) SFD for all members, c) Property, d) Shear bending, e) Deflection, f) Concrete design, and g) Design and analysis
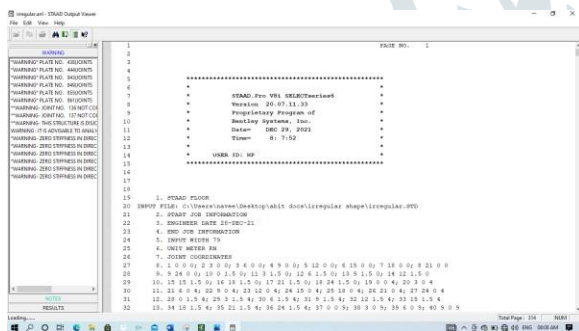
V. RESULTS

Fig 7 Staad output quantities

VI. CONCLUSION

1. Staad Pro is used to analyses and design a multi-story residential structure down to the smallest detail.

2. STAAD PRO can determine the amount of reinforcement required for every concrete segment.

According to IS: 456 standards, the software includes a variety of parameters (2000).

Shear, bending, and deflection are all characteristics of beams and columns.

The building's structural elements are protected against shear and bending.

This kind of reinforcement is designed to withstand both shear and bending stress. 6. Design for Shear reinforcement.

For the construction, it is cost-effective to use a large amount of steel.

8. STAAD Pro is software that allows us to analyses and design buildings quickly, efficiently, and accurately.

FUTURE SCOPE

1.This present study considered to only LIVE LOAD & DEAD LOAD. The same may be extended to wind & seismic analysis.

2.This analysis is done for 2D frame structures. This may extend to 3D-structures.

REFERENCES:

[1] Aradhanna Chavan "Analysis, Design and Estimation of G+4 Residential building", "International Journal of Engineering Research and Technology", vol. 10, no. 6, June 2021.

[2] Deshmukh D.R, Yadav.A.K , Supekar S.N , Thakur A.B, Sonawane H.P and Jain I.M "Analysis and Design of G+19 Storied Building using StaadPro" , " International Journal of Engineering Research and Application" ,vol. 6, no. 7, pp. 17-19, 2016.

[3] Preeti Singh, "Design and Comparison of Multi-Storied Building in all Seismic Zones", International Journal for Scientific Research & Development (IJSRD), vol. 5, pp. 538-539, 2017.

[4] Aman, Nalwadgi M, Vishal T and Gajendra "Analysis and Design of multi-storey building by using Stadd-pro", "International Research Journal of Engineering and Technology" vol. 3, no. 6, June 2016, 888- 891.

[5] Annop. A, Hussian F, Neeraja R, Chandran Rahul , S Shabina and S Varsha "Planning analysis and Design of multi-storey Building By Staad.Pro.V8i" , "International Journal of Scientific and Engineering Research", vol. 7, no. 4 , April-2016.

[6] IS Code 456-2000 (Design of RC structural elements)

[7] IS code SP-16 (Depth & percentage of Reinforcement