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ijirset@gmail.com



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Response Spectrum Analysis of G+10 Storey Building for Different Seismic Zones Using STAAD PRO

Meenal V. Dhengre¹, Prof. G.D. Awchat²

PG Student, Department of Civil Engineering, Guru Nanak Institute of Technology, Nagpur, Maharashtra, India¹

Assistant Professor, Department of Civil Engineering, Guru Nanak Institute of Technology, Nagpur,
Maharashtra, India²

ABSTRACT—In India with a seismic moderate zone, the equivalent static force method to estimate the seismic force, subsequent vulnerability and behaviour of RC building under seismic load is inadequate. From past seismic tremors, it is seen that on the off chance that the structures are not appropriately examined and developed with required quality, then it may lead to great destruction and loss to human lives. It has been demonstrated that numerous structures are completely or halfway harmed because of the quake. This reality was never disregarded while plan of multi-story structures by the basic specialists, scientists to guarantee wellbeing against tremor powers while erection. In this Project seismic reaction of a private G+10 RC outline building is breaking down by the direct examination methodologies of Equivalent Static Lateral Force and Response Spectrum techniques utilizing Stadd Pro Ultimate software according to the Seems to be 1893-2002-Part-1. These analyses are carried out by considering different seismic zones. A substitute response like lateral force, story drift, displacements, base shear are plotted to think about the consequences of the static and dynamic investigation.

KEYWORDS: Earthquake, Seismic Zones, Multi-Storey Building, Response Spectrum Method, STAAD Pro

I. INTRODUCTION

1.1 Background of the Study

A seismic tremor might be characterized as the arrival of versatile vitality by sudden slip on a blame and coming about ground shaking and transmitted brought about by slip. Tremors are one of the most exceedingly bad among the cataclysmic events. Around 1 lakh tremors of extent in excess of three hit the earth each year. As indicated by a preservationist gauge of in excess of 15 million, human lives have been lost and harm worth hundred billion of dollars have been dispensed in the written history due to these.

In present scenario, transformation of India due to urbanization, modernization & industrialization represents the level of development of our country. Rapid development indicates the scarcity of land and increases the demand of high-rise buildings. In today's era of modernization, major share in infrastructures are occupied by high-rise building structure and increases the demand of engineers & architect to plan & construct high-rise structures with more and more complex individual plan and elevation. The Indian subcontinent has suffered some of the greatest earthquakes & have most active seismic zone in the world. Prior decade, consideration of earthquake forces in structural design was neglected but today its consideration is significant one. Even though there is early advancement in field of seismic safety, moderate earthquakes in India are still became reason of thousands of people deaths and major property loss, representing the poor seismic performance of the existing infrastructure. There is a necessity: to build a more specialized environment for planning, analysing, designing, detailing and constructing earthquake resistant high- raised multi-storeyed structure by following seismic codal provisions. An earthquake-resistant high- raised multi-storeyed building has features like Good Structural Configuration, Lateral Strength, Adequate Stiffness, Good Ductility which required adequate knowledge and experience to achieve in different zones of India. Bureau of Indian Standards [IS 1893 (part 1):2002] has grouped INDIA into four seismic zones and same structure in different zone have different behaviour under seismic load and have varying requirements for effective seismic designs of high-raised structure because of categorisation of zone as per intensities or magnitude of earthquake. Structural Analysis determines

behaviour of structures so as to predict the responses of actual structures under the upgrading of predictable loading & outside environment during the service lifespan of structure. The present research describes the behaviour of (G+10) symmetrical high-rise multi-storey building structure under seismic analysis to withstand earthquake forces, which it will be subjected during an earthquake. Analysing the effect of Indian seismic zones mainly (Zone II (Mumbai) & Zone IV (Nagpur)) ONSAME (G+ 10) high-rise multi-storey building structure by the direct examination methodologies of static (Equivalent static lateral Force) and Dynamic (Response Spectrum techniques) is examined.

The present analysis is done using STADD.Pro (V8i) which provides a much faster approach to structural analysis and designing with chances of minimum error according to the code 1893-2002-Part-1. the software being used gives the calculation of support reactions, shear forces, axial force, bending moment, Base shear, seismic forces and displacement, stress, strain & deformation or deflection for a structural components of building (such as Beams, columns & slabs) The main parameters consider in this study to compare effect of Indian seismic zones (Zone II (Mumbai) & Zone IV (Nagpur)) on the seismic performance of (G+ 10) high rise multi-storey building structure with methods of seismic analysis. Analytical results are compared to achieve the most suitable earthquake resisting & economic structure against the lateral forces.

1.2 Earthquake

The portion accomplishes a prologue to the fundamental qualities of the tremor safe plan of structures with an extraordinary accentuation on related extra highlights in contrast with structural building plan. It is essential for Planning of Earthquake Resistant Structures constantly, tremors end the thousands of people life's, and wreck belongings value billions. It is essential that structures are proposed to contradict seismic tremor forces, to diminish the loss of life. additional structure assumes a critical job. Here, various tips and methods utilized in planning Earthquake Resistant structures are talked about.

A seismic tremor is a sudden; A seismic tremor is the shaking of the surfaces of the Earth, coming about in view of the unexpected entry of imperativeness in the Earth's lithosphere that makes seismic waves. Shakes can keep running in size from those that are feeble to the point that they can't be felt to those savage enough to fling people around and demolish whole urban networks. The seismicity or seismic activity of a domain insinuates the repeat, type and size of tremors experienced over some stretch of time. At the Earth's surface, seismic tremors show themselves by shaking and a portion of the time development of the ground.

Table 1.1 : List of natural and man-made earthquake sources

Natural Source	Man-made Source
• Tectonic Earthquakes • Volcanic Earthquakes • Rock Falls/Collapse of Cavity • Microseism	• Controlled Sources (Explosives) • Reservoir Induced Earthquakes • Mining Induced Earthquakes Cultural • noise (Industry, Traffic, etc)

At the point when the focal point of a vast quake is found seaward, the seabed might be movement adequately to cause a wave. Seismic tremors can likewise trigger destruction of property, landslide, and at times volcanic movement injury of people and even kills. For a gigantic number of years, the powers of tectonic plates have mold the Earth as the enormous plates that structure the Earth's surface move progressively finished. A seismic tremor's purpose of introductory burst is called its focus or hypocenter. The focal point is the point at ground level straightforwardly over the hypocenter.

