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# A REVIEW ON "RESEARCH ANALYSIS OF FACTORS INFLUENCING THE DESIGN OF PREFABRICATED IDENTIFIED ASSEMBLY BUILDINGS"

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**ABSTRACT-** Seismic analysis is a major tool in earthquake engineering which is used to understand the response of buildings due to seismic excitations in a simpler manner. It is a part of structural analysis and a part of structural design where earthquake is prevalent. This technical paper highlights the project work pertaining to the structural analysis and design of a multipurpose auditorium using a computer software, Extended 3D Analysis of building System, abbreviated as STAAD PRO. Shape of the auditorium was linear (rectangular). This includes planning, analysis of loads and designing of structural elements based on different loading conditions. Planning of acoustic and vision point of view were taken from National Building Code, and the limit state method of collapse using respective IS codes. AutoCAD® was used for drawing plan, elevation and section of auditorium. Design and analysis were done manually and the results were verified using STAAD PRO.

**KEYWORDS:** Structural Analysis, Design, Staad Pro, Autocad, Auditorium, AutoCAD

## I. INTRODUCTION

### 1.1 BACKGROUND OF THE STUDY

In this project analysis and design auditorium by using STAAD Pro Software and also seismic analysis and design of an auditorium. This project highlights the project work pertaining to the structural design and analysis of a multipurpose auditorium using computer software, Staad Pro V8i. Planning of vision point of view and acoustics were taken from National building code, and therefore the limit state method of collapse using Indian Standard Codes. AutoCAD software version 2016 was used for drawing plan, section and elevation of auditorium. Design and analysis is done using Staad Pro. v8i software and verified by manual method.

These are the buildings where groups of people meet or gather for amusement, recreation, social, religious, political, civil, travel, and similar purposes; such as theatres, motion picture houses, marriage halts, town halls, auditoriums, exhibition halls, assembly halls museums. A covered or open enclosure where people can assemble for attending any seminar given on the stage. An Auditorium is a room built to accommodate the audience to sit and watch presentation or any stage performances. An auditorium is a large space that is the move of a multipurpose facility. A auditorium or multi-purposes hall is usually a large space that is built to the needs and specifications of the entertainment. An auditorium may be a various purpose facility where an area built to enable an audience to listen to and watch performances. For movie theatres, the number of auditoria (or auditoriums) is expressed because the quantity of screens. Auditoria are often found in community hall, entertainment venues and theatres, and can be used for presentation, rehearsal, humanities productions, or as a learning space. Each size is exclusive, with specific guidelines governing row size, row spacing, and exit ways. In a continental arrangement, all seats are located during a central section. In order to catch abreast of the greater length of rows allowed, building codes would require wider row spacing, wider aisles, and strategically located exit doors. Various researchers have done work in this area.

### 1.2 ASSEMBLY BUILDINGS

Assembly building means a building or part thereof where groups of people congregate or gather for amusement, recreation, social religious, patriotic, civil travel and similar purposes. Examples of assembly buildings are Theaters,

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concert halls, Banquet halls, gaming areas, Restaurants, Community halls, Gymnasiums, Lecture halls, Libraries, Places of religious worship.

***Place of assembly, entertainment or recreation, including any of the following:***

- bingo halls, broadcasting, recording and film studios open to the public, casinos, dance halls
- entertainment, conference, exhibition and leisure centres
- funfairs and amusement arcades
- museums and art galleries, non-residential clubs, theatres, cinemas, concert halls
- educational establishments, dancing schools, gymnasia, swimming pool buildings, riding schools, skating rinks, sports pavilions, sports stadia
- law courts
- churches and other buildings of worship, crematoria
- libraries open to the public, non-residential day centres, clinics, health centres and surgeries
- passenger stations and termini for air, rail, road or sea travel
- public toilets
- zoos and menageries.

### 1.2.1 Types of Buildings

Types of buildings can be classified based on several criteria such as size, function, construction, style, design etc. However, the International Building Code (IBC 2018) and Uniform Building Code (UBC) categorize buildings based on occupancy and use.

Criteria from IBC and UBC are logical since they control the design and construction of structures. Added to that, each building type represent varying levels of hazard and risk to building occupants and adjacent properties.

#### 1.2.1.1 Types of buildings Based on IBC and UBC

As mentioned above, the international building code classified types of buildings based on occupancy and use, main types of buildings are classified based on the occupancies and utilization of buildings used to determine subordinate buildings within certain type of building.

1. Assembly Buildings: Assembly buildings are used for meeting or gathering of peoples for certain purposes.For instance, religious, social, eating food and drinking, consumption, or awaiting transportation. The International Building Code (IBC 2018) divided assembly buildings into Group A-1, A-2, A-3, A-4, A-5, and A-6. The description of each group can be found in the International Building Code 2018.
Examples of assembly buildings are Theaters, concert halls, Banquet halls, gaming areas, Restaurants, Community halls, Gymnasiums, Lecture halls, Libraries, Places of religious worship and many more.

2. Business Buildings: Business buildings are employed for offices, professional transactions, and other business related services for example storage of accounts.
Example- Airport traffic control towers, Ambulatory care facilities, Banks, Clinic, Electronic data processing, Food processing establishments, Laboratories: testing and research, Post offices, Professional services (architects, attorneys, dentists, physicians, engineers, etc.). These are all examples of business buildings.

3. Educational Buildings: Educational buildings are built for different purposes such as education, training, supervision, and care provision for students and trainees of different stages.
Examples of educational buildings are college, training institute, school, and day care centre.

4. Factory and Industrial Buildings: As the name may suggest, factory and industrial buildings are constructed for assembling, disassembling, fabricating, finishing, manufacturing, packaging, repair or processing operations. It should be known that the level of hazard posed in these type of facilities are low.
Example- Aircraft manufacturing buildings, factory, gas plant, power plant, refineries, diaries, and laundries are examples of factory and industrial buildings.

5. High hazard Buildings: These types of buildings are built to manufacturing, processing, generation or storage of highly combustible and flammable or explosive materials that pose high physical or health hazard.
Examples of hazardous materials include fireworks, hydrogen peroxide, and cyanide. Lastly, high hazard buildings are further divided into H-1, H-2, H-3, H-4 and H-5.

6. Institutional Buildings: Institutional buildings are constructed for several reasons such as provision of care or supervision to individuals who are not capable of self-preservation without physical help, or persons detained for correctional purposes. Moreover, institutional buildings are divided into sub groups which include I-1, I-2, I-3 and I-4.

Example- Institutional building examples include foster care facilities, detoxification facilities, hospitals, nursing homes, psychiatric hospitals Alcohol and drug centers, assisted living facilities, congregate care facilities, care facilities, and social rehabilitation facilities.

7. Mercantile Buildings: These types of buildings are utilized for the display and sale of merchandise which includes stocks of goods, wares or merchandise incidental to such purposes and accessible to the public.
Example- Finally, mercantile buildings include department stores, drug stores, markets, sales rooms, motor fuel-dispensing facilities, retail or wholesale stores, greenhouses for display and sale of plants that provide public access.

8. Residential Buildings:

- Residential buildings are constructed and equipped for the purpose of sleeping.
- Apartment houses, dormitories, fraternities and sororities, hotels, and motels are examples of residential buildings.

9. Storage Buildings:

- These types of buildings are employed for storage of various materials which are not hazardous for instance bamboos, canvas and leather, books and paper, boots and shoes, clothing, woolen wearing apparel, and furniture.
- Examples of such buildings include garage, warehouse, cold storage, and transit sheds.

10. Utility and Miscellaneous Buildings

- Examples of utility and miscellaneous buildings include agricultural buildings, aircraft hangars, communication equipment structures, grain silos, tanks, and towers

## 1.3 AUDITORIUM

An auditorium is a room built to enable an audience to hear and watch performances. Auditoria can be found in entertainment venues, community halls, and theaters, and may be used for rehearsal, presentation, performing arts productions, or as a space. The term is taken from Latin (from auditorium fromauditorius ("'pertaining to hearing'"); the concept is taken from the Greek auditorium, which had a series of semi-circular seating shelves in the theatre, divided by broad 'belts', called diazomata, with eleven rows of seats between each.

***Components of an Auditorium:***

1. Beam: Beams are structural elements that resists loads applied laterally to their axis. They typically transfer loads imposed along their length to their end points where the loads are transferred to walls, columns, foundations, and so on.
2. Column: A column is a vertical structural member intended to transfer a compressive load. For example, a column might transfer loads from a ceiling, floor or roof slab or from a beam, to a floor or foundations. They have good compressive strength.