The dynamic response of structure to seismic tremor ground development is the most basic explanation behind shudder incited mischief to structures. The mischief that a structure suffers essentially depends not upon its removing, anyway after accelerating. While dislodging is the genuine detachment the ground and building may move in the midst of a shudder, stimulating is an extent of how quickly they change speed as they move. The standard method to manage seismic tremor safe arrangement of structures depends on outfitting the structure with quality, solidness and inelastic twisting limits which are incredible to withstand a given component of shudder formed drive.

1.3 Protection from Earthquakes

For a structure to remain safe in the midst of seismic tremor trembling, The earthquake- resistant bracing has been designed for homes with a mullion-and-transom design, and connects the horizontal beams with the vertical submit. when exposed to wind or tremors, the connectors need to be rigid sufficient to maintain deformation to a minimal – but additionally elastic sufficient to resist strong earthquakes. If deformation does occur, it does not cause important pressure – in other words, the constructing sways, but does not fall apart.

1.4 Design philosophy of Earthquake Resistant Building

- Beneath minor but visit shaking, the primary individuals from the structures that bring vertical and horizontal powers ought not to be harmed; besides structures parts that do not deliver load may additionally aid repairable damage.
- under mild yet incidental shaking, the principle individuals might also aid repairable harm, whilst unique elements that don't deliver load may hold repairable harm.
- Beneath stable/tough however unusual shaking, the number one people may additionally aid critical damage, yet the structure ought not fall.
- whereas, a notable part of the abrupt are caught up within the pressure driven liquids and simply little is transmitted above to the undercarriage of the car. on the point when seismic energy is transmitted thru them, dampers ingest a few part of it, and consequently soggy the motion of the structure.

1.5 Analysis of the Structure

The building was divided into portal frames. The structure was partitioned into gateway Outlines and these casing have been investigated utilizing the STAAD.Pro.2000 Programming. The Ten-story gateway was ruined down for live load, dead load and Earthquake load combinations. The examination gave the force rising in the individuals, to be specific transverse

beam and sections, because of the above burdens and these individuals were intended for the severest of force acquired because of the load combination.

1.6 Seismic Zone of India

The changeable topography at various areas in the nation infers that the probability of harming seismic tremors occurring at various areas is having different seismic zone values for different locations. In this way, a seismic region map is essential so structures and different structures situated in various areas can be intended to withstand distinctive dimension of ground shaking. The current zoning of map divided into four zones in India II, III, IV and V.

Based on the past seismic history, Bureau of Indian Standards grouped the country into four seismic zones namely Zone-II, Zone-III, Zone-IV and Zone-V. Of all these four zones, Zone-V is the most seismic active region whereas Zone-II is the least.

Table 1.2 : Seismic Zone Intensity in MM Scale

Seismic Zone	Intensity on M.M Scale
Zone-II (Low-Intensity Zone)	6 (or less)
Zone-III (Moderate Intensity Zone)	7
Zone-IV (Severe Intensity Zone)	8
Zone-V (Very Severe Intensity Zone)	9 (and above)

1.6.1 Regions that fall under the Earthquake (seismic) Zones in India

Zone-V covers entire northeastern India, some parts of Jammu and Kashmir, some parts of Ladakh, Himachal Pradesh, Uttarakhand, Rann of Kutch in Gujarat, some parts of North Bihar and Andaman & Nicobar Islands.

Zone-IV covers remaining parts of Jammu & Kashmir, Ladakh and Himachal Pradesh, Union Territory of Delhi, Sikkim, northern parts of Uttar Pradesh, Bihar and West Bengal, parts of Gujarat and small portions of Maharashtra near the west coast and Rajasthan.

Zone-III comprises of Kerala, Goa, Lakshadweep islands, remaining parts of Uttar Pradesh, Gujarat and West Bengal, parts of Punjab, Rajasthan, Madhya Pradesh, Bihar, Jharkhand, Chhattisgarh, Maharashtra, Odisha, Andhra Pradesh, Tamil Nadu and Karnataka.

Zone-II covers remaining parts of the country

1.8 Objectives

- To analysis and design of Earthquake resistant of multistory building.
- To analyse the seismic response of a structure with the help of software STAAD.Pro 2000.
- To check Seismic response on shapes of buildings via rectangular shape, and square shape in different Zones of India and design earthquake resistant multi-storeyed building on that basis using STAAD-Pro software.
- Study of reactions, shear forces, axial force, bending moment, seismic forces and node displacement during assigning process And restrained them by applying suitable property and material in different zones.

II. LITERATURE REVIEW

The literature survey has been pioneered effort in this regard. Various seismic design concepts, mechanics, material behavioral properties and STAAD PRO concepts form literatures help to establish comparative study between existing and new experimentation.

The terminologies referred from literatures for designing are discussed as follows.

Bhattacharjee et al[1] The goal of this undertaking is to analyses and design layout a multistory building [G+21 (3 dimensional body)] mistreatment STAAD professional. the making plans involves load calculations manually and reading the whole structure through STAAD expert. the planning methods employed in STAAD-pro analysis square measure limit country style conformist to Indian Everyday Code of look at. STAAD.seasoned alternatives a progressive interface, image equipment, effective analysis and fashion engines with advanced finite element and dynamic evaluation abilities. From version generation, evaluation and fashion to image and end result verification, STAAD.seasoned is that the professional's opportunity. ab initio we generally tend to began with the analysis of easy a pair of dimensional frames and manually checked the accuracy of the software device with our consequences. The effects attempted to be terribly accurate. we generally tend to analyzed and d esigned a G+7 degree building together with basement [2-D body] ab initio for all capability load combos [useless, stay, and unstable loads]. STAAD.seasoned encompasses a terribly interactive interface that permits the customers to draw the frame and input the load values and dimensions. Then in keeping with the favored criteria appointed it analyses the structure and styles the individuals with reinforcement details for RCC frames. we tend to continuing with our paintings with a few extra multistory 2-D and 3-D frames beneath varied load combinations. Our final paintings became the right analysis and style of a G+21 3-D RCC frame beneath numerous load mixtures. we generally tend to thought of a 3-D RCC frame with the dimensions of four bays. The coordinate axis consisted of G+ floors. the whole numbers of beams in every floor were twenty-eight and consequently the numbers of columns have been sixteen. the bottom floor peak became 4m and the rest of the 5 floors had a top of 3.6 m. The structure became subjected to self weight, dead load, stay load, wind load and risky loads underneath the burden case info of STAAD.pro.