3. Slab: A slab is a structural element, made of concrete, that is used to create flat horizontal surfaces such as floors, roof decks and ceilings. A slab is generally several inches thick and supported by beams, columns, walls, or the ground. A slab of reinforced concrete that serves as a flat roof. Concrete slabs can be prefabricated off-site and lowered into place or may be poured in-situ using formwork.
4. Roof Truss: A joint framed structure that sustained the inclined, vertical or horizontal loads. A truss consist of angles, channels, plates and eye bars. It is a framework, typically consisting of rafters, posts, and struts, supporting a roof, bridge or other structure. They are supporting the roofs of auditoriums, cinema halls, stadiums, railways, stations, airports and others.

## 1.4 STRUCTURAL ANALYSIS AND DESIGN

The aim of structural design is to achieve an acceptable probability that the structure being designed will perform the function for which it is created and will safely withstand the influence that will act on it throughout its useful life. These influences are primarily the loads and the other forces to which it will be subjected. The effects due to temperature fluctuations, foundation settlements etc. should be also considered. The design methods used for the design of reinforced concrete structures are working stress method, ultimate load method and limit state method.

### 1.4.1 History of Structural Analysis

A structure refers to a system of two or more connected parts used to support a load. It may be considered as an assembly of two or more basic components connected to each other so that they carry the design loads safely without causing any serviceability failure. Once a preliminary design of a structure is fixed, the structure then must be analyzed to make sure that it has its required strength and rigidity. The loadings are supposed to be taken from respective design codes and local specifications, if any. The forces in the members and the displacements of the joints are found using the theory of structural analysis. The whole structural system and its loading conditions might be of complex nature, so to make the analysis simpler, certain simplifying assumptions related to the material quality, member geometry, nature of applied loads, their distribution, the type of connections at the joints and the support conditions are used. This shall help making the process of structural analysis simpler to quite an extent.

### 1.4.2 Methods of structural analysis

When the number of unknown reactions or the number of internal forces exceeds the number of equilibrium equations available for the purpose of analysis, the structure is called a statically indeterminate structure. Many structures are statically indeterminate. This indeterminacy may be as a result of added supports or extra members, or by the general form of the structure.
While analyzing any indeterminate structure, it is essential to satisfy equilibrium, compatibility, and force-displacement conditions for the structure.

#### 1.4.2.1 Force method

The force method developed first by James Clerk Maxwell and further developed later by Otto Mohr and Heinrich Muller-Breslau was one of the first methods available for analysis of statically indeterminate structures. This method is also called compatibility method or the method of consistent displacements. In this method, the compatibility and force displacement requirements for the given structure are first defined in order to determine the redundant forces. Once these forces are determined, the remaining reactive forces on the given structure are found out by satisfying the equilibrium requirements.

#### 1.4.2.2 Displacement method

In the displacement method, first load-displacement relations for the members of the structure are written and then the equilibrium requirements for the same are satisfied. The unknowns in the equations are displacements. Unknown displacements are written in terms of the loads or forces by using the load-displacement relations and then these equations are solved to determine the displacements. As the displacements are determined, the loads are found out from

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the compatibility and load- displacement equations. Some classical techniques used to apply the displacement method are discussed.

**1.4.2.3 Slope deflection method**

This method was first devised by Heinrich Manderla and Otto Mohr to study the secondary stresses in trusses and was further developed by G. A. Maney in order to extend its application to analyze indeterminate beams and framed structures. The basic assumption of this method is to consider the deformations caused only by bending moments.
It is assumed that the effects of shear force or axial force deformations are negligible in indeterminate beams or frames. The fundamental slope-deflection equation expresses the moment at the end of a member as the superposition of the end moments caused due to the external loads on the member, with the ends being assumed as restrained, and the end moments caused by the displacements and actual end rotations. Slope-deflection equations are applied to each of the members of the structure. Using appropriate equations of equilibrium for the joints along with the slope-deflection equations of each member, a set of simultaneous equations with unknowns as the displacements are obtained. Once the values of these displacements are found, the end moments are found using the slope-deflection equations.

**1.4.2.4 Moment distribution method**

This method of analyzing beams and multi-storey frames using moment distribution was introduced by Prof. Hardy Cross in 1930, and is also sometimes referred to as Hardy Cross method. It is an iterative method. Initially all the joints are temporarily restrained against rotation and fixed end moments for all the members are written down. Each joint is then released one by one in succession and the unbalanced moment is distributed to the ends of the members in the ratio of their distribution factors. These distributed moments are then carried over to the far ends of the joints. Again the joint is temporarily restrained before moving on to the next joint. Same set of operations are performed at each joint till all the joints are completed and the results obtained are up to desired accuracy.

The method does not involve solving a number of simultaneous equations, which may get quite complicated while dealing with large structures, and is therefore preferred over the slope-deflection method.

**1.4.2.5 Kani's method**

This method was first developed by Prof. Gasper Kani of Germany in the year 1947. This is an indirect extension of slope deflection method. This is an efficient method due to simplicity of moment distribution. The method offers an iterative scheme for applying slope deflection method of structural analysis. Whereas the moment distribution method reduces the number of linear simultaneous equations and such equations needed are equal to the number of translator displacements, the number of equations needed is zero in case of the Kani's method.

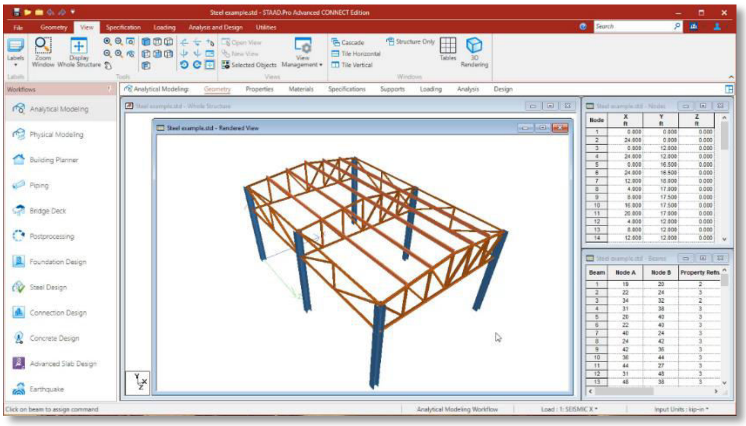
**1.5 INTERFACE OF STAAD PRO SOFTWARE**

**1.5.1 OVERVIEW**

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.

**1.5.2 STAAD PRO**

The STAAD Pro Graphical User Interface: it's wont to generate the model, which might then be analyzed mistreatment the STAAD engine. Once analysis and style are completed, the user interface also can be wont to read the results diagrammatically. The STAAD analysis and magnificence engine: it is a general calculation engine for structural analysis and integrated Steel, Concrete, Timber and metal vogue. To begin with we've got resolved some sample problems practice STAAD skilled and checked the accuracy of the results with manual calculations. The results were to satisfaction and were correct. With the initial section of our project we've got done calculations concerning loadings on buildings and conjointly thought of seismal and wind masses. Structural analysis contains the set of physical laws and arithmetic needed to review and predicts the behavior of structures. Structural analysis may be viewed additional abstractly as a way to drive the engineering style method or prove the soundness of a style while not a dependence on directly testing it. To perform associate in nursing correct analysis a structural engineer should confirm such data as structural masses, geometry, support conditions and material properties. The results of such Associate in nursing analysis generally embrace support reactions, stresses and displacements. This data is then compared to criteria that indicate the conditions of failure.



**[Fig.1.2: STAAD PRO working Interface on Auditorium]**

**1.5.3 Advantages of STAAD PRO software**

- Flexible modeling environment
- Availability of wide ranges for designing code
- Open architecture
- All feature of structural engineering
- Report and documentation
- Quality assurances
- International code

Investigation of structure of different components of structure.

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

### 1.5.4 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

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

## II. LITERATURE REVIEW

### 2.1 ORIGIN OF THE PROJECT

1. Selection of site and Planning –The site selection for an auditorium building is done by as per relevant site availability and condition.
2. Size and Shape- The dimensions is fixed in reference to the amount of people required to be seated. The building height is decided by considerations as presence of balcony, ventilation.
3. Stage - the dimensions of the stage depends on the sort of performance the hall is to require for.
4. Rear Wall -The building rear walls is kept flat otherwise it can be convex in shape.
5. Side Wall -Where the side walls are not kept parallel as within the case of a fan shaped hall, the walls may remain reflective and should be architecturally finished in any required manner, if sound soaking material isn't required from other considerations.