The seismic load esteems were produced by STAAD.Pro taking into consideration the given seismic powers at totally extraordinary statures and carefully perpetual by the determinations of IS 875.unstable burden computations were finished after IS 1893 - 2000.The materials were explicit and cross-segments of the shaft and section individuals were delegated. The backings at the base of the structure were conjointly explicit as attached. The codes of training to be pursued were conjointly explicit for style reason with elective fundamental subtleties. At that point STAAD.Pro was acclimated break down the structure and style the individuals. inside the post-handling mode, when finishing of the arranging, we can take a shot at the structure and concentrate the twisting minute and shear drive esteems with the created graphs. we will in general may check the avoidance of differed individuals underneath the given stacking blends. the arranging of the structure relies on the base needs as recommended inside the Indian ordinary Codes. The base needs relating the auxiliary wellbeing of structures square measure being covered by strategy



for partitioning down the last style hundreds that should be expected for dead hundreds, mandatory hundreds, and elective outer hundreds, the structure would be required modern. Severe adjustment to stacking norms advised amid this code, it's trusted, can ensure the basic wellbeing of the structures that square measure being planned. Structure and basic parts were typically planned by Limit State system. refined and skyscraper structures might want frightfully time taking and bulky computations abuse run of the mill manual ways. STAAD.Pro gives US a brisk, productive, simple to utilize and address stage for breaking down.

Saatcioglu, M. and Humar, J[2] The projected 2005 edition of the National codification of North yank country specifies dynamic analysis as a result of the foremost well-liked methodology for computing unstable vogue deflections, and force whereas to maintain the equivalent static force methodology for an areas of low seismicity and for the buildings with positive height boundaries. Comprising of the flexible modular reaction range approach or the numerical mix direct time history philosophy, or nonlinear (inelastic) reaction history examination. while each straight and nonlinear examinations might want cautious explanatory displaying, the last needs extra issues for appropriate recreation of hysteretic reaction partner degree requires an uncommon report that includes expand survey of support partner degree supporting investigations by an independent group of architects, with talks on scientific demonstrating of structures, auxiliary components, and hysteretic reaction. A discourse of the assurance of basic amount to be used in relationship with the proportional static power technique is introduced.

Duan, X.N. and Chandler, A.M[3] Based on Associate in Nursing uneven multistory frame constructing model, this paper investigates the have an impact on of a constructing's better vibration modes on its useless torsional reaction and evaluates the adequacy of the provisions of modern seismic building codes and consequently the modal analysis method in accounting for improved malleability demand in frames settled at or close to the stiff fringe of such buildings. it's entire that the affect of upper vibration modes at the response of the top-storey columns of stiff-edge frames will boom extensively with the building's standard unconnected lateral quantity and consequently the significance of the stiffness eccentricity. the appliance of the equal static torsional provisions of certain building codes may want to cause non-conservative estimates of the height malleability call for, extensively for systems with massive stiffness eccentricity. In these instances, the critical additives rectangular degree prone to immoderate extra malleability demand and, consequently, could also be difficulty to appreciably a number of severe structural harm than in corresponding radially symmetrical buildings. it's observed that frequently choppy homes excited properly into the useless vary won't be carefully designed mistreatment linear elastic modal evaluation idea. unique caution is wanted once making use of this method to the look of stiff-aspect body additives in extremely choppy systems.

Fu, F.[4] A third-dimensional limited part model structured by the creator was utilized in this paper to inquire about the dynamic breakdown of a multi-story steel composite edge building. The anticipated model will speak to the world 3-D conduct of the multi-story working underneath the sharp segment evacuation circumstances. upheld this model, consistent amount contemplates were distributed to inquire about the basic conduct with varieties in: quality of steel, quality of cement and support work measure. Through the consistent amount examine, the measures to relieve dynamic breakdown inside the future style were advised.

Mwafy [5] Attributable to the straightforwardness of springless static sucker examination contrasted with springless powerful investigation, the investigation of this framework has been the theme of the numerous examinations as of late. amid this paper, the legitimacy and along these lines the import ance of this framework square measure surveyed by examination with 'dynamic sucker' romanticized envelopes got from dynamic unique breakdown investigation. this is frequently attempted misuse common and fake seismic tremor records required on twelve RC structures of different qualities. This includes sequential scaling and use of each accelerogram pursued by evaluation the very pinnacle of reaction, up to the activity of the auxiliary breakdown. The consequences of more than 100 springless unique examinations utilizing a cautious second demonstrating methodology for everything about twelve RC systems are used to accumulate the dynamic weakling envelopes and contrast these and the static sucker results with very surprising burden designs. savy relationship is gotten between the determined admired envelopes of the dynamic examinations and static weakling results for a plot class of structure. wherever inconsistencies were resolved, serious examinations bolstered Fourier plentifulness investigation of the reaction were attempted and traditionalist suspicions were recommended.

III. INTERFACE OF STAAD PRO SOFTWARE

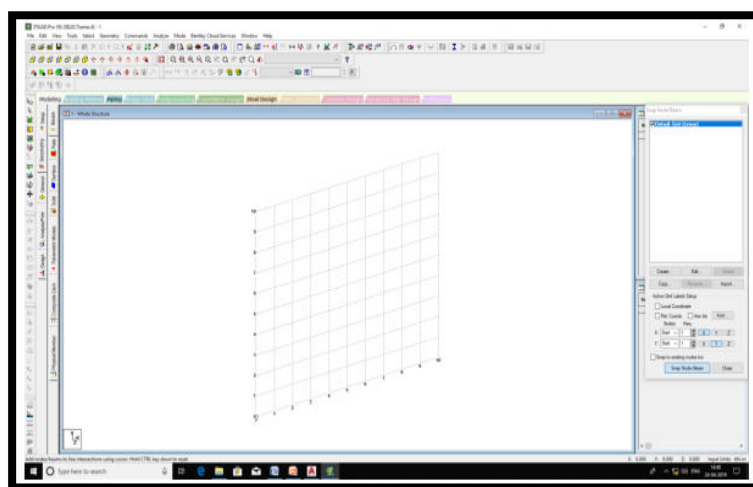
3.1 GENERAL

In each part of human development we required structures to live in or to get what we need. In any case, it isn't just structure structures however to fabricate proficient structures with the goal that it can satisfy the principle reason for what it was made for. Here comes the job of structural designing and all the more exactly the job of investigation of structure.

There are numerous established strategies to take care of plan issue, and with time new programming's additionally becoming an integral factor. Here in this undertaking work dependent on programming named Staad professional has been used. Few standard issues likewise have been unraveled to demonstrate how Staad star can be utilized in various cases. These ordinary issues have been settled utilizing essential idea of stacking, examination, condition according to IS code. These essential strategies might be discovered helpful for further investigation of issues. Examination of the structure intends to assurance of the inside powers like hub pressure bowing minute, shear constrain and so on in the segment part for which the part are to be planned under the activity of given outside burden. The plan is procedure of segment percussion from the examination results by utilizing appropriate investigation method. The point of configuration is to accomplishment of a satisfactory likelihood that structures being planned will perform agreeably amid their proposed life.

3.2 STAAD PRO

STAAD or (STAAD.Pro) is a structural analysis and design software application originally developed by Research Engineers International in 1997. In late 2005, Research Engineers International was bought by Bentley Systems. STAAD.Pro is one of the most widely used structural analysis and design software products worldwide. It supports over 90 international steel, concrete, timber & aluminium design codes. It can make use of various forms of analysis from the traditional static analysis to more recent analysis methods like p-delta analysis, geometric non-linear analysis, Pushover analysis (Static-Non Linear Analysis) or a buckling analysis. It can also make use of various forms of dynamic analysis methods from time history analysis to response spectrum analysis. The response spectrum analysis feature is supported for both user defined spectra as well as a number of international code specified spectra. Additionally, STAAD.Pro is interoperable with applications such as RAM Connection, AutoPIPE, SACS and many more engineering design and analysis applications to further improve collaboration between the different disciplines involved in a project. STAAD can be used for analysis and design of all types of structural projects from plants, buildings, and bridges to towers, tunnels, metro stations, water/wastewater treatment plants and more.



(Figure3.1 : STAAD PRO working Interface)

3.2.1 Advantages of STAAD PRO software

- i) Flexible modeling environment
- ii) Availability of wide ranges for designing code
- iii) Open architecture
- iv) All feature of structural engineering
- v) Report and documentation
- vi) Quality assurances
- vii) International code

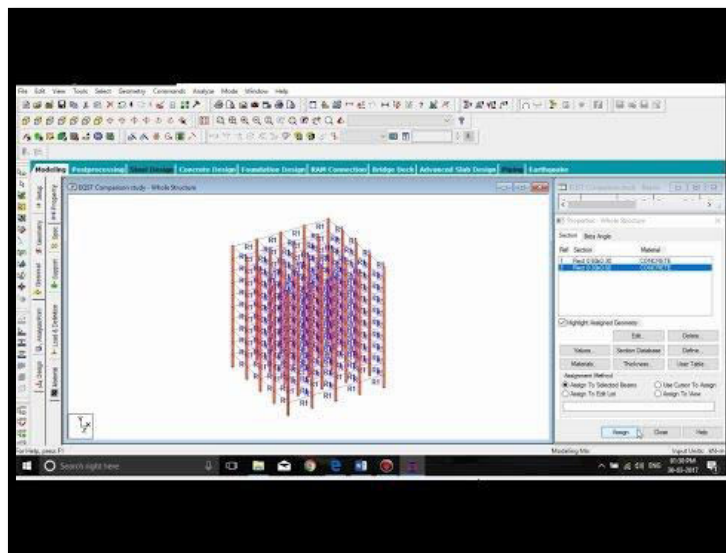
Investigation of structure of different components of structure.

- i) Planning of different parts of a structure with section situating
- ii) Introduction of STAAD.Pro
- iii) Modeling of the structure in the STAAD.Pro giving all limit conditions (Underpins, stacking and so on)
- iv) Analysis and Design of different basic parts of the modular structure
- v) Study of investigation Data of the product
- vi) Detailing of shafts, segments, piece with area proportioning and fortification.

3.2.2 Aim of STAAD PRO

This undertaking goes for relearning of idea of basic plan with the assistance of PC helps. Quickly we have experienced finishing calls attention to of the venture work

- i) Comprehension of plan and itemizing idea.
- ii) Main goal for example learning of STAAD.Pro programming bundle.
- iii) Learning of examination and plan procedure which can be valuable in the field.
- iv) Understanding of seismic tremor obstruction plan idea.
- v) Approach for expert practice in the field of basic designing



(Figure 3.2: Seismic Analysis of 10 Storey RCC Building Using Staad Pro V8i)

IV. PROPOSED METHODOLOGY

4.1 METHODS OF ANALYSIS

The most commonly used methods of analysis for determining the design seismic forces acting on a structure as a results of ground shaking are based on the approximation that the effects of yielding can be accounted for by linear analysis of the building, using the design spectrum for inelastic systems. Forces and displacements due to each

horizontal component of ground motion are separately determined by analysis of an idealized building having one lateral degree of freedom per floor in the direction of the ground motion component being considered. Such analysis may be carried out by the equivalent static procedure (static method) or response spectrum analysis procedure (dynamic method). Both the equivalent static and response spectrum analysis procedures lead directly to lateral forces in the direction of the ground motion component. The significant difference between linear static and linear dynamic analysis is the level of the forces and their distribution along the height of the structure. The equivalent static method is mainly suited for preliminary design of the building. The preliminary design of the building is then used for response spectrum analysis or any other refined method such as the elastic time history method. For this study, seismic analysis is carried out by linear static analysis and response spectrum analysis.

4.1.1 Equivalent Static Analysis

It is one of the method for calculating the seismic loads. The high rise structures are not considered for the design simple static method. In practical as it does not take into account all the factors that are the importance of the foundation condition. The equivalent static analysis is used to design only for the small structures. In this method only one mode is considered for each direction. The earthquake resistant designing for the low rise structures the equivalent static method is enough. Tall structures are needed more than two modes and mass weight of each story to design earthquake resistant loads. This is not suitable to design those structures and dynamic analysis method to be used for high rise structures.

4.1.2 Response Spectrum Analysis

The seismic forces strikes the foundation of a structure will move with the ground motion. It shows that structure movement is generally more than the ground motion. The movement of the structure as compared to the ground is referred as the dynamic amplification. It depends on the natural frequency of vibration, damping, type of foundation, method of detailing of the structure. The response “design acceleration spectrum” which refers to the max acceleration called spectral acceleration coefficient S_a/g , as a function of the structure for a specified damping ratio for earthquake excitation at the base for a single degree freedom system. The revised IS 1893-2002 uses the dynamic analysis by response spectrum.