An auditorium may be a various purpose facility where an area built to enable an audience to listen to and watch performances. For movie theatres, the number of auditoria (or auditoriums) is expressed because the quantity of screens. Auditoria are often found in community hall, entertainment venues and theatres, and can be used for presentation, rehearsal, humanities productions, or as a learning space. Each size is exclusive , with specific guidelines governing row size, row spacing, and exit ways. In a continental arrangement, all seats are located during a central section. In order to catch abreast of the greater length of rows allowed, building codes would require wider row spacing, wider aisles, and strategically located exit doors. Various researchers have done work in this area. The Auditorium allows for huge conferences, displays and performances. Auditorium consists of assembly halls, show off halls, auditoriums and theatres. This thesis is about designing an auditorium using STAAD pro tool. This tool saves time for calculations and studying the structure. Project is primarily based on limit state concept, the structure shall be designed to resist, it must bare all loads liable to act on it at some point of its lifestyles; it shall additionally satisfy the serviceability requirements, including limitations on deflection and cracking.

### 2.2 LITERATURE REVIEW RELATED TO AUDITORIUM

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

#### REASEARCH ARTICLE 1

#### [1] Analysis and design of auditorium by using STAAD Pro Software

Manoj Nallanathe, Ramesh.bhaskar, B.v.Pavan Kumar (2018), This project deals with the design of a multi-purpose auditorium so as to accommodate 900 persons. The main concept design of auditorium building vision & acoustical purpose. The dimensions auditorium building is 55*22 mtswith out include of compound wall & balcony arena. Required area is calculated as per NBC. This includes planning, analysis of loads and designing of structural elements based on the loads coming on them (live loads, dead loads, wind loads as per IS:875 part-1,2,3). The shape of the auditorium is linear (rectangular). Auditorium consists of assembly halls, show off halls, concert halls, auditoriums and theatres. This is so because the plan is based on acoustic and vision point of view, which are taken from NBC part-VIII, for which linear shape is best suitable . The design pattern of seating arrangements, floor height, celing ,stair case & remain parameters necessary for design of auditorium interior part by using ADA code book. The drafting of auditorium planning by using auto-cadd tool & design of rcc building by using Staad Pro software. The building was analyzed& designed using STAAD Pro. The dimensions of column is 0.3*0.8 m & beam 0.3 *1.5 m are challenge think to sustain with an maximum bending moment with an critical section of beam &column .Actually beam design for long span construction should be prefer PT beams instead of R.c.c beam. Normally if we use PT beam is size should be reduce half of the depth of beam size. In this case our project deals R.C.c beam 1.5 m depth of beam but PT beam size is 0.75 m.

The maximum footing size is 4.0*4.0 mts with deep of 1.5 m. STAAD Pro give satisfactory results when checked with manual design also. Designing is an art of finding out dimensions of a structural member and amount of other materials (reinforcement, prestressing etc.) which will be sufficient to withstand different types of loads and forces applied on that member, at the same time it will be economic and providing serviceability. In other words, "the basic objective in structural analysis and design is to produce a structure capable of resisting all applied loads without failure during its intended life".

## RESEARCH ARTICLE 2

**[2] Design and analysis of auditorium using STAAD Pro software**

Akshay K. Ghuge, Durgesh H. Tupe, Gajendra R. Gandhe (2021), This project deals with the design and analysis of the auditorium which is located at Aurangabad in Maharashtra State. Auditorium can be used for all types of formal assembly, lectures, seminars, functions, award ceremony, cultural activities like dramatic plays, singing and dancing. The Project is based on limit state concept, the structure is designed to resist and liable to bare all loads liable to act on it. It should be satisfying the requirement of serviceability within the limitation of Deflection and Cracking. The analysis done using STAAD-Pro and Structural Detailing had done using AUTO-CAD. The project was aimed on the analysis and design of an auditorium building located at Aurangabad City in Maharashtra State.