In this method takes into account all the five important engineering properties of the structures.

- i. The fundamental natural period of vibration of the building (T in seconds)
- ii. The damping properties of the structure
- iii. Type of foundation provided for the building
- iv. Importance factor of the building
- v. The ductility of the structure represented by response reduction factor.

4.1.3 Response Spectrum Method by using STAAD Pro

This is accurate method of analysis. The design lateral force at each floor in each mode is computed by STAAD Pro in accordance with IS: 1893 (Part 1)-2002. The software provides result for design values, modal masses and storey wise base shear.

Methodology: The design lateral shear force at each floor in each mode is computed by STAAD in accordance with the IS: 1893 (Part 1) -2002 following equation.

$$Q_{ik} = A_k \cdot f_{ik} \cdot P_k \cdot W_k \text{ and } V_{ik} = Q_{ik}$$

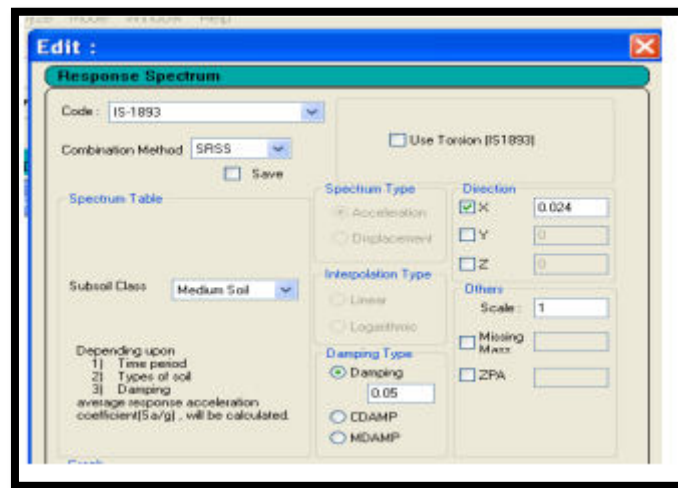
STAAD utilizes the following procedure to generate the lateral seismic loads

1. User provides the value for $Z/2 \cdot I/R$ as factors for input spectrum.
2. Program calculates time periods for first six modes or as specified by the user.
3. Program calculates S_a/g for each mode utilizing time period and damping for each mode.
4. The program calculates design horizontal acceleration spectrum A_k for different modes.

5. The program then calculates mode participation factor for different modes.
6. The peak lateral seismic force at each floor in each mode is calculated.
7. All response quantities for each mode are calculated.
8. The peak response quantities are then combined as per method (CQC or SRSS or ABS or TEN or CSM) as defined by the user to get the final results.

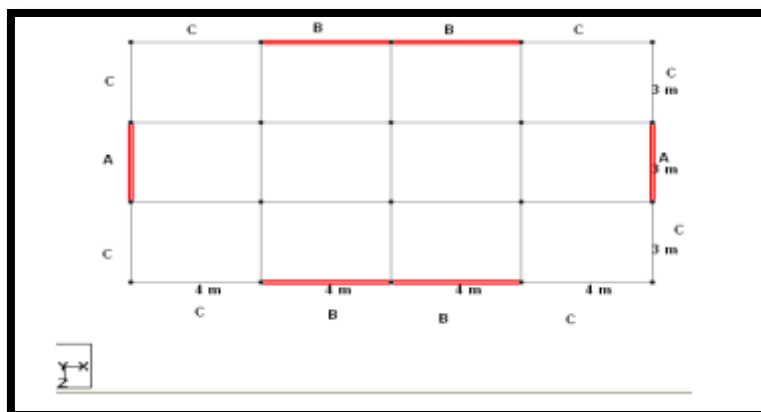
4.1.4 Analysis of Building With Response Spectrum Method

Seismic Analysis of high-rise building having following data is analyzed for different models of lateral load resisting systems.



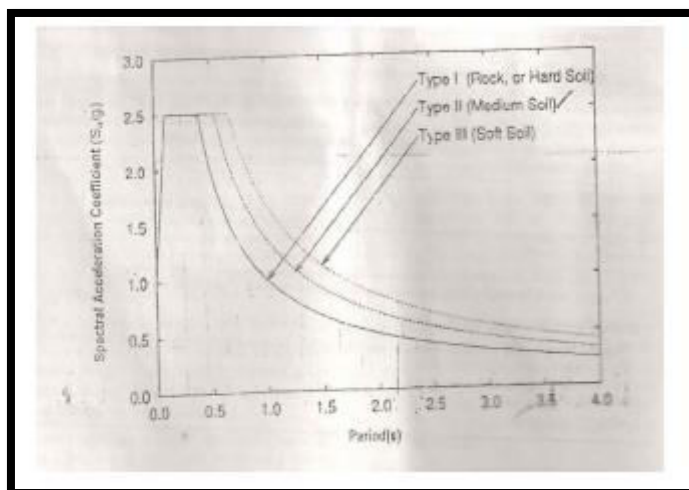
(Figure 4.1 : Response Spectrum data specification)

For present work response spectrum method as per IS:1893-2002 is carried out for reinforced concrete moment resisting frame having (G+10) storey situated in zone IV. The floor to floor height of the building is 3m. The total height of building is 45m.



(Figure 4.2 : Plan of building showing location of braced frame & shear wall frame)

Design Parameters: The design spectrum used is of medium soil as per IS 1893 Part I (2002).

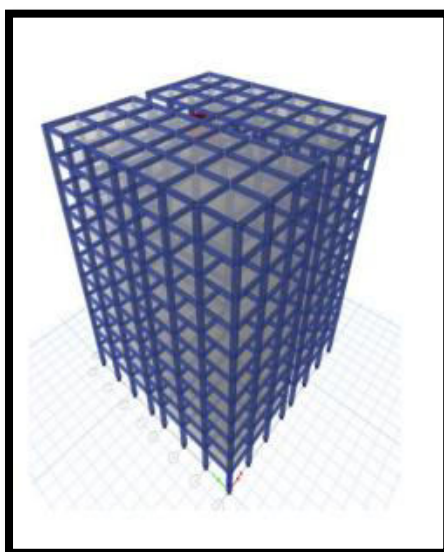


(Figure 4.3 : Response spectrum for soil as per IS 1893 Part I (2002))

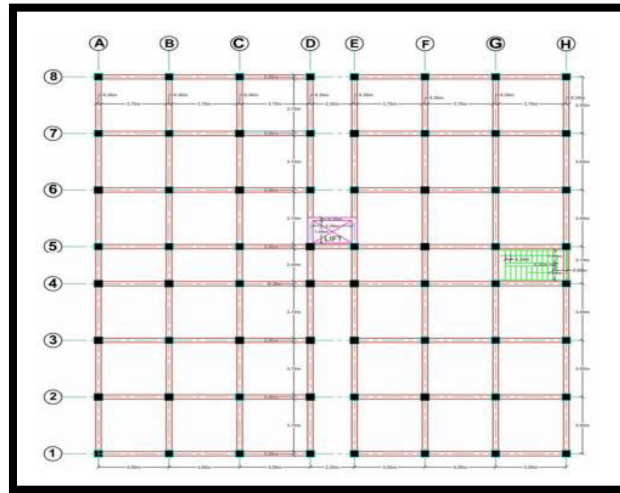
4.2 ZONE FACTORS FOR DIFFERENT ZONES IN INDIA

Table 8.1 : Seismic Zone factors

Zone	Seismic coefficient	Seismic zone factor
V	0.08	0.36
IV	0.05	0.24
III	0.04	0.16
II	0.02	0.1



(Figure4.4 : 3D Model)



(Figure 4.5: Model Layout)

4.3 LOADS CONSIDERED

4.3.1 DEAD LOADS

As per IS: 875 (Part 1) - 1987 (Incorporating IS: 1911-1967) (Reaffirmed 1997) Edition 3.1 (1997-12), Indian Standard code of practice for design loads (other than earthquake) for buildings and structures (part-1), dead loads unit weights of building materials and stored materials All permanent constructions of the structure kind the dead masses. The load includes of the weights of walls, partitions floor finishes, false ceilings, false floors and also the alternative permanent constructions within the buildings. The unit weights of plain concrete and ferroconcrete created with sand gravel or crushed natural stone mixture could also be taken as 24 KN/m and 25 KN/m severally.

4.3.2 IMPOSED LOADS

As per IS: 875 (Part 2) - 1987 (Reaffirmed 1997), Indian Standard code of practice for design loads (other than earthquake) for buildings and structures. Imposed load is created by the supposed use or occupancy of a building together with the burden of movable partitions, distributed and targeted masses, load thanks to impact and vibration and mud masses. Obligatory masses don't embrace masses thanks to wind, unstable (seismal) activity, snow and masses obligatory thanks to temperature changes to that the structure is subjected to creep and shrinkage of the structure, the differential settlements to that the structure might bear.

4.3.3 WIND LOAD

As per IS: 875 (Part 3) - 1987 (Reaffirmed 1997) Indian Standard code of practice for design loads (other than earthquake) for buildings and structures. Wind is air in motion relative to the surface of the planet. The first explanation for wind is derived to earth's rotation and variations in terrestrial radiation. The radiation effects area unit primarily to blame for convection either upwards or down. The wind typically blows horizontal to the bottom at air current speeds. Since vertical elements of region motion area unit comparatively tiny, the term 'wind' denotes virtually solely the horizontal wind, vertical winds area unit continually known per se. The wind speeds area unit assessed with the help of anemometers or anemographs that area unit put in at earth science observations at heights typically varied from ten to thirty meters on top of ground.

4.4 WORKING WITH STAAD.PRO

4.4.1 INPUT GENERATION

The graphical user interface (or user) communicates with the STAAD analysis engine through the STAAD INPUT file. That computer file could be a document consisting of a series of commands that square measure dead consecutive. The commands contain either directions or knowledge concerning analysis and/or design (style). The STAAD computer file may be created through a text editor or the graphical user interface modeling facility. In general, any text editor is also utilized to edit/create the STAAD computer file. The graphical user interface modeling facility creates the computer file through Associate in nursing interactive menu-driven graphics homeward-bound procedure.

4.4.2 TYPES OF STRUCTURES

A Structure is often outlined as associate degree assemblage of components. STAAD is capable of analyzing and planning structures consisting of frame, plate/shell and solid components. Virtually any style of structure is often analyzed by STAAD. A SPACE structure, that may be a 3-dimensional framed structure with hundreds applied in any plane, is that the most general. A PLANE structure is sure by a worldwide X-Y frame of reference with hundreds within the same plane. A TRUSS structure consists of truss members who might have solely axial member forces and no bending within the members. A FLOOR structure may be a 2 or 3-dimensional structure having no horizontal (global X or Z) movement of the structure [FX, FZ & MY square measure restrained at each joint]. The ground framing (in worldwide X-Z plane) of a building is a perfect example of a FLOOR structure. Columns also can be sculptural with the ground during a FLOOR structure as long because the structure has no horizontal loading. If there's any horizontal load, it should be analyzed as an area structure.

4.4.3 GENERATION OF THE STRUCTURE

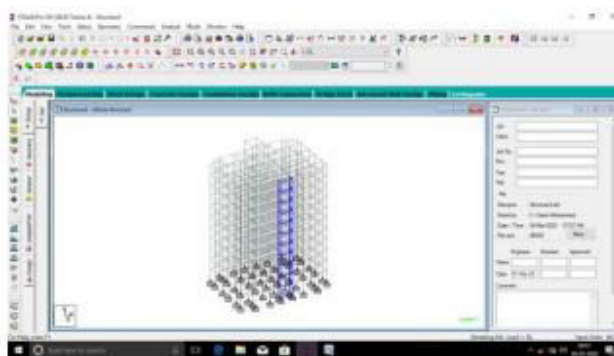
The structure could also be generated from the computer file or mentioning the co-ordinates within the graphical user interface. The figure below shows the graphical user interface generation technique. E structure.

4.4.4 MATERIAL CONSTANTS

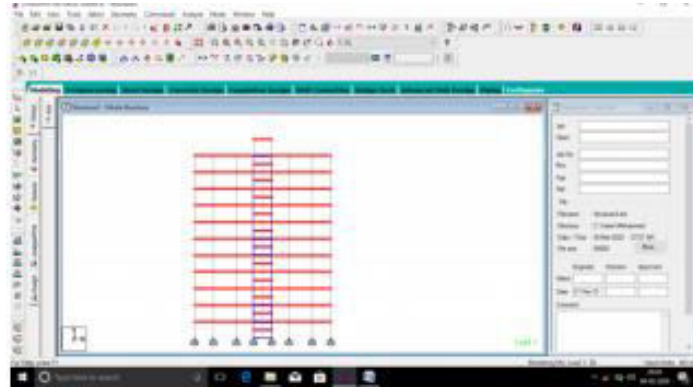
The material constants are: modulus of elasticity (E); weight density (DEN); Poisson's ratio (POISS); co-efficient of thermal enlargement (ALPHA), Composite Damping Damping Ratio, and beta twelve angle (BETA) or coordinates for any reference (REF) purpose. E value for members should be provided or the analysis won't be performed. Weight density (DEN) is employed only self-weight of the structure is to be taken under consideration.