- The construction of auditorium presents a solution of many cultural events programs being held.
- It was analysis using STADD.PRO using generic loading which proved to be premium software of great potential in analysis and design sections of construction industry.
- All the structural components were detailed by using AutoCAD 2016.
- The analysis and design were done according to standard specifications.
- Used IS-456:2000 & SP-16, for the design of the STRUCTURAL MEMBERS. i.e., followed the LIMIT STATE method.
- The various difficulties encountered in the design process and the various constraints faced by the structural engineer while meeting the requirements of architectural drawing were also well.
- Materials used are M20 grade concrete and Fe 415 steel unless mentioned in the particular design elements.

## RESEARCH ARTICLE 3

**[3] Design and Analysis of Auditorium by Using STAAD Pro**

S.Harish, L.Ramaprasad Reddy (2017), The Auditorium allows for huge conferences, displays and performances. Auditorium consists of assembly halls, show off halls, auditoriums and theatres. This thesis is about designing an auditorium using STAAD pro tool. This tool saves time for calculations and studying the structure. Project is primarily based on limit state concept, the structure shall be designed to resist, it must bare all loads liable to act on it at some point of its lifestyles; it shall additionally satisfy the serviceability requirements, including limitations on deflection and cracking. The suited limit for the protection and serviceability necessities before failure happens is known as a ―limit state. The aim of design is to achieve appropriate chances that the structure will not unfit for the use. For which it's indented, that it's going to not attain a limit state. The project is about "Designing and Planning of Auditorium". As this is a prayer hall all the members of the staff assemble here. The total project includes designing of structural members like slab, beams, columns, footings. The designing has been done based on reference of IS code 456:2000 for concrete and SP 16 for steel. The software AutoCAD was used for drawings (plan, section, &elevation) and for drawing reinforcement details of slabs, columns, beams & footings. Various load combinations as per IS code were used, considering seismic load as the major apart from other loads. The structure is stable under various load combinations. This project concludes that the moments and forces appearing in the structure were significantly lower than in case of plane frame under similar loading conditions. Also the project shows that for long spans structures are considerably cost effective than plane frame structures. From the analysis process the values obtained are plotted as bar graph and line graph. Base shear and storey drift are the two parameters which are compared here for medium soil condition and soft soil condition. Base shear is an estimate of the maximum expected lateral force on the base of the structure due to seismic activity. It is high in soft soil condition. The storey displacement is the lateral sway of the story with respect to its base. According to the report the value of storey displacement at 4.5m are maximum in both medium and soft soil conditions.

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**RESEARCH ARTICLE 4**

**[4] Structural Analysis and Design of an Auditorium using Extended-3D Analysis of Building System**

Ashwini Mareena Sam, Devika J S, Panchami P S, Muhammad Salih N, Rajeev Kumar P (2020), This technical paper highlights the project work pertaining to the structural analysis and design of a multipurpose auditorium using a computer software, Extended3D Analysis of building System, abbreviated as ETABS®.

Shape of the auditorium was linear (rectangular). This includes planning, analysis of loads and designing of structural elements based on different loading conditions. Planning of acoustic and vision point of view were taken from National Building Code, and the limit state method of collapse using respective IS codes. Auditoria can be found in entertainment venues, community halls, and theatres, and may be used for rehearsal, presentation, performing arts productions, or as a learning space. Seating arrangements in an auditorium seating layout (or assembly space) are either be identified as "multiple-aisle" or "continental." These terms are commonly found in design standards manuals, building codes, and similar architectural reference documents. Each size is unique, with specific guidelines governing row size, row spacing, and exit ways. Basically, a multiple-aisle arrangement will have a maximum of 14–16 chairs per row with access to an aisle-way at both ends. In a continental arrangement, all seats are located in a central section. Here the maximum quantity of chairs per row can greatly exceed the limits established in a multiple-aisle arrangement. In order to compensate for the greater length of rows allowed, building codes will require wider row spacing, wider aisles, and strategically located exit doors. Although it would seem like more space is called for, a continental seating plan is often not any less efficient than a multiple-aisle arrangement. In fact, if it is carefully planned, a continental arrangement can frequently accommodate more seating within the same space. This work highlighted the analysis and design of a multipurpose auditorium at Pathanapuram municipality, Kerala state using ETABS® software. Preliminary drawings were done using AutoCAD®. For completeness, a cost estimation for the construction was also carried out and the estimated cost was found as Rs 1,22,00000/-.