4.5 ANALYSIS OF BUILDING ELEMENTS IN STAAD PRO

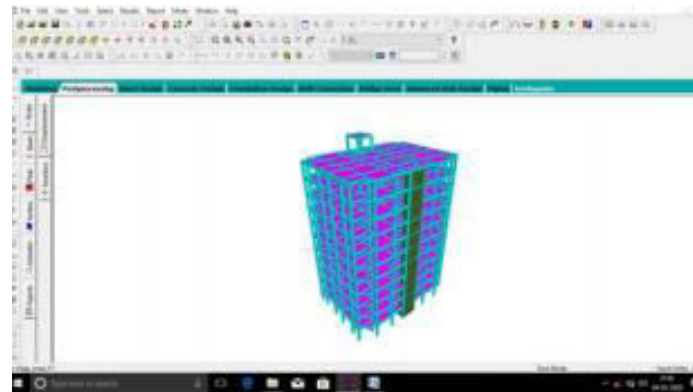
The modeling analysis is done in the STAAD PRO.



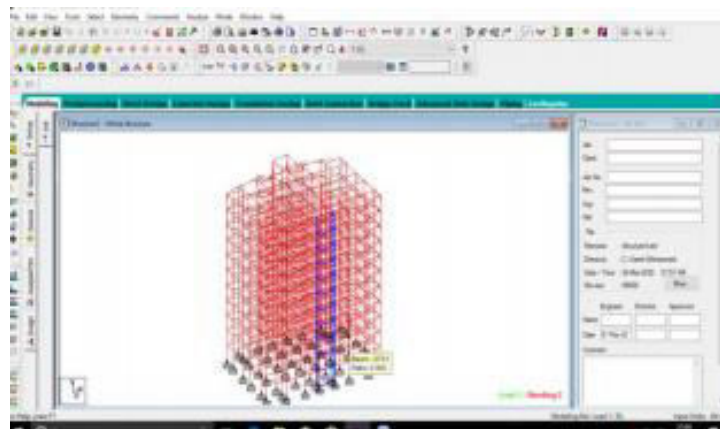
(Figure 4.6 :3d modeling view)



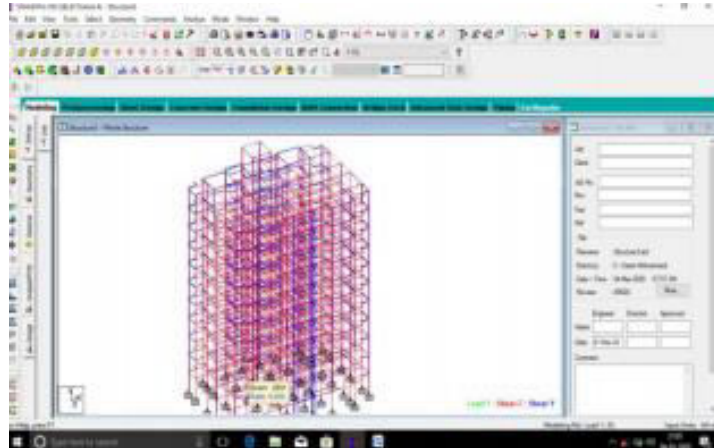
(Figure4.7 :Beams representation)



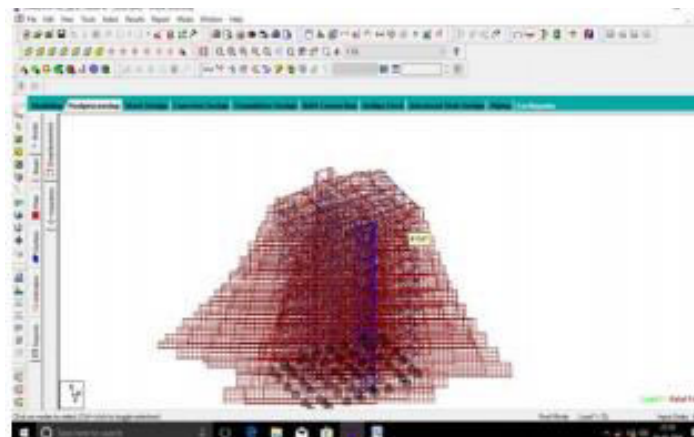
(Figure4.8 :3D rendering view)



(Figure4.9 : Bending moment diagram)



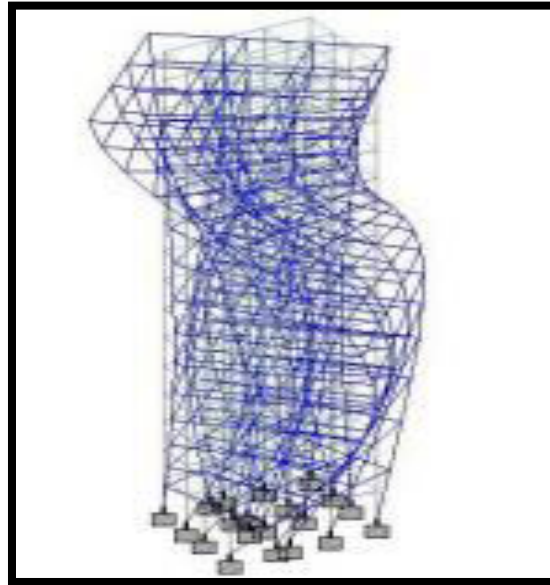
(Figure4.10 :Shear force diagram)



(Figure4.11 :Axial force diagram)



(Figure4.12 :Footing analysis)



(Figure 4.13 : mode shape in dynamic analysis)

V. RESULTS

5.1 SEISMIC BASE SHEAR CALCULATION

The design of base shear is the sum of lateral forces applied at all levels that are finally transferred to the ground.

$$V_b = A_h \cdot W$$

$$A_h = (Z/I/2R)(S_a/g)$$

The fundamental natural period for buildings are in IS 1893(part 1) 2002 Class 7.6.

$T_a = 0.075h^{0.75}$ for moment resisting RC frame building without brick infill walls

$T_a = 0.085h^{0.75}$ for moment resisting steel frame building without brick infill walls

$T_a = 0.09h/\sqrt{d}$ for all other buildings including moment resisting RC frame building with brick infill walls.

Fundamental natural period for buildings with brick infill walls

$$T_a = 0.09h/\sqrt{d}$$

$$Z = 0.16$$

$$I = 1.5$$

$$R = 5$$

$$S_a/g = 2.5$$

$$V_b = A_h \cdot W$$

$$A_h = (Z/I/2R)(S_a/g)$$

The fundamental periods on both x and z directions are respectively given below: $T_x = 0.383$ Sec, $T_z = 0.492$ Sec. From figure 2 of IS 1893, S_a/g is found to be 2.5 for both the periods, so the design horizontal seismic coefficient (A_h) will be same which will result in producing the same amount of base shear in both the directions.

$$A_h = (Z/I/2R)(S_a/g) = (0.16 \times 1.5/2 \times 5) \times (2.5) = 0.06$$

$$V_b = A_h \times W = 0.06 \times 75935.75 \text{ kN} = 4556.145 \text{ kN}$$

So the base shear for 6 story building is found to be equal to 4556.145 kN

Now the base shear is laterally distributed as per IS-1893-2002,

$$Q_i = ((W_i h_i^2) / (\sum W_i h_i^2)) \times V_b$$

Table 5.1: lateral distribution of base shear force

i	W_i (kN)	h_i (m)	$W_i h_i^2$ (kNm ²)	Q_i (kN)
1	13520.375	4	216326	59.02
2	13520.375	8	865304	234.1
3	13520.375	12	1946934	531.22
4	13520.375	16	3461216	944.4
5	13520.375	20	5408150	1475.62
6	8333.875	24	4800312	1309.77
Σ	75935.75		16698242	4554.13

These lateral forces (Q_i) are obtained and applied to the building laterally considering the center of mass and the response is obtained using equivalent static analysis.

5.2 ANALYSIS

Based on the external loads, structural materials and structural model, there are different types of analysis process such as linear static analysis, linear dynamic analysis, nonlinear static analysis and nonlinear dynamic analysis.

The analysis options are set before analysis. The analysis is performed with a scale factor 1. The number of modes is initially set as 1.5 after analysis. If the cumulative mass participation factor is less than 95 percentage, then it is modified accordingly with base shear values obtained for the earthquake load case, the new scale factor is calculated and again the model is analyzed for the new scale factor. It can be observed that the base shear value calculated from the code and by the software with the new scale factor are the same.

And the combination load is applied in Staad Pro by using formula which are given bellow.

- 1) 1.5(DL+IL)
- 2) 1.2(DL+IL+-EL)
- 3) 1.5(DL+ - EL)
- 4) 0.9DL+ - 1.5EL

Table 5.2: showing primary load cases and combination load case

Primary Load Cases		
Number	Name	Type
1	SEISMIC LOAD +X	Seismic
2	SEISMIC +Z	Seismic
3	DL	Dead
4	LL	Live

Combination Load Cases				
Comb.	Combination L/C Name	Primary	Primary L/C Name	Factor
5	COMBINATION LOAD CASE 5	3	DL	1.50
		4	LL	1.50
6	COMBINATION LOAD CASE 6	3	DL	1.20
		4	LL	1.20
		1	SEISMIC LOAD +X	1.20
7	COMBINATION LOAD CASE 7	3	DL	1.20
		4	LL	1.20
		1	SEISMIC LOAD +X	-1.20
8	COMBINATION LOAD CASE 8	3	DL	1.50
		1	SEISMIC LOAD +X	1.50
9	COMBINATION LOAD CASE 9	3	DL	1.50
		1	SEISMIC LOAD +X	-1.50
10	COMBINATION LOAD CASE 10	3	DL	0.90
		1	SEISMIC LOAD +X	1.50
11	COMBINATION LOAD CASE 11	3	DL	0.90
		1	SEISMIC LOAD +X	-1.50

5.2.1 The result below is after analyzing by using Staad Pro

Table 5.3 shows the base shear in Tx and Tz

*	*
* TIME PERIOD FOR X 1893 LOADING =	0.38300 SEC
* SA/G PER 1893=	2.500, LOAD FACTOR= 1.000
* VB PER 1893=	0.0600 X 74365.16= 4461.91 KN
*	*

*	*
* TIME PERIOD FOR Z 1893 LOADING =	0.49200 SEC
* SA/G PER 1893=	2.500, LOAD FACTOR= 1.000
* VB PER 1893=	0.0600 X 74365.16= 4461.91 KN
*	*

Manually the calculation of base shear = 4556.145 kN and software calculation = 4461.91kN
 $4461.91\text{kN} \leq 4556.145\text{ kN}$ so it is safe

Table 5.4 showing the base shear force laterally distributed by Staad Pro analysis

i	h_i (m)	Q_i (KN)
1	4	61.189
2	8	245.189
3	12	551.676
4	16	980.757
5	20	1647.06
6	24	976.039
Σ		= 4461.91

V. CONCLUSION

- To conclude, STADD. Pro is versatile software having the ability to determine the reinforcement required for any concrete section based on its loading and determine the nodal deflections against lateral forces.
- Stadd.Pro& ETABS (version 2017) gives hardly any variation in results compared to the results computed manually.
- Irregular configuration of structure is more susceptible to earthquake load than regular shaped buildings.
- The variation of seismic load, wind load, shear force and bending moment with the height is showing a direct relationship
- Seismic zone-V have more value of Zone Factor and show critical behaviour during seismic analysis of G+10 structure. Steel quantity required for seismic zone-V is higher than 53.84%, 13.89% and 8.31% as compared to zone II, zone-III and zone-IV
- The behavior of a building during earthquakes depends critically on its overall shape, size and geometry, in addition to how the earthquake forces were carried to the ground
- Stadd.Pro allows you to follow the criteria of several design codes for eg. The Indian standards relating to loads, designs, analysis etc.
- Stadd.Pro is a much easier and faster way of analysing and designing a structure when compared to manual computation. .
- Stadd.Pro is a user-friendly way to analyse the structure as its GUI is very easy to work with and the software is quite versatile.

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