**RESEARCH ARTICLE 5**

**[5] Analysis of a Structural and Sesmic Design of an Auditorium**

RupeeshS.and Prabhakaran P. A.(2021), Methodology is the systematic, theoretical analysis of the methods applied to a field of study. It comprises the theoretical analysis of the body of methods and principles associated with a branch of knowledge. A methodology does not set out to provide solutions. A methodology offers the theoretical underpinning for understanding which method, set of methods, or best practices can be applied to a specific case, for example, to calculate a specific result. With the increasing seismic activities in the recent times an efficient design of the pile foundations to resist the estimated earthquake loads is a major concerned issue.

In this interest, this study deals with the estimation of the seismic loads on a super structure as per the two international codes selected, IS 1893 and EN 1998. Different cases are considered assuming the location of the structure to be in different seismic zones of India and on different ground types (Type C and Type D).

The estimated seismic loads are applied to the SAP2000 model of the structure and analyzed to find the maximum (design) foundation loads. Liquefaction potential was evaluated, before proceeding to the pile design, for the selected soil profiles in the Guwahati region. Then the pile is designed for a selected case of seismic zone V and the ground type C. The pile is first designed for using the Indian Standard IS 2911. Then the design was checked against lateral deflection and limiting moment capacity of pile for the estimated lateral loads and moments under seismic condition using commonly used method called the Characteristic Load Method. Further the seismic design is revised for both the cases considering the soil profile to be liquefiable.

- The base shear increases significantly as the soil condition changes from medium soil to soft soil.
- In our case the base shear increased by 35.95%
- The storey drift is also affected due to the change in the soil conditions, it increases as the soil stiffness decreases.
- In our case the storey drift increased in the range of 8% to 14%.

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## III. CODAL PROVISIONS

### 3.1 DESIGN PHILOSOPHY

- 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.

### 3.2 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 G+1-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. Precisely when a building is shown to the seismic tremor vibrations its establishment will move to and from with the ground. These vibrations can be incredibly marvelous, making stresses and deformation all through the structure making the upper edges of the building swing from a few mms to different inches' reliant on their stature size and mass. This is reliably material for structures everything being equivalent, paying little heed to whether single storied or multi-storied in high-chance seismic tremor zones.

### 3.3 SEISMIC ZONES 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 3.1: 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) |

#### 3.3.1 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

### 3.4 IMPORTANT OF SEISMIC DESIGN CODES

Ground vibrations during earthquake cause forces and deformations in structures. Structures should be planned withstand such powers and disfigurements. Seismic codes help to improve the conduct of structures so that may withstand the quake impact without huge death toll and property. Nations around the globe have techniques laid out in the seismic code to help configuration builds in the arranging, planning, enumerating and developing of structures.

***a. A tremor safe has four ethics in it, specifically:***

i) Good Structural Configuration: its size, shape and a basic framework conveying loads are to such an extent that they guarantee an immediate and smooth stream of latency powers to the ground.
ii) Lateral Strength: The most extreme sidelong (even) compel that it can oppose is with the end goal that the harm initiated in it doesn't result in breakdown.
iii) Adequate Stiffness: Its sidelong burden opposing framework is to such an extent that the seismic tremor – in fact distortions in it don't harm its substance under low-to-direct shaking.
iv) Good Ductility: Its ability to experience extensive disfigurements under extreme seismic tremor shaking even in the wake of yielding is improved by positive structure and itemizing procedures.
b. Indian Seismic Codes:
Seismic codes are extraordinary to an area or nation. They think about the nearby seismology, acknowledged dimension of seismic hazard, structures typologies, and materials and strategies utilized in development.

***The Bureau of Indian Standards (BIS) the accompanying Seismic Codes:***

• IS 1893 (PART 1) 2002, Indian Standard Criteria for Earthquakes Resistant of Design Structures (5the update). • IS 4326, 1993, Indian Standard Code of training for Earthquake Resistant Design and Construction of Buildings. (second update).
• IS 13827, 1993, Indian Standard Guidelines for improving Earthquake Resistant of Earthen structures.
• IS 13828, 1993 Indian Standard Guidelines for improving Earthquake Resistant of Low Strength Masonry Buildings.
• IS 13920, 1993, Indian Standard Code for training for Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces. The directions in these gauges don't guarantee that structures endure no harm amid the tremor of all greatness. In any case, to the degree conceivable, they guarantee that structures can react to tremor shaking of moderate forces without auxiliary harm and of substantial powers without all out breakdown.

